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DETERMINING ATMOSPHERIC DEPOSITION INPUTS TO TWO SMALL WATERSHEDS AT ACADIA NATIONAL PARK

By

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B. A. Columbia University, 1994

A THESIS

Submitted in Partial Fulfillment of the

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The University of Maine

May, 2002

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DETERMINING ATMOSPHERIC DEPOSITION INPUTS TO TWO SMALL WATERSHEDS AT ACADIA NATIONAL PARK

By Sarah J. Nelson

Thesis Advisor: Dr. J. Steve Kahl

An Abstract of the Thesis Presented
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Two small upland watersheds have been gauged and monitored at Acadia National Park since 1998. Cadillac Brook watershed burned in a wildfire in 1947. Hadlock Brook watershed has been undisturbed for several centuries, and serves as the reference site. Precipitation and throughfall volume and chemistry data have been collected using wet-only and continuously open collectors. Hydrologic and chemical inputs to the sites have been determined for each site.

Differences in watershed and vegetation characteristics control the input of water and major ions to these watersheds. Vegetation type was the dominant control on enhancement of precipitation across the heterogeneous watersheds. Relative annual enhancement of throughfall over wet-only deposition for coniferous stands at Hadlock was 2.0 for NH_4 and NO_3, 2.7 for SO_4, 7.1-7.3 for Cl and Na, 6.8 for Ca, 92 for Mg, and 58 for K. Enhancement was similar for mixed stands, intermediate for deciduous stands, and lowest (except Cl and Na) at scrub and open sites. At Cadillac, enhancement was slightly lower for each ion, but the same pattern, coniferous ≈ mixed > deciduous >

scrub/open, was observed. Seasonal differences were important, with highest deposition in fall and summer; however, wet deposition inputs of Cl and Na were highest in winter.

Elemental stream flux was calculated using discharge data from the U. S. Geological Survey, combined with periodic water chemistry data. The chemical mass balance in the watersheds was determined from stream outputs minus wet inputs, where negative values indicate retention within the watershed. At Cadillac and Hadlock, H, Mg, K, NH_4, and NO_3 are retained; Ca and SO_4 are lost. Retention of DIN (NO_3 plus NH_4) was 96% at Cadillac and 72% at Hadlock, indicating that differences related to vegetation and/or soils control the relative patterns of retention and release.

ACKNOWLEDGMENTS

This work could not have begun without the support of Steve Kahl. Taking on a graduate student from a non-science background, and entrusting me with such an important and enriching project, all the time knowing how much to advise and how much to challenge, are the characteristics of a true mentor. Thank you Steve for this incredible opportunity. Ivan Fernandez deserves many thanks for lots of sessions with drafts and data, and for always helping me to re-focus ‘The Question’. Key contributions to this manuscript were made by Chris Cronan, who has presented me with plenty of opportunities to work harder and understand more in class and in this research. Alan White brought a fresh perspective to the work and was instrumental in the tough statistical analyses. Bill Halteman and Rachel Keats also assisted with the statistics portion of the work. Kathleen Weathers of IES provided crucial guidance on early versions of the manuscript.

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Others contributed to this project – Heather Shoven, John Peckenham, Molly Schauffler, and Janet Eckhoff who were around in the beginning and the 'new' Water Resources grads – Emily Seger, Catherine Schmitt, Bjorn Lake, and Raquel Reinhardt, as well as Dina Page and Tanya Hyssong, who have provided motivation as I have finished this work. Two graduate students in particular deserve special mention: Laura Wilson, who has always kept me on track, and Ewan Whitaker, who helped me find my way around the Park.

My family has given me all the freedom I have needed to choose my own education, often making significant sacrifices themselves – and I am grateful for that. Finally, thank you to Ken Johnson, who has been an exceptional partner and research colleague. Many thanks also to John Hyland, Eddy, Henry, and Vega, who provide a quiet kind of encouragement; and Norman Cook for providing the soundtrack.

To close, I would like to acknowledge the contributions of Senator George J. Mitchell to this work. Senator Mitchell, who provided a context for this research with his far-reaching legislation, has given researchers in this field not only justification, but also inspiration.

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Chapter 1

INTRODUCTION

Acadia National Park in Maine (Acadia) is designated a Class I area by federal Clean Air Act regulations (40 CFR §52.21). However, it is well documented that the Park receives elevated inputs of sulfur (S) and nitrogen (N) (Kahl *et al.*, 1991; Heath *et al.*, 1993; NADP/NTN, 2001). In addition to long range transport of pollutants from power plant and industrial sources, emissions from automobiles of more than three million annual visitors contribute NO_x and SO_x, precursors to acid rain.

Continued deposition of N, even with decreases in sulfur dioxide (SO_2) emissions, may result in nitrogen saturation of forests (Aber *et al.*, 1989 and 1998; Kahl *et al.*, 1993a; Driscoll *et al.*, 2001), or contribute to surface water acidification (Kahl *et al.*, 1993b; Stoddard, 1994; Aber *et al.*, 1998). Acidification of some aquatic resources has been documented in the Park (Kahl *et al.*, 1985; Kahl, 1995 and 1999), including seasonal episodic acidification (Kahl *et al.*, 1985 and 1992; Heath *et al.*, 1992). At Acadia, loading of nutrients from upland sources to estuaries may contribute to eutrophication (Ketchum and Cass, 1986; Nielsen *et al.*, 1997).

Acadia National Park is located at the temperate and boreal transition zone in North America. Vegetation communities are patchy and heterogeneous, in part due to a major wildfire that burned over 10,000 acres (4,000 ha) in the Park in 1947. The Park has a variety of freshwater resources including lakes, lowland valley streams, mountain brooks, bogs, and marshes. Chemically resistant bedrock underlies thin or absent soils, providing little acid neutralizing capacity. Acadia's topography is moderate to steep, with short residence time for surface water runoff. As a result, the surface waters at Acadia are generally poorly buffered and sensitive to atmospheric loading of pollutants (Heath *et al.*, 1993) and nutrients. Acadia's location on Mount Desert Island in Maine and its prominent topography lead to frequent immersion in pollutant-enriched clouds and coastal fogs.

Atmospheric deposition of pollutants to complex terrain is not spatially uniform (Lovett *et al.*, 1999; Weathers *et al.*, 1992, 1995, 2000a). This heterogeneity is especially significant at Acadia because of the varied topography, steep slopes, and the differences among vegetation types in terms of canopy interception of contaminants (Weathers *et al.*, 2000a). Seasonal meteorology influences wind direction, and thus controls the chemistry of precipitation depending on the source of the air mass. Streamwater data from Hadlock Brook and Cadillac Brook, the two streams draining the study watersheds for this research, show different patterns in N and S export. One explanation for watershed differences in export may be landcover characteristics that affect both deposition rates and ecosystem processing.

In forested catchments, suites of landscape features, such as vegetation type and elevation, may drive the enhancement of wet precipitation (Weathers *et al.*, 2000a). For instance, if a certain vegetation type has a greater atmospheric pollutant scavenging efficiency than another, we expect throughfall inputs between the two types to reflect that difference in efficiency. The throughfall approach for investigating watershed processes allows investigators to assess inputs in forested, mountainous areas with diverse, patchy land use histories (Rustad *et al.*, 1994; Weathers *et al.*, 1992, 1995, 2000a, 2000b), such as the paired watersheds at Acadia.

A mass balance approach to small watershed studies requires measures of inputs and export. Inputs to watersheds can be measured by quantifying wet plus dry deposition across the landscape (Weathers *et al.*, 1992; Lawrence and Fernandez 1993; Lovett, 1994; Matzner and Meiwes, 1994; Rustad *et al.*, 1994; Houle *et al.*, 1999a and 1999b). Canopy throughfall consists of wet deposition (including occult deposition), dry deposition, and the net product of canopy exchange processes such as plant uptake and release (Lawrence and Fernandez 1993; Houle *et al.*, 1999a). The chemistry of throughfall provides a reasonable estimate of total deposition to a watershed or landscape for more conservative ions, and it is often significantly different from the chemistry of wet-only samples (Lindberg and Lovett, 1992; Lovett, 1994; Rustad *et al.*, 1994; Rea *et al.*, 2000).

1.1. Background

This thesis is a component of an ongoing study of a pair of watersheds with similar physical characteristics but with different vegetation types, in part due to disturbance by fire in 1947 (Figure 1). The research is part of a long-term ecological investigation begun in 1998, in collaboration with the United States Geological Survey (USGS) and National Park Service (NPS), funded in part by the Environmental Protection Agency (EPA). The natural experimental design utilizes contrasting vegetation and soil characteristics between the two watersheds that exist, in part, due to the severe wildfire that burned one of the watersheds in 1947. The non-burned watershed, Hadlock Brook Watershed, drains the southwest slope of Sargent Mountain. The ‘experimental’ watershed is Cadillac Brook Watershed, located on the steep southeastern slope of Cadillac Mountain, much of which was burned in the 1947 fire.

The current focus of the PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network) project, of which this research is a component, is atmospheric deposition of N and mercury (Hg), and their ecological consequences. Both elements are of major concern, both regionally and to the Park Service at Acadia. This project offers the advantage of parallel paired watershed design (instrumentation and plot layout) with the acidic deposition experiment on paired watersheds at the nearby Bear Brook Watershed in Maine (BBWM) (Kahl *et al.*, 1993b; Norton and Fernandez, 1999).

1.2. Objectives

The main objective of this research was to **estimate inputs of major ions to the two watersheds at Acadia National Park**. Inputs were determined by: 1) comparing measured throughfall to wet-only data from the NADP (National Atmospheric Deposition Program, NADP, 2001) and 2), identifying landscape factors that influence throughfall deposition in the PRIMENet paired watershed study. The suite of factors to be analyzed for their influence on throughfall deposition in this study includes vegetation type, percent canopy coverage, elevation, aspect, and site disturbance history.

Data from throughfall chemistry and wet-only samples were used to develop the input portion of a mass balance equation for each study watershed (e.g., Heath *et al.*, 1992; Kahl *et al.*, 1999). An analysis of the relationship between wet-only precipitation and throughfall was intended to provide researchers with a tool for using wet-only data to estimate total inputs to the watersheds using relationships with a few significant landscape features.

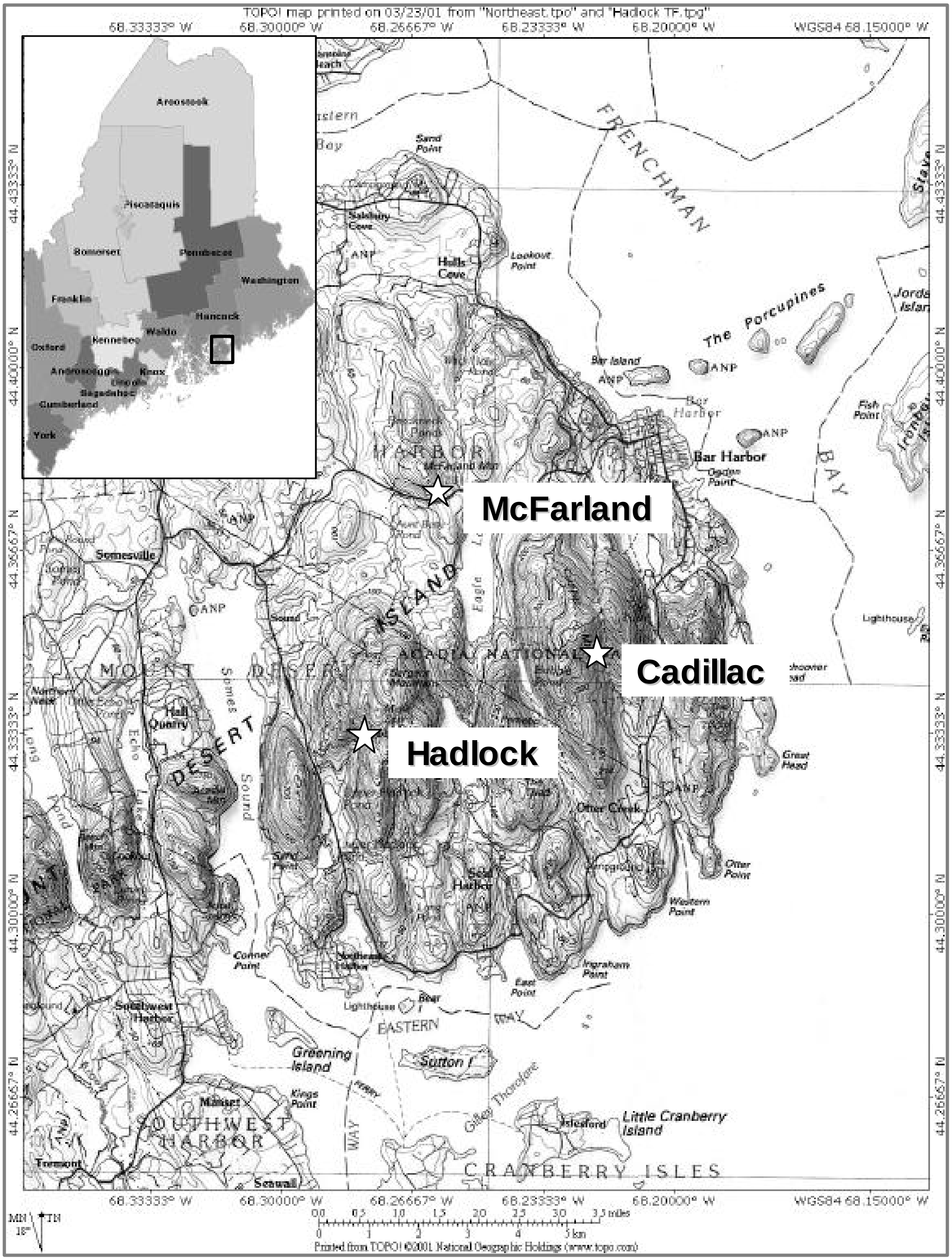

Figure 1. Locations of PRIMENet study sites at Acadia National Park, on Mount Desert Island, Maine.

Chapter 2

RELATED RESEARCH

2.1. Prior Research at Acadia

Acadia National Park is a unique location for biogeochemical research because it is located in an ecotone with vegetation types from both temperate and boreal ecosystems. Acadia's coastal topography provides contrasts between higher elevation rocky outcrops and estuarine wetland areas. Acadia's mountains, the highest on the East Coast, intercept pollution in air masses tracking from inland sources. Steep hydrologic flowpaths over granite bedrock make Acadia's water resources vulnerable to stress from atmospheric deposition.

2.1.1. Episodic Acidification

Episodic acidification in coastal streams in Maine can be attributed to five possible factors: 1) increased nitrate (NO_3) concentration, 2) increased organic acidity, 3) an increase in the anionic fraction of sulfate (SO_4), 4) the salt effect, and 5) a decrease in base cation concentration (dilution) due to increased discharge (Kahl *et al.*, 1992; Heath *et al.*, 1993). The salt effect occurs when sodium (Na) displaces a hydrogen ion (H) via ion exchange in soils and HCl in solution percolates into streams (Heath *et al.*, 1992). Evidence for episodic acidification through sea salt exchange at Acadia comes from prior work at the Hadlock Pond Watershed (Heath *et al.*, 1993). Episodic acidification resulting specifically from acidic deposition would be an effect of increased NO_3 concentration, or less commonly, an increase in the anionic fraction of SO_4 (Kahl *et al.*, 1992).

2.1.2. Acidic Deposition and Surface Water Acidification

The Clean Air Act Amendments of 1990 (CAAA) called for a reduction in SO_2 emissions in the U. S. Regional evaluations have assessed the effectiveness of Phase I implementation of the CAAA (Stoddard *et al.*, 1999; Driscoll *et al.*, 2001). Acid neutralizing capacity (ANC) in surface waters has not recovered despite significant reductions in SO_2 emissions. Delays in recovery may be explained by insufficient base cation weathering compared to H inputs (Reuss and Johnson, 1985; Bailey *et al.*, 1996; Driscoll *et al.*, 2001).

In the Northeast, continued N deposition from the atmosphere may explain delays in surface water recovery from acidification (Aber *et al.*, 1998). As a result, N saturation remains a primary focus of research in the Northeast (Aber *et al.*, 1989, 1998; Kahl *et al.*, 1993a; Matzner and Meiwes, 1994). Potential negative effects of continued N deposition may include: increased NO_3 and aluminum (Al) mobility, cation depletion, soil and water acidification, and forest decline (Aber *et al.*, 1998).

Recent findings suggest that land use history may precondition forest response to N deposition (Aber *et al.* 1998; Magill *et al.*, 1997). Recently, higher N retention at Cadillac Brook watershed was linked to the disturbance history using a mass balance approach and wet precipitation inputs (Campbell *et al.*, in review). This research focuses on quantifying total inputs, which may be significantly higher than wet inputs, to the two small watersheds. Total atmospheric deposition is generally taken to consist of wet deposition, dry deposition, cloud and fog water deposits, and the net effect of canopy processes at a forested site.

2.2. Atmospheric Deposition

2.2.1. Wet Precipitation Inputs

Collected only during snow or rain events, wet-only precipitation data have been used as part of a national network to identify gross patterns of baseline deposition across the U. S. For instance, wet-only data show that while S emissions have decreased due to Clean Air legislation beginning in the 1970's, N has shown no similar trend since 1980 (National Atmospheric Deposition Program (NADP), 2001). Wet-only precipitation data are available for Acadia's McFarland Hill site from the NADP (Figures 2a and 2b). At Acadia, sea-salt corrected wet deposition was calculated at 450 eq ha^{-1} yr^{-1} for SO_4 and 180 eq ha^{-1} yr^{-1} for NO_3 (Kahl *et al.*, 1993a).

Although wet-only data from the NADP are extremely useful due to standardized collection and analysis techniques, the spatial scale of NADP data may not be appropriate for small watershed research. At Acadia, there is currently one NADP wet-only collection site, at McFarland Hill (Site ME98). Earlier research projects have deployed additional wet-only and bulk collectors in other areas of the Park. For bulk precipitation collectors, pH and non-weighted concentrations of major ions were similar between the McFarland Hill site and at Hadlock Pond Watershed (Heath *et al.*, 1992; Heath *et al.*, 1993). The NADP reports similar concentrations of H, SO_4, and NO_3 across Maine, but higher concentrations of marine-derived substances at coastal sites (Figure 3).

Dry deposition can be a major input to coastal watersheds (Rustad *et al.*, 1994). In landscapes with complex terrain, wet-only data have been found to dramatically underestimate deposition to the landscape (Ivens *et al.*, 1990; Joslin and Wolfe, 1992; Lindberg and Lovett, 1992; Beier *et al.*, 1992; Lovett 1992; others).

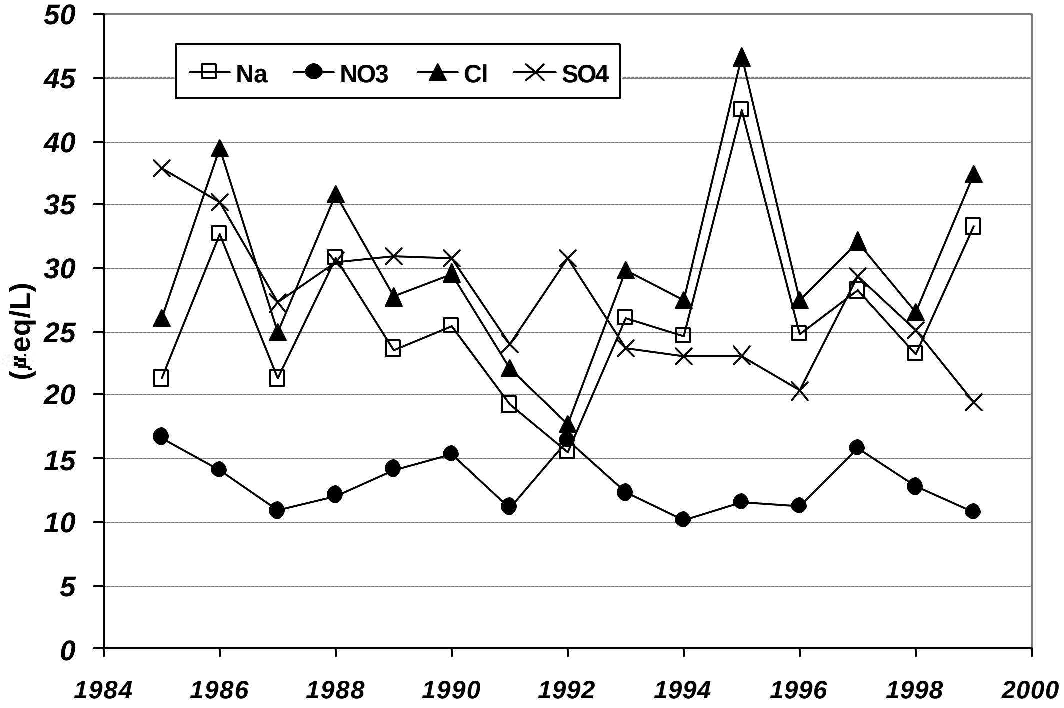

Figure 2a. Acid anions and marine compounds in NADP wet-only samples from McFarland Hill at Acadia National Park, 1985-1999.

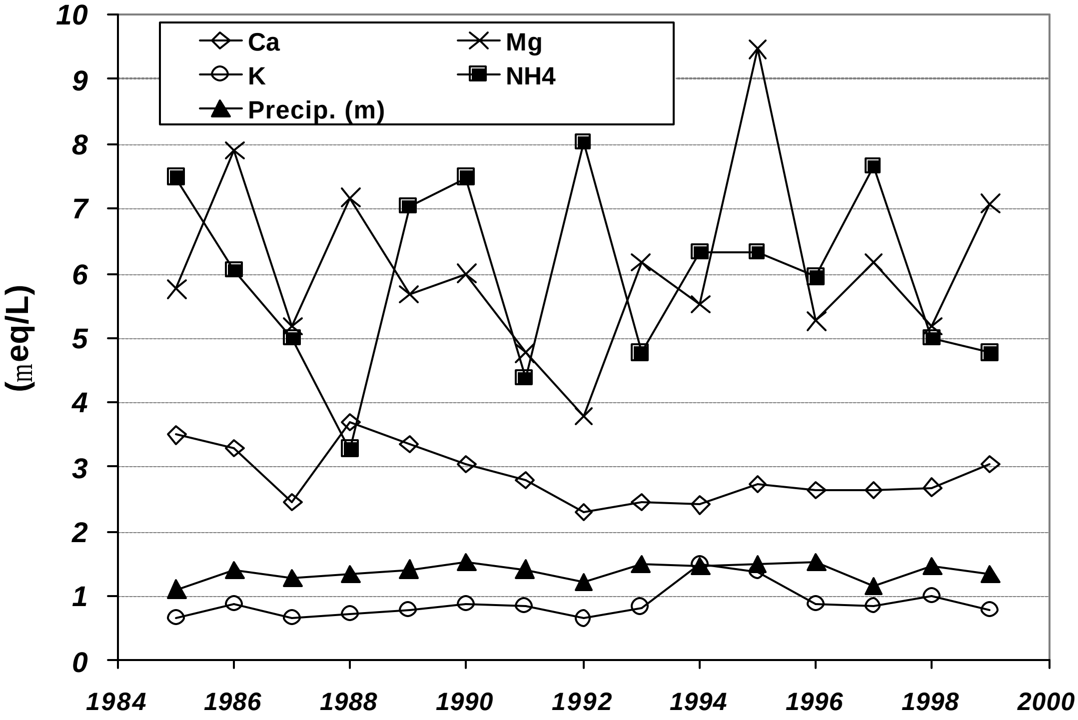

Figure 2b. Cations and precipitation depth in NADP wet-only samples from McFarland Hill at Acadia National Park, 1985-1999.

The outflux of SO_4 from northeastern watersheds exceeds the wet atmospheric flux, with dry deposition and cloud or fog inputs responsible for the deficit; bleeding of stored S may occur during periods of higher deposition (Cosby *et al.*, 1996).

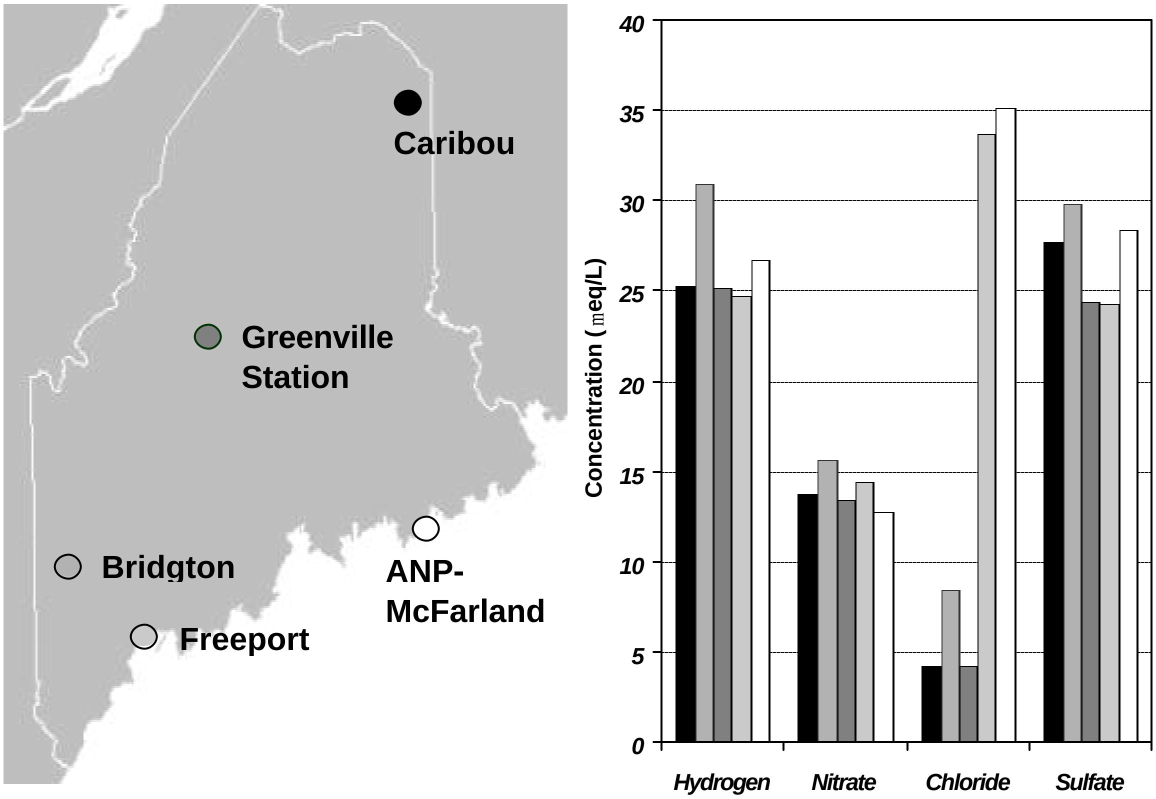

Figure 3. Mean H$^+$ and anion concentrations at NADP sites across Maine, 1980-1999. Concentrations are relatively consistent except Cl at coastal sites (NADP data, 2001).

2.2.2. Cloud and Fog Inputs

Enhanced dry deposition to coastal conifer-dominated sites in Maine may result from marine influences, coniferous canopy efficiency at filtering the atmosphere, and inputs from cloud and coastal fog water (Weathers *et al.*, 1988; Rustad *et al.*, 1994). Deposition by immersion in clouds has been shown to account for 40-50% of the total SO_4 load in the Smoky Mountains, Tennessee and Whiteface, New York (Lindberg and Lovett, 1992). In western Virginia, net throughfall (throughfall SO_4 + stemflow SO_4 – wet SO_4)

was 24 times higher during a high cloud immersion period than in a low cloud immersion period (Joslin and Wolfe, 1992).

Fogs on the mid-coast region of Maine had some of the lowest pH values and highest NO_3 and SO_4 concentrations in North America (Weathers *et al.*, 1988; Jagels *et al.*, 1989). Coastal fogs in Maine had up to three times the major ion concentrations and lower pH compared to inland mountain cloudwater (Kimball *et al.*, 1988). High atmospheric loading, extreme conditions, and short growing seasons typical of high elevation ecosystems may be compounded by exposure to coastal fogs, and potentially contribute to chronic and episodic acidification (Weathers *et al.*, 2000a).

2.3. Methods for Determining Total Deposition

2.3.1. Modeling Dry Deposition

There have been two general approaches to determine total deposition to a landscape under the assumption that wet-only deposition is an inadequate measure of total inputs: modeling deposition fluxes and measuring throughfall and stemflow fluxes. One modeling approach or inferential technique is frequently referred to as the 'big leaf' model. To quantify dry deposition using the big leaf model, the various processes involved with deposition are characterized as resistance to diffusion from the free atmosphere to surfaces (Meyers *et al.*, 1991). The dry deposition flux is determined by multiplying the concentration of a substance in air by the deposition velocity of that substance, and is the inverse of the aerodynamic, boundary layer, and surface uptake resistance (Meyers *et al.*, 1991). Finally, the deposition estimates obtained using the big leaf model need to be scaled to the forest canopy, using modeled factors to scale deposition from surrogate surfaces to a rough canopy surface (Lindberg and Lovett, 1992; Lovett, 1992). The inferential method is often used to determine deposition of SO_2, SO_4, nitric acid (HNO_3), and NO_3. The method allows researchers to separate dry deposition into aerosol, fine, and coarse particle deposition, but requires frequent micrometeorological sampling and assumptions must be made regarding canopy structure and uptake.

2.3.2. Throughfall and Stemflow

Researchers have used throughfall and stemflow inputs to estimate total deposition, often in comparison to results from inferential techniques. Considered a conservative ion, S is often used to compare methods. In Europe, modeling results compared favorably with throughfall plus stemflow deposition on a large scale for deciduous forests, but the EMEP-RAINS model, which characterized long-range transport and large-scale land cover patterns, underestimated inputs to coniferous sites (Ivens *et al.*, 1990). At a mountainous site in western Virginia, the models underestimated dry deposition of SO_4 as compared to throughfall fluxes by as much as 67% (Joslin and Wolfe, 1992). Researchers suggested that complex topography, edge effects, coarse particle exclusion, and underestimation of surface wetness by the model may have been sources of the discrepancy (Joslin and Wolfe, 1992).

It has been suggested that throughfall provides a useful estimate of total atmospheric deposition of SO_4 (Joslin and Wolfe, 1992; Lindberg and Lovett, 1992) and Na, which has been used to develop predictive relationships with other ions that are more canopy reactive (Beier *et al.*, 1992; Hultberg and Ferm, 1995). Advantages of using throughfall to estimate deposition are: 1) throughfall techniques are better suited to complex terrain, where micrometeorological techniques are not feasible, and 2) throughfall and stemflow provide the point-specific data necessary for extrapolating to the watershed scale (Lindberg and Lovett, 1992). However, there are several assumptions inherent in the use of throughfall data to quantify atmospheric deposition. The remainder of this chapter will address each assumption by referring to published research on each topic.

2.4. Assumptions in Estimating Total Deposition Using Throughfall

2.4.1. There is negligible leaching from the canopy of root-derived substances.

To address the assumption of negligible translocation and leaching of S, Cape *et al.* (1992) added labeled S (as $^{35}SO_4$) to soil just under the litter layer, then traced the labeled S through a Scots pine forest. The researchers determined that only a small amount, less than 3% of total measured deposited S, was actually translocated from roots and subsequently leached (Cape *et al.*, 1992). Tree stem injection studies have found that S taken up by roots accounted for 3-15% of total SO_4 enrichment in pine, maple, and poplar throughfall; the remaining 85-97% was attributed to dry deposition (Garten *et al.*, 1988; Joslin and Wolfe, 1992; Lindberg and Lovett, 1992).

2.4.2. Analytes of interest are not canopy-reactive, or canopy reactions can be understood or quantified.

Rainwater passing through the forest canopy is enriched in elements such as potassium (K), magnesium (Mg), and calcium (Ca) and is typically depleted in H and ammonium (NH_4) (Hansen *et al.*, 1994). Canopy uptake of nitrogen dioxide) NO_2, HNO_3, and ammonia (NH_3), and some uptake of H and NH_4 have been found at several research sites, including the Howland Integrated Forest Study (HIFS) in Maine (McLaughlin *et al.*, 1996) and at Walker Branch Watershed, Tennessee (Lindberg, 1986). Approximately 50% of acidity was neutralized at the HIFS (spruce-fir) site (Lawrence and Fernandez, 1991). Ca is an important base cation, and generally has moderate interaction with the canopy, but is not as seasonally affected in terms of leaching as other base cations K or Mg (Houle *et al.*, 1999b). Greater than 70% of K in throughfall can be derived from leaf leaching, while less than 50% of Ca and 20% to 70% of Mg may originate from leaf leaching (Houle *et al.*, 1999b).

Canopy exchange of Na and Cl is usually insignificant, and Cl can be used as a conservative tracer (Draaijers *et al.*, 1996). If the molar Na: Cl ratio is less than the ratio in seawater, Cl may be leaching from leaves (Bäumler and Zech, 1997). Increased leaching of base cations and Cl occurs during the period of senescence for deciduous sites and dormancy for coniferous sites (Neary and Gizyn, 1994). Ulrich (1983) suggested that dry deposition of Na indicates the ability of the canopy to capture particles and aerosols from the atmosphere. Further, all Na in throughfall may be assumed to originate as dry deposition in coastal areas, because leaching would be insignificant compared to dry deposition (Beier *et al.*, 1992).

Sulfate is considered to be a conservative ion (Lovett, 1994) and the least variable of the major ions (Houle *et al.*, 1999a). Weathers *et al.* (1998) have demonstrated a linear relationship (r^2=0.96) between non-marine S deposition and total N deposition. Houle *et al.* (1999b) used SO_4-S and net canopy exchange (NCE) of SO_4 in multiple regressions to predict base cation exchange by the canopy in Quebec. Their analysis gave r^2 values between 0.76 and 0.93 for the predicted vs. observed values of NCE for Ca and Mg, and r^2 values between 0.09 and 0.65 for the NCE of Na and K (Houle *et al.*, 1999b). These results suggest that scaling up values from wet deposition using a tracer compound may work for some base cations, but their role in canopy processes must first be understood.

2.4.3. All of the substance deposited to the canopy or absorbed by the foliage can be washed off or leached by subsequent rain events.

Granat and Hällgren (1992) addressed leaf washing in northern Sweden by fumigating a forest plot with controlled levels of SO_2 and comparing modeled results to measured throughfall and atmospheric fluxes. Researchers concluded that SO_2, the gaseous phase often deposited or taken up directly by stomata, can be washed off but it is a relatively slow process, on the order of weeks to months (Granat and Hällgren, 1992). Noting the correlation of SO_4 and Ca in throughfall, Hultberg and Ferm (1995) suggested that SO_2 taken up through stomata can essentially pass through the leaf by binding with Ca as a counter ion, and subsequently leaching out in throughfall. Researchers have assumed that almost all deposited S is actually recouped in throughfall after some time (Joslin and Wolfe, 1992). In a labeling study, researchers reported that only about 7% of deposited S was taken up by foliage (Garten *et al.*, 1988).

In Maine, a net canopy exchange (NCE) value close to zero implies that uptake and leaching of S approximately balance at this spruce site (Johnson and Lindberg, 1992). It is important that deposited SO_2 appears in throughfall, as up to 75% of the dry deposited portion of total S may be SO_2 (Meyers *et al.*, 1991). At the Integrated Forest Study site in Maine, amounts of SO_2 were comparable to the amount of fine and coarse particle SO_4 in dry deposition (Johnson and Lindberg, 1992).

2.4.4. An appropriate number of collectors have been used.

There are numerous sources of error with throughfall collection procedures (Draiijers *et al.*, 1996). Careful design of collectors before deployment or calibration of data after analysis can correct some of these errors. A thorough study of throughfall variability in

Quebec ranked major ions in order of highest to lowest variability across a mixed hardwood forest (Table 1; Houle *et al.*, 1999a). Variability was attributed to the reactivity of the ion with the canopy (Houle *et al.*, 1999a). The number of collectors needed to estimate deposition with 10% precision and a confidence of 95% ranged from 21 for SO_4 to 165 for NH_4, on a weekly collection basis (Houle *et al.*, 1999a). Spatial variability decreased according to the length of the study period; monthly estimates were much less variable than weekly (Houle *et al.*, 1999a). Annual fluxes calculated from throughfall have relatively little uncertainty, as all the noise is damped out by the relatively long time step (Houle *et al.*, 1999a).

Table 1. Number of collectors required to estimate throughfall deposition of various ions using a precision of 10, 15, or 20% and a confidence of 90 or 95% (Houle *et al.*, 1999a).

Precision (%)	**Confidence (%)**	**Volume**	**Cl**	**NO_3**	**SO_4**	**NH_4**	**Ca**	**K**	**Mg**	**Na**	**H**
10	**95**	21	49	39	21	165	58	119	155	47	160
	90	15	35	28	8	116	41	84	109	33	113
15	**95**	10	23	19	10	75	27	54	70	22	72
	90	8	17	13	8	53	19	38	50	16	51
20	**95**	7	14	11	7	43	16	31	41	13	42
	90	5	10	8	5	30	12	22	29	10	30

2.4.5. Stemflow is a relatively small proportion of the total flux.

In the Netherlands, stemflow was found to contribute only about 15% of the throughfall flux, decreasing in areas with lower stem densities (Draiijers and Erisman, 1993). Across the U.S., stemflow was only a significant (defined as greater that 5% of the total flux) portion of total S deposition at three sites: Coweeta pine, Georgia pine, and Huntington forest hardwood (Lindberg and Lovett, 1992). This research at Acadia does not quantify stemflow; however, at nearby Bear Brook Watershed in Maine, stemflow represented less than 5% of the hydrologic and chemical flux to soils, with the exception of K (Fernandez et al., 1999).

2.4.6. There is a relationship between wet-only precipitation and throughfall.

Many studies have shown that throughfall volume is generally less than wet-only volume due to canopy interception (Granat and Hallgren, 1992; Lovett *et al.*, 1999). Interception loss was found to be approximately 0.1-0.5 cm per event (Satterlund, 1972, in Joslin and Wolfe, 1992). Relationships between throughfall and wet-only chemistry are rarely as straightforward. Early research assumed a constant relationship between wet and dry deposition chemistry (Ulrich, 1983). However, further investigation has shown that different processes drive dry and wet deposition (Beier *et al.*, 1992; Ollinger *et al.*, 1993). In the Northeast, wet deposition sources are primarily from inland areas to the west, and dry deposition sources are primarily urban areas to the south, as determined by a regional modeling approach (Ollinger *et al.*, 1993).

Different source areas make a direct relationship between dry and wet deposition difficult to determine; however, Beier *et al.* (1993) used Na as an indicator of dry deposition in coastal areas. Beier *et al.* (1992) suggested that net throughfall concentrations of Na and Cl near the ocean and SO_4 in industrial areas, where dry deposition overwhelms leaching contributions, can be assumed to all be from dry deposition. Beier *et al.* (1993) argue that the ratio of Na in net throughfall to that in wet deposition can be used to scale up concentrations of other ions of interest.

2.4.7. Cloud and fog water contributions appear in throughfall.

For this research project, cloud and fog water are assumed to drip from the canopy into throughfall collectors when saturated because collectors are continuously open. Researchers have used a throughfall volume:wet volume relationship to identify periods of time when cloudwater contributions were significant; cloudwater inputs were assumed to occur when throughfall volume was greater than wet-only volume (Joslin and Wolfe, 1992). For direct measurement of cloudwater contributions, passive string collectors (Lindberg and Lovett, 1992), active string collectors, and artificial trees (Joslin and Wolfe, 1992) have been used.

2.4.8. The landscape has been representatively sampled.

Throughfall chemistry and volume have been found to be highly temporally and spatially variable in intensive studies (Hansen *et al.*, 1994; Bailey *et al.*, 1996; Whelan *et al.*, 1998; Lovett *et al.*, 1999; Houle *et al.*, 1999a, 1999b). The error in throughfall measurements for one study was estimated at approximately 32% due to non-representative sampling, where only two gutters were used to represent an entire stand (Draiijers and Erisman, 1993). Four landscape features that affect S and N deposition rates across heterogeneous landscapes that have been identified are: vegetation type and structure, aspect, elevation, and edges or gaps in the forest canopy (Weathers *et al.*, 2000a).

Several research efforts have assessed the effects of individual landscape features on atmospheric deposition (Cronan and Reiners, 1983; Lawrence and Fernandez, 1993; Hansen *et al.*, 1994; Bailey *et al.*, 1996; Whelan *et al.*, 1998; Lovett *et al.*, 1999; Houle *et al.*, 1999a, 1999b; Weathers *et al.*, 1992, 1995, others) and one has looked at the combined effects (Weathers *et al.*, 2000a). This thesis research assumes that by representatively sampling a heterogeneous landscape, we can identify landscape factors that drive deposition.

2.4.8.1. Vegetation Type: Deciduous versus Coniferous. Throughfall chemistry is different under different canopies due in part to ion exchange reactions that occur more readily in deciduous canopies, and canopy architecture (Cronan and Reiners, 1983; Matzner and Meiwes, 1994; Bailey *et al.*, 1996; Lovett *et al.*, 1999; Houle *et al.*, 1999b; Weathers *et al.*, 2000a). Deciduous throughfall generally has a higher pH due to ion exchange of H for base cations or a 'weak base buffering' effect, whereby the canopy releases organic or bicarbonate salts (Cronan and Reiners, 1983). Throughfall under conifer canopies demonstrates a net acidification, likely due to NH_4 uptake or nitrification, washout of dry deposition, or leaching of organic acids from the canopy (Cronan and Reiners, 1983). Solutions collected under deciduous canopies exhibit a spike in ANC in the fall, due to K and associated alkalinity from leaf senescence (Cronan and Reiners, 1983). During the growing season, S deposition was highest under mixed canopies (Lovett *et al.*, 1999). Across Europe, total S deposition ranged from 50-100% greater under coniferous than under deciduous canopies (Ivens *et al.*, 1990).

2.4.8.2. Topography: Elevation and Aspect. Landscape factors are often interrelated and cannot easily be studied independently. Typically, studies of topography are linked to vegetation types. The most common example is a study design in which high elevation sites have coniferous vegetation while lower elevation sites have deciduous vegetation (Cronan and Reiners, 1983; Lovett et al., 1999).

Enhanced deposition at high versus low elevations may be due to orographic enhancement of precipitation volume, higher leaf area in high elevation conifers (Cronan and Reiners, 1983), or increased rates of cloudwater and dry deposition (Weathers *et al.*, 1998 and 2000a). More wind at high elevations may also enhance dry deposition although the typical lower stomatal conductance of high elevation trees may counteract the enhancement for some substances, particularly SO_2 (Lovett *et al.*, 1999). In New York, SO_4 deposition was found to increase thirteen-fold across an elevational gradient from 800 to 1275 meters; above 1000 meters, vegetation types were primarily coniferous or mixed conifer-deciduous, in contrast to the lower elevation deciduous (Lovett *et al.*, 1999). Lack of enhancement of precipitation volume was attributed to interception loss, which occurs when cloudwater deposits subsequently evaporate (Lovett *et al.*, 1999).

Weathers *et al.* (2000a) calculated enhancement factors (EFs) for various landscape conditions using lead in the forest floor as an index for total deposition. EFs have been calculated using 1) the ratio of the mean for high elevation stands to the mean for low elevation stands, 2) the mean ratio for west facing, high elevation versus low elevation stands; and 3) the mean ratio for edge versus interior zones (Weathers *et al.*, 2000a). The enhancement factors were used to scale up background deposition by multiplying mean annual deposition by the EF and using area weighting to represent the appropriate contribution of each forest type (Weathers *et al.*, 2000a). Using calculated EFs, there was significant enhancement of total deposition at west versus non-west sites (Weathers *et al.*, 2000a). The EFs for west aspects were 2.5 for conifer sites and 1.0 for deciduous sites (Weathers *et al.*, 2000a).

2.4.8.3. Canopy Structure. High spatial variability in throughfall may indicate differences in canopy structure (Lovett *et al.*, 1999). In New York, cloud deposition was, on average, three times greater at forest edges than interior areas, reflecting higher wind speeds and the characteristics of forest structure at edges (Beier *et al.*, 1992; Weathers *et al.*, 1995; 2000a). The importance of forest edges has been stressed, and even suggested as a potential tool for estimating deposition by using tracers and the rate of attenuation of deposition from the edge to interior of a forest patch. (Beier *et al.*, 1992).

Relatively high rates of deposition in coniferous sites are likely due to canopy roughness and canopy retention of foliage all year (Whelan *et al.*, 1998; Lovett *et al.*, 1999). After approximately 40% of the stem volume was removed in an experimental German watershed, interception and deposition rates were reduced up to 45% (Bäumler and Zech, 1997). Bailey *et al.* (1996) found that throughfall differed from bulk precipitation chemistry year round, pointing to significant canopy interception even in deciduous stands in winter.

Chapter 3

METHODS

3.1. Site Description

3.1.1. Climate

Acadia National Park is located at the temperate and boreal transition zone in North America. Its coastal location and prominent topography result in frequent cloud and fog cover. Mean annual temperature for Bar Harbor, Maine is 45.5° F (7.5° C) (Acadia National Park Official Website, 2001). Prevalent wind direction at Bar Harbor is 220° to 240°, or west-southwest (Zielinski, 2001, pers. comm.). Average annual precipitation for Acadia National Park is 140 cm. (NADP, 1999). Seasonal precipitation is relatively evenly distributed, with minimum values occurring in summer and the highest monthly amount in November (Table 2).

Table 2. Mean seasonal precipitation at Acadia National Park.

Season	Precipitation (cm)
Winter	40.9
Spring	38.2
Summer	24.4
Fall	39.1

3.1.2. Physical Characteristics

Cadillac Brook watershed is drained by a headwater stream unofficially called Cadillac Brook. The stream begins at about 440 meters in a small valley, extends down through open bedrock sections via multiple small drainage channels and overland flow, and comes together again in the bottom third of the watershed. Typical fall baseflow for Cadillac Brook is 18 liters per second (USGS Online Data, 1999). Hadlock Brook watershed is drained by first-order Hadlock Brook. The stream headwaters are a 0.73-

hectare woodland bog at the north end, descending through spruce-fir forests until reaching the USGS gauging station. Typical fall baseflow for Hadlock Brook is 21 liters per second (USGS Online Data, 1999).

Table 3. Summary of Watershed characteristics for the PRIMENet Study.

Watershed	Minimum Elevation (m)	Maximum Elevation (m)	Average Slope	Aspect	Watershed Area (ha)
Cadillac Brook	122	468	28%	E-SE	31.6
Hadlock Brook	137	380	20%	W-SW	47.2

The highest points of both watersheds are exposed bedrock surfaces as a result of continental glaciation that ended about 14,000 years ago. Soils are thin, discontinuous, and largely organic and are underlain by till. Dorr Mountain lies to the east of Cadillac, but does not reach as high an elevation, allowing much of the upper portion of the watershed direct exposure to marine aerosols. Bedrock is Cadillac Granite of Devonian age (Gilman *et al.*, 1988). Glacial debris and down-slope migration of exfoliated granite bedrock have produced local talus slopes.

3.1.3. Vegetation

Cadillac Brook Watershed is comprised of three relatively distinct zones that reflect burn zones during the fire of 1947 and related landscape characteristics. Macroscopic charred particles found in forested hollows in the watershed and reconstruction of the fire boundary provide evidence that the bottom third of the watershed was largely burned in the 1947 fire (Schauffler *et al.*, in review). Forest communities in this portion of the watershed are heterogeneous, largely early successional types, dominated by American beech (*Fagus grandifolia*), striped maple (*Acer pensylvanicum*), and some mixed spruce-fir (*Picea rubens-Abies balsamea*) and hardwood stands. The center section of the watershed consists of steep slopes, with more open-canopy, sub-alpine scrub or shrub type communities, such as blueberry-ash shrub (*Vaccinium angustifolium-Sorbus americana*), red spruce-grey birch (*Picea rubens-Betula populifolia*) communities, and a large section that consists primarily of patchy, mixed stands. The top section of the watershed does not appear to have burned in the 1947 fire, with a relatively large area of older spruce-fir forest and some mixed to open shrub summit communities.

Hadlock Brook Watershed has been largely undisturbed for the past five hundred years, based on paleoecological reconstruction (Schauffler *et al.*, in preparation). Most of the watershed is spruce-fir forest. Summit shrubland communities exist at higher elevations. There are woodland bogs at the north and south ends of the watershed, which are primarily sphagnum (*Sphagnum spp.*), black spruce (*Picea mariana*), and various shrub types. A small patch of deciduous forest exists just upstream of the USGS stream gauging station. A landcover classification was provided for this study by the National Park Service, and analyzed for the two watersheds (Figures 5a and 5b and Appendix A).

3.2. Field Instrumentation

The PRIMENet paired watershed study at Acadia has several field components (Figures 5a and 5b). Six soil plots were located in each watershed. Soil plots were fifteen by fifteen meters, and were located to provide coverage of representative soil in closed canopy forest types. An Aerochem Metrics wet-only collector was located in each watershed for comparison to the nearby Acadia National Park McFarland Hill NADP site (Figure 1); wet-only samples were collected weekly (Figure 4). Bulk

Figure 4. AerocheMetrics sampler installation at Hadlock Brook watershed.

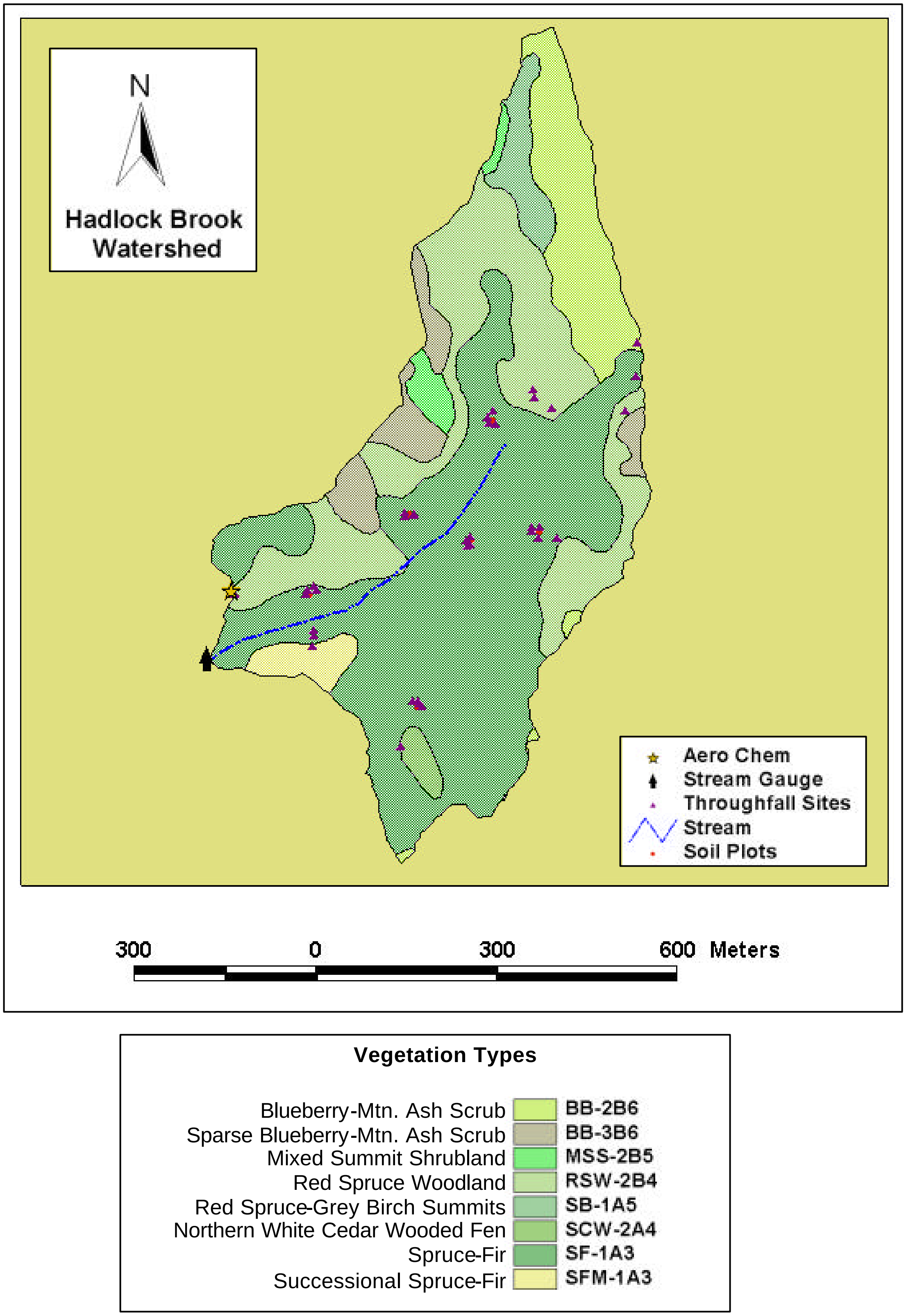

Figure 5a. Hadlock Brook watershed (47.2 hectares), undisturbed. Detailed vegetation attributes presented in Appendix A.

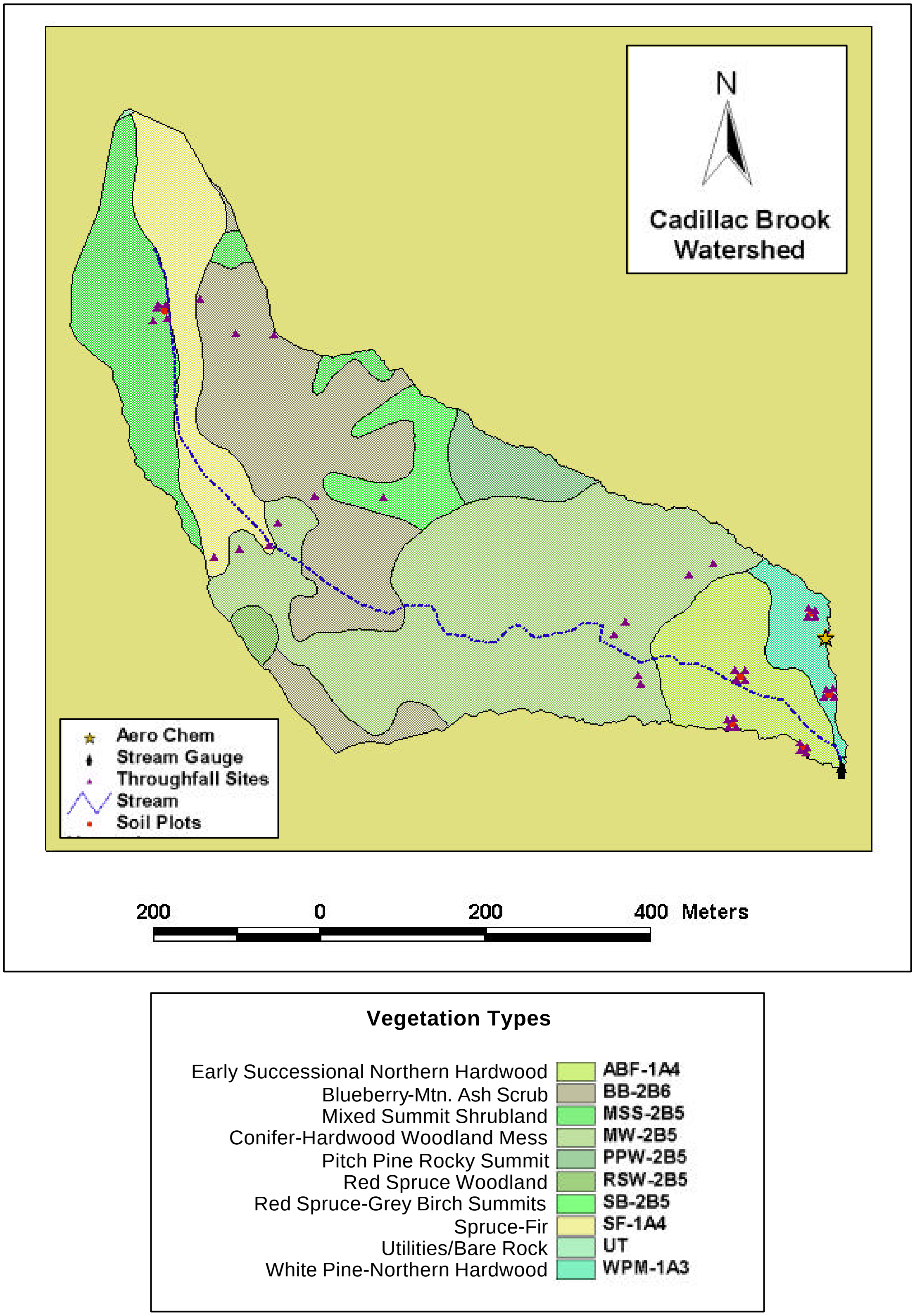

Figure 5b. Cadillac Brook watershed (31.6 hectares), much of which burned in 1947. Detailed vegetation attributes presented in Appendix A.

precipitation collectors were located at the wet-only site in each watershed, and at the National Park Service NADP site at McFarland Hill. Bulk samples were collected on the throughfall-sampling schedule.

Streams were instrumented, using natural control, with USGS stage recorders that recorded stage at five-minute intervals. Stage was used to calculate streamflow in each stream based on stage relationships and the stream profile. Streamwater grab samples were collected at least biweekly for full lab analysis, following standard stream sampling procedures (Kahl *et al.*, 1992; Peck *et al.*, 1993). Automated ISCO samplers were used beginning in 2000 for event sampling (Figure 6). Stream elevational transect sites were sampled quarterly in 2000, with locations draining sub-catchments defined by forest type.

Figure 6. ISCO autosampler used at PRIMENet stream sites. The datalogger (left) locks into place above the sample bottles.

3.3. Experimental Design

We chose a stratified random experimental design. Transect collector sites were stratified using four distinct elevational transects with at least 100 vertical meters difference between transects and within eight meters of a target elevation for each collector. At least six individual collectors were sited within each transect, filling in the existing matrix based on soil plots. Transects incorporated soil plot sites whenever feasible. Within each elevational transect, collectors were sited to provide a representative sample of vegetation types, as determined from aerial photos, site inspection, and land cover classifications. For many of the transect sites, the vegetation types were shrub/scrub summit types or open, giving a full range of landcover categories for the two watersheds. Collector posts were left in the ground during off-seasons to allow for replication across field seasons.

Throughfall solutions were collected in 1999 and 2000 from a maximum of 36 (Hadlock Brook watershed) and 41 (Cadillac Brook watershed) collectors (Figures 5a and 5b). Four throughfall collectors (one per quadrant) were placed in each of the six soil plots. The lack of soil in much of Cadillac Brook watershed and top portion of Hadlock Brook watershed eliminated the feasibility of soil plot locations in those areas of the watersheds. Therefore, additional collectors ('transect' collectors, 16 at Cadillac and 11 at Hadlock) were deployed individually to capture elevation and aspect variability not represented in soil plot locations.

In 2000, throughfall sample solutions were collected from all four soil plot-based collectors three times; for the other seven collections, solutions were taken from two collectors selected at each plot (the A and C collectors, roughly southeast and northwest quadrants). Solutions were always collected from transect sites. Throughfall collectors were deployed from August 1 – November 19, 1999 and from May 1 – November 18, 2000.

3.4. Throughfall Collector Design

Throughfall collectors (Figure 7) were based on the design of Lawrence and Fernandez (1993). Sixteen-centimeter diameter Nalgene collection funnels were placed at a height of one meter above the ground. The funnel neck was attached to 75 cm. of Nalgene ½" I.D. tubing, which was half-looped to minimize evaporation. Tubing ran into one liter HDPE collection jars through a drilled cap.

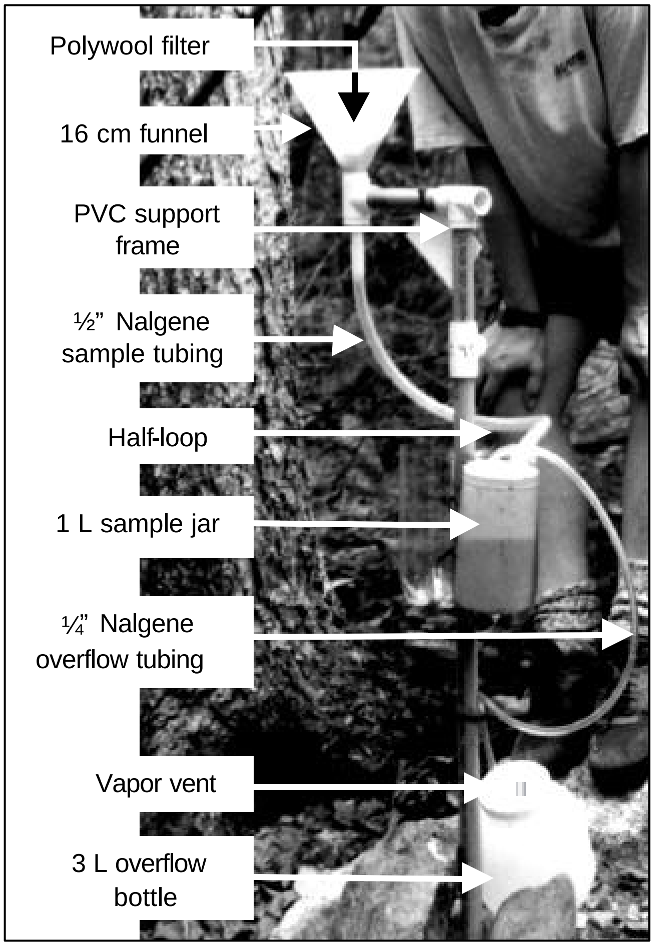

Figure 7. Throughfall collector design. The collector is a funnel-bottle type, based on the design of Lawrence and Fernandez (1993).

Collectors located on soil plot sites had a three-liter overflow bottle for measurement of total volume for large events. Overflow bottles were placed on the ground at the collector base, and attached to the one liter collection bottles via ¼” I.D. Nalgene tubing. A short section of ¼” I.D. tubing, folded at the top and drilled with two 1-millimeter holes, allowed venting of air pressure in the sample or overflow jar. A de-ionized water (DI) rinsed polywool plug was inserted into the neck of each funnel to exclude insect frass and plant litter from the collection bottle.

3.5. Throughfall Sample Collection Procedures

We collected throughfall solutions after a volume of 500-1000 mL of precipitation had accumulated, usually every two to three weeks. These volumes equal a depth of 2.55 cm to 5.10 cm of deposition. The National Park Service at Acadia monitors precipitation using rain gauges at nearby McFarland Hill.

Prior research has addressed the issue of chemical stability versus collection interval of throughfall samples in the field. Biological activity is responsible for decreased concentrations of NH_4 with increased collection time, and strongly correlated with inorganic N concentrations (Liechty and Mroz, 1991). The stability of N in throughfall samples decreased with increasing atmospheric deposition of inorganic N (Liechty and Mroz, 1991, others). A one-week collection interval reduced N transformations. In stands with high N fluxes, throughfall concentration and flux estimates of H may be positively biased and NH_4 may be negatively biased when using collection intervals greater than two weeks without preservatives to limit biological activity (Liechty and Mroz, 1991). Due to the study location in a National Park, it was not feasible to preacidify sample containers in the field; therefore, N results from biologically active compounds have a large potential error.

