

**Precipitation Chemistry at Mount Rainier (Paradise Ranger Station)
Collection Site
Final Report for Data collected between June 1, 2011 and May 30,
2012**

Cooperative Agreement between NPS and CWU, Agreement number
H9453070012

James Agren, Naomi Beebe and Anne M. Johansen*
Chemistry Department, Central Washington University, 400 E. University Way,
Ellensburg, WA 98926-7539

*To whom correspondence should be addressed:

e-mail: johansea@cwu.edu
phone: (509)963-2164
fax: (509)963-1050

Introduction

In order to understand the relationship between natural processes and perturbations brought about by human activities, precipitation chemistry must be studied over a long-term period. By sampling on a continuous basis with consistent techniques, we are seeking to accumulate valuable chemical precipitation data that will enable the atmospheric science community to track atmospheric changes that come as a consequence of modifications in anthropogenic emissions and land use both regionally and globally.



Figure 1: Map of Washington State with NADP sites

Our methods on Mt. Rainier closely resemble those of the existing NADP (National Atmospheric Deposition Program) sites in the state of Washington (depicted in Figure 1): Hoh (WA14), La Grande (WA21), Marblemount (WA19) and Tahoma Woods (WA99). The Hoh site (WA14) is located on the Olympic Peninsula, and is assumed not to include anthropogenic contaminants from the Seattle/Tacoma area. Marblemount (WA19) is located only 60 miles east of the Puget Sound in northwestern Washington along state highway 20 and on the western face of the North Cascade Range at an elevation of 123 m. The two

closest sites to our Mt. Rainier Paradise Ranger Station (hereafter referred to as Mt. Rainier) site are: La Grande (WA21), which is located to the west of Mount Rainier just south of the town of Eatonville, at an elevation of 617 m, and nearby Tahoma Woods (WA99), at an elevation of 421 m and approximately 3 miles south east of the Paradise Ranger Station. While the first three sites have been operating since 1984, the Tahoma Woods site has only been active since fall 1999. Our site, Mt. Rainier Paradise Ranger Station, is located at 1654 m elevation and has been active for precipitation collection and analyses, on and off, since 1989.

Experimental

Precipitation Collection

Collection of wet deposition in the form of rain and snow is carried out with large 5 gallon white plastic containers with an opening of 29 cm in diameter. During periods when there is no snow on the ground, a dry-wet collector of the same type as at the NADP sites is used, otherwise a bucket is placed on top of a collection tower at Paradise. During snowfall months, the bucket is capped with an inverted funnel with a smaller opening to prevent bucket over-filling during the one-week sampling period.

Weekly sample collection is performed by Mount Rainier National Park Biological Technician Rebecca Lofgren or assistants. This procedure consists of removal of the bucket containing 1-, and sometimes 2-weeks worth of precipitation, replacing it with a new cleaned one, and shipping the capped used bucket back to us for analysis. Buckets are received at CWU where the amount of collected precipitation is determined based on the mass difference of the full and empty bucket. It should be noted that beginning with Sample M-07-35 (12/5/07)

a new preservation procedure was implemented in order to assure that sample storage over longer time periods was feasible. For that purpose, the received sample is split among three 120 mL trace clean sample bottles. Conductivity, pH, and anions are determined from the original sample. Concentrated nitric acid is added to the second sample until a pH of 2.0 is reached to preserve the cations calcium, potassium, magnesium, and sodium until analysis. Similarly, concentrated sulfuric acid is added to the third sample until a pH of 2.0 is reached to ensure preservation of ammonium until analysis. The bucket is then thoroughly cleaned and boxed up for shipment back to Mt. Rainier. All procedures, including those described below are documented in detail in Standard Operating Procedures (SOPs) contained within our CWU Chemical Analysis Laboratory Quality Assurance/Quality Control Manual (QA/QC Manual, updated Feb. 2008).

Chemical and Data Analysis

Determination of inorganic cations (Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+}) is accomplished by using Ion Chromatography (IC), with EPA Method 300.7. Inorganic anions (Cl^- , NO_3^- , SO_4^{2-}) are quantified by IC in anion mode using EPA Method 300.0. Conductivity and pH are measured using an YSI 3200 Conductivity Meter and an Orion model 420A pH Meter (EPA Methods 120.1 and 150.1, respectively). While the CWU Chemical Analysis Laboratory had been EPA accredited for pH since at least 1999, accreditation for the additional eight components was completed in spring 2006 and the laboratory has passed proficiency tests satisfactorily since then.

Observed sample concentrations (C_i) are corrected for the potential loss of water by evaporation by multiplication with the ratio of collected precipitation volume (V_i) over the actual precipitation volumes as recorded at the Mt. Rainier ($V_{Mt.Rainier}$) site by NPS staff:

$$C_{i,corr} = \frac{C_i V_i}{V_{Mt.Rainier}} \quad (\text{Eqn. 1})$$

Note that when our measured volume, V_i , was larger than that predicted by the NOAA Paradise Station precipitation volume, $V_{Mt.Rainier}$, comparison was made with NRC data. If our volume still exceeded the predicted amount, we were not able to make corrections with Eqn. 1 and $V_{Mt.Rainier}$ was equaled to V_i . During the current sampling period this occurred in 11 out of the 36 collected samples, i.e., 31% of cases (see grey shaded entries in Table 1).

Quarterly volume weighted average concentrations are computed analogously to the other NADP sites:

$$C_{i,corr,quarter} = \frac{\sum C_{i,corr} V_{Mt.Rainier}}{\sum V_{Mt.Rainier}} \quad (\text{Eqn. 2})$$

Note that for pH, the quarterly volume weighted average value had been calculated analogously from the negative logarithm of the resulting volume weighted average proton (H^+) concentration as calculated with Eqn. 2. From 2000 to present (for the time period that all raw data was available), however, the correction accounting for evaporation in the concentration of protons was removed. This was motivated by the discrepant pH values observed compared to Tahoma Woods when the correction was performed, and because it is unlikely that the pH changes significantly as a result of evaporation in a proton-buffered system such as these environmental samples are.

Included in the report are the current Method Detection Limits (MDL) for each inorganic species analyzed with Ion Chromatography (IC) (see SOP in QA/QC Manual). These detection limits are based on the standard deviations of the last 30 QC samples.

Detectable quantities (i.e., values other than 0) that fell below the current limits are highlighted in green in Table 1, and are still considered in the trend analysis portion of this report instead of omitting these completely or substituting these with zeros because either of the latter options would skew the data more strongly.

Deposition loads for all anions and cations for the years 1993-present are computed for each quarter and totaled annually where data is available for all four quarters of the year. The following equation was used to estimate quarterly deposition loads:

$$DepositionLoad_{Quarterly} = \sum \frac{C_i \cdot V_i \left(\frac{1 \mu mol}{|z|} \right) \left(\frac{1 mol}{1000000 \mu mol} \right) MW_{ion} \left(\frac{1 kg}{1000 g} \right)}{A_{Opening} \cdot \frac{1 Hectare}{10000000 cm^2}} \quad (Eqn. 3)$$

C_i is the sample concentration expressed in $\mu eq/L$, z is the charge of the ion, and $A_{opening}$ is the area of the opening of the bucket, which varies with year and precipitation type. Where information was lacking, assumptions were made based on reports and bucket logs from previous years including the following: pre-10/98 bucket opening area=440.0 cm^2 , post-10/98 bucket opening area=660.5 cm^2 , funnel #2 opening area=146.3 cm^2 , funnel #3 opening area=128.7 cm^2 , and funnel #4 opening area = 201.1 cm^2 . Information was not available pertaining to the area of funnel #1, therefore, data prior to Summer 1993 was not included. Reference to critical load values could only be found for SO_4^{2-} and these were specific for the Rocky Mountains [Fox et al., 1989] where the reported value of 20.0 $kg ha^{-1} yr^{-1} SO_4^{2-}$ critical load is by a factor of 11.5 larger than the values that we determined in the reported period.

Statistical Analysis

Time Series Analysis and Student t-Test

A sequence of observations recorded over time, such as the present one, is known as a time series. Precipitation time series are affected by three basic components: the underlying trend (T), seasonal variations (S) and random events (residual, R). Estimates of T, S, and R, are obtained through the time series decomposition of quarterly volume weighted average concentrations, $C_{i,corr,quarter}$ with the statistical software MINITAB16 [MINITAB, 2013]. Assumptions include a multiplicative model:

$$C_{i,corr,quarter} = T \times S \times R \quad (Eqn. 3)$$

and a linear trend:

$$T = b + m \cdot year \quad (Eqn. 4)$$

Time series decomposition outputs (model and trend line with equation) and the observed data are plotted in Figures 2 through 7 for important anthropogenic species, in addition to pH and the ratio of cationic over anionic charges. The significance of the trend and seasonality for each component is computed by the model and can be judged by the P-values that are noted within each graph.

P-values represent the probability that the null hypothesis is true, e.g., a p-value of .05 indicates that there is a 5% probability for the null hypothesis, i.e., a significance of the observed trend or seasonal variation at the 95% confidence interval (C.I.). In this study, the standard P-value of ≤ 0.05 is used to determine if a significant trend is observed in the overall data.

Data for Tahoma Woods, which has been active for twelve years as of the current sampling period, are shown at the bottom of each Figure. Due to the proximity of this site to Mt. Rainier, data for the latter site are included in this plot (dotted) for direct visual comparison. Furthermore, paired student t-tests are performed on all ten components to determine if the two sites display significantly different chemical characteristics within the 95% C.I., i.e., P-values ≤ 0.05 demonstrate significant difference (see results below).