Washoff of dry deposition and exchange processes require fine temporal resolution to separate the two processes (Hansen *et al.*, 1994). In this research, estimating total deposition of ions was the primary objective; internal leaf leaching was not specifically investigated for substances such as K. Results from more conservative ions, such as SO_4 and Cl, are more likely to be indicative of total deposition. Houle *et al.* (1999a) have determined variability for the various ions and total numbers of collectors necessary to keep error margins within certain limits for a mixed site in Quebec (Table 1). For this study, the number of collectors per watershed is large enough to allow for a precision of 20% and confidence of 90% for cations and for precision of 10% and confidence of 90% for anions (Houle *et al.*, 1999a).

Samples were collected by two teams, one per watershed, and were usually completed simultaneously in a window of about three hours. During collection, sample bottles were

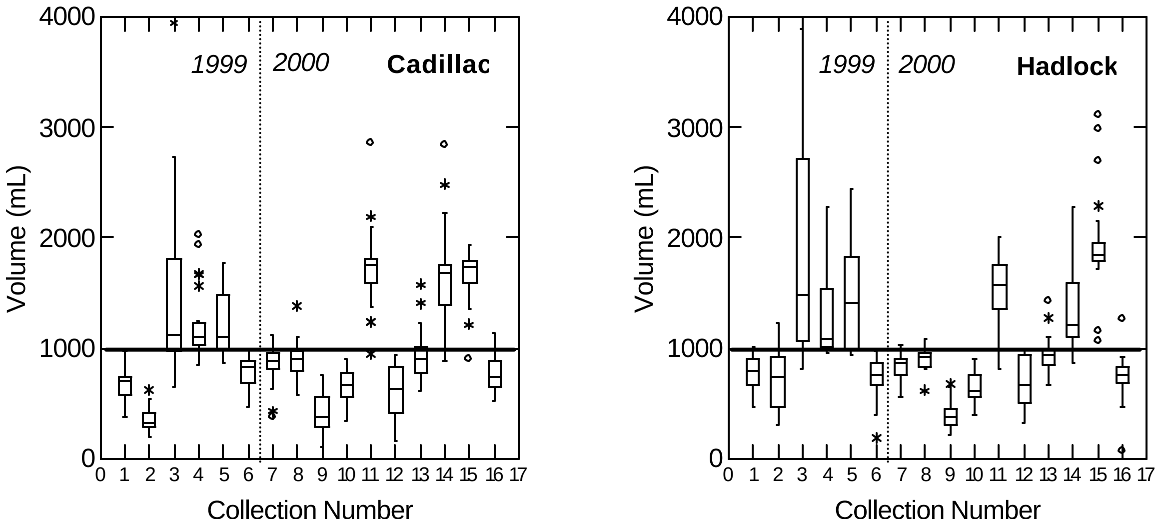

Figure 8. Total sample volumes for each throughfall collection for the PRIMENet watersheds in 1999 and 2000. The thick horizontal line is sample bottle capacity; volumes above this line were measured in overflow bottles.

removed and capped. Water in the Nalgene tubing was discarded. Samples were labeled in the field. The polywool plugs were replaced. The funnel, tubing, and jar lid were rinsed with 400 mL of DI water. A new sample jar was screwed into the *in situ* lid. Overflow volumes, if any, were measured in the field using plastic beakers. In 2000, there were three collections for which there were overflow amounts for more than half of the collectors; in 1999, there were three overflow collections, due to large storms from Hurricane Floyd and a late fall storm (Figure 8).

For the first overflow event in 1999, we collected and analyzed samples from one overflow bottle per plot (Figure 9). Specific conductance was generally higher in overflow than in sample bottles. We tried to adjust the sampling schedule to minimize overflow events for this reason. Overflow precipitation does not bypass the primary sample bottle but must pass through at least the top section of the primary sample (Figure 7); we assumed at least some mixing occurred. We did not analyze overflow volumes in subsequent collections.

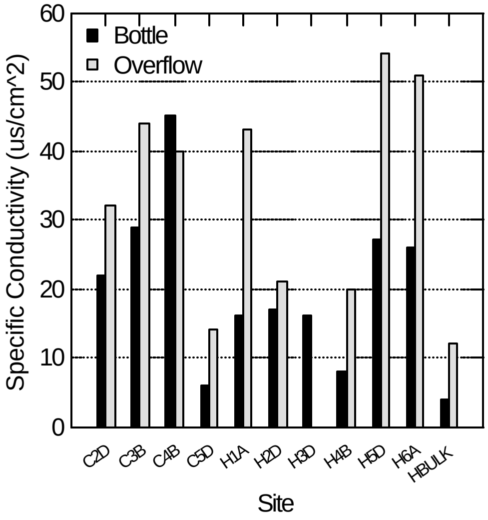

Figure 9. Specific conductivity for overflow and sample bottles for one site at each plot, September 22, 1999.

Samples from the funnel-bottle bulk collector located at each Aerochem site and the McFarland Hill bulk collector were taken using the same procedures. Depth of precipitation from a stick gauge co-located at each bulk collector was recorded. A bottle blank was collected at each watershed for each collection by filling a randomly selected clean sample jar with DI water at the first field plot. Samples were iced at the vehicle and returned to the lab within two hours, where they were refrigerated until processing. Sample volume was determined by weighing in the lab and recorded with overflow volumes for each site.

3.6. GPS and GIS Methods

Watershed boundaries and throughfall collector sites were located with a Trimble Pro-XL GPS unit with an accuracy of 0.5 meters. Soil plot locations were determined with a Trimble Geo-Explorer with accuracy of 5 meters. GPS data were imported into MapInfo Professional for post-processing. Final coverages were imported into ArcInfo for use by future researchers and Acadia National Park. Vegetation maps were provided by the USGS and National Park Service, merged with PRIMENet feature data, and further interpreted using Erdas IMAGINE Software at the Maine Image Analysis Lab housed in the Department of Forest Management at the University of Maine (Figures 5a and 5b and Appendix A).

3.7. Landscape Data Collection

3.7.1. Vegetation Type

Information regarding vegetation type was collected in the summer of 1999 and checked with more specific guidelines in the summer of 2000. Data collected in 2000 included identification to the species level for vegetation types influencing the collector area (Table 4). The dominance of a species over a collector determined the vegetation type. Data collected in 2000 were cross-referenced with data from 1999 as a quality check.

To determine the vegetation type at a given site, we defined the area around the funnel that may influence throughfall chemistry. Throughfall literature generally defines

Table 4. Vegetation type designations for species found in the PRIMENet watersheds. Many of the herbaceous species are found in conjunction with woody shrubs, and are in those cases considered scrub; if herbaceous or woody shrubs are below the collector funnel, the site is considered open.

Species Name	Common Name	Vegetation Type Category
Picea rubens	Red Spruce	Coniferous
Abies balsamea	Balsam Fir	Coniferous
Betula papyrifera	Paper Birch	Deciduous
Picea glauca	White Spruce	Coniferous
Vaccinium angustifolium	Late Low Blueberry	Scrub/Open
Sibbaldiopsis tridentata	Three-toothed Cinquefoil	Scrub/Open
Sorbus americana	American Mountain Ash	Scrub
Nemopanthus [collinus]	Mountain Holly	Scrub
Viburnum	Nannyberry, Arrowwood, Highbush Cranberry	Scrub
Kalmia	Mountain Laurel, Bog Laurel	Scrub
Acer rubrum	Red Maple	Deciduous
Thuja occidentalis	Northern White Cedar	Coniferous
Alnus incana	Grey/White/Speckled Alder	Scrub
Carex trisperma	Three-Seeded Sedge	Scrub/Open
Picea mariana	Black Spruce	Coniferous
Ericaceae	Laurel and Leatherleaf shrubs	Scrub/Open
Cyperaceae	Sedges	Scrub/Open
Sphagnum	Sphagnum moss	Scrub/Open
Betula populifolia	Grey/White Birch	Deciduous
Pinus rigida	Pitch Pine	Coniferous
Aronia melanocarpa	Black Chokeberry	Scrub
Deschampsia flexuosa	Common Hairgrass	Scrub/Open
Schizachyrium scoparium	Little Bluestem	Scrub/Open
Pinus strobus	Eastern White Pine	Coniferous
Acer saccharum	Sugar Maple	Deciduous
Acer pensylvanicum	Striped Maple	Deciduous
Populus tremuloides	Quaking Aspen	Deciduous
Populus grandidentata	Big-tooth Aspen	Deciduous

the vegetation type at a given site based on the overall stand type in the area (Cronan and Reiners, 1983; Matzner and Meiwes, 1994; Bailey *et al.*, 1996; Lovett *et al.*, 1999; Houle *et al.*, 1999b; Weathers *et al.*, 2000a). I was not able to find a method for determining vegetation type on the finer, site-specific scale. Therefore, I defined the area of interest as the area over the funnel, if the funnel's sides were projected upward in a conical shape at approximately a 75º angle (Figure 10). To prepare the vegetation data for analysis, I coded species by determining the primary, secondary, and tertiary species in the area of interest (Appendix B). The rank of the species was determined by visual inspection; the primary vegetation type was considered the tree or trees taking up most of the occupied space in the area of interest.

For instance, collector site HT1E has several small striped maple (*Acer pensylvanicum*) trees in the area above the funnel (primary, code 3), a large red maple (*Acer rubrum*) above the funnel (secondary, code 2), and a small spruce (*Picea rubens*) tree just within the area of interest (tertiary, code 1). The weighting scheme is collapsed

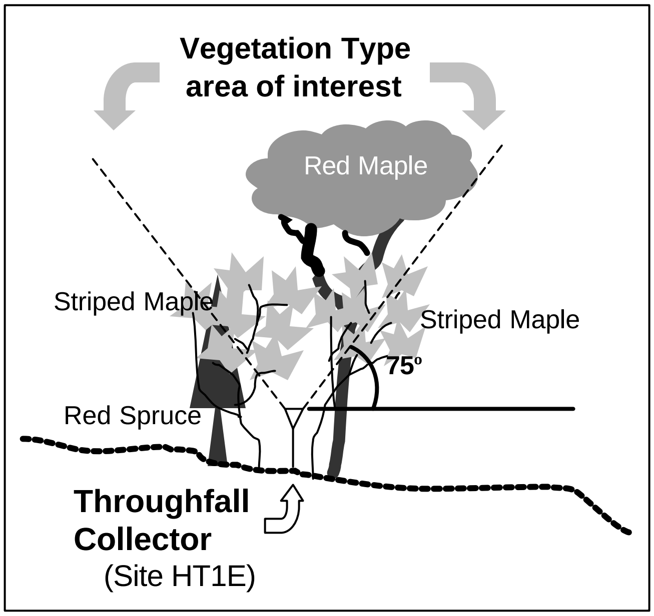

Figure 10. Area sampled for vegetation type determination.

to a final ratio; for site HT1E, 5 deciduous:1 coniferous (Figure 10). The final vegetation type is decided by the dominant vegetation type based on this weighted ratio; at HT1E, deciduous. Ratios of 3:3, 3:2, or 2:3 are given a mixed designation. Since the data will be used for throughfall analysis, deciduous and coniferous are used to describe the structure of the canopy more than standardized forest community types.

3.7.2. Canopy Coverage

Canopy coverage was determined using a LI-COR LAI-2000 Plant Canopy Analyzer during the 2000 field season. The LI-COR analyzer consists of two fisheye optical sensors and two computerized units. A base unit and sensor were deployed nearby in an area without canopy coverage. The base and remote sensors were calibrated and time-synchronized before sampling began. The base unit took light readings throughout the sampling period. The remote unit was carried to each location and the optical sensor was placed over the funnel of each throughfall collector. A light reading was taken at each throughfall collector in this manner. LI-COR readings were taken on uniformly clear or uniformly overcast days in all cases, to minimize error from light fluctuations due to clouds. LI-COR readings were taken around midday, in approximately 3-hour periods of time, to minimize error due to time of day.

Data from the base and remote units were downloaded to a PC in the lab, and LI-COR software merged the values by time. The relative coverage, DIFN, (diffuse non-interceptance) was determined by comparing time-synchronized readings for the open and sample sites. The DIFN value is considered to be a single-value representation of canopy structure, and is in essence canopy light absorption. The only assumption inherent in the DIFN value is that there is no light scattering by foliage. Although the LI-

COR also calculates a value for LAI (Leaf Area Index) for each site, this value depends on various assumptions, such as foliage being black and randomly oriented, which are usually not appropriate in this type of field situation (LI-COR, Inc., 1992). The value of DIFN, or gap fraction, was converted into a percent coverage (Appendix B).

Researchers from the Institute of Ecosystem Studies (IES) also measured canopy coverage in some areas that overlapped with this study (Weathers *et al.*, 1998, unpublished data). IES researchers used a digital fisheye photography method for determining gap fraction, where photos processed by a software program that calculated how many artificially created cells are covered versus open (Figures 11a and 11b). Measurements were taken by both teams of researchers at four sites near the PRIMENet watersheds. In comparison to canopy coverage determined for this thesis: IES photographic analysis openness values tend to be higher than LI-COR values; the change in IES numbers from location to location was in the same direction as LI-COR numbers; and, the openness values increase when IES researchers zoomed in on the area directly overhead (Sam Simkin, pers. comm., 2000).

Figure 11a. Fisheye photo of site IES 64 (coniferous), near Hadlock Brook watershed. Photo credit: Institute of Ecosystem Studies, Millbrook, NY.

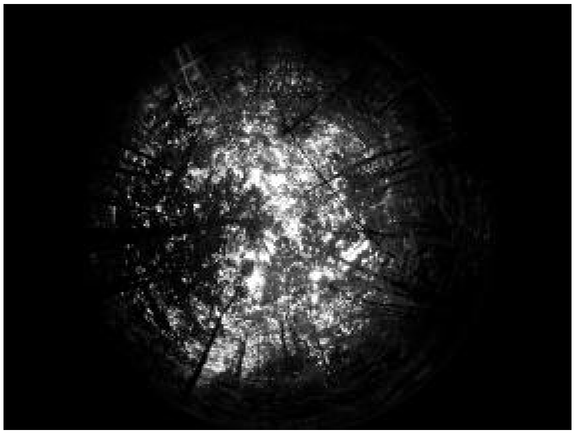

Figure 11b. Fisheye photo of site IES 127 (deciduous), near Cadillac Brook watershed. Photo credit: Institute of Ecosystem Studies, Millbrook, NY.

Both methods are widely accepted and difference in results does not affect the relative difference between collector sites within a study. For more detailed information on the various methods available for collecting canopy coverage information and validation of LI-COR use, refer to Davies-Colley, 1998.

3.7.3. Aspect

Aspect was determined as the fall line for each individual collector using a liquid-filled magnetic compass (Figure 12). Compass readings were corrected for true north (Appendix B). For analysis as a discrete variable, compass readings were classified as north, south, east, or west, based on division of the compass into quadrants.

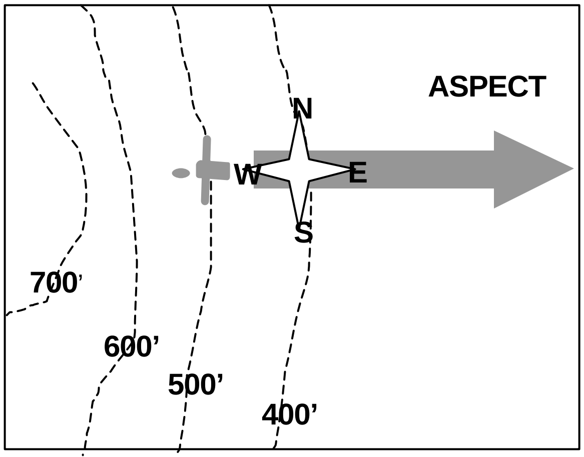

Figure 12. Field measurement of aspect.

3.7.4. Elevation

Elevation was measured at each throughfall collector site during the field seasons of 1999 and 2000 using a model EB833 Electronic Altimeter, accurate to +/- 5.5 meters. The temperature-compensated altimeter uses barometric pressure change with elevation to measure change in elevation from a known elevation, where calibration occurs. Calibration benchmarks for this thesis research were bedrock outcrops at the USGS gauging stations. A calibration at the end of the sampling period at the starting benchmark allows measurements to be adjusted by a simple arithmetic increment. Altimeter readings were taken only on clear days when barometric pressure was predicted to be stable. Elevations at both sites were cross-checked by referencing Seal Harbor and

Southwest Harbor 7.5' USGS Quadrangles. Elevations were rounded to the nearest three-meter increment for analysis (Appendix B).

3.7.5. Fire Disturbance History

Burned or unburned status at particular collector sites was determined using paleo-ecological methods including soil cores in wet hollows, increment cores, and a GIS layer representing the reconstructed boundaries of the fire of 1947 (Schauffler *et al.*, in preparation, 2001). Burned and unburned sites were coded as 1 and 0, respectively, for analysis as a discrete variable (Appendix B).

3.8. Laboratory Methods

Throughfall and streamwater samples were analyzed for major ion chemistry at the Senator George J. Mitchell Center for Environmental and Watershed Research - Geochemistry and Environmental Engineering Research Laboratory (GEERL), using standard methods (Peck *et al.*, 1993; Norton and Fernandez, 1999) in place for more than a decade as part of several major Environmental Protection Agency (EPA) projects. Performance evaluation (audit) samples are used to estimate intra-laboratory analytical precision and accuracy, and to estimate inter-laboratory precision and bias. The Mitchell Center's GEERL participates in Long Range Transport of Atmospheric Pollutants (LRTAP), Watershed Manipulation Project, EPA Water Pollution and Water Studies, and National Institutes of Water Research, Norway (NIVA) audit programs to ensure data quality (Youden, 1969). Quality assurance staff from EPA-Corvallis conduct laboratory audits periodically to ensure compliance with approved procedures.

Throughfall samples were analyzed for major anions (Cl, NO_3, SO_4), cations (Ca, Mg, K, Na), NH_4, Si, DOC (dissolved organic carbon), Al (total aluminum), total N, equilibrated pH, conductivity and apparent color. Samples with an equilibrated pH greater than 5.5 were analyzed for ANC. Streamwater samples were analyzed for major anions (Cl, NO_3, SO_4), cations (Ca, Mg, K, Na), NH_4, Si, DOC, Al (total), Al (exchangeable), Total N, Total P (total phosphorus), equilibrated pH, closed-cell pH, ANC (acid neutralizing capacity), and apparent color. A general overview of methods for analytes used in this research is presented below. For more specific information, refer to George Mitchell Center - GEERL Standard Operating Procedures (SOPs).

3.8.1. Sample Container Preparation

All plasticware and aliquot bottles were high density polyethylene (HDPE). Acid-washing entailed (1) soaking articles in 10% solution of hydrochloric acid, (2) thoroughly rinsing twice with tap water, (3) rinsing immediately at least twice with water of a conductivity less than 20 µS/cm, and (4) rinsing twice with water of a conductivity less than 2 µS/cm (ASTM (1984) Type 1 water). Plastic bottles are capped and stored partly filled with deionized water to prevent precipitation of any slight amount of solutes remaining after the washing process. As bottles are selected for use, the conductivity of the water in at least 10% of the bottles is checked. Any bottles that contain water with a conductivity greater than 3 µS/cm are re-rinsed with Type I water before use.

3.8.2. DOC (Dissolved Organic Carbon)

An OI Analytical model 700 Total Organic Carbon Analyzer (most 1999 samples) or an OI Analytical model 1010 Total Organic Carbon Analyzer (2000 samples) was used for sample DOC analysis. Samples to be analyzed for DOC (dissolved organic carbon) were filtered through a 0.4 µ filter, then CO_2 released by persulfate oxidation of the organic carbon in an acidified sample was measured. DOC standards normally range between 0.5-20 ppm, to bracket the field samples. A 5 ppm check sample, an external 5 ppm standard, and a de-ionized water blank were run every 10 samples or sample run; a filtered laboratory blank was run with every 10 samples. Lab SOPs recommend a holding time of 14 days for samples to be analyzed for DOC.

3.8.3. Anions (Cl, NO_3, SO_4)

Major anions in throughfall and streamwater samples for this project were analyzed using ion chromatography (IC). All throughfall and streamwater samples were collected and stored in HDPE (high-density polyethylene) bottles prior to analysis. Samples were brought to ambient temperature, filtered through a 0.4 µ filter, and stored at 4° C. Standards and samples were brought to ambient temperature before analysis. Lab SOPs recommend sample holding times of 28 days for Cl and SO_4; 7 days for NO_3.

The instrument used to measure anions was a Dionex model DX-500 Ion Chromatography System, a Dionex AS14 4 mm column and guard with a CD20 Conductivity Meter, GP50 gradient pump, and AS40 autosampler run using Peaknet 5.1 software. A 5 mL sample was taken for anion analysis. Anions in the sample were separated by retention times. Sample concentration was calculated from the standard curve established for each analyte. An external standard, a DIW blank, and a filtered lab blank were analyzed with every 10 samples or each run. Standards ranged from 4.0 – 400 µeq/L in water for Cl and SO_4; standards ranged from 1.0 – 50 µeq/L in water for NO_3.

3.8.4. Cations (Ca, Mg, K, Na) and Aluminum

Cations were analyzed by Perkin-Elmer 3300 XL axial view inductively coupled plasma atomic emission spectroscopy (ICP-AES). Samples were filtered through 0.4µ into 60 mL HDPE bottles and acidified with nitric acid to pH <2.0. Lab SOPs recommend a holding time of six months after acidification. The ICP system used was a CETAC U-6000AT ultrasonic nebulizer, an AS-90 Plus autosampler, and Perkin-Elmer WinLab 32 software. The five elements were analyzed simultaneously and the acceptable standard curve was established daily for each element. Sample concentration was calculated from the standard curve. The calibration range for Al was 10 ug/L – 500 ug/L; for Ca was 0.05 mg/L - 5 mg/L; for K was 0.05 mg/L – 2.5 mg/L, and for Mg and Na was 0.05 mg/L to 25 mg/L. Samples above the range were diluted and reanalyzed.

3.8.5. Equilibrated pH

The analysis of pH is the measurement of the activity of H^+ in a solution. The definition of pH is the $-\log[H^+]$. The measurement of equilibrated pH used a Radiometer SAC80 sample changer, Radiometer TIM900 Titration Manager and TimTalk 9 software, and a Radiometer combined glass electrode. The electrode was calibrated using buffer solutions at pH 4 and pH 7, and a check standard acid solution with pH 4.70. The slope of the two-point calibration curve must have fallen between 98% and 102%, or the analyzer was re-calibrated. A pH 7 and standard acid check were run after calibration.

Ambient temperature was entered into the TIM 900. Samples were at room temperature before analysis. The TIM 900 software was activated and aeration apparatus attached to the control arm of the sample changer. The aeration apparatus consisted of a plastic aeration frit connected to a tank of standard air, with 300 ppm CO_2. The electrode was submersed in each sample for 120 seconds before taking a final reading, which was saved into a data file to be reported. A lab blank (pH 5.6) and a dilute standard acid check (pH 4.70) were run at least every ten samples. Lab SOPs recommend a sample holding time of 7 days for equilibrated pH.

3.8.6. ANC (Acid Neutralizing Capacity)

ANC in natural waters is the Gran plot calculation (Peck *et al.*, 1993) of the titratable bases, usually bicarbonate and DOC in these samples. Positive ANC is usually considered to be a result of HCO_3^- concentrations. The Gran plot analysis was performed by incremental inflection point titration with sulfuric acid. The titrant was added in pre-defined increments according to the steepness of the titration curve when an electrode stability criterion was met. The instrumentation for ANC determination consisted of a Radiometer SAC80 sample changer, Radiometer ABU91 Autoburette, Radiometer TIM900 Titration Manager and TimTalk 9 software, and a Radiometer combined glass electrode.

The calibration procedure was the same as for equilibrated pH, above. After calibration, a standard acid, deionized water (DIW), and pH 6 check were run, and the conductivity of DIW was recorded. Standards with ANCs of 20, 40, 80, and 200 were run, with acceptable limits of 4% for the 200 standard and ± 4 µeq/L for the standards with values less than 100. The sample was pre-dosed with acid to a pH of 4.1, then titrated to 3.5 pH. Inflection points from the titration curve were saved to a results file in the TimTalk software, and a gran plot was used for final calculation of ANC for each sample. The r^2 value for each gran plot must have been at least 0.999 or the sample was re-analyzed. Recommended holding time for samples to be analyzed for ANC was 14 days.

3.8.7. Ammonium and Silica

A Technicon® TRAACS 800™ Autoanalyzer (Bran + Luebbe) (all 1999 and many 2000 samples) or an ALPKEM Flow Solution™ IV Autoanalyzer (OI Analytical) (some 2000 samples) was used for sample analysis. Samples to be analyzed were filtered through a 0.45 µm membrane filter, acidified with two drops of 1:1 H_2SO_4 per 60 mL sample, and stored at 4°C until analysis. Samples were analyzed within 28 days of collection.

The determination of ammonium utilized the Berthelot reaction, whereby ammonium reacts with alkaline phenol and hypochlorite to form indophenol blue in an amount that is proportional to the ammonium concentration. The color was intensified with sodium nitroferricyanide, and a disodium EDTA solution was added to eliminate the precipitation of hydroxides of calcium and magnesium. The absorbance was measured at 660 nm. Standards ranged from 0.1 to 1.0 mg/L NH_4. Two laboratory QC samples and one ERA QC sample were run after every ten samples.

The determination of silica was based on the reaction of silica in solution as silicic acid or silicate with ammonium molybdate in an acid matrix to form ß-molybdosilicic acid. The complex was reduced by ascorbic acid to form molybdenum blue. An oxalic acid solution was added to suppress phosphate interference. The absorbance was measured at 660 nm. Standards ranged from 0.5 to 5.0 mg/L Si. Three laboratory QC samples were run after every ten samples.

3.8.8. Total Nitrogen

A Technicon® TRAACS 800™ Autoanalyzer (Bran + Luebbe) (all 1999 and most 2000 samples) or an ALPKEM Flow Solution™ IV Autoanalyzer (OI Analytical) (some

2000 samples) was used for total nitrogen analysis. A 10-ml aliquot of each sample was pipetted into a glass vial and stored at 4°C until digested and analyzed. Samples were analyzed within 28 days of collection. When digested, samples were oxidized with an alkaline persulfate in an autoclave at 120°C and 15 psi. This process converts all nitrogen containing compounds to nitrate. Nitrate is then reduced quantitatively to nitrite by copperized cadmium in the form of an open tubular cadmium reactor (OTCR). The reduced nitrite reacts under acidic conditions with sulfanilimide to form a diazo compound that couples with N-(1-naphthyl)ethylenediamine dihydrochloride to form a reddish-purple azo dye. The absorbance is measured at 540 nm. Standards ranged from 0.1 to 2.0 mg/L NO_3 - N. Two laboratory QC samples containing organic nitrogen and one laboratory QC sample containing inorganic nitrogen were run after every ten samples. Also, a nitrite standard was run following a nitrate standard of the same concentration after every twenty samples to check the OTCR efficiency.

3.8.9. Apparent Color

Apparent color is a measure of the dissolved and suspended solids in a sample. It is usually closely correlated with DOC and often used as a quality analysis check. Apparent color analysis was only run for throughfall samples in 1999. Light at a wavelength of 457.5 nm was passed through an unfiltered sample in a Milton Roy Spectronic 601 spectrophotometer. The absorbance at this wavelength can be converted into a color value; color is linear in relation to absorbance at this wavelength. Three standard curves were constructed using dilutions of a platinum-cobalt standard stock solution. A QC standard of known value was run every ten samples, and a lab blank (zero color) was run every twenty samples. Lab SOPs recommend a holding time of 7 days for samples to be analyzed for apparent color.

3.8.10. Conductivity

Conductivity, also called specific conductance, is a measure of electrically charged species in a solution. Conductivity was measured using a Yellow Springs Instrument (YSI) Model number 3200 digital conductivity meter equipped with a temperature sensor, and YSI probe 3253. The probe was rinsed eight times with deionized water, then with sample, then the cell was filled with sample. A reading was taken in three to ten seconds. Between samples, the probe was rinsed eight times with nanopure water. A 10 µmho/cm standard was run as a calibration check every ten samples. A lab blank was also run every ten samples. A new cell constant was configured when a new bottle of conductivity calibrator was opened, or when standard runs were unacceptable as defined by Mitchell Center SOPs. Lab SOPs recommend a sample holding time of 14 days for conductivity analysis.

3.9. Data Validation

3.9.1. Quality Control (QC)

Analytical data were reported in a Laboratory Information Management System (Conifer Environmental LIMS Version 2.50 for Windows, 1994, Telecation, Inc.), and transferred to a Microsoft Excel spreadsheet. They were then screened for QC, including field and lab blank values, and replicate analyses for precision. Laboratory blank samples were made for each analyte that requires sample preparation. These samples reflected control of contamination during sample preparation. The laboratory blank was made from reagent grade water and was prepared in the same manner as a sample. For samples not requiring preparation, a laboratory blank was used to monitor background changes in measurement systems. These laboratory blanks were made from reagent grade water and treated in an identical fashion to samples prepared for these tests. The laboratory and reagent blank values were expected to be less than twice the analytical detection limit (Appendix C). Instrument operators were responsible for preliminary data reduction and validation (Section 3.8).

3.9.2. Quality Assurance (QA)

All samples were evaluated for ion balance using the formula:

$$\frac{[H^+] + [NH_4^+] + [Ca^{2+}]+[Mg^{2+}]+[K^+]+[Na^+]+([Al(\mu g/L)]^* \, 0.112)}{ANC + [Cl^-]+[NO_3^-]+[SO_4^{2-}]+[DOC(mg/L)]^*4}$$

where all units are µeq/L unless specified. Multipliers for Al and DOC charge were used as in Kahl *et al.* (1989). The EPA acceptability range was +/- 20 % or the data are re-evaluated and/or samples re-analyzed (Peck, 1992). Ion balances for throughfall were calculated and averaged 0.96 for 1999 and 0.94 for 2000 (Figures 13a and 13b). Samples with incomplete chemistry were inspected qualitatively against other samples at nearby sites and from other sample periods.

Backup files were archived, and hard-copy printouts were made of all output and placed in the project file. Accepted data were uploaded to mainframe SAS for manipulations including ion balances, sea-salt corrections, conductance calculations, and statistical processing. Data used in statistical analyses for this thesis research met the acceptable standards (Appendix D). The QC/QA procedures for wet-only precipitation data were the same as used in throughfall data validation. Accepted wet-only data were uploaded to SAS for further analyses (Appendix E).

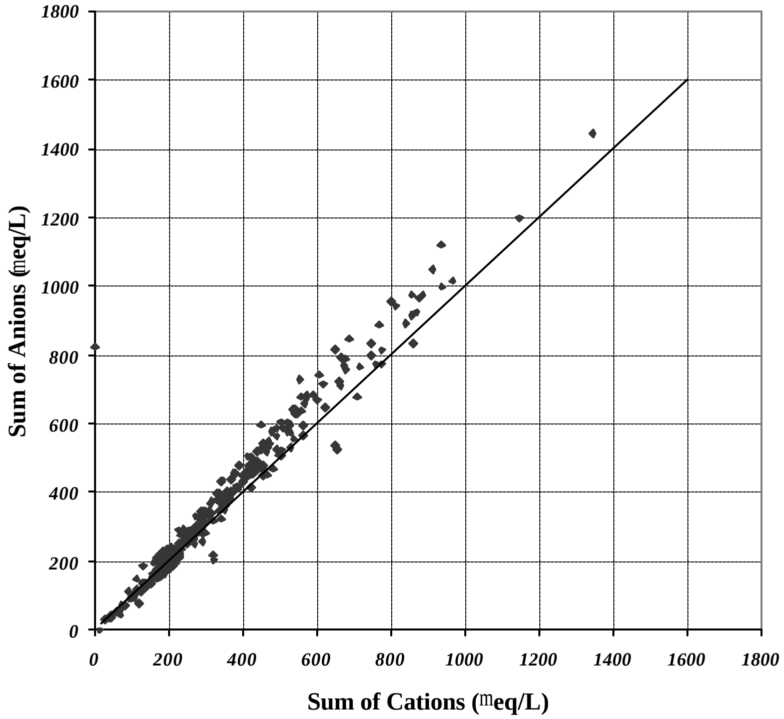

Figure 13a. Calculated ion balance ratios (including DOC and Al) for throughfall samples from 1999.

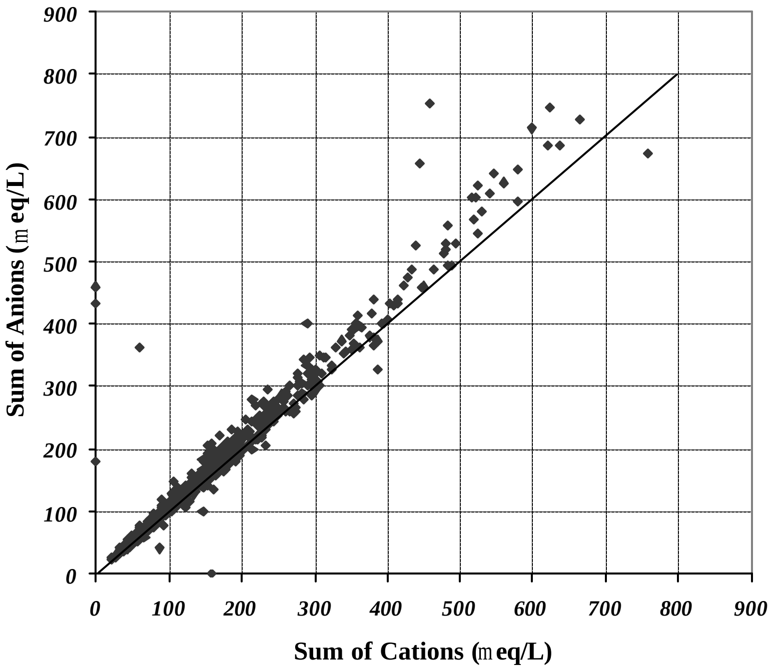

Figure 13b. Calculated ion balance ratios (including DOC and Al) for throughfall samples from 2000.

3.10. Input Calculations

3.10.1. Throughfall and Wet-only Input Calculations

Landscape feature data were merged into a spreadsheet by each unique collector name (Appendix B). This file was then uploaded to mainframe SAS and merged with the uploaded throughfall chemistry data for each sampling date and collector name. The SAS routines created for analysis of these throughfall data (Appendix F) accomplished several objectives:

- merged landscape feature data with chemistry,
- performed calculations to correct ion concentrations and deposition for the influence of marine aerosol deposition,
- calculated ion-balances as a secondary check on data quality,
- utilized volume data to determine depth of precipitation for each event,
- calculated deposition based on the depth of precipitation, catch area of the funnel, and chemistry data,
- calculated deposition on a watershed scale by multiplying collector-scaled deposition by total area of the watershed,
- calculated deposition based on the bulk collector at McFarland Hill only; and,
- calculated deposition scaled by landscape features using the relative areas represented by each landscape feature and deposition means for that feature type.

The SAS job created to process wet-only (AerocheMetrics) precipitation data (Appendix F) also accomplished objectives 2-5, and calculated deposition based on the wet-only collectors at each watershed, similar to number 7, above.

3.10.2. Statistical Methods: Temporal and Landscape Factors

Two response variables were selected for the statistical analyses of landscape and temporal factors. The first response variable was SO_4. SO_4 is commonly used as an indicator of differences in deposition due to landscape factors (Lovett et al., 1999; Weathers et al., 2000a; others). SO_4 is considered a conservative ion, having little net interaction with the forest canopy. Therefore, any differences in deposition of SO_4 should be able to be attributed to differences in loading at different locations or elevations, or differences due to filtering efficiency of canopy types.

Likewise, Na has been used as a conservative indicator of deposition (Ulrich, 1983; Beier et al., 1992). In coastal areas, almost all of the Na deposited to the land's surface may be assumed to originate as dry deposition (Beier et al., 1992). For this research, collection-based deposition measurements of Na and SO_4, calculated from the concentration times volume of precipitation for each observation, were converted into a measure of deposition in eq/ha/da by dividing the deposition for each collection by the number of days in each collection period.

The suite of potential predictor variables included both landscape and temporal factors. Predictor variables that were confounded by other factors (e.g., due to the experimental design) were excluded from the analysis. No statistical tests were performed for the variables year, disturbance history, and aspect. The variables elevation and canopy coverage were continuous variables, and vegetation type, watershed, and season were discrete variables. Since there were multiple predictor variables, both continuous and discrete, and because interaction effects were likely to be important, I ran an Analysis of Covariance (ANCOVA) where the continuous variables were covariates using SYSTAT version 9 software (SPSS Inc., 1998). In SYSTAT, a General Linear Model (GLM) can be used to estimate and test any univariate or multivariate model, including multiple regression, ANOVA and ANCOVA, and principal components.

A GLM was constructed using chemical variables SO_4 and Na as dependent variables and elevation, canopy coverage, watershed, vegetation, and season as independent variables. In addition, the interaction effects of the classes of vegetation type, watershed, and season with elevation and canopy coverage were examined in concurrent GLM runs. I used general linear models with decreasing complexity to describe the significant effects and finally, make generalizations regarding landscape factors. There were three model runs: a full model, using all of the possible main and interaction effects (31 effects total); a reduced model, using only the significant main effects and their interactions as determined by the first run (14 effects total), and a simplified model.

For the simplified model, I ran the same GLM, but allowed the software to use effects coding for the dummy categorical variables. Using effects coding, significant differences are determined relative to the overall mean. Dummy coding, which was used in the full and reduced models, determined significance by comparison to a reference category. For instance, coniferous vegetation was the randomly chosen reference vegetation type; differences were determined relative to coniferous vegetation in the full and reduced model, and relative to the mean for all vegetation types for the simplified model. Notably, the open vegetation category was separate from the scrub category in the final simplified model run.

In order to use the ANCOVA approach, two major assumptions needed to be met. First, the data must be normally distributed. Because of the high degree of variability in throughfall measurements, the data were log-transformed to meet the assumption of normal distribution. I examined a normal probability plot of the log-transformed values and determined that the first assumption was met (Appendix G). Second, the errors calculated by comparing observed values to those predicted by the model (residuals) must be normally distributed. I evaluated residual plots from the reduced model run to determine whether the errors were normally distributed (Appendix G).

Since the log-transformed data set met the two assumptions, the ANCOVA approach was used. For the full and reduced models, each discrete variable was separated into a number of dummy (0/1) variables for each of the classes represented, leaving out one of each category as the reference condition. Because there were only one or two observations for open sites for each collection and because open sites were usually not completely exposed but surrounded by vegetation, scrub and open were compressed into a single scrub category for the statistical analyses. We recognize that for a true measure of 'open' deposition, the McFarland Hill bulk site should be used.

3.10.3. TF: NADP Ratios

Weekly concentration data and precipitation depths for NADP site ME98 (Acadia National Park, McFarland Hill) were downloaded from the NADP website to use as a baseline for constructing quantitative throughfall – NADP ratios. The NADP only calculates deposition on seasonal or annual time steps; therefore, it was necessary to calculate deposition in periods to match the semi-weekly throughfall collection periods. Deposition was calculated weekly for the winter and early spring periods, when throughfall was not collected. Deposition was calculated using a SAS routine that multiplied depth by concentrations, and scaled up to eq/ha.

Ratios of throughfall to NADP wet-only data were calculated by dividing the mean deposition for each sampling period and vegetation type within each watershed by the calculated NADP deposition for each period. The ratios were averaged by season for logistical reasons. Ratios were checked for validity by ensuring that the ratios of open sites to NADP depositions were near one.

3.10.4. Winter Ratio Determination

To estimate winter inputs, a ratio had to be calculated for each ion for winter deposition. Despite leaf-off or dormant conditions, winter throughfall deposition is higher than bulk deposition consistently in the northeast (Bailey *et al*., 1996; Houle *et al.*, 1999b). Spring ratios were used, in the absence of snow collections, for winter for this research because both periods represent leaf-off conditions at Acadia.

3.10.5. Ratio Method for Inputs: QA

The finalized ratio matrix was entered into a SAS routine along with calculated NADP deposition data (Appendix F). The 'ratio method' was then run for the water year 2000, October 1 1999 – September 31, 2000. The ratio method performed the following tasks:

- input calculated NADP deposition amounts for each analyte (base deposition);
- input the matrix of ratios for each watershed, season, and vegetation type;
- merged the ratios with the deposition amounts for each vegetation type (expanded the matrix to distribute the base deposition to each type and watershed);
- calculated scaled-up deposition by multiplying base deposition and the ratio for each watershed, season, and vegetation type;

- calculated the mean deposition for each watershed, vegetation type, and collection and saved each mean as a final estimate by vegetation type;
- multiplied the deposition for each vegetation type by the relative coverage of that vegetation type in each watershed for each collection, resulting in a vegetation-weighted deposition estimate for each watershed.
- summed the vegetation-weighted estimates for each collection and watershed into an annual deposition total for each watershed.

For quality assurance, deposition totals were calculated using both the throughfall and ratio method estimates for summer and fall, seasons for which throughfall data were available. The sums were weighted by vegetation type using the same relative coverages in both SAS routines.

3.10.6. Watershed Mass Balances

Mass balances for the PRIMENet watersheds were calculated using the same methods employed in the Bear Brook Watershed Study (Kahl *et al.*, 1999). A general mass balance equation representing the fluxes for a catchment is:

solutes in outflow = solutes from atmosphere + solutes from weathering ±
solutes from change in biomass ± **change in exchange pool** (Drever, 1997).

This thesis research evaluates the contribution of solutes from the atmosphere (inputs) as total (wet plus dry) deposition, modified by landscape features. The Cadillac granite bedrock in the two sites has a slow weathering rate and is assumed to be tight with respect to losses to groundwater for mass balance purposes (Likens and Bormann, 1995). PRIMENet researchers used measured and calculated inputs, stream chemistry data and interpolated values, and measured discharge to complete mass balance calculations for each watershed; only the input side of mass balances is reported in this thesis study. The input side of mass balances was calculated using SAS statistical software (Appendix F).

To estimate deposition to the PRIMENet watersheds and assess the mass balances, it was necessary to analyze data using a water year as the base time unit. NADP data were used with ratios to estimate deposition during the period that throughfall collectors were not deployed, November 20, 1999 – April 30, 2000. Throughfall data, NADP data, and ratios were used to estimate inputs; streamwater chemical and hydrologic fluxes were calculated for the PRIMENet watersheds using the methods of Kahl *et al*., (1999).

As a preliminary check of data compatibility, a water budget was constructed. Hydrologic inputs from the NADP website (in mm) were converted to liters per hectare and summed for each watershed area, and compared to the values from the PRIMENet streamwater outfluxes, taking into account that evapo-transpiration is about 40% of precipitation in Maine (Knox and Nordenson, 1955; Haines *et al.*, 1989; Kahl, 1998). PRIMENet streamflow data were provided courtesy of the USGS and hourly flow values were used for mass balances.

Chapter 4

RESULTS

4.1. Inter-annual Differences in Throughfall Concentrations

Throughfall samples were collected six times in 1999 and ten times in 2000 (Figure 14). Descriptive statistics were calculated for concentrations of major ions in throughfall for the two-year period (Table 5). Although 1999 and 2000 mean daily precipitation was the same (0.33 cm), there were 20 days with precipitation above 2.5 cm in 1999 compared to seven in 2000 (NADP data, 2001). In the balance of this chapter, indicator ion (SO_4 and Na) deposition data will be examined sequentially by various factors that control the chemistry and thus the chemical loading to each watershed.

Table 5. Descriptive chemistry for sixteen throughfall collections at Acadia National Park, August 1999 to November 2000. The 'NM' preceding SO_4 denotes 'non-marine' for marine corrected concentrations.

	Depth	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	$NMSO_4$	NH_4	EqpH
						Cadillac						
n	437	441	441	441	440	442	442	442	442	441	441	440
	mm	←				μeq/L					→	
Min.	6	5	<0.5	8	0.1	<1.0	<0.8	<1.0	<0.9	4	<1.1	3.90
Max.	196	277	249	816	126	171	183	473	605	258	94	7.02
Median	46	53	16	58	27	16	20	22	49	42	2	4.58
Mean	52	60	24	93	34	26	29	44	74	51	7	4.72
St. Dev.	27	42	30	104	27	25	30	67	76	37	11	0.61
						Hadlock						
n	430	431	431	431	429	430	430	429	430	431	430	429
	mm	←				μeq/L					→	
Min.	3	4	<0.5	5	0.1	<1.0	<0.8	<1.0	4.3	3	<1.1	3.61
Max.	194	289	257	1120	245	119	200	338	848	275	107	6.85
Median	47	63	23	84	40	22	27	31	72	51	7	4.40
Mean	54	77	36	118	48	28	33	42	98	65	13	4.50
St. Dev.	29	57	39	121	36	22	27	38	93	51	16	0.52

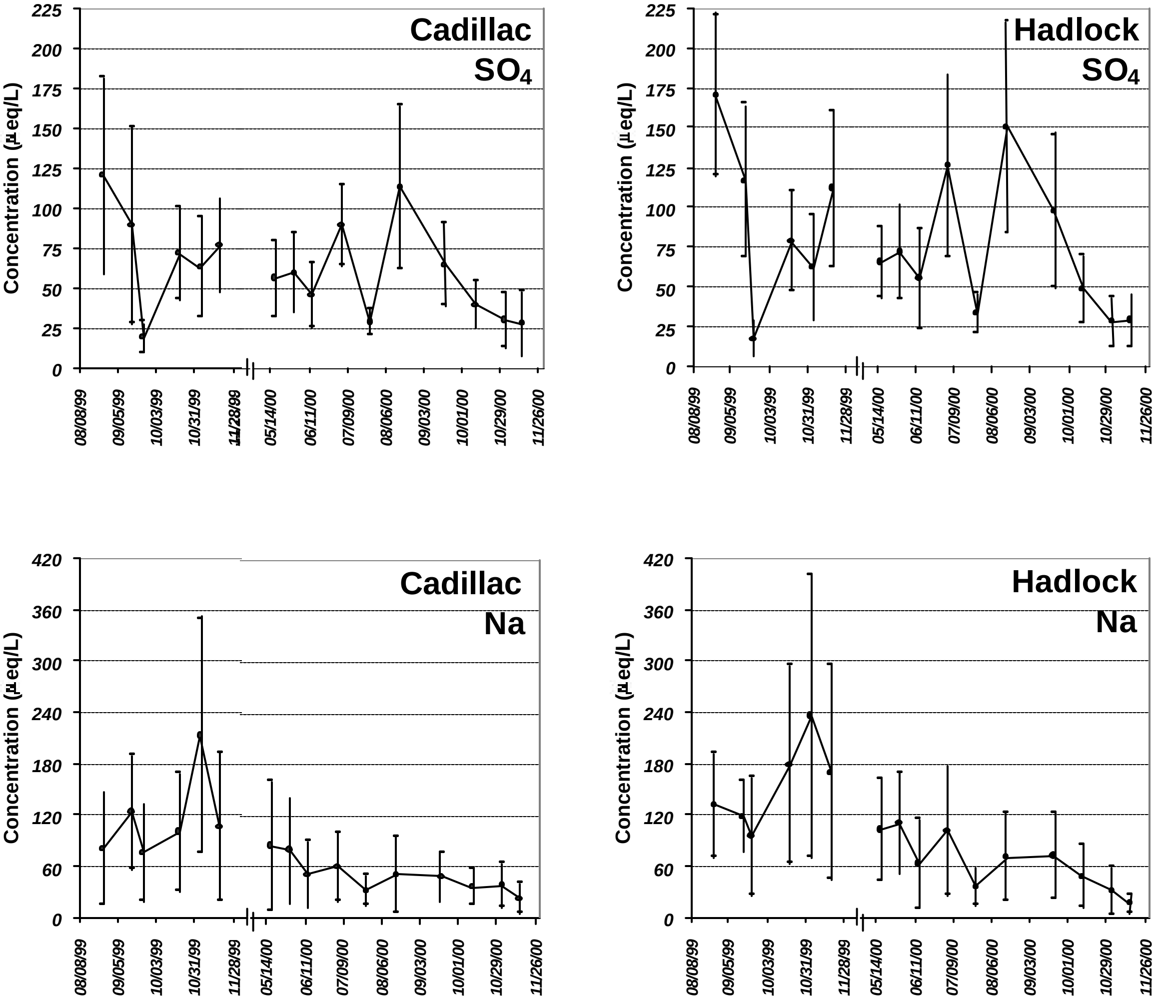

Figure 14. Mean concentration of SO_4 and Na at Cadillac and Hadlock Brook watersheds for 16 throughfall collections in 1999 and 2000. Standard deviations are plotted for each sampling date.

4.2. Factors Excluded from Analysis

4.2.1. Disturbance History

Disturbance history (burned versus unburned) was not included in the final analysis of the importance of landscape factors. Due to the experimental design, all of the burned sites fell within Cadillac Brook watershed and unburned sites in the upper section of Cadillac and in Hadlock Brook watershed (Figure 15). We did not assess the importance of burned versus unburned sites within Cadillac Brook watershed because of the confounding effects of vegetation type and elevation differences.

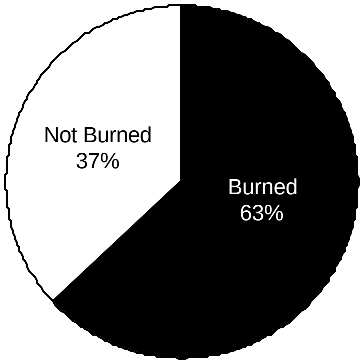

Figure 15. Percent of burned and non-burned sites in Cadillac Brook watershed. All of the sites in Hadlock Brook watershed were not burned.

4.2.2. Aspect

Although each of the four aspect classes were represented between the two watersheds, a thorough analysis of aspect effects was not possible in the final analysis. There were uneven numbers of sites located in the aspect classes; for instance, only 1-2 sites per collection were in north aspects (Figure 16). Generally, most of the sites reflected the overall orientation of each watershed. Hadlock Brook watershed faces generally south-southwest, while Cadillac faces generally south-southeast. Differences due solely to the effect of aspect were not separable from whole-watershed or vegetation effects.

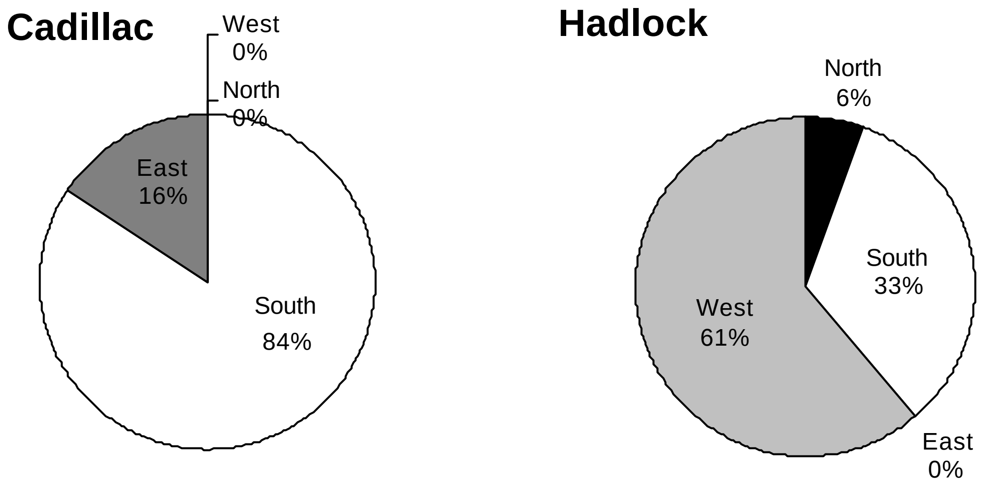

Figure 16. Percent of sites in each aspect in the two PRIMENet watersheds. Cadillac Brook watershed was dominated by south facing sites, and Hadlock Brook watershed was primarily south and west facing sites.

4.3. Factors Included in Analysis

4.3.1. Watershed Differences

Mean deposition values were higher at Hadlock than at Cadillac Brook watershed during the period of this research for all of the major ions reported in Table 5 (Figure 14). In the full effects model, only interactions of watershed and other factors were significant. For Na, watershed x canopy coverage (P=0.01), and watershed x scrub (P=0.013) were significant. The interaction of watershed and elevation was significant for Na (P=0.032) and SO_4 (P=0.002). In the reduced model, watershed x canopy coverage (P=0.006), and watershed x scrub (P=0.004) remained important for Na. The interaction of watershed and elevation was again significant for both Na and SO_4 ($P \leq 0.001$).

In the simplified model, the main effect watershed was significant (P=0.045) for SO_4 and for Na (P=0.019) (Figure 17). The interaction of watershed and elevation was again significant for both Na (P=0.008) and SO_4 (P=0.03).

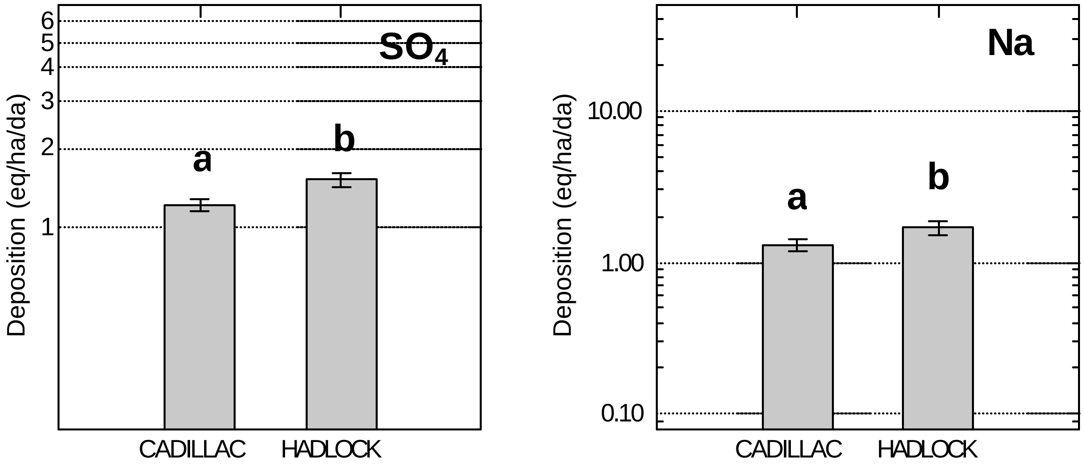

Figure 17. Deposition of SO_4 and Na for each watershed. Standard errors are plotted at p=0.95. SO_4 was higher at Hadlock than Cadillac (P=0.045) and Na was higher at Hadlock than Cadillac (P=0.019).

4.3.2. Vegetation Type

The distribution of vegetation types was somewhat weighted toward coniferous and mixed in Hadlock compared to Cadillac (Figure 18). Cadillac Brook watershed is composed of a highly heterogeneous mix of vegetation types, resulting in fairly even percentages of the major vegetation types. At Cadillac, the high elevation, semi-bald sites are classified as scrub. The Cadillac ridgeline within the study watershed is mostly spruce due to the deeply incised and perennially moist stream channel and its unburned status; the Hadlock ridgeline is largely bald and scrub/ semi-bald areas.

In the full model, there were significant effects for some vegetation types. The coniferous vegetation type was the reference condition for the vegetation dummy

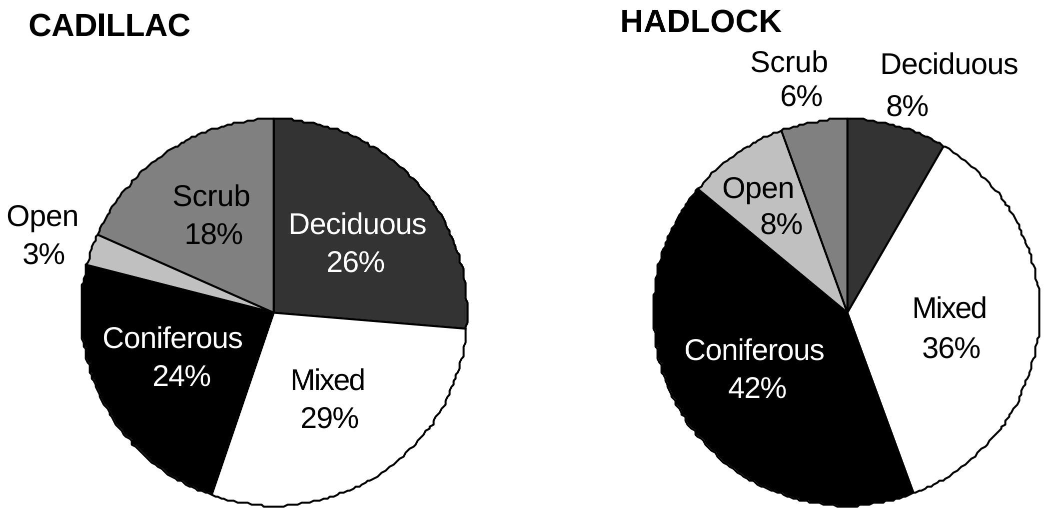

Figure 18. Percent of throughfall samplers in each vegetation type for the two PRIMENet watersheds.

variables. For SO_4, mixed vegetation was significant (P=0.007); for Na, mixed vegetation type was significant (P<0.001) as was scrub (P=0.016). Significant interactions for SO_4 deposition were mixed vegetation x elevation (P=0.001) and scrub vegetation x elevation (P=0.009). For Na, interaction effects of scrub x elevation (P<0.001) and mixed x elevation (P=0.01) were significant.

In the reduced model, mixed vegetation lost significance for SO_4; however, scrub vegetation become significant (P<0.001)(Figure 19). For Na, the same main effects of vegetation type were significant (mixed P<0.001; scrub P<0.001)(Figure 19). For SO_4, the interaction of scrub x elevation (P=0.001) remained significant. For Na, the same interactions, scrub x elevation (P<0.001) and mixed x elevation (P<0.001), were significant. In the simplified model, the main effect vegetation type was significant for both Na and SO_4 ($P \leq 0.005$), and the interaction effect vegetation type x elevation (P<0.001) were significant interactions. In both watersheds, mixed and coniferous sites had the highest throughfall deposition for SO_4 and Na; scrub sites generally had the lowest deposition.

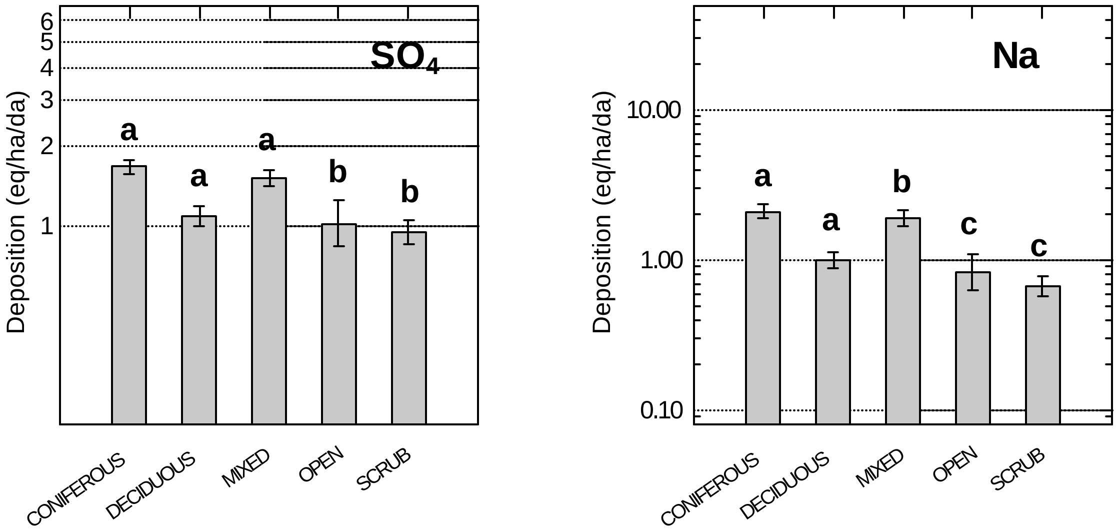

Figure 19. Deposition of SO_4 and Na (in eq/ha/day) for each vegetation type for throughfall collections at both PRIMENet watersheds. Standard errors are shown at p=0.95.

4.3.3. Elevation

Cadillac Brook watershed has a wider range of elevations than Hadlock Brook watershed; however, sampling sites are clustered at the high and low ends of that range

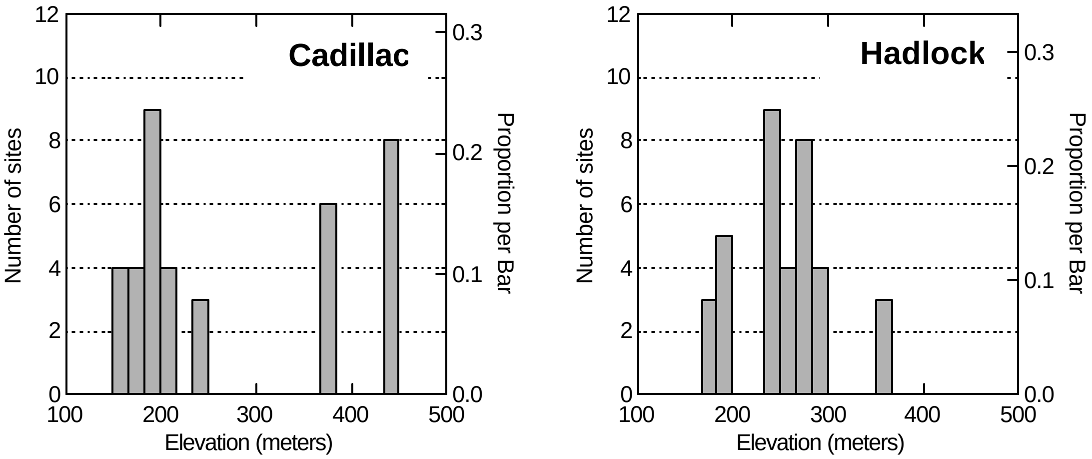

Figure 20. Histogram showing the distribution of sampling sites by elevation for each watershed.

(Figure 20). The analysis of the main effect elevation pooled the two watersheds, resulting in a continuous elevation gradient; however, it is important to note that not all elevations are present in each watershed.

In the full model, the main effect elevation was only significant for SO_4 (P=0.046). In the reduced model, the main effect elevation was no longer significant for SO_4; however, the interactions of watershed x elevation and watershed x vegetation type were

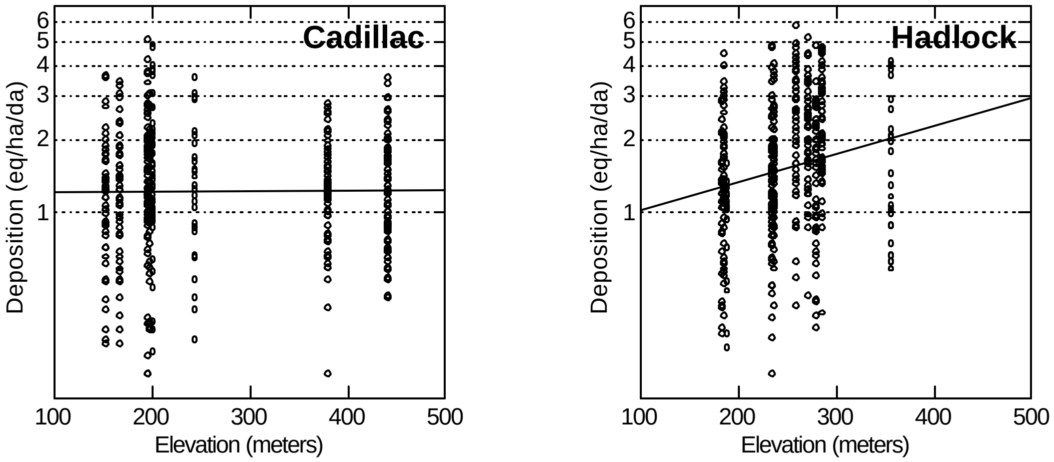

Figure 21a. Scatterplot and regression line showing the relationship of elevation and SO_4 for each watershed.