Results and Discussion

Data

Results from the 2011-2012 Mt. Rainier precipitation monitoring study are presented in Table 1, arranged in a quarterly format consistent with the NADP's quarter system: summer is June-August, fall is September-November, winter is December-February, and spring is March-May. During the 2011-2012 52-week period, 36 samples were collected. When precipitation was very low, e.g., in the summer, no sample was obtained. This occurred 11 times during the current report period. In other instances, for a variety of pertinent reasons, the bucket contained 2- or 3-week samples. Three 2-week samples and one 3-week sample were collected during this year. In addition, one sample was clearly contaminated and thus omitted from further analysis (yellow sample in Table 1). The resulting 4 new seasonal data points are plotted along with all previously determined seasonal results in the corresponding plots in Figures 2 through 7 for each of the parameters. Analogous data for the other 4 NADP sites are presented in Tables 3 through 7. Figure 8 shows the difference in the pH value with the precipitation volume corrected for evaporation and without correction, compared to data from Tahoma Woods.

Paired Student T-tests were performed on data from the two nearby locations, Mt. Rainier and Tahoma Woods. For comparison, results for quarterly averaged data from last year's report are presented in Table 8a and including this year's data in Table 8b:

Table 8a: Paired Student T-test results for quarterly Mt. Rainier and Tahoma Woods (1999-2011)	
Component	P-Value
SO ₄ ²⁻	0.249
NO₃⁻	0.000
H ⁺	0.067*
NH ₄ ⁺	0.358
Ca²⁺	0.000
Cl ⁻	0.090
Mg²⁺	0.005
Na ⁺	0.150
K ⁺	0.069
(+)/(-)	0.131
Sample: n = 47 Bold indicates values are significantly different (i.e. P \leq 0.05). *Evaporation correction removed in 2011.	

Table 8b: Paired Student T-test results for quarterly Mt. Rainier and Tahoma Woods (1999-2012)	
Component	P-Value
SO ₄ ²⁻	0.271
NO₃⁻	0.000
H⁺	0.001*
NH ₄ ⁺	0.091
Ca²⁺	0.000
Cl ⁻	0.160
Mg²⁺	0.012
Na ⁺	0.064
K ⁺	0.051
(+)/(-)	0.134
Sample: n = 51 Bold indicates values are significantly different (i.e. P \leq 0.05). *Evaporation correction removed in 2011.	

These results reveal that nitrate, protons, calcium, and magnesium are significantly different in Tahoma Woods compared to Mt. Rainier. To further determine whether Tahoma Woods and Mt. Rainier are significantly different in their precipitation chemistry we intended to perform paired Student T-tests on weekly samples for the entire sampling period since 2000. However, since weekly sample container removal and placement dates did not match between the two sites, we decided to compare monthly weighted average values to reduce potential errors. The outcome of the paired Student T-tests applied to the monthly averages, which amounted to 131 samples, resulted in the same components to be significantly different as show in Table 8b in addition sodium showing a significant difference as well.

Trend and Seasonality Analyses

Trend and seasonality analyses of selected atmospheric pollutant indicators for the Hoh, La Grande, Marblemount, Mt. Rainier and Tahoma Woods sites are presented graphically in Figures 2 through 7. To ease comparative visual interpretation between each site, each figure presents the data for one species at all five sites with the same scale on both the x- and y-axes, with exception for the Tahoma Woods x-axis, which spans only over the twelve years of activity. Figures display observed and modeled data in addition to the linear trend line and its equation. Significance of the null hypothesis in the trend appears immediately after the trend line equation within the plot and the significance of seasonality is also reported. Each Figure, i.e., component, is presented and discussed separately in the following section.

SO₄²⁻ is typically considered anthropogenic in nature, and can have volcanic, sea-salt, and biogenic components. The latter two sources are assumed to be of minor significance in the present case due to the distance from the coast. Volcanic activity was present from Mt. St. Helens during the fall of 2004, particularly in early October, but no clear signal was observed during the corresponding monitoring period [Kittelson *et al.*, 2006]. The anthropogenic source is mainly from sulfur contained in fossil fuel that is first oxidized to gaseous SO₂ during combustion and then further oxidized to SO₄²⁻ thus generating two protons in the process and increasing acidity.

Concentrations are plotted in Figure 2 and show a decreasing trend for all sites except Hoh. There seem to be significant seasonal patterns at all sites, where minima occur in the winter, probably due to higher amounts of precipitation which lead to more rainout of pollutants and dilution of chemical components.

The paired student t-test on the Tahoma Woods and Mt. Rainier SO₄²⁻ seasonal data shows that there is no significant difference between the two sites (Table 8b).

NO₃⁻ is an oxidation product of NO_x species produced in high temperature combustion processes and is thus predominantly anthropogenic in origin. These data, presented in Figure 3, show significant decreasing trends in La Grande, Marblemount, and Mt. Rainier and close to a significant negative trend at Tahoma Woods (P=0.055). Seasonal fluctuations are significant at all sites except Tahoma Woods. Analogous to SO₄²⁻, the Hoh site displays the lowest overall concentrations compared to the other sites, the seasonal fluctuations are small and there is no significant trend. Mt. Rainier and Tahoma Woods data show significant difference in NO₃⁻ concentrations over the complete 12-year period (Table 8b). Overall, concentrations for Tahoma Woods and Mt. Rainier are similar and fall between the low concentrations observed at Hoh and the higher concentrations observed at Marblemount and La Grande.

H⁺ and pH (the negative logarithm of the activity of H⁺), are direct measures of acidity in precipitation and are plotted in Figures 4a and 4b, respectively. The formation of SO₄²⁻ and

NO_3^- in the atmosphere is associated with the production of 3 H^+ , thus lowering pH. Since SO_4^{2-} and NO_3^- display decreased trends at all of the sites except Hoh, H^+ is expected to decrease and pH is expected to increase. These negative trends are significant in all sites except Hoh, where a significant positive H^+ trend and associated negative trend in pH is observed. La Grande and Marblemount display the lowest pH averaging around 5.1, which is significantly lower than the pH of unpolluted water in equilibrium with the current atmosphere (pH 5.6). The overall increasing trend in pH is the largest at Mt. Rainier, with 0.017 pH units per year. Seasonal patterns are significant for pH at all sites except Mt. Rainier and Tahoma Woods. Tahoma Woods and Mt. Rainier do not show significant differences in H^+ at the 95% CI according to the paired student t-test. Statistical analysis for pH changed as of 2011, as the evaporation correction factor was removed from the H^+ concentrations. Table 9 presents the pH at Mt. Rainier as it had been calculated before (by correcting for evaporation) and as it was measured directly, in addition to the pH at Tahoma Woods. Absolute differences between the Mt. Rainier and Tahoma Woods sites are calculated for each measure and based on the sum of these differences, as the bottom of the table, it was established that the measured pH was going to be used for all statistical evaluations. Figure 8 is also a graphic comparison of the corrected and uncorrected pH values as presented in Table 9.

NH_4^+ is derived from gaseous ammonia (NH_3), which is primarily emitted from soils, industry and animal waste, and it contributes to acid neutralization ($\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$). The Hoh and Marblemount sites show significant negative trends while at Mt. Rainier there is a significant positive trend (Figure 5). This latter observation is new since last year's report as last year's ammonium concentrations seem elevated compared to past years. Hoh also exhibits the smallest concentrations and fluctuations. Hoh and Tahoma Woods are the only sites that do not display a significant seasonal pattern. There is no significant difference between Mt. Rainier and Tahoma Woods from the paired student-t test.

Ca^{2+} is a tracer for limestone that can reach the atmosphere in the form of suspended dust, but it can also reach the atmosphere from emissions of coal combustion. It is typically associated with CO_3^{2-} or O^{2-} , which have the ability to take up protons thus buffering the system against pH drop. Ca^{2+} is plotted in Figure 6 and shows a significant upward trend at Hoh and downward trend at Mt. Rainier. Seasonal trends are observed at Hoh and La Grande. Comparisons between the Mt. Rainier and Tahoma Woods data reveal significant differences between the two sites, however, the decreasing trend at Mt. Rainier has brought Ca^{2+} concentrations in the past 5 years closer to those observed at Tahoma Woods.

[+]/[-] is defined as the ratio between the summed up positive and summed up negative charges in precipitation. Figure 7 depicts this data for the five sites. Carbonate species, which cannot be detected by the IC, are the only missing major components that have not been taken into consideration in the determination of this parameter. Significant increases in the charge ratio are observed at La Grande, Marblemount, and Mt. Rainier, which can be explained by the drops in both SO_4^{2-} and NO_3^- at these sites. Hoh and Tahoma Woods do not display clear trends in charge ratio. Mt. Rainier displays the most extreme charge ratio in that there is a downward trend up until 2003 followed by a continuous upward trend that is much steeper than that seen in La Grande and Marblemount. The decrease observed at Mt. Rainier prior to 2004 could be attributed to the samples having contained a contaminating amount of Cl^- due to the acid cleaning procedure of the bucket, leading to a lowering of the charge ratio. Since then, the cleaning procedure was changed to only utilizing deionized water. The drastic upward trend since 2004 is not readily understood. Seasonal fluctuations are significant at La Grande, Marblemount and Mt. Rainier and display opposite maxima and minima to anionic species, thus also indicating that the negatively charged

anions play a major role in the seasonal variations observed for the charge ratio. Ratios for Mt. Rainier and Tahoma Woods are not significantly different.

Conclusions

In agreement with previous reports, precipitation chemistry at Paradise, Mt. Rainier, seems to fall between the low contaminant levels at Hoh and the higher levels at La Grande and Marblemount [Agren *et al.*, 2012; Baker and Johansen, 2004; Bolstad and Duncan, 2000; Johansen and Lenington, 2003; Kittelson *et al.*, 2006; Lenington *et al.*, 2005; Sorey and Johansen, 2007]. Significant negative trends can be identified for sulfate for all sites except Hoh. Nitrate also shows significant negative trends at all sites except (i) Tahoma Woods, where it is close to significant ($P=0.055$), and (ii) Hoh where it is neutral. Associated with these negative trends in acidic anions a positive trend is observed in pH at all sites except Hoh, where pH values have decreased significantly. These observations support the fact that emissions regulations are effective and apparent at this high elevation site.