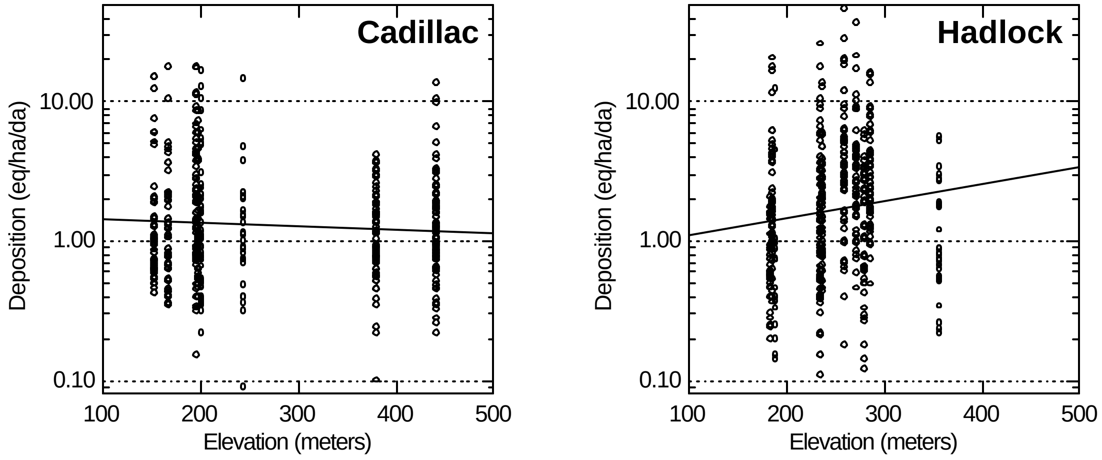

Figure 21b. Scatterplot and regression line showing the relationship of elevation and Na for each watershed.

significant (Figure 21a and b). However, in no case did the R^2 exceed 0.24. In the simplified model, the main effect elevation was significant for both Na and SO_4 ($P \leq 0.005$). For Na, the interaction effect elevation x canopy coverage was significant ($P < 0.001$).

4.3.4. Canopy Coverage

Most of the sites sampled for throughfall had >70% or <10% canopy coverage with few intermediate sites (Figure 22). In the full model, canopy coverage and its interaction with

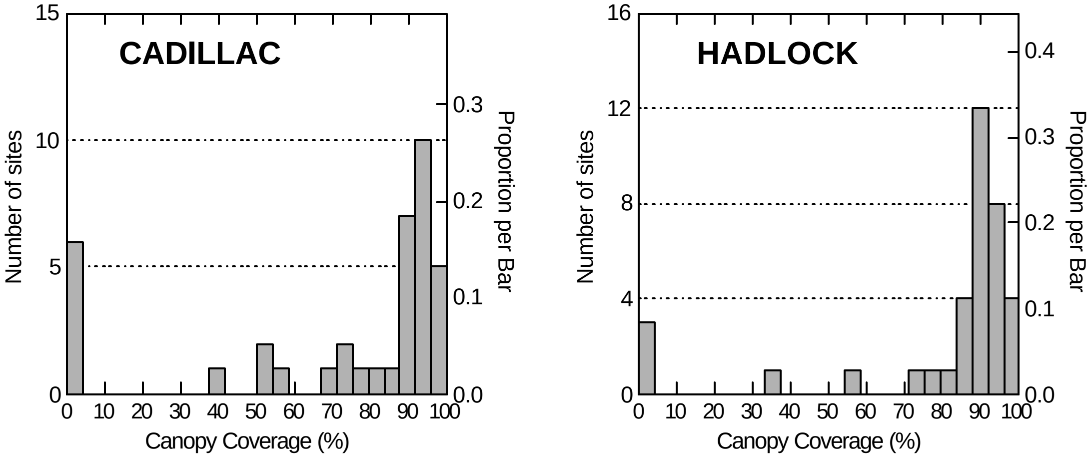

Figure 22. Histogram showing the distribution of sampling sites by canopy coverage for each watershed.

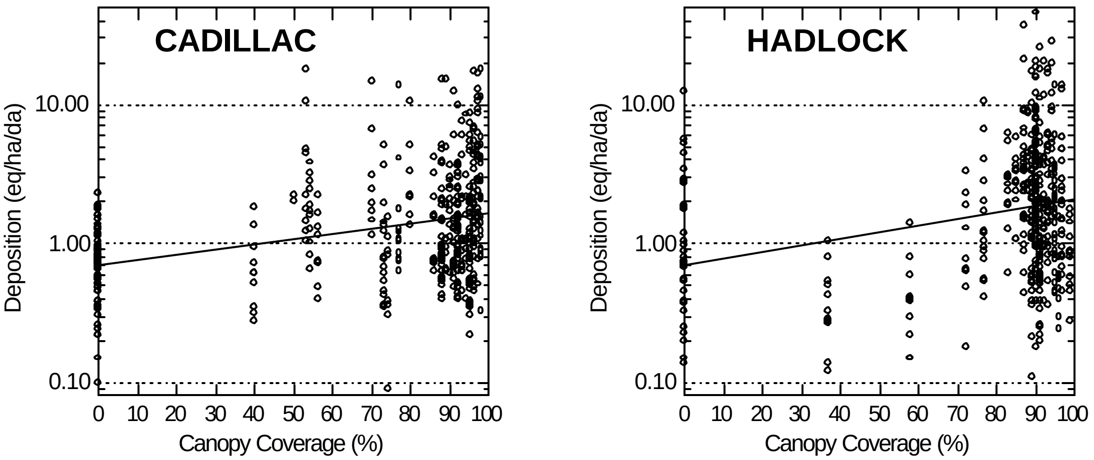

Figure 23. Canopy coverage and Na for each watershed.

other variables were generally not significant (P=0.161-0.928), despite an apparent pattern of increasing deposition with increasing canopy coverage (Figure 23). The only exception was the interaction of mixed vegetation x canopy coverage for Na (P=0.013). In the reduced model, mixed x canopy coverage remained significant for Na (P=0.001), and watershed x canopy coverage was significant for Na (P=0.006). Again, the R^2 for the reduced run of the multiple regression did not exceed 0.24 in any case.

4.3.5. Seasonal Differences

The assumption was made that seasonal patterns would affect enhancement of precipitation. For biologically active ions, such as K, the data bear out this assumption (Figure 24). Potassium concentrations were highest in the fall, due primarily to internal leaf leaching prior to senescence. Statistically, there were very few significant effects of season. For Na in the simplified model, season was significant (P=0.009).

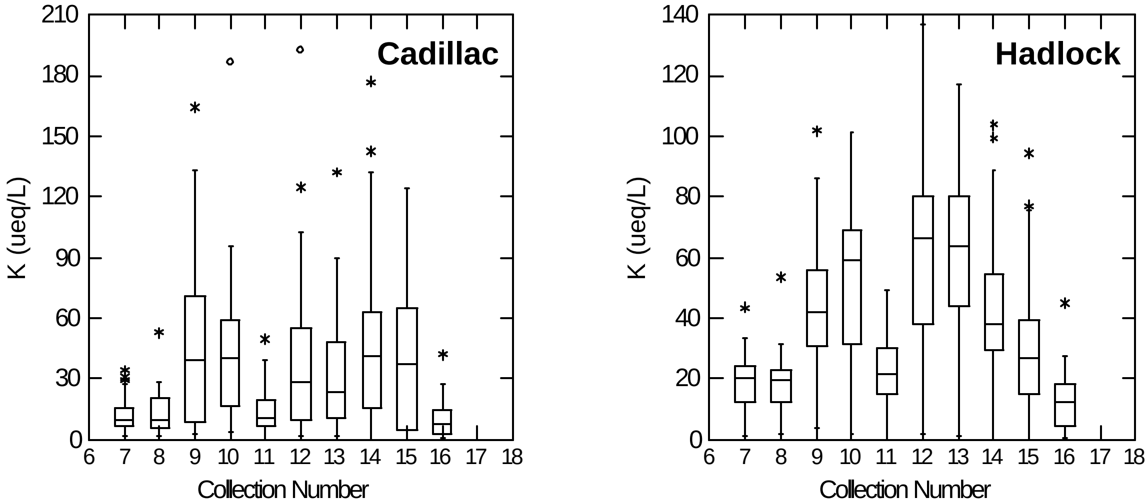

Figure 24. K concentrations in Cadillac and Hadlock throughfall for 2000, showing seasonal patterns. Collections 7 and 8 were spring, collections 9-12 were summer (Collection 12 was late August), and 13-16 were fall collections.

4.4. Comparison Between Sites: Wet-only Precipitation

Data from all three AeroChems were compared by sampling period. The mean concentrations over the period for which all sample types overlapped were similar for all of the major ions (Figure 25 and Figure 26).

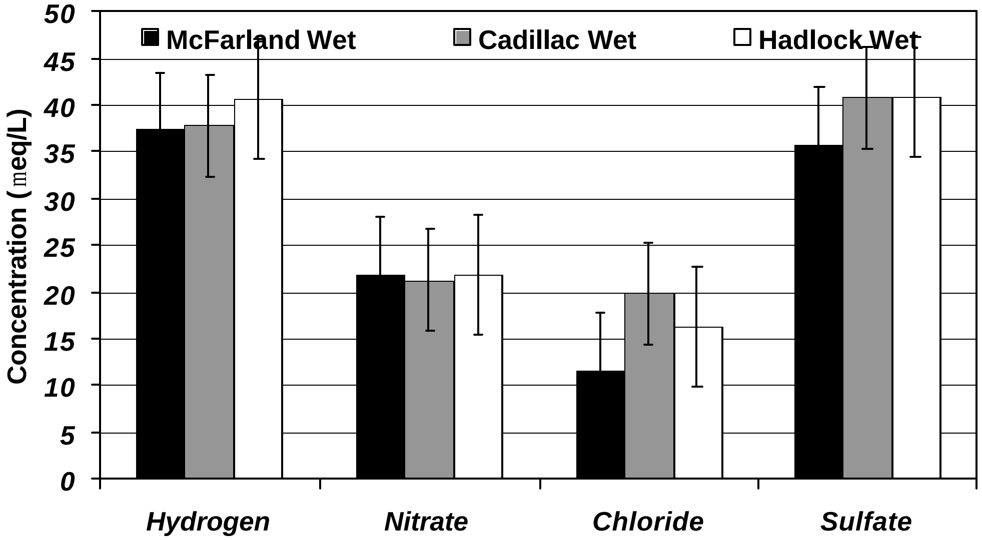

Figure 25. Concentrations of major anions and H from wet-only collectors at Cadillac Brook watershed, Hadlock Brook watershed, and McFarland Hill (NADP, 2001). Error bars show the standard error. Data were analyzed for May – November 2000, the period in which all three sample types coincided.

4.5. Comparison of Throughfall, Bulk, and Wet-only Data

Mean concentrations of major ions in bulk samplers were not different than those measured in wet-only samplers for any of the analytes sampled, with the exception of slightly lower NH_4 and NO_3 concentrations (Figure 26). Mean throughfall concentrations were plotted with bulk and wet-only concentrations (Figure 26) and are higher than bulk or wet-only concentrations for base cations, Cl, and SO_4. Mean H concentrations were slightly lower in throughfall than wet-only or bulk samples; the lowest mean H concentration was at Cadillac Brook watershed, in deciduous throughfall.

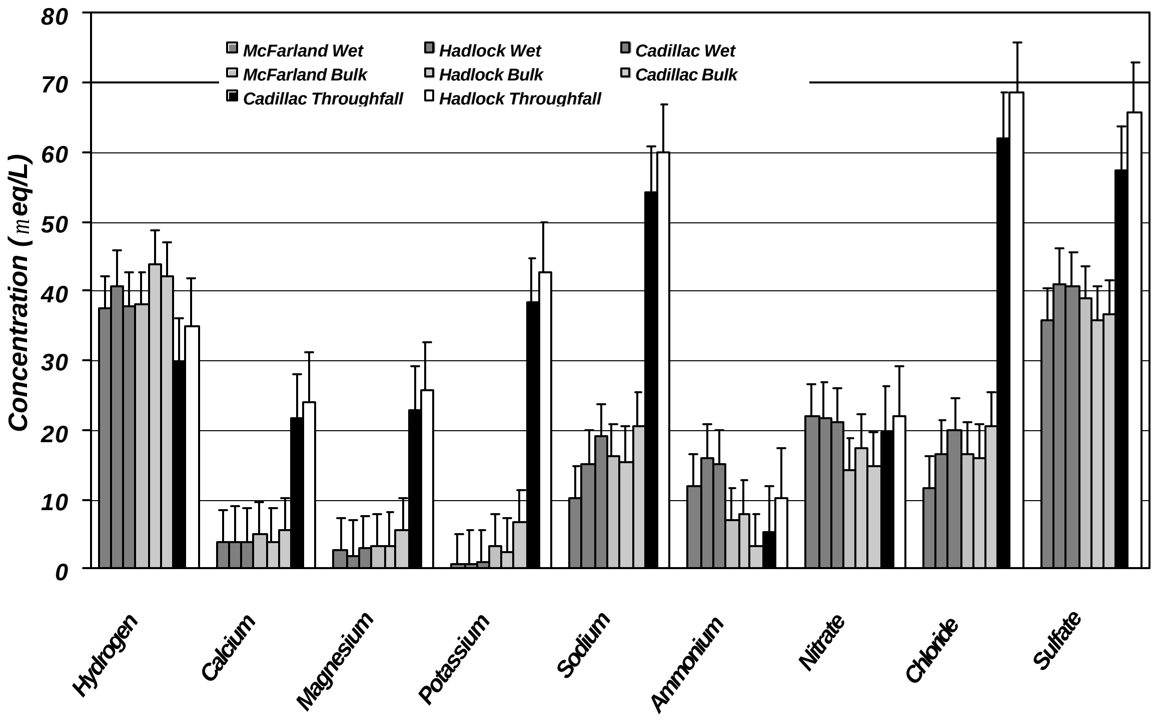

Figure 26. Mean concentrations of major ions in bulk, wet-only, and throughfall samples for May-November, 2000. Error bars denote the standard error. Throughfall concentrations are higher than bulk or wet-only for base cations, Cl, and SO_4. (McFarland Hill wet-only data from NADP online data, 2001.)

CHAPTER 5

DISCUSSION

5.1. Inter-annual Differences in Throughfall Concentrations

The two study years, 1999 and 2000, bracketed the normal range of precipitation conditions at Acadia. In 1999, there was an extended drought, a hurricane depositing 18 cm of precipitation, and a major storm in November. In 2000, precipitation was relatively evenly distributed over the field season. Sulfate concentrations were higher in August of 1999 than in the same month of 2000, likely due to dry deposition during the drought period that was washed off in the first collection (Figure 27). Concentrations probably decreased following the hurricane in September due to depletion of dry-deposited substances on the canopy.

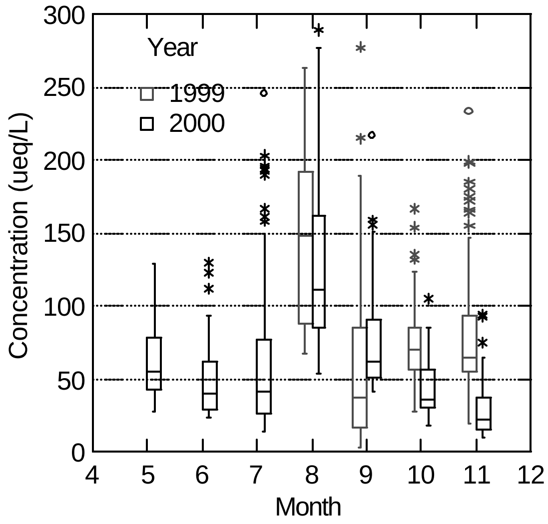

Figure 27. Sulfate concentration by month for 1999 and 2000. Box plots show relatively high concentrations in August of 1999 (first precipitation following drought) and decreasing in September 1999 (washout during Hurricane Floyd).

5.2. Factors Controlling Throughfall Flux

Five factors were analyzed for their effects on SO_4 and Na in throughfall at small watersheds at Acadia: watershed, vegetation type, elevation, canopy coverage, and season. Deposition at Hadlock Brook watershed was postulated to be higher than at Cadillac Brook watershed for three reasons: 1) Hadlock Brook watershed faces generally southwest, in the direction of pollutant-laden air masses; 2) Hadlock Brook watershed is composed primarily of coniferous vegetation, which has been found more efficient at raking substances from air masses (Cronan and Reiners, 1983; Matzner and Meiwes, 1994; Bailey *et al.*, 1996; Lovett *et al.*, 1999; Houle *et al.*, 1999b; Weathers *et al.*, 2000a); and, 3) the fire at Cadillac Brook watershed has produced a landscape that is more sparsely vegetated. Cadillac Brook watershed reaches a higher elevation than Hadlock, but deposition enhancement due to elevation was expected to be overwhelmed by the enhancement due to vegetation and aspect effects.

According to the literature, deposition varies over the seasons, with lowest deposition of many substances during leaf-off and higher deposition when foliage arrays are present to intercept substances (Cronan and Reiners, 1983; Houle *et al.*, 1999a; others). After noting that marine-derived substances, particularly Cl and Na, were higher in NADP precipitation in winter (Figure 28), it was hypothesized that the magnitude of loading in winter may overwhelm the effect of reduced canopy coverage for marine-derived

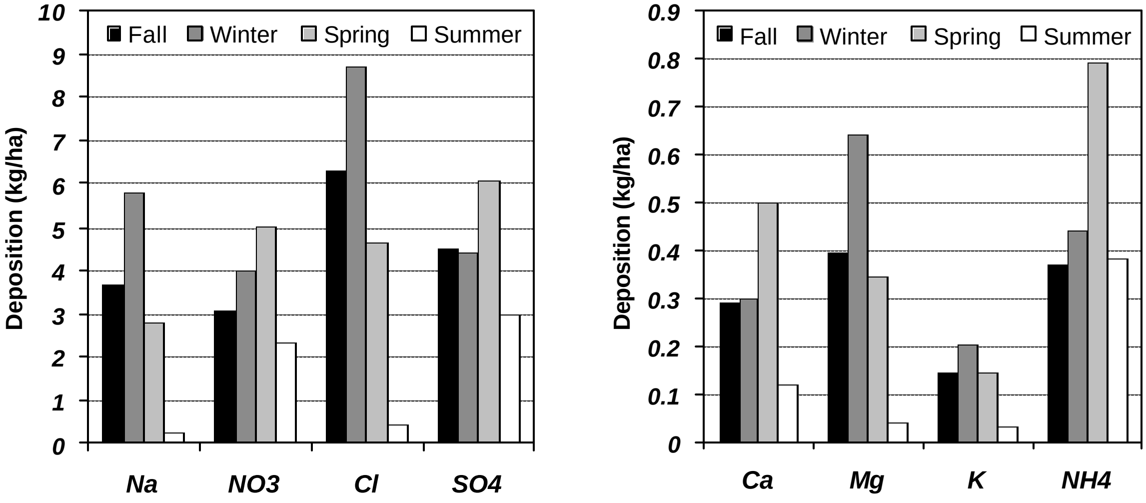

Figure 28. Seasonal deposition totals (in kg/ha) of major ions in wet-only precipitation collected at NADP site ME98, Acadia National Park, McFarland Hill (NADP, 2001). Seasonal totals represent roughly water year 2000, running from September 1999 through the end of August 2000. Note different scales on the two graphs. Wet-only deposition is generally highest in winter or spring.

substances (Figure 29). If onshore storm tracks in winter are influencing loading to the terrestrial landscape, and if reduced canopy interception is an important mechanism in winter, then deposition of anthropogenic or terrestrially derived substances in winter would be lower (Figure 29). The factors exhibiting the strongest significant effect on throughfall concentrations were chosen for the final steps of constructing the input side of mass balances.

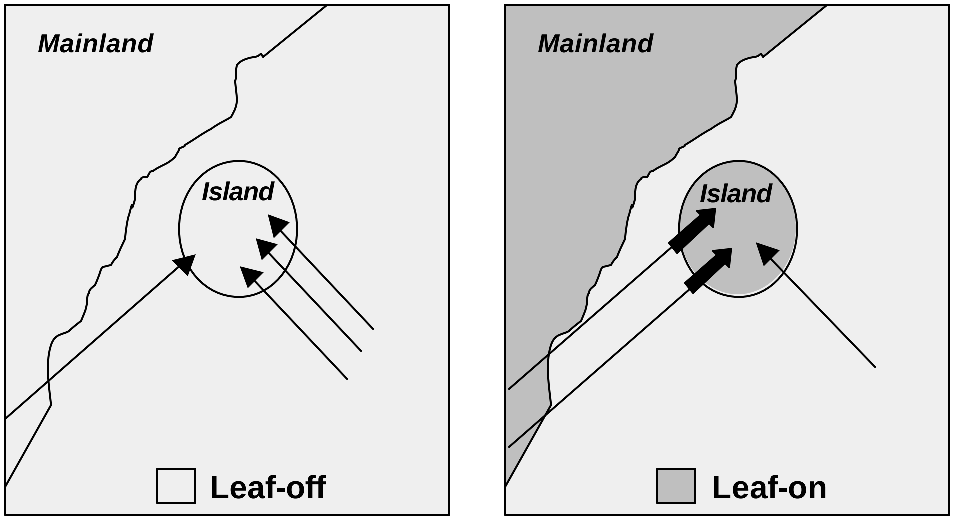

Figure 29. Conceptualization of the relative effect of vegetation type and marine versus terrestrial air masses on a northeastern U. S. island. Leaf-off (winter) conditions likely result in lower enhancement by vegetation type, while simultaneously, changes in general storm track bring in more marine-derived substances.

5.2.1. Differences Between Watersheds

Although mean values for deposition were higher at Hadlock Brook watershed than at Cadillac Brook watershed, the main effect of watershed was only significant in the simplified model (refer to 3.10.2 for model definitions). Although it was not possible to statistically test the effect of aspect because of uneven distribution of sampling sites across the fours major aspects, it was possible to compare throughfall deposition between the two watersheds and thus the two primary aspects sampled. Hadlock Brook watershed faces southwest, while Cadillac Brook watershed faces southeast.

For SO_4, southwest:southeast throughfall factors, based on mean deposition, are 1.3 for conifer and 1.0 for deciduous sites. For a throughfall study in New York, enhancement factors (EFs) were calculated for various landscape conditions using lead (Pb) in the forest floor as an index for deposition (Weathers *et al.*, 2000a). The mean Pb content at, for instance, a west-facing site was compared to the mean Pb content at a non-west site to get the enhancement factor for west:non-west aspect (Weathers *et al.*, 2000a). The EFs for west aspects were 2.5 for conifer sites and 1.0 for deciduous sites in the New York study (Weathers *et al.*, 2000a).

Although Weathers *et al.* (2000a) analyzed data by using suites of landscape factors, such as high-elevation west-facing conifer sites, there is reasonable agreement in relative west:east EFs. The prevailing wind direction for both the Acadia region and the New York sites is west to east, downwind of major pollutant sources. Therefore it is logical that throughfall concentrations on west aspects are higher than east aspects at Acadia as well as in New York.

5.2.2. Vegetation Type

Based on the literature, vegetation type was expected to be a major factor controlling deposition (see 2.4.8.1). The experimental design of Weathers *et al.* (2000a) did not allow for a direct comparison between vegetation types because suites of landscape factors were compared. However, along the same (west) aspect at the same (high) elevation, Pb content in the forest floor was greater in coniferous than deciduous stands. In the study at Acadia, vegetation type was significant for both Na and SO_4 deposition;

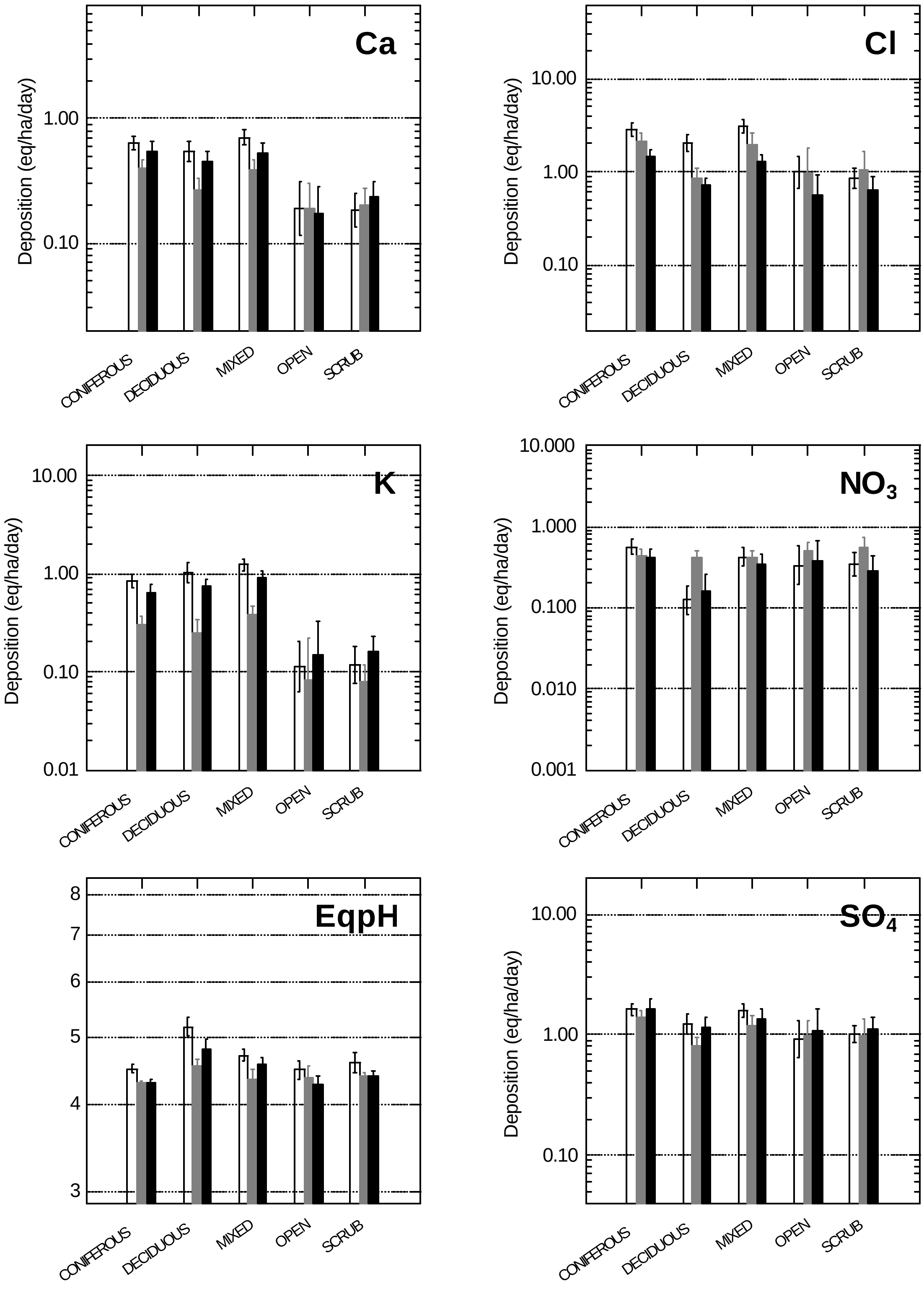

Figure 30. Deposition of major ions and mean equilibrated pH in paired watersheds at Acadia, by vegetation type and season. Standard errors are plotted at p=0.95.

however, deciduous was not different from coniferous. Scrub/open and mixed were significantly different than coniferous.

An unexpected result was that deposition of SO_4 and Na at mixed sites was significantly higher than at either conifer or deciduous sites. Higher deposition at mixed sites may result from the typically layered canopy that occurs at those sites. At Cadillac, the mixed type often consists of deciduous vegetation with a regenerating spruce-fir understory; at Hadlock, there is often a spruce-fir overstory with deciduous vegetation filling in small disturbances. As expected, deciduous and mixed sites had the highest deposition of K in each season (Figure 30). Deciduous sites had the highest pH in all seasons (Figure 30). Deposition of NO_3 was lowest during the growing season in deciduous sites (Figure 30).

5.2.3. Elevation

Several mechanisms for enhancement of substances in throughfall have been proposed for high elevation sites. Deposition enhancement at high elevations (greater than 1000 m) may be the result of: 1) increased rainfall due to orographic effects; 2) increased frequency of cloud coverage; 3) increases due to dry deposition; and, 4) shift in vegetation type from deciduous to coniferous (Lovett *et al.*, 1998;Weathers *et al.*, 2000a). Elevation was significant for SO_4, and some of its interactions with vegetation type and watershed were significant for both SO_4 and Na. For SO_4, there was a slight increase in deposition with increasing elevation; however, there were fewer observations at higher elevations.

Deposition was expected to be higher at high elevations because of exposure to high loading from fog and cloudwater, other mechanisms may overwhelm the elevation effect at Acadia. For instance, the elevation effect may not be as strong at Acadia because the topography, while dramatic in comparison to surrounding lowlands, reaches an elevation of only 468 meters at Cadillac Mountain Summit. Most areas above 300 meters are sparsely vegetated in both watersheds, limiting inteception. In addition, the character of high elevation conifer sites at these two watersheds was quite different than low-elevation conifer sites. Red spruce woodland was dominant in high points of Hadlock Brook watershed, and pitch pine and cedar were found in high elevation areas in both watersheds. The lower elevation conifer sites had a continuous canopy and tall stature, while high elevation conifers were often stunted or windblown.

I evaluated coniferous and open vegetation types individually to determine if vegetation character may overwhelm the elevation effect. For both Na and SO_4, deposition decreased slightly with elevation for coniferous sites (Figure 31). I extracted observations from the three open sites, CBULK (195 m), HBULK (189 m), and HT4F

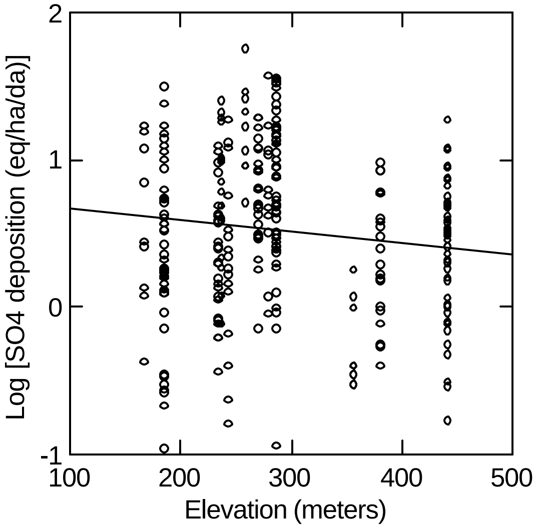

Figure 31. Deposition of SO_4 at conifer sites at Cadillac and Hadlock watersheds. There was a weak but significant decrease in deposition with increasing elevation.

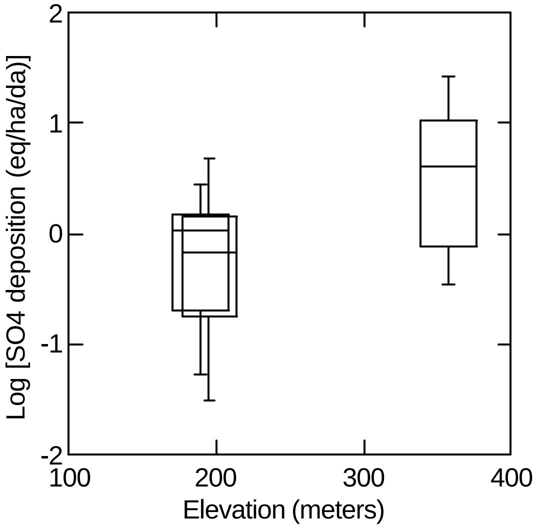

Figure 32. Deposition of SO_4 at three open sites in the study watersheds. In contrast to the pattern for conifer sites, deposition at open sites increases with elevation.

(357 m) from the data set to evaluate patterns over time for sites minimally affected by vegetation (Figure 32). There was significant enhancement of deposition at the high elevation bulk site for both SO_4 and Na, indicating that there may be higher atmospheric loading at high elevation, but that canopy structure ultimately controls what reaches the ground. The sparser nature of the canopy at higher elevation sites, along with a different species mix, reduces the scavenging efficiency of the vegetation at these exposed sites.

5.2.4. Canopy Coverage

Deposition of Na and SO_4 increased with canopy coverage; however, canopy coverage did not prove to significantly affect deposition in this research. There was large variability in deposition at sites with similar canopy coverage, masking any statistical effects. Qualitatively, the highest values for deposition occurred at the highest percentages of canopy coverage (Figure 23). Many sites with lower percent canopy coverage had lower deposition, although there was a great deal of variability at low coverage sites. A similar pattern was found at Hubbard Brook in New Hampshire, where the lowest Ca values in NTF (net throughfall) occurred at the site with the lowest LAI (Leaf Area Index) (Lovett *et al.*, 1996).

Canopy coverage and vegetation type are closely related, with mixed and deciduous canopies typically having higher coverage than open and scrub sites. Deciduous canopies can have higher canopy coverage during the growing season. Deciduous canopy architecture maximizes incident light exposure and effectively blocks more open sky to an observer beneath the canopy (Figure 11a and 11b). Deciduous sites, in fall and early spring, have lower canopy coverage. I assumed that vegetation type and seasonal patterns would overwhelm general effects of canopy coverage.

5.2.5. Season

Season was not a significant factor affecting deposition of SO_4 and Na in this study. I did not collect samples from December to April, and therefore missed the winter and early spring seasons. Bailey *et al.* (1996) and Bäumler and Zech (1997) found a significant seasonal pattern, even for conservative tracers, due primarily to changes in canopy architecture in winter. Canopy-reactive ions such as K and NO_3 would show strong seasonal patterns, especially in deciduous stands, with leaf senescence in fall (Figure 30).

The lack of winter data presented problems for calculation of deposition, and should be addressed in future studies. Winter and spring are the period of highest loading for Na and Cl (Figure 28). Few published studies have specifically addressed estimation of total deposition in winter. In Europe, cores or snow pits were used to estimate inputs in winter, but winter concentrations were found to be the lowest on a seasonal basis (Maupetit *et al.*, 1994; Kuhn *et al.*, 1998; Winiwarter *et al.*, 1998). Although NADP collection techniques may over- or under- estimate precipitation volume or ion concentration due to collector inefficiency in winter (Williams *et al.*, 1998; Zeller *et al.*, 1999), NADP collections were in close agreement with snowpack surveys in Colorado (Heuer *et al.*, 1999). Houle *et al.* (1999b) measured throughfall under forest canopies in the growing and dormant seasons, but did not discuss use of the data in estimating a winter input budget.

5.2.6. Summary of Factors Controlling Throughfall Flux

Vegetation type was determined to be the most important factor driving deposition in each watershed for each season, although many of the interactions warrant further investigation. The effects of elevation on total deposition should be evaluated in future work; the complex interactions between vegetation types and elevation may be useful in refining deposition estimates and modeling. Season was considered to be a controlling factor based on established relationships in the literature, even though its effects were limited in this research.

5.3. The Throughfall:Wet-only Ratio Approach

Throughfall provides an estimate of total deposition to a forested watershed, but throughfall collection is logistically difficult and expensive for watershed studies, and long-term records are rare. In contrast, NADP data are readily available on the World Wide Web, often with 15 to 20 year records. However, NADP chemistry does not include inputs from dry and occult deposition, which can be two to three times the wet-only value (Rustad *et al.*, 1994).

This research project provides high-resolution watershed-based throughfall data near an official NADP site during the non-freezing seasons (Figure 26). Each watershed also has partial year coverage by independent NADP-compatible collectors. Using these data, the goal was to estimate annual deposition to each watershed. Because of missing winter throughfall, I used the ratio between NADP and throughfall data in the non-freezing seasons, then used those relationships to scale up NADP concentrations when throughfall was not available.

5.3.1. Base Concentrations from NADP

NADP wet-only data were baseline deposition. Data were plotted through time to investigate the temporal patterns of precipitation inputs at the NADP site (Figure 28).

Late winter and early spring wet-only precipitation had higher concentrations of anions and cations than summer and fall, driven by Na and Cl concentrations (Figure 28).

Strong storms occur in winter at Acadia, and track along the coastal edge. The counterclockwise circulation deposits marine aerosols. In summer, most precipitation is from convective storms tracking across inland regions. The same pattern was found in Hiroshima, Japan, where winter storms originated from marine sources (Seto *et al.*, 2000). The potential for elevated deposition in winter because of general weather patterns indicates the need for better techniques to estimate deposition when throughfall data are not available.

Conceptually, I predicted total annual inputs to each watershed by using NADP data to describe seasonal patterns and vegetation type to scale up those inputs (Figure 33). The interplay between NADP inputs for each season and the influence of vegetation type on baseline NADP inputs was the subject of the final stages of this research.

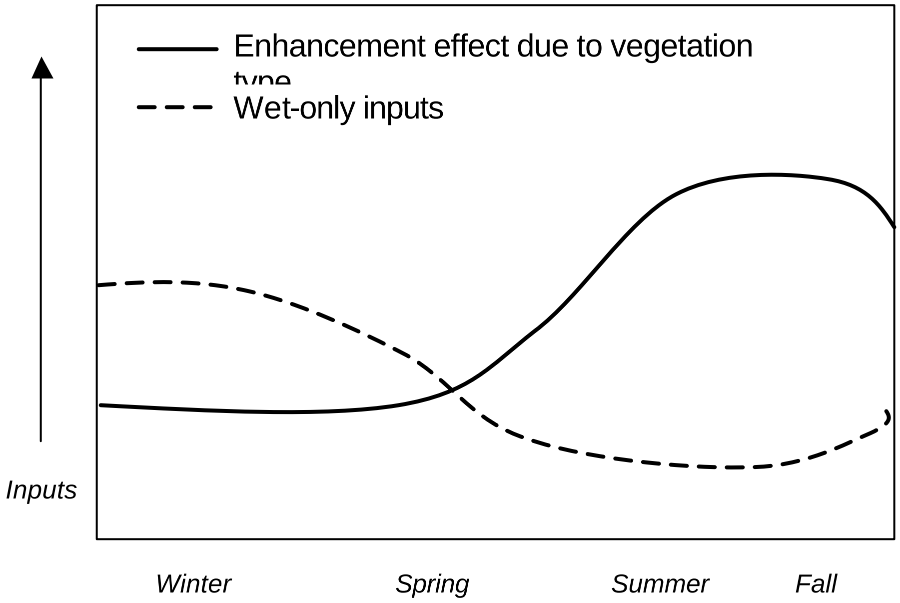

Figure 33. The conceptual model for calculating inputs based on wet-only data as an identifier of seasonal patterns and enhancement due to landscape factors, here attributed to vegetation type.

5.3.2. Calculated Throughfall:NADP Ratios

Ratios of throughfall:NADP deposition were calculated for each sampling period for which throughfall and NADP deposition data were matched. The mean ratio for each watershed, season, and vegetation type was used in later steps of this project (Table 6). Spring ratios were used for winter because of similar patterns for spring and winter observed in the NADP data (Figure 28). Spring was defined as March 1 to May 31 of each year. Leaf-on occurred in mid- to late May. Spring and winter enhancement ratios were assumed to be similar due to leaf-off.

5.3.3. Regional Enhancement Estimates

Throughfall: NADP ratios corroborate enhancement reported by other studies in the northeast region (Figure 34). Annual enhancement of throughfall deposition over wet deposition for Ca was 4.5 for deciduous and 4.9 for coniferous canopies in Quebec (Houle *et al.*, 1999b). At Acadia, the mean enhancement for Ca was 4.2-4.5 for deciduous and 5.6-6.8 for conifer sites. Although Ca may leach more readily from deciduous canopies, particularly during senescence in fall, the greater scavenging efficiency and year-round foliage of coniferous sites may make up the difference. Higher SO_4 at unburned sites reflects the increased scavenging efficiency of a coniferous canopy.

Nitrate was taken up by vegetation at deciduous sites in both watersheds. Results at Acadia support those at Hubbard Brook, in which nitrate uptake at a regenerating deciduous stand was reported as similar to that at a coniferous stand, and was higher than at a more mature deciduous site (Lovett *et al.*, 1996). It is difficult to distinguish any differences between NO_3 uptake at burned and unburned sites; annual enhancement at both watersheds was 0.7.

Table 6. Throughfall:NADP deposition ratios for paired watersheds at Acadia National Park. Ratios were determined using throughfall and NADP data from synchronized sampling periods in 1999 and 2000. Ratios were determined for each season and vegetation type. For winter, spring ratios were used.

Hadlock Brook watershed

	Vegetation Type	Ca	Cl	H	K	H_2O	Mg	NA	NH_4	NM-SO_4	NO_3	SO_4
FALL	Open	3.28	2.66	2.18	20.7	1.12	3.98	3.07	2.39	2.01	2.70	2.00
	Scrub/shrub	1.08	0.85	1.07	12.0	0.94	0.62	0.94	1.19	1.12	0.76	1.05
	Hardwood	5.52	2.09	1.19	102	0.83	4.78	1.59	1.52	1.58	0.79	1.65
	Mixed	10.4	5.66	2.70	132	1.01	8.77	5.01	5.65	3.32	4.62	3.68
	Softwood	11.0	5.86	3.38	101	1.00	8.89	5.22	6.43	3.81	5.39	4.09
SPRING	Open	2.06	3.87	1.25	9.16	0.71	3.65	3.50	0.74	1.31	1.18	1.45
	Scrub/shrub	1.15	1.35	0.95	4.88	0.80	1.31	1.27	0.63	0.80	0.80	0.83
	Hardwood	2.33	2.02	0.58	16.1	0.78	2.71	1.98	0.55	0.80	0.69	0.87
	Mixed	3.13	5.84	1.40	20.7	0.72	5.61	5.78	0.41	1.25	0.82	1.47
	Softwood	3.09	5.85	1.57	17.1	0.73	5.39	5.96	0.26	1.33	0.70	1.55
SUMMER	Open	4.37	6.63	15.1	41.7	1.13	9.06	7.31	0.76	1.48	1.02	3.30
	Scrub/shrub	1.51	2.29	13.8	15.3	1.11	1.81	2.64	0.75	.	0.46	2.17
	Hardwood	6.91	3.98	3.95	95.8	1.01	10.70	4.18	1.50	1.52	0.68	2.63
	Mixed	9.88	9.99	9.03	138	0.93	17.26	10.8	1.06	3.64	1.13	3.57
	Softwood	9.94	10.8	12.1	96.8	0.93	17.23	11.9	1.20	4.09	1.18	3.78

Cadillac Brook watershed

	Vegetation Type	Ca	Cl	H	K	H_2O	Mg	NA	NH_4	NM-SO_4	NO_3	SO_4
FALL	Open	1.32	1.48	1.63	7.96	0.85	1.58	1.73	0.59	1.26	0.87	1.24
	Scrub/shrub	4.62	2.70	1.40	36.2	1.03	4.44	2.63	0.75	1.63	1.19	1.63
	Hardwood	7.44	2.98	0.62	124	0.85	5.31	2.25	0.83	2.14	0.55	2.16
	Mixed	10.8	5.34	1.28	140	0.85	8.71	4.33	1.78	2.99	2.73	3.31
	Softwood	8.24	4.42	1.42	76.2	0.97	7.01	4.03	2.20	2.42	1.74	2.76
SPRING	Open	0.88	1.19	1.01	2.00	0.74	1.25	1.28	0.49	0.69	0.75	0.71
	Scrub/shrub	1.46	2.71	1.14	3.59	0.75	2.94	2.75	0.71	0.96	1.01	1.04
	Hardwood	2.03	2.18	1.10	13.8	0.76	2.79	2.11	0.42	0.86	0.83	0.93
	Mixed	3.06	5.63	1.18	18.8	0.61	5.86	5.61	0.18	1.08	0.80	1.29
	Softwood	2.75	4.39	1.44	9.75	0.83	5.05	4.82	0.46	1.28	1.11	1.42
SUMMER	Open	1.80	2.84	11.1	24.1	1.02	3.46	3.50	0.09	1.64	0.56	1.95
	Scrub/shrub	3.44	5.14	13.4	22.5	1.08	5.98	5.89	0.37	.	0.48	2.33
	Hardwood	6.54	4.08	6.38	79.9	0.96	8.76	4.39	0.33	1.85	0.52	2.21
	Mixed	7.94	7.24	5.71	104	0.86	13.52	7.76	0.71	2.34	0.84	2.50
	Softwood	8.54	8.05	10.5	72.5	1.07	14.68	9.39	0.47	3.12	1.12	3.27

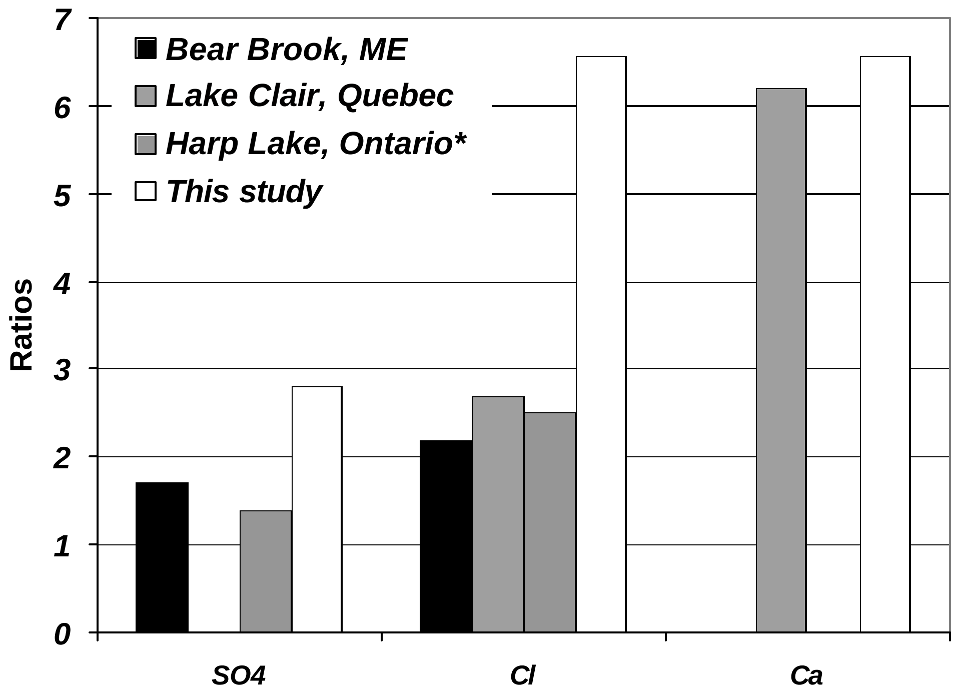

Figure 34. Throughfall enhancement for the growing season for Bear Brook, Maine (Rustad *et al.*, 1994); Lake Clair, Quebec (Houle *et al.*, 1999b); Harp Lake, Ontario (Neary and Gizyn, 1994); and this study.

5.3.4. Annual Enhancement Estimates

There were three general expectations of throughfall enhancement based on the literature (Rustad *et al.*, 1994; Weathers *et al.*, 2000a; others):

- deposition at Hadlock should be greater than Cadillac;
- enhancement at conifer sites should be greater than deciduous, scrub, or open; and
- west-facing sites should have higher deposition than east-facing sites.

An analysis of annual enhancement addressed these hypotheses. Relative annual enhancement for coniferous stands at Hadlock (undisturbed, southwest aspect) was 2.0 for NH_4, 2.0 for NO_3, 2.7 for SO_4, 7.1-7.3 for Cl and Na, 6.8 for Ca, 92 for Mg, and 58 for K (Table 7). Enhancement was similar for mixed stands at Hadlock, intermediate for deciduous stands, and lowest (except Na and Cl) in scrub and open sites. Na and Cl were enhanced at the open sites at Hadlock, perhaps due to contact with higher-elevation fog.

At Cadillac Brook watershed (burned, southeast aspect), annual enhancement in coniferous stands was 0.9 for NH_4, 1.3 for NO_3, 2.2 for SO_4, 5.3-5.8 for Cl and Na, 5.6 for Ca, 8.0 for Mg, and 42 for K (Table 7). Again, coniferous enhancement was generally similar to that at mixed sites, higher than deciduous, and higher still than open and scrub.

Table 7. Annual enhancement of deposition in throughfall as compared to wet-only deposition. Annual enhancement was calculated as the average of the seasonal ratios for each watershed and vegetation type.

Watershed	Ca	Cl	H^+	K	H_2O	Mg	Na	NH_4	NMSO	NO_3	SO_4
Hadlock											
Open	2.94	4.26	4.96	20.2	0.92	5.08	4.35	1.15	1.53	1.52	2.05
Scrub	1.22	1.46	4.20	9.26	0.91	1.26	1.53	0.80	0.90	0.70	1.22
Deciduous	4.27	2.53	1.57	57.6	0.85	5.22	2.43	1.03	1.18	0.71	1.50
Mixed	6.63	6.83	3.63	77.8	0.84	9.31	6.83	1.88	2.36	1.85	2.55
Coniferous	6.78	7.09	4.66	58.1	0.85	9.23	7.27	2.03	2.64	1.99	2.74
Cadillac											
Open	1.22	1.68	3.69	9.0	0.84	1.89	1.95	0.42	1.07	0.73	1.15
Scrub	2.74	3.31	4.26	16.5	0.90	4.07	3.51	0.63	1.18	0.92	1.51
Deciduous	4.51	2.86	2.30	58.0	0.83	4.91	2.71	0.50	1.43	0.68	1.56
Mixed	6.21	5.96	2.34	70.2	0.73	8.49	5.83	0.71	1.87	1.29	2.10
Coniferous	5.57	5.31	3.71	42.1	0.93	7.95	5.77	0.90	2.03	1.27	2.22

Annual enhancement numbers revealed two surprising patterns. First, enhancement of Cl and Na in open sites did not occur in Cadillac to the same degree as Hadlock. While high elevation fog and cloudwater may have contributed to the excess enhancement at Hadlock, the greater abundance of open sites in lower elevations at Cadillac may have balanced out any fog or cloud contributions in its higher elevation open sites.

Second, Cadillac Brook watershed vegetation enhances total deposition to a lesser degree than Hadlock, even for marine aerosols such as Cl, despite the fact that Cadillac faces the open ocean. This pattern is particularly apparent in non-marine sulfate enhancement, 2.6 at Hadlock and 2.0 at Cadillac, likely indicating a secondary effect of watershed aspect. Hadlock was expected to receive elevated inputs due to its orientation in relation to downwind pollution sources; these data appear to corroborate that pattern.

5.4. Calculating Input Estimates

5.4.1. NADP: Watershed Wet-only Estimates

As a baseline estimate of inputs to the two watersheds, annual deposition was calculated using NADP concentrations and depths for the water year 2000, October 1, 1999 – September 30 2000 (Table 8).

Table 8. NADP deposition for each season and summed for the water year 2000.

Season	Ca	Cl	H	K	Mg	Na	NH_4	$NMSO_4$	NO_3	SO_4	H_2O
	eq/ha/season										mm
Fall	11	112	70	2	20	105	21	72	48	84	429
Spring	25	131	112	4	28	121	44	113	81	127	466
Summer	6	13	32	1	3	11	21	33	37	62	95
Winter	15	246	89	5	52	253	24	67	64	92	336
Annual Total	57	502	303	12	104	490	110	285	230	365	1326

5.4.2. Comparison of Ratio Method and Inputs Calculated from Throughfall

As a check of the ratio method, total inputs calculated using the ratio method (no actual throughfall data included) were compared to total inputs calculated using measured throughfall data (Table 9). The ratio method estimates predicted inputs within 25% of actual measured throughfall inputs for the growing season for Ca, Cl, Mg, K, and Na at both watersheds, and for NH_4 and NO_3 at Cadillac. In order to more accurately predict NO_3 and NH_4, another factor should be incorporated into future modeling efforts.

Table 9. Estimates of inputs of each chemical parameter using the ratio method and throughfall method for the growing season of 2000 for the two PRIMENet watersheds at Acadia National Park.

Parameter	**Cadillac Brook watershed**		**Hadlock Brook watershed**	
(eq/ha)	Ratio Method	Throughfall	Ratio Method	Throughfall
Ca	66	54	61	53
Cl	207	174	203	187
SO_4	222	172	252	201
NO_3	70	67	97	67
Mg	65	60	57	59
K	84	69	69	69
Na	181	162	181	170
NH_4	24	22	50	35
H	395	119	547	149
Water (cm)	37	30	39	31

Ratio method estimates were within 30% of observed inputs for SO_4 at both watersheds. The ratio method does not predict H within 100% for either watershed. The comparison presented in Table 9 is not a true sensitivity analysis because ratios were calculated in part from throughfall data from 2000, used to estimate inputs, then compared to 2000 data. However, 1999 deposition data were also included in ratio generation. A true test of the ratio method would compare to throughfall data from a year that did not contribute to the ratio matrix.

5.5. Refining Annual Deposition Estimates

Concentrations from throughfall for each individual site and collection period for the 2000 water year were used in the first step of the input budget calculations. Individual sites, often a few meters apart, had markedly different concentrations of major ions and water volume. Data were not pooled statistically prior to input calculations to preserve the variability between sites in the early stages of calculations. Mean concentrations for each sampling year were calculated for future reference (Tables 10 and 11).

Table 10. Mean concentrations of major ions in throughfall (μeq/L) and throughfall water depth (mm) by watershed, season, and vegetation type for 1999. Note: there was only one collection in the summer of 1999.

Season	Vegetation	Ca	Mg	K	Na	SO_4	NO_3	Cl	H	NH_4	Water
						μeq/L					mm
Cadillac Brook watershed											
Fall	Deciduous	35	40	83	89	56	17	129	26	6	52
Fall	Mixed	47	61	88	166	80	36	227	35	9	48
Fall	Open	6	13	6	65	36	18	64	48	8	40
Fall	Scrub	9	15	3	55	59	52	59	85	23	39
Fall	Coniferous	25	40	29	138	62	34	179	43	11	52
Summer	Deciduous	39	30	57	48	91	35	53	28	6	35
Summer	Mixed	72	73	88	117	153	76	140	42	20	31
Summer	Open	7	10	12	41	71	31	37	59	1	40
Summer	Coniferous	53	67	60	121	159	82	133	62	11	35
Hadlock Brook watershed											
Fall	Deciduous	14	19	32	64	43	26	77	45	13	48
Fall	Mixed	36	47	60	162	80	52	209	55	16	56
Fall	Open	4	11	2	50	28	15	46	39	8	89
Fall	Scrub	6	9	3	35	55	46	41	86	25	34
Fall	Coniferous	39	51	49	180	87	56	233	62	17	61
Summer	Deciduous	15	22	50	40	80	34	43	20	41	33
Summer	Mixed	56	62	81	124	165	76	145	57	41	38
Summer	Open	2	6	3	30	68	31	26	55	14	37
Summer	Coniferous	64	68	65	153	189	85	168	80	38	39

Table 11. Mean concentrations of major ions in throughfall (µeq/L) and throughfall water depth (mm) by watershed, season, and vegetation type for 2000.

Season	Vegetation	Ca	Mg	K	Na	SO_4	NO_3	Cl	H	NH_4	Water
						µeq/L					mm
Cadillac Brook watershed											
Fall	Deciduous	15	13	55	25	35	6	40	7	2	60
Fall	Mixed	23	24	55	51	54	24	68	19	5	67
Fall	Open	3	3	3	19	25	8	19	31	2	69
Fall	Scrub	10	10	11	27	32	11	32	27	2	65
Fall	Coniferous	16	15	23	42	41	15	50	24	3	69
Spring	Deciduous	14	14	14	42	43	23	46	39	9	46
Spring	Mixed	29	41	25	149	79	30	160	54	5	37
Spring	Open	6	6	2	22	33	20	23	38	10	45
Spring	Scrub	10	16	4	56	49	28	60	43	14	45
Spring	Coniferous	18	25	10	88	61	27	87	46	8	50
Summer	Deciduous	21	18	39	29	54	11	34	27	4	50
Summer	Mixed	31	36	62	72	81	28	79	32	11	46
Summer	Open	8	8	13	21	51	19	22	56	2	44
Summer	Scrub	14	11	11	33	53	20	34	47	5	48
Summer	Coniferous	25	25	27	54	74	25	53	45	5	53
Hadlock Brook watershed											
Fall	Deciduous	20	18	51	19	41	10	32	7	5	54
Fall	Mixed	21	22	48	49	52	28	60	25	11	69
Fall	Open	13	14	11	45	47	31	45	45	6	62
Fall	Scrub	3	2	4	11	23	8	11	22	4	58
Fall	Coniferous	20	22	37	50	58	27	60	32	15	66
Spring	Deciduous	16	15	17	40	39	18	44	21	11	47
Spring	Mixed	22	30	23	120	71	23	129	52	8	43
Spring	Open	15	22	12	83	73	35	102	50	14	43
Spring	Scrub	8	8	5	30	37	20	34	34	11	48
Spring	Coniferous	22	30	20	124	75	20	131	59	5	43
Summer	Deciduous	28	24	47	30	67	21	34	23	14	45
Summer	Mixed	29	34	50	70	84	24	78	43	6	46
Summer	Open	18	21	21	51	78	36	57	60	8	51
Summer	Scrub	6	4	9	15	46	17	16	45	9	49
Summer	Coniferous	32	36	46	83	99	26	91	63	9	44

To calculate inputs during the season when throughfall was collected, the entire data matrix was entered into a mainframe SAS statistical routine. First, throughfall concentrations were multiplied by the depth of water measured at each site. Then, mean deposition for each vegetation type and collection period was summed to provide a seasonal input total (Table 12a and b). Next, the mean deposition for each vegetation type and collection period was multiplied by the relative area of each vegetation type in each watershed (Table 12a and b). Chemical data for the period for which throughfall was not collected (November 19, 1999 – April 30, 2000) from the NADP website were run through the ratio method SAS routine. The ratio method estimates for parts of Fall 1999, Winter 1999-2000, and Spring 2000 were vegetation-weighted and later added to the throughfall inputs for the remainder of the water year to yield an annual input estimate (Table 12a and b).

The total mass inputs for each vegetation type were calculated from the combined throughfall and ratio estimates for water year 2000 (Table 13). A comparison of the mass input for each watershed for each vegetation type indicated the importance of sampling throughfall under a range of types when the landscape is heterogeneous, as it is at Cadillac Brook watershed. At Cadillac Brook watershed, inputs under coniferous, deciduous, mixed, and scrub canopies all contribute more than 10% of the total for most analytes (Figure 35). Inputs at open sites contributed less to the total than the other vegetation types. Cadillac Brook watershed is a mosaic of vegetation types and seral stages from early regeneration in burned sites to mature pitch pines and cedars in sites that were not burned. The relatively uniformly distributed vegetation types (Figure 18) contributed relative to their size and enhancement capacities.

Table 12a. Estimates of seasonal deposition inputs (eq/ha) for Cadillac Brook watershed for water year 2000. Summed inputs for each vegetation type were multiplied by the proportion of each vegetation type to provide a vegetation-weighted input estimate. Throughfall (TF) estimates were calculated from samples collected May 1 to Nov. 18; winter estimates (Ratio) were calculated using the enhancement ratios for each vegetation type. Fall and spring periods included both throughfall and ratio estimates, which were summed for each season.

		Deciduous		**Mixed**		**Open**		**Scrub**		**Coniferous**	
		3.9 ha		11.46 ha		0.01 ha		13.05 ha		3.18 ha	
		TF	*Ratio*	*TF*	*Ratio*	*TF*	*Ratio*	*TF*	*Ratio*	*TF*	*Ratio*
Fall	Ca	58	8	78	12	10	2	15	5	51	9
Spring		13	38	20	57	6	16	9	27	18	51
Summer		31		35		10		21		40	
Winter			30		45		13		21		40
Fall	Cl	239	42	446	75	113	21	113	38	350	62
Spring		45	239	109	618	21	131	54	297	86	482
Summer		51		89		34		65		94	
Winter			536		1385		293		667		1080
Fall	H	59	4	77	8	109	11	94	9	81	9
Spring		38	84	40	91	35	78	39	88	49	111
Summer		47		42		81		80		77	
Winter			98		105		90		102		128
Fall	K	98	34	108	38	8	2	11	10	58	21
Spring		14	37	19	50	2	5	4	10	10	26
Summer		51		68		17		18		42	
Winter			73		99		11		19		51
Fall	Mg	65	13	102	21	26	4	27	11	77	17
Spring		14	65	28	136	5	29	14	68	24	117
Summer		27		40		11		20		41	
Winter			146		307		66		154		265
Fall	Na	172	28	326	54	108	22	106	33	270	50
Spring		40	214	99	568	20	130	51	278	86	488
Summer		46		80		34		63		93	
Winter			533		1418		324		695		1218
Fall	NH_4	14	1	16	2	15	1	14	1	14	3
Spring		8	10	3	4	10	12	13	18	8	11
Summer		6		13		2		8		8	
Winter			10		4		12		17		11
Fall	NM-	104	11	119	15	71	7	68	8	94	12
Spring	SO_4	35	61	44	77	29	49	39	69	52	91
Summer		80		84		71		80		112	
Winter			57		72		46		64		85
Fall	NO_3	43	2	81	9	46	3	45	4	59	6
Spring		21	46	20	44	19	42	25	56	28	62
Summer		19		30		22		30		38	
Winter			53		52		48		65		72
Fall	SO_4	128	14	165	22	83	8	80	11	130	18
Spring		40	77	55	107	31	59	45	86	61	118
Summer		85		93		75		87		121	
Winter			86		119		65		96		131

Table 12b. Estimates of seasonal deposition inputs (eq/ha) for Hadlock Brook watershed for water year 2000. Summed inputs for each vegetation type were multiplied by the proportion of each vegetation type to provide a vegetation-weighted input estimate. Throughfall (TF) estimates were calculated from samples collected May 1 to Nov. 18; winter estimates (Ratio) were calculated using the enhancement ratios for each vegetation type. Fall and spring periods included both throughfall and ratio estimates, which were summed for each season.

		Deciduous		**Mixed**		**Open**		**Scrub**		**Coniferous**	
		0.51 ha		0.86 ha		0.36 ha		21.35 ha		24.12 ha	
	eq/ha	*TF*	*Ratio*	*TF*	*Ratio*	*TF*	*Ratio*	*TF*	*Ratio*	*TF*	*Ratio*
Fall	Ca	30	6	79	12	17	4	9	1	88	13
Spring		15	43	20	58	13	38	7	21	20	57
Summer		45		45		32		9		43	
Winter			34		46		30		17		45
Fall	Cl	145	29	501	80	155	37	127	12	560	82
Spring		42	222	121	641	85	425	29	148	119	642
Summer		53		115		98		29		123	
Winter			497		1436		952		332		1439
Fall	H	63	8	105	18	127	14	102	7	134	22
Spring		20	45	48	108	43	96	33	73	53	121
Summer		29		65		111		82		88	
Winter			52		125		111		85		140
Fall	K	59	28	119	36	16	6	10	3	105	27
Spring		16	43	21	55	9	24	5	13	17	46
Summer		72		91		40		12		61	
Winter			85		109		48		26		90
Fall	Mg	40	12	110	22	37	10	27	2	119	22
Spring		14	63	28	130	19	85	7	30	27	125
Summer		38		50		36		6		49	
Winter			142		294		191		69		283
Fall	Na	116	20	373	62	137	38	109	12	417	65
Spring		38	200	108	585	70	354	26	129	110	603
Summer		46		105		89		28		114	
Winter			500		1461		885		321		1507
Fall	NH_4	21	2	41	7	28	3	25	1	42	7
Spring		10	14	7	10	13	18	12	16	5	6
Summer		23		10		14		16		14	
Winter			13		10		18		15		6
Fall	NM-SO_4	72	8	127	17	97	10	74	6	145	20
Spring		33	57	51	89	53	94	33	57	54	95
Summer		103		118		130		78		123	
Winter			53		83		87		53		89
Fall	NO_3	43	3	109	15	65	9	42	2	130	18
Spring		17	38	21	45	30	65	20	44	17	39
Summer		33		36		59		28		34	
Winter			44		53		76		52		45
Fall	SO_4	87	11	179	24	114	13	87	7	203	27
Spring		37	72	63	122	62	120	36	69	67	128
Summer		108		130		140		81		135	
Winter			80		135		134		76		143

Table 13. Input of major ions (in eq/ha/yr) by each vegetation type for each watershed, water year 2000.

Cadillac (31.6 ha)					
	Deciduous 3.9 ha	Mixed 11.46 ha	Open 0.01 ha	Scrub 13.05 ha	Coniferous 3.18 ha
Ca	178	247	57	98	209
Cl	1152	2722	613	1234	2154
H	330	363	404	412	455
K	307	382	45	72	208
Mg	330	634	141	294	541
Na	1033	2545	638	1226	2205
NH_4	49	42	52	71	55
NM-SO_4	348	411	273	328	446
NO_3	184	236	180	225	265
SO_4	430	561	321	405	579

Hadlock (47.2 ha)					
	Deciduous 0.51 ha	Mixed 0.86 ha	Open 0.36 ha	Scrub 21.35 ha	Coniferous 24.12 ha
Ca	173	260	134	64	266
Cl	988	2894	1752	677	2965
H	217	469	502	382	558
K	302	431	143	69	346
Mg	309	634	378	141	625
Na	920	2694	1573	625	2816
NH_4	82	85	94	85	80
NM-SO_4	326	485	471	301	526
NO_3	178	279	304	188	283
SO_4	395	653	583	356	703

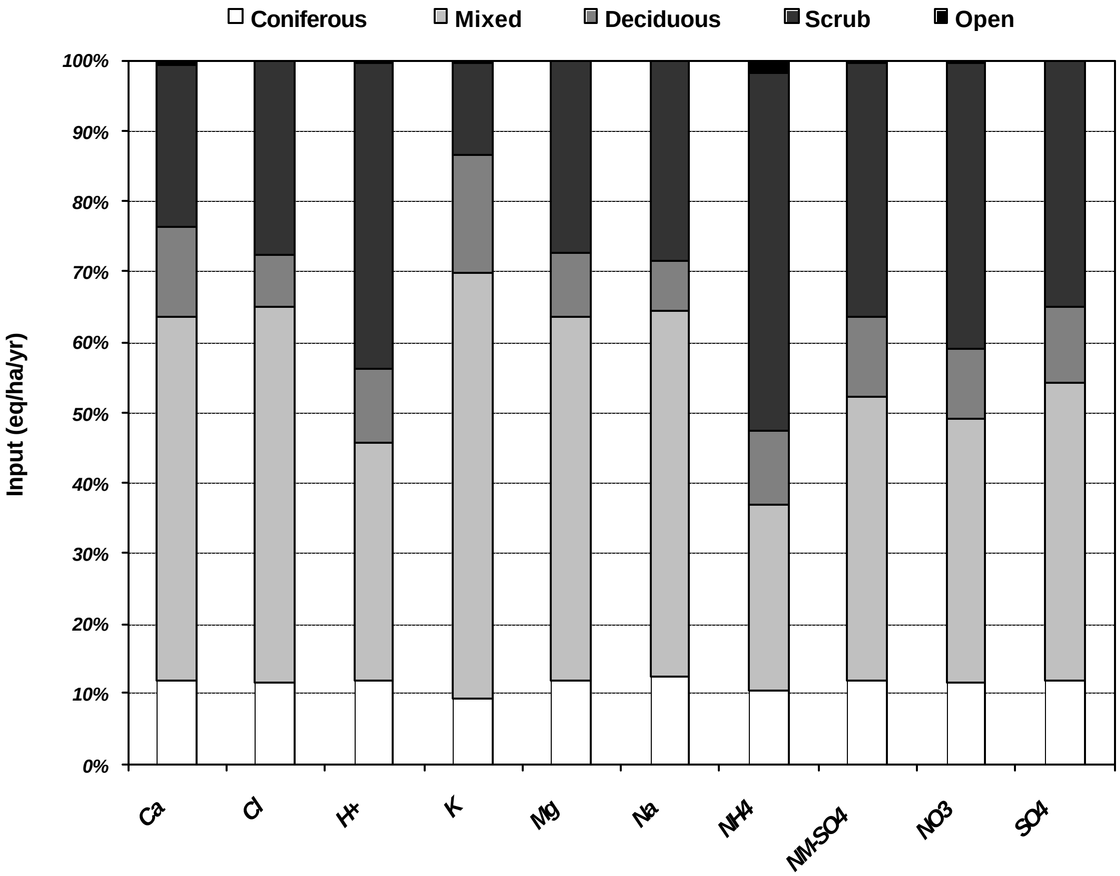

Figure 35. Percent of total mass input of major ions for each vegetation type at Cadillac Brook watershed for water year 2000. Each bar segment represents the contribution, in percent, of each respective vegetation type to the estimated deposition across the watershed area (Table 13).

At Hadlock Brook watershed, the contribution of coniferous to the total input is relatively large (Figure 36). The area of scrub vegetation (21.35 ha) at Hadlock is similar in size to coniferous (24.12 ha). However, the enhancement capacity of scrub is much lower than coniferous, and the relative contribution of scrub is decreased accordingly. At Hadlock, deposition at scrub sites was lower than at open sites on a per hectare basis (Table 12). Lower scrub deposition at Hadlock ran contrary to the pattern at Cadillac, and to the expected pattern. There are at least two possibilities that would explain low deposition at the two scrub sites at Hadlock. First, there may have been a shadow effect, whereby the two sites, both located in small canopy gaps in relatively sheltered areas, received less precipitation and deposition because they may have been located in the rain shadow of surrounding trees. Second, the scrub types at the two collectors may not have been representative of the vegetation types designated as scrub/shrub on the vegetation map used for final areas in the input calculations. Therefore, scrub deposition at Hadlock should be taken as a conservative estimate. Scrub areas contribute more to the total input estimate for SO_4, NO_3, and H. The scrub areas at Hadlock are located in the highest portions of the watershed. Hadlock Brook watershed faces generally southwest, toward inland sources of NO_x and SO_x. Therefore, higher scrub contributions at Hadlock may indicate deposition on west aspects.

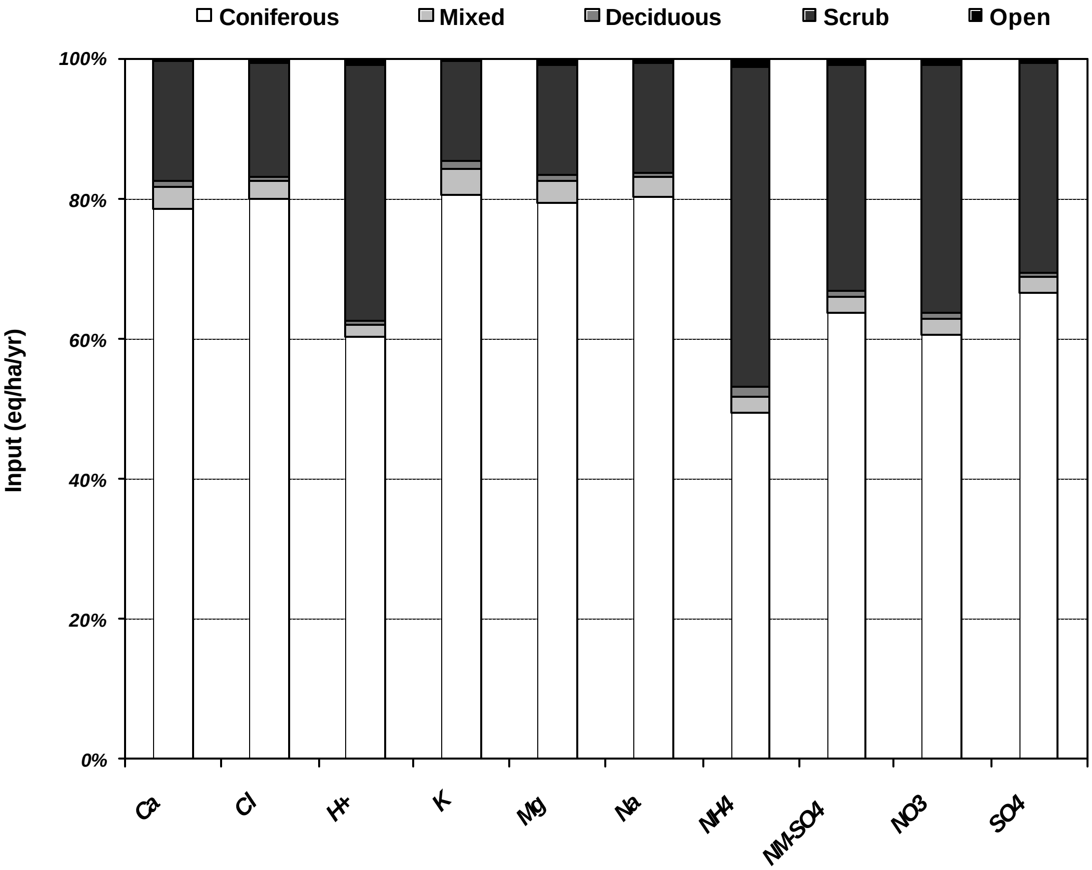

Figure 36. Percent of total mass input of major ions for each vegetation type at Hadlock Brook watershed for water year 2000. Each bar segment represents the contribution, in percent, of each respective vegetation type to the estimated deposition across the watershed area (calculated from Table 13).

5.6. Input/Export Relationships

5.6.1. Water Balance

USGS and NADP data from October 1 1999 – September 30, 2000 were used to calculate water yields (Table 14). We analyzed water fluxes from events following Hurricane Floyd in 1999 as a quality assurance check. After an upland watershed is thoroughly wet by a storm, water fluxes from subsequent events in spring or fall (leaf off) should be in the ratio of true watershed areas. The assumption was made that both watersheds received exactly the same amount of precipitation. The ratio of the area of Cadillac: Hadlock is 0.67. For the storm episodes in fall of 1999 and spring of 2000 that met the criteria, the average water yield ratio was 0.64, corroborating the watershed areas delineated on the ground and calculated using GIS.

Table 14. Water Budget for PRIMENet watersheds for water year 2000. Inputs were based on NADP rain gauge depths. Discharge was calculated from USGS stream gauge data. Precipitation inputs were scaled from ratios determined using on-site raingauges and NADP weekly totals.

Water Year 2000 (October 1 1999 - September 30 2000)			
	Precipitation inputs *(cm)*	Stream discharge *(cm)*	Water yield *Percent*
Cadillac	135	83	61
Hadlock	144	100	69

5.6.2. Chemical Inputs

To determine chemical fluxes from the two watersheds, the vegetation-weighted annual deposition estimates, with measured throughfall for the growing season and ratio-determined estimates for winter and spring, were used as inputs (Figure 37; Table 15). The inputs of SO_4 were 482 (Cadillac) and 545 (Hadlock) eq/ha; inputs of Cl were 1856 (Cadillac) and 1913 (Hadlock) eq/ha. For comparison, the average throughfall input of SO_4 at the Bear Brook Watershed, Maine was 677 eq/ha/yr and average throughfall input of Cl was 435 eq/ha/yr from 1989-1992 (Rustad *et al.*, 1994; Table 16). Deposition of marine-derived substances should be higher at Acadia than at the inland Bear Brook site due to proximity to the ocean; however, SO_4 emissions have declined slightly since the early 1990s and the Acadia watersheds have large relatively large areas of bare rock and scrub vegetation. In comparison to wet-only data from NADP for water year 2000, NO_3 and NH_4 input estimates for the two watersheds are relatively low. The enhancement ratios for these canopy-reactive substances were often less than one for the forested sites, indicating uptake of the substances. Dry deposition has been estimated at 40-50% of wet deposition in New England (Stoddard *et al.*, 1994). With 50% of wet deposition added to the NO_3 input, retention of NO_3 at Hadlock would become 78%. Weathers *et al.* (1998) established a relationship between total S and total N deposition in New York; this approach may be used in the future to better estimate total N deposition at Acadia.

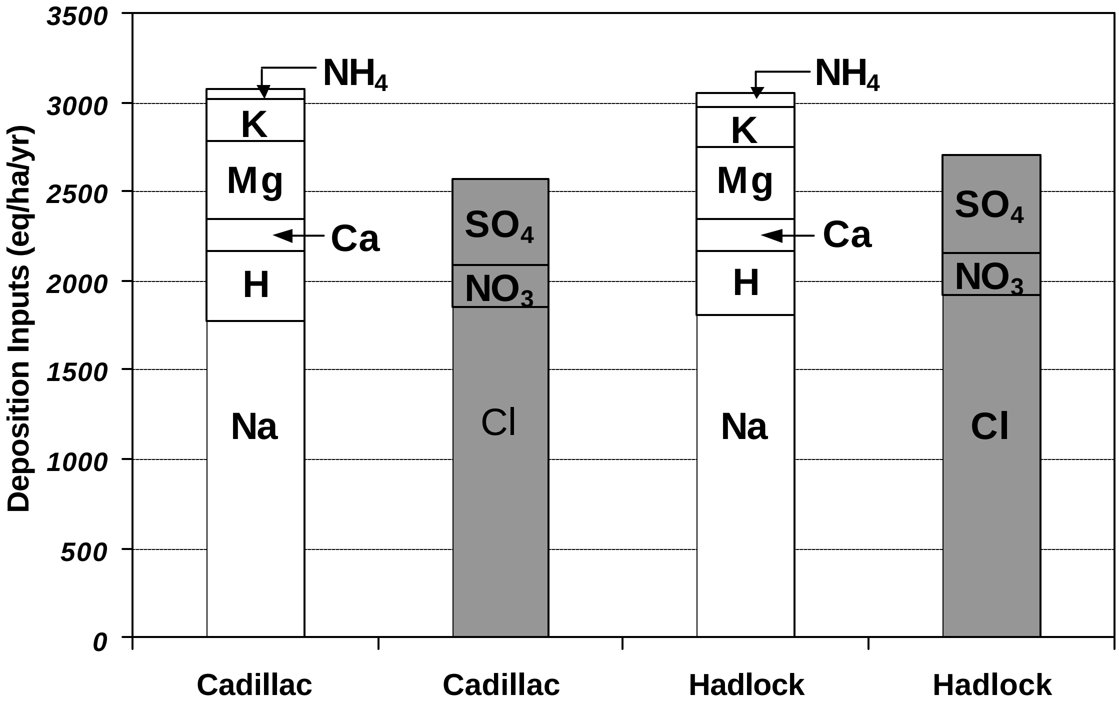

Figure 37. Inputs to the PRIMENet watersheds for water year 2000. Cations and anions in deposition were estimated using throughfall for the growing season and enhancement ratios in conjunction with NADP data for the dormant season.

While input estimates were scaled up for winter and early spring using the enhancement ratios, the estimates may be conservative. One hypothesis was that there would be higher deposition at Hadlock than at Cadillac Brook watershed. While deposition is slightly higher at Hadlock (Table 15), there are three possible sources of error in the estimates for one or both watersheds. First, deposition may have been under-estimated in scrub sites at Hadlock due to the rain shadow effect or sampling at non-representative sites. Scrub vegetation constitutes about half of the watershed area at Hadlock, so an error in the scrub estimate would have a potentially large effect. If the deposition rate (Table 12b) for open sites at Hadlock were substituted for the potentially erroneous scrub rate, deposition of, as examples, SO_4 at Hadlock would have been 649 eq/ha; Cl deposition would have been 2407 eq/ha.

Second, we assumed that spring (leaf-off) ratios could be used for winter estimation. However, spring ratios were derived from May throughfall deposition values, and probably do not accurately reflect winter deposition. It is likely that actual winter deposition is much higher than that estimated here, particularly for Cl, Na, and marine components driven by ocean-derived weather patterns in winter. Future research should address this issue by sampling throughfall in winter to derive empirical ratios as derived for the other seasons in this research. Third, the potential effects of elevation and aspect were not explicitly addressed in the mass balance portion of this study. It is conceivable that inputs at Hadlock were relatively low, because these additional factors were not included in scaling up winter deposition.

The results of this study indicate the importance of using an adequate number of samplers, and of sampling representative vegetation types. For instance, if all of the vegetation at Hadlock were assumed to be coniferous vegetation, the total input estimate would have been 882 eq/ha for SO_4 and 3335 eq/ha for Cl, over 50% higher than the vegetation weighted estimate. If all of Cadillac were designated mixed vegetation, the input estimate would have been 840 eq/ha for SO_4 and 3591 eq/ha for Cl, almost twice as high as the vegetation weighted input estimate.

Table 15. Mass balances for the PRIMENet watersheds for water year 2000. Inputs were calculated from throughfall data when available, and NADP data and ratios for the interim period. Streamwater outfluxes were calculated using the methods of Kahl *et al.*, 1999. Mass balance was calculated as watershed flux – TF Input. Retention was calculated as 100*(input-output)/input.

		INPUTS	OUTFLUX	MASS BALANCE	RETENTION
			eq/ha/yr		*percent*
	H	388	12	-376	97
C	Ca	173	454	281	-162
A	Mg	447	286	-161	36
D	K	227	40	-187	82
I	Na	1779	1555	-224	13
L	NH_4	56	6	-50	89
L	Cl	1856	1608	-248	13
A	NO_3	228	4	-224	98
C	SO_4	482	626	144	-30
	NO_3+NH_4	284	10	-274	96
	H	362	34	-328	91
H	Ca	174	714	540	-310
A	Mg	404	395	-9	2
D	K	222	73	-149	67
L	Na	1807	1949	142	-8
O	NH_4	83	10	-73	88
C	Cl	1913	2102	189	-10
K	NO_3	241	81	-160	66
	SO_4	545	948	403	-74
	NO_3+NH_4	324	91	-233	72

5.6.3. Chemical Mass Balances

Streamwater outfluxes were calculated by interpolating chemistry based on hourly discharge measurements at each site (Kahl *et al.*, 1999). The mass balance is calculated as outflux - inputs, so a negative number indicates retention in the watershed and a positive number indicates a loss from the watershed (Table 15). The results show retention of H, Mg, K, NH_4, and NO_3 at Cadillac and Hadlock Brook watersheds, with losses of Ca and SO_4. Cl and Na balanced to within 15% at each watershed.

Outfluxes were determined for Penobscot Brook, at a sampling station 50 meters downstream of the Hadlock site but draining a roughly equivalent catchment area, in 1989 (Heath *et al.*, 1993). Outfluxes for Hadlock Brook watershed were consistent with those determined by Heath *et al.*, (1993) (Table 16). For water year 2000, data for outfluxes and mass balances were available for East Bear Brook (Table 16). Cadillac and Hadlock Brook watersheds bracket the outfluxes of East Bear for Ca, Mg, K, NO_3, and SO_4, with Cadillac exporting the least and Hadlock the most of these ions. For Cl and Na, Bear Brook outfluxes were the lowest, due to its inland location and thus lower

Table 16. Comparison of fluxes and mass balances across Maine from periods during 1989-1999. Cadillac and Hadlock fluxes were calculated for this study for water year 2000 (Table 15). NADP inputs were downloaded from the NADP/NTN website. Throughfall inputs from Bear Brook are from Rustad *et al.*, 1994. Bear Brook (East Bear) outfluxes were calculated by Kahl, 2001 (unpubl. data). Outfluxes from Penobscot Brook, roughly the same watershed as Hadlock Brook, were calculated from data reported in Heath *et al.*, 1993, and scaled up for the water year 1989 as described in the text, using flux ratios from Bear Brook. Mass balances from Penobscot Brook were sea salt corrected, as reported in Heath *et al.*, 1993. All units are eq/ha.

	INPUTS				**OUTFLUX**				**MASS BALANCE**		
	Cadillac WY 2000	**Hadlock** WY 2000	**NADP** WY 2000	**BBWM TF** 1989-92	**Cadillac** WY 2000	**Hadlock** WY 2000	**Heath *et al.*** 1993	**BBWM** WY 2000	**Cadillac** WY 2000	**Hadlock** WY 2000	**Heath *et al.*** 1993
H	388	362	350	-	12	34	40	54	-376	-328	-380
Ca	173	174	57	-	454	714	740	542	281	540	500
Mg	447	404	111	-	286	395	400	218	-161	-9	125
K	227	222	13	-	40	73	90	51	-187	-149	55
Na	1779	1807	522	-	1555	1949	1520	836	-224	142	275
NH_4	56	83	108	-	6	10	-	13	-50	-73	-
Cl	1856	1913	540	435	1608	2102	1270	826	-248	189	-
NO_3	228	241	229	-	4	81	60	15	-224	-160	-
SO_4	482	545	359	677	626	948	1190	844	144	403	450
NO_3+ NH_4	284	324	337	-	10	91	-	28	-274	-233	-255

inputs of these ions. Outfluxes of NH_4 and H were lowest at Cadillac, intermediate at Hadlock, and highest at Bear Brook, presumably because of neutralization of incident acidity and uptake of NH_4 at Cadillac, the regenerating site.

5.6.4. Nitrogen Dynamics

Inputs for Hadlock Brook watershed were expected to be higher than inputs at Cadillac because of the landscape contrasts and the output supports this hypothesis, although inputs at scrub sites at Hadlock may have been underestimated. Landscape contrasts were also hypothesized to control retention and loss from the watersheds. Specifically, Cadillac Brook watershed should retain more N because of the regenerating forest and depleted soil pools. The mass balances support this hypothesis as well. Retention of NO_3 in Cadillac Brook watershed was 98%. In Hadlock Brook watershed, retention of NO_3 was 66%. Streamwater export, 4 eq/ha/yr at Cadillac and 81 eq/ha/yr at Hadlock, is driving this difference, with comparable inputs at both watersheds.

Campbell *et al.* (2002) calculated retention of DIN (NO_3 + NH_4) at 96% for Cadillac and 69% for Hadlock, based on monthly estimates from 1999-2000. The DIN values for this study are 96% (Cadillac) and 72% (Hadlock), in close agreement. A substantial portion of NO_3 at Hadlock Brook watershed is lost from the watershed, and may indicate some level of N saturation in this undisturbed spruce-fir forest.

Stoddard (1994) described four stages of watershed N saturation that correspond to forest N saturation. In Stage 0, surface waters have low NO_3 concentrations most of the year, with maximum concentrations in spring driven by runoff from snowmelt. In Stage 1, the seasonal pattern is amplified; with episodes of surface water NO_3 that exceed those typical of deposition. In Stage 3, baseflow concentrations of NO_3 are elevated. In Stage

4, extremely high NO_3 concentrations accompany the lack of coherent seasonal patterns. In water year 2000, the seasonal pattern of increased streamwater NO_3 in spring, coincident with spring runoff, was observed at Hadlock Brook watershed (Figure 38). Both advanced stand age and high levels of soil N may be linked to high levels of watershed N loss (Stoddard, 1994).

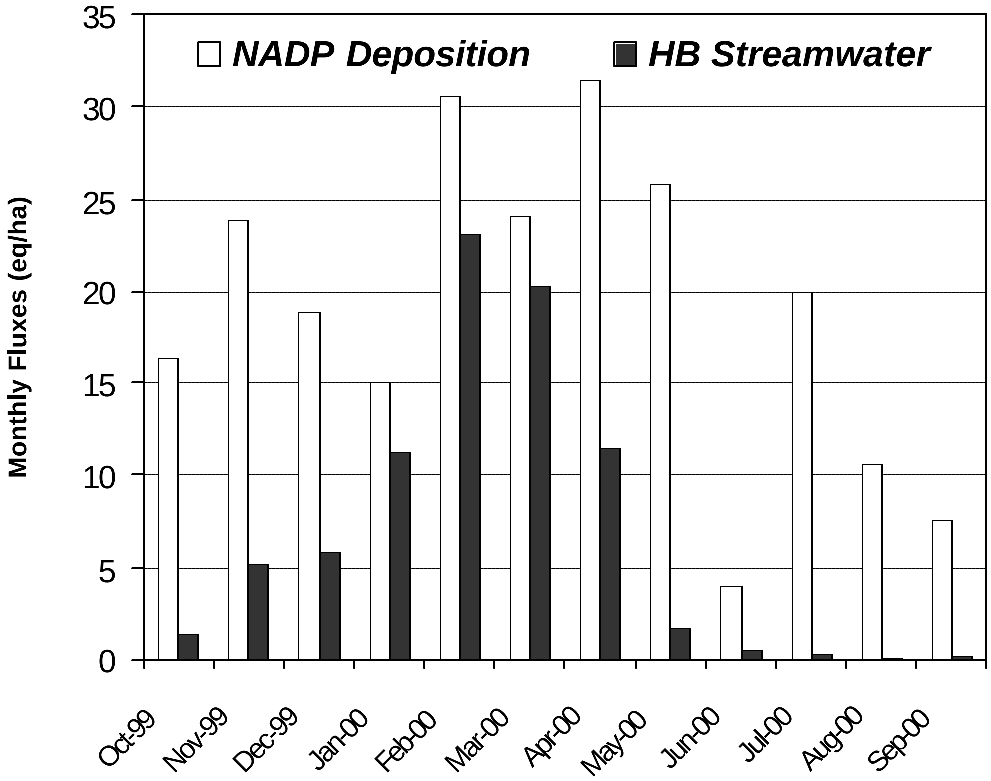

Figure 38. Monthly streamwater NO_3 fluxes from Hadlock Brook and NADP monthly precipitation NO_3 fluxes for water year 2000. According to Stoddard (1994), key characteristics of Stage 1 N saturation are “episodes of surface-water NO_3 that exceed concentrations typical of deposition”.

5.7. Summary

NADP baseline data reveal seasonal shifts in deposition of major ions. Vegetation type drives enhancement of throughfall as compared to wet-only inputs. The seasonal shifts appear to be at least as important as vegetation in determining total inputs. Although vegetation type explains why deposition is higher or lower in forested watersheds, the seasonal patterns that presumably have to do with larger scale climate or weather patterns describe the overall pattern. It may be possible to estimate the enhancement factors for vegetation regionally and use them with local NADP data to describe potential total deposition.

The ratio method provides a first step in modeling deposition to these two watersheds; however, canopy processing, other landscape effects such as elevation, and weather patterns have not been taken into account. To rectify inputs calculated using ratios and throughfall to streamwater outfluxes, adjustments may need to be made. Nevertheless, annual enhancement ratios, calculated directly from throughfall comparisons to NADP, are instructive in elucidating patterns due to watershed aspect and vegetation type. Mass balance results support the hypotheses that 1) Deposition is higher in conifer-dominated Hadlock Brook watershed and 2) there is higher NO_3 retention in Cadillac Brook watershed despite thinner or absent soils compared to Hadlock Brook watershed. The retention may be attributed to regenerating vegetation and depleted soil pools.

Chapter 6

IMPLICATIONS AND FUTURE WORK

There is renewed concern about mercury (Hg) fish consumption advisories (Center for Disease Control, 2001), standards for cleaner air in National Parks (Bangor Daily News, August 22, 2001), increased vehicle traffic on Mount Desert Island (Bangor Daily News, August 4, 2001), and pressure for development (Bangor Daily News, August 2, 2001) at Acadia. These issues point to a need for continued monitoring, dynamic modeling of loading of contaminants, and research that is publicly accessible and interpreted for policymaking.

This research has determined that vegetation type, in part, drives deposition of SO_4, NO_3, and major ions in the two gauged PRIMENet watersheds established in 1998. It has also provided a means by which to estimate inputs to the small watersheds using relationships with readily available NADP data. If refined, the seasonal throughfall:NADP ratio approach may provide a cost-effective estimate of total inputs to a forested landscape.

Research by Johnson (2002) has provided a compatible database of Hg throughfall information for the PRIMENet watersheds for the same period of time. The two PRIMENet watersheds were sampled intensively for landscape controls on Hg inputs (Johnson, 2001) and major ion inputs (this paper) in small watersheds. In complementary research, Weathers *et al.* (1998) are estimating deposition of SO_4 and NO_3 and landscape interactions over the entire Park using a coarser grid of sampling.

The next logical step in this ongoing research is to contrast the data collected at different spatial scales to see how a general model of contaminant deposition, appropriate for both landscape and watershed scales, can be created. This information must be verified with stream chemistry that integrates the processes occurring in watersheds. Therefore, our future objective is to refine and verify a deposition model to provide park management with predictions for the regions and watersheds at greatest risk from high loading of specific contaminants, and thus at risk from ecological effects such as acidification, N saturation, or Hg bioaccumulation. To realize this objective, we propose to:

1. Verify and refine the Weathers *et al.* park-scale deposition map for sulfur and N by using the results from our intensive small watershed throughfall data network.
2. Scale this refined and merged GIS model to the entire Park for all 17 PRIMENet analytes, including Hg.
3. Use a field season of stream chemistry to compare watersheds predicted to have low deposition loading with watersheds predicted to have high deposition loading.
4. Continue the PRIMENet intensive watershed monitoring for stream chemistry and flow to enable calculation of elemental mass balances.

The predictive deposition map for Hg will accomplish a primary objective of PRIMENet Hg research: to determine why seemingly similar lake and stream watersheds could have fish with very different concentrations of bioaccumulated Hg. We proposed that landscape differences could explain the differences, and used the 1947 fire as a natural experimental design in our study of contrasting watersheds.

Annual enhancement data from the PRIMENet watersheds show that landscape factors such as vegetation type affect inputs, particularly in areas with patchy, heterogeneous vegetation. Further, aspect or elevation may have a secondary effect on deposition and could be added to a predictive model. Producing a predictive deposition map for contaminants is intended to provide a management tool to determine where biota will have the highest concentrations of Hg. This predictive capability may be applicable at much broader scales and for other analytes, and for example, may help resolve the problem of widespread fish health consumption advisories by relating suites of landscape attributes to contaminant loading.

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APPENDICES

Appendix A

ACADIA NATIONAL PARK VEGETATION MAP METADATA

Appendix A.1.

ACADIA NATIONAL PARK MAPPING ATTRIBUTE & MODIFIER CONVENTIONS

The following is the conventional format for attributing vegetative map codes for Acadia National Park digital map development. The attribute format is designed using alpha-numeric values, alternating back and forth to distinguish modifiers that reflect vegetative characteristics within the mapped polygon. Non vegetative codes only have the alpha code.

1. A **map code** begins with an alpha string developed by UMESC mappers to describe the vegetation being mapped. The intent is to link the map unit as best possible to TNC's vegetation classification, within the limits of mapping complexity and photo signatures. This alpha string can be up to four places, but may be as short as two places.
Examples:
PGCH, RSW, OF, TG

2. Next, a single digit numeric code is assigned to describe the **coverage density** within the polygon delineated. A hyphen separates the coverage density from the map code.
Examples:
PGCH-1, RSW-2, OF-1, TG-2

3. Then, a single alpha code follows the coverage density modifier to describe the **coverage pattern** within the polygon delineated.
Examples:
PGCH-1A, RSW-2B, OF-1B, TG-2A

4. Lastly, another single digit numeric code follows the coverage pattern modifier to describe **tree & shrub heights**. This code is only used with map codes representing forest, woodland, shrubland, and dwarf-shrubland situations. It is not used with map codes representing herbaceous.
Examples:
RSW-2B4, OF-1B5

Appendix A.2.

MODIFIER CODE DEFINITIONS

Coverage Density

1	Closed Canopy/Continuous (60-100% coverage)
2	Open Canopy/Discontinuous (25-60% coverage)
3	Dispersed-Sparse Canopy (10-25% coverage)

Coverage Pattern

A	Evenly Dispersed
B	Clumped/Bunched
C	Gradational/Transitional
D	Regularly Alternating

Height

1	30-50 meters	(98-162 feet)
2	20-30 meters	(65-98 feet)
3	12-20 meters	(40-65 feet)
4	5-12 meters	(16-40 feet)
5	0.5-5 meters	(1.5-16 feet)
6	<0.5 meters	(<1.5 feet)

Appendix A.3.

VEGETATION CODES

Table A.1. Vegetation codes used in the PRIMENet watershed clips. Codes from the beta map from the USGS-NPS Vegetation Mapping Project, courtesy of the Upper Midwest Environmental Services Center, 1999.

Map Code	Map Name	Descriptive Name
ABF	Populus (tremuloides, grandidentata)-Betula (populifolia, papyrifera)	Early successional northern hardwood forests
BB	Vaccinium angustifolium-Sorbus americana dwarf shrubland	Blueberry - mountain ash summit shrub heath (includes Deschampsia-Danthonia Summit vegetation)
MSS	Nemopanthus-Viburnum/ Kalmia shrubland	Mixed summit shrubland, usually with stunted spruce or fir
MW	Picea rubens- (Pinus strobus)- Betula spp (pop,pap) - Acer rubrum - mixed woodland	Conifer-hardwood woodland mess, each contribute 25-75% of total tree cover
PPW	Pinus rigida / Aronia melanocarpa/ Deschampsia flexuosa-Schizachyrium scoparium Woodland	Pitch pine rocky summit
RSW	Picea rubens / Vaccinium angustifolium-Sibbaldiopsis tridentata Woodland	Red spruce woodland
SB	Picea rubens-Betula populifolia/ Nemopanthus mixed woodland summit	Red spruce -grey birch summits
SCW	Thuja occidentalis-Abies balsamea/ Alnus incana/Carex trisperma saturated woodland	Northern white cedar wooded fen
SF	Picea rubens - Abies balsamea - Betula papyrifera Forest and Picea (rubens,glauca) Abies balsamifera Forest	Spruce-fir and maritime spruce-fir forests
SFM	Picea rubens - Abies balsamea-Acer rubrum Forest	Successional spruce fir forests
UT	Transportation, utilities, and communications	
WPM	Acer saccharum - Pinus strobus / Acer pensylvanicum Forest	White pine-northern hardwood forest

Appendix B
PHYSICAL CHARACTERISTICS AT THROUGHFALL SITES

Table B.1. Throughfall site characteristics.

Site	Compass Reading	Burned/ Unburned	Canopy Coverage	Elevation	Vegetation Type	Aspect
C1A	119	1	87.5	152	Deciduous	South
C1B	119	1	88.7	152	Deciduous	South
C1C	119	1	90.9	152	Mixed	South
C1D	119	1	92.7	152	Deciduous	South
C2A	110	1	87.7	198	Deciduous	South
C2B	110	1	95.4	198	Deciduous	South
C2C	110	1	95.9	198	Deciduous	South
C2D	110	1	95.3	198	Deciduous	South
C3A	171	1	91.5	168	Mixed	South
C3B	171	1	52.6	168	Coniferous	South
C3C	171	1	73.2	168	Deciduous	South
C3D	171	1	92.7	168	Mixed	South
C4A	159	1	98.1	195	Mixed	South
C4B	159	1	97.0	195	Mixed	South
C4C	159	1	95.8	195	Mixed	South
C4D	159	1	98.2	195	Mixed	South
C5A	121	1	97.2	201	Mixed	South
C5B	121	1	93.5	201	Mixed	South
C5C	121	1	95.2	201	Deciduous	South
C5D	121	1	95.3	201	Deciduous	South
C6A	100	0	91.9	442	Coniferous	South
C6B	100	0	70.0	442	Coniferous	South
C6C	100	0	77.4	442	Coniferous	South
C6D	100	0	80.0	442	Mixed	South
CBULK	161	1	0.0	195	Open	South
CT2A	81	1	56.1	244	Coniferous	East
CT2B	98	1	50.0	244	Deciduous	East
CT2C	116	1	74.1	244	Scrub	East
CT2D	101	1	88.1	244	Coniferous	South
CT2E	121	1	50.0	244	Mixed	East
CT2F	121	1	70.0	244	Deciduous	South
CT4A	111	0	91.9	381	Coniferous	South
CT4B	101	0	0.0	381	Scrub	East
CT4C	95	0	0.0	381	Scrub	East
CT4D	109	0	86.1	381	Coniferous	East
CT4E	107	0	90.0	381	Scrub	East
CT4F	129	0	0.0	381	Scrub	South
CT5A	149	0	0.0	442	Mixed	South
CT5D	145	0	53.5	442	Coniferous	South

Table B.1. continued.

Site	Compass Reading	Burned/ Unburned	Canopy Coverage	Elevation	Vegetation Type	Aspect
CT5E	151	0	0.0	442	Scrub	South
CT5F	159	0	39.7	442	Scrub	South
H1A	161	0	92.1	186	Coniferous	South
H1B	161	0	87.1	186	Coniferous	South
H1C	161	0	93.4	186	Coniferous	South
H1D	161	0	92.6	186	Mixed	South
H2A	255	0	88.8	235	Deciduous	West
H2B	255	0	91.3	235	Mixed	West
H2C	255	0	77.2	235	Coniferous	West
H2D	255	0	94.4	235	Coniferous	West
H3A	256	0	96.7	238	Coniferous	West
H3B	256	0	95.3	238	Mixed	West
H3C	256	0	95.3	238	Mixed	West
H3D	256	0	97.0	238	Mixed	West
H4A	271	0	90.0	287	Coniferous	West
H4B	271	0	86.7	287	Coniferous	West
H4C	271	0	89.7	287	Coniferous	West
H4D	271	0	95.3	287	Coniferous	West
H5A	211	0	91.3	271	Mixed	West
H5B	211	0	87.9	271	Coniferous	West
H5C	211	0	88.5	271	Coniferous	West
H5D	211	0	86.9	271	Mixed	West
H6A	200	0	89.5	259	Mixed	South
H6B	200	0	93.5	259	Coniferous	South
H6C	200	0	89.8	259	Mixed	South
H6D	200	0	89.9	259	Mixed	South
HBULK	201	0	0.0	189	Open	South
HT1D	281	0	91.4	183	Mixed	West
HT1E	308	0	98.6	183	Deciduous	North
HT1F	300	0	96.4	183	Deciduous	North
HT2F	190	0	57.9	235	Scrub	South
HT3A	236	0	83.3	280	Coniferous	West
HT3B	249	0	72.0	280	Mixed	West
HT3C	254	0	84.5	280	Mixed	West
HT3F	254	0	36.8	280	Scrub	West
HT4B	202	0	91.0	357	Coniferous	South
HT4D	190	0	0.0	357	Open	South
HT4F	290	0	0.0	357	Open	West
PARKB	180	0	0.0	183	Open	South

Appendix C

LABORATORY AND FIELD BLANK DATA, 1999-2000

Table C.1. Laboratory and field blank concentration data for 1999 and 2000 throughfall sample runs.

Site ID	Sample Date	EqpH	Cond	Color	DOC	Ca	Mg	K	Na	Si	Al	NH4	Cl	NO_3	SO_4	Total N
			µS /cm^2	PCU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
CFBL	08/25/99	5.79	1.2	1	0.4	0.00	0.00	0.00	0.01	0.06	6.0	0.00	2	0.6	1	.
HFBL	08/25/99	5.77	1.3	1	0.7	0.00	0.00	0.00	0.01	0.06	7.0	0.00	2	0.5	2	.
CFBL	09/15/99	5.58	1.2	57	0.8	0.03	0.00	0.00	0.00	0.03	0.0	0.00	2	0.5	1	.
HFBL	09/15/99	5.50	0.8	1	0.8	0.02	0.00	0.00	0.00	0.03	0.0	0.00	2	0.4	1	.
CFBL	09/22/99	5.29	2.0	1	0.3	0.01	0.00	0.03	0.02	0.05	0.0	0.00	2	0.5	2	.
HFBL	09/22/99	5.43	1.0	2	0.2	0.00	0.00	0.02	0.01	0.06	0.0	0.00	2	0.5	1	.
CFBL	10/20/99	5.45	1.0	1	0.4	0.02	0.00	0.03	0.01	0.09	0.0	0.00	3	0.2	1	.
HFBL	10/20/99	5.47	1.0	2	0.2	0.01	0.00	0.04	0.02	0.09	0.0	0.00	3	0.1	1	.
CFBL	11/04/99	5.43	2.0	1	0.1	0.00	0.00	0.02	0.02	0.02	0.0	0.00	2	0.1	1	.
HFBL	11/04/99	4.13	4.0	.	0.2	0.00	0.00	0.02	0.02	0.00	0.0	0.00	3	0.2	1	.
CFBL	11/05/99	5.43	1.0	.	0.2	0.00	0.00	0.02	0.01	0.02	0.0	0.00	2	0.1	1	.
CFBL	11/18/99	5.49	1.0	1	0.2	0.02	0.00	0.02	0.02	0.25	11.8	0.00	2	0.1	1	.
CFBL	11/19/99	5.47	2.0	1	0.1	0.01	0.00	0.02	0.01	0.13	11.7	0.00	2	0.1	1	.
HFBL	11/19/99	5.50	1.0	12	0.2	0.01	0.00	0.02	0.01	0.19	11.6	0.00	2	0.1	1	.
CFBL	05/17/00	5.57	1.6	.	0.2	0.00	0.00	0.01	0.01	0.01	0.00	0.00	1	0.1	1	0.01
CFBL	05/18/00	5.56	1.3	.	0.2	0.01	0.00	0.01	0.00	0.01	0.00	0.00	1	0.0	1	0.02
CFBL	05/31/00	5.40	1.0	.	0.1	0.00	0.00	0.01	0.00	0.01	0.00	0.00	1	0.2	0	0.01
CFBL	06/13/00	5.36	1.4	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	0.0	0	0.00
CFBL	07/05/00	5.51	0.9	.	0.4	0.00	0.00	0.01	0.03	0.00	3.20	0.00	2	0.3	1	0.00
CFBL	07/26/00	5.38	1.1	.	.	.	.	.	.	.	.	0.00	.	.	.	0.01
CFBL	08/17/00	.	2.1	.	.	0.01	0.00	0.02	0.02	.	0.00	0.00	2	0.0	1	0.00
CFBL	09/19/00	5.63	1.1	.	0.1	0.00	0.00	0.01	0.01	0.00	0.00	0.00	2	0.0	0	0.01
CFBL	09/20/00	5.63	1.1	.	0.1	0.00	0.00	0.01	0.04	0.00	1.00	0.00	2	0.3	0	0.02
CFBL	10/12/00	5.62	1.2	.	0.3	0.00	0.00	0.00	0.00	0.02	0.00	0.00	2	0.0	0	0.02
CFBL	10/13/00	5.57	1.2	.	0.2	0.00	0.00	0.00	0.00	0.02	0.00	0.00	2	0.0	0	0.00
CFBL	11/01/00	5.66	1.0	.	0.1	0.01	0.00	0.02	0.02	0.00	1.50	0.00	2	0.2	0	0.01
CFBL	11/15/00	5.62	2.2	.	0.2	0.01	0.00	0.02	0.02	0.00	0.60	0.00	2	0.2	0	0.01
HFBL	05/17/00	5.53	1.3	.	0.3	0.00	0.00	0.00	0.00	0.01	0.00	0.00	2	0.1	1	0.02
HFBL	05/31/00	5.47	1.0	.	0.3	0.00	0.00	0.02	0.00	0.01	0.00	0.00	1	0.0	0	0.02
HFBL	06/14/00	5.41	1.2	.	0.2	0.00	0.00	0.00	0.01	0.02	0.00	0.00	2	0.1	0	0.02
HFBL	07/05/00	5.47	1.0	.	0.3	0.01	0.00	0.04	0.09	0.00	4.00	0.00	4	0.4	1	0.03
HFBL	07/26/00	5.26	1.7	.	0.1	0.00	0.00	0.01	0.01	3.76	0.00	0.00	1	0.0	0	0.02
HFBL	08/17/00	.	1.3	.	.	0.00	0.00	0.01	0.01	.	0.20	0.00	1	0.0	1	0.00
HFBL	09/21/00	5.64	1.4	.	0.2	0.00	0.00	0.00	0.00	0.00	0.90	0.00	1	0.0	0	0.02
HFBL	10/12/00	5.71	1.1	.	0.2	0.00	0.00	0.00	0.00	0.02	0.00	0.00	2	0.2	0	0.01
HFBL	11/02/00	5.71	1.3	.	0.1	0.01	0.00	0.02	0.00	0.00	1.80	0.00	1	0.1	0	0.00
HFBL	11/16/00	5.67	1.7	.	0.1	0.00	0.00	0.01	0.00	0.00	0.50	0.00	1	0.0	0	0.03
LBL	05/17/00	5.57	0.6	.	0.3	0.00	0.00	0.00	0.00	0.01	10.20	0.00	1	0.1	1	.
LBL	05/17/00	5.57	0.7	.	0.2	0.00	0.00	0.00	0.00	0.02	0.00	0.00	1	0.0	1	.
LBL	05/17/00	5.59	0.5	.	0.2	0.00	0.00	0.00	0.00	0.02	0.00	0.00	1	0.1	1	.
LBL	05/17/00	5.57	0.6	.	0.1	0.00	0.00	0.00	0.00	0.02	0.00	0.00	1	0.0	1	.
LBL	05/17/00	5.57	0.4	.	0.1	0.00	0.00	0.00	0.00	0.02	0.00	0.00	1	0.0	1	.
LBL	05/18/00	5.55	0.6	.	0.1	0.00	0.00	0.01	0.00	0.03	0.00	0.00	1	0.0	1	.
LBL	05/18/00	5.59	0.6	.	0.1	0.00	0.00	0.01	0.00	0.03	0.00	0.00	1	0.0	1	.
LBL	05/31/00	5.46	1.0	.	0.2	0.00	0.00	0.02	0.03	0.01	0.00	0.00	1	0.0	0	0.01
LBL	05/31/00	5.44	1.0	.	0.0	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0	0.1	0	0.01

Table C.1. continued.

Site ID	Sample Date	EqpH	Cond µS /cm	Color PCU	DOC mg/L	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Si mg/L	Al µg/L	NH4 µeq/L	Cl µeq/L	NO$_3$ µeq/L	SO$_4$ µeq/L	Total N mg/L
LBL	05/31/00	5.44	1.0	.	0.3	0.00	0.00	0.02	0.01	0.00	0.00	0.00	1	0.0	0	.
LBL	05/31/00	5.42	10.0	.	0.2	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0	0.0	0	.
LBL	05/31/00	5.45	1.0	.	0.1	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0	0.0	0	.
LBL	06/13/00	5.38	0.6	.	0.4	0.00	0.00	0.00	0.00	0.01	0.00	0.00	2	0.1	0	.
LBL	06/13/00	5.38	0.6	.	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	0.1	0	.
LBL	06/13/00	5.36	0.6	.	0.1	0.00	0.00	0.00	0.00	0.02	0.00	0.00	1	0.1	0	.
LBL	06/14/00	5.38	0.7	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	0.0	0	.
LBL	06/14/00	5.40	0.8	.	0.3	0.00	0.00	0.00	0.00	0.02	1.00	0.00	1	0.0	0	.
LBL	06/14/00	5.45	0.7	.	0.1	0.00	0.00	0.00	0.00	0.02	0.00	0.00	2	0.0	0	.
LBL	07/05/00	5.54	0.6	.	0.2	0.00	0.00	0.00	0.01	0.00	1.80	0.00	.	.	.	.
LBL	07/05/00	5.52	0.5	.	.	0.00	0.00	0.00	0.01	0.00	1.80	0.00	.	.	.	.
LBL	07/05/00	5.52	0.7	.	0.1	0.00	0.00	0.00	0.00	0.00	1.20	0.00	1	0.2	.	.
LBL	07/05/00	5.66	0.7	.	0.2	0.00	0.00	0.00	0.02	0.00	1.40	0.00	2	0.3	1	0.00
LBL	07/05/00	5.44	0.6	.	.	0.00	0.00	0.02	0.05	0.00	1.30	0.00	.	.	.	.
LBL	07/05/00	5.50	0.7	.	.	0.00	0.00	0.02	0.05	0.00	1.40	0.00	2	0.2	1	.
LBL	07/26/00	5.40	0.6	.	0.1	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1	0.0	1	.
LBL	07/26/00	5.42	0.6	.	0.2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1	0.2	1	.
LBL	07/26/00	5.38	0.8	.	0.1	0.00	0.00	0.01	0.00	0.00	0.00	0.00	2	0.0	1	.
LBL	07/26/00	5.38	0.7	.	0.1	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	07/26/00	5.38	0.6	.	0.3	0.00	0.00	0.02	0.01	0.00	0.00	0.00	1	0.0	0	.
LBL	07/26/00	5.37	0.7	.	0.3	0.00	0.00	0.02	0.01	0.00	0.00	0.00	1	0.0	0	.
LBL	07/26/00	5.40	0.7	.	0.2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	07/26/00	5.38	0.7	.	0.2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	08/17/00	.	0.6	.	0.3	0.01	0.00	0.02	0.02	0.00	0.00	0.00	2	0.2	1	.
LBL	08/17/00	.	0.7	.	0.3	0.01	0.00	0.01	0.02	0.00	0.00	0.00	1	0.0	1	.
LBL	08/17/00	.	0.7	.	0.1	0.00	0.00	0.01	0.03	0.00	0.00	0.00	1	0.2	1	.
LBL	08/17/00	.	0.6	.	0.3	0.00	0.00	0.02	0.03	0.00	0.00	0.00	1	0.2	1	.
LBL	08/17/00	.	0.6	.	0.2	0.00	0.00	0.02	0.03	0.00	0.00	0.00	1	0.0	1	.
LBL	08/17/00	.	0.7	.	.	0.00	0.00	0.01	0.01	0.00	0.00	0.00	.	.	.	.
LBL	09/19/00	5.60	0.7	.	0.2	0.01	0.00	0.04	0.04	0.00	1.10	0.00	3	0.3	0	.
LBL	09/19/00	5.64	0.6	.	0.2	0.01	0.00	0.01	0.01	0.02	1.10	0.00	2	0.0	0	.
LBL	09/20/00	5.68	0.7	.	0.2	0.08	0.02	0.07	0.16	0.01	0.00	0.00	1	0.0	0	.
LBL	09/20/00	5.60	0.6	.	0.3	0.08	0.02	0.07	0.16	0.00	2.90	0.00	1	0.0	0	.
LBL	09/21/00	5.69	0.6	.	0.1	0.00	0.00	0.00	0.00	0.00	1.00	0.00	.	.	.	.
LBL	09/21/00	5.65	0.7	.	0.2	0.00	0.00	0.00	0.00	0.00	1.10	0.00	1	0.0	0	.
LBL	09/21/00	5.67	0.6	.	0.2	0.00	0.00	0.01	0.10	0.00	2.80	0.00	1	0.0	0	.
LBL	10/12/00	5.03	0.5	.	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	10/12/00	5.31	0.6	.	0.2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	2	0.0	0	.
LBL	10/12/00	5.30	0.5	.	.	0.00	0.00	0.01	0.00	0.00	0.00	0.00	.	.	.	.
LBL	10/12/00	5.31	0.7	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	10/12/00	5.31	0.7	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	10/12/00	5.64	0.7	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	10/12/00	5.65	0.6	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	10/13/00	5.65	0.6	.	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	10/13/00	5.65	0.6	.	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	0.0	0	.
LBL	11/01/00	5.71	.	.	0.0	0.01	0.00	0.01	0.01	0.00	1.80	0.00	1	.	.	.
LBL	11/01/00	5.71	1.0	.	0.1	0.02	0.00	0.04	0.06	0.00	2.10	0.00	1	.	.	.
LBL	11/02/00	5.69	0.7	.	0.1	0.02	0.00	0.02	0.02	0.00	2.20	0.00	1	0.0	1	.

Table C.1. continued.

Site ID	Sample Date	EqpH	Cond	Color	DOC	Ca	Mg	K	Na	Si	Al	NH4	Cl	NO_3	SO_4	Total N
			µS /cm	PCU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
LBL	11/02/00	5.68	0.7	.	0.1	0.01	0.00	0.01	0.00	0.00	1.50	0.00	1	0.0	0	.
LBL	11/02/00	5.72	0.7	.	0.1	0.01	0.00	0.01	0.01	0.00	1.10	0.00	1	0.0	0	.
LBL	11/03/00	5.57	0.7	.	0.1	0.01	0.00	0.01	0.00	0.00	1.80	0.00	.	.	.	.
LBL	11/03/00	5.57	0.7	.	0.2	0.02	0.00	0.04	0.05	0.00	2.10	0.00	1	0.0	0	.
LBL	11/15/00	5.61	0.6	.	0.1	0.01	0.00	0.02	0.01	0.00	0.70	0.00	1	0.1	0	.
LBL	11/15/00	5.66	0.5	.	0.1	0.00	0.00	0.01	0.00	0.00	0.50	0.00	1	0.0	0	.
LBL	11/15/00	5.67	0.6	.	0.1	0.00	0.00	0.01	0.00	0.00	0.50	0.00	1	0.0	0	.
LBL	11/16/00	5.69	0.6	.	0.0	0.00	0.00	0.01	0.00	0.00	0.50	0.00	1	0.0	0	.
LBL	11/16/00	5.63	0.6	.	0.0	0.00	0.00	0.01	0.00	0.00	0.60	0.00	1	0.0	0	.
LBL	11/16/00	5.61	0.6	.	0.1	0.00	0.00	0.01	0.02	0.00	0.50	0.00	1	0.0	0	.