Sulfate, nitrate and ammonium display a seasonal pattern with concentrations at a minimum during the winter months. In comparing the Tahoma Woods site with Mt. Rainier, there seem to be statistically significant differences for H^+ , Mg^{2+} , Ca^{2+} , and NO_3^- . It is feasible that Tahoma Woods is closer to anthropogenic pollutant sources and thus concentrations for the anions and the proton are higher there. In the case of the two cations listed, however, the Mt. Rainier site displays larger concentrations possibly due to localized disturbed soils.

Although there is no direct evidence for Asian pollution reaching the Pacific Northwest, the continued collection and analysis of long-term and consistent data is essential in determining the impact that intercontinental atmospheric transport of pollutants exerts on pristine areas such as Mt. Rainier.

References

- Agren, J., C. Johnson, and A. M. Johansen (2012), Precipitation Chemistry at Mount Rainier (Paradise Ranger Station) Collection Site, Final Report for Data collected between June 2, 2010 and June 1, 2011, CWU, Ellensburg, WA.
- Baker, D. J., and A. M. Johansen (2004), Precipitation Chemistry at Mount Rainier (Paradise Ranger Station) Collection Site; Final Report for Data collected between June 1, 2002 and May 31, 2003, Central Washington University, Ellensburg, WA.
- Bolstad, D. B., and L. C. Duncan (2000), Precipitation Chemistry Mount Rainier (Paradise Ranger Station) Collection Site: Annual and Seasonal Data for January 1, 2000 to September 27, 2000., Central Washington University, Ellensburg, WA.
- Fox, D. G., A. M. Bartusa, J. Byrne, and e. al. (1989), Rep. RM-168, U.S. Department of Agriculture, Forest Service, Rocky Mountain Experiment Station, Fort Collins, CO.
- Johansen, A. M., and M. Lenington (2003), Precipitation Chemistry at Mount Rainier (Paradise Ranger Station) Collection Site; Final Report for Data collected between June 1, 2001 and May 31, 2002, Central Washington University, Ellensburg, WA.
- Kittelson, I., M. Sorey, and A. M. Johansen (2006), Precipitation Chemistry at Mount Rainier (Paradise Ranger Station) Collection Site; Final Report for Data collected between June 1, 2004 and May 31, 2005, Central Washington University, Ellensburg, WA.
- Lenington, M., M. Jones, D. J. Baker, and A. M. Johansen (2005), Precipitation Chemistry at Mount Rainier (Paradise Ranger Station) Collection Site; Final Report for Data collected between June 1, 2003 and May 31, 2004, Central Washington University, Ellensburg, WA.
- MINITAB (2013), Minitab for Windows, v. 16, edited, Minitab Inc., State College, PA.
- Sorey, M., and A. M. Johansen (2007), Precipitation Chemistry at Mount Rainier (Paradise Ranger Station) Collection Site Final Report for Data collected between June 1, 2005 and May 31, 2006, Central Washington University, Ellensburg, WA.

Tables and Figures

Table 1: Summary of Weekly Precipitation Data for 2011/2012 at Mount Rainier Paradise Ranger Station Summer 2011

Sample ID	Collection Date	Week (sum.'11)	Collection Volume	Precipitation Volume	NOAA Paradise Precipitation	Cond.	Measured pH	Adjusted pH	Adjusted H+	Unadjusted H+	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]	
	(M/D/Y)		(L)	(L)	(cm)	(mS/cm)					µeq/L									
M-11-19	6/9/2011	1	2.37	3.25	4.93	4.02	4.93	5.07	8.57	11.75	1.27	1.84	8.61	0.81	3.51	7.28	2.42	9.88	1.42	
M-11-20	6/15/2011	2	0.87	1.74	2.64	1.69	5.04	5.34	4.53	9.12	0.72	0.52	0.64	0.83	0.93	2.76	1.28	1.28	2.40	
M-11-21	6/22/2011	3	2.45	2.45	1.80	2.96	5.03	5.03	9.33	9.33	1.74	0.42	4.18	0.83	3.40	5.13	5.36	3.86	1.39	
M-11-22	6/29/2011	4	0.50	0.50	0.00	6.78	4.89	4.89	12.88	12.88	4.76	2.65	8.67	3.55	5.75	4.23	3.02	1.76	4.24	
	7/6/2011	5																		
M-11-23	7/14/2011	6	0.64	0.84	0.48	4.55	5.05	5.17	6.82	8.91	3.38	3.69	2.99	7.91	63.86	10.04	7.04	5.37	4.04	
M-11-24	7/20/2011	7	0.72	0.72	0.91	6.94	5.00	5.00	10.00	10.00	2.69	3.95	2.22	7.95	37.80	10.19	9.48	4.03	2.73	
M-11-25	7/27/2011	8	1.19	1.34	0.20	4.79	5.10	5.15	7.07	7.94	4.78	2.45	4.39	4.67	19.69	9.17	9.52	3.44	1.98	
	8/3/2011	9																		
	8/10/2011	10																		
	8/18/2011	11																		
M-11-26	8/24/2011	12	0.17	0.17	0.25	4.78	5.02	5.02	9.55	9.55	7.00	2.46	1.81	2.55	5.75	12.32	6.25	4.11	1.28	
Volume weighted average concentrations Summer 2011:						3.88	5.00	5.09	8.09	10.02	2.22	1.71	4.90	2.45	12.03	6.66	4.66	5.21	2.05	
Total Volume:			8.92	11.02																
Sample count:			8																	

Fall 2011

Sample ID	Collection Date	Week (fall '11)	Collection Volume	Precipitation Volume	NOAA Paradise Precipitation	Cond.	Measured pH	Adjusted pH	Adjusted H+	Unadjusted H+	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]	
	(M/D/Y)		(L)	(L)	(cm)	(mS/cm)					µeq/L									
	9/1/2011	13																		
	9/7/2011	14																		
	9/14/2011	15																		
M-11-27	9/21/2011	16	3.24	3.24	2.49	2.83	5.58	5.58	2.63	2.63	0.89	0.50	1.47	0.41	0.04	7.61	4.33	2.90	0.40	
M-11-28	9/29/2011	17	3.39	4.76	7.21	2.37	6.76	6.91	0.12	0.17	1.24	1.07	3.63	0.48	1.01	2.61	1.29	4.05	0.96	
M-11-29	10/5/2011	18	2.98	2.98	1.30	5.07	5.68	5.68	2.09	2.09	8.17	1.39	7.36	1.15	13.59	9.03	9.10	2.77	1.62	
M-11-30	10/12/2011	19	6.73	6.73	5.11	3.38	5.33	5.33	4.68	4.68	1.95	1.63	7.44	0.49	15.07	4.55	1.22	7.65	2.33	
	10/19/2011	20																		
M-11-31	10/26/2011	21	6.10	6.10	7.90	2.41	5.48	5.48	3.31	3.31	1.65	0.48	1.90	0.27	0.11	3.21	1.04	2.06	1.22	
M-11-32	11/2/2011	22	4.02	4.02	0.74	2.20	5.49	5.49	3.24	3.24	0.88	1.04	4.27	0.32	5.76	3.76	1.09	5.99	1.43	
M-11-33	11/9/2011	23	1.75	1.93	2.92	3.73	7.07	7.11	0.08	0.09	1.71	1.16	4.10	0.28	5.13	5.17	2.57	6.84	0.86	
M-11-34	11/21/2011	24-25	5.87	15.18	22.99	1.98	5.72	6.13	0.74	1.91	0.77	1.40	7.05	0.90	1.17	2.00	1.35	7.49	1.22	
M-11-35	11/30/2011	26	10.96	12.63	19.13	3.18	6.40	6.46	0.35	0.40	2.15	0.60	2.81	0.31	0.84	1.49	0.00	2.68	1.70	
Volume weighted average concentrations Fall 2011:						2.77	5.70	5.78	1.66	1.99	1.77	1.04	4.75	0.54	3.63	3.27	1.59	4.96	1.41	
Total Volume:			45.04	57.58																
Sample count:			9																	

Winter 2011 - 12

Sample ID	Collection Date	Week (winter '12)	Collection Volume	Precipitation Volume	NOAA Paradise Precipitation	Cond.	Measured pH	Adjusted pH	Adjusted H+	Unadjusted H+	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]	
	(M/D/Y)		(L)	(L)	(cm)	(mS/cm)					µeq/L									
	12/8/2011	27																		
	12/14/2011	28																		
M-11-36	12/21/2011	29	0.18	1.06	8.26	0.39	5.62	6.39	0.41	2.40	1.10	0.27	0.19	0.08	0.17	0.48	0.50	0.19	3.58	
M-11-37	1/11/2012	30-32	3.32	5.01	38.91	1.76	5.50	5.68	2.10	3.16	1.11	0.94	4.33	0.43	1.92	0.99	1.22	3.66	2.03	
M-12-01	1/25/2012	33-34	3.73	4.38	19.74	4.58	6.37	6.44	0.36	0.43	1.57	3.46	16.43	0.86	3.37	2.86	0.00	17.47	1.28	
M-12-02	2/1/2012	35	1.33	1.57	9.78	4.43	5.84	5.91	1.22	1.45	1.86	1.53	6.37	1.25	8.95	2.53	2.93	15.33	1.03	
M-12-03	2/8/2012	36	0.21	0.24	1.88	4.92	6.00	6.06	0.86	1.00	38.76	10.71	4.13	6.23	0.49	2.09	0.00	10.52	4.86	
M-12-04	2/15/2012	37	0.37	0.37	2.87	2.52	5.67	5.67	2.15	2.14	11.16	2.75	3.43	1.27	17.02	3.09	4.06	4.10	3.36	
M-12-05	2/23/2012	38	3.43	3.73	29.01	1.90	5.60	5.64	2.31	2.51	2.58	1.05	5.26	0.60	15.46	1.64	1.44	4.87	3.45	
M-12-06	2/29/2012	39	0.81	0.82	6.35	3.14	5.68	5.69	2.06	2.09	6.13	4.62	23.83	2.19	14.73	5.58	3.03	22.25	1.74	
M-12-07	3/7/2012	40	1.25	1.25	9.32	3.18	5.53	5.53	2.95	2.95	7.05	3.11	11.08	0.94	3.00	4.59	2.24	12.40	1.46	
Volume weighted average concentrations Winter 2011-12:						2.82	5.78	5.80	1.60	2.08	2.90	2.04	8.63	0.82	6.43	2.17	1.27	9.50	2.16	
Total Volume:			14.63	18.42																
Sample count:			9																	