Appendix D

THROUGHFALL DATA, 1999-2000

Table D.1. Throughfall concentrations of major ions for the PRIMENet watersheds and McFarland Hill bulk collector for 1999 and 2000.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C1A	08/25/99	88	40.0	58	40	29.4	29.6	41.7	61.8	1.4	0.63	5.5	12.5	4.40
C1B	08/25/99	84	34.5	40	40	34.4	23.0	27.4	42.2	1.1	0.59	6.6	10.9	4.40
C1C	08/25/99	82	25.6	52	19	40.4	36.2	79.5	47.4	1.3	0.66	0.6	23.2	4.73
C1D	08/25/99	86	39.5	44	40	31.4	26.3	39.1	43.5	1.5	0.66	2.8	15.2	4.40
C2A	08/25/99	102	35.2	68	11	50.9	37.8	97.7	51.8	1.2	0.63	1.1	19.9	4.95
C2B	08/25/99	118	39.3	83	6	53.9	41.1	107	70.9	1.6	0.81	5.0	13.7	5.25
C2C	08/25/99	88	33.4	54	23	57.9	35.4	58.8	41.8	1.4	0.63	6.6	28.5	4.63
C2D	08/25/99	91	39.8	39	42	33.9	26.3	29.4	47.4	1.2	0.73	12.7	16.6	4.38
C3A	08/25/99	87	39.1	38	47	21.0	19.7	30.7	40.9	1.1	0.62	12.2	12.9	4.33
C3B	08/25/99	159	81.6	133	62	53.4	66.6	60.3	121	3.4	1.24	10.5	20.5	4.21
C3C	08/25/99	78	33.9	38	44	13.5	18.9	30.7	37.4	1.2	0.60	13.9	11.5	4.36
C3D	08/25/99	80	38.0	45	37	22.0	27.1	34.5	40.0	1.1	0.55	10.0	11.7	4.43
C4A	08/25/99	162	97.4	144	52	82.8	78.1	92.8	129	2.9	1.75	13.9	32.0	4.28
C4B	08/25/99	263	127	326	50	145	160	184	250	4.9	2.79	15.5	56.3	4.30
C4C	08/25/99	251	123	295	66	121	133	83.6	251	3.6	2.39	23.3	44.0	4.18
C4D	08/25/99	108	44.1	95	23	63.4	54.3	73.4	79.2	1.9	1.02	2.8	24.0	4.63
C5A	08/25/99	252	157	207	72	93.3	113	129	164	6.4	2.49	94.2	38.2	4.14
C5B	08/25/99	91	29.1	59	9	54.9	40.3	88.2	55.7	1.6	0.60	3.3	27.9	5.06
C5C	08/25/99	87	21.8	58	4	43.9	33.7	92.3	43.1	1.1	0.60	3.3	18.0	5.43
C5D	08/25/99	92	36.1	46	31	42.4	27.1	45.8	43.1	1.1	0.52	2.8	12.1	4.51
CBULK	08/25/99	71	30.9	37	59	7.49	9.9	12.3	40.9	0.9	0.57	0.6	11.5	4.23
H1A	08/25/99	228	108	237	98	84.8	100	71.9	199	3.6	2.10	46.5	42.1	4.01
H1B	08/25/99	92	47.9	65	50	16.0	22.2	18.7	63.5	1.7	0.61	33.8	9.0	4.30
H1C	08/25/99	177	90.8	180	72	55.9	71.6	58.6	159	3.1	1.44	46.0	25.0	4.14
H1D	08/25/99	103	51.5	66	58	21.0	28.8	30.2	71.3	1.9	0.87	33.2	13.1	4.24
H2A	08/25/99	80	34.0	43	20	15.0	22.2	50.4	39.6	2.6	0.50	41.0	14.2	4.70
H2B	08/25/99	205	109	180	76	72.9	91.3	88.5	166	3.5	1.86	45.4	33.0	4.12
H2C	08/25/99	163	79.4	115	65	48.9	54.3	59.3	110	2.6	1.49	34.3	24.1	4.19
H2D	08/25/99	162	73.1	112	42	49.4	61.7	114	104	3.1	1.54	49.9	27.4	4.38
H3A	08/25/99	256	115	242	74	106	90.5	118	203	4.8	2.41	66.5	44.6	4.13
H3B	08/25/99	126	53.9	87	2	48.4	60.1	153	55.7	2.6	0.99	38.8	27.8	5.65
H3C	08/25/99	144	56.8	99	23	70.4	48.5	105	76.1	2.5	0.98	39.3	20.3	4.64
H3D	08/25/99	127	57.4	74	29	41.4	46.9	92.1	67.0	2.4	1.06	36.0	20.5	4.54
H4A	08/25/99	242	96.1	156	98	75.8	77.3	72.6	149	3.4	2.57	54.3	36.4	4.01
H4B	08/25/99	184	106	194	105	59.4	61.7	36.8	182	2.8	1.81	28.8	22.8	3.98
H4C	08/25/99	192	101	180	98	61.4	66.6	52.4	174	3.0	1.89	33.8	28.0	4.01
H4D	08/25/99	153	26.4	101	45	55.9	54.3	80.5	97.9	1.4	2.09	7.2	25.9	4.35
H5A	08/25/99	163	40.9	142	41	60.9	55.9	105	102	2.2	1.22	21.6	32.8	4.39
H5B	08/25/99	163	84.2	154	98	51.4	57.6	41.9	133	2.6	1.23	27.1	26.5	4.01
H5C	08/25/99	242	48.6	184	83	101	94.6	83.6	177	2.8	2.33	26.6	50.1	4.08
H5D	08/25/99	213	104	245	105	68.9	77.3	50.6	217	3.0	1.81	32.7	29.1	3.98
H6A	08/25/99	201	105	236	105	61.9	79.0	51.4	214	2.6	1.44	25.5	21.8	3.98
H6B	08/25/99	207	128	268	115	59.9	78.1	37.1	239	3.2	1.80	37.1	20.1	3.94
H6C	08/25/99	182	91.1	158	56	58.4	64.2	70.6	128	3.9	1.44	83.1	27.0	4.25
H6D	08/25/99	184	92.9	159	72	55.4	64.2	62.4	141	3.3	1.60	52.1	26.4	4.14
HBULK	08/25/99	68	31.3	26	55	2.50	5.76	2.81	29.6	0.9	1.27	13.9	6.2	4.26
C1A	09/15/99	47	0.6	135	1	57.4	73.2	195	90.9	0.8	0.69	11.1	39.6	6.01
C1B	09/15/99	56	0.7	154	9	74.9	68.3	227	87.4	0.8	0.00	1.7	80.4	5.07

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C1C	09/15/99	58	1.0	289	8	132	177	473	167	1.9	0.66	6.6	167	5.10
C1D	09/15/99	50	0.7	141	2	74.9	72.4	185	77.9	.	0.41	1.1	67.7	5.70
C2A	09/15/99	78	0.9	208	0	64.4	79.0	338	70.9	0.8	0.00	0.0	60.1	6.72
C2B	09/15/99	61	1.2	167	0	70.9	48.5	302	86.6	1.4	0.47	0.6	40.8	6.64
C2C	09/15/99	38	1.3	136	3	105	111	256	161	1.1	0.39	12.2	90.4	5.50
C2D	09/15/99	47	1.1	140	1	80.3	83.1	208	76.6	0.8	0.40	0.0	60.0	6.20
C3A	09/15/99	96	0.8	154	1	54.4	69.9	353	60.0	1.0	0.00	0.0	58.1	6.30
C3B	09/15/99	68	6.7	201	0	81.3	119	261	140	1.8	0.71	48.8	14.9	6.42
C3C	09/15/99	48	0.6	132	1	35.4	43.6	198	65.7	0.8	0.00	0.0	43.9	5.90
C3D	09/15/99	38	0.6	119	1	45.4	61.7	147	77.0	0.9	0.00	0.0	39.4	6.07
C4A	09/15/99	142	57.7	326	19	121	137	317	197	4.6	1.95	60.9	76.3	4.73
C4B	09/15/99	178	48.0	395	35	112	137	261	285	3.4	1.68	4.4	67.1	4.45
C4C	09/15/99	157	24.0	336	28	115	180	130	295	2.5	1.77	6.6	63.8	4.55
C4D	09/15/99	94	0.9	261	1	132	132	240	141	1.3	0.65	60.9	61.0	5.89
C5A	09/15/99	277	168	458	42	171	183	463	216	6.6	2.54	66.5	73.8	4.38
C5B	09/15/99	57	0.8	175	1	114	91.3	355	84.4	1.6	0.00	3.9	96.4	6.01
C5C	09/15/99	57	0.8	164	0	115	154	422	81.8	.	0.00	1.7	97.4	7.02
C5D	09/15/99	215	1.0	301	.	113	100	465	53.5	0.9	0.00	1.1	76.3	.
C6A	09/15/99	77	9.3	122	40	47.9	55.1	70.8	116	1.2	1.20	0.0	34.3	4.40
C6B	09/15/99	86	21.6	110	42	32.4	28.8	62.4	114	1.4	0.86	8.9	15.6	4.38
C6D	09/15/99	84	16.6	113	44	21.5	21.4	80.5	107	1.5	0.59	7.2	19.6	4.36
CBULK	09/15/99	41	6.2	82	51	15.0	17.3	13.8	99.2	0.4	0.40	0.0	22.9	4.29
H1A	09/15/99	146	55.2	212	60	64.4	69.9	108	167	4.8	1.40	47.6	44.3	4.22
H1B	09/15/99	51	6.5	119	1	19.0	23.9	75.9	83.5	2.7	0.44	66.5	23.8	6.23
H1C	09/15/99	161	56.0	263	60	80.3	89.7	127	199	3.9	1.61	60.9	41.7	4.22
H1D	09/15/99	62	8.4	129	0	28.9	34.5	121	78.7	4.6	0.69	99.7	28.1	6.73
H2A	09/15/99	36	0.5	89	25	24.0	24.7	136	68.7	0.9	0.00	10.0	40.7	4.61
H2B	09/15/99	189	87.2	217	71	87.8	89.7	134	176	4.0	1.73	52.6	55.4	4.15
H2C	09/15/99	113	42.4	185	62	50.4	58.4	122	124	2.3	1.22	17.2	37.7	4.21
H2D	09/15/99	115	37.8	187	36	46.9	52.6	182	117	3.0	1.32	42.7	32.4	4.44
H3A	09/15/99	140	53.7	186	71	83.8	64.2	182	129	3.0	1.71	28.8	46.7	4.15
H3B	09/15/99	65	7.8	155	1	43.9	42.0	286	56.1	2.0	0.79	7.8	42.0	6.27
H3C	09/15/99	88	37.8	131	32	60.4	38.7	113	80.5	2.5	0.79	25.5	25.6	4.50
H3D	09/15/99	53	8.4	167	0	47.4	46.9	338	58.3	2.4	0.79	10.5	53.6	6.35
H4A	09/15/99	167	53.9	132	112	63.4	58.4	91.0	135	2.9	2.12	29.9	38.8	3.95
H4B	09/15/99	158	83.9	136	98	57.9	46.9	72.4	120	3.0	1.19	36.0	23.3	4.01
H4C	09/15/99	145	76.4	136	105	53.4	51.0	81.6	107	3.1	1.13	29.9	31.2	3.98
H4D	09/15/99	80	2.6	79	34	56.9	41.1	84.6	78.7	1.7	1.72	0.0	30.2	4.47
H5A	09/15/99	78	12.4	110	12	53.9	42.0	231	73.1	2.0	0.81	6.6	53.8	4.93
H5B	09/15/99	121	44.5	157	63	49.9	51.8	78.8	121	2.6	0.96	45.4	30.5	4.20
H5C	09/15/99	139	22.2	155	68	87.3	64.2	96.1	159	2.8	1.79	22.7	47.2	4.17
H5D	09/15/99	169	57.9	159	100	55.9	55.1	61.6	154	2.6	1.12	33.8	32.9	4.00
H6A	09/15/99	163	67.4	179	117	61.4	64.2	79.3	181	3.2	1.16	22.7	29.9	3.93
H6B	09/15/99	163	81.7	137	135	45.9	50.2	43.7	149	2.6	0.91	39.3	17.7	3.87
H6C	09/15/99	115	52.4	162	65	51.4	48.5	96.7	109	2.7	0.97	34.3	30.4	4.19
H6D	09/15/99	167	62.2	173	102	55.4	59.2	96.1	153	2.6	1.05	34.3	29.9	3.99
HBULK	09/15/99	28	7.3	63	38	6.99	13.2	2.30	73.5	0.4	0.00	0.0	6.6	4.42
C1A	09/22/99	32	3.7	140	16	16.0	26.3	25.3	135	0.2	0.00	0.6	5.2	4.80
C1B	09/22/99	33	8.4	170	22	21.5	33.7	11.0	142	0.2	0.00	0.0	8.6	4.66
C1C	09/22/99	23	3.1	122	13	11.5	23.9	15.1	106	0.2	0.49	0.6	3.4	4.88
C1D	09/22/99	21	3.9	95	12	17.5	19.7	10.0	91.8	0.2	0.00	0.6	3.6	4.91

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C2A	09/24/99	27	0.8	66	3	12.5	14.8	39.4	57.4	0.2	0.00	1.1	10.7	5.46
C2B	09/24/99	8	0.5	26	2	4.99	4.94	10.5	20.9	0.2	0.00	0.6	1.9	5.63
C2C	09/24/99	6	0.5	17	10	2.50	4.11	3.07	17.0	0.1	0.00	0.6	2.3	5.01
C2D	09/24/99	22	5.1	98	21	12.5	18.9	8.44	86.6	0.2	0.00	0.6	3.1	4.68
C3A	09/24/99	16	1.0	66	3	11.0	17.3	15.1	63.1	0.2	0.00	0.6	5.0	5.51
C3B	09/24/99	28	4.0	157	18	13.0	29.6	12.5	146	0.2	0.00	0.6	3.8	4.75
C3C	09/24/99	19	5.4	90	15	7.98	18.9	5.88	89.6	0.2	0.00	0.6	2.1	4.83
C3D	09/24/99	12	2.7	39	10	3.99	8.23	4.86	40.0	0.1	0.00	0.6	1.4	5.02
C4A	09/24/99	10	0.7	30	8	6.99	5.76	9.46	33.9	0.3	0.00	0.6	4.2	5.12
C4B	09/24/99	40	0.7	243	21	35.4	45.2	33.0	207	0.5	0.00	0.6	9.6	4.68
C4C	09/24/99	20	1.6	68	2	19.0	14.8	25.3	81.8	0.4	0.00	0.6	7.9	5.74
C4D	09/24/99	32	3.0	168	28	21.5	29.6	16.4	194	0.5	0.00	0.6	13.4	4.56
C5A	09/24/99	28	0.6	130	7	15.5	22.2	43.2	117	0.6	0.00	0.6	10.1	5.16
C5B	09/24/99	11	0.5	32	3	6.49	7.40	9.7	31.3	0.2	0.00	0.6	2.2	5.51
C5C	09/24/99	12	0.6	49	3	8.48	10.7	10.0	40.0	0.2	0.00	0.6	2.6	5.47
C5D	09/24/99	9	0.7	18	7	3.99	4.11	4.35	17.0	0.1	0.00	0.6	1.4	5.18
C6A	09/22/99	13	2.2	56	8	7.49	13.2	8.95	54.4	0.2	0.00	0.6	5.2	5.10
C6B	09/22/99	7	0.7	22	6	2.50	4.11	4.60	25.7	0.9	0.00	0.6	2.2	5.23
C6C	09/22/99	.	.	.	11	0.00	0.00	0.51	0.00	.	0.00	0.0	.	4.95
C6D	09/22/99	20	1.3	90	7	7.98	16.5	21.2	90.9	0.4	0.00	0.0	5.1	5.15
CBULK	09/24/99	5	0.7	14	12	0.00	0.00	1.79	14.4	0.2	0.00	0.6	2.4	4.92
H1A	09/22/99	11	3.2	67	15	9.48	10.7	10.0	79.2	0.5	0.00	5.5	13.3	4.81
H1B	09/22/99	9	3.3	38	13	3.99	7.40	4.09	33.5	0.2	0.00	0.6	1.4	4.90
H1C	09/22/99	31	6.0	182	26	22.0	32.1	19.4	161	1.4	0.00	6.6	7.4	4.58
H1D	09/22/99	17	6.1	85	16	7.98	14.0	17.1	80.9	0.5	0.00	2.8	4.5	4.80
H2A	09/22/99	9	1.5	45	8	3.49	8.23	10.0	37.8	0.4	0.00	0.6	1.7	5.11
H2B	09/22/99	26	5.0	156	25	16.5	24.7	24.8	141	0.7	0.00	0.6	6.4	4.60
H2C	09/22/99	17	6.4	89	20	8.48	13.2	17.4	84.4	0.4	0.00	0.6	5.3	4.69
H2D	09/22/99	15	5.3	72	15	8.48	12.3	26.1	72.2	0.4	0.00	2.2	11.4	4.82
H3A	09/22/99	8	1.8	36	17	7.98	4.94	12.5	47.4	0.6	0.00	0.0	16.6	4.78
H3B	09/22/99	14	3.6	57	6	7.98	9.9	19.7	49.2	0.3	1.27	0.6	3.7	5.20
H3C	09/22/99	17	3.5	49	10	12.0	9.05	35.0	39.6	0.5	0.00	0.6	6.4	5.00
H3D	09/22/99	15	3.3	75	8	9.48	13.2	22.5	66.6	0.4	1.25	0.6	4.1	5.08
H4A	09/22/99	42	8.1	265	58	34.4	42.0	25.1	188	1.1	0.00	2.2	8.6	4.24
H4B	09/22/99	6	1.5	30	10	11.0	10.7	19.4	65.7	0.3	0.00	1.1	10.2	5.01
H4C	09/22/99	6	1.8	26	11	2.99	0.00	4.60	27.4	0.4	0.00	0.6	2.5	4.97
H4D	09/22/99	15	0.5	51	12	9.48	9.9	24.0	45.2	0.4	0.00	0.0	7.8	4.93
H5A	09/22/99	13	3.6	70	11	8.48	11.5	26.3	51.8	0.3	0.60	0.6	5.0	4.96
H5B	09/22/99	19	4.5	107	25	12.0	17.3	10.5	106	0.6	0.00	1.7	5.8	4.60
H5C	09/22/99	21	3.2	100	30	17.5	16.5	14.1	101	0.5	0.00	0.6	8.2	4.52
H5D	09/22/99	20	4.3	120	35	30.4	39.5	19.7	192	0.5	0.00	3.9	14.3	4.46
H6A	09/22/99	21	4.7	142	23	25.9	39.5	24.0	207	0.9	0.00	0.6	13.0	4.64
H6B	09/22/99	51	12.5	360	48	30.4	58.4	18.4	294	0.7	0.43	2.8	6.0	4.32
H6C	09/22/99	6	1.3	27	8	3.99	4.11	6.14	23.9	1.0	0.00	0.0	2.0	5.10
H6D	09/22/99	27	6.4	158	35	16.0	24.7	14.1	137	0.4	0.00	1.1	5.8	4.46
HBULK	09/22/99	4	1.6	12	7	3.49	9.9	1.79	44.4	0.1	0.49	0.6	6.7	5.17
C1A	10/20/99	73	13.9	103	16	30.4	29.6	82.1	78.3	0.6	0.62	2.2	20.0	4.79
C1B	10/20/99	64	2.8	95	2	34.9	23.9	67.0	56.1	0.4	0.51	1.7	9.9	5.62
C1C	10/20/99	73	16.9	113	20	29.9	34.5	69.8	76.1	0.6	0.54	1.7	7.8	4.70
C1D	10/20/99	76	5.5	131	5	53.9	41.1	85.7	57.9	0.4	0.53	1.1	17.9	5.34
C2A	10/20/99	132	1.3	120	2	37.4	27.1	149	69.6	0.6	0.54	1.1	12.4	5.73

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C2B	10/20/99	82	4.8	127	1	32.4	25.5	112	56.6	0.6	0.44	1.1	10.3	6.01
C2C	10/20/99	57	9.6	70	23	19.5	20.6	43.2	55.2	0.3	0.46	1.1	7.6	4.63
C2D	10/20/99	60	10.6	83	21	29.4	23.9	39.1	50.9	0.5	0.00	1.1	6.1	4.67
C3A	10/20/99	76	18.7	142	36	34.4	32.9	87.4	59.2	0.5	0.50	1.1	9.0	4.44
C3B	10/20/99	49	21.3	158	23	22.5	34.5	28.4	141	0.7	0.00	1.1	6.4	4.63
C3C	10/20/99	40	16.7	77	37	16.0	20.6	18.7	57.0	0.4	0.44	5.0	3.9	4.43
C3D	10/20/99	60	16.6	99	25	20.0	28.0	62.6	56.6	0.5	0.00	2.2	9.4	4.61
C4A	10/20/99	82	57.4	217	60	42.4	50.2	31.7	178	1.3	0.00	3.9	8.1	4.22
C4B	10/20/99	87	21.7	308	28	48.9	59.2	68.3	224	0.9	0.00	1.1	11.3	4.56
C4C	10/20/99	94	27.7	370	41	60.9	73.2	39.4	320	1.3	0.43	1.1	15.8	4.39
C4D	10/20/99	61	28.6	184	8	37.9	43.6	61.6	139	1.0	0.00	1.1	7.6	5.08
C5A	10/20/99	167	50.0	296	48	58.4	68.3	135	216	1.3	0.00	1.7	15.3	4.32
C5B	10/20/99	83	2.9	122	5	27.4	24.7	82.8	76.1	0.3	0.00	1.1	5.7	5.30
C5C	10/20/99	71	2.0	103	6	38.9	30.4	53.2	59.6	0.4	0.00	1.1	6.0	5.21
C5D	10/20/99	80	9.5	81	17	25.9	25.5	67.2	56.6	0.4	0.00	2.2	8.5	4.76
C6A	10/20/99	36	10.5	83	23	14.5	20.6	19.2	74.4	0.4	0.00	2.2	6.7	4.63
C6B	10/20/99	42	16.4	72	21	17.5	23.0	32.5	68.7	0.5	0.00	3.9	19.9	4.68
C6C	10/20/99	34	8.1	44	22	13.0	14.0	21.2	45.2	0.4	0.00	3.3	7.3	4.66
C6D	10/20/99	59	8.2	169	8	24.5	38.7	60.6	148	0.7	0.00	2.2	15.0	5.08
CBULK	10/20/99	52	28.8	87	71	9.48	19.7	7.16	77.4	0.6	0.00	6.1	6.2	4.15
H1A	10/20/99	68	37.5	200	26	30.9	42.0	55.7	154	2.1	0.00	35.5	14.1	4.59
H1B	10/20/99	44	27.5	112	41	15.5	22.2	29.2	82.7	0.9	0.00	12.7	6.2	4.39
H1C	10/20/99	46	30.6	171	35	21.0	32.1	32.0	120	1.2	0.00	15.5	10.5	4.46
H1D	10/20/99	49	29.0	120	20	18.0	26.3	73.1	88.7	1.4	0.00	22.7	19.7	4.70
H2A	10/20/99	41	18.0	85	28	15.0	21.4	38.6	62.6	0.6	0.00	5.0	9.4	4.55
H2B	10/20/99	68	34.5	205	26	30.9	47.7	89.0	161	1.0	0.00	3.3	24.2	4.58
H2C	10/20/99	105	72.0	276	37	45.9	73.2	79.0	228	2.0	0.00	28.8	18.4	4.43
H2D	10/20/99	57	31.4	133	23	22.0	30.4	61.1	100	1.1	0.00	10.5	12.0	4.64
H3A	10/20/99	84	49.3	238	48	44.4	47.7	69.8	180	1.6	0.40	6.6	13.1	4.32
H3B	10/20/99	69	33.8	147	11	29.9	37.8	85.7	101	1.2	0.00	3.3	12.0	4.94
H3C	10/20/99	50	17.4	129	28	31.9	27.1	52.9	80.9	0.7	0.00	1.7	8.3	4.56
H3D	10/20/99	66	37.4	160	30	29.4	37.0	60.9	111	1.1	0.00	7.2	9.4	4.53
H4A	10/20/99	102	63.9	258	81	43.4	51.0	56.3	208	1.7	0.41	12.2	13.7	4.09
H4B	10/20/99	108	84.9	342	72	54.9	61.7	68.3	281	2.1	0.00	23.3	14.8	4.14
H4C	10/20/99	91	70.9	261	68	39.9	55.1	40.7	237	1.8	0.00	11.6	10.3	4.17
H4D	10/20/99	72	0.7	174	8	31.4	42.8	91.8	117	0.8	0.95	3.3	21.7	5.08
H5A	10/20/99	70	21.6	191	27	33.4	37.0	106	100	1.0	0.00	8.9	14.6	4.57
H5B	10/20/99	105	39.8	280	40	54.4	59.2	68.3	197	1.8	0.00	21.1	24.5	4.40
H5C	10/20/99	86	51.0	230	59	37.4	47.7	40.7	179	1.8	0.00	22.2	11.1	4.23
H5D	10/20/99	135	94.9	406	72	63.9	93.0	56.8	345	2.7	0.46	30.5	19.2	4.14
H6A	10/20/99	123	97.4	478	52	70.9	105	89.8	403	2.4	0.00	26.0	25.1	4.28
H6B	10/20/99	154	152	617	89	76.8	128	69.6	531	3.6	0.64	40.4	18.3	4.05
H6C	10/20/99	64	26.0	213	17	38.9	52.6	66.5	142	1.4	.	18.3	23.5	4.77
H6D	10/20/99	82	44.1	286	55	37.9	51.0	48.8	229	1.3	0.00	11.1	12.2	4.26
HBULK	10/20/99	28	12.8	23	39	3.49	5.76	2.30	23.9	0.4	0.00	7.8	1.5	4.41
C1A	11/05/99	44	0.8	223	5	34.4	56.8	98.4	141	0.3	0.66	1.1	26.7	5.29
C1B	11/05/99	31	0.5	188	12	32.4	50.2	55.5	131	0.3	0.59	1.1	23.6	4.91
C1C	11/05/99	55	12.1	248	17	24.5	48.5	44.0	166	0.4	0.49	1.1	6.7	4.77
C1D	11/05/99	59	3.5	231	9	56.9	68.3	62.1	163	0.3	0.66	1.1	25.1	5.05
C2A	11/05/99	34	2.8	157	8	11.5	29.6	24.8	115	0.2	0.00	1.1	2.8	5.10
C2B	11/05/99	38	2.9	205	9	18.0	37.8	26.6	138	0.2	0.00	1.1	2.0	5.05

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C2C	11/05/99	55	1.5	179	4	34.4	48.5	43.5	108	0.3	0.43	1.1	14.4	5.39
C2D	11/05/99	56	0.2	174	4	40.4	51.0	57.0	127	0.3	0.44	1.1	17.4	5.41
C3A	11/05/99	72	1.7	168	11	51.9	55.9	69.0	98.3	0.3	0.55	1.1	25.2	4.94
C3B	11/05/99	50	5.6	264	2	27.9	53.5	51.4	177	0.4	0.45	1.1	10.6	5.77
C3C	11/05/99	26	4.7	127	17	4.99	25.5	8.95	100	0.2	0.00	2.8	2.0	4.77
C3D	11/05/99	31	6.4	180	18	11.0	34.5	17.6	125	0.2	0.40	1.7	3.3	4.75
C4A	11/05/99	108	75.1	710	79	94.3	132	33.5	526	1.4	1.04	1.7	7.3	4.10
C4B	11/05/99	94	16.5	573	19	78.8	104	64.9	388	0.6	0.77	1.1	9.4	4.71
C4C	11/05/99	80	30.0	495	23	65.4	85.6	38.9	336	1.4	0.75	4.4	8.5	4.64
C4D	11/05/99	44	5.5	281	23	33.9	54.3	45.0	184	0.3	0.46	1.1	3.9	4.63
C5A	11/05/99	147	39.2	759	51	83.8	128	86.7	505	0.9	0.82	1.1	7.0	4.29
C5B	11/05/99	78	0.3	279	1	36.4	51.8	95.6	172	0.3	0.50	1.1	6.1	5.99
C5C	11/05/99	85	0.4	246	1	63.9	73.2	73.6	154	0.3	0.47	1.1	18.4	6.00
C5D	11/05/99	117	0.4	259	11	52.9	58.4	103	174	0.2	0.46	1.1	18.4	4.95
C6A	11/04/99	47	4.8	264	13	21.5	46.1	23.3	179	0.3	0.66	1.1	7.0	4.89
C6B	11/04/99	50	13.1	285	21	21.5	47.7	22.2	197	0.4	0.54	1.1	4.7	4.67
C6C	11/04/99	66	8.4	380	28	38.9	66.6	23.0	252	0.4	0.60	1.7	5.2	4.55
C6D	11/04/99	56	4.3	301	22	25.9	55.9	34.0	200	0.3	0.77	1.1	17.7	4.65
CBULK	11/05/99	20	4.1	78	16	0.00	15.6	2.56	75.3	0.1	0.00	.	1.6	4.79
CT4A	11/04/99	58	13.6	376	42	35.9	58.4	11.8	259	0.5	0.55	1.7	3.3	4.38
CT4D	11/04/99	117	29.7	816	32	95.3	125	23.8	605	0.7	0.47	3.3	3.2	4.49
CT5D	11/04/99	38	13.1	201	32	11.0	34.5	6.90	156	0.4	0.47	2.8	1.7	4.50
H1A	11/04/99	60	28.4	364	56	36.9	58.4	39.4	233	0.8	0.68	5.0	7.8	4.25
H1B	11/04/99	30	12.8	164	24	11.0	29.6	15.1	115	0.4	0.43	4.4	2.9	4.62
H1C	11/04/99	53	28.2	298	54	28.9	49.4	21.0	210	0.8	0.62	3.9	5.7	4.27
H1D	11/04/99	33	12.9	176	27	10.5	28.8	16.4	120	0.5	0.43	4.4	2.9	4.57
H2A	11/04/99	24	6.0	121	39	4.49	23.0	10.2	93.5	0.2	0.39	2.2	2.1	4.41
H2B	11/04/99	68	25.7	407	46	38.4	67.5	35.3	259	0.7	0.65	1.1	6.6	4.34
H2C	11/04/99	76	28.9	475	55	49.4	78.1	32.7	301	0.7	0.66	3.9	5.6	4.26
H2D	11/04/99	46	16.4	249	32	20.0	38.7	39.6	164	0.6	0.54	3.3	5.0	4.49
H3A	11/04/99	62	38.5	320	50	41.9	51.8	32.2	209	0.9	7.11	2.2	6.9	4.30
H3B	11/04/99	41	18.5	207	26	23.5	37.0	27.1	131	0.5	0.57	2.8	4.5	4.59
H3C	11/04/99	32	11.2	159	26	19.5	25.5	24.8	104	0.4	0.47	2.2	4.0	4.59
H3D	11/04/99	34	11.1	160	17	15.5	28.8	28.6	112	0.4	0.46	1.7	3.7	4.76
H4A	11/04/99	88	44.4	433	71	58.9	77.3	44.7	269	1.0	0.94	2.8	8.2	4.15
H4B	11/04/99	47	26.0	221	47	19.5	32.9	19.9	158	0.6	0.69	3.3	4.2	4.33
H4C	11/04/99	63	36.2	284	54	27.9	48.5	28.4	211	1.4	0.71	3.3	5.3	4.27
H4D	11/04/99	64	14.1	312	29	39.9	62.5	49.4	198	0.6	1.91	1.1	7.0	4.54
H5A	11/04/99	44	10.3	202	21	18.0	28.0	59.1	127	0.7	0.66	3.9	8.8	4.67
H5B	11/04/99	66	31.0	360	59	41.9	57.6	25.1	228	0.8	0.70	6.1	5.7	4.23
H5C	11/04/99	88	23.2	436	68	71.4	70.7	44.0	244	0.8	0.87	3.9	10.2	4.17
H5D	11/04/99	102	55.2	577	91	63.4	98.7	30.9	421	1.2	1.08	7.2	7.5	4.04
H6A	11/04/99	72	29.7	437	55	34.9	66.6	27.4	303	0.9	0.72	3.3	5.8	4.26
H6B	11/04/99	172	117	1120	115	119	200	45.3	848	2.2	1.84	10.5	8.7	3.94
H6C	11/04/99	57	31.8	342	46	33.4	60.1	23.3	233	1.0	0.74	3.3	4.4	4.34
H6D	11/04/99	117	71.1	751	81	82.8	137	39.4	526	1.4	1.14	3.3	6.6	4.09
HBULK	11/04/99	21	5.0	90	16	0.00	17.3	3.07	70.9	0.2	0.39	3.9	0.8	4.80
C1A	11/18/99	73	67.9	112	68	28.9	42.8	21.2	85.3	1.4	0.71	17.2	10.2	4.17
C1B	11/18/99	67	54.6	79	83	16.0	19.7	4.86	74.4	1.2	0.58	23.8	2.4	4.08
C1C	11/18/99	59	53.2	76	76	11.0	19.7	6.90	65.7	1.2	0.57	22.7	2.7	4.12
C1D	11/18/99	64	52.9	74	78	15.5	20.6	5.88	71.3	1.2	0.57	23.3	2.7	4.11

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C2A	11/18/99	58	46.3	67	81	10.5	16.5	4.35	64.4	1.1	0.54	22.2	2.0	4.09
C2B	11/18/99	65	50.3	80	78	13.0	20.6	8.69	67.9	1.2	0.55	22.2	2.3	4.11
C2C	11/18/99	62	52.5	65	91	8.98	16.5	3.58	57.0	1.2	0.52	23.3	2.1	4.04
C2D	11/18/99	56	46.2	58	81	8.98	14.0	3.32	57.4	1.1	0.51	22.2	1.4	4.09
C3A	11/18/99	64	49.9	66	81	11.5	18.1	5.11	58.7	1.2	0.59	22.7	2.1	4.09
C3B	11/18/99	94	96.1	168	91	27.4	47.7	15.6	137	2.0	0.70	9.4	4.6	4.04
C3C	11/18/99	53	46.2	62	85	6.99	14.0	3.84	57.0	1.1	0.53	22.7	2.3	4.07
C3D	11/18/99	60	51.1	67	81	8.48	16.5	4.86	65.7	1.3	0.53	23.8	2.2	4.09
C4A	11/18/99	115	135	217	91	44.4	60.9	26.3	195	2.5	1.03	16.1	4.7	4.04
C4B	11/18/99	155	145	341	81	56.9	80.6	79.5	281	2.5	1.21	7.8	11.0	4.09
C4C	11/18/99	147	136	322	100	57.9	77.3	24.8	258	2.4	0.96	18.8	8.7	4.00
C4D	11/18/99	72	59.1	120	56	24.0	34.5	19.7	109	1.3	0.63	16.6	4.5	4.25
C5A	11/18/99	180	249	486	126	73.9	118	52.9	403	4.3	1.28	22.2	9.9	3.90
C5B	11/18/99	64	51.8	88	69	17.0	23.9	20.5	73.5	1.2	0.54	20.5	2.4	4.16
C5C	11/18/99	63	52.7	76	81	16.0	21.4	7.93	67.4	1.2	0.53	19.9	2.3	4.09
C5D	11/18/99	60	50.2	66	79	12.5	16.5	5.63	66.6	1.2	0.67	23.3	2.3	4.10
C6A	11/18/99	71	49.9	63	72	12.0	20.6	13.6	69.6	1.0	0.61	17.2	4.2	4.14
C6B	11/18/99	86	86.0	78	100	16.5	31.3	9.7	72.6	1.8	0.62	33.2	3.1	4.00
C6C	11/18/99	87	68.8	111	69	21.0	32.9	13.3	123	1.4	0.69	18.3	4.0	4.16
C6D	11/18/99	102	89.6	102	93	22.5	46.1	18.7	93.1	1.9	0.70	23.8	5.1	4.03
CBULK	11/18/99	62	50.2	60	89	6.49	14.0	2.81	59.2	1.2	0.53	26.6	2.2	4.05
CT2A	11/18/99	57	47.4	61	81	8.98	14.0	2.81	59.2	1.1	0.52	23.8	2.2	4.09
CT2B	11/18/99	56	43.2	54	76	8.48	8.23	7.42	59.6	1.0	0.53	21.6	2.1	4.12
CT2C	11/18/99	54	44.0	55	79	7.98	13.2	4.35	56.1	1.1	0.54	22.2	2.1	4.10
CT2D	11/18/99	85	83.6	138	91	22.0	34.5	6.39	132	1.8	0.64	31.0	2.9	4.04
CT2E	11/18/99	60	49.6	69	87	8.48	16.5	3.32	64.8	1.2	0.54	25.5	2.3	4.06
CT2F	11/18/99	76	209	489	115	89.8	123	40.4	387	3.6	1.11	17.2	9.2	3.94
CT4A	11/19/99	106	112	199	98	27.9	53.5	13.3	184	2.1	0.80	22.2	3.8	4.01
CT4B	11/19/99	56	47.0	46	89	6.99	9.9	1.79	39.6	1.2	0.54	26.0	1.6	4.05
CT4C	11/19/99	58	49.3	48	93	6.99	10.7	2.05	40.5	2.3	0.55	25.5	1.7	4.03
CT4D	11/19/99	78	83.3	103	78	23.5	28.8	7.16	103	1.8	0.64	24.9	3.1	4.11
CT4E	11/19/99	75	73.9	107	79	17.5	32.9	9.46	104	1.5	0.83	15.0	4.8	4.10
CT4F	11/19/99	57	49.8	47	89	8.48	10.7	2.05	40.9	1.2	0.55	25.5	1.6	4.05
CT5D	11/19/99	77	69.1	129	93	14.5	29.6	6.14	108	1.5	0.63	26.6	2.6	4.03
CT5E	11/19/99	56	47.7	50	87	7.49	10.7	1.79	41.3	1.1	0.54	24.9	1.5	4.06
CT5F	11/19/99	56	52.4	60	76	11.0	17.3	2.56	63.9	1.2	0.61	23.3	1.6	4.12
H1A	11/19/99	125	114	219	98	38.4	48.5	44.5	170	2.3	0.84	20.5	10.8	4.01
H1B	11/19/99	60	52.8	64	78	10.5	14.8	10.7	65.7	1.3	0.98	22.7	2.9	4.11
H1C	11/19/99	97	102	179	95	26.9	43.6	22.0	160	2.1	0.73	26.0	5.8	4.02
H1D	11/19/99	69	65.0	75	83	13.5	21.4	12.0	72.6	1.5	0.59	25.5	3.3	4.08
H2A	11/19/99	57	50.5	54	91	6.99	12.3	7.42	53.5	1.2	0.51	24.9	2.9	4.04
H2B	11/19/99	130	155	263	110	42.4	74.0	29.9	241	2.8	0.89	23.3	6.8	3.96
H2C	11/19/99	87	93.3	129	81	24.5	37.8	22.2	122	2.0	0.68	19.4	5.6	4.09
H2D	11/19/99	103	109	161	83	30.4	49.4	39.1	137	2.1	0.72	22.2	6.0	4.08
H3A	11/19/99	122	124	189	105	43.4	48.5	36.8	167	2.4	0.86	17.7	7.5	3.98
H3B	11/19/99	79	75.7	93	69	26.4	33.7	22.0	89.2	1.7	0.67	21.6	4.8	4.16
H3C	11/19/99	83	73.4	95	93	26.9	26.3	18.2	82.7	1.4	0.64	17.2	4.3	4.03
H3D	11/19/99	80	79.0	91	76	23.5	32.1	21.7	80.9	1.6	0.60	22.7	4.6	4.12
H4A	11/19/99	138	150	218	126	42.4	53.5	42.4	183	2.8	0.99	21.1	8.0	3.90
H4B	11/19/99	175	198	434	178	67.4	101	39.1	326	3.7	1.36	32.7	6.7	3.75
H4C	11/19/99	166	208	376	138	62.4	92.1	58.8	288	3.9	1.28	34.9	10.0	3.86

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H4D	11/19/99	102	50.9	121	56	29.4	37.0	38.1	113	2.4	0.99	8.3	6.7	4.25
H5A	11/19/99	92	36.3	89	42	15.0	18.1	58.6	84.0	1.0	0.62	12.2	8.6	4.38
H5B	11/19/99	112	119	199	110	32.4	48.5	23.3	168	2.7	0.87	27.7	6.3	3.96
H5C	11/19/99	130	107	201	93	44.4	50.2	42.2	184	2.2	0.99	15.5	9.9	4.03
H5D	11/19/99	198	217	456	182	70.9	109	40.9	421	4.0	1.43	28.3	10.2	3.74
H6A	11/19/99	141	154	333	126	40.4	74.0	31.7	265	2.8	0.91	26.6	7.1	3.90
H6B	11/19/99	185	229	675	155	63.9	123	34.0	509	4.4	1.62	44.9	7.2	3.81
H6C	11/19/99	233	242	355	245	62.9	90.5	53.2	271	.	1.25	41.6	14.3	3.61
H6D	11/19/99	111	126	213	115	29.9	50.2	22.2	187	2.4	0.78	22.2	5.0	3.94
HBULK	11/19/99	58	50.1	43	95	5.49	9.05	1.79	36.1	1.2	0.54	27.7	1.7	4.02
HT1D	11/19/99	62	53.6	68	71	17.5	20.6	8.69	62.6	1.3	0.53	24.9	2.6	4.15
HT1E	11/19/99	72	50.8	79	46	25.9	26.3	16.6	70.5	1.2	0.54	19.9	3.9	4.34
HT1F	11/19/99	63	53.7	63	81	16.5	19.7	5.88	60.9	2.6	0.56	24.9	2.5	4.09
HT2F	11/19/99	53	45.2	42	83	6.99	9.9	3.07	36.1	1.1	0.53	24.4	2.3	4.08
HT3A	11/19/99	164	178	364	145	68.4	85.6	28.9	316	3.5	1.43	29.4	13.3	3.84
HT3B	11/19/99	78	68.9	108	81	15.5	27.1	23.5	92.2	1.6	0.65	23.3	5.3	4.09
HT3C	11/19/99	199	257	549	186	94.3	110	37.8	435	.	1.82	43.2	11.1	3.73
HT3F	11/19/99	56	46.4	39	89	5.99	9.05	2.81	33.9	1.4	0.51	26.0	2.1	4.05
C1A	05/18/00	40	23.6	38	39	10.5	11.5	6.39	41.3	0.7	0.00	11.1	4.6	4.41
C2A	05/18/00	42	25.8	39	36	13.5	12.3	7.93	41.3	0.9	0.00	12.2	3.4	4.44
C2B	05/18/00	42	22.1	49	33	15.0	15.6	12.5	48.7	0.8	0.00	8.9	4.3	4.48
C2C	05/18/00	40	24.9	36	39	13.5	14.0	9.46	37.4	0.9	0.00	5.0	4.0	4.41
C2D	05/18/00	39	23.6	30	32	11.0	9.9	7.67	31.8	0.7	0.00	15.5	3.7	4.50
C3A	05/18/00	55	39.8	40	48	18.5	19.7	8.95	45.2	1.1	0.44	11.1	4.1	4.32
C3B	05/18/00	58	36.7	85	37	25.4	30.4	16.6	87.0	1.1	0.55	7.8	6.1	4.43
C3C	05/18/00	39	23.9	29	35	10.5	9.05	5.88	28.3	0.8	0.37	13.3	2.6	4.45
C4A	05/18/00	101	36.4	221	55	40.9	58.4	30.9	210	1.2	1.07	2.2	12.5	4.26
C4B	05/18/00	80	27.6	176	44	32.9	44.4	27.1	170	1.0	0.80	3.9	10.4	4.36
C4C	05/18/00	129	48.3	344	76	49.4	79.0	29.7	339	1.4	1.39	2.8	18.6	4.12
C4D	05/18/00	53	17.7	94	18	28.4	28.8	27.6	102	1.0	0.59	8.9	8.8	4.74
C5A	05/18/00	117	49.5	282	69	41.4	72.4	34.3	261	1.5	1.12	1.1	11.0	4.16
C5B	05/18/00	44	23.8	49	25	16.0	14.8	15.3	46.1	0.8	0.42	17.7	4.1	4.61
C5C	05/18/00	43	26.3	44	18	18.0	16.5	27.4	39.6	0.8	0.40	15.5	5.9	4.75
C5D	05/18/00	39	24.3	31	37	10.5	9.05	6.90	30.0	0.8	0.38	12.2	3.5	4.43
C6A	05/17/00	62	19.3	71	43	16.0	23.9	12.8	90.0	0.7	0.00	1.1	7.5	4.37
C6B	05/17/00	58	10.3	82	28	19.0	25.5	12.0	103	0.5	0.00	4.4	7.9	4.56
C6C	05/17/00	48	27.3	47	38	12.0	16.5	10.2	49.2	0.7	0.00	7.8	3.9	4.42
C6D	05/17/00	50	21.4	76	38	19.0	21.4	9.21	70.9	0.6	0.00	4.4	5.7	4.42
CBULK	05/18/00	38	24.2	26	39	7.98	7.40	2.81	26.5	0.7	0.38	14.4	2.4	4.41
CT4A	05/17/00	61	29.7	111	49	19.5	29.6	7.93	111	0.8	0.00	8.3	5.1	4.31
CT4B	05/17/00	41	27.2	32	38	10.0	10.7	2.56	31.3	0.8	0.00	17.7	2.1	4.42
CT4C	05/17/00	41	25.4	32	37	7.49	8.23	2.05	29.6	0.8	0.80	19.9	1.8	4.43
CT4D	05/17/00	59	31.9	109	39	26.9	30.4	10.7	102	0.8	0.00	10.5	3.9	4.41
CT4E	05/17/00	68	34.7	124	59	18.0	34.5	9.21	121	0.8	0.00	7.2	6.1	4.23
CT4F	05/17/00	43	27.6	37	37	11.0	11.5	3.32	37.0	0.8	0.00	16.1	2.4	4.43
CT5D	05/17/00	48	26.0	84	46	10.0	19.7	5.37	90.5	0.6	0.00	8.9	3.7	4.34
CT5E	05/17/00	37	22.3	27	36	5.49	6.58	1.28	26.5	0.6	0.00	15.5	1.4	4.44
H1A	05/17/00	64	23.2	94	56	17.5	25.5	15.6	101	0.8	0.41	5.0	9.6	4.25
H1B	05/17/00	44	21.8	43	41	9.48	9.9	10.5	39.6	0.7	0.00	13.3	5.1	4.39
H1C	05/17/00	76	25.6	129	59	19.0	29.6	21.2	138	0.8	0.47	5.0	10.6	4.23
H1D	05/17/00	69	25.9	100	58	18.5	25.5	18.4	103	0.9	0.42	7.8	9.1	4.24

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H2A	05/17/00	37	21.0	22	34	6.99	5.76	6.65	22.6	0.7	0.00	12.2	2.7	4.47
H2B	05/17/00	92	28.9	181	68	24.0	43.6	24.0	179	0.8	0.69	1.1	12.6	4.17
H2C	05/17/00	64	26.7	95	50	16.5	24.7	19.7	97.4	0.8	0.00	6.6	7.0	4.30
H2D	05/17/00	63	16.8	76	44	15.5	20.6	26.3	88.7	0.7	0.38	0.6	8.8	4.36
H3A	05/17/00	74	17.0	113	59	24.5	25.5	29.9	118	0.8	0.00	1.1	15.2	4.23
H3B	05/17/00	51	20.8	65	31	19.0	18.1	21.0	75.7	0.9	0.00	8.9	7.4	4.51
H3C	05/17/00	58	10.0	66	50	21.0	18.1	31.5	76.6	0.7	0.57	0.6	14.3	4.30
H3D	05/17/00	51	19.2	57	28	14.5	17.3	22.0	68.3	0.8	0.00	12.2	8.9	4.56
H4A	05/17/00	103	13.7	191	74	24.0	36.2	29.2	187	0.8	0.91	1.1	15.1	4.13
H4B	05/17/00	56	19.6	90	48	14.0	20.6	23.5	91.4	0.8	0.54	3.9	8.4	4.32
H4C	05/17/00	53	24.7	71	42	12.0	18.9	18.9	78.7	0.8	0.00	7.2	5.8	4.38
H4D	05/17/00	66	7.4	84	28	24.5	26.3	43.5	98.7	0.6	1.29	3.9	14.9	4.56
H5A	05/17/00	45	18.0	55	28	12.0	10.7	19.4	64.4	0.8	0.00	11.1	4.8	4.55
H5B	05/17/00	78	23.9	140	62	21.0	30.4	18.4	146	0.9	0.60	5.0	11.6	4.21
H5C	05/17/00	92	9.6	150	56	28.9	31.3	24.3	165	0.8	0.84	1.7	17.3	4.25
H5D	05/17/00	93	21.0	194	71	22.5	39.5	21.0	191	0.9	0.79	2.8	13.0	4.15
H6A	05/17/00	92	28.7	193	58	21.5	42.0	33.2	198	1.0	0.63	2.2	12.5	4.24
H6B	05/17/00	107	38.5	241	66	28.9	55.1	28.9	231	1.1	0.80	1.7	11.5	4.18
H6C	05/17/00	45	22.9	51	40	11.5	14.8	10.5	46.5	0.7	0.00	9.4	4.7	4.40
H6D	05/17/00	78	26.1	143	52	20.0	32.9	23.5	149	0.9	0.50	5.5	10.4	4.28
HBULK	05/17/00	38	22.5	26	33	7.49	4.11	4.60	26.5	0.8	0.00	18.3	1.9	4.48
HT1D	05/17/00	43	20.8	36	28	14.5	12.3	10.5	33.5	0.7	0.00	13.3	4.2	4.55
HT1E	05/17/00	44	18.3	47	13	22.5	17.3	21.0	46.5	1.0	0.00	17.7	5.4	4.90
HT1F	05/17/00	39	20.1	29	28	12.5	10.7	9.46	28.3	0.9	0.00	12.2	3.5	4.55
HT3A	05/17/00	81	18.5	119	55	28.9	28.8	12.5	129	0.8	0.84	5.0	10.8	4.26
HT3B	05/17/00	48	14.0	56	31	10.5	12.3	18.4	72.2	0.7	0.00	7.2	6.0	4.51
HT3C	05/17/00	98	32.3	180	68	31.9	45.2	19.2	174	1.0	1.08	3.3	11.1	4.17
HT3F	05/17/00	36	21.2	18	34	6.49	4.11	4.35	17.0	0.7	0.00	15.0	2.4	4.47
HT4D	05/17/00	98	35.2	163	59	25.4	46.1	29.9	163	0.9	0.62	0.0	9.0	4.23
HT4F	05/17/00	39	23.2	24	36	8.48	6.58	1.28	22.6	0.7	0.00	18.3	1.7	4.44
C1A	05/31/00	43	19.8	63	35	15.5	20.6	20.5	49.2	0.6	0.48	5.0	7.1	4.45
C1C	05/31/00	32	9.4	26	26	9.48	12.3	21.0	24.4	0.4	0.46	3.3	10.2	4.58
C2A	05/31/00	49	24.2	70	41	17.0	19.7	21.5	55.7	0.7	0.43	9.4	7.2	4.39
C2C	05/31/00	42	14.0	57	49	17.5	18.1	16.4	46.5	0.5	0.48	1.1	9.1	4.31
C3A	05/31/00	47	21.4	58	60	13.0	15.6	19.2	44.8	0.7	0.54	1.1	6.4	4.22
C3C	05/31/00	54	29.5	56	74	11.5	13.2	9.7	44.8	0.8	0.40	12.7	5.0	4.13
C4A	05/31/00	82	25.5	145	66	28.9	39.5	28.4	132	0.9	0.91	1.1	11.2	4.18
C4C	05/31/00	114	33.0	255	93	35.9	56.8	25.3	226	1.1	1.23	8.3	14.5	4.03
C5A	05/31/00	126	34.8	318	85	42.9	74.9	52.9	261	1.5	1.32	2.2	16.2	4.07
C5C	05/31/00	44	19.6	59	42	17.0	18.9	27.1	47.0	0.6	0.38	1.1	9.5	4.38
C6A	05/31/00	61	18.8	58	40	14.5	18.9	10.5	56.1	0.5	0.54	6.1	5.5	4.40
C6C	05/31/00	47	24.0	38	65	8.98	11.5	8.44	35.2	0.6	0.44	6.1	4.4	4.19
CBULK	05/31/00	28	15.4	19	38	3.99	4.11	1.53	17.0	0.4	0.00	5.0	5.6	4.42
CT4A	05/31/00	79	33.3	112	59	18.0	29.6	5.37	109	0.8	0.91	9.4	5.6	4.23
CT4B	05/31/00	46	26.2	56	41	8.48	13.2	3.58	48.3	0.7	0.38	13.3	2.1	4.39
CT4C	05/31/00	49	28.4	65	42	8.98	14.8	2.56	56.6	0.7	0.40	17.2	1.8	4.38
CT4D	05/31/00	72	38.3	133	62	33.4	35.4	14.3	118	0.8	0.53	11.1	4.7	4.21
CT4E	05/31/00	78	35.8	73	63	14.0	25.5	8.69	78.3	0.9	0.79	8.9	6.6	4.20
CT4F	05/31/00	49	28.2	95	41	15.5	21.4	6.14	87.0	0.7	0.42	10.0	3.7	4.39
CT5D	05/31/00	73	33.9	109	54	14.5	25.5	5.88	107	0.8	0.61	14.4	5.1	4.27
CT5E	05/31/00	49	26.6	57	43	7.49	12.3	2.05	49.6	0.7	0.41	17.7	2.0	4.37

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
CT5F	05/31/00	42	24.0	63	35	7.98	14.0	2.30	55.7	0.6	0.37	13.3	2.0	4.45
H1A	05/31/00	70	21.8	169	74	26.9	40.3	20.2	134	0.8	0.90	7.2	9.6	4.13
H1C	05/31/00	61	22.2	143	72	19.0	30.4	14.6	128	0.7	0.79	4.4	7.6	4.14
H2A	05/31/00	38	22.2	44	35	7.98	9.9	6.65	37.8	0.6	0.40	12.7	3.5	4.46
H2C	05/31/00	63	21.9	111	48	18.0	28.0	13.3	95.3	0.6	0.65	6.1	6.7	4.32
H3A	05/31/00	103	16.8	194	112	39.4	39.5	29.4	158	0.7	1.22	3.9	15.1	3.95
H3C	05/31/00	73	17.4	118	62	27.9	27.1	18.7	103	0.7	0.90	7.2	12.8	4.21
H4A	05/31/00	118	20.0	203	78	28.9	42.8	22.2	175	0.8	1.33	3.9	12.2	4.11
H4C	05/31/00	73	24.3	139	52	20.0	31.3	11.0	119	0.7	0.66	7.8	5.7	4.28
H5A	05/31/00	79	28.9	167	66	26.9	41.1	30.2	128	0.9	0.68	10.0	7.8	4.18
H5C	05/31/00	84	11.5	149	76	31.4	35.4	19.4	132	0.7	1.03	4.4	12.1	4.12
H6A	05/31/00	112	36.7	275	102	32.4	60.9	19.2	225	0.9	0.94	3.9	8.7	3.99
H6C	05/31/00	88	33.5	232	91	32.9	54.3	20.5	168	0.8	0.74	6.6	6.4	4.04
HBULK	05/31/00	36	23.2	36	34	6.99	8.23	2.05	32.2	0.6	0.00	13.3	1.8	4.47
HT1D	05/31/00	44	22.0	85	0	24.5	25.5	53.4	68.3	1.3	0.38	22.7	6.4	6.41
HT1E	05/31/00	39	19.9	65	9	22.5	20.6	31.7	51.3	0.8	0.37	7.8	4.8	5.05
HT1F	05/31/00	39	7.4	59	6	24.0	23.0	26.8	51.3	0.8	0.41	2.2	7.5	5.20
HT2F	05/31/00	44	25.3	47	39	10.5	10.7	6.14	42.2	0.7	0.42	12.2	3.5	4.41
HT3A	05/31/00	102	18.5	236	68	35.4	49.4	14.1	184	0.7	1.21	4.4	9.7	4.17
HT3B	05/31/00	58	16.4	114	42	20.0	27.1	24.0	98.7	1.2	0.63	15.5	7.1	4.38
HT3C	05/31/00	103	22.9	204	69	30.9	40.3	19.4	178	0.8	1.28	6.6	12.8	4.16
HT3F	05/31/00	31	14.7	38	29	7.49	9.9	5.37	30.5	0.4	0.00	6.1	2.7	4.54
HT4B	05/31/00	29	17.8	25	30	5.49	4.94	4.35	24.4	0.5	0.00	11.1	2.2	4.53
HT4D	05/31/00	108	38.6	189	107	28.9	46.9	20.7	169	0.9	0.90	6.6	7.8	3.97
HT4F	05/31/00	121	64.7	174	29	.	.	.	.	1.9	.	30.5	0.9	4.54
PARKB	05/31/00	41	23.5	26	35	9.48	5.76	1.79	23.1	0.6	0.44	14.4	1.7	4.45
C1A	06/13/00	42	1.6	61	26	26.4	25.5	57.3	46.1	0.9	0.64	2.8	31.7	4.58
C1C	06/13/00	43	2.0	76	30	31.4	31.3	77.5	55.7	0.9	0.80	2.8	39.1	4.53
C2A	06/13/00	61	1.8	66	4	38.9	27.1	70.6	47.9	1.2	0.50	2.8	22.4	5.36
C2C	06/13/00	38	2.4	41	4	27.9	22.2	78.5	31.3	1.0	0.39	2.2	27.0	5.35
C3A	06/13/00	36	4.7	45	21	24.5	21.4	52.7	29.6	0.6	0.52	2.8	29.8	4.67
C3C	06/13/00	35	5.1	33	25	18.0	16.5	32.2	24.4	0.8	0.00	1.7	15.4	4.61
C4A	06/13/00	50	2.2	96	25	26.9	32.9	57.3	77.4	1.2	0.95	2.8	21.7	4.60
C4C	06/13/00	93	22.5	197	.	38.9	51.0	63.2	168	.	1.74	27.1	30.1	.
C5A	06/13/00	94	1.8	183	3	46.4	60.1	133	146	2.4	1.44	2.2	30.2	5.47
C5C	06/13/00	62	0.9	71	1	47.4	37.0	164	45.7	1.4	0.50	2.8	42.1	6.11
C6A	06/13/00	62	13.2	82	59	25.0	32.9	45.3	61.8	0.9	1.26	1.1	18.5	4.23
C6C	06/13/00	60	34.1	75	44	23.0	28.8	34.0	63.1	1.0	0.91	19.4	12.4	4.36
CBULK	06/13/00	28	13.7	22	33	9.48	8.23	8.44	19.1	0.6	0.00	1.7	8.1	4.48
CT4B	06/13/00	25	14.0	28	27	9.48	8.23	9.46	23.1	0.5	0.00	3.3	7.4	4.57
CT4C	06/13/00	30	16.2	24	28	10.5	7.40	5.37	20.9	0.5	0.00	2.2	3.9	4.55
CT4D	06/13/00	25	16.8	34	18	13.0	10.7	8.69	28.7	0.5	0.00	2.8	3.6	4.74
CT4E	06/13/00	43	27.6	65	47	13.5	18.1	11.8	63.1	0.7	0.66	1.1	7.3	4.33
CT4F	06/13/00	24	14.2	22	24	9.48	6.58	7.42	20.9	0.5	0.00	1.7	4.0	4.62
CT5A	06/13/00	59	28.0	85	8	22.5	28.8	77.7	66.1	1.1	0.77	1.7	8.3	5.10
CT5D	06/13/00	37	20.2	45	29	12.5	14.8	10.7	42.6	0.7	0.49	3.3	6.1	4.54
CT5E	06/13/00	30	17.2	18	29	9.48	5.76	3.07	16.1	0.5	0.00	7.2	3.2	4.54
CT5F	06/13/00	27	17.1	22	26	8.98	7.40	7.42	20.4	0.5	0.00	1.1	4.1	4.58
H1A	06/14/00	66	17.7	110	74	31.9	36.2	39.6	98.3	1.2	1.27	2.2	21.0	4.13
H1C	06/14/00	37	12.8	44	17	13.0	18.9	42.4	38.3	0.7	0.51	1.1	10.3	4.77
H2A	06/14/00	64	12.7	52	55	24.0	26.3	47.8	47.0	0.8	0.65	2.2	23.7	4.26

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H2C	06/14/00	61	29.9	87	56	25.0	36.2	48.8	75.3	1.2	0.95	1.1	16.6	4.25
H3A	06/14/00	65	27.2	92	79	23.0	29.6	41.7	90.9	1.1	1.39	5.0	20.6	4.10
H3C	06/14/00	46	5.9	51	36	22.0	19.7	49.6	40.9	0.7	0.84	6.6	16.7	4.44
H4A	06/14/00	55	15.9	75	37	15.5	20.6	30.2	74.0	0.8	1.04	1.7	13.6	4.43
H4C	06/14/00	130	78.4	199	145	46.9	74.0	56.5	161	2.1	1.93	1.1	21.1	3.84
H5A	06/14/00	31	3.4	35	19	13.5	13.2	38.4	30.9	0.6	0.00	2.2	13.5	4.73
H5C	06/14/00	92	15.9	153	81	49.9	51.0	55.2	119	1.2	1.59	1.7	25.3	4.09
H6A	06/14/00	112	55.4	245	87	40.9	77.3	85.9	194	1.9	1.86	3.9	29.3	4.06
H6C	06/14/00	36	14.4	50	26	13.5	18.9	32.7	40.0	0.7	0.52	4.4	9.3	4.59
HBULK	06/14/00	28	12.3	9	28	7.98	5.76	8.95	7.40	0.5	0.00	0.6	3.9	4.56
HT1D	06/14/00	24	10.8	30	0	27.9	23.9	73.6	17.8	0.8	0.00	2.2	9.3	6.74
HT1E	06/14/00	34	3.2	34	0	26.4	22.2	78.5	27.8	1.0	0.00	7.8	13.7	6.53
HT1F	06/14/00	37	1.0	34	1	43.9	36.2	67.0	26.1	0.8	0.00	3.3	23.2	6.27
HT2F	06/14/00	28	10.7	12	19	8.98	6.58	13.8	8.70	0.4	0.00	2.2	4.6	4.71
HT3A	06/14/00	78	22.6	111	79	25.4	36.2	30.9	104	1.3	1.55	16.6	18.4	4.10
HT3B	06/14/00	39	0.8	62	.	30.9	44.4	102	43.9	1.6	0.61	1.7	20.1	.
HT3C	06/14/00	52	18.8	71	49	16.0	21.4	31.7	75.3	0.9	1.00	1.7	12.3	4.31
HT3F	06/14/00	26	8.5	14	25	6.99	6.58	18.2	8.27	0.4	0.00	0.6	4.2	4.61
HT4B	06/14/00	25	14.2	11	24	6.99	4.94	4.35	9.14	0.4	0.00	0.6	3.2	4.62
HT4D	06/14/00	123	78.0	190	.	45.9	73.2	44.5	157	2.0	1.67	0.6	17.0	.
HT4F	06/14/00	36	21.9	22	28	15.0	7.40	3.84	22.2	0.6	0.00	0.6	2.9	4.55
PARKB	06/14/00	25	16.2	14	25	8.48	4.11	2.56	13.1	0.5	0.00	5.0	3.5	4.61
C1A	07/05/00	76	36.7	31	59	18.0	16.5	31.2	31.3	2.5	0.51	13.9	10.6	4.23
C1C	07/05/00	83	33.4	52	35	33.9	45.2	82.6	47.9	1.5	1.01	2.8	24.5	4.45
C2A	07/05/00	76	31.2	37	55	27.9	20.6	35.3	36.1	1.2	0.49	1.1	14.2	4.26
C2C	07/05/00	70	12.1	32	37	24.5	26.3	50.9	29.1	1.0	0.51	1.1	20.9	4.43
C3A	07/05/00	76	27.0	34	43	22.5	21.4	58.8	31.8	1.2	0.66	1.1	17.1	4.37
C3C	07/05/00	67	22.1	28	56	15.0	17.3	33.8	24.4	0.8	0.42	7.8	19.8	4.25
C4A	07/05/00	104	60.5	94	55	50.4	55.1	77.5	85.3	1.7	1.49	2.8	25.9	4.26
C4C	07/05/00	158	60.4	234	56	66.4	85.6	95.4	204	2.4	2.10	1.7	37.5	4.25
C5A	07/05/00	142	91.6	151	18	56.9	69.1	186	128	4.1	2.33	16.1	36.2	4.75
C5C	07/05/00	70	20.5	33	25	33.4	28.8	54.7	27.0	1.4	0.42	7.8	17.2	4.60
C6A	07/05/00	134	28.6	75	56	43.4	46.1	61.9	85.3	1.3	1.69	2.2	22.3	4.25
C6C	07/05/00	104	51.0	51	68	25.4	28.8	53.2	53.9	1.3	1.01	6.6	15.9	4.17
CBULK	07/05/00	71	35.6	28	72	10.0	10.7	30.4	27.8	1.2	0.60	1.1	11.5	4.14
CT2A	07/05/00	78	42.1	46	38	22.5	19.7	58.8	45.2	1.2	0.44	6.1	8.4	4.42
CT2C	07/05/00	61	11.5	29	15	25.4	18.9	47.0	26.1	0.8	0.44	2.2	13.6	4.81
CT2D	07/05/00	100	70.6	60	40	58.4	45.2	46.8	72.2	2.0	0.90	10.5	13.8	4.40
CT4A	07/05/00	83	46.8	82	71	27.9	34.5	16.9	74.4	1.4	0.96	10.0	12.2	4.15
CT4B	07/05/00	81	44.4	52	83	15.5	18.9	13.8	51.8	1.1	0.56	11.1	9.5	4.08
CT4C	07/05/00	68	39.7	30	78	7.98	8.23	3.32	31.8	1.0	0.54	12.7	4.6	4.11
CT4D	07/05/00	118	51.3	106	45	65.4	47.7	35.5	93.1	1.3	1.08	2.8	17.5	4.35
CT4E	07/05/00	94	47.0	66	69	22.5	28.8	45.0	53.9	1.3	1.23	9.4	14.9	4.16
CT4F	07/05/00	98	52.4	72	89	25.0	23.0	11.0	69.6	1.4	0.83	8.9	6.4	4.05
CT5A	07/05/00	85	80.0	70	78	18.5	23.9	22.2	65.7	1.2	0.74	5.0	11.1	4.11
CT5D	07/05/00	95	63.7	91	85	22.5	36.2	9.7	90.5	1.5	0.97	12.2	8.3	4.07
CT5E	07/05/00	65	33.4	26	71	7.98	7.40	3.84	27.4	1.0	0.46	13.3	3.9	4.15
CT5F	07/05/00	68	31.0	36	74	7.49	9.05	3.32	38.3	0.9	0.42	11.1	4.7	4.13
H1A	07/05/00	150	56.4	197	87	59.4	69.9	60.1	152	1.8	1.79	6.6	30.6	4.06
H1C	07/05/00	100	45.4	111	65	32.9	41.1	46.3	97.9	1.3	1.17	9.4	17.5	4.19
H2A	07/05/00	70	24.1	39	85	17.0	14.8	25.6	40.5	0.8	0.63	5.0	20.6	4.07

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H2C	07/05/00	114	41.9	85	66	31.4	37.0	64.4	71.8	1.2	1.09	1.7	18.3	4.18
H3A	07/05/00	194	54.2	226	105	74.9	72.4	89.2	168	2.0	2.36	9.4	36.8	3.98
H3C	07/05/00	115	40.1	89	74	44.4	38.7	57.3	72.2	1.3	1.19	5.5	20.8	4.13
H4A	07/05/00	161	43.8	138	98	43.4	49.4	65.2	110	1.7	1.91	10.0	24.4	4.01
H4C	07/05/00	193	71.4	264	102	65.4	83.1	78.0	207	2.2	2.14	4.4	28.2	3.99
H5A	07/05/00	101	32.9	85	71	30.9	36.2	59.1	72.6	1.1	0.97	4.4	25.8	4.15
H5C	07/05/00	167	13.3	180	71	67.9	63.3	101	130	1.4	2.11	4.4	73.7	4.15
H6A	07/05/00	203	104	322	110	64.4	93.8	87.7	254	2.5	2.03	6.6	29.6	3.96
H6C	07/05/00	130	50.3	152	74	41.9	55.1	59.1	119	1.4	1.19	4.4	17.3	4.13
HBULK	07/05/00	66	34.6	19	78	3.99	4.94	2.56	19.6	1.0	0.37	15.0	5.1	4.11
HT1D	07/05/00	72	31.9	45	17	34.9	34.5	37.3	39.6	1.0	0.44	2.2	9.4	4.76
HT1E	07/05/00	102	40.6	61	4	36.9	27.1	72.6	53.1	2.0	0.76	41.0	9.7	5.36
HT1F	07/05/00	87	34.0	41	11	37.9	36.2	52.9	36.5	1.2	0.51	8.9	9.2	4.94
HT2F	07/05/00	65	36.1	18	72	4.99	4.94	4.09	20.0	1.0	0.00	17.7	3.9	4.14
HT3A	07/05/00	196	60.8	245	112	64.4	81.4	40.7	201	2.0	3.16	11.6	25.0	3.95
HT3C	07/05/00	245	66.3	282	100	75.3	94.6	64.7	245	1.9	3.02	10.5	29.6	4.00
HT3F	07/05/00	68	26.8	22	62	7.98	8.23	16.9	20.4	1.1	0.41	15.0	6.0	4.21
HT4B	07/05/00	69	30.4	16	76	5.49	4.94	7.16	17.0	0.8	0.43	10.5	4.7	4.12
HT4D	07/05/00	190	98.2	184	95	61.4	77.3	78.2	155	2.1	2.03	8.9	21.1	4.02
HT4F	07/05/00	41	40.3	37	83	8.48	9.05	2.05	39.2	1.1	0.58	17.7	3.8	4.08
PARKB	07/05/00	58	27.8	14	62	4.49	4.11	2.30	14.8	1.0	0.41	19.9	4.1	4.21
C1A	07/26/00	26	1.2	27	22	6.49	9.05	8.44	25.2	0.2	0.00	1.1	5.5	4.66
C1B	07/26/00	24	2.2	23	17	9.48	8.23	6.90	21.8	0.2	0.00	1.1	3.6	4.78
C1C	07/26/00	21	2.5	30	4	10.0	12.3	26.6	25.7	0.3	0.00	2.8	8.1	5.36
C1D	07/26/00	24	1.9	24	14	8.48	8.23	9.21	23.1	0.3	0.00	1.1	4.5	4.84
C2A	07/26/00	27	2.4	26	20	10.0	9.05	10.5	23.5	0.3	0.00	1.1	5.5	4.69
C2B	07/26/00	22	0.8	31	6	10.5	9.9	15.1	27.4	0.2	0.00	1.7	3.9	5.23
C2C	07/26/00	24	0.2	25	15	11.5	11.5	12.0	23.1	0.6	0.00	1.1	7.0	4.83
C2D	07/26/00	30	0.2	27	13	11.0	12.3	26.8	23.1	0.3	0.00	1.1	6.9	4.90
C3A	07/26/00	24	5.3	22	20	6.99	7.40	10.2	20.4	0.3	0.00	2.2	4.3	4.69
C3B	07/26/00	28	8.6	29	20	12.0	12.3	13.8	25.7	0.6	0.00	1.7	5.1	4.70
C3C	07/26/00	22	3.8	19	17	3.99	8.23	9.7	18.3	0.7	0.00	3.3	4.7	4.77
C3D	07/26/00	26	6.0	21	20	5.49	9.05	9.46	19.1	0.4	0.00	1.7	3.1	4.70
C4A	07/26/00	25	5.1	38	15	12.5	14.0	23.5	35.2	0.4	0.38	2.2	9.4	4.81
C4B	07/26/00	27	3.1	46	13	13.5	15.6	27.6	48.3	0.5	0.45	4.4	11.0	4.89
C4C	07/26/00	47	12.8	89	30	27.4	29.6	30.7	98.7	0.7	1.00	1.1	16.4	4.53
C4D	07/26/00	31	5.2	55	0	18.5	19.7	49.6	37.8	1.2	0.00	33.8	8.1	6.42
C5A	07/28/00	32	11.4	58	14	17.5	20.6	39.4	52.2	0.8	0.56	3.9	11.7	4.85
C5B	07/28/00	28	0.6	33	9	14.0	12.3	17.9	31.8	0.5	0.00	1.7	5.7	5.03
C5C	07/28/00	25	0.3	26	1	16.0	15.6	35.5	23.5	0.6	0.00	1.1	6.3	5.91
C5D	07/28/00	24	0.2	21	13	10.0	9.05	12.8	19.6	0.3	0.00	1.1	5.3	4.88
C6A	07/26/00	36	3.3	35	24	10.0	12.3	18.9	29.6	0.3	0.00	1.1	5.8	4.62
C6B	07/26/00	23	0.3	27	16	10.0	13.2	6.39	29.6	0.2	0.00	0.6	6.2	4.79
C6C	07/26/00	28	1.4	22	14	6.49	9.05	14.3	20.9	0.1	0.00	1.1	4.7	4.84
C6D	07/26/00	48	0.7	58	25	16.0	20.6	24.3	47.4	0.2	0.00	1.1	7.6	4.61
CBULK	07/26/00	21	0.2	16	22	2.50	4.11	2.30	15.7	0.2	0.00	0.6	2.9	4.66
CT2A	07/28/00	28	4.9	29	9	7.98	9.9	16.6	29.1	0.2	0.00	0.6	3.2	5.05
CT2C	07/28/00	22	0.2	24	18	15.5	9.05	11.3	22.2	0.2	0.00	2.2	9.2	4.75
CT2D	07/28/00	35	7.3	55	15	23.5	20.6	10.7	51.8	0.4	0.00	1.7	5.8	4.82
CT4A	07/26/00	51	9.3	75	36	18.0	25.5	10.5	70.5	0.4	0.42	1.1	7.2	4.44
CT4B	07/26/00	27	1.8	27	26	4.49	7.40	5.37	23.9	0.2	0.00	1.1	3.1	4.59

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
CT4C	07/26/00	37	14.1	39	43	4.99	9.05	1.79	36.5	0.4	0.00	2.8	2.4	4.37
CT4D	07/26/00	31	1.5	64	17	21.0	17.3	10.2	50.0	0.2	0.00	1.1	5.5	4.76
CT4E	07/26/00	42	1.3	67	30	8.98	18.1	19.9	63.5	0.2	0.43	1.1	9.2	4.52
CT4F	07/26/00	23	2.7	39	19	6.99	8.23	3.32	36.1	0.2	0.00	1.1	2.9	4.71
CT5A	07/26/00	23	4.8	21	24	2.99	4.94	5.88	19.6	0.2	0.00	1.1	2.7	4.62
CT5D	07/26/00	38	10.1	42	37	7.49	14.8	4.09	40.0	0.3	0.00	2.8	4.4	4.43
CT5E	07/26/00	24	9.2	19	32	2.99	4.11	0.00	17.8	0.3	0.00	1.1	1.9	4.49
CT5F	07/26/00	17	3.0	16	20	2.99	0.00	1.53	14.8	0.2	0.00	1.1	1.9	4.70
H1A	07/26/00	26	6.3	36	26	10.0	12.3	14.1	33.9	0.4	0.37	2.8	8.5	4.58
H1B	07/26/00	25	7.5	21	29	4.99	5.76	1.02	19.1	0.3	0.00	1.7	6.0	4.54
H1C	07/26/00	34	12.0	52	28	12.0	18.1	22.8	44.8	0.7	0.49	7.2	10.5	4.55
H1D	07/26/00	33	11.1	45	38	11.5	14.0	17.6	36.5	0.5	0.52	6.1	10.2	4.42
H2A	07/26/00	21	0.2	15	8	5.49	9.9	27.6	11.7	0.2	0.00	0.6	7.2	5.10
H2B	07/26/00	30	8.3	47	21	12.5	18.1	43.5	40.5	0.6	0.63	1.1	15.4	4.68
H2C	07/26/00	28	3.1	42	22	17.0	14.8	18.9	36.5	0.3	0.57	11.1	8.7	4.65
H2D	07/26/00	35	5.3	31	24	10.5	13.2	27.9	25.2	0.5	0.44	1.7	9.1	4.62
H3A	07/26/00	52	13.1	58	45	24.0	22.2	32.5	58.7	0.8	0.92	2.8	17.3	4.35
H3B	07/26/00	37	8.0	35	14	16.0	22.2	38.6	29.1	0.6	0.43	0.6	11.3	4.84
H3C	07/26/00	31	5.8	26	14	18.0	12.3	49.4	23.5	0.5	0.44	2.2	12.0	4.85
H3D	07/26/00	28	3.2	28	14	13.5	14.0	32.2	30.0	0.5	0.50	1.1	11.2	4.86
H4A	07/26/00	40	4.0	58	37	14.0	17.3	27.6	48.7	0.5	0.80	4.4	15.6	4.43
H4B	07/26/00	43	11.2	34	44	11.0	13.2	15.3	38.7	0.5	0.65	1.1	11.4	4.36
H4C	07/26/00	31	6.5	27	24	7.49	9.9	15.3	24.8	0.3	0.00	2.8	6.4	4.62
H4D	07/26/00	32	3.3	34	16	15.5	17.3	34.0	33.9	0.5	0.90	3.3	12.3	4.79
H5A	07/26/00	24	2.1	22	20	8.48	9.05	19.4	21.3	0.4	0.00	0.6	8.9	4.70
H5B	07/26/00	45	5.1	58	44	15.5	19.7	24.5	62.2	0.6	0.76	1.1	16.7	4.36
H5C	07/26/00	42	0.3	66	38	19.5	18.9	38.1	68.7	0.7	0.90	1.1	25.0	4.42
H5D	07/26/00	47	4.1	63	35	15.0	20.6	26.6	70.5	0.6	0.88	2.8	17.3	4.46
H6A	07/26/00	45	6.5	74	29	15.0	22.2	33.2	67.0	0.5	0.56	4.4	13.2	4.54
H6B	07/26/00	50	18.9	79	41	17.5	25.5	27.9	75.7	0.8	0.72	44.3	14.2	4.39
H6C	07/26/00	22	5.4	31	12	8.98	11.5	21.7	23.9	0.4	0.00	4.4	6.5	4.93
H6D	07/26/00	43	9.5	61	38	16.0	21.4	26.8	61.3	0.6	0.69	1.1	14.5	4.42
HBULK	07/26/00	21	8.5	9	28	0.00	0.00	0.00	8.70	0.2	0.00	2.8	1.5	4.55
HT1D	07/26/00	21	4.0	15	1	14.0	18.9	18.9	13.5	0.5	0.00	0.6	4.6	6.09
HT1E	07/26/00	32	6.5	23	6	16.0	11.5	20.5	20.0	0.4	0.00	3.3	3.6	5.21
HT1F	07/26/00	19	4.4	15	1	13.5	18.1	13.0	13.5	0.4	0.00	1.7	4.4	5.84
HT2F	07/26/00	18	4.9	15	23	3.49	0.00	3.32	14.8	0.2	0.00	1.1	2.5	4.64
HT3A	07/26/00	38	8.0	40	40	12.0	16.5	12.5	45.2	0.7	0.84	5.0	13.7	4.40
HT3B	07/26/00	22	0.0	18	16	5.49	8.23	18.2	17.4	0.2	0.00	1.7	6.8	4.79
HT3C	07/26/00	67	13.2	65	51	19.5	23.9	21.5	80.9	0.9	1.23	7.8	19.0	4.29
HT3F	07/26/00	20	2.8	11	23	0.00	0.00	2.56	10.0	0.2	0.00	1.1	2.3	4.64
HT4B	07/26/00	15	0.6	13	13	0.00	0.00	5.63	12.2	0.1	0.00	2.2	2.0	4.89
HT4D	07/26/00	61	15.2	77	43	20.0	23.9	34.8	65.3	0.6	0.68	0.0	11.6	4.37
HT4F	07/26/00	24	8.1	18	30	3.99	4.11	0.00	17.4	0.3	0.00	1.7	2.4	4.52
PARKB	07/26/00	25	0.4	20	15	7.49	6.58	11.0	17.0	1.5	0.00	1.1	5.0	4.83
C1A	08/17/00	97	24.8	31	65	22.0	18.9	28.4	30.9	0.9	0.66	7.2	12.9	4.19
C1C	08/17/00	126	37.7	53	45	45.4	44.4	103	44.4	1.3	0.94	1.1	31.6	4.35
C2A	08/17/00	98	32.2	34	60	29.4	18.1	28.9	36.1	1.0	0.34	12.2	9.4	4.22
C2C	08/17/00	102	26.4	37	37	41.4	33.7	56.5	33.5	1.0	0.00	3.9	20.4	4.43
C3A	08/17/00	133	49.8	41	50	24.0	21.4	43.5	40.9	2.4	0.36	85.3	9.0	4.30
C3C	08/17/00	96	30.2	28	72	14.0	13.2	25.6	29.1	1.0	0.00	8.9	7.7	4.14

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C4A	08/17/00	162	33.7	97	25	73.4	70.7	125	92.7	1.8	1.54	18.8	34.5	4.60
C4C	08/17/00	277	82.4	181	112	88.3	113	84.4	222	3.4	2.42	37.1	46.2	3.95
C5A	08/17/00	243	106	129	55	88.3	101	192	122	4.6	2.37	55.4	51.6	4.26
C5C	08/17/00	111	20.2	36	17	51.4	32.1	70.3	25.2	1.2	0.35	0.6	11.7	4.77
C6A	08/17/00	125	24.0	40	63	24.5	27.1	55.0	45.7	1.1	0.87	6.1	16.4	4.20
C6C	08/17/00	100	32.3	35	60	16.0	18.9	42.2	34.8	1.0	0.51	11.1	11.4	4.22
CBULK	08/17/00	83	25.5	21	95	8.48	7.40	9.7	23.1	0.9	0.00	3.3	13.1	4.02
CT2A	08/17/00	122	21.0	33	71	21.5	14.8	51.9	30.5	0.7	0.00	1.1	8.7	4.15
CT2C	08/17/00	89	36.8	29	46	48.9	16.5	27.4	20.9	0.6	0.00	1.1	13.7	4.34
CT2D	08/17/00	152	30.8	49	71	63.9	39.5	38.6	63.5	1.3	0.56	12.7	16.8	4.15
CT4A	08/17/00	115	30.8	57	81	33.9	33.7	11.0	87.0	1.0	0.80	6.1	15.1	4.09
CT4B	08/17/00	54	0.3	24	40	8.48	9.9	11.0	25.2	0.5	0.00	0.6	7.5	4.40
CT4C	08/17/00	81	29.5	25	76	9.48	5.76	1.53	24.4	0.9	0.00	17.2	3.3	4.12
CT4D	08/17/00	96	8.5	59	43	43.4	27.1	22.2	77.4	0.5	0.44	1.7	13.2	4.37
CT4E	08/17/00	113	16.1	59	68	21.0	31.3	29.9	81.3	0.7	0.91	0.6	17.3	4.17
CT4F	08/17/00	71	13.0	15	63	39.9	5.76	1.79	17.8	0.5	0.00	0.0	4.4	4.20
CT5A	08/17/00	67	19.1	13	56	6.99	6.58	5.88	16.1	0.8	0.00	0.0	4.6	4.25
CT5D	08/17/00	102	29.1	43	83	17.5	24.7	8.44	61.3	0.9	0.57	0.6	10.7	4.08
CT5E	08/17/00	68	25.6	19	78	9.48	4.11	2.05	18.7	0.8	0.00	8.9	4.5	4.11
CT5F	08/17/00	58	13.8	24	58	13.5	4.11	3.07	21.3	0.5	0.00	2.8	4.1	4.24
H1A	08/17/00	168	53.0	85	100	50.4	51.0	57.3	96.1	2.7	1.34	46.0	31.4	4.00
H1C	08/17/00	161	56.8	112	79	41.4	55.9	76.5	113	2.4	1.31	44.9	27.7	4.10
H2A	08/17/00	80	33.6	19	65	12.5	11.5	29.2	17.4	1.3	0.00	22.2	13.8	4.19
H2C	08/17/00	125	38.5	64	65	35.9	37.8	66.5	65.3	1.6	1.02	16.1	26.5	4.19
H3A	08/17/00	262	59.8	111	93	93.3	79.0	137	108	3.1	2.39	43.2	48.2	4.03
H3C	08/17/00	192	15.4	93	5	66.9	51.8	578	43.9	2.4	1.80	7.8	92.8	5.32
H4A	08/17/00	258	25.5	137	123	68.4	73.2	104	150	2.1	2.64	13.9	46.9	3.91
H4C	08/17/00	170	33.0	54	68	40.4	43.6	72.4	65.7	1.7	1.08	15.5	22.9	4.17
H5A	08/17/00	110	24.1	45	32	36.4	33.7	102	41.3	1.4	0.68	9.4	27.1	4.50
H5C	08/17/00	225	10.4	136	87	87.8	76.5	106	153	2.0	2.26	12.2	52.0	4.06
H6A	08/17/00	206	54.8	135	100	48.9	61.7	91.3	152	1.9	1.26	22.2	30.3	4.00
H6C	08/17/00	129	48.3	45	78	31.4	30.4	50.1	41.8	1.7	0.78	26.0	15.4	4.11
HBULK	08/17/00	82	36.6	17	87	6.49	4.11	1.53	17.0	1.0	0.00	18.8	4.0	4.06
HT1D	08/17/00	91	32.1	30	8	50.9	39.5	48.8	29.1	1.3	0.00	13.9	13.4	5.09
HT1E	08/17/00	126	42.9	42	34	46.9	23.0	70.3	34.8	1.5	0.52	27.7	10.1	4.47
HT1F	08/17/00	132	45.2	33	5	60.9	47.7	60.6	27.8	2.1	0.38	39.9	13.1	5.26
HT2F	08/17/00	78	29.6	18	78	7.49	4.94	5.11	19.1	0.9	0.00	19.9	2.6	4.11
HT3A	08/17/00	215	31.8	101	135	57.9	69.1	44.5	135	1.9	2.25	10.5	39.1	3.87
HT3B	08/17/00	110	28.2	51	52	25.4	24.7	71.9	59.6	1.2	0.51	12.2	18.5	4.28
HT3C	08/17/00	289	60.3	135	148	73.9	77.3	80.5	169	2.5	2.55	23.3	40.2	3.83
HT3F	08/17/00	66	18.2	14	62	6.99	4.11	4.86	15.7	0.7	0.00	16.1	5.4	4.21
HT4B	08/17/00	68	8.7	32	45	11.5	9.05	31.5	33.1	0.4	0.00	1.7	9.4	4.35
HT4D	08/17/00	176	46.7	77	83	40.9	42.0	79.5	80.9	1.5	1.00	7.8	18.5	4.08
HT4F	08/17/00	85	33.2	21	81	6.99	5.76	1.79	23.9	0.8	0.00	19.4	3.6	4.09
PARKB	08/17/00	104	35.1	19	120	7.98	4.94	1.28	18.3	1.1	0.00	12.2	5.2	3.92
C1A	09/20/00	47	10.7	25	22	12.0	10.7	27.1	30.9	0.7	0.00	1.1	8.0	4.65
C1C	09/20/00	56	16.4	48	6	30.4	25.5	84.6	38.3	0.9	0.61	2.2	16.9	5.20
C2A	09/20/00	51	23.0	39	22	15.5	10.7	23.5	38.7	1.2	0.00	18.3	4.3	4.65
C2C	09/20/00	56	15.9	39	8	31.4	24.7	48.1	36.5	1.2	0.00	1.7	10.5	5.12
C3A	09/20/00	58	27.0	42	39	14.5	13.2	24.5	40.5	1.2	0.00	6.1	4.4	4.41
C3C	09/20/00	47	22.4	29	43	9.48	11.5	18.9	30.9	0.9	0.00	3.3	6.1	4.37

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C4A	09/20/00	89	63.8	80	21	47.4	44.4	90.0	58.7	2.6	1.06	19.4	18.1	4.68
C4C	09/20/00	144	80.6	173	52	69.4	74.0	68.3	169	3.2	1.85	37.7	28.6	4.28
C5A	09/20/00	141	116	112	55	53.9	63.3	132	84.4	3.6	1.63	29.9	23.4	4.26
C5C	09/20/00	52	10.2	40	2	36.4	23.9	74.7	33.9	1.0	0.38	1.7	10.9	5.79
C6A	09/19/00	73	19.4	51	19	18.0	18.9	82.8	43.9	1.2	0.97	2.2	12.7	4.72
C6C	09/19/00	53	23.4	34	46	11.5	11.5	25.3	35.2	0.8	0.39	2.8	8.5	4.34
CBULK	09/20/00	45	18.1	24	60	5.49	6.58	4.60	25.7	0.6	0.00	1.1	10.3	4.22
CT2A	09/20/00	55	12.1	44	25	16.0	12.3	28.4	42.2	0.7	0.00	1.1	4.6	4.60
CT2C	09/20/00	47	15.4	29	10	35.9	9.9	24.3	26.1	0.6	0.00	1.7	4.9	4.99
CT2D	09/20/00	59	14.4	56	17	47.4	28.8	21.2	49.6	1.1	0.46	2.8	10.0	4.76
CT4A	09/19/00	77	32.7	80	58	25.4	23.0	15.1	71.8	1.6	0.58	17.2	9.4	4.24
CT4B	09/19/00	47	19.5	31	41	9.48	10.7	14.3	31.3	0.6	0.00	1.7	4.1	4.39
CT4C	09/19/00	54	21.7	34	54	7.98	7.40	1.28	35.2	0.6	0.00	7.8	2.4	4.27
CT4D	09/19/00	66	37.6	64	50	35.9	21.4	17.1	64.8	1.0	0.49	2.8	8.7	4.30
CT4E	09/19/00	73	25.5	41	56	19.0	22.2	25.6	44.8	0.7	1.10	2.2	14.7	4.25
CT4F	09/19/00	56	27.1	37	54	13.5	9.05	5.37	41.3	0.7	0.00	6.1	3.9	4.27
CT5A	09/19/00	54	25.4	35	47	10.5	10.7	8.95	34.4	0.7	0.00	8.3	4.8	4.33
CT5D	09/19/00	73	38.3	80	71	20.0	24.7	10.5	73.5	1.0	0.58	8.3	7.6	4.15
CT5E	09/19/00	48	20.7	28	62	6.49	5.76	3.58	30.9	0.7	0.00	1.1	5.2	4.21
CT5F	09/19/00	53	26.4	28	58	8.98	5.76	2.56	29.1	0.7	0.00	7.8	3.1	4.24
H1A	09/21/00	120	66.8	123	42	46.9	50.2	61.6	94.0	3.2	1.33	94.2	22.2	4.38
H1C	09/21/00	81	50.1	99	22	26.4	34.5	76.2	68.7	2.4	0.98	45.4	17.7	4.66
H2A	09/21/00	47	21.8	33	11	10.5	14.0	47.0	28.7	1.6	0.00	30.5	12.5	4.95
H2C	09/21/00	91	48.0	82	25	28.4	32.9	72.6	53.9	2.5	0.94	52.1	20.5	4.60
H3A	09/21/00	156	76.4	139	23	60.9	51.8	117	98.7	4.3	1.75	107	29.2	4.63
H3C	09/21/00	129	44.2	92	24	61.9	43.6	103	60.5	3.1	1.29	84.8	27.9	4.62
H4A	09/21/00	149	42.7	105	85	42.4	43.6	71.3	88.7	1.7	1.71	16.6	23.7	4.07
H4C	09/21/00	106	60.4	116	72	36.4	39.5	50.9	94.8	1.7	0.96	16.1	15.6	4.14
H5A	09/21/00	65	16.5	50	13	25.9	24.7	105	46.1	1.4	0.70	10.0	21.8	4.88
H5C	09/21/00	132	22.6	104	44	51.9	50.2	89.5	90.9	2.1	1.61	28.8	39.2	4.36
H6A	09/21/00	159	111	210	93	60.4	74.9	83.9	180	3.1	1.37	22.2	22.0	4.03
H6C	09/21/00	87	44.1	105	2	30.9	33.7	61.1	67.4	3.3	0.68	188	15.2	5.66
HBULK	09/21/00	48	20.4	20	51	3.99	4.94	1.28	22.2	0.6	0.00	6.1	3.5	4.29
HT1D	09/21/00	48	10.5	10	1	39.4	34.5	70.3	27.0	1.1	0.00	1.1	13.9	6.07
HT1E	09/21/00	77	25.8	48	2	36.9	20.6	88.2	39.6	1.2	0.47	17.7	10.7	5.73
HT1F	09/21/00	66	27.2	33	2	40.4	35.4	53.2	29.6	1.1	0.00	3.9	10.2	5.62
HT2F	09/21/00	48	19.4	19	44	4.99	4.94	4.60	21.8	0.7	0.00	12.2	3.3	4.36
HT3A	09/21/00	151	71.0	151	93	59.4	69.1	40.7	134	2.3	2.03	26.6	24.8	4.03
HT3B	09/21/00	63	22.8	50	27	16.5	20.6	64.4	46.1	1.1	0.44	2.2	14.4	4.57
HT3C	09/21/00	216	145	209	110	85.3	83.9	75.4	196	4.4	2.53	78.1	28.7	3.96
HT3F	09/21/00	41	16.2	21	34	6.99	6.58	11.8	20.0	1.0	0.00	10.5	6.6	4.47
HT4B	09/21/00	50	9.2	19	42	5.99	5.76	10.5	22.2	0.4	0.00	1.1	6.1	4.38
HT4D	09/21/00	151	115	147	102	57.9	55.9	62.9	138	2.6	1.31	12.7	17.9	3.99
HT4F	09/21/00	62	32.6	46	54	7.49	11.5	2.56	55.7	0.8	0.41	15.0	3.0	4.27
PARKB	09/20/00	46	13.7	17	50	3.99	4.11	0.00	20.4	0.5	0.00	1.7	2.4	4.30
C1A	10/12/00	40	3.0	37	1	12.5	13.2	59.1	23.9	0.4	0.00	1.1	9.9	5.95
C1B	10/12/00	74	0.2	95	0	40.9	29.6	132	22.6	0.7	0.00	1.7	13.5	6.49
C1C	10/12/00	36	6.8	59	1	17.0	17.3	78.8	36.5	0.5	0.00	1.1	11.5	6.02
C1D	10/12/00	35	13.6	47	5	14.0	12.3	64.7	21.8	0.4	0.00	1.1	8.8	5.29
C2A	10/12/00	29	4.7	38	1	12.5	9.9	46.8	25.7	0.5	0.00	1.1	6.1	5.99
C2B	10/12/00	34	3.2	45	1	15.5	12.3	55.0	28.7	0.4	0.00	1.1	4.5	6.24

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
C2C	10/12/00	27	2.4	35	1	13.0	12.3	45.3	23.9	0.3	0.00	0.6	6.5	6.26
C2D	10/12/00	26	11.5	31	9	13.5	11.5	26.8	19.6	0.4	0.00	0.6	5.1	5.05
C3A	10/12/00	62	7.7	81	13	16.0	14.0	85.7	26.5	0.3	0.00	1.1	6.5	4.90
C3B	10/12/00	30	14.7	39	18	12.0	12.3	22.2	34.4	0.5	0.00	1.1	4.9	4.74
C3C	10/12/00	28	11.8	33	19	6.49	8.23	26.6	21.8	0.3	0.00	0.6	3.5	4.72
C3D	10/12/00	31	8.5	43	8	11.0	14.0	42.7	19.6	0.3	0.00	1.1	5.7	5.11
C4A	10/12/00	41	38.8	64	24	23.0	22.2	41.7	60.0	1.1	0.00	1.7	9.5	4.62
C4B	10/12/00	57	18.6	104	7	33.9	33.7	82.1	66.6	0.7	0.00	1.1	15.6	5.13
C4C	10/12/00	77	60.8	129	51	41.9	46.9	40.7	129	1.6	0.89	2.8	20.3	4.29
C4D	10/12/00	46	0.2	101	1	31.4	26.3	106	47.4	0.6	0.00	1.1	13.5	6.07
C5A	10/12/00	85	57.8	104	18	27.4	31.3	115	70.9	2.0	0.41	13.3	13.1	4.75
C5B	10/12/00	33	10.8	41	1	17.0	13.2	63.4	26.5	0.5	0.00	1.1	6.4	6.24
C5C	10/12/00	48	0.0	70	0	28.9	21.4	142	24.4	0.4	0.00	1.1	16.5	6.69
C5D	10/12/00	53	0.0	53	0	19.0	14.0	177	23.9	0.4	0.00	1.1	22.9	6.52
C6A	10/13/00	55	23.1	43	28	15.0	16.5	44.7	39.2	0.8	0.43	1.7	10.8	4.55
C6B	10/13/00	36	4.1	42	17	18.0	22.2	17.1	35.2	0.4	0.00	2.8	8.1	4.78
C6C	10/13/00	33	16.3	36	22	10.5	13.2	26.6	30.0	0.5	0.38	4.4	15.3	4.65
C6D	10/13/00	27	7.1	35	7	14.5	11.5	46.0	25.7	0.3	0.00	1.1	13.3	5.18
CBULK	10/12/00	23	9.9	20	31	2.99	4.11	1.79	19.6	0.3	0.00	1.1	4.5	4.51
CT2A	10/12/00	31	0.2	52	1	14.5	15.6	39.4	35.2	0.2	0.00	1.1	4.8	5.85
CT2C	10/12/00	23	0.0	42	0	26.9	14.0	36.3	21.8	0.4	0.00	1.1	5.9	6.40
CT2D	10/12/00	38	21.2	78	4	29.9	19.7	55.2	53.5	0.7	0.00	1.1	8.7	5.38
CT4A	10/13/00	34	12.9	50	30	11.5	12.3	6.90	43.9	0.4	0.00	2.2	4.4	4.53
CT4B	10/13/00	30	9.3	30	18	7.98	9.05	21.2	23.5	0.3	0.00	1.1	5.2	4.74
CT4C	10/13/00	34	14.8	48	35	4.99	10.7	1.79	44.8	0.3	0.00	1.7	1.2	4.46
CT4D	10/13/00	40	22.3	50	28	21.0	13.2	15.3	43.5	0.6	0.00	2.2	5.0	4.56
CT4E	10/13/00	37	13.1	65	33	7.98	14.0	6.90	64.8	0.4	0.00	1.7	4.4	4.48
CT4F	10/13/00	38	25.3	33	35	8.48	9.05	3.84	35.7	0.5	0.00	5.0	2.1	4.45
CT5A	10/13/00	27	13.7	27	28	4.99	6.58	8.69	25.2	0.4	0.00	2.2	5.0	4.56
CT5D	10/13/00	44	30.7	48	48	10.5	15.6	6.39	43.1	0.7	0.00	4.4	4.3	4.32
CT5E	10/13/00	33	15.8	32	35	4.49	7.40	0.00	31.8	0.4	0.00	4.4	2.2	4.45
CT5F	10/13/00	34	18.7	26	39	4.99	6.58	0.00	26.1	0.4	0.00	2.8	1.9	4.41
H1A	10/12/00	53	28.9	80	32	21.5	24.7	44.2	52.6	1.4	0.48	18.3	16.0	4.50
H1B	10/12/00	29	16.0	27	5	6.99	8.23	25.1	18.7	1.0	0.00	27.1	6.6	5.29
H1C	10/12/00	22	12.4	33	8	6.49	9.05	42.7	22.2	0.6	0.00	6.1	8.9	5.08
H1D	10/12/00	35	23.5	35	16	8.98	10.7	35.3	25.2	1.0	0.00	22.2	7.9	4.80
H2A	10/12/00	28	14.9	19	21	6.49	8.23	29.4	14.4	0.5	0.00	2.2	7.7	4.68
H2B	10/12/00	52	40.0	70	39	20.0	25.5	37.6	67.0	1.0	0.00	8.9	11.5	4.41
H2C	10/12/00	44	23.6	53	22	14.0	18.9	46.5	36.5	0.8	0.00	8.3	12.1	4.65
H2D	10/12/00	32	16.9	40	20	10.0	11.5	39.1	28.3	0.6	0.00	6.6	9.0	4.70
H3A	10/12/00	69	42.8	80	30	27.4	24.7	99.5	62.2	1.2	0.63	5.5	21.9	4.53
H3B	10/12/00	36	18.4	46	2	14.0	12.3	104	25.7	0.8	0.00	2.8	17.6	5.62
H3C	10/12/00	36	11.6	46	21	18.0	12.3	70.3	25.7	0.5	0.00	1.1	18.9	4.67
H3D	10/12/00	42	25.2	47	13	17.0	14.8	69.8	33.9	0.8	0.00	3.9	14.6	4.87
H4A	10/12/00	63	26.2	73	50	21.0	23.9	34.3	60.0	0.8	0.52	5.5	12.6	4.30
H4B	10/12/00	69	46.0	99	55	24.5	27.1	38.1	86.1	1.2	0.49	9.4	11.3	4.26
H4C	10/12/00	39	21.9	41	32	10.0	11.5	24.3	36.5	0.6	0.00	5.0	7.3	4.49
H4D	10/12/00	70	17.5	61	28	31.4	32.9	61.4	51.8	0.8	1.30	1.1	20.3	4.55
H5A	10/12/00	34	13.1	35	9	12.0	11.5	62.4	22.6	0.5	0.00	1.1	10.7	5.03
H5B	10/12/00	57	40.5	81	50	21.5	25.5	33.5	61.8	1.2	0.00	15.0	12.9	4.30
H5C	10/12/00	66	15.6	87	39	28.9	28.8	46.0	63.9	0.9	0.58	10.0	17.7	4.41

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H5D	10/12/00	69	40.2	104	48	23.5	31.3	38.4	86.1	1.4	0.48	13.9	15.8	4.32
H6A	10/12/00	71	50.5	129	51	26.4	34.5	51.4	101	1.5	0.39	13.9	14.5	4.29
H6B	10/12/00	85	90.8	178	56	35.9	48.5	48.8	154	2.2	0.68	32.7	15.6	4.25
H6C	10/12/00	36	23.0	41	13	12.0	13.2	33.8	30.5	0.9	0.00	19.9	9.2	4.87
H6D	10/12/00	75	59.3	132	58	32.4	40.3	57.5	92.7	1.6	0.47	13.9	15.3	4.24
HBULK	10/12/00	19	10.0	9	76	0.00	0.00	0.00	7.83	0.2	0.00	2.8	1.3	4.12
HT1D	10/12/00	29	12.4	29	3	22.0	16.5	40.4	18.7	0.4	0.00	1.7	6.7	5.60
HT1E	10/12/00	64	10.3	53	2	28.9	17.3	88.7	21.3	0.4	0.00	1.1	9.1	5.67
HT1F	10/12/00	39	7.0	41	0	39.9	32.1	59.1	16.5	0.4	0.00	1.1	9.9	6.85
HT2F	10/12/00	19	6.6	9	19	2.50	0.00	2.56	8.27	0.2	0.00	1.7	1.9	4.72
HT3A	10/12/00	78	44.5	101	63	30.9	38.7	23.0	94.0	1.3	0.72	11.1	15.5	4.20
HT3B	10/12/00	31	12.7	30	14	8.48	11.5	31.7	24.4	0.5	0.00	2.8	6.9	4.86
HT3C	10/12/00	105	81.3	146	76	44.4	47.7	34.3	137	2.0	1.00	20.5	15.4	4.12
HT3F	10/12/00	22	10.8	11	26	2.99	0.00	2.81	10.0	0.3	0.00	1.7	2.0	4.58
HT4B	10/12/00	25	3.9	20	16	4.49	5.76	7.16	20.4	0.2	0.00	1.1	3.2	4.80
HT4D	10/12/00	73	63.6	103	66	25.9	28.8	29.2	98.3	1.4	0.37	7.8	9.0	4.18
HT4F	10/12/00	31	19.2	25	32	5.49	5.76	0.00	26.5	0.4	0.00	6.1	1.4	4.49
PARKB	10/12/00	21	7.3	17	7	2.50	0.00	9.7	17.4	0.5	0.00	6.1	2.0	5.17
C1A	11/01/00	20	4.2	48	1	11.5	14.8	43.0	31.8	0.2	0.37	1.7	11.7	5.93
C1C	11/01/00	19	3.5	39	0	10.5	12.3	38.9	27.4	0.2	0.00	1.7	6.4	6.36
C2A	11/01/00	47	0.0	64	1	16.5	14.8	84.6	22.6	0.3	0.00	1.1	7.1	6.30
C2C	11/01/00	17	0.4	31	0	12.0	12.3	37.1	19.1	0.2	0.00	1.1	6.0	6.39
C3A	11/01/00	54	0.1	87	0	18.5	18.9	113	20.0	0.2	0.00	1.1	12.9	6.34
C3C	11/01/00	34	0.2	57	2	16.0	21.4	84.6	30.5	0.2	0.00	2.8	19.7	5.69
C4A	11/01/00	26	28.3	59	13	18.0	17.3	37.1	43.9	0.7	0.00	2.2	6.6	4.88
C4C	11/01/00	51	48.5	148	23	42.4	50.2	50.9	121	1.2	0.81	1.7	18.2	4.64
C5A	11/01/00	93	33.0	114	4	40.4	40.3	115	59.2	0.9	0.40	2.2	12.7	5.41
C5C	11/01/00	36	0.3	52	0	20.5	20.6	108	28.3	0.2	0.00	2.2	11.6	7.00
C6A	11/03/00	32	10.5	56	13	15.5	18.9	44.5	40.9	0.5	0.67	0.6	12.2	4.89
C6C	11/03/00	23	11.4	38	16	8.48	10.7	16.1	32.6	0.4	0.44	1.1	6.2	4.79
CBULK	11/01/00	16	3.3	18	14	2.99	0.00	3.84	18.7	0.1	0.00	2.8	2.6	4.85
CT2A	11/01/00	36	1.3	81	2	16.0	19.7	54.0	37.0	0.2	0.00	1.1	3.4	5.65
CT2C	11/01/00	23	0.2	127	0	65.4	70.7	124	24.4	0.6	1.14	1.7	36.2	6.91
CT2D	11/01/00	37	17.1	128	2	36.9	28.0	65.2	83.1	0.5	0.47	1.7	11.6	5.75
CT4A	11/03/00	38	28.1	95	31	21.5	23.9	11.5	87.4	0.6	0.00	2.8	5.2	4.51
CT4B	11/03/00	19	5.5	22	15	3.99	5.76	3.07	21.3	0.1	0.00	0.6	1.2	4.82
CT4C	11/03/00	20	6.2	36	15	3.99	7.40	1.28	32.6	0.1	0.00	1.7	0.7	4.81
CT4D	11/03/00	18	7.2	43	11	9.48	9.05	5.88	36.1	0.2	0.00	1.1	2.2	4.95
CT4E	11/03/00	22	10.0	53	21	5.99	10.7	4.35	47.4	0.2	0.00	0.6	2.3	4.67
CT4F	11/03/00	16	5.6	19	13	2.99	3.29	1.28	16.1	0.1	0.00	2.2	0.8	4.88
CT5A	11/03/00	20	4.8	24	16	3.99	5.76	7.16	23.5	0.2	0.00	0.6	0.7	4.80
CT5D	11/03/00	32	20.7	74	31	11.5	18.9	5.88	58.7	0.4	0.00	3.3	3.4	4.51
CT5E	11/03/00	15	4.0	22	14	2.50	4.11	0.00	21.3	0.1	0.00	1.1	0.5	4.86
CT5F	11/03/00	11	4.4	15	11	2.50	0.00	0.00	14.8	0.1	0.00	0.6	0.5	4.95
H1A	11/02/00	27	15.7	45	10	13.5	13.2	31.5	30.9	1.0	0.00	12.2	10.3	5.01
H1C	11/02/00	21	19.1	37	13	10.0	14.0	28.6	27.0	0.7	0.40	4.4	8.3	4.87
H2A	11/02/00	18	6.4	33	9	5.49	8.23	45.8	18.7	0.2	0.00	1.7	9.8	5.05
H2C	11/02/00	22	13.8	38	10	7.98	9.9	24.0	29.6	0.6	0.00	7.8	5.8	4.98
H3A	11/02/00	25	22.5	34	16	11.5	10.7	33.2	26.5	0.9	0.40	1.7	7.6	4.80
H3C	11/02/00	27	8.4	50	9	15.5	13.2	75.4	16.5	0.4	0.00	1.7	18.5	5.05
H4A	11/02/00	22	17.8	35	22	9.48	10.7	15.1	27.8	0.6	0.39	2.2	5.7	4.65

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H4C	11/02/00	33	38.0	48	30	13.0	15.6	28.9	37.4	0.9	0.45	7.2	7.5	4.52
H5A	11/02/00	13	2.0	16	2	2.99	0.00	25.6	13.1	0.2	0.00	3.9	5.0	5.63
H5C	11/02/00	42	24.7	78	24	21.5	22.2	39.1	57.0	0.9	0.60	8.3	11.7	4.62
H6A	11/02/00	43	53.5	103	37	20.5	28.0	39.4	91.8	1.2	0.52	9.4	9.8	4.43
H6C	11/02/00	14	7.4	41	9	11.0	11.5	32.7	14.4	0.4	0.00	2.2	7.4	5.03
HBULK	11/02/00	10	1.9	8	10	0.00	0.00	1.28	8.27	0.1	0.00	1.7	0.8	4.98
HT1D	11/02/00	23	0.2	52	0	23.0	22.2	66.7	16.5	0.2	0.00	2.2	12.5	6.36
HT1E	11/02/00	53	0.2	56	0	30.9	30.4	94.4	20.0	0.3	0.00	2.2	14.9	6.64
HT1F	11/02/00	55	0.0	45	2	28.9	31.3	77.0	13.1	0.2	0.00	2.2	15.4	5.71
HT2F	11/02/00	11	2.0	9	9	0.00	0.00	3.84	8.70	0.1	0.00	1.1	1.3	5.05
HT3A	11/02/00	41	53.9	68	39	24.5	29.6	16.6	53.1	1.2	0.70	11.1	7.9	4.41
HT3B	11/02/00	16	10.1	19	12	4.99	8.23	14.3	15.2	0.3	0.00	2.8	3.9	4.92
HT3C	11/02/00	41	54.3	66	35	22.0	24.7	17.9	60.9	1.5	0.69	16.6	9.0	4.46
HT3F	11/02/00	15	3.5	11	12	2.50	0.00	4.09	11.3	0.1	0.00	5.0	1.6	4.91
HT4B	11/02/00	14	3.2	20	11	2.50	4.11	3.07	19.6	0.1	0.00	1.1	0.9	4.95
HT4D	11/02/00	65	90.4	125	65	34.4	39.5	25.1	119	1.7	0.78	10.5	7.4	4.19
HT4F	11/02/00	15	4.0	19	11	2.99	4.11	0.00	19.6	0.1	0.00	3.3	0.7	4.95
PARKB	11/01/00	14	1.2	16	11	0.00	0.00	0.00	16.5	0.1	0.00	1.1	0.7	4.95
C1A	11/15/00	16	2.0	21	10	3.99	4.94	8.44	22.2	0.1	0.07	0.6	2.2	5.01
C1C	11/15/00	29	1.9	34	5	7.98	9.05	27.1	32.6	0.2	0.22	1.1	4.0	5.26
C2A	11/15/00	15	2.2	17	10	5.49	4.94	7.16	17.4	0.1	0.07	0.6	2.2	5.01
C2C	11/15/00	20	2.5	21	11	6.49	6.58	9.7	20.4	0.1	0.09	0.6	2.3	4.97
C3A	11/15/00	14	1.3	16	6	3.99	4.11	9.46	15.2	0.1	0.11	0.6	2.0	5.20
C3C	11/15/00	12	2.4	15	10	2.00	3.29	5.11	14.8	0.1	0.06	1.1	1.6	5.00
C4A	11/15/00	46	2.8	36	29	12.0	12.3	18.9	39.2	0.4	0.37	0.6	8.4	4.54
C4C	11/15/00	43	1.1	49	28	12.0	13.2	14.1	55.7	0.3	0.40	1.1	9.9	4.55
C5A	11/15/00	94	5.8	70	32	22.0	28.0	42.2	87.0	0.5	0.46	1.1	10.9	4.49
C5C	11/15/00	17	0.2	20	1	5.49	6.58	22.2	18.3	0.1	0.07	1.1	2.6	6.01
C6A	11/15/00	26	0.3	11	14	4.99	5.76	21.7	13.9	0.2	0.50	1.1	8.3	4.86
C6C	11/15/00	37	2.7	14	19	6.49	8.23	14.6	15.2	0.2	0.29	1.1	4.2	4.71
CBULK	11/15/00	14	2.6	12	17	1.50	2.47	0.77	12.2	0.1	0.06	1.1	3.1	4.77
CT2A	11/15/00	17	1.7	18	7	4.99	4.94	11.3	17.8	0.1	0.06	0.6	2.1	5.16
CT2C	11/15/00	14	0.3	22	2	10.0	10.7	23.3	14.8	0.2	0.09	1.1	6.4	5.75
CT2D	11/15/00	20	2.4	30	7	8.98	7.40	10.5	29.6	0.1	0.10	0.6	2.8	5.15
CT4A	11/15/00	55	3.1	22	35	11.0	10.7	3.32	32.2	0.3	0.20	1.7	4.6	4.46
CT4B	11/15/00	16	2.6	10	13	1.50	2.47	3.58	10.0	0.1	0.04	1.1	1.3	4.88
CT4C	11/15/00	17	3.5	16	18	2.50	3.29	0.77	15.7	0.1	0.05	1.1	0.8	4.74
CT4D	11/15/00	32	5.4	16	30	7.49	4.94	3.32	17.0	0.2	0.09	1.7	3.0	4.53
CT4E	11/15/00	75	10.5	28	51	10.0	18.1	6.65	37.0	0.3	0.23	1.1	5.5	4.29
CT4F	11/15/00	18	3.3	8	19	2.00	1.65	0.51	7.40	0.1	0.04	1.7	1.2	4.72
CT5A	11/15/00	24	3.5	8	19	2.50	4.11	2.81	9.57	0.1	0.07	1.1	1.4	4.73
CT5D	11/15/00	24	2.8	14	22	2.99	4.11	2.56	17.4	0.2	0.21	1.1	1.9	4.65
CT5E	11/15/00	14	3.9	12	15	1.50	2.47	0.77	12.2	0.1	0.10	1.1	0.9	4.81
CT5F	11/15/00	15	4.1	8	17	1.00	1.65	0.77	7.83	0.1	0.04	1.7	1.0	4.77
H1A	11/16/00	28	2.6	17	19	6.49	5.76	17.6	18.3	0.4	0.29	4.4	8.3	4.71
H1C	11/16/00	20	3.1	10	16	3.49	4.11	10.0	13.1	0.3	0.21	1.7	4.6	4.79
H2A	11/16/00	13	2.9	7	13	2.00	2.47	4.86	6.53	0.1	0.08	0.6	2.2	4.89
H2C	11/16/00	46	5.5	18	27	7.49	9.9	17.4	23.1	0.4	0.31	1.1	6.7	4.57
H3A	11/16/00	41	2.3	16	31	11.0	7.40	24.5	22.6	0.4	0.51	1.1	11.7	4.51
H3C	11/16/00	29	1.3	13	28	8.98	5.76	22.8	14.8	0.3	0.36	1.7	10.4	4.56
H4A	11/16/00	53	1.9	13	37	6.99	7.40	14.8	26.1	0.4	0.51	1.7	9.9	4.43

Table D.1. continued.

Site	Collection	SO_4	NO_3	Cl	H^+	Ca	Mg	K	Na	Total N	Al	NH_4	DOC	EqpH
		ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	ueq/L	mg/L N	umol/L	ueq/L	mg/L	
H4C	11/16/00	30	3.3	16	21	4.49	5.76	19.2	14.8	0.3	0.36	1.1	6.8	4.68
H5A	11/16/00	23	1.5	10	6	3.99	3.29	45.0	16.1	0.3	0.18	1.1	8.7	5.25
H5C	11/16/00	58	1.1	23	29	14.5	13.2	27.4	39.2	0.5	0.58	2.8	13.7	4.54
H6A	11/16/00	29	1.6	18	22	4.49	5.76	16.6	23.5	0.3	0.26	1.1	7.4	4.66
H6C	11/16/00	17	2.1	7	15	2.99	2.47	4.35	7.40	0.2	0.11	1.1	2.7	4.81
HBULK	11/16/00	11	2.9	6	12	1.00	0.82	1.02	5.22	0.1	0.04	0.6	0.9	4.91
HT1D	11/16/00	13	1.8	8	7	4.99	3.29	8.18	8.27	0.1	0.06	1.1	2.2	5.13
HT1E	11/16/00	16	1.5	9	4	6.49	4.94	16.4	10.4	0.2	0.11	0.6	3.4	5.36
HT1F	11/16/00	16	1.8	10	12	6.99	5.76	5.37	9.57	0.2	0.07	1.1	2.5	4.91
HT2F	11/16/00	15	2.9	6	14	1.50	1.65	1.53	6.09	0.1	0.06	1.1	1.2	4.85
HT3A	11/16/00	39	2.6	10	30	6.49	7.40	7.16	22.2	0.4	0.39	2.2	8.0	4.52
HT3B	11/16/00	20	1.2	10	7	2.50	3.29	22.0	9.57	0.2	0.13	0.6	4.1	5.18
HT3C	11/16/00	58	9.5	19	41	8.48	9.05	11.5	35.7	0.5	0.48	3.3	8.6	4.39
HT3F	11/16/00	12	3.4	5	14	1.00	0.82	0.51	4.35	0.1	0.06	1.7	1.1	4.85
HT4B	11/16/00	20	3.3	9	15	3.49	3.29	2.30	10.0	0.1	0.06	1.1	1.1	4.83
HT4D	11/16/00	65	7.5	23	40	9.48	11.5	13.8	35.7	0.4	0.30	0.6	6.7	4.40
HT4F	11/16/00	19	5.8	7	20	2.50	1.65	0.77	6.96	0.2	0.07	0.6	1.0	4.70
PARKB	11/15/00	15	2.5	5	19	1.00	0.82	0.51	4.35	0.1	0.07	1.1	1.2	4.73

Table D.2. Throughfall volumes and deposition of major ions for the PRIMENet watersheds and McFarland Hill bulk collector for 1999 and 2000.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C1A	08/25/99	631	13.1	19.4	12.5	9.2	9.3	1.7	18.2	27.6	12.6	0.44	25.7
C1B	08/25/99	739	10.1	15.5	14.6	12.7	8.5	2.4	14.7	30.9	12.7	0.40	29.4
C1C	08/25/99	725	28.7	17.1	6.7	14.6	13.1	0.2	18.8	29.6	9.2	0.47	27.6
C1D	08/25/99	698	13.6	15.1	13.8	10.9	9.1	1.0	15.3	29.9	13.7	0.52	28.3
C2A	08/25/99	712	34.6	18.3	4.0	18.0	13.4	0.4	24.1	36.1	12.5	0.43	33.6
C2B	08/25/99	674	36.0	23.8	1.9	18.1	13.8	1.7	27.8	39.6	13.2	0.54	36.7
C2C	08/25/99	922	27.0	19.2	10.8	26.6	16.2	3.0	24.8	40.4	15.3	0.64	37.8
C2D	08/25/99	569	8.3	13.4	11.8	9.6	7.5	3.6	11.0	25.8	11.3	0.34	24.6
C3A	08/25/99	965	14.7	19.6	22.5	10.1	9.5	5.9	18.2	41.8	18.8	0.53	39.9
C3B	08/25/99	704	21.1	42.4	21.6	18.7	23.3	3.7	46.6	55.7	28.6	1.19	50.9
C3C	08/25/99	878	13.4	16.3	19.1	5.9	8.3	6.0	16.6	34.1	14.8	0.52	32.4
C3D	08/25/99	842	14.5	16.8	15.6	9.2	11.4	4.2	18.9	33.5	15.9	0.46	31.6
C4A	08/25/99	586	27.1	37.7	15.3	24.1	22.8	4.0	42.0	47.2	28.4	0.85	42.9
C4B	08/25/99	547	50.0	68.1	13.6	39.4	43.4	4.2	88.7	71.6	34.6	1.33	62.4
C4C	08/25/99	374	15.6	46.8	12.3	22.6	24.8	4.3	54.9	46.7	22.9	0.67	41.0
C4D	08/25/99	479	17.5	18.9	5.6	15.1	12.9	0.7	22.6	25.7	10.5	0.45	23.4
C5A	08/25/99	401	25.7	32.6	14.5	18.6	22.5	18.8	41.3	50.3	31.3	1.28	46.0
C5B	08/25/99	677	29.7	18.8	2.9	18.5	13.6	1.1	19.9	30.7	9.8	0.54	28.6
C5C	08/25/99	527	24.2	11.3	1.0	11.5	8.8	0.9	15.2	22.8	5.7	0.29	21.2
C5D	08/25/99	742	16.9	15.9	11.4	15.7	10.0	1.0	17.0	34.0	13.3	0.41	32.2
CBULK	08/25/99	802	4.9	16.3	23.5	3.0	3.9	0.2	14.8	28.3	12.3	0.35	26.8
H1A	08/25/99	539	19.3	53.4	26.2	22.7	26.7	12.5	63.6	61.1	29.0	0.97	54.6
H1B	08/25/99	672	6.2	21.2	16.8	5.3	7.4	11.3	21.7	30.8	16.0	0.57	28.5
H1C	08/25/99	935	27.2	74.1	33.7	26.0	33.3	21.4	83.7	82.3	42.2	1.44	73.7
H1D	08/25/99	.	.	.	.	.	.	.	.	.	.	.	.
H2A	08/25/99	659	16.5	13.0	6.5	4.9	7.3	13.4	14.1	26.2	11.1	0.85	24.8
H2B	08/25/99	808	35.6	66.6	30.5	29.3	36.7	18.3	72.4	82.4	43.8	1.41	74.9
H2C	08/25/99	463	13.7	25.3	14.9	11.3	12.5	7.9	26.5	37.5	18.3	0.60	34.8
H2D	08/25/99	856	48.7	44.1	17.8	21.0	26.3	21.2	47.7	69.0	31.1	1.32	64.1
H3A	08/25/99	681	40.0	68.7	25.1	35.8	30.7	22.5	82.0	86.7	39.0	1.63	78.3
H3B	08/25/99	661	50.5	18.3	0.7	15.9	19.7	12.8	28.6	41.4	17.7	0.86	38.5
H3C	08/25/99	734	38.5	27.8	8.4	25.7	17.7	14.4	36.2	52.6	20.7	0.91	48.8
H3D	08/25/99	570	26.1	19.0	8.2	11.7	13.3	10.2	21.0	36.0	16.3	0.68	33.8
H4A	08/25/99	945	34.1	70.1	45.9	35.7	36.4	25.5	73.3	113.8	45.2	1.60	106.2
H4B	08/25/99	994	18.2	89.9	51.8	29.4	30.5	14.2	95.9	91.0	52.4	1.38	81.1
H4C	08/25/99	809	21.1	69.9	39.3	24.7	26.8	13.6	72.4	77.3	40.7	1.21	69.8
H4D	08/25/99	815	32.7	39.7	18.1	22.7	22.0	2.9	41.0	62.0	10.7	0.57	57.8
H5A	08/25/99	1004	52.2	50.8	20.3	30.4	27.9	10.8	70.9	81.4	20.4	1.10	74.1
H5B	08/25/99	874	18.2	57.7	42.5	22.3	25.0	11.8	67.0	70.9	36.6	1.13	64.0
H5C	08/25/99	621	25.8	54.6	25.7	31.3	29.2	8.2	56.8	74.8	15.0	0.87	68.9
H5D	08/25/99	786	19.8	84.9	40.9	26.9	30.2	12.8	95.8	83.3	40.7	1.17	73.4
H6A	08/25/99	919	23.5	97.7	47.9	28.3	36.1	11.7	107.9	91.9	48.0	1.19	80.7
H6B	08/25/99	956	17.6	113.8	54.6	28.5	37.2	17.7	127.5	98.5	60.9	1.52	85.3
H6C	08/25/99	516	18.1	32.9	14.4	15.0	16.5	21.3	40.6	46.7	23.4	1.00	42.5
H6D	08/25/99	807	25.0	56.4	29.1	22.2	25.8	20.9	63.8	73.9	37.3	1.32	67.3
HBULK	08/25/99	743	1.0	10.9	20.3	0.9	2.1	5.1	9.6	25.1	11.6	0.33	24.1
C1A	09/15/99	292	28.3	13.2	0.1	8.3	10.6	1.6	19.6	6.8	0.1	0.11	4.8
C1B	09/15/99	305	34.5	13.3	1.3	11.4	10.4	0.3	23.4	8.5	0.1	0.13	6.1

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	NMSO$_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C1C	09/15/99	323	76.0	26.8	1.3	21.2	28.4	1.1	46.4	9.3	0.2	0.31	4.5
C1D	09/15/99	247	22.7	9.6	0.2	9.2	8.9	0.1	17.3	6.1	0.1	.	4.4
C2A	09/15/99	325	54.6	11.5	0.0	10.4	12.8	0.0	33.6	12.6	0.1	0.12	9.1
C2B	09/15/99	386	57.9	16.6	0.0	13.6	9.3	0.1	32.1	11.7	0.2	0.27	8.4
C2C	09/15/99	381	48.5	30.4	0.6	19.9	21.1	2.3	25.8	7.2	0.2	0.21	4.5
C2D	09/15/99	298	30.9	11.4	0.1	11.9	12.3	0.0	20.8	7.0	0.2	0.11	4.8
C3A	09/15/99	542	95.2	16.2	0.1	14.7	18.9	0.0	41.5	25.9	0.2	0.26	21.6
C3B	09/15/99	431	55.9	29.9	0.1	17.4	25.6	10.5	43.1	14.6	1.4	0.39	10.1
C3C	09/15/99	400	39.4	13.1	0.3	7.1	8.7	0.0	26.3	9.6	0.1	0.16	6.8
C3D	09/15/99	370	27.0	14.2	0.2	8.4	11.4	0.0	21.9	7.0	0.1	0.16	4.7
C4A	09/15/99	298	47.0	29.2	2.8	18.0	20.4	9.0	48.3	21.1	8.6	0.68	16.1
C4B	09/15/99	623	80.8	88.3	11.0	34.8	42.3	1.4	122.4	55.2	14.9	1.05	42.5
C4C	09/15/99	482	31.3	70.7	6.8	27.5	43.2	1.6	80.6	37.6	5.8	0.60	29.3
C4D	09/15/99	274	32.7	19.3	0.2	18.0	18.1	8.3	35.6	12.8	0.1	0.18	9.1
C5A	09/15/99	307	70.7	33.0	6.4	26.1	27.9	10.2	70.0	42.3	25.7	1.01	35.1
C5B	09/15/99	198	35.0	8.3	0.1	11.3	9.0	0.4	17.2	5.6	0.1	0.16	3.8
C5C	09/15/99	269	56.5	10.9	0.0	15.4	20.6	0.2	21.9	7.6	0.1	.	5.4
C5D	09/15/99	247	57.2	6.6	.	13.9	12.3	0.1	37.0	26.4	0.1	0.10	22.6
C6A	09/15/99	546	19.2	31.6	10.8	13.0	15.0	0.0	33.1	20.9	2.5	0.33	17.5
C6B	09/15/99	.	.	.	.	.	.	.	.	.	.	.	.
C6D	09/15/99	531	21.3	28.2	11.5	5.7	5.7	1.9	29.9	22.2	4.4	0.40	19.1
CBULK	09/15/99	384	2.6	18.9	9.8	2.9	3.3	0.0	15.7	7.8	1.2	0.07	6.2
H1A	09/15/99	482	25.8	40.0	14.4	15.4	16.8	11.4	50.8	35.0	13.2	1.15	29.8
H1B	09/15/99	314	11.9	13.0	0.1	3.0	3.7	10.4	18.6	8.0	1.0	0.42	6.0
H1C	09/15/99	1039	65.7	103.0	31.1	41.5	46.3	31.5	135.9	83.2	28.9	2.02	69.2
H1D	09/15/99	509	30.8	19.9	0.0	7.3	8.7	25.3	32.7	15.7	2.1	1.16	12.3
H2A	09/15/99	366	24.7	12.5	4.5	4.4	4.5	1.8	16.2	6.6	0.1	0.17	4.9
H2B	09/15/99	875	58.2	76.5	30.8	38.2	39.0	22.9	94.5	82.3	38.0	1.74	72.5
H2C	09/15/99	302	18.3	18.6	9.3	7.6	8.8	2.6	27.8	17.0	6.4	0.35	14.1
H2D	09/15/99	549	49.7	32.1	9.9	12.8	14.4	11.7	51.1	31.4	10.3	0.82	26.1
H3A	09/15/99	826	74.6	53.1	29.1	34.5	26.4	11.8	76.4	57.5	22.1	1.23	49.6
H3B	09/15/99	458	65.3	12.8	0.1	10.0	9.6	1.8	35.3	14.8	1.8	0.46	11.2
H3C	09/15/99	459	25.7	18.4	7.2	13.8	8.8	5.8	29.9	20.1	8.6	0.57	17.0
H3D	09/15/99	332	55.8	9.6	0.1	7.8	7.7	1.7	27.6	8.8	1.4	0.40	5.9
H4A	09/15/99	810	36.7	54.3	45.2	25.5	23.5	12.1	53.2	67.3	21.7	1.17	61.8
H4B	09/15/99	1220	43.9	72.9	59.3	35.1	28.5	21.9	82.5	95.9	50.9	1.82	87.4
H4C	09/15/99	978	39.7	51.9	50.9	26.0	24.8	14.6	66.2	70.6	37.2	1.51	63.7
H4D	09/15/99	859	36.2	33.6	14.5	24.3	17.6	0.0	33.8	34.2	1.1	0.73	30.7
H5A	09/15/99	639	73.4	23.2	3.7	17.1	13.3	2.1	35.0	24.8	3.9	0.64	21.2
H5B	09/15/99	918	36.0	55.4	28.8	22.8	23.7	20.7	71.7	55.3	20.3	1.19	47.9
H5C	09/15/99	760	36.4	60.2	25.6	33.0	24.3	8.6	58.6	52.6	8.4	1.06	46.5
H5D	09/15/99	1103	33.8	84.5	54.9	30.7	30.2	18.5	87.3	92.7	31.8	1.43	83.7
H6A	09/15/99	1021	40.3	91.7	59.7	31.2	32.6	11.5	90.9	82.8	34.2	1.63	73.4
H6B	09/15/99	970	21.1	72.0	65.1	22.2	24.2	19.0	66.1	78.7	39.4	1.25	71.8
H6C	09/15/99	552	26.5	29.9	17.7	14.1	13.3	9.4	44.5	31.6	14.4	0.74	27.0
H6D	09/15/99	747	35.7	56.9	38.0	20.6	22.0	12.8	64.3	62.1	23.1	0.97	55.4
HBULK	09/15/99	422	0.5	15.4	8.0	1.5	2.8	0.0	13.2	5.9	1.5	0.08	4.5
C1A	09/22/99	1592	20.1	106.8	12.6	12.6	20.8	0.4	110.9	25.3	2.9	0.16	13.9
C1B	09/22/99	1510	8.3	106.9	16.4	16.1	25.3	0.0	127.7	24.8	6.3	0.17	11.6
C1C	09/22/99	1652	12.4	87.2	10.8	9.4	19.6	0.5	100.3	18.9	2.5	0.17	8.5
C1D	09/22/99	1158	5.7	52.9	7.1	10.1	11.4	0.3	54.7	12.1	2.2	0.12	6.4
C2A	09/24/99	1189	23.3	34.0	2.1	7.4	8.8	0.7	39.0	16.0	0.5	0.13	11.9
C2B	09/24/99	3944	20.6	41.0	4.6	9.8	9.7	1.1	51.0	15.7	1.0	0.39	10.4