Spring 2012

Sample ID	Collection Date	Week (spring '12)	Collection Volume	Precipitation Volume	NOAA Paradise Precipitation	Cond.	Measured pH	Adjusted pH	Adjusted H+	Unadjusted H+	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]	
	(M/D/Y)		(L)	(L)	(cm)	(mS/cm)					µeq/L									
M-12-08	3/14/2012	41	1.62	1.62	9.42	2.16	5.53	5.53	2.95	2.95	2.95	1.04	3.63	0.63	11.87	3.96	0.00	6.90	2.13	
M-12-09	3/27/2012	42-43	1.86	1.95	15.14	2.47	5.64	5.66	2.19	2.29	4.95	2.18	5.87	0.89	15.87	3.84	2.78	7.72	2.24	
M-12-10	4/4/2012	44	1.43	1.78	13.84	1.98	5.38	5.47	3.36	4.17	2.62	0.87	3.22	0.74	18.23	3.66	2.32	4.98	2.72	
M-12-11	4/11/2012	45	0.08	0.20	1.55	ADL	5.68	6.06	0.88	2.09	9.18	4.70	11.06	3.60	9.39	10.61	7.59	8.94	1.47	
M-12-12	4/17/2012	46	0.21	0.38	2.97	1.35	5.64	5.90	1.26	2.29	2.21	0.90	1.47	0.37	9.34	2.32	1.90	2.23	2.58	
M-12-13	4/26/2012	47	0.99	1.26	9.78	1.90	5.55	5.65	2.22	2.82	3.45	0.87	1.97	0.66	6.93	2.54	3.02	3.13	1.92	
M-12-14	5/2/2012	48	4.75	4.75	6.68	2.01	5.60	5.60	2.51	2.51	2.36	0.69	2.13	0.57	4.90	3.57	2.41	4.11	1.31	
M-12-15	5/9/2012	49	3.36	3.86	5.84	2.09	5.58	5.64	2.29	2.63	3.37	1.10	3.17	0.92	3.85	3.95	2.29	3.40	1.56	
	5/16/2012	50																		
M-12-16	5/23/2012	51	5.46	5.80	8.79	2.20	5.51	5.54	2.91	3.09	2.76	0.75	3.31	0.86	3.54	2.66	2.95	3.35	1.60	
M-12-17	5/30/2012	52	1.04	1.16	1.75	3.05	5.27	5.32	4.84	5.37	11.46	1.79	7.86	3.17	5.88	6.15	4.92	3.71	2.40	
Volume weighted average concentrations Spring 2012:						2.14	5.53	5.57	2.71	2.98	3.50	1.05	3.47	0.91	7.13	3.58	2.58	4.31	1.78	
Total Volume:			20.82	22.76																
Sample count:			10																	

Yellow highlight indicates a contaminated sample, as the results were well above our detection limit.

Numbers in gray boxes indicate cases when collection volume was used as precipitation volume because numbers derived from NOAA Paradise data were lower.

Numbers in green indicate that values fell below the Method Detection Limit before evaporation correction. See chart below for 2012 computed MDLs.

2012 Method Detection Limits (MDL)**

** Derived from last 30 QC.

	Ca	Mg	Na	K	NH ₄	SO ₄	NO ₃	Cl
MDL(µeq/L)	1.77	1.59	0.46	0.46	0.55	3.01	2.09	3.65
M.W.	40.08	24.31	22.99	39.10	18.03	96.06	62.00	35.45
Charge	2	2	1	1	1	2	1	1