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	NMSO_4
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C2C	09/24/99	1098	1.7	9.3	5.3	1.4	2.2	0.3	9.3	3.3	0.3	0.06	2.3
C2D	09/24/99	1796	7.5	77.3	18.7	11.1	16.9	0.5	87.6	19.7	4.6	0.20	10.6
C3A	09/24/99	912	6.8	28.6	1.4	5.0	7.8	0.3	29.9	7.3	0.5	0.08	4.2
C3B	09/24/99	2216	13.8	160.7	19.6	14.3	32.6	0.6	173.1	30.9	4.4	0.26	13.0
C3C	09/24/99	1027	3.0	45.8	7.6	4.1	9.7	0.3	46.0	9.7	2.8	0.08	5.0
C3D	09/24/99	990	2.4	19.7	4.7	2.0	4.1	0.3	19.2	5.9	1.3	0.05	3.9
C4A	09/24/99	2675	12.6	45.2	10.1	9.3	7.7	0.7	39.9	13.3	0.9	0.41	9.2
C4B	09/24/99	997	16.4	102.7	10.4	17.6	22.4	0.3	120.5	19.8	0.3	0.27	7.4
C4C	09/24/99	1005	12.7	40.9	0.9	9.5	7.4	0.3	34.0	10.0	0.8	0.20	6.5
C4D	09/24/99	1061	8.6	102.4	14.5	11.3	15.6	0.3	88.7	16.9	1.6	0.26	7.7
C5A	09/24/99	1965	42.2	114.0	6.8	15.1	21.7	0.5	127.1	27.4	0.6	0.54	14.2
C5B	09/24/99	1807	8.7	28.2	2.8	5.8	6.7	0.5	28.8	9.9	0.5	0.18	6.9
C5C	09/24/99	961	4.8	19.1	1.6	4.1	5.1	0.3	23.4	5.7	0.3	0.08	3.3
C5D	09/24/99	2725	5.9	23.0	9.0	5.4	5.6	0.8	24.4	12.2	0.9	0.16	9.7
C6A	09/22/99	654	2.9	17.7	2.6	2.4	4.3	0.2	18.2	4.2	0.7	0.06	2.3
C6B	09/22/99	929	2.1	11.9	2.7	1.2	1.9	0.3	10.2	3.2	0.3	0.43	2.2
C6C	09/22/99	.	.	.	.	.	.	.	.	.	.	.	.
C6D	09/22/99	792	8.4	35.8	2.8	3.1	6.5	0.0	35.5	7.9	0.5	0.17	4.2
CBULK	09/24/99	931	0.8	6.6	5.6	0.0	0.0	0.3	6.5	2.3	0.3	0.09	1.6
H1A	09/22/99	3677	18.2	144.8	28.3	17.3	19.6	10.1	122.6	20.1	5.9	0.95	7.5
H1B	09/22/99	983	2.0	16.4	6.2	2.0	3.6	0.3	18.6	4.4	1.6	0.10	2.5
H1C	09/22/99	1473	14.2	118.0	19.3	16.1	23.5	4.9	133.4	22.7	4.4	1.03	8.9
H1D	09/22/99	1065	9.1	42.9	8.4	4.2	7.4	1.5	45.0	9.0	3.2	0.26	4.4
H2A	09/22/99	2206	10.9	41.5	8.5	3.8	9.0	0.6	49.4	9.9	1.6	0.48	4.8
H2B	09/22/99	2608	32.2	182.3	32.6	21.4	32.0	0.7	202.4	33.7	6.5	0.86	12.8
H2C	09/22/99	1116	9.7	46.9	11.3	4.7	7.3	0.3	49.4	9.4	3.6	0.19	4.3
H2D	09/22/99	1867	24.2	67.1	14.1	7.9	11.5	2.1	66.9	13.9	4.9	0.37	7.0
H3A	09/22/99	3840	23.9	90.6	31.7	15.3	9.4	0.0	68.8	15.3	3.4	1.22	8.2
H3B	09/22/99	811	7.9	19.8	2.5	3.2	4.0	0.2	23.0	5.6	1.5	0.10	3.3
H3C	09/22/99	1121	19.5	22.1	5.6	6.7	5.0	0.3	27.3	9.5	2.0	0.26	6.7
H3D	09/22/99	994	11.1	32.9	4.1	4.7	6.5	0.3	37.1	7.4	1.6	0.21	3.6
H4A	09/22/99	1194	14.9	111.6	34.2	20.5	24.9	1.3	157.4	24.9	4.8	0.65	8.7
H4B	09/22/99	921	8.9	30.1	4.5	5.0	4.9	0.5	13.7	2.7	0.7	0.13	1.3
H4C	09/22/99	3453	7.9	47.1	18.4	5.1	0.0	1.0	44.7	10.3	3.1	0.60	5.7
H4D	09/22/99	1871	22.4	42.1	10.9	8.8	9.2	0.0	47.5	14.0	0.5	0.40	9.1
H5A	09/22/99	1057	13.9	27.2	5.8	4.5	6.1	0.3	36.8	6.8	1.9	0.16	3.0
H5B	09/22/99	1178	6.1	62.0	14.7	7.0	10.1	1.0	62.7	11.1	2.6	0.35	4.7
H5C	09/22/99	2415	16.9	121.3	36.3	21.0	19.8	0.7	120.1	25.2	3.8	0.55	12.8
H5D	09/22/99	2704	26.5	258.7	46.6	40.9	53.1	5.2	161.4	26.9	5.8	0.69	10.2
H6A	09/22/99	3132	37.5	322.0	35.7	40.4	61.5	0.9	221.3	32.7	7.3	1.36	9.9
H6B	09/22/99	939	8.6	137.6	22.4	14.2	27.3	1.3	168.2	23.8	5.8	0.30	6.4
H6C	09/22/99	3093	9.4	36.8	12.2	6.1	6.3	0.0	41.5	9.2	2.0	1.54	4.9
H6D	09/22/99	978	6.8	66.9	16.9	7.8	12.0	0.5	76.9	13.1	3.1	0.19	5.2
HBULK	09/22/99	3891	3.5	85.9	13.1	6.8	19.1	1.1	23.2	7.7	3.1	0.15	5.3
C1A	10/20/99	1036	42.3	40.4	8.4	15.7	15.3	1.1	53.1	37.6	7.2	0.29	32.1
C1B	10/20/99	1086	36.2	30.3	1.3	18.9	12.9	0.9	51.3	34.6	1.5	0.21	29.3
C1C	10/20/99	1101	38.2	41.7	10.9	16.4	18.9	0.9	61.9	40.0	9.3	0.31	33.6
C1D	10/20/99	1012	43.1	29.1	2.3	27.1	20.7	0.6	66.0	38.3	2.8	0.22	31.4
C2A	10/20/99	1074	79.5	37.2	1.0	20.0	14.5	0.6	64.1	70.5	0.7	0.29	63.9
C2B	10/20/99	1936	108.1	54.5	0.9	31.2	24.6	1.1	122.3	79.0	4.6	0.62	66.3
C2C	10/20/99	1561	33.6	42.9	18.2	15.1	16.0	0.9	54.4	44.3	7.5	0.26	38.6
C2D	10/20/99	1674	32.6	42.4	17.8	24.5	19.9	0.9	69.1	50.0	8.8	0.42	42.8
C3A	10/20/99	1067	46.4	31.4	19.3	18.3	17.5	0.6	75.4	40.3	9.9	0.24	32.6

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C3B	10/20/99	1664	23.5	117.0	19.4	18.6	28.6	0.9	130.8	40.6	17.6	0.61	27.0
C3C	10/20/99	1242	11.5	35.2	23.0	9.9	12.7	3.1	47.6	24.7	10.3	0.25	19.8
C3D	10/20/99	981	30.6	27.6	12.0	9.7	13.7	1.1	48.3	29.3	8.1	0.22	24.3
C4A	10/20/99	1097	17.3	97.1	32.9	23.1	27.4	2.1	118.4	44.8	31.3	0.71	32.5
C4B	10/20/99	2031	69.0	226.4	27.8	49.4	59.8	1.1	311.2	87.9	21.9	0.87	55.7
C4C	10/20/99	1135	22.2	180.5	23.0	34.4	41.3	0.6	208.9	53.1	15.6	0.73	31.5
C4D	10/20/99	1137	34.9	78.5	4.7	21.5	24.7	0.6	104.1	34.5	16.2	0.54	23.7
C5A	10/20/99	1237	82.9	133.1	29.5	35.9	42.0	1.0	182.2	102.8	30.8	0.80	83.9
C5B	10/20/99	1103	45.5	41.8	2.8	15.1	13.5	0.6	66.9	45.5	1.6	0.16	38.6
C5C	10/20/99	1030	27.3	30.5	3.2	19.9	15.6	0.6	52.8	36.4	1.0	0.18	30.9
C5D	10/20/99	1006	33.7	28.3	8.7	13.0	12.8	1.1	40.5	40.0	4.8	0.19	35.8
C6A	10/20/99	1208	11.5	44.7	14.1	8.7	12.4	1.3	49.9	21.6	6.3	0.26	16.5
C6B	10/20/99	1206	19.5	41.2	12.5	10.5	13.8	2.3	43.2	25.2	9.8	0.31	20.7
C6C	10/20/99	964	10.2	21.7	10.5	6.2	6.7	1.6	21.1	16.3	3.9	0.18	14.1
C6D	10/20/99	849	25.6	62.7	3.5	10.3	16.3	0.9	71.4	24.9	3.5	0.30	17.5
CBULK	10/20/99	896	3.2	34.5	31.6	4.2	8.8	2.7	38.8	23.2	12.8	0.27	19.2
H1A	10/20/99	1515	42.0	116.4	19.4	23.3	31.6	26.7	150.7	51.3	28.3	1.58	35.7
H1B	10/20/99	1104	16.0	45.4	22.4	8.5	12.2	7.0	61.5	24.2	15.1	0.47	17.8
H1C	10/20/99	2285	36.3	136.5	39.4	23.8	36.5	17.6	194.4	52.3	34.8	1.36	32.2
H1D	10/20/99	1210	44.0	53.4	12.0	10.8	15.8	13.7	72.2	29.5	17.5	0.84	22.0
H2A	10/20/99	1014	19.5	31.6	14.2	7.6	10.8	2.5	42.9	20.7	9.1	0.28	16.3
H2B	10/20/99	1824	80.7	145.7	23.9	28.1	43.3	3.0	186.0	61.7	31.3	0.91	42.5
H2C	10/20/99	991	39.0	112.2	18.3	22.6	36.1	14.2	136.1	51.8	35.5	0.99	37.7
H2D	10/20/99	1057	32.1	52.8	12.0	11.5	16.0	5.5	69.9	30.0	16.5	0.58	22.7
H3A	10/20/99	1821	63.2	163.2	43.4	40.2	43.2	6.0	215.6	76.1	44.7	1.45	53.8
H3B	10/20/99	1191	50.8	60.1	6.8	17.7	22.4	2.0	87.1	40.9	20.0	0.71	31.9
H3C	10/20/99	975	25.7	39.2	13.4	15.5	13.2	0.8	62.6	24.3	8.4	0.34	17.8
H3D	10/20/99	952	28.8	52.5	14.0	13.9	17.5	3.4	75.8	31.3	17.7	0.52	23.4
H4A	10/20/99	1043	29.2	108.1	42.2	22.5	26.5	6.3	133.9	52.9	33.2	0.88	39.1
H4B	10/20/99	1767	60.0	247.4	63.7	48.3	54.2	20.5	300.7	94.9	74.6	1.85	63.9
H4C	10/20/99	1913	38.7	225.6	64.3	38.0	52.5	11.1	248.4	86.6	67.5	1.71	60.9
H4D	10/20/99	1049	47.9	60.8	4.3	16.4	22.3	1.7	90.8	37.6	0.4	0.39	28.2
H5A	10/20/99	1004	52.8	50.2	13.4	16.7	18.5	4.4	95.4	35.0	10.8	0.48	25.1
H5B	10/20/99	1000	34.0	97.8	19.8	27.1	29.5	10.5	139.3	52.2	19.8	0.90	37.8
H5C	10/20/99	1067	21.6	94.9	31.3	19.9	25.3	11.8	122.1	45.7	27.1	0.96	33.0
H5D	10/20/99	1015	28.7	174.4	36.6	32.3	46.9	15.4	205.0	68.2	47.9	1.36	47.0
H6A	10/20/99	1077	48.1	215.8	28.1	38.0	56.4	14.0	256.1	65.9	52.2	1.29	39.4
H6B	10/20/99	954	33.0	251.9	42.3	36.5	60.9	19.2	292.8	73.1	72.1	1.71	42.8
H6C	10/20/99	1183	39.1	83.5	10.0	22.9	31.0	10.8	125.4	37.7	15.3	0.82	24.7
H6D	10/20/99	1533	37.2	174.8	41.9	28.9	38.9	8.5	218.1	62.5	33.6	0.99	40.0
HBULK	10/20/99	2046	2.3	24.4	39.6	3.6	5.9	7.9	23.4	28.5	13.0	0.40	26.1
C1A	11/05/99	1101	53.9	77.2	2.8	18.9	31.1	0.6	122.2	24.1	0.4	0.18	11.5
C1B	11/05/99	1113	30.7	72.7	6.8	18.0	27.8	0.6	104.1	17.2	0.3	0.16	6.4
C1C	11/05/99	1087	23.8	89.9	9.2	13.2	26.2	0.6	134.1	29.7	6.5	0.19	15.9
C1D	11/05/99	1125	34.8	91.1	5.0	31.8	38.2	0.6	129.3	33.0	2.0	0.17	19.7
C2A	11/05/99	1017	12.6	58.1	4.0	5.8	15.0	0.6	79.4	17.2	1.4	0.09	9.0
C2B	11/05/99	1603	21.2	110.0	7.1	14.3	30.2	0.9	163.5	30.3	2.3	0.18	13.4
C2C	11/05/99	1060	22.9	57.1	2.1	18.2	25.6	0.6	94.4	29.0	0.8	0.13	19.2
C2D	11/05/99	1443	40.9	90.9	2.8	29.0	36.6	0.8	124.9	40.2	0.1	0.20	27.3
C3A	11/05/99	1104	37.9	54.0	6.3	28.5	30.7	0.6	92.3	39.5	0.9	0.14	30.0
C3B	11/05/99	1767	45.2	156.0	1.5	24.6	47.0	1.0	232.1	44.0	4.9	0.37	20.0
C3C	11/05/99	1114	5.0	55.2	9.4	2.8	14.1	1.5	70.4	14.4	2.6	0.09	7.1
C3D	11/05/99	1029	9.0	64.1	9.1	5.6	17.7	0.9	92.1	15.9	3.3	0.10	6.3

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C4A	11/05/99	1026	17.1	268.7	40.5	48.1	67.2	0.8	362.4	55.1	38.3	0.71	17.7
C4B	11/05/99	870	28.1	167.9	8.4	34.1	45.2	0.5	248.0	40.7	7.1	0.27	15.1
C4C	11/05/99	1570	30.4	262.6	17.9	51.1	66.8	3.5	386.6	62.5	23.4	1.09	22.5
C4D	11/05/99	965	21.6	88.3	11.3	16.3	26.1	0.5	134.9	21.1	2.6	0.15	7.2
C5A	11/05/99	990	42.7	248.5	25.3	41.3	62.8	0.5	373.8	72.4	19.3	0.45	33.8
C5B	11/05/99	1489	70.8	127.6	0.8	27.0	38.4	0.8	206.7	57.8	0.2	0.24	36.4
C5C	11/05/99	952	34.9	72.7	0.5	30.3	34.7	0.5	116.5	40.3	0.2	0.15	28.2
C5D	11/05/99	939	47.9	81.3	5.2	24.7	27.3	0.5	121.0	54.7	0.2	0.11	42.2
C6A	11/04/99	1534	17.8	136.4	9.8	16.4	35.2	0.8	201.5	35.9	3.7	0.20	15.0
C6B	11/04/99	935	10.3	91.7	9.9	10.0	22.2	0.5	132.6	23.3	6.1	0.19	9.6
C6C	11/04/99	1514	17.3	189.7	21.2	29.3	50.2	1.3	286.2	49.7	6.3	0.33	20.1
C6D	11/04/99	1474	24.9	146.4	16.4	19.0	41.0	0.8	220.7	41.1	3.2	0.18	18.3
CBULK	11/05/99	921	1.2	34.5	7.4	0.0	7.2	.	35.7	9.2	1.9	0.06	5.5
CT4A	11/04/99	.	.	.	.	.	.	.	.	.	.	.	.
CT4D	11/04/99	.	.	.	.	.	.	.	.	.	.	.	.
CT5D	11/04/99	.	.	.	.	.	.	.	.	.	.	.	.
H1A	11/04/99	1401	27.4	162.5	39.2	25.7	40.7	3.5	253.7	41.8	19.8	0.56	15.6
H1B	11/04/99	1048	7.9	59.9	12.5	5.7	15.4	2.3	85.5	15.6	6.7	0.21	6.8
H1C	11/04/99	2370	24.7	247.2	63.3	34.1	58.2	4.6	351.4	62.5	33.3	0.90	26.2
H1D	11/04/99	1433	11.7	85.3	19.2	7.5	20.5	3.2	125.5	23.5	9.2	0.32	10.6
H2A	11/04/99	992	5.0	46.2	19.2	2.2	11.4	1.1	59.7	11.8	3.0	0.10	5.7
H2B	11/04/99	1938	34.0	250.0	44.1	37.0	65.0	1.1	392.4	65.6	24.8	0.65	25.0
H2C	11/04/99	980	16.0	147.0	26.8	24.1	38.1	1.9	231.6	37.1	14.1	0.35	13.1
H2D	11/04/99	1520	30.0	124.3	24.5	15.1	29.2	2.5	188.3	34.8	12.4	0.45	15.3
H3A	11/04/99	1833	29.4	190.8	45.7	38.2	47.3	2.0	291.8	56.5	35.1	0.82	26.4
H3B	11/04/99	1278	17.2	83.3	16.3	14.9	23.5	1.8	131.6	26.1	11.8	0.34	12.5
H3C	11/04/99	955	11.8	49.6	12.2	9.2	12.1	1.1	75.5	15.2	5.3	0.19	7.4
H3D	11/04/99	982	14.0	54.6	8.5	7.6	14.1	0.8	78.2	16.6	5.4	0.18	8.5
H4A	11/04/99	970	21.6	129.9	34.2	28.4	37.3	1.3	209.0	42.5	21.4	0.48	20.9
H4B	11/04/99	1202	11.9	94.4	28.0	11.6	19.7	2.0	132.2	28.1	15.5	0.38	14.4
H4C	11/04/99	2084	29.4	218.3	55.7	29.0	50.3	3.4	294.5	65.3	37.5	1.45	34.9
H4D	11/04/99	1947	47.8	191.7	27.9	38.7	60.6	1.1	302.2	62.0	13.7	0.53	30.8
H5A	11/04/99	2442	71.8	154.8	26.0	21.8	34.0	4.7	245.4	53.5	12.5	0.85	28.1
H5B	11/04/99	1082	13.5	122.5	31.7	22.6	31.0	3.3	193.8	35.5	16.7	0.45	15.5
H5C	11/04/99	1159	25.4	141.0	39.0	41.1	40.8	2.2	251.4	50.7	13.4	0.46	24.8
H5D	11/04/99	1425	21.9	298.5	64.7	44.9	70.0	5.1	409.1	72.3	39.1	0.85	30.0
H6A	11/04/99	1891	25.7	284.8	51.7	32.9	62.7	3.1	411.1	67.7	27.9	0.83	25.2
H6B	11/04/99	940	21.2	396.7	53.7	55.5	93.5	4.9	523.8	80.4	54.7	1.03	26.3
H6C	11/04/99	1437	16.6	166.7	32.7	23.9	42.9	2.4	244.5	40.8	22.7	0.68	15.5
H6D	11/04/99	985	19.3	257.9	39.8	40.6	67.3	1.6	368.0	57.3	34.8	0.69	19.3
HBULK	11/04/99	1786	2.7	63.0	14.1	0.0	15.3	3.4	80.0	18.7	4.4	0.16	10.4
C1A	11/18/99	747	7.9	31.7	25.1	10.8	15.9	6.4	41.6	27.1	25.2	0.52	22.8
C1B	11/18/99	671	1.6	24.8	27.8	5.3	6.6	8.0	26.4	22.4	18.2	0.40	19.6
C1C	11/18/99	794	2.7	25.9	30.0	4.3	7.8	9.0	30.0	23.3	21.0	0.47	20.2
C1D	11/18/99	765	2.2	27.2	29.5	5.9	7.8	8.9	28.2	24.4	20.1	0.46	21.4
C2A	11/18/99	853	1.8	27.3	34.5	4.4	7.0	9.4	28.4	24.6	19.6	0.47	21.7
C2B	11/18/99	793	3.4	26.8	30.6	5.1	8.1	8.7	31.6	25.6	19.8	0.47	22.4
C2C	11/18/99	856	1.5	24.3	38.8	3.8	7.0	9.9	27.7	26.4	22.4	0.51	23.5
C2D	11/18/99	893	1.5	25.5	36.1	4.0	6.2	9.8	25.8	24.9	20.5	0.49	22.2
C3A	11/18/99	952	2.4	27.8	38.5	5.4	8.6	10.8	31.3	30.3	23.6	0.57	27.1
C3B	11/18/99	913	7.1	62.4	41.4	12.5	21.7	4.3	76.3	42.7	43.7	0.91	34.8
C3C	11/18/99	902	1.7	25.6	38.2	3.1	6.3	10.2	27.8	23.8	20.7	0.49	20.9
C3D	11/18/99	820	2.0	26.8	33.2	3.5	6.7	9.7	27.3	24.5	20.8	0.53	21.7

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C4A	11/18/99	554	7.3	53.7	25.1	12.2	16.8	4.4	59.8	31.7	37.2	0.69	25.5
C4B	11/18/99	853	33.7	119.4	34.5	24.1	34.2	3.3	144.7	65.8	61.5	1.06	50.8
C4C	11/18/99	670	8.3	85.8	33.3	19.3	25.8	6.3	107.3	49.0	45.3	0.80	37.9
C4D	11/18/99	672	6.6	36.4	18.8	8.0	11.6	5.6	40.1	24.1	19.8	0.43	19.9
C5A	11/18/99	681	17.9	136.5	42.7	25.0	39.9	7.5	164.7	61.0	84.4	1.46	44.0
C5B	11/18/99	758	7.7	27.7	26.1	6.4	9.0	7.7	33.2	24.1	19.5	0.45	20.7
C5C	11/18/99	786	3.1	26.4	31.8	6.2	8.4	7.8	29.7	24.6	20.6	0.47	21.6
C5D	11/18/99	691	1.9	22.9	27.3	4.3	5.7	8.0	22.7	20.6	17.3	0.41	18.3
C6A	11/18/99	775	5.2	26.8	27.9	4.6	7.9	6.6	24.3	27.4	19.2	0.39	24.9
C6B	11/18/99	963	4.7	34.8	47.9	7.9	15.0	15.9	37.4	41.2	41.2	0.86	37.3
C6C	11/18/99	941	6.2	57.4	32.4	9.8	15.4	8.6	52.0	40.7	32.2	0.66	35.4
C6D	11/18/99	657	6.1	30.4	30.5	7.3	15.1	7.8	33.3	33.3	29.3	0.62	29.9
CBULK	11/18/99	892	1.2	26.3	39.6	2.9	6.2	11.8	26.6	27.5	22.3	0.53	24.8
CT2A	11/18/99	972	1.4	28.6	39.3	4.3	6.8	11.5	29.5	27.6	22.9	0.53	24.5
CT2B	11/18/99	888	3.3	26.3	33.5	3.7	3.6	9.5	23.9	24.7	19.1	0.44	22.3
CT2C	11/18/99	720	1.6	20.1	28.5	2.9	4.7	7.9	19.7	19.3	15.8	0.39	17.3
CT2D	11/18/99	935	3.0	61.3	42.4	10.2	16.1	14.4	64.2	39.5	38.9	0.84	32.9
CT2E	11/18/99	887	1.5	28.6	38.4	3.7	7.3	11.2	30.4	26.5	21.9	0.53	23.3
CT2F	11/18/99	987	19.8	190.1	56.4	44.1	60.6	8.4	240.1	37.3	102.6	1.77	12.5
CT4A	11/19/99	611	4.0	55.9	29.7	8.5	16.3	6.7	60.5	32.2	34.0	0.64	26.0
CT4B	11/19/99	860	0.8	16.9	38.1	3.0	4.2	11.1	19.7	24.0	20.1	0.51	21.9
CT4C	11/19/99	864	0.9	17.4	40.1	3.0	4.6	11.0	20.6	24.9	21.2	0.99	22.8
CT4D	11/19/99	467	1.7	23.9	18.0	5.4	6.7	5.8	23.9	18.1	19.4	0.42	15.6
CT4E	11/19/99	870	4.1	45.0	34.4	7.6	14.2	6.5	46.3	32.5	32.0	0.65	27.7
CT4F	11/19/99	601	0.6	12.2	26.6	2.5	3.2	7.6	14.1	17.0	14.9	0.36	15.6
CT5D	11/19/99	890	2.7	47.8	41.3	6.4	13.1	11.8	57.1	34.1	30.6	0.66	28.2
CT5E	11/19/99	920	0.8	18.9	39.9	3.4	4.9	11.4	22.9	25.6	21.8	0.50	23.3
CT5F	11/19/99	639	0.8	20.3	24.1	3.5	5.5	7.4	19.1	17.8	16.7	0.38	15.8
H1A	11/19/99	654	14.5	55.2	31.8	12.5	15.8	6.7	71.3	40.7	37.1	0.75	33.3
H1B	11/19/99	713	3.8	23.3	27.5	3.7	5.3	8.1	22.7	21.3	18.7	0.46	18.9
H1C	11/19/99	972	10.6	77.4	46.2	13.0	21.1	12.6	86.6	46.9	49.3	1.02	38.0
H1D	11/19/99	844	5.0	30.5	34.9	5.7	9.0	10.7	31.5	29.0	27.3	0.63	25.7
H2A	11/19/99	808	3.0	21.5	36.7	2.8	5.0	10.0	21.7	22.9	20.3	0.48	20.7
H2B	11/19/99	908	13.5	108.9	49.5	19.2	33.4	10.5	118.8	58.7	70.0	1.26	46.4
H2C	11/19/99	418	4.6	25.3	16.9	5.1	7.9	4.0	26.8	18.1	19.4	0.42	15.3
H2D	11/19/99	871	17.0	59.4	36.0	13.2	21.4	9.6	69.8	44.6	47.2	0.91	37.4
H3A	11/19/99	866	15.9	72.0	45.1	18.7	20.9	7.6	81.4	52.6	53.4	1.03	44.1
H3B	11/19/99	602	6.6	26.7	20.7	7.9	10.1	6.5	27.9	23.7	22.7	0.51	20.8
H3C	11/19/99	904	8.2	37.2	42.0	12.1	11.8	7.7	42.7	37.3	33.0	0.63	32.9
H3D	11/19/99	739	8.0	29.7	27.9	8.6	11.8	8.4	33.5	29.4	29.0	0.59	26.0
H4A	11/19/99	864	18.2	78.7	54.1	18.2	23.0	9.0	93.7	59.3	64.5	1.20	49.6
H4B	11/19/99	580	11.3	94.0	51.3	19.4	29.2	9.4	125.2	50.5	57.1	1.07	37.6
H4C	11/19/99	823	24.1	117.9	56.5	25.5	37.7	14.3	154.0	68.0	85.2	1.60	52.1
H4D	11/19/99	915	17.3	51.5	25.6	13.4	16.9	3.8	55.1	46.4	23.2	1.09	40.7
H5A	11/19/99	925	26.9	38.6	19.2	6.9	8.3	5.6	41.0	42.3	16.7	0.46	38.1
H5B	11/19/99	790	9.1	66.0	43.1	12.7	19.1	10.9	78.2	44.0	46.8	1.06	35.9
H5C	11/19/99	781	16.4	71.3	36.3	17.3	19.5	6.0	78.1	50.5	41.6	0.85	42.4
H5D	11/19/99	659	13.4	138.1	59.7	23.2	35.6	9.3	149.5	64.9	71.1	1.31	49.5
H6A	11/19/99	736	11.6	97.0	46.1	14.8	27.1	9.7	121.9	51.6	56.4	1.03	39.0
H6B	11/19/99	703	11.9	178.0	54.2	22.3	42.9	15.7	236.1	64.7	80.1	1.54	40.3
H6C	11/19/99	184	4.9	24.8	22.5	5.8	8.3	3.8	32.5	21.3	22.2	.	18.0
H6D	11/19/99	877	9.7	81.4	50.1	13.1	21.9	9.7	92.9	48.4	55.0	1.05	38.8
HBULK	11/19/99	814	0.7	14.6	38.7	2.2	3.7	11.2	17.4	23.5	20.3	0.49	21.7

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
HT1D	11/19/99	778	3.4	24.2	27.4	6.8	8.0	9.6	26.3	24.0	20.7	0.50	21.3
HT1E	11/19/99	678	5.6	23.8	15.4	8.8	8.9	6.7	26.6	24.3	17.1	0.40	21.5
HT1F	11/19/99	756	2.2	22.9	30.6	6.2	7.4	9.4	23.7	23.7	20.2	0.98	21.2
HT2F	11/19/99	678	1.0	12.2	28.1	2.4	3.3	8.2	14.2	17.9	15.2	0.37	16.4
HT3A	11/19/99	515	7.4	81.0	37.0	17.5	21.9	7.5	93.3	42.0	45.6	0.90	32.4
HT3B	11/19/99	612	7.2	28.1	24.7	4.7	8.3	7.1	32.9	23.7	21.0	0.49	20.4
HT3C	11/19/99	403	7.6	87.2	37.3	18.9	22.1	8.7	110.1	39.9	51.5	.	28.5
HT3F	11/19/99	705	1.0	11.9	31.3	2.1	3.2	9.1	13.7	19.6	16.3	0.49	18.2
C1A	05/18/00	885	2.9	18.7	17.6	4.7	5.2	5.0	17.2	18.1	10.7	0.30	16.3
C2A	05/18/00	891	3.6	18.8	16.5	6.1	5.6	5.5	17.7	19.1	11.7	0.39	17.3
C2B	05/18/00	878	5.6	21.8	14.8	6.7	7.0	4.0	22.0	18.8	9.9	0.37	16.5
C2C	05/18/00	953	4.6	18.2	18.9	6.6	6.8	2.4	17.5	19.4	12.1	0.42	17.6
C2D	05/18/00	942	3.7	15.3	15.2	5.3	4.7	7.5	14.4	18.7	11.3	0.33	17.3
C3A	05/18/00	379	1.7	8.7	9.3	3.6	3.8	2.1	7.7	10.6	7.7	0.20	9.8
C3B	05/18/00	863	7.3	38.3	16.4	11.2	13.4	3.4	37.4	25.5	16.2	0.49	21.7
C3C	05/18/00	926	2.8	13.4	16.8	5.0	4.3	6.3	13.7	18.4	11.3	0.37	17.0
C4A	05/18/00	648	10.2	69.5	18.2	13.5	19.3	0.7	73.1	33.4	12.0	0.39	25.8
C4B	05/18/00	854	11.8	73.9	19.0	14.3	19.4	1.7	76.7	34.9	12.0	0.44	26.9
C4C	05/18/00	429	6.5	74.2	16.6	10.8	17.3	0.6	75.3	28.2	10.6	0.30	20.5
C4D	05/18/00	918	12.9	47.7	8.5	13.3	13.5	4.2	44.0	24.8	8.3	0.45	20.3
C5A	05/18/00	625	10.9	83.2	22.1	13.2	23.1	0.4	89.9	37.3	15.8	0.46	28.0
C5B	05/18/00	784	6.1	18.4	9.8	6.4	5.9	7.1	19.6	17.6	9.5	0.32	15.6
C5C	05/18/00	768	10.7	15.5	7.0	7.0	6.4	6.1	17.2	16.8	10.3	0.33	15.1
C5D	05/18/00	812	2.9	12.4	15.4	4.3	3.7	5.0	12.8	16.2	10.1	0.31	14.8
C6A	05/17/00	852	5.6	39.1	18.5	6.9	10.4	0.5	30.9	27.0	8.4	0.28	23.8
C6B	05/17/00	956	5.9	50.1	13.4	9.2	12.4	2.2	40.0	28.3	5.0	0.25	24.2
C6C	05/17/00	1119	5.8	28.1	21.7	6.8	9.4	4.4	26.8	27.4	15.6	0.38	24.6
C6D	05/17/00	991	4.7	35.9	19.2	9.6	10.8	2.2	38.4	25.3	10.8	0.32	21.3
CBULK	05/18/00	1040	1.5	14.1	20.6	4.2	3.9	7.6	13.8	20.2	12.8	0.34	18.7
CT4A	05/17/00	915	3.7	52.0	22.9	9.1	13.8	3.9	51.8	28.5	13.9	0.35	23.1
CT4B	05/17/00	915	1.2	14.6	17.7	4.7	5.0	8.3	14.9	19.1	12.7	0.38	17.6
CT4C	05/17/00	830	0.9	12.5	15.7	3.2	3.5	8.4	13.6	17.4	10.8	0.35	16.0
CT4D	05/17/00	969	5.3	50.5	19.2	13.3	15.0	5.2	53.9	29.2	15.8	0.39	23.6
CT4E	05/17/00	949	4.5	58.6	28.5	8.7	16.7	3.5	60.0	32.9	16.8	0.39	26.7
CT4F	05/17/00	994	1.7	18.8	18.8	5.6	5.8	8.1	18.8	21.8	14.0	0.41	19.9
CT5D	05/17/00	978	2.7	45.1	22.8	5.0	9.9	4.4	41.9	24.0	13.0	0.31	19.6
CT5E	05/17/00	765	0.5	10.4	14.2	2.1	2.6	6.1	10.5	14.4	8.7	0.24	13.4
H1A	05/17/00	599	4.8	31.0	17.2	5.3	7.8	1.5	28.7	19.6	7.1	0.24	16.6
H1B	05/17/00	910	4.9	18.4	18.9	4.4	4.6	6.2	20.0	20.4	10.1	0.31	18.4
H1C	05/17/00	867	9.4	61.0	26.0	8.4	13.1	2.2	57.1	33.6	11.3	0.36	27.7
H1D	05/17/00	599	5.6	31.4	17.6	5.6	7.8	2.4	30.6	21.1	7.9	0.27	17.9
H2A	05/17/00	916	3.1	10.6	15.8	3.3	2.7	5.7	10.3	17.3	9.8	0.30	16.2
H2B	05/17/00	1025	12.6	93.5	35.4	12.5	22.8	0.6	94.7	48.1	15.1	0.42	38.3
H2C	05/17/00	655	6.6	32.6	16.7	5.5	8.2	2.2	31.7	21.4	8.9	0.26	18.1
H2D	05/17/00	890	12.0	40.3	19.8	7.0	9.3	0.3	34.5	28.6	7.6	0.31	25.0
H3A	05/17/00	757	11.6	45.7	22.7	9.4	9.8	0.4	43.6	28.6	6.6	0.29	24.1
H3B	05/17/00	860	9.2	33.2	13.6	8.3	7.9	3.9	28.5	22.4	9.1	0.38	19.4
H3C	05/17/00	919	14.7	35.9	23.5	9.8	8.5	0.3	30.9	27.2	4.7	0.34	24.0
H3D	05/17/00	679	7.6	23.7	9.5	5.0	6.0	4.2	19.7	17.7	6.7	0.29	15.6
H4A	05/17/00	743	11.1	70.7	28.1	9.1	13.7	0.4	72.4	39.0	5.2	0.28	31.6
H4B	05/17/00	809	9.7	37.7	19.8	5.8	8.5	1.6	37.1	23.1	8.1	0.31	19.3
H4C	05/17/00	945	9.1	38.0	20.1	5.8	9.1	3.5	34.2	25.6	11.9	0.37	22.0
H4D	05/17/00	901	20.0	45.4	12.7	11.2	12.1	1.8	38.6	30.3	3.4	0.28	26.3

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
H5A	05/17/00	858	8.5	28.2	12.3	5.2	4.7	4.9	24.1	19.7	7.9	0.35	17.2
H5B	05/17/00	887	8.3	65.9	27.9	9.5	13.8	2.3	63.4	35.3	10.8	0.42	28.8
H5C	05/17/00	864	10.7	72.9	24.8	12.8	13.8	0.7	66.1	40.6	4.2	0.35	33.7
H5D	05/17/00	812	8.7	79.3	29.3	9.3	16.4	1.1	80.4	38.5	8.7	0.37	30.2
H6A	05/17/00	829	14.1	83.7	24.3	9.1	17.7	0.9	81.6	38.9	12.1	0.42	30.5
H6B	05/17/00	764	11.3	90.2	25.8	11.3	21.5	0.6	93.9	41.7	15.0	0.44	32.0
H6C	05/17/00	818	4.4	19.4	16.6	4.8	6.2	3.9	21.3	18.8	9.6	0.30	16.6
H6D	05/17/00	857	10.3	65.0	22.9	8.7	14.4	2.4	62.5	34.1	11.4	0.38	27.6
HBULK	05/17/00	874	2.1	11.8	14.8	3.3	1.8	8.2	11.6	16.9	10.0	0.36	15.7
HT1D	05/17/00	869	4.6	14.9	12.5	6.4	5.5	5.9	16.0	19.1	9.2	0.33	17.4
HT1E	05/17/00	956	10.2	22.7	6.1	11.0	8.4	8.6	22.9	21.5	8.9	0.47	19.1
HT1F	05/17/00	881	4.3	12.7	12.7	5.6	4.8	5.5	13.0	17.5	9.0	0.39	16.2
HT3A	05/17/00	758	4.8	49.8	21.3	11.2	11.1	1.9	46.0	31.3	7.2	0.30	26.6
HT3B	05/17/00	992	9.3	36.5	15.6	5.3	6.2	3.6	28.3	24.3	7.1	0.33	21.4
HT3C	05/17/00	626	6.1	55.4	21.6	10.2	14.5	1.1	57.5	31.3	10.3	0.31	25.4
HT3F	05/17/00	979	2.2	8.5	16.9	3.2	2.1	7.5	9.0	18.0	10.6	0.36	17.1
HT4D	05/17/00	567	8.7	47.1	17.0	7.4	13.3	0.0	47.2	28.4	10.2	0.26	23.5
HT4F	05/17/00	931	0.6	10.7	17.2	4.0	3.1	8.7	11.4	18.5	11.0	0.35	17.3
C1A	05/31/00	976	10.2	24.5	17.7	7.7	10.2	2.5	31.4	21.4	9.9	0.30	18.2
C1C	05/31/00	571	6.1	7.1	7.7	2.8	3.6	1.0	7.6	9.3	2.7	0.12	8.5
C2A	05/31/00	926	10.1	26.3	19.2	8.0	9.3	4.4	33.1	23.2	11.4	0.32	19.7
C2C	05/31/00	1041	8.7	24.7	26.0	9.3	9.6	0.6	30.3	22.3	7.4	0.29	19.2
C3A	05/31/00	1104	10.8	25.2	33.9	7.3	8.8	0.6	32.7	26.5	12.1	0.39	23.1
C3C	05/31/00	807	4.0	18.4	30.5	4.7	5.4	5.2	23.1	22.2	12.1	0.33	19.9
C4A	05/31/00	791	11.5	53.2	26.7	11.7	15.9	0.4	58.5	33.1	10.3	0.35	27.0
C4C	05/31/00	617	8.0	71.2	29.4	11.3	17.9	2.6	80.3	35.9	10.4	0.33	27.6
C5A	05/31/00	613	16.6	81.6	26.6	13.4	23.4	0.7	99.5	39.4	10.9	0.47	29.1
C5C	05/31/00	853	11.8	20.4	18.1	7.4	8.2	0.5	25.7	19.1	8.5	0.28	16.5
C6A	05/31/00	915	4.9	26.2	18.6	6.8	8.8	2.8	27.1	28.5	8.8	0.25	25.7
C6C	05/31/00	1378	5.9	24.8	45.4	6.3	8.1	4.3	26.7	33.0	16.9	0.39	30.3
CBULK	05/31/00	741	0.6	6.4	14.4	1.5	1.6	1.9	7.2	10.6	5.8	0.14	9.8
CT4A	05/31/00	923	2.5	51.2	27.7	8.5	13.9	4.4	52.7	37.2	15.7	0.40	31.8
CT4B	05/31/00	921	1.7	22.7	19.1	4.0	6.2	6.2	26.3	21.6	12.3	0.31	18.9
CT4C	05/31/00	876	1.1	25.3	18.6	4.0	6.6	7.7	29.1	21.9	12.7	0.31	18.9
CT4D	05/31/00	959	7.0	57.7	30.2	16.4	17.3	5.4	65.1	35.2	18.7	0.41	28.5
CT4E	05/31/00	903	4.0	36.1	29.1	6.4	11.7	4.1	33.6	35.9	16.5	0.39	32.5
CT4F	05/31/00	726	2.3	32.2	15.1	5.7	7.9	3.7	35.2	18.2	10.4	0.25	14.5
CT5D	05/31/00	980	2.9	53.7	26.9	7.2	12.8	7.2	54.5	36.5	17.0	0.42	30.9
CT5E	05/31/00	985	1.0	24.9	21.4	3.8	6.2	8.9	28.6	24.6	13.4	0.35	21.7
CT5F	05/31/00	901	1.1	25.6	16.3	3.7	6.4	6.1	29.0	19.3	11.0	0.28	16.3
H1A	05/31/00	812	8.4	55.7	30.7	11.2	16.7	3.0	70.0	29.0	9.0	0.34	21.8
H1C	05/31/00	995	7.4	64.9	36.8	9.6	15.5	2.2	72.6	31.0	11.3	0.35	23.5
H2A	05/31/00	1016	3.4	19.6	18.0	4.1	5.1	6.6	22.8	19.7	11.5	0.31	17.3
H2C	05/31/00	818	5.5	39.8	20.0	7.5	11.7	2.5	46.3	26.3	9.1	0.27	21.5
H3A	05/31/00	996	14.9	80.2	57.0	20.0	20.1	2.0	98.6	52.3	8.5	0.37	42.2
H3C	05/31/00	969	9.2	50.8	30.5	13.8	13.4	3.6	58.3	36.1	8.6	0.34	30.1
H4A	05/31/00	965	11.0	86.1	38.2	14.2	21.1	1.9	99.9	58.1	9.8	0.40	47.8
H4C	05/31/00	964	5.4	58.4	25.8	9.8	15.4	3.8	68.4	35.9	12.0	0.34	28.8
H5A	05/31/00	881	13.6	57.7	29.7	12.1	18.5	4.5	75.1	35.5	13.0	0.42	27.8
H5C	05/31/00	825	8.2	55.5	31.9	13.2	14.9	1.9	62.7	35.4	4.8	0.28	28.9
H6A	05/31/00	1087	10.6	125.0	56.8	18.0	33.8	2.2	152.5	62.1	20.4	0.52	46.4
H6C	05/31/00	827	8.6	71.0	38.5	13.9	22.9	2.8	97.9	37.1	14.1	0.35	27.0
HBULK	05/31/00	890	0.9	14.6	15.4	3.2	3.7	6.0	16.3	16.3	10.5	0.27	14.7

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
HT1D	05/31/00	823	22.4	28.7	0.2	10.3	10.7	9.5	35.7	18.5	9.2	0.55	14.8
HT1E	05/31/00	951	15.4	24.9	4.3	10.9	10.0	3.8	31.5	18.9	9.7	0.40	15.7
HT1F	05/31/00	840	11.5	22.0	2.7	10.3	9.9	0.9	25.3	16.7	3.2	0.33	14.1
HT2F	05/31/00	910	2.8	19.6	18.1	4.9	5.0	5.7	21.8	20.4	11.7	0.30	18.2
HT3A	05/31/00	920	6.6	86.4	31.7	16.6	23.2	2.1	110.8	47.9	8.7	0.35	36.4
HT3B	05/31/00	930	11.4	46.9	19.8	9.5	12.9	7.4	54.1	27.5	7.8	0.57	21.9
HT3C	05/31/00	615	6.1	56.0	21.7	9.7	12.6	2.1	64.0	32.3	7.2	0.26	25.7
HT3F	05/31/00	932	2.6	14.5	13.7	3.6	4.7	2.9	18.1	14.7	7.0	0.19	12.9
HT4B	05/31/00	939	2.1	11.7	14.1	2.6	2.4	5.3	12.0	13.9	8.5	0.23	12.7
HT4D	05/31/00	921	9.7	79.3	50.4	13.6	22.0	3.1	88.8	50.7	18.1	0.44	41.6
HT4F	05/31/00	895	.	.	13.2	.	.	13.9	79.5	55.3	29.5	0.88	47.0
PARKB	05/31/00	332	0.3	3.9	6.0	1.6	1.0	2.4	4.4	6.9	4.0	0.11	6.5
C1A	06/13/00	323	9.4	7.6	4.3	4.4	4.2	0.5	10.1	6.9	0.3	0.15	5.9
C1C	06/13/00	308	12.2	8.8	4.6	4.9	4.9	0.4	11.9	6.8	0.3	0.14	5.5
C2A	06/13/00	397	14.3	9.7	0.9	7.9	5.5	0.6	13.4	12.4	0.4	0.25	11.0
C2C	06/13/00	376	15.1	6.0	0.9	5.4	4.3	0.4	7.9	7.3	0.5	0.19	6.5
C3A	06/13/00	376	10.1	5.7	4.1	4.7	4.1	0.5	8.6	6.9	0.9	0.12	6.0
C3C	06/13/00	375	6.2	4.7	4.7	3.4	3.1	0.3	6.3	6.7	1.0	0.15	6.0
C4A	06/13/00	110	3.2	4.3	1.4	1.5	1.8	0.2	5.4	2.8	0.1	0.06	2.2
C4C	06/13/00	191	6.2	16.4	.	3.8	5.0	2.6	19.2	9.1	2.2	.	7.1
C5A	06/13/00	274	18.7	20.4	0.5	6.5	8.4	0.3	25.6	13.1	0.3	0.34	10.5
C5C	06/13/00	201	16.9	4.7	0.1	4.9	3.8	0.3	7.3	6.4	0.1	0.15	5.6
C6A	06/13/00	395	9.1	12.4	11.9	5.0	6.6	0.2	16.5	12.5	2.7	0.19	10.8
C6C	06/13/00	426	7.4	13.7	9.5	5.0	6.3	4.2	16.3	13.0	7.4	0.21	11.4
CBULK	06/13/00	204	0.9	2.0	3.4	1.0	0.9	0.2	2.3	2.9	1.4	0.06	2.7
CT4B	06/13/00	634	3.1	7.5	8.7	3.1	2.7	1.1	9.1	8.1	4.5	0.17	7.2
CT4C	06/13/00	549	1.5	5.8	7.9	2.9	2.1	0.6	6.7	8.4	4.5	0.15	7.7
CT4D	06/13/00	680	3.0	10.0	6.3	4.5	3.7	1.0	11.8	8.7	5.8	0.17	7.5
CT4E	06/13/00	756	4.5	24.3	18.0	5.2	7.0	0.4	25.1	16.6	10.6	0.26	14.0
CT4F	06/13/00	432	1.6	4.6	5.3	2.1	1.5	0.4	4.8	5.3	3.1	0.11	4.8
CT5A	06/13/00	281	11.1	9.5	1.1	3.2	4.1	0.2	12.2	8.5	4.0	0.16	7.2
CT5D	06/13/00	493	2.7	10.7	7.3	3.1	3.7	0.8	11.3	9.3	5.1	0.17	8.1
CT5E	06/13/00	602	0.9	4.9	8.9	2.9	1.8	2.2	5.5	9.2	5.3	0.15	8.6
CT5F	06/13/00	652	2.5	6.8	8.7	3.0	2.5	0.4	7.3	9.0	5.7	0.17	8.2
H1A	06/14/00	259	5.2	13.0	9.8	4.2	4.8	0.3	14.5	8.7	2.3	0.16	7.2
H1C	06/14/00	379	8.2	7.4	3.3	2.5	3.7	0.2	8.5	7.2	2.5	0.14	6.3
H2A	06/14/00	213	5.2	5.1	6.0	2.6	2.9	0.2	5.7	7.0	1.4	0.09	6.4
H2C	06/14/00	286	7.1	11.0	8.2	3.6	5.3	0.2	12.7	8.9	4.4	0.18	7.6
H3A	06/14/00	375	8.0	17.4	15.2	4.4	5.7	1.0	17.6	12.4	5.2	0.21	10.6
H3C	06/14/00	352	8.9	7.3	6.5	3.9	3.5	1.2	9.2	8.3	1.1	0.12	7.3
H4A	06/14/00	480	7.4	18.1	9.1	3.8	5.0	0.4	18.4	13.5	3.9	0.20	11.6
H4C	06/14/00	328	9.5	26.9	24.2	7.8	12.4	0.2	33.3	21.8	13.1	0.35	18.3
H5A	06/14/00	407	8.0	6.4	3.9	2.8	2.7	0.5	7.3	6.4	0.7	0.12	5.7
H5C	06/14/00	258	7.3	15.6	10.7	6.6	6.7	0.2	20.1	12.1	2.1	0.16	10.0
H6A	06/14/00	222	9.7	22.0	9.9	4.6	8.8	0.4	27.8	12.7	6.3	0.22	9.8
H6C	06/14/00	408	6.8	8.3	5.4	2.8	3.9	0.9	10.4	7.5	3.0	0.15	6.4
HBULK	06/14/00	505	2.3	1.9	7.1	2.1	1.5	0.1	2.3	7.2	3.2	0.13	7.0
HT1D	06/14/00	386	14.5	3.5	0.0	5.5	4.7	0.4	5.9	4.7	2.1	0.16	4.1
HT1E	06/14/00	449	18.0	6.4	0.1	6.1	5.1	1.8	7.8	7.8	0.7	0.23	7.0
HT1F	06/14/00	316	10.8	4.2	0.1	7.1	5.8	0.5	5.5	6.0	0.2	0.13	5.4
HT2F	06/14/00	487	3.4	2.2	4.8	2.2	1.6	0.6	3.0	7.0	2.7	0.11	6.6
HT3A	06/14/00	334	5.3	17.8	13.5	4.3	6.2	2.8	18.9	13.3	3.9	0.23	11.3
HT3B	06/14/00	307	15.9	6.9	.	4.8	7.0	0.3	9.7	6.1	0.1	0.24	5.1

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
HT3C	06/14/00	395	6.4	15.2	9.9	3.2	4.3	0.3	14.3	10.5	3.8	0.18	9.0
HT3F	06/14/00	458	4.2	1.9	5.7	1.6	1.5	0.1	3.3	6.1	2.0	0.09	5.7
HT4B	06/14/00	653	1.4	3.0	8.0	2.3	1.6	0.2	3.7	8.3	4.7	0.14	8.0
HT4D	06/14/00	320	7.3	25.6	.	7.5	12.0	0.1	31.0	20.1	12.7	0.33	16.9
HT4F	06/14/00	672	1.3	7.6	9.7	5.1	2.5	0.2	7.5	12.3	7.5	0.19	11.6
PARKB	06/14/00	518	0.7	3.4	6.5	2.2	1.1	1.3	3.7	6.6	4.3	0.13	6.2
C1A	07/05/00	688	11.0	11.0	20.7	6.3	5.8	4.9	10.9	26.7	12.9	0.86	25.6
C1C	07/05/00	655	27.6	16.0	11.9	11.3	15.1	0.9	17.4	27.7	11.2	0.51	25.9
C2A	07/05/00	754	13.6	13.9	21.1	10.7	7.9	0.4	14.2	29.2	12.0	0.45	27.8
C2C	07/05/00	777	20.2	11.6	14.7	9.7	10.4	0.4	12.7	27.8	4.8	0.38	26.4
C3A	07/05/00	703	21.1	11.4	15.3	8.1	7.7	0.4	12.2	27.3	9.7	0.42	26.0
C3C	07/05/00	630	10.8	7.8	18.1	4.8	5.6	2.5	9.0	21.5	7.1	0.24	20.6
C4A	07/05/00	621	24.5	27.0	17.4	16.0	17.5	0.9	29.8	33.0	19.2	0.55	29.9
C4C	07/05/00	342	16.6	35.5	9.8	11.6	14.9	0.3	40.8	27.6	10.5	0.41	23.3
C5A	07/05/00	359	34.1	23.4	3.3	10.4	12.7	2.9	27.7	26.0	16.8	0.75	23.2
C5C	07/05/00	608	17.0	8.4	7.8	10.4	8.9	2.4	10.2	21.7	6.4	0.42	20.7
C6A	07/05/00	382	12.1	16.6	11.0	8.5	9.0	0.4	14.6	26.1	5.6	0.25	24.6
C6C	07/05/00	621	16.9	17.1	21.4	8.1	9.1	2.1	16.2	33.0	16.2	0.42	31.3
CBULK	07/05/00	691	10.7	9.8	25.5	3.5	3.8	0.4	9.9	25.0	12.6	0.41	24.0
CT2A	07/05/00	711	21.3	16.4	13.8	8.1	7.2	2.2	16.7	28.3	15.3	0.45	26.6
CT2C	07/05/00	638	15.3	8.5	5.0	8.3	6.2	0.7	9.4	19.9	3.7	0.27	18.9
CT2D	07/05/00	536	12.8	19.7	10.9	16.0	12.4	2.9	16.4	27.3	19.3	0.54	25.7
CT4A	07/05/00	896	7.7	34.0	32.4	12.8	15.8	4.6	37.5	37.9	21.4	0.62	34.1
CT4B	07/05/00	700	4.9	18.5	29.7	5.5	6.8	4.0	18.6	28.9	15.9	0.41	27.0
CT4C	07/05/00	807	1.4	13.1	32.0	3.3	3.4	5.2	12.4	28.0	16.3	0.40	26.7
CT4D	07/05/00	353	6.4	16.8	8.0	11.8	8.6	0.5	19.1	21.3	9.2	0.24	19.3
CT4E	07/05/00	899	20.6	24.7	31.7	10.3	13.2	4.3	30.3	43.1	21.6	0.58	40.0
CT4F	07/05/00	491	2.8	17.4	22.3	6.3	5.8	2.2	18.0	24.6	13.1	0.34	22.7
CT5A	07/05/00	552	6.3	18.5	21.9	5.2	6.7	1.4	19.7	23.9	22.5	0.33	21.9
CT5D	07/05/00	907	4.5	41.9	39.4	10.4	16.7	5.6	42.1	44.0	29.5	0.71	39.6
CT5E	07/05/00	893	1.7	12.5	32.3	3.6	3.4	6.1	11.8	29.6	15.2	0.43	28.4
CT5F	07/05/00	817	1.4	16.0	30.9	3.1	3.8	4.6	15.0	28.3	12.9	0.37	26.8
H1A	07/05/00	481	14.7	37.3	21.4	14.6	17.2	1.6	48.3	36.8	13.8	0.44	31.8
H1C	07/05/00	722	17.0	36.1	23.8	12.1	15.2	3.5	40.9	36.8	16.7	0.48	32.6
H2A	07/05/00	581	7.6	12.0	25.2	5.0	4.4	1.5	11.6	20.8	7.1	0.24	19.6
H2C	07/05/00	535	17.6	19.6	18.0	8.6	10.1	0.5	23.2	31.1	11.4	0.32	28.7
H3A	07/05/00	497	22.6	42.6	26.6	19.0	18.4	2.4	57.3	49.2	13.7	0.50	43.3
H3C	07/05/00	565	16.5	20.8	21.4	12.8	11.1	1.6	25.7	33.2	11.6	0.36	30.5
H4A	07/05/00	816	27.1	46.0	40.7	18.1	20.5	4.2	57.5	67.0	18.2	0.72	61.1
H4C	07/05/00	606	24.1	63.9	31.6	20.2	25.7	1.4	81.6	59.7	22.1	0.66	51.2
H5A	07/05/00	616	18.6	22.8	22.2	9.7	11.4	1.4	26.7	31.7	10.3	0.34	29.0
H5C	07/05/00	493	25.4	32.7	17.8	17.1	15.9	1.1	45.3	42.0	3.3	0.35	37.3
H6A	07/05/00	690	30.9	89.6	38.6	22.7	33.0	2.3	113.4	71.5	36.6	0.87	59.7
H6C	07/05/00	497	15.0	30.2	18.8	10.6	14.0	1.1	38.5	33.0	12.8	0.35	29.0
HBULK	07/05/00	785	1.0	7.8	31.1	1.6	2.0	6.0	7.6	26.4	13.9	0.38	25.6
HT1D	07/05/00	776	14.8	15.7	6.9	13.8	13.7	0.9	17.8	28.5	12.6	0.39	26.7
HT1E	07/05/00	865	32.0	23.4	1.9	16.3	12.0	18.1	26.9	45.0	17.9	0.89	42.2
HT1F	07/05/00	625	16.9	11.7	3.7	12.1	11.5	2.8	13.1	27.7	10.8	0.39	26.4
HT2F	07/05/00	818	1.7	8.4	30.2	2.1	2.1	7.4	7.5	27.1	15.1	0.40	26.4
HT3A	07/05/00	605	12.6	62.0	34.6	19.9	25.1	3.6	75.6	60.5	18.8	0.61	52.7
HT3C	07/05/00	400	13.2	50.0	20.4	15.4	19.3	2.1	57.6	50.0	13.5	0.40	44.1
HT3F	07/05/00	579	5.0	6.0	18.2	2.4	2.4	4.4	6.5	20.1	7.9	0.34	19.4
HT4B	07/05/00	636	2.3	5.5	24.6	1.8	1.6	3.4	5.2	22.4	9.9	0.26	21.9

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
HT4D	07/05/00	897	35.8	70.9	43.7	28.1	35.4	4.1	84.2	87.0	44.9	0.97	78.3
HT4F	07/05/00	746	0.8	14.9	31.7	3.2	3.4	6.7	14.1	15.6	15.3	0.40	14.1
PARKB	07/05/00	799	0.9	6.0	25.1	1.8	1.7	8.1	5.7	23.6	11.3	0.41	23.1
C1A	07/26/00	1411	6.1	18.2	15.7	4.7	6.5	0.8	19.4	18.7	0.9	0.17	16.7
C1B	07/26/00	1753	6.2	19.5	14.8	8.5	7.4	1.0	20.6	21.5	2.0	0.15	19.3
C1C	07/26/00	1632	22.1	21.4	3.6	8.3	10.3	2.3	25.0	17.5	2.1	0.27	14.9
C1D	07/26/00	1235	5.8	14.5	9.1	5.3	5.2	0.7	15.1	15.1	1.2	0.16	13.6
C2A	07/26/00	1681	9.0	20.1	17.5	8.6	7.8	1.0	22.3	23.2	2.1	0.27	20.9
C2B	07/26/00	1793	13.8	25.1	5.4	9.6	9.0	1.5	28.4	20.1	0.7	0.21	17.2
C2C	07/26/00	1775	10.9	20.9	13.4	10.4	10.4	1.0	22.6	21.7	0.2	0.56	19.4
C2D	07/26/00	1371	18.8	16.1	8.8	7.7	8.6	0.8	18.9	21.0	0.1	0.24	19.0
C3A	07/26/00	2188	11.4	22.8	22.8	7.8	8.3	2.5	24.6	26.8	5.9	0.32	24.3
C3B	07/26/00	1683	11.9	22.0	17.1	10.3	10.6	1.4	24.9	24.0	7.4	0.47	21.5
C3C	07/26/00	1729	8.6	16.1	15.0	3.5	7.3	2.9	16.8	19.4	3.4	0.60	17.7
C3D	07/26/00	1384	6.7	13.5	14.1	3.9	6.4	1.2	14.8	18.4	4.2	0.31	16.8
C4A	07/26/00	1639	19.7	29.5	13.0	10.4	11.7	1.9	31.8	20.9	4.3	0.35	17.6
C4B	07/26/00	2028	28.6	50.0	13.3	13.9	16.2	4.6	47.6	27.9	3.2	0.52	23.0
C4C	07/26/00	946	14.8	47.7	14.2	13.2	14.3	0.5	43.0	22.7	6.2	0.35	18.2
C4D	07/26/00	1234	31.2	23.8	0.2	11.6	12.4	21.3	34.6	19.5	3.3	0.78	15.9
C5A	07/28/00	1435	28.8	38.2	10.3	12.8	15.1	2.8	42.5	23.4	8.3	0.58	19.0
C5B	07/28/00	1481	13.5	24.0	7.1	10.6	9.3	1.3	24.9	21.2	0.5	0.34	18.6
C5C	07/28/00	1576	28.6	18.9	1.0	12.8	12.6	0.9	20.9	20.1	0.2	0.46	17.9
C5D	07/28/00	1772	11.6	17.7	11.9	9.0	8.2	1.0	19.0	21.7	0.2	0.31	19.7
C6A	07/26/00	1811	17.5	27.3	22.2	9.2	11.4	1.0	32.3	33.3	3.0	0.25	29.9
C6B	07/26/00	1584	5.2	23.9	13.1	8.1	10.6	0.4	21.8	18.6	0.2	0.15	16.3
C6C	07/26/00	2098	15.3	22.4	15.5	6.9	9.7	1.2	23.5	30.0	1.5	0.14	27.5
C6D	07/26/00	2864	35.5	69.3	35.9	23.3	30.1	1.6	84.8	70.1	1.0	0.34	61.4
CBULK	07/26/00	1890	2.2	15.1	21.1	2.4	4.0	0.5	15.4	20.3	0.2	0.14	18.7
CT2A	07/28/00	1781	15.1	26.5	8.1	7.3	9.0	0.5	26.4	25.4	4.5	0.21	22.7
CT2C	07/28/00	1791	10.3	20.3	16.2	14.1	8.3	2.0	21.9	20.1	0.2	0.14	17.8
CT2D	07/28/00	1806	9.9	47.7	13.9	21.6	18.9	1.5	50.7	32.3	6.7	0.40	27.0
CT4A	07/26/00	1762	9.4	63.4	32.6	16.1	22.9	1.0	67.4	45.8	8.4	0.34	38.9
CT4B	07/26/00	1782	4.9	21.8	23.4	4.1	6.7	1.0	24.5	24.5	1.6	0.20	22.0
CT4C	07/26/00	1703	1.6	31.7	37.1	4.3	7.9	2.4	33.9	32.1	12.3	0.31	28.6
CT4D	07/26/00	1772	9.2	45.2	15.7	18.9	15.6	1.0	57.9	28.0	1.4	0.15	22.0
CT4E	07/26/00	1845	18.8	59.8	28.4	8.5	17.0	1.0	63.1	39.5	1.2	0.15	33.0
CT4F	07/26/00	1799	3.1	33.1	17.9	6.4	7.6	1.0	35.8	21.1	2.5	0.18	17.4
CT5A	07/26/00	1722	5.2	17.2	21.1	2.6	4.3	1.0	18.5	20.2	4.2	0.17	18.3
CT5D	07/26/00	1758	3.7	35.9	33.3	6.7	13.3	2.5	37.7	34.1	9.1	0.30	30.2
CT5E	07/26/00	1816	0.0	16.5	30.0	2.8	3.8	1.0	17.6	22.2	8.5	0.24	20.4
CT5F	07/26/00	1718	1.3	13.0	17.5	2.6	0.0	1.0	14.0	14.9	2.6	0.14	13.5
H1A	07/26/00	1519	10.9	26.3	20.4	7.7	9.6	2.1	27.9	20.2	4.9	0.34	17.3
H1B	07/26/00	944	0.5	9.2	13.9	2.4	2.8	0.8	10.1	12.0	3.6	0.16	11.0
H1C	07/26/00	1494	17.3	34.2	21.5	9.1	13.8	5.5	39.6	25.9	9.1	0.50	21.8
H1D	07/26/00	812	7.3	15.1	15.8	4.8	5.8	2.5	18.6	13.7	4.6	0.22	11.7
H2A	07/26/00	1560	22.0	9.3	6.3	4.4	7.9	0.4	11.9	16.7	0.2	0.12	15.5
H2B	07/26/00	1414	31.4	29.2	15.1	9.0	13.1	0.8	33.9	21.6	6.0	0.45	18.1
H2C	07/26/00	1343	13.0	25.0	15.3	11.6	10.1	7.6	28.8	19.2	2.1	0.18	16.2
H2D	07/26/00	1375	19.6	17.7	16.8	7.4	9.2	1.2	21.7	24.6	3.7	0.32	22.3
H3A	07/26/00	1029	17.0	30.8	23.5	12.6	11.7	1.5	30.5	27.3	6.9	0.41	24.2
H3B	07/26/00	1161	22.9	17.3	8.6	9.5	13.2	0.3	20.7	21.9	4.7	0.35	19.8
H3C	07/26/00	1333	33.6	16.0	9.6	12.2	8.4	1.5	17.7	21.1	3.9	0.36	19.3
H3D	07/26/00	930	15.3	14.2	6.5	6.4	6.6	0.5	13.3	13.3	1.5	0.26	11.9