Table 3: Mount Rainer Paradise Ranger Station Seasonal Precipitation Data

Season	Year	Cond	M pH (uS/cm)	Adj. pH	Adjusted H+	Unadj H+	Ca	Mg	Na	K	NH	SO	NO	Cl	Adjusted [+/]-
Winter	1989 00			5.53	2.95		3.78	3.36	14.10	4.36	0.50	8.30	2.72	12.14	1.25
Spring	1989 25			5.08	8.34		1.88	0.99	2.51	0.11	1.34	5.60	3.67	3.74	1.17
Summer	1989 50														
Fall	1989 75														
Winter	1990 00			4.95	11.20		1.27	1.70	5.44	0.25	0.64	8.59	0.84	4.17	1.51
Spring	1990 25			5.17	6.80		2.15	0.95				4.07	3.03	2.87	0.99
Summer	1990 50														
Fall	1990 75														
Winter	1991 00														
Spring	1991 25														
Summer	1991 50														
Fall	1991 75														
Winter	1992 00														
Spring	1992 25														
Summer	1992 50			4.73	18.65		5.67	0.72	2.84	1.05	1.99	15.49	5.87	2.57	1.29
Fall	1992 75			5.44	3.60		0.51	2.19	6.91	0.41	0.63	3.81	1.43	6.23	1.24
Winter	1993 00			5.31	4.92		1.54	2.04	6.39	1.18	0.42	3.86	1.51	6.17	1.43
Spring	1993 25			5.36	4.38		3.70	1.96	2.54	0.56	1.74	5.76	3.12	2.88	1.27
Summer	1993 50						2.20	3.44	3.52	0.69					
Fall	1993 75			4.57	27.18		3.33	1.65	8.85	1.66	2.37	5.95	4.57	3.34	3.25
Winter	1994 00			5.50	3.19		9.63	3.45	3.81	2.07	2.64	5.96	4.34	5.93	1.53
Spring	1994 25			5.30	4.96		6.67	1.99	4.03	1.18	3.50	9.89	4.86	5.56	1.10
Summer	1994 50			5.40	3.95		4.80	1.49	4.50	1.69	3.63	6.74	6.98	4.05	1.13
Fall	1994 75			5.44	3.59		8.69	1.78	4.11	0.87	1.62	5.30	3.56	9.12	1.15
Winter	1995 00			5.79	1.63		5.04	1.06	2.79	7.17	2.40	3.43	8.04	5.41	1.19
Spring	1995 25			5.06	8.66		2.31	2.45	6.97	1.01	1.89	7.44	3.76	11.65	1.02
Summer	1995 50			4.99	10.20		1.30	1.71	5.38	1.34		14.10	2.36	8.15	0.81
Fall	1995 75			5.48	3.31		1.71	4.05	2.65			4.74		5.63	1.13
Winter	1996 00			5.63	2.34		1.05	1.18	5.86	0.63		6.15	0.89	1.37	1.32
Spring	1996 25			5.48	3.29		12.90	2.28	3.77	1.14	1.91	7.95	1.86	5.50	1.65
Summer	1996 50														
Fall	1996 75			5.64	2.29		5.84	4.83		12.07		9.47	3.43	6.92	1.26
Winter	1997 00														
Spring	1997 25														
Summer	1997 50														
Fall	1997 75			5.35	4.51		1.16	2.37	8.42	1.93	0.40	6.06	2.24	10.67	0.99
Winter	1998 00			5.58	2.66		0.88	1.83	6.89	0.58	0.10	1.30	1.10	9.56	1.08
Spring	1998 25			5.29	5.07		1.72	0.98	3.01	2.30	3.24	4.11	6.39	6.78	0.94
Summer	1998 50			4.93	11.87		1.76	2.26	4.50	1.03	5.80	18.00	9.79	6.88	0.79
Fall	1998 75			5.34	4.62		0.45	1.52	5.95	0.50	0.51	5.99	3.97	10.60	0.66
Winter	1999 00	3.39		5.41	3.90		2.03	2.02	7.89	0.34	0.58	3.51	1.46	11.57	1.01
Spring	1999 25	4.90		5.17	6.74		3.33	2.18	8.08	0.84	2.54	7.86	4.71	11.01	1.01
Summer	1999 50	5.16		5.12	7.65		2.16	0.94	1.97	0.90	6.09	8.98	6.63	4.31	0.99
Fall	1999 75	4.31		5.21	6.10		1.67	1.33	3.31	0.91	0.80	6.20	3.77	6.02	0.88
Winter	2000 00	3.40	5.35	6.05	0.90	4.50	0.67	0.78	3.78	0.31	0.45	1.63	1.15	7.44	0.67
Spring	2000 25	5.29	5.11	5.69	2.06	7.85	1.50	2.42	5.67	0.75	1.68	7.06	3.72	18.74	0.48
Summer	2000 50	5.29	5.17	5.17	6.74	6.74	0.72	3.08	1.96	0.78	2.88	7.17	4.59	5.37	0.94
Fall	2000 75	7.55	4.94	4.94	11.49	11.49	0.73	0.57	3.99	0.33	1.45	14.48	2.33	7.13	0.78
Winter	2001 00														
Spring	2001 25														
Summer	2001 50	10.38	4.84	4.93	11.71	14.30	3.93	3.07	3.25	0.76	3.16	10.49	4.38	34.26	0.53
Fall	2001 75	5.85	5.04	5.38	4.17	9.22	4.25	4.29	9.71	0.66	0.96	5.60	1.10	28.37	0.69
Winter	2002 00	4.84	5.30	5.42	3.77	5.05	2.72	2.89	4.18	0.33	0.56	3.61	1.48	21.21	0.55
Spring	2002 25	9.49	4.74	4.91	12.33	18.13	4.70	3.28	4.71	0.43	1.62	6.33	3.66	31.36	0.65
Summer	2002 50	9.18	4.51	4.90	12.70	31.23	3.30	5.13	2.72	0.91	2.04	7.61	5.75	39.42	0.51
Fall	2002 75	7.74	5.04	5.13	7.43	9.06	2.80	6.33	7.16	0.82	1.02	7.17	3.89	41.88	0.48
Winter	2003 00	7.43	4.90	4.90	12.49	16.42	2.45	3.41	4.25	0.32	0.45	3.19	2.49	26.05	0.74
Spring	2003 25	3.26	5.13	5.31	4.91	7.41	3.43	3.66	3.56	0.42	1.56	3.75	3.38	8.95	1.09
Summer	2003 50	12.05	5.10	5.13	7.38	8.03	7.95	14.97	18.48	19.44	15.03	24.07	12.65	33.39	1.19
Fall	2003 75	2.67	5.28	5.38	4.22	5.24	4.82	4.96	9.09	2.10	0.65	8.21	2.43	10.95	1.20
Winter	2004 00	4.48	5.24	5.36	4.34	5.77	4.11	3.34	5.66	0.94	0.28	8.87	2.49	10.90	0.84
Spring	2004 25	3.39	4.99	5.28	5.21	10.12	2.65	1.56	3.59	0.55	1.24	7.08	2.64	5.06	1.00
Summer	2004 50	4.53	5.12	5.28	5.25	7.61	2.03	0.27	3.37	1.26	2.77	3.84	1.96	2.30	1.84
Fall	2004 75	4.14	5.27	5.35	4.51	5.39	2.25	0.82	7.52	0.71	0.53	5.05	2.10	7.41	1.12
Winter	2005 00	2.75	5.56	5.71	1.94	2.75	1.59	0.35	3.58	0.29	0.36	2.45	1.00	5.69	0.89
Spring	2005 25	5.46	5.26	5.36	4.42	5.55	2.83	0.43	4.56	0.46	2.07	7.50	4.32	10.81	0.65
Summer	2005 50	7.04	5.15	5.23	5.87	7.14	2.72	0.85	5.20	1.43	7.05	7.29	5.17	7.67	1.15
Fall	2005 75	3.25	5.22	5.41	3.92	5.98	1.23	0.44	3.54	0.41	0.72	4.25	2.66	6.65	0.76
Winter	2006 00	3.39	5.26	5.47	3.38	5.56	1.18	1.73	4.27	0.22	0.28	1.97	1.13	5.27	1.32
Spring	2006 25	5.80	5.12	5.22	5.97	7.53	1.50	2.33	3.94	0.32	2.51	4.34	3.18	5.53	1.27
Summer	2006 50	6.68	5.02	5.02	9.51	9.63	1.27	2.94	4.27	0.66	3.73	8.06	4.79	3.20	1.39
Fall	2006 75	1.73	5.68	5.94	1.15	2.09	0.65	1.38	2.46	0.42	0.28	1.92	0.67	2.72	1.19
Winter	2007 00	2.26	5.58	5.79	1.61	2.62	1.40	2.02	6.26	0.28	0.31	2.14	0.69	6.26	1.31
Spring	2007 25	2.98	5.48	5.53	2.92	3.34	2.51	0.78	3.86	0.94	3.02	4.27	2.58	4.20	1.27
Summer	2007 50	5.57	5.82	5.90	1.27	1.51	4.32	2.01	3.14	5.43	25.62	8.12	5.29	5.07	2.26
Fall	2007 75	3.07	5.03	5.04	9.03	9.42	1.32	0.80	5.36	0.35	1.49	4.21	1.82	6.72	1.44
Winter	2008 00	2.33	5.00	5.23	5.87	9.92	1.25	2.22	7.59	0.31	1.38	2.36	0.82	8.77	1.56
Spring	2008 25	2.68	4.86	5.00	9.92	13.85	1.46	3.34	3.33	0.52	2.85	5.48	2.23	4.43	1.76
Summer	2008 50	2.92	5.51	5.53	2.92	3.09	2.35	2.47	3.74	0.88	6.00	5.40	3.95	2.48	1.55
Fall	2008 75	2.91	5.37	5.42	3.79	4.27	2.50	2.75	7.34	0.74	3.31	5.54	2.39	5.33	1.54
Winter	2009 00	1.14	5.58	5.65	2.24	2.63	0.99	1.65	2.60	0.34	1.43	0.92	0.57	2.09	2.58
Spring	2009 25	2.64	5.25	5.39	4.04	5.60	4.22	2.62	6.99	0.74	2.30	7.29	1.86	5.45	1.43
Summer	2009 50	6.53	5.71	5.73	1.88	1.97	6.45	3.93	10.10	6.64	17.98	13.07	5.47	6.59	1.87
Fall	2009 75	2.36	5.73	5.88	1.32	1.85	1.74	1.38	11.34	3.13	1.65	2.99	1.66	5.65	2.00
Winter	2010 00	0.68	5.97	6.50	0.32	1.07	1.68	0.48	1.91	1.01	0.39	0.66	0.68	1.03	2.44
Spring	2010 25	3.32	5.26	5.52	1.83	3.03	2.19	2.80	13.25	1.03	1.80	5.18	1.92	12.12	1.10
Summer	2010 50	2.19	5.41	5.45	3.58	3.89	1.91	0.48	2.62	0.49	1.75	5.59	2.62	1.60	1.10
Fall	2010 75	1.67	5.28	5.46	3.50	5.20	1.47	0.37	4.63	0.47	1.34	3.56	1.05	2.57	1.64
Winter	2011 00	1.73	5.39	5.49	3.22	4.03	0.99	0.54	4.30	0.37	0.80	3.84	1.15	3.16	1.25
Spring	2011 25	2.32	5.20	5.26	5.46	6.37	1.62	0.73	2.99	0.23	1.89	5.11	3.07	4.10	1.05
Summer	2011 50	3.88	5.00	5.09	8.09	10.02	2.22	1.71	4.90	2.45	12.03	6.66	4.66	5.21	1.90
Fall	2011 75	2.77	5.70	5.78	1.66	1.99	1.77	1.04	4.75	0.					

Table 4: LaGrande NADP Site Seasonal Precipitation Data													
Season	Year	Cond (uS/cm)	pH	H ⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺ (ueq/L)	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cr	[+]/[-]
Winter	1989.00	6.76	5.00	9.93	1.60	2.80	12.79	0.23	0.55	10.00	4.32	14.89	0.95
Spring	1989.25	5.63	5.15	7.16	2.25	1.81	7.13	0.31	2.94	10.17	6.90	7.67	0.87
Summer	1989.50	9.58	4.92	12.02	4.79	2.14	6.53	0.64	7.54	21.20	11.86	7.08	0.84
Fall	1989.75	6.38	5.08	8.30	2.40	1.73	7.09	0.49	3.27	10.12	6.40	8.01	0.95
Winter	1990.00	4.33	5.28	5.25	0.85	2.14	10.18	0.20	1.94	5.06	2.52	11.99	1.05
Spring	1990.25	9.29	4.83	14.76	1.80	1.81	6.74	0.36	3.88	16.21	7.87	7.56	0.93
Summer	1990.50	8.47	4.85	14.16	1.10	1.07	4.52	0.33	4.93	14.48	7.24	5.44	0.96
Fall	1990.75	5.04	5.20	6.34	1.65	1.40	6.00	0.26	3.99	8.56	4.27	6.88	1.00
Winter	1991.00	4.61	5.22	6.01	1.05	1.40	6.61	0.26	1.22	6.27	2.94	7.62	0.98
Spring	1991.25	5.77	5.07	8.51	1.25	1.56	6.74	0.41	2.77	9.10	5.52	7.25	0.97
Summer	1991.50	12.66	4.68	20.80	2.30	1.40	5.13	0.54	5.82	25.39	11.76	5.39	0.85
Fall	1991.75	9.19	4.87	13.49	1.70	3.62	17.75	1.20	1.16	13.56	5.39	20.28	0.99
Winter	1992.00	4.02	5.26	5.55	0.95	1.48	6.83	0.20	0.94	4.71	3.44	7.50	1.02
Spring	1992.25	6.64	5.05	8.85	2.10	1.40	4.79	0.49	5.10	14.10	7.23	5.08	0.86
Summer	1992.50	11.74	4.70	20.14	1.75	0.99	4.44	0.38	5.71	24.64	11.34	4.03	0.83
Fall	1992.75	4.65	5.27	5.37	1.10	1.81	8.35	0.46	2.00	7.52	3.18	9.08	0.96
Winter	1993.00	4.16	5.32	4.75	0.85	1.73	8.70	0.54	0.55	4.92	3.24	8.77	1.01
Spring	1993.25	5.45	5.10	8.00	2.05	1.56	5.66	0.54	3.99	8.87	6.21	5.75	1.05
Summer	1993.50	14.41	4.59	25.88	1.40	1.48	6.87	0.59	7.76	25.87	15.02	6.49	0.93
Fall	1993.75	7.52	5.01	9.89	1.40	1.32	6.18	0.64	5.99	16.21	7.87	6.07	0.84
Winter	1994.00	4.81	5.19	6.52	1.50	1.97	9.22	0.82	2.27	6.50	3.27	9.96	1.13
Spring	1994.25	9.18	4.91	12.19	2.30	4.20	17.88	0.56	3.49	11.73	7.02	19.78	1.05
Summer	1994.50	10.45	4.74	18.11	1.25	1.48	6.87	0.59	4.71	17.08	8.52	6.63	1.02
Fall	1994.75	5.28	5.09	8.22	1.00	1.40	6.44	0.69	1.05	6.21	3.26	7.31	1.12
Winter	1995.00	4.45	5.14	7.28	0.80	0.90	5.31	0.59	1.66	5.48	2.86	6.04	1.15
Spring	1995.25	7.02	4.97	10.74	1.55	1.48	6.09	0.51	6.43	9.37	7.95	5.84	1.16
Summer	1995.50	10.11	4.78	16.67	1.95	1.81	8.27	0.89	6.04	14.31	9.57	8.86	1.09
Fall	1995.75	4.79	5.14	7.33	0.85	1.56	8.83	0.43	2.72	5.64	3.05	9.34	1.20
Winter	1996.00	3.74	5.28	5.25	0.70	1.48	8.48	0.28	1.83	3.12	2.45	8.69	1.26
Spring	1996.25	7.56	4.93	11.86	2.05	1.73	8.27	0.33	3.55	11.12	5.77	8.77	1.08
Summer	1996.50	10.04	4.72	18.97	1.10	1.40	6.70	0.41	2.27	17.48	4.94	6.83	1.05
Fall	1996.75	6.53	5.01	9.77	1.15	2.30	10.96	0.38	1.22	8.64	2.87	12.19	1.09
Winter	1997.00	5.33	5.20	6.25	0.80	2.88	14.49	0.38	1.11	4.83	3.39	16.70	1.04
Spring	1997.25	6.22	5.02	9.66	1.35	1.48	6.09	0.49	3.10	9.35	4.77	6.91	1.05
Summer	1997.50	9.82	4.77	16.90	1.30	1.07	4.22	0.41	5.16	15.98	9.02	4.65	0.98
Fall	1997.75	5.74	5.15	7.13	1.00	2.80	13.31	0.46	1.22	6.02	3.10	15.26	1.06
Winter	1998.00	4.34	5.22	5.97	0.95	1.97	9.05	0.38	0.55	3.92	2.44	10.32	1.13
Spring	1998.25	9.97	4.82	15.07	3.49	2.14	6.87	0.46	4.77	14.85	10.65	7.62	0.99
Summer	1998.50	7.11	4.87	13.43	1.65	0.74	2.13	0.87	2.33	12.69	4.47	3.22	1.04
Fall	1998.75	4.19	5.18	6.65	0.50	0.82	3.61	0.26	1.11	4.40	2.58	4.15	1.16
Winter	1999.00	3.92	5.29	5.09	0.85	2.14	10.05	0.33	1.00	3.29	1.94	11.51	1.16
Spring	1999.25	8.79	4.88	13.21	3.99	2.47	8.70	0.54	3.38	15.19	6.37	9.73	1.03
Summer	1999.50	12.56	4.65	22.18	2.20	1.32	4.61	0.33	5.16	23.43	7.37	5.28	0.99
Fall	1999.75	4.53	5.12	7.57	0.90	0.58	2.70	0.26	1.28	6.10	3.08	3.13	1.08
Winter	2000.00	4.43	5.21	6.14	0.80	1.48	7.35	0.20	0.83	4.31	3.19	8.43	1.05
Spring	2000.25	8.74	4.86	13.84	1.75	1.89	8.57	0.79	2.33	14.33	5.26	9.70	1.00
Summer	2000.50	12.41	4.68	20.70	1.75	2.06	10.18	0.49	4.44	19.25	10.81	10.49	0.98
Fall	2000.75	9.88	4.74	18.28	1.25	0.74	3.09	0.23	3.10	17.04	6.29	3.58	0.99
Winter	2001.00	7.60	5.04	9.14	2.20	3.21	16.27	0.43	2.22	7.08	6.19	17.77	1.08
Spring	2001.25	8.42	4.95	11.22	4.29	2.63	10.27	0.69	3.10	13.35	7.45	10.95	1.01
Summer	2001.50	7.38	4.86	13.93	1.20	0.58	1.87	0.28	2.55	12.50	4.40	2.40	1.06
Fall	2001.75	5.08	5.12	7.62	1.25	0.99	4.92	0.51	2.00	5.77	3.86	5.78	1.12
Winter	2002.00	4.21	5.27	5.33	1.10	1.56	8.61	0.26	0.72	3.27	2.68	9.93	1.11
Spring	2002.25	6.20	5.12	7.53	1.55	1.89	9.35	0.38	4.10	7.67	6.18	10.78	1.01
Summer	2002.50	8.38	4.93	11.70	1.85	1.56	5.13	0.66	8.15	12.83	10.05	5.81	1.01
Fall	2002.75	6.93	5.06	8.71	1.55	1.97	9.79	0.38	4.05	7.10	7.02	11.82	1.02
Winter	2003.00	3.69	5.33	4.67	0.90	0.82	4.52	1.59	1.16	2.40	3.27	6.74	1.10
Spring	2003.25	8.33	4.99	10.23	2.50	2.22	8.48	2.30	7.54	10.02	10.63	11.14	1.05
Summer	2003.50	11.04	4.78	16.41	3.49	1.73	6.00	0.95	11.86	14.75	16.90	6.88	1.05
Fall	2003.75	4.82	5.24	5.78	1.40	1.32	6.96	1.00	1.77	5.60	3.69	8.18	1.04
Winter	2004.00	4.44	5.27	5.37	1.10	1.48	7.87	0.51	1.66	3.37	3.90	9.65	1.06
Spring	2004.25	5.28	5.16	6.97	1.85	1.23	5.26	0.61	3.71	7.08	5.27	6.07	1.07
Summer	2004.50	4.35	5.14	7.21	1.00	0.66	3.31	0.28	2.38	5.50	4.02	3.81	1.11
Fall	2004.75	5.91	5.09	8.09	1.40	1.73	7.92	0.69	2.00	5.54	5.50	9.73	1.05
Winter	2005.00	5.55	5.14	7.24	1.45	1.32	7.35	0.33	1.11	3.19	4.05	10.69	1.05
Spring	2005.25	6.32	5.04	9.06	2.35	1.23	4.87	0.46	4.32	7.46	7.32	6.35	1.06
Summer	2005.50	7.73	4.89	12.91	2.30	0.90	3.35	0.51	4.82	7.27	9.21	5.87	1.11
Fall	2005.75	5.67	5.18	6.64	1.65	1.81	9.09	0.61	1.83	5.04	3.24	11.99	1.07
Winter	2006.00	4.53	5.36	4.34	3.14	2.06	9.53	0.49	1.44	2.92	2.24	11.68	1.25
Spring	2006.25	7.00	4.99	10.14	2.84	1.23	3.79	0.59	5.60	6.96	8.81	6.94	1.07
Summer	2006.50	8.42	4.85	14.26	2.40	0.91	2.35	0.64	6.71	8.96	10.60	5.02	1.11
Fall	2006.75	4.65	5.19	6.52	1.30	1.48	7.53	0.49	1.44	4.81	3.05	8.91	1.12
Winter	2007.00	4.49	5.29	5.13	1.55	1.97	10.05	0.77	0.50	3.37	2.36	12.07	1.12
Spring	2007.25	4.73	5.16	6.93	2.20	1.48	5.87	0.87	2.05	4.54	4.79	7.19	1.17
Summer	2007.50	6.35	4.97	10.69	1.70	1.07	4.00	0.54	5.21	6.98	8.02	5.45	1.14
Fall	2007.75	5.53	5.13	7.36	2.05	1.81	7.66	1.48	2.16	7.12	3.66	9.31	1.12
Winter	2008.00	4.92	5.39	4.08	3.14	2.72	13.62	1.10	0.67	4.00	2.98	16.11	1.10
Spring	2008.25	6.49	5.12	7.67	3.09	2.22	9.48	0.72	5.82	9.31	6.78	11.23	1.06
Summer	2008.50	6.39	5.00	9.93	1.55	1.73	7.66	0.69	1.33	7.65	5.16	8.89	1.05
Fall	2008.75	4.09	5.31	4.93	1.70	1.40	6.26	0.72	2.27	3.96	3.82	7.42	1.14
Winter	2009.00	3.61	5.26	5.55	1.50	0.74	3.18	0.38	0.78	2.71	3.18	5.81	1.15
Spring	2009.25	4.63	5.28	5.28	2.35	1.73	7.35	1.00	1.61	5.25	3.15	8.41	1.15
Summer	2009.50	4.63	5.10	7.91	1.40	0.49	1.61	0.41	3.22	6.04	5.48	2.00	1.11
Fall	2009.75	5.80	5.16	6.98	2.20	2.55	11.48	1.94	1.28	5.75	4.63	13.23	1.12
Winter	2010.00	3.10	5.36	4.32	2.05	0.91	4.26	0.51	1.05	2.06	2.19	4.85	1.44
Spring	2010.25	5.12	5.18	6.56	2.79	1.89	7.48	0.67	2.88	5.71	5.29	8.66	1.13
Summer	2010.50	6.63	5.00	10.00	1.75	1.65	7.18	0.67	5.10	7.06	8.05	8.24	1.13
Fall	2010.75	4.04	5.18	6.67	1.00	0.82	3.52	0.44	1.77	3.92	3.84	4.06	1.20
Winter	2011.00	4.03	5.23	5.86	0.75	1.40	6.31	0.28	1.16	2.83	3.68	7.42	1.13
Spring	2011.25	4.71	5.25	5.60	1.90	2.30	9.14	0.44	2.77	5.58	3.77	10.58	1.11
Summer	2011.50	5.15	5.11	7.78	1.15	1.32	5.00	0.69	4.99	6.65	4.95	5.78	1.20
Fall	2011.75	4.13	5.29	5.12	1.05	2.06	9.27	0.38	0.67</				