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
H4A	07/26/00	1339	18.9	33.3	25.4	9.5	11.8	3.0	39.6	27.3	2.7	0.34	23.2
H4B	07/26/00	1592	12.5	31.4	35.5	8.9	10.7	0.9	27.6	34.9	9.1	0.39	32.1
H4C	07/26/00	2003	15.7	25.3	24.5	7.6	10.1	2.8	27.6	31.7	6.6	0.32	28.8
H4D	07/26/00	1410	24.5	24.4	11.7	11.1	12.4	2.4	24.5	23.0	2.4	0.35	20.5
H5A	07/26/00	1621	16.1	17.6	16.5	7.0	7.5	0.5	18.2	19.8	1.7	0.30	18.0
H5B	07/26/00	1771	22.2	56.2	39.4	14.0	17.8	1.0	52.4	40.7	4.6	0.53	35.2
H5C	07/26/00	1256	24.4	44.0	24.4	12.5	12.1	0.7	42.3	26.9	0.2	0.42	22.5
H5D	07/26/00	1543	20.9	55.5	27.3	11.8	16.2	2.2	49.6	37.0	3.2	0.48	31.9
H6A	07/26/00	1563	26.5	53.4	23.0	11.9	17.7	3.5	59.0	35.9	5.2	0.42	29.8
H6B	07/26/00	1672	23.8	64.6	34.8	14.9	21.8	37.8	67.4	42.7	16.1	0.64	35.7
H6C	07/26/00	1665	18.5	20.3	10.0	7.6	9.8	3.8	26.3	18.7	4.6	0.37	16.0
H6D	07/26/00	1515	20.8	47.4	29.4	12.3	16.5	0.9	47.2	33.2	7.3	0.46	28.4
HBULK	07/26/00	1847	0.0	8.2	26.6	0.0	0.0	2.6	8.5	19.8	8.0	0.23	18.9
HT1D	07/26/00	1758	17.0	12.1	0.7	12.5	17.0	0.5	13.5	18.8	3.6	0.45	17.4
HT1E	07/26/00	1764	18.4	18.0	5.5	14.4	10.4	3.0	20.7	28.8	5.9	0.32	26.7
HT1F	07/26/00	1822	12.1	12.5	1.3	12.5	16.8	1.5	13.9	17.7	4.1	0.39	16.2
HT2F	07/26/00	1677	2.8	12.7	19.6	3.0	0.0	0.9	12.8	15.4	4.2	0.20	14.1
HT3A	07/26/00	1783	11.4	41.2	36.2	10.9	15.0	4.5	36.4	34.6	7.3	0.62	30.8
HT3B	07/26/00	1814	16.8	16.1	15.0	5.1	7.6	1.5	16.7	20.4	0.0	0.19	18.6
HT3C	07/26/00	1664	18.2	68.7	43.5	16.5	20.3	6.6	55.2	56.9	11.2	0.75	51.2
HT3F	07/26/00	1746	2.3	8.9	20.4	0.0	0.0	1.0	9.8	17.8	2.5	0.17	16.8
HT4B	07/26/00	1738	5.0	10.8	11.4	0.0	0.0	2.0	11.5	13.3	0.5	0.12	12.1
HT4D	07/26/00	1784	31.7	59.4	38.8	18.2	21.7	0.0	70.1	55.5	13.8	0.56	48.3
HT4F	07/26/00	1774	0.0	15.7	27.3	3.6	3.7	1.5	16.3	21.7	7.3	0.24	20.0
PARKB	07/26/00	896	5.0	7.8	6.8	3.4	3.0	0.5	9.1	11.4	0.2	0.66	10.5
C1A	08/17/00	590	8.5	9.3	19.4	6.6	5.7	2.2	9.3	29.2	7.5	0.26	28.2
C1C	08/17/00	475	24.8	10.8	10.8	11.0	10.8	0.3	12.8	30.5	9.1	0.32	29.2
C2A	08/17/00	763	11.2	14.1	23.5	11.5	7.0	4.7	13.2	38.2	12.5	0.39	36.8
C2C	08/17/00	763	22.0	13.0	14.5	16.1	13.1	1.5	14.4	39.7	10.3	0.39	38.2
C3A	08/17/00	669	14.8	14.0	17.1	8.2	7.3	29.1	14.0	45.4	17.0	0.83	44.0
C3C	08/17/00	633	8.3	9.4	23.4	4.5	4.3	2.9	9.0	31.0	9.8	0.32	30.1
C4A	08/17/00	408	25.9	19.3	5.2	15.3	14.7	3.9	20.2	33.7	7.0	0.36	31.6
C4C	08/17/00	277	11.9	31.4	15.9	12.5	15.9	5.2	25.6	39.1	11.6	0.49	36.5
C5A	08/17/00	163	16.0	10.1	4.6	7.3	8.4	4.6	10.7	20.2	8.8	0.38	19.1
C5C	08/17/00	344	12.3	4.4	3.0	9.0	5.6	0.1	6.3	19.5	3.5	0.21	18.8
C6A	08/17/00	830	23.3	19.3	26.7	10.4	11.5	2.6	16.9	52.9	10.2	0.47	51.2
C6C	08/17/00	793	17.1	14.1	24.4	6.5	7.7	4.5	14.2	40.5	13.1	0.40	39.0
CBULK	08/17/00	631	3.1	7.4	30.7	2.7	2.4	1.1	6.8	26.7	8.2	0.28	26.0
CT2A	08/17/00	946	25.1	14.7	34.2	10.4	7.1	0.5	15.9	58.9	10.1	0.36	57.2
CT2C	08/17/00	176	2.5	1.9	4.1	4.4	1.5	0.1	2.6	8.0	3.3	0.05	7.7
CT2D	08/17/00	915	18.0	29.6	33.0	29.8	18.4	5.9	22.9	71.0	14.4	0.60	68.6
CT4A	08/17/00	946	5.3	42.0	39.2	16.4	16.3	2.9	27.5	55.5	14.9	0.48	52.7
CT4B	08/17/00	176	1.0	2.3	3.6	0.8	0.9	0.0	2.2	4.8	0.0	0.04	4.6
CT4C	08/17/00	915	0.7	11.4	35.4	4.4	2.7	8.0	11.7	37.8	13.8	0.40	36.6
CT4D	08/17/00	402	4.6	15.9	8.7	8.9	5.6	0.3	12.1	19.7	1.7	0.11	18.4
CT4E	08/17/00	911	13.9	37.8	31.4	9.7	14.5	0.3	27.4	52.5	7.5	0.33	49.7
CT4F	08/17/00	589	0.5	5.4	19.0	12.0	1.7	0.0	4.5	21.3	3.9	0.14	20.9
CT5A	08/17/00	589	1.8	4.8	16.9	2.1	2.0	0.0	3.9	20.1	5.7	0.23	19.7
CT5D	08/17/00	890	3.8	27.9	37.8	7.9	11.2	0.3	19.5	46.3	13.2	0.40	44.3
CT5E	08/17/00	600	0.6	5.7	23.8	2.9	1.3	2.7	5.8	20.8	7.8	0.25	20.2
CT5F	08/17/00	648	1.0	7.0	19.0	4.5	1.4	0.9	7.9	19.2	4.6	0.18	18.4
H1A	08/17/00	434	12.7	21.3	22.1	11.2	11.3	10.2	18.8	37.2	11.7	0.59	35.3
H1C	08/17/00	544	21.2	31.3	22.0	11.5	15.5	12.5	31.1	44.7	15.8	0.67	41.5

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
H2A	08/17/00	510	7.6	4.5	16.8	3.2	3.0	5.8	4.9	20.8	8.7	0.33	20.3
H2C	08/17/00	363	12.3	12.1	12.0	6.7	7.0	3.0	11.9	23.2	7.1	0.29	21.9
H3A	08/17/00	327	22.8	18.0	15.6	15.6	13.2	7.2	18.5	43.7	10.0	0.51	41.8
H3C	08/17/00	450	132.7	10.1	1.1	15.4	11.9	1.8	21.4	44.1	3.5	0.56	41.9
H4A	08/17/00	556	29.5	42.4	34.9	19.4	20.8	3.9	38.9	73.2	7.2	0.58	69.2
H4C	08/17/00	612	22.6	20.5	21.1	12.6	13.6	4.8	16.9	53.1	10.3	0.54	51.3
H5A	08/17/00	620	32.1	13.1	10.0	11.5	10.7	3.0	14.2	34.8	7.6	0.45	33.3
H5C	08/17/00	484	26.1	37.8	21.5	21.7	18.9	3.0	33.6	55.6	2.6	0.49	52.1
H6A	08/17/00	732	34.1	56.9	37.3	18.3	23.0	8.3	50.4	76.9	20.5	0.71	71.7
H6C	08/17/00	404	10.3	8.6	16.0	6.5	6.3	5.4	9.3	26.6	10.0	0.34	25.6
HBULK	08/17/00	633	0.5	5.5	28.1	2.1	1.3	6.1	5.5	26.5	11.8	0.31	25.9
HT1D	08/17/00	986	24.6	14.7	4.1	25.6	19.9	7.0	15.1	45.8	16.1	0.66	44.2
HT1E	08/17/00	983	35.3	17.5	17.0	23.5	11.6	13.9	21.1	63.2	21.5	0.76	61.0
HT1F	08/17/00	931	28.8	13.2	2.6	28.9	22.7	18.9	15.7	62.7	21.5	0.98	61.1
HT2F	08/17/00	932	2.4	9.1	36.9	3.6	2.3	9.5	8.6	37.1	14.1	0.44	36.2
HT3A	08/17/00	962	21.8	66.2	66.2	28.4	33.9	5.2	49.6	105.5	15.6	0.91	100.4
HT3B	08/17/00	936	34.3	28.5	25.1	12.2	11.8	5.8	24.4	52.5	13.5	0.58	50.0
HT3C	08/17/00	717	29.5	61.7	54.1	27.0	28.3	8.5	49.4	105.7	22.1	0.91	100.6
HT3F	08/17/00	918	2.3	7.3	28.9	3.3	1.9	7.5	6.6	30.9	8.5	0.32	30.2
HT4B	08/17/00	809	13.0	13.6	18.4	4.7	3.7	0.7	13.2	28.1	3.6	0.17	26.7
HT4D	08/17/00	939	38.1	38.8	39.8	19.6	20.1	3.7	36.9	84.3	22.4	0.70	80.5
HT4F	08/17/00	983	0.9	12.0	40.8	3.5	2.9	9.7	10.5	42.6	16.7	0.42	41.5
PARKB	08/17/00	479	0.3	4.5	29.4	2.0	1.2	3.0	4.6	25.4	8.6	0.27	24.9
C1A	09/20/00	1135	15.7	17.9	13.0	6.9	6.2	0.6	14.5	27.2	6.2	0.42	25.7
C1C	09/20/00	1070	46.2	20.9	3.4	16.6	13.9	1.2	26.2	30.6	9.0	0.49	27.9
C2A	09/20/00	1407	16.9	27.8	16.1	11.1	7.7	13.1	28.0	36.6	16.5	0.85	33.7
C2C	09/20/00	896	22.0	16.7	3.5	14.4	11.3	0.8	17.8	25.6	7.3	0.56	23.8
C3A	09/20/00	654	8.2	13.5	13.0	4.8	4.4	2.0	14.0	19.4	9.0	0.39	17.9
C3C	09/20/00	1164	11.2	18.3	25.3	5.6	6.8	2.0	17.2	27.9	13.3	0.50	26.1
C4A	09/20/00	899	41.3	26.9	9.6	21.7	20.4	8.9	36.7	40.8	29.3	1.17	37.0
C4C	09/20/00	745	26.0	64.2	19.9	26.4	28.1	14.3	65.8	54.7	30.6	1.20	47.9
C5A	09/20/00	607	40.9	26.1	17.0	16.7	19.6	9.3	34.7	43.7	35.9	1.11	40.1
C5C	09/20/00	733	27.9	12.7	0.6	13.6	8.9	0.6	15.0	19.4	3.8	0.39	17.9
C6A	09/19/00	1222	51.7	27.4	11.9	11.2	11.8	1.4	31.8	45.5	12.1	0.72	42.2
C6C	09/19/00	1575	20.3	28.3	36.7	9.2	9.3	2.2	27.3	42.6	18.8	0.63	39.8
CBULK	09/20/00	1003	2.4	13.1	30.8	2.8	3.4	0.6	12.3	23.0	9.3	0.29	21.8
CT2A	09/20/00	639	9.3	13.8	8.2	5.2	4.0	0.4	14.3	17.9	3.9	0.22	16.4
CT2C	09/20/00	927	11.5	12.3	4.8	17.0	4.7	0.8	13.7	22.2	7.3	0.30	20.8
CT2D	09/20/00	940	10.2	23.8	8.3	22.7	13.8	1.3	26.9	28.3	6.9	0.53	25.5
CT4A	09/19/00	844	6.5	30.9	24.8	11.0	9.9	7.4	34.4	33.2	14.1	0.68	29.6
CT4B	09/19/00	923	6.7	14.7	19.2	4.5	5.0	0.8	14.6	22.1	9.2	0.27	20.6
CT4C	09/19/00	937	0.6	16.8	25.7	3.8	3.5	3.7	16.3	25.8	10.4	0.28	24.1
CT4D	09/19/00	752	6.6	24.9	19.2	13.8	8.2	1.1	24.6	25.3	14.4	0.37	22.8
CT4E	09/19/00	902	11.8	20.6	25.9	8.7	10.2	1.0	18.9	33.6	11.7	0.34	31.6
CT4F	09/19/00	882	2.4	18.6	24.2	6.1	4.1	2.7	16.7	25.2	12.2	0.32	23.5
CT5A	09/19/00	912	4.2	16.0	21.8	4.9	5.0	3.9	16.3	25.1	11.8	0.32	23.4
CT5D	09/19/00	899	4.8	33.7	32.5	9.2	11.3	3.8	36.7	33.5	17.6	0.44	29.7
CT5E	09/19/00	936	1.7	14.7	29.4	3.1	2.7	0.5	13.4	22.9	9.9	0.31	21.5
CT5F	09/19/00	768	1.0	11.4	22.5	3.5	2.3	3.0	11.0	20.8	10.3	0.28	19.6
H1A	09/21/00	786	24.7	37.7	16.7	18.8	20.1	37.8	49.3	48.1	26.8	1.30	43.0
H1C	09/21/00	988	38.4	34.6	11.0	13.3	17.4	22.9	49.9	40.8	25.3	1.19	35.7
H2A	09/21/00	909	21.8	13.3	5.2	4.9	6.5	14.1	15.3	21.8	10.1	0.75	20.2
H2C	09/21/00	674	25.0	18.5	8.6	9.8	11.3	17.9	28.2	31.3	16.5	0.86	28.4

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
H3A	09/21/00	803	48.1	40.5	9.6	24.9	21.2	43.8	56.9	63.9	31.3	1.74	58.0
H3C	09/21/00	873	46.0	26.9	10.7	27.6	19.4	37.8	41.0	57.5	19.7	1.39	53.2
H4A	09/21/00	972	35.4	44.0	42.2	21.0	21.6	8.2	52.1	73.9	21.2	0.82	68.5
H4C	09/21/00	1277	33.2	61.8	47.2	23.7	25.7	10.5	75.6	69.1	39.4	1.09	61.3
H5A	09/21/00	1424	76.5	33.5	9.6	18.9	17.9	7.2	36.3	47.2	12.0	1.03	43.5
H5C	09/21/00	904	41.3	41.9	20.1	23.9	23.1	13.3	48.0	60.9	10.4	0.97	55.9
H6A	09/21/00	1107	47.4	101.7	52.7	34.1	42.3	12.5	118.6	89.8	62.7	1.72	77.5
H6C	09/21/00	721	22.5	24.8	0.8	11.4	12.4	69.3	38.6	32.0	16.2	1.22	28.0
HBULK	09/21/00	1029	0.7	11.6	26.9	2.1	2.6	3.2	10.5	25.2	10.7	0.32	24.1
HT1D	09/21/00	986	35.4	13.6	0.4	19.8	17.4	0.6	5.0	24.1	5.3	0.56	23.6
HT1E	09/21/00	983	44.2	19.9	0.9	18.5	10.3	8.9	24.1	38.6	12.9	0.58	36.1
HT1F	09/21/00	931	25.3	14.1	1.1	19.2	16.8	1.8	15.7	31.4	12.9	0.54	29.7
HT2F	09/21/00	932	2.2	10.3	20.8	2.4	2.3	5.8	9.0	22.8	9.2	0.33	21.9
HT3A	09/21/00	962	20.0	65.8	45.8	29.1	33.9	13.1	74.1	74.1	34.8	1.14	66.5
HT3B	09/21/00	936	30.8	22.0	12.9	7.9	9.8	1.1	23.9	30.1	10.9	0.54	27.6
HT3C	09/21/00	717	27.6	71.8	40.1	31.2	30.7	28.6	76.5	79.0	53.0	1.62	71.1
HT3F	09/21/00	918	5.5	9.4	15.9	3.3	3.1	4.9	9.8	19.2	7.6	0.45	18.2
HT4B	09/21/00	809	4.3	9.2	17.2	2.5	2.4	0.5	7.8	20.6	3.8	0.18	19.8
HT4D	09/21/00	939	30.1	66.1	49.0	27.7	26.8	6.1	70.4	72.3	55.1	1.23	65.1
HT4F	09/21/00	983	1.3	27.9	26.9	3.8	5.8	7.5	23.1	31.1	16.4	0.42	28.7
PARKB	09/20/00	920	0.0	9.6	23.5	1.9	1.9	0.8	8.0	21.6	6.4	0.25	20.8
C1A	10/12/00	1564	47.1	19.1	0.9	10.0	10.5	0.9	29.5	31.9	2.4	0.30	28.9
C1B	10/12/00	1716	115.3	19.8	0.3	35.8	25.9	1.5	83.2	64.8	0.2	0.57	56.2
C1C	10/12/00	1244	50.0	23.2	0.6	10.8	11.0	0.7	37.4	22.8	4.3	0.33	19.0
C1D	10/12/00	1311	43.3	14.5	3.4	9.3	8.3	0.7	31.4	23.4	9.1	0.28	20.2
C2A	10/12/00	1392	33.2	18.2	0.7	8.9	7.0	0.8	27.0	20.6	3.3	0.34	17.8
C2B	10/12/00	1753	49.2	25.7	0.5	13.8	11.0	1.0	40.2	30.4	2.9	0.38	26.2
C2C	10/12/00	1045	24.1	12.8	0.3	6.9	6.6	0.3	18.7	14.4	1.3	0.18	12.5
C2D	10/12/00	1787	24.5	17.8	8.1	12.3	10.5	0.5	28.3	23.7	10.5	0.36	20.8
C3A	10/12/00	2221	97.1	30.1	14.3	18.1	15.8	1.3	91.8	70.3	8.7	0.37	60.8
C3B	10/12/00	1630	18.5	28.6	15.1	10.0	10.3	0.9	32.4	24.9	12.2	0.41	21.6
C3C	10/12/00	942	12.8	10.5	9.2	3.1	4.0	0.3	15.9	13.5	5.7	0.15	11.8
C3D	10/12/00	2014	43.9	20.1	8.0	11.3	14.4	1.1	44.2	31.9	8.7	0.35	27.3
C4A	10/12/00	1605	34.1	49.2	19.6	18.8	18.2	1.4	52.4	33.6	31.8	0.86	28.2
C4B	10/12/00	1997	83.6	67.8	7.6	34.6	34.4	1.1	106.0	58.1	19.0	0.75	47.1
C4C	10/12/00	880	18.3	57.8	23.0	18.8	21.1	1.2	57.9	34.6	27.3	0.70	28.6
C4D	10/12/00	1990	107.2	48.1	0.9	31.9	26.7	1.1	102.5	46.7	0.2	0.61	36.1
C5A	10/12/00	1104	64.5	39.9	10.0	15.5	17.6	7.5	58.6	47.9	32.6	1.13	41.8
C5B	10/12/00	1527	49.4	20.7	0.4	13.2	10.3	0.9	31.9	25.7	8.4	0.41	22.4
C5C	10/12/00	972	70.6	12.1	0.1	14.4	10.6	0.5	34.7	23.8	0.0	0.22	20.2
C5D	10/12/00	940	84.7	11.5	0.1	9.1	6.7	0.5	25.4	25.4	0.0	0.20	22.8
C6A	10/13/00	996	22.7	19.9	14.3	7.6	8.4	0.8	21.9	27.9	11.7	0.39	25.7
C6B	10/13/00	2480	21.7	44.6	21.0	22.7	28.1	3.5	53.1	45.6	5.2	0.51	40.1
C6C	10/13/00	1886	25.6	28.9	21.5	10.1	12.7	4.3	34.6	31.8	15.7	0.50	28.2
C6D	10/13/00	2842	66.7	37.2	9.6	21.0	16.7	1.6	50.8	39.2	10.3	0.44	33.9
CBULK	10/12/00	1782	1.6	17.8	28.1	2.7	3.7	1.0	18.2	20.9	9.0	0.25	19.0
CT2A	10/12/00	1703	34.2	30.6	1.2	12.6	13.6	1.0	45.2	26.9	0.2	0.17	22.3
CT2C	10/12/00	1713	31.7	19.0	0.3	23.6	12.2	1.0	36.7	20.1	0.0	0.32	16.3
CT2D	10/12/00	1746	49.2	47.7	3.7	26.7	17.6	1.0	69.5	33.9	18.9	0.66	26.7
CT4A	10/13/00	1642	5.8	36.8	24.7	9.6	10.3	1.9	41.9	28.5	10.8	0.34	24.2
CT4B	10/13/00	1681	18.2	20.1	15.6	6.8	7.8	1.0	25.7	25.7	8.0	0.25	23.1
CT4C	10/13/00	1607	1.5	36.7	28.4	4.1	8.8	1.4	39.4	27.9	12.1	0.25	23.8
CT4D	10/13/00	1668	13.1	37.0	23.4	17.8	11.2	1.9	42.6	34.0	19.0	0.49	29.6

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
CT4E	10/13/00	1720	6.1	56.9	29.1	7.0	12.3	1.5	57.0	32.5	11.5	0.32	26.6
CT4F	10/13/00	1744	3.4	31.7	31.6	7.5	8.1	4.4	29.4	33.8	22.5	0.46	30.8
CT5A	10/13/00	1618	7.2	20.8	22.7	4.1	5.4	1.8	22.3	22.3	11.3	0.30	20.0
CT5D	10/13/00	1681	5.5	36.9	41.0	9.0	13.4	3.8	41.2	37.7	26.3	0.62	33.5
CT5E	10/13/00	1680	0.0	27.2	30.4	3.8	6.3	3.8	27.4	28.3	13.5	0.33	25.5
CT5F	10/13/00	1617	0.0	21.5	32.1	4.1	5.4	2.3	21.5	28.1	15.4	0.35	25.8
H1A	10/12/00	1012	22.8	27.2	16.3	11.1	12.7	9.4	41.3	27.4	14.9	0.71	23.1
H1B	10/12/00	2156	27.6	20.6	5.6	7.7	9.0	29.9	29.7	31.9	17.6	1.12	28.8
H1C	10/12/00	2033	44.3	23.0	8.6	6.7	9.4	6.3	34.2	22.8	12.9	0.63	19.3
H1D	10/12/00	1356	24.4	17.5	11.0	6.2	7.4	15.3	24.2	24.2	16.3	0.70	21.7
H2A	10/12/00	1105	16.6	8.1	11.8	3.7	4.6	1.2	10.7	15.8	8.4	0.26	14.7
H2B	10/12/00	1938	37.2	66.2	38.5	19.7	25.2	8.8	69.2	51.4	39.6	1.03	44.3
H2C	10/12/00	1062	25.2	19.8	12.1	7.6	10.3	4.5	28.7	23.8	12.8	0.45	20.9
H2D	10/12/00	2281	45.5	32.9	23.2	11.6	13.4	7.7	46.6	37.2	19.7	0.72	32.4
H3A	10/12/00	1591	80.7	50.5	24.0	22.3	20.0	4.5	64.9	56.0	34.7	0.96	49.3
H3B	10/12/00	1346	71.3	17.6	1.6	9.6	8.5	1.9	31.6	24.7	12.6	0.54	21.5
H3C	10/12/00	1863	66.8	24.4	20.3	17.1	11.7	1.1	43.7	34.2	11.0	0.48	29.7
H3D	10/12/00	1133	40.4	19.6	7.8	9.8	8.6	2.2	27.2	24.3	14.6	0.45	21.5
H4A	10/12/00	1775	31.0	54.4	45.4	19.0	21.6	5.0	66.1	57.1	23.7	0.75	50.2
H4B	10/12/00	1233	24.0	54.2	34.6	15.4	17.1	5.9	62.3	43.4	28.9	0.74	37.0
H4C	10/12/00	1916	23.7	35.7	31.6	9.8	11.3	4.9	40.1	38.1	21.4	0.61	34.0
H4D	10/12/00	862	27.0	22.8	12.4	13.8	14.5	0.5	26.8	30.8	7.7	0.33	28.0
H5A	10/12/00	1439	45.8	16.6	6.9	8.8	8.5	0.8	25.7	25.0	9.6	0.35	22.3
H5B	10/12/00	990	16.9	31.2	25.3	10.8	12.9	7.6	40.9	28.8	20.5	0.63	24.6
H5C	10/12/00	1401	32.9	45.7	27.8	20.7	20.6	7.1	62.2	47.2	11.2	0.61	40.7
H5D	10/12/00	1595	31.2	70.1	38.9	19.1	25.4	11.3	84.6	56.2	32.7	1.12	47.4
H6A	10/12/00	1477	38.7	76.4	38.6	19.9	26.0	10.4	97.2	53.5	38.1	1.12	43.5
H6B	10/12/00	1398	34.8	109.8	40.1	25.6	34.6	23.3	127.0	60.6	64.8	1.57	47.5
H6C	10/12/00	1337	23.0	20.8	9.2	8.2	9.0	13.6	28.0	24.6	15.7	0.63	21.7
H6D	10/12/00	1571	46.1	74.3	46.1	26.0	32.3	11.1	105.8	60.1	47.5	1.26	49.2
HBULK	10/12/00	1049	0.0	4.2	40.6	0.0	0.0	1.5	4.8	10.2	5.4	0.12	9.7
HT1D	10/12/00	1159	23.9	11.1	1.5	13.0	9.7	1.0	17.1	17.1	7.3	0.25	15.4
HT1E	10/12/00	963	43.6	10.5	1.1	14.2	8.5	0.5	26.0	31.4	5.1	0.21	28.8
HT1F	10/12/00	1160	35.0	9.8	0.1	23.6	19.0	0.7	24.3	23.1	4.1	0.22	20.6
HT2F	10/12/00	1080	1.4	4.6	10.5	1.4	0.0	0.9	5.0	10.5	3.6	0.09	10.0
HT3A	10/12/00	1170	13.7	56.1	37.7	18.5	23.1	6.6	60.3	46.6	26.6	0.78	40.3
HT3B	10/12/00	1105	17.9	13.7	7.8	4.8	6.5	1.6	16.9	17.5	7.2	0.30	15.7
HT3C	10/12/00	1112	19.4	78.0	43.0	25.2	27.1	11.6	82.8	59.6	46.1	1.14	51.0
HT3F	10/12/00	1152	1.7	5.9	15.5	1.8	0.0	1.0	6.5	12.9	6.3	0.16	12.3
HT4B	10/12/00	1106	4.0	11.5	8.9	2.5	3.2	0.6	11.3	14.1	2.2	0.09	12.9
HT4D	10/12/00	1133	16.9	56.8	38.2	15.0	16.6	4.5	59.5	42.2	36.8	0.80	36.0
HT4F	10/12/00	1166	0.0	15.8	19.3	3.3	3.4	3.6	14.9	18.4	11.4	0.24	16.9
PARKB	10/12/00	931	4.6	8.3	3.2	1.2	0.0	2.9	8.1	10.0	3.5	0.24	9.1
C1A	11/01/00	1213	26.6	19.7	0.7	7.1	9.2	1.0	29.7	12.4	2.6	0.13	9.3
C1C	11/01/00	1887	37.4	26.4	0.4	10.1	11.9	1.6	37.5	18.3	3.4	0.19	14.4
C2A	11/01/00	1604	69.3	18.5	0.4	13.5	12.1	0.9	52.4	38.5	0.0	0.25	33.1
C2C	11/01/00	1939	36.7	18.9	0.4	11.8	12.2	1.1	30.7	16.8	0.4	0.19	13.6
C3A	11/01/00	1695	97.3	17.3	0.4	16.0	16.4	1.0	75.2	46.7	0.1	0.17	38.9
C3C	11/01/00	1583	68.4	24.6	1.6	12.9	17.3	2.2	46.0	27.5	0.2	0.19	22.7
C4A	11/01/00	1920	36.3	43.0	12.9	17.6	16.9	2.2	57.8	25.5	27.7	0.67	19.5
C4C	11/01/00	896	23.3	55.3	10.5	19.4	22.9	0.8	67.7	23.3	22.2	0.55	16.3
C5A	11/01/00	1590	93.3	48.0	3.2	32.8	32.7	1.8	92.5	75.4	26.8	0.71	65.9
C5C	11/01/00	1483	81.5	21.4	0.1	15.5	15.6	1.7	39.3	27.2	0.2	0.18	23.2

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
C6A	11/03/00	1360	30.9	28.4	8.9	10.7	13.1	0.4	38.9	22.2	7.3	0.34	18.2
C6C	11/03/00	1530	12.6	25.5	12.7	6.6	8.3	0.9	29.7	18.0	8.9	0.31	14.9
CBULK	11/01/00	1930	3.8	18.4	13.9	2.9	0.0	2.7	17.7	15.8	3.2	0.14	13.9
CT2A	11/01/00	1758	48.4	33.2	2.0	14.3	17.7	1.0	72.7	32.3	1.2	0.13	24.8
CT2C	11/01/00	1768	112.1	22.0	0.1	59.0	63.8	1.5	114.6	20.7	0.2	0.53	8.9
CT2D	11/01/00	1783	59.3	75.6	1.6	33.6	25.4	1.5	116.4	33.7	15.6	0.45	21.6
CT4A	11/03/00	1739	10.2	77.6	27.4	19.0	21.2	2.5	84.3	33.7	24.9	0.51	25.0
CT4B	11/03/00	1759	2.8	19.1	13.6	3.6	5.2	0.5	19.7	17.1	4.9	0.11	15.0
CT4C	11/03/00	1680	1.1	28.0	13.3	3.4	6.3	1.4	30.9	17.1	5.3	0.12	14.0
CT4D	11/03/00	1749	5.2	32.2	10.0	8.5	8.1	1.0	38.4	16.1	6.4	0.14	12.1
CT4E	11/03/00	1822	4.0	44.1	19.9	5.6	9.9	0.5	49.3	20.5	9.3	0.19	15.4
CT4F	11/03/00	1776	1.2	14.6	11.9	2.7	3.0	2.0	17.2	14.5	5.1	0.12	12.7
CT5A	11/03/00	1699	6.2	20.4	13.7	3.5	5.0	0.5	20.8	17.3	4.2	0.14	15.2
CT5D	11/03/00	1735	5.2	52.0	27.4	10.2	16.7	2.9	65.5	28.3	18.3	0.38	21.6
CT5E	11/03/00	1793	0.0	19.5	12.6	2.3	3.8	1.0	20.1	13.7	3.7	0.09	11.6
CT5F	11/03/00	1695	0.0	12.8	9.7	2.2	0.0	0.5	13.0	9.5	3.8	0.09	8.2
H1A	11/02/00	1928	30.9	30.4	9.6	13.3	12.9	12.0	44.3	26.6	15.4	0.99	22.0
H1C	11/02/00	2152	31.4	29.6	14.8	11.0	15.4	4.9	40.6	23.1	21.0	0.74	18.9
H2A	11/02/00	1149	26.8	11.0	5.2	3.2	4.8	1.0	19.3	10.6	3.8	0.14	8.6
H2C	11/02/00	1722	21.1	26.0	9.2	7.0	8.7	6.8	33.4	19.3	12.1	0.50	15.9
H3A	11/02/00	2289	38.8	31.0	18.5	13.4	12.5	1.9	39.7	29.2	26.3	1.00	25.1
H3C	11/02/00	2703	104.0	22.8	12.3	21.3	18.2	2.3	69.0	37.2	11.6	0.59	30.1
H4A	11/02/00	2985	23.0	42.4	34.1	14.4	16.3	3.4	53.3	33.5	27.1	0.85	28.0
H4C	11/02/00	1070	15.8	20.4	16.5	7.1	8.5	3.9	26.2	18.0	20.7	0.49	15.3
H5A	11/02/00	3107	40.5	20.7	3.7	4.7	0.0	6.1	25.4	20.6	3.2	0.35	18.0
H5C	11/02/00	1942	38.8	56.5	23.8	21.3	22.0	8.2	77.3	41.6	24.5	0.88	33.6
H6A	11/02/00	1792	36.0	83.9	34.0	18.7	25.6	8.6	94.2	39.3	48.9	1.11	29.6
H6C	11/02/00	1850	30.9	13.5	8.8	10.4	10.9	2.1	38.7	13.2	7.0	0.37	9.2
HBULK	11/02/00	1959	1.3	8.3	10.5	0.0	0.0	1.7	8.0	10.0	1.9	0.07	9.2
HT1D	11/02/00	1864	63.5	15.7	0.4	21.8	21.1	2.1	49.5	21.9	0.2	0.21	16.8
HT1E	11/02/00	1839	88.5	18.8	0.2	29.0	28.6	2.1	52.5	49.7	0.2	0.23	44.3
HT1F	11/02/00	1785	70.1	11.9	1.8	26.4	28.5	2.0	41.0	50.1	0.0	0.18	45.9
HT2F	11/02/00	1776	3.5	7.9	8.1	0.0	0.0	1.0	8.2	10.0	1.8	0.09	9.1
HT3A	11/02/00	1857	15.7	50.3	36.9	23.2	28.1	10.5	64.4	38.8	51.1	1.16	32.2
HT3B	11/02/00	1785	13.0	13.9	10.9	4.5	7.5	2.5	17.3	14.6	9.2	0.29	12.8
HT3C	11/02/00	1814	16.6	56.4	32.1	20.3	22.8	15.4	61.1	37.9	50.3	1.41	31.6
HT3F	11/02/00	1828	3.8	10.5	11.5	2.3	0.0	4.7	10.3	14.0	3.3	0.10	12.9
HT4B	11/02/00	1845	2.9	18.4	10.6	2.3	3.9	1.0	18.8	13.2	3.0	0.08	11.2
HT4D	11/02/00	1834	23.4	111.1	60.4	32.2	36.9	9.8	117.0	60.8	84.6	1.61	48.7
HT4F	11/02/00	1834	0.0	18.3	10.5	2.8	3.8	3.1	17.8	14.0	3.7	0.09	12.2
PARKB	11/01/00	878	0.0	7.4	5.0	0.0	0.0	0.5	7.2	6.3	0.5	0.04	5.5
C1A	11/15/00	517	2.2	5.9	2.6	1.1	1.3	0.1	5.5	4.2	0.5	0.03	3.6
C1C	11/15/00	626	8.7	10.4	1.8	2.6	2.9	0.4	10.9	9.3	0.6	0.05	8.1
C2A	11/15/00	633	2.3	5.6	3.2	1.8	1.6	0.2	5.5	4.8	0.7	0.05	4.3
C2C	11/15/00	712	3.5	7.4	3.9	2.4	2.4	0.2	7.6	7.3	0.9	0.05	6.5
C3A	11/15/00	735	3.5	5.7	2.4	1.5	1.5	0.2	6.0	5.3	0.5	0.03	4.6
C3C	11/15/00	653	1.7	4.9	3.3	0.7	1.1	0.4	5.0	4.0	0.8	0.04	3.5
C4A	11/15/00	584	5.6	11.7	8.6	3.6	3.7	0.2	10.7	13.7	0.8	0.11	12.6
C4C	11/15/00	692	5.0	19.7	10.0	4.2	4.6	0.4	17.3	15.2	0.4	0.12	13.4
C5A	11/15/00	674	14.5	29.9	11.1	7.6	9.6	0.4	24.1	32.3	2.0	0.17	29.8
C5C	11/15/00	532	6.0	5.0	0.3	1.5	1.8	0.3	5.4	4.6	0.1	0.03	4.1
C6A	11/15/00	950	10.5	6.7	6.7	2.4	2.8	0.5	5.3	12.6	0.1	0.09	12.1
C6C	11/15/00	1145	8.5	8.9	11.4	3.8	4.8	0.6	8.2	21.6	1.6	0.09	20.8

Table D.2. continued.

Site	Collection	Volume	K	Na	H^+	Ca	Mg	NH_4	Cl	SO_4	NO_3	Total N	$NMSO_4$
		mL	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	eq/ha	kg/ha	eq/ha
CBULK	11/15/00	690	0.3	4.3	6.0	0.5	0.9	0.4	4.2	4.9	0.9	0.04	4.5
CT2A	11/15/00	733	4.2	6.7	2.6	1.9	1.8	0.2	6.7	6.4	0.6	0.04	5.7
CT2C	11/15/00	584	6.9	4.4	0.5	3.0	3.2	0.3	6.6	4.2	0.1	0.05	3.5
CT2D	11/15/00	918	4.9	13.9	3.3	4.2	3.5	0.3	14.1	9.4	1.1	0.06	7.9
CT4A	11/15/00	933	1.6	15.3	16.5	5.2	5.1	0.8	10.5	26.2	1.5	0.12	25.1
CT4B	11/15/00	889	1.6	4.5	6.0	0.7	1.1	0.5	4.5	7.3	1.2	0.05	6.8
CT4C	11/15/00	833	0.3	6.7	7.7	1.1	1.4	0.5	6.8	7.2	1.5	0.04	6.5
CT4D	11/15/00	877	1.5	7.6	13.2	3.3	2.2	0.7	7.2	14.3	2.4	0.08	13.6
CT4E	11/15/00	871	3.0	16.4	22.8	4.4	8.0	0.5	12.4	33.3	4.7	0.13	32.0
CT4F	11/15/00	688	0.2	2.6	6.7	0.7	0.6	0.6	2.8	6.3	1.2	0.04	6.0
CT5A	11/15/00	875	1.3	4.3	8.3	1.1	1.8	0.5	3.6	10.7	1.6	0.05	10.3
CT5D	11/15/00	878	1.1	7.8	10.0	1.3	1.8	0.5	6.3	10.8	1.3	0.08	10.1
CT5E	11/15/00	896	0.4	5.6	7.1	0.7	1.1	0.5	5.5	6.4	1.8	0.05	5.8
CT5F	11/15/00	840	0.3	3.4	7.3	0.4	0.7	0.7	3.4	6.4	1.8	0.05	6.1
H1A	11/16/00	580	5.2	5.4	5.8	1.9	1.7	1.3	5.0	8.3	0.8	0.12	7.8
H1C	11/16/00	63	3.9	5.1	6.3	1.4	1.6	0.6	3.9	7.8	1.2	0.10	7.4
H2A	11/16/00	467	1.2	1.6	3.1	0.5	0.6	0.1	1.7	3.1	0.7	0.03	2.9
H2C	11/16/00	484	4.3	5.7	6.6	1.8	2.4	0.3	4.4	11.4	1.4	0.09	10.9
H3A	11/16/00	723	9.1	8.3	11.4	4.0	2.7	0.4	5.9	15.1	0.8	0.15	14.5
H3C	11/16/00	824	9.6	6.2	11.6	3.8	2.4	0.7	5.5	12.2	0.5	0.12	11.6
H4A	11/16/00	778	5.9	10.4	14.7	2.8	2.9	0.7	5.2	21.0	0.8	0.16	20.5
H4C	11/16/00	906	8.9	6.8	9.7	2.1	2.7	0.5	7.4	13.9	1.5	0.13	13.1
H5A	11/16/00	1261	29.0	10.4	3.6	2.6	2.1	0.7	6.4	14.8	1.0	0.17	14.1
H5C	11/16/00	761	10.6	15.2	11.2	5.6	5.1	1.1	8.9	22.5	0.4	0.19	21.6
H6A	11/16/00	817	6.9	9.8	9.1	1.9	2.4	0.5	7.5	12.1	0.7	0.11	11.3
H6C	11/16/00	677	1.5	2.6	5.3	1.0	0.9	0.4	2.4	5.9	0.7	0.06	5.6
HBULK	11/16/00	804	0.4	2.1	5.0	0.4	0.3	0.2	2.5	4.5	1.2	0.04	4.3
HT1D	11/16/00	679	2.8	2.9	2.6	1.7	1.1	0.4	2.8	4.5	0.6	0.05	4.2
HT1E	11/16/00	727	6.1	3.9	1.6	2.4	1.8	0.2	3.3	5.9	0.6	0.07	5.6
HT1F	11/16/00	701	1.9	3.4	4.4	2.5	2.1	0.4	3.6	5.7	0.6	0.06	5.4
HT2F	11/16/00	683	0.5	2.1	4.9	0.5	0.6	0.4	2.1	5.2	1.0	0.04	5.0
HT3A	11/16/00	755	2.8	8.5	11.6	2.5	2.9	0.9	3.9	15.0	1.0	0.15	14.6
HT3B	11/16/00	526	5.9	2.6	1.8	0.7	0.9	0.1	2.7	5.4	0.3	0.06	5.1
HT3C	11/16/00	823	4.8	15.0	17.1	3.6	3.8	1.4	8.0	24.4	4.0	0.22	23.5
HT3F	11/16/00	774	0.2	1.7	5.6	0.4	0.3	0.7	2.0	4.7	1.3	0.05	4.5
HT4B	11/16/00	921	1.1	4.7	7.0	1.6	1.5	0.5	4.2	9.4	1.6	0.07	9.0
HT4D	11/16/00	926	6.5	16.9	18.8	4.5	5.4	0.3	10.9	30.7	3.5	0.18	29.6
HT4F	11/16/00	917	0.4	3.3	9.3	1.2	0.8	0.3	3.3	8.9	2.7	0.07	8.6
PARKB	11/15/00	757	0.2	1.7	7.2	0.4	0.3	0.4	1.9	5.8	1.0	0.04	5.6

Appendix E

WET-ONLY DATA, 1999-2000

Table E.1. Wet-only concentrations for McFarland Hill (NADP Data, 2001) and the PRIMENet watersheds for 1999 and 2000.

Site	Year	Month	Day	EqpH	Ca	SO_4	Cl	NO_3	Mg	K	Na	Si	NH_4	ANC	Cond	App Color
					µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L	µeq/L	µeq/L	µs /cm^2	PCU
McFarland	1999	1	5	5.13	2	12	49	2	9	1	40	.	2	.	11	.
McFarland	1999	1	12	4.59	3	19	34	16	7	1	28	.	3	.	17	.
McFarland	1999	1	19	4.69	4	27	83	9	16	2	73	.	3	.	21	.
McFarland	1999	1	26	4.97	1	10	23	5	4	1	19	.	1	.	8	.
McFarland	1999	2	9	4.98	5	23	140	4	26	3	123	.	1	.	24	.
McFarland	1999	2	16	4.49	.	.	.	.	.	.	.	.	.	.	45	.
McFarland	1999	2	23	4.50	3	33	23	16	4	1	19	.	11	.	21	.
McFarland	1999	3	2	5.28	1	2	9	1	1	0	4	.	1	.	4	.
McFarland	1999	3	9	4.65	9	42	209	17	39	4	180	.	7	.	40	.
McFarland	1999	3	16	5.28	0	4	3	4	1	0	2	.	1	.	3	.
McFarland	1999	3	30	4.54	2	23	6	18	2	0	5	.	7	.	16	.
McFarland	1999	4	6	4.21	22	106	26	67	7	1	23	.	78	.	45	.
McFarland	1999	4	13	4.27	15	60	37	62	10	1	33	.	35	.	39	.
McFarland	1999	4	27	4.48	14	44	11	24	4	1	10	.	13	.	22	.
McFarland	1999	5	11	5.10	2	6	3	6	1	0	2	.	2	.	5	.
McFarland	1999	5	25	5.00	1	10	6	5	1	0	4	.	2	.	6	.
Cadillac	1999	6	8	4.43	12	48	15	37	0	4	14	1	20	-42	24	19
McFarland	1999	6	8	4.51	10	40	9	30	3	1	7	.	28	.	21	.
Cadillac	1999	6	15	4.56	8	48	7	25	2	3	6	3	20	-38	20	10
McFarland	1999	6	15	4.39	12	58	6	36	4	1	3	.	33	.	27	.
McFarland	1999	6	29	4.56	3	27	3	15	2	0	3	.	9	.	16	.
Cadillac	1999	7	6	4.48	4	58	12	34	0	3	11	2	20	-63	29	7
Hadlock	1999	7	6	4.51	4	52	13	29	0	3	12	2	17	-64	26	9
McFarland	1999	7	6	4.40	3	33	6	20	2	0	4	.	8	.	21	.
McFarland	1999	7	13	4.31	4	46	6	28	2	0	3	.	16	.	28	.
McFarland	1999	7	20	4.83	2	8	3	9	1	0	3	.	1	.	8	.
McFarland	1999	7	27	4.08	10	102	11	49	3	1	8	.	32	.	51	.
Cadillac	1999	8	3	4.20	10	90	14	44	6	3	17	2	33	-91	43	8
McFarland	1999	8	10	4.28	3	48	11	24	2	1	8	.	13	.	29	.
Cadillac	1999	8	17	4.32	0	66	20	29	5	1	21	1	19	-70	34	5
Hadlock	1999	8	17	4.31	0	66	20	31	4	0	20	1	19	-72	35	4
McFarland	1999	8	17	4.25	3	50	17	29	3	1	13	.	12	.	33	.
McFarland	1999	8	24	4.72	9	23	6	14	2	0	4	.	1	.	14	.
Cadillac	1999	8	31	4.66	.	21	80	7	.	.	.	1	17	-20	.	10
Hadlock	1999	8	31	4.53	4	19	49	6	0	0	6	1	7	-28	.	2
Cadillac	1999	9	14	4.94	5	21	80	7	11	3	80	2	5	-5	17	7
Hadlock	1999	9	14	4.79	5	20	51	6	10	1	44	1	3	-21	14	4
McFarland	1999	9	14	4.86	4	21	37	7	7	1	32	.	2	.	14	.
Cadillac	1999	9	21	4.61	3	24	88	9	16	2	82	1	4	-26	20	5
Hadlock	1999	9	21	4.63	0	18	64	8	12	2	62	1	4	-23	16	4
McFarland	1999	9	21	4.85	4	19	66	8	12	1	54	.	3	.	17	.
Cadillac	1999	9	28	5.48	4	6	3	6	0	1	1	2	1	-13	5	1
McFarland	1999	9	28	5.00	1	10	3	5	0	0	1	.	2	.	5	.
McFarland	1999	10	5	4.31	4	48	49	25	10	1	42	.	11	.	31	.
McFarland	1999	10	12	4.55	5	29	37	17	7	1	31	.	6	.	21	.
Cadillac	1999	10	19	4.67	3	20	31	7	6	2	24	4	6	-26	13	3
Hadlock	1999	10	19	4.36	3	35	11	13	0	2	9	4	12	-46	18	4

Table E.1. continued.

Site	Year	Month	Day	EqpH	Ca	SO_4	Cl	NO_3	Mg	K	Na	Si	NH_4	ANC	Cond	App Color
					µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L	µeq/L	µeq/L	µs /cm^2	PCU
McFarland	1999	10	19	4.89	2	15	20	6	3	1	17	.	2	.	10	.
Cadillac	1999	10	26	4.90	3	13	60	3	11	2	52	3	2	-11	13	2
Hadlock	1999	10	26	4.92	0	11	38	4	7	2	39	3	3	-10	10	2
McFarland	1999	10	26	5.22	2	8	31	2	6	1	27	.	1	.	8	.
McFarland	1999	11	9	5.11	3	17	69	4	12	1	75	.	3	.	14	.
McFarland	1999	11	16	4.29	3	42	26	36	4	1	20	.	17	.	31	.
McFarland	1999	11	23	4.78	3	15	23	10	4	1	20	.	3	.	12	.
McFarland	1999	11	30	5.06	1	10	26	4	4	1	22	.	2	.	8	.
McFarland	1999	12	7	4.97	0	8	6	6	2	0	6	.	2	.	6	.
McFarland	1999	12	14	4.63	1	12	11	19	2	0	11	.	4	.	14	.
McFarland	1999	12	21	4.71	5	19	77	14	14	2	82	.	2	.	21	.
McFarland	2000	1	4	4.15	7	65	37	57	7	2	30	.	29	.	46	.
McFarland	2000	1	11	4.82	6	28	151	9	35	3	173	.	3	.	31	.
McFarland	2000	1	18	5.00	3	12	70	5	13	1	60	.	1	.	14	.
McFarland	2000	1	25	5.05	2	7	8	4	2	1	7	.	1	.	6	.
McFarland	2000	2	1	4.80	6	26	147	11	37	3	135	.	1	.	28	.
McFarland	2000	2	15	4.30	6	52	90	36	16	2	80	.	20	.	39	.
McFarland	2000	2	22	4.12	10	73	103	63	21	2	98	.	19	.	56	.
McFarland	2000	2	29	4.84	2	12	15	12	2	0	13	.	1	.	10	.
McFarland	2000	3	7	4.70	1	13	3	12	1	0	3	.	2	.	11	.
McFarland	2000	3	14	4.75	4	18	19	10	3	1	17	.	5	.	12	.
McFarland	2000	3	21	3.93	24	115	28	**	7	2	29	.	65	.	76	.
McFarland	2000	3	28	4.50	9	50	125	21	23	3	117	.	16	.	35	.
McFarland	2000	4	4	4.34	10	47	38	35	9	1	33	.	17	.	30	.
McFarland	2000	4	11	4.29	14	59	167	40	44	3	151	.	12	.	51	.
McFarland	2000	4	18	4.49	3	33	41	20	8	1	38	.	9	.	23	.
Cadillac	2000	4	21	4.50	3	35	44	14	9	0	35	0	10	.	20	5
Cadillac	2000	4	25	4.93	2	16	24	7	5	0	21	0	4	.	10	7
Hadlock	2000	4	25	4.75	2	18	19	9	0	0	17	0	5	.	11	7
McFarland	2000	4	25	4.94	3	13	19	7	3	1	17	.	2	.	9	.
McFarland	2000	5	2	4.46	7	30	11	23	3	1	10	.	6	.	20	.
Cadillac	2000	5	9	4.53	7	45	7	30	0	1	5	0	28	.	22	.
Hadlock	2000	5	9	4.52	7	41	8	28	0	1	4	0	27	.	20	.
McFarland	2000	5	9	4.48	7	44	5	28	2	2	4	.	25	.	23	.
Cadillac	2000	5	16	4.51	4	33	26	18	5	0	20	1	14	.	19	10
Hadlock	2000	5	16	4.51	3	31	15	17	0	0	10	1	16	.	17	6
McFarland	2000	5	16	4.58	4	30	14	16	3	1	13	.	13	.	17	.
Cadillac	2000	5	23	4.28	13	76	87	44	20	3	96	0	38	.	44	11
Hadlock	2000	5	23	4.24	14	74	89	46	20	3	95	0	34	.	46	9
McFarland	2000	5	23	4.24	11	66	50	37	12	2	49	.	26	.	40	.
Cadillac	2000	5	30	4.72	0	15	3	11	0	0	0	0	8	.	11	7
Hadlock	2000	5	30	4.79	2	20	5	12	0	1	3	0	9	.	8	6
McFarland	2000	5	30	4.79	1	13	2	10	1	0	1	.	5	.	9	.
Cadillac	2000	6	13	4.70	6	24	16	17	4	0	15	0	12	.	14	9
Hadlock	2000	6	13	4.73	5	22	8	16	0	0	7	0	12	.	12	14
McFarland	2000	6	13	4.87	5	15	9	12	2	1	7	.	8	.	10	.
Cadillac	2000	6	20	4.35	3	46	13	26	0	2	12	0	16	.	27	.
Hadlock	2000	6	20	4.31	0	50	7	24	0	0	6	0	18	.	26	5
McFarland	2000	6	20	4.47	2	25	2	17	1	0	1	.	5	.	17	.
Cadillac	2000	6	27	4.28	3	59	26	38	6	0	24	0	22	.	34	5
Hadlock	2000	6	27	4.24	4	60	28	38	7	0	27	0	23	.	34	7

Table E.1. continued.

Site	Year	Month	Day	EqpH	Ca	SO_4	Cl	NO_3	Mg	K	Na	Si	NH_4	ANC	Cond	App Color
					µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L	µeq/L	µeq/L	µs /cm^2	PCU
McFarland	2000	6	27	4.24	5	59	23	35	5	1	21	.	18	.	35	.
McFarland	2000	7	3	3.98	4	75	6	68	2	1	3	.	18	.	55	.
Hadlock	2000	7	5	4.11	0	58	10	41	0	0	6	0	22	.	.	6
Cadillac	2000	7	11	4.27	2	51	4	26	0	0	5	0	11	.	27	3
Hadlock	2000	7	11	4.53	3	32	7	12	2	1	7	0	17	.	15	3
McFarland	2000	7	11	4.51	1	32	3	13	1	0	2	.	10	.	17	.
Cadillac	2000	7	18	5.22	0	5	11	2	0	0	10	0	2	.	5	3
Hadlock	2000	7	18	5.28	0	3	6	2	0	0	6	0	1	.	3	3
Hadlock	2000	7	26	3.91	5	113	38	42	8	2	33	0	26	.	61	4
Cadillac	2000	7	28	4.11	4	72	30	28	7	2	27	0	17	.	36	5
McFarland	2000	8	1	4.83	1	17	5	4	1	0	6	.	3	.	8	.
Cadillac	2000	8	8	4.00	0	102	19	44	0	0	13	0	37	.	52	8
Hadlock	2000	8	8	4.12	4	78	16	36	0	2	15	1	29	.	40	7
McFarland	2000	8	8	4.01	4	86	11	52	2	1	7	.	30	.	51	.
McFarland	2000	8	15	4.33	12	57	3	39	2	1	2	.	32	.	30	.
Cadillac	2000	8	22	4.34	8	48	10	28	0	0	9	0	24	.	24	8
Hadlock	2000	8	22	4.23	11	55	9	33	0	0	7	0	26	.	29	9
McFarland	2000	8	22	4.41	4	35	10	22	2	1	9	.	11	.	22	.
McFarland	2000	8	29	4.34	3	40	40	25	8	1	35	.	9	.	28	.
McFarland	2000	9	5	4.43	3	41	3	21	1	0	2	.	11	.	24	.
Cadillac	2000	9	12	4.43	6	46	19	20	4	1	20	0	14	.	22	6
Hadlock	2000	9	12	4.37	4	45	17	21	0	0	18	0	12	.	22	4
Cadillac	2000	9	19	4.29	0	51	19	26	0	0	20	0	19	.	29	4
McFarland	2000	9	19	4.36	4	39	15	22	3	0	13	.	11	.	24	.
Hadlock	2000	9	20	4.36	6	50	17	25	0	0	17	0	17	.	25	5
Cadillac	2000	9	26	4.37	2	35	13	25	0	0	12	0	12	.	22	4
Hadlock	2000	9	26	4.37	2	35	12	25	0	0	10	0	12	.	22	4
McFarland	2000	9	26	4.42	2	29	8	21	2	0	6	.	7	.	20	.
Cadillac	2000	10	10	4.77	2	19	25	7	5	2	23	0	4	.	12	6
Hadlock	2000	10	10	4.80	1	13	8	7	1	0	7	0	3	.	8	4
McFarland	2000	10	10	4.72	2	15	8	8	2	0	7	.	3	.	11	.
Cadillac	2000	10	24	4.72	3	26	28	8	5	3	29	0	5	.	11	3
Hadlock	2000	10	24	4.81	0	17	13	5	0	0	13	0	4	.	7	2
McFarland	2000	10	24	4.96	1	11	5	4	1	0	4	.	2	.	7	.
Cadillac	2000	10	31	4.93	5	15	14	4	0	2	13	0	3	.	6	2
Hadlock	2000	10	31	4.95	0	13	8	4	0	0	7	0	3	.	6	2
McFarland	2000	10	31	5.01	1	10	18	2	3	0	15	.	0	.	7	.
Cadillac	2000	11	7	5.19	2	9	8	3	1	2	8	0	3	.	4	4
Hadlock	2000	11	7	4.99	1	11	4	4	1	1	3	0	4	.	5	3
McFarland	2000	11	7	5.03	1	8	6	3	1	0	5	.	1	.	6	.
Cadillac	2000	11	21	4.63	3	22	47	16	10	2	42	0	6	.	16	5
Hadlock	2000	11	21	4.69	2	18	34	13	7	1	31	0	5	.	13	5
McFarland	2000	11	21	4.65	2	19	41	12	7	1	37	.	3	.	17	.
Hadlock	2000	11	28	5.18	2	11	31	4	7	1	30	0	2	.	9	3
Cadillac	2000	12	5	4.97	5	20	69	5	12	2	57	0	3	.	15	2
Cadillac	2000	12	19	4.76	4	27	122	6	24	3	102	0	3	.	.	3

Appendix F

KEY QA AND DEPOSITION FORMULAE

Ion balances for throughfall:

$$\frac{[H^+] + [NH_4^+] + [Ca^{2+}]+[Mg^{2+}]+[K^+]+[Na^+]+([Al(mg/L)]*\ 0.074)}{ANC + [Cl^-]+[NO_3^-]+[SO_4^{2-}]+[DOC(mg/L)]*4.5^*}$$

**For streamwater, DOC is multiplied by 3.5*

Marine Corrections:

Starting units are meq/L and are then converted to mg/L in the formula.

DILFACT (Dilution Factor) = Cl/28.21/19350

where 19350 is the concentration (ppm) of Cl in seawater (Stumm and Morgan, 1981).

NMCA=((CA/49.9)-(DILFACT*412))*49.9
NMMG=((MG/82.26)-(DILFACT*1290))*82.26
NMK=((K/25.57)-(DILFACT*400))*25.57
NMNA=((NA/43.5)-(DILFACT*10770))*43.5
NMSO4=((SO4/20.82)-(DILFACT*2710))*20.82
NMCL=((CL/28.21)-(DILFACT*19350))*28.21

Converting throughfall volumes to precipitation depth:

Slightly different funnel sizes were used in the two sampling years:

For 2000: PrecipDepth(mm) = Volume(mL)*10/196 cm^2
For 1999: PrecipDepth mm) = Volume(mL)*10/201 cm^2

Calculating deposition at each collector site:

Convert depth of precipitation and concentration to deposition in eq/ha

$$Deposition_{Ion\ A} = PrecipDepth(mm) * [Ion\ A(meq/L)] / 100$$

Where 100 is a factor that converts depth (mm) to m, then L/ha and also converts meq to eq

Scaling deposition to the watershed:

Multiply mean deposition for each vegetation type for each collection by the proportion of each vegetation type in each watershed and sum over all collections and for each watershed; time is determined by the analyst (e.g., monthly, seasonal or annual deposition)

$$\text{Watershed Inputs (eq)} = \underset{i=TimeA}{\overset{TimeB}{S}} (\ MeanDep_{\ Ion\ A(Vegtype\ A)} * Area_{\ Vegtype\ A})$$

Then divide by the total watershed area to get deposition in eq/ha/time

Veg-weighted deposition(eq/ha/time)=Watershed Inputs(eq)/Watershed Area(ha)

Calculating deposition based on wet-only deposition and ratios:

For each vegetation type, multiply NADP deposition (eq/ha) by the vegetation-specific enhancement ratio

$$Deposition_{Ion\ A}(eq/ha) = NADP\ Dep_{Ion\ A}\ (eq/ha) * Ratio_{Ion\ A}$$

Then multiply by the area of each vegetation type, and sum over time and watershed area; divide by the total watershed area to get units of eq/ha/time

Appendix G

STATISTICAL ASSUMPTIONS

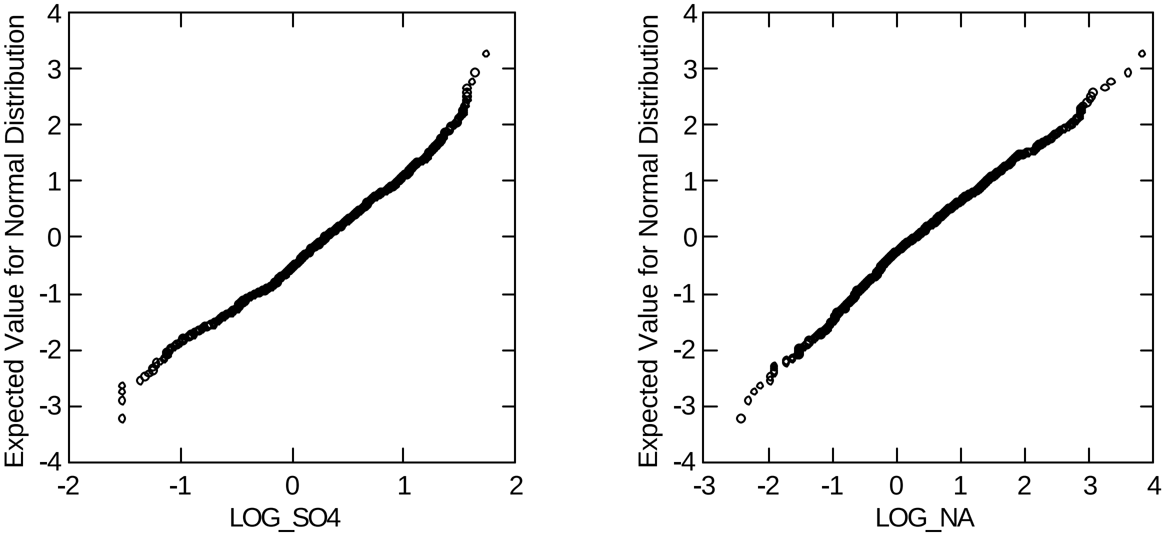

Figure G.1. Normal Probability plot for the log-transformed values of Na and SO_4 (in eq/ha/day). The normal probability plot shows the actual values on the X-axis and those that would be expected in a normal distribution on the Y-axis. The values should approximate a 1: 1 relationship.

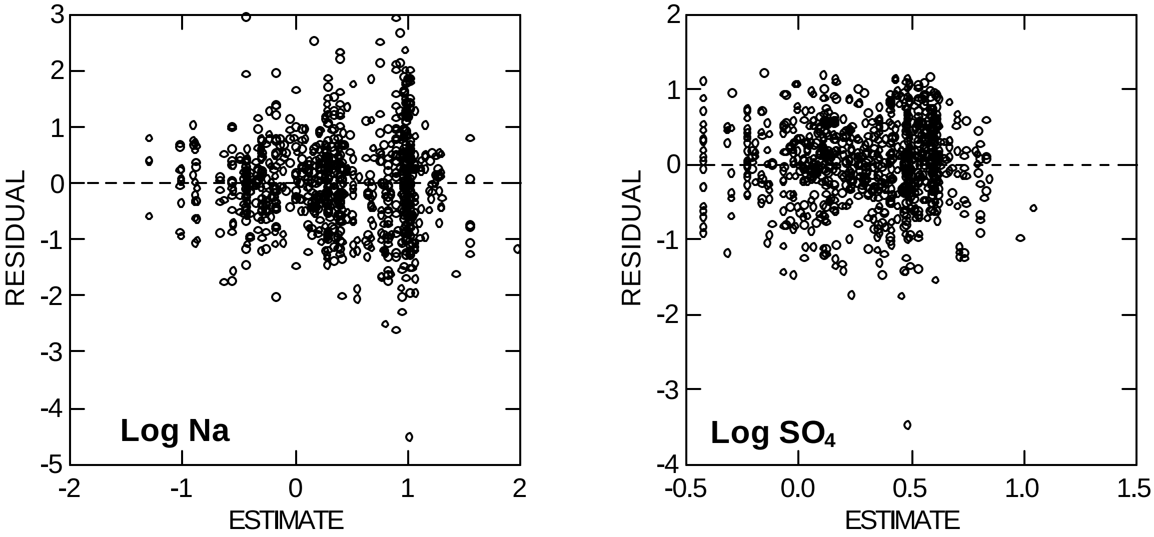

Figure G.2. Residual plot for the log-transformed values of Na and SO_4 (in eq/ha/day). The residual plot shows the distribution of error terms of the dependent variable.

BIOGRAPHY OF THE AUTHOR

Sarah J. Nelson was born in Marlborough, Massachusetts on October 19, 1973. She was raised in Berlin, Massachusetts and graduated from Tahanto Regional High School in 1991. She attended Johns Hopkins University in Baltimore and Columbia University in New York, graduating from Columbia *cum laude* with a Bachelor's Degree in Art History in 1994. After working in museums and volunteering with the Water Quality Monitoring program on the Assabet River, she moved to Maine in 1998 to pursue a Master's degree in Ecology and Environmental Sciences, co-founding the Water Resources Concentration.

After receiving her degree, Sarah will be continuing as a Research Associate at the Senator George J. Mitchell Center for Environmental and Watershed Research, to begin a career in Water Resources Research. Sarah is a candidate for the Master of Science degree in Ecology and Environmental Sciences from The University of Maine in May, 2002.