Table 5: Hoh NADP Site Seasonal Precipitation Data

Season	Year	Cond (uS/cm)	pH	H ⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺ (ueq/L)	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]
Winter	1988.00	11.02	5.36	4.34	2.89	10.94	48.37	1.10	0.55	8.92	1.35	59.78	0.97
Spring	1988.25	6.24	5.32	4.82	2.50	5.18	23.06	0.49	0.61	6.69	1.32	27.08	1.04
Summer	1988.50	6.56	5.29	5.11	2.69	4.28	21.84	0.59	0.55	7.31	0.77	23.22	1.12
Fall	1988.75	5.66	5.40	3.94	1.35	5.10	22.45	0.56	0.55	4.60	0.61	27.56	1.04
Winter	1989.00	4.81	5.43	3.74	1.10	3.95	18.31	0.28	0.55	4.23	0.97	21.61	1.04
Spring	1989.25	4.35	5.44	3.61	1.60	3.29	14.92	0.31	1.05	4.75	1.03	17.24	1.08
Summer	1989.50	3.78	5.39	4.06	0.90	1.23	5.26	0.23	1.55	5.69	2.60	6.18	0.92
Fall	1989.75	4.16	5.47	3.40	0.75	2.55	11.79	0.43	1.50	4.04	1.42	13.79	1.06
Winter	1990.00	8.25	5.43	3.75	1.90	8.64	38.72	0.79	4.32	6.77	1.18	46.69	1.06
Spring	1990.25	6.42	5.33	4.71	1.90	4.61	20.18	0.56	1.33	6.87	2.66	23.75	1.00
Summer	1990.50	4.66	5.26	5.50	0.55	2.06	9.66	0.41	0.83	5.73	2.84	11.06	0.97
Fall	1990.75	4.75	5.44	3.66	1.35	3.78	18.18	0.38	0.89	3.67	1.11	20.00	1.14
Winter	1991.00	4.66	5.41	3.90	1.05	3.95	17.62	0.38	0.55	3.54	1.39	20.79	1.07
Spring	1991.25	4.97	5.39	4.06	1.75	3.62	16.49	0.51	0.67	5.27	2.13	19.41	1.01
Summer	1991.50	2.89	5.45	3.56	2.69	0.74	3.18	0.20	0.61	3.21	1.68	3.39	1.33
Fall	1991.75	5.19	5.39	4.10	1.15	4.36	20.10	0.43	0.55	4.35	1.16	23.98	1.04
Winter	1992.00	6.82	5.40	3.99	2.25	6.58	29.02	0.66	0.67	5.73	1.45	33.26	1.07
Spring	1992.25	4.06	5.53	2.96	1.45	2.71	11.14	0.33	1.16	4.46	2.08	12.64	1.03
Summer	1992.50	3.72	5.70	1.98	0.75	1.15	6.00	0.28	1.55	5.35	3.02	5.47	0.85
Fall	1992.75	6.28	5.41	3.94	1.60	5.76	25.88	0.66	0.55	5.37	1.45	29.34	1.06
Winter	1993.00	5.93	5.41	3.90	1.10	5.59	24.88	0.51	0.67	4.94	1.32	28.77	1.05
Spring	1993.25	5.12	5.39	4.06	2.00	3.70	15.92	0.61	1.33	5.56	2.18	18.36	1.06
Summer	1993.50	6.63	5.27	5.36	1.45	4.52	20.49	0.72	0.94	8.33	2.73	22.77	0.99
Fall	1993.75	6.77	5.45	3.58	1.30	4.69	21.97	0.59	0.72	5.04	1.45	22.40	1.14
Winter	1994.00	4.95	5.36	4.40	1.05	3.78	19.58	0.66	2.05	3.69	1.45	21.27	1.19
Spring	1994.25	5.25	5.32	4.84	2.05	3.78	16.44	0.41	1.66	5.31	2.26	18.03	1.14
Summer	1994.50	8.86	5.05	8.83	1.40	5.35	24.27	0.59	0.72	8.81	2.29	27.31	1.07
Fall	1994.75	7.76	5.28	5.30	1.55	6.42	34.32	0.66	0.78	5.98	1.45	36.59	1.11
Winter	1995.00	4.82	5.41	3.88	0.90	3.70	18.44	0.38	0.89	3.08	1.16	20.48	1.14
Spring	1995.25	7.09	5.27	5.35	2.15	5.84	25.80	0.74	1.11	6.60	1.82	30.83	1.04
Summer	1995.50	5.96	5.10	7.98	1.05	2.30	11.22	0.31	2.11	6.48	3.32	12.64	1.11
Fall	1995.75	5.63	5.30	5.01	1.10	4.36	20.92	0.56	1.00	4.75	1.61	23.16	1.12
Winter	1996.00	7.49	5.26	5.53	2.20	5.76	26.06	1.53	2.11	7.81	2.79	30.58	1.05
Spring	1996.25	6.17	5.13	7.46	1.40	3.04	15.23	0.38	1.61	7.19	1.66	16.95	1.13
Summer	1996.50	5.38	5.31	4.94	1.15	3.70	17.97	0.43	1.05	4.65	1.35	20.09	1.12
Fall	1996.75	5.80	5.37	4.27	1.15	5.02	25.32	0.51	0.55	3.96	1.40	28.07	1.10
Winter	1997.00	5.34	5.22	6.04	1.45	3.70	17.05	0.43	0.89	5.15	1.94	19.27	1.12
Spring	1997.25	3.98	5.24	5.74	0.50	1.48	7.09	0.28	0.83	4.17	2.06	7.81	1.13
Summer	1997.50	9.12	5.33	4.69	2.10	8.72	43.46	0.89	0.55	6.94	1.68	47.56	1.08
Fall	1997.75	6.97	5.40	4.01	1.75	6.58	31.32	0.61	0.55	4.75	1.16	35.66	1.08
Winter	1998.00	6.56	5.26	5.56	2.59	4.77	22.93	0.56	0.67	6.46	2.69	24.18	1.11
Spring	1998.25	3.99	5.14	7.28	0.50	0.41	1.70	0.18	0.55	4.65	2.45	2.03	1.16
Summer	1998.50	5.78	5.34	4.52	1.15	4.61	21.45	0.54	0.55	4.27	1.08	25.36	1.07
Fall	1998.75	7.24	5.35	4.49	1.80	6.75	32.32	0.69	0.89	5.50	0.90	36.67	1.09
Winter	1999.00	9.56	5.31	4.91	3.19	8.80	41.63	0.87	1.05	8.50	1.71	47.25	1.05
Spring	1999.25	5.92	5.12	7.67	1.65	2.47	10.96	0.36	1.72	6.52	3.13	12.55	1.12
Summer	1999.50	4.18	5.39	4.04	1.05	2.30	12.27	0.36	0.55	3.08	1.21	13.79	1.14
Fall	2000.00	4.67	5.37	4.25	1.20	3.04	14.96	0.33	0.55	3.23	1.48	16.98	1.12
Winter	2000.25	5.29	5.28	5.27	1.90	3.13	15.27	0.64	0.78	5.42	2.35	16.95	1.09
Spring	2000.50	6.34	5.06	8.69	1.15	2.39	11.75	0.28	0.55	7.12	2.44	13.43	1.08
Summer	2000.75	5.66	5.25	5.68	1.20	3.37	16.88	0.41	0.55	5.31	1.60	19.21	1.08
Fall	2001.00	8.25	5.28	5.31	2.35	6.83	35.06	0.69	0.94	6.60	1.82	39.24	1.07
Winter	2001.25	7.44	5.28	5.22	2.59	5.51	26.88	0.79	0.83	7.29	2.05	30.35	1.05
Spring	2001.50	4.05	5.25	5.65	0.90	0.90	4.66	0.20	0.55	4.37	1.79	5.50	1.10
Summer	2001.75	6.29	5.36	4.36	1.75	5.02	24.80	0.72	0.55	4.52	1.15	29.48	1.06
Fall	2002.00	7.09	5.40	3.96	1.60	6.00	30.54	0.64	0.55	4.79	1.02	36.19	1.03
Winter	2002.25	7.20	5.38	4.19	2.30	4.85	23.71	0.61	1.00	5.98	2.16	27.00	1.04
Spring	2002.50	5.00	5.17	6.84	0.60	1.32	6.87	0.28	1.55	5.50	3.00	7.84	1.07
Summer	2002.75	8.15	5.37	4.28	1.75	7.16	33.58	0.74	0.72	5.77	1.48	39.75	1.03
Fall	2003.00	5.81	5.43	3.68	1.75	4.52	22.27	0.51	0.55	4.04	0.97	27.36	1.03
Winter	2003.25	6.06	5.38	4.16	1.75	4.28	20.53	0.74	1.05	5.15	1.58	24.46	1.04
Spring	2003.50	6.73	5.15	7.16	1.60	3.29	16.27	0.56	2.00	8.08	2.76	18.96	1.04
Summer	2003.75	7.05	5.39	4.07	1.85	4.94	24.67	0.61	0.61	4.60	1.16	29.68	1.04
Fall	2004.00	5.78	5.38	4.16	1.60	3.87	20.23	0.46	0.55	3.50	1.40	23.87	1.07
Winter	2004.25	6.71	5.32	4.80	2.30	4.36	20.79	0.54	0.94	5.77	2.56	25.39	1.00
Spring	2004.50	5.29	5.23	5.83	1.15	2.06	11.53	0.28	0.61	5.92	1.81	13.34	1.02
Summer	2004.75	5.41	5.37	4.30	1.65	3.45	17.66	0.43	0.61	4.58	1.21	20.65	1.10
Fall	2005.00	4.81	5.36	4.36	1.30	2.47	13.09	0.31	0.33	3.27	1.39	15.26	1.06
Winter	2005.25	7.95	5.29	5.14	2.69	6.09	29.45	0.69	1.05	7.35	2.19	34.59	1.02
Spring	2005.50	5.55	5.16	6.97	1.50	2.30	10.61	0.38	0.78	6.25	2.84	12.53	1.04
Summer	2005.75	5.92	5.35	4.47	1.65	4.20	19.66	0.54	0.33	4.94	1.19	23.61	1.04
Fall	2006.00	6.30	5.46	3.43	2.54	4.61	22.71	0.54	0.11	3.85	1.11	26.77	1.07
Winter	2006.25	6.05	5.28	5.27	2.84	3.62	16.70	0.49	1.28	6.21	2.66	19.35	1.07
Spring	2006.50	3.86	5.24	5.78	1.35	0.74	3.22	0.49	0.50	4.48	2.60	3.70	1.12
Summer	2006.75	10.79	5.01	9.71	2.60	8.14	38.76	0.97	1.16	12.35	3.27	44.06	1.03
Fall	2007.00	**	**	**	**	**	**	**	**	**	**	**	**
Winter	2007.25	7.50	5.12	7.59	1.95	3.70	18.05	0.92	0.83	8.23	2.13	20.68	1.06
Spring	2007.50	3.92	5.21	6.12	0.95	1.15	5.61	0.33	0.33	4.33	2.11	6.57	1.11
Summer	2007.75	5.56	5.32	4.84	1.75	3.87	17.79	0.51	0.89	5.37	1.65	21.72	1.03
Fall	2008.00	9.49	5.35	4.45	2.79	9.38	45.07	1.00	0.17	6.58	1.19	52.36	1.05
Winter	2008.25	9.30	5.24	5.70	3.09	8.06	36.71	0.97	1.50	9.44	2.32	43.50	1.01
Spring	2008.50	4.54	5.21	6.19	1.10	1.56	8.70	0.44	0.17	5.62	1.23	10.27	1.06
Summer	2008.75	6.29	5.45	3.55	2.45	4.85	22.66	0.59	1.05	5.48	1.48	27.14	1.03
Fall	2009.00	3.71	5.47	3.40	1.20	2.06	12.22	0.28	0.22	2.35	0.52	14.27	1.13
Winter	2009.25	10.29	5.25	5.66	3.84	9.95	45.55	1.20	1.33	10.79	2.23	51.91	1.04
Spring	2009.50	5.18	5.09	8.20	2.15	1.23	5.00	0.51	1.05	7.25	2.48	6.04	1.15
Summer	2009.75	5.49	5.41	3.93	1.75	4.11	21.32	0.61	0.17	4.21	0.95	24.66	1.07
Fall	2010.00	4.77	5.43	3.69	2.00	3.37	16.84	0.51	0.28	3.13	1.19	19.24	1.13
Winter	2010.25	12.16	5.40	3.96	4.49	12.92	59.33	1.36	0.78	9.87	1.65	68.66	1.03
Spring	2010.50	6.43	5.17	6.84	2.10	3.13	15.18	1.07	2.50	8.85	2.77	17.52	1.06
Summer	2010.75	5.07	5.34	4.59	1.25	3.29	15.62	0.49	0.72	4.25	1.36	18.96	1.06
Fall	2011.00	4.93	5.37	4.22	1.20	3.87							

Table 6: Marblemount NADP Site Seasonal Precipitation Data

Season	Year	Cond (uS/cm)	pH	H ⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺ (ueq/L)	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]
Winter	1988.00	5.31	5.14	7.28	1.45	2.39	11.01	0.23	0.55	6.71	3.48	12.61	1.00
Spring	1988.25	5.42	5.05	8.87	1.20	2.06	5.00	0.13	0.55	6.81	3.61	6.38	1.06
Summer	1988.50	7.18	4.90	12.47	2.05	2.14	3.09	0.10	0.55	10.73	4.37	3.72	1.08
Fall	1988.75	4.66	5.11	7.73	0.65	3.62	5.31	0.15	0.72	5.89	2.95	9.17	1.01
Winter	1989.00	4.97	5.14	7.21	2.30	2.22	5.61	0.41	0.55	6.33	4.23	7.08	1.04
Spring	1989.25	5.40	5.07	8.41	1.95	1.15	3.87	0.20	2.22	7.89	5.19	4.09	1.04
Summer	1989.50	8.81	4.85	14.00	1.30	0.82	2.65	0.49	5.88	16.00	11.36	3.02	0.83
Fall	1989.75	5.38	5.07	8.59	0.80	0.90	4.61	0.13	2.44	7.37	5.13	4.85	1.01
Winter	1990.00	4.87	5.20	6.25	1.55	2.06	9.57	0.51	3.44	4.75	3.05	8.15	1.47
Spring	1990.25	5.83	5.14	7.33	1.75	1.15	3.92	0.54	3.27	9.77	8.52	4.65	0.78
Summer	1990.50	7.24	4.98	10.45	1.25	0.99	3.35	0.69	6.87	11.66	9.68	4.09	0.93
Fall	1990.75	4.35	5.21	6.11	0.75	1.15	5.18	0.15	2.55	4.50	3.73	5.75	1.14
Winter	1991.00	4.49	5.18	6.68	0.60	1.07	4.87	0.28	0.61	4.00	3.82	5.98	1.02
Spring	1991.25	5.62	5.10	7.94	2.50	1.48	5.39	0.28	2.94	7.62	7.45	5.78	0.98
Summer	1991.50	7.63	4.98	10.45	7.53	1.81	2.57	0.95	2.72	11.85	9.73	2.62	1.08
Fall	1991.75	5.43	5.09	8.15	0.65	1.65	9.05	0.31	1.11	6.87	4.37	8.97	1.03
Winter	1992.00	4.93	5.19	6.41	0.70	1.48	6.74	0.20	0.72	5.39	3.32	7.67	0.99
Spring	1992.25	6.67	5.05	8.85	2.40	1.81	5.53	0.33	2.88	11.06	8.69	5.73	0.86
Summer	1992.50	7.24	5.03	9.29	1.75	0.49	2.35	0.28	5.43	9.75	10.11	1.86	0.90
Fall	1992.75	4.51	5.21	6.22	1.25	1.40	6.05	0.28	1.22	6.46	3.87	7.48	0.92
Winter	1993.00	4.03	5.17	6.71	0.50	0.66	3.26	0.10	0.67	4.10	4.02	3.98	0.98
Spring	1993.25	4.73	5.11	7.71	1.50	0.82	2.70	0.36	3.33	7.27	6.86	2.60	0.98
Summer	1993.50	5.61	5.11	7.73	0.95	0.82	3.65	0.31	4.82	9.02	8.58	3.55	0.86
Fall	1993.75	6.47	4.99	10.14	1.00	1.32	6.05	0.31	2.66	9.27	7.13	6.77	0.93
Winter	1994.00	4.07	5.19	6.44	1.75	1.23	5.87	0.15	2.27	4.42	4.03	6.18	1.21
Spring	1994.25	7.33	4.89	12.85	2.30	1.56	6.09	0.28	3.77	9.58	8.55	6.40	1.09
Summer	1994.50	30.90	4.23	58.88	1.50	1.23	5.70	0.61	17.74	52.91	28.23	7.62	0.97
Fall	1994.75	6.37	5.04	9.16	0.80	1.81	8.22	0.20	1.11	6.14	3.98	9.59	1.08
Winter	1995.00	4.80	5.18	6.65	3.89	1.73	5.53	0.49	1.33	3.92	3.50	6.26	1.43
Spring	1995.25	5.42	5.01	9.79	1.40	0.90	3.65	0.23	3.27	5.77	6.87	3.72	1.18
Summer	1995.50	7.57	4.86	13.84	0.65	0.74	3.57	0.20	4.66	8.85	8.31	3.44	1.15
Fall	1995.75	4.86	5.12	7.66	0.50	1.32	6.74	0.15	1.39	5.23	2.98	7.42	1.14
Winter	1996.00	3.66	5.22	6.08	0.55	0.82	5.05	0.10	2.11	2.79	3.37	4.82	1.34
Spring	1996.25	6.47	5.02	9.46	1.65	1.48	7.18	0.28	4.82	7.02	7.87	7.36	1.12
Summer	1996.50	8.81	4.81	15.31	0.80	0.99	5.48	0.28	4.93	11.04	9.74	5.13	1.07
Fall	1996.75	5.04	5.08	8.38	1.00	1.23	5.70	0.20	1.28	5.42	4.08	6.40	1.12
Winter	1997.00	4.37	5.13	7.35	0.45	1.15	5.92	0.13	0.61	3.44	4.05	6.52	1.11
Spring	1997.25	5.82	5.05	8.87	1.05	1.81	7.87	0.36	2.11	6.79	5.36	8.77	1.05
Summer	1997.50	5.71	4.97	10.69	0.80	0.58	2.61	0.26	2.99	6.21	7.03	2.62	1.13
Fall	1997.75	5.61	5.10	7.93	0.90	1.81	8.87	0.26	1.39	4.92	4.53	9.82	1.10
Winter	1998.00	4.22	5.14	7.21	0.75	1.23	5.39	0.13	0.61	3.56	3.29	6.21	1.17
Spring	1998.25	7.47	4.89	12.76	2.45	1.40	4.44	0.26	2.66	8.96	9.18	5.05	1.03
Summer	1998.50	10.05	4.72	19.14	1.55	0.82	2.78	0.26	3.99	11.69	13.87	3.41	0.99
Fall	1998.75	3.97	5.16	6.95	0.50	0.74	3.05	0.13	1.05	3.75	3.40	3.47	1.17
Winter	1999.00	3.75	5.16	6.95	0.55	0.74	3.31	0.10	0.89	3.15	3.45	3.84	1.20
Spring	1999.25	7.34	4.91	12.30	2.40	1.40	4.83	0.20	2.16	8.67	8.65	5.53	1.02
Summer	1999.50	7.90	4.91	12.45	2.20	2.06	2.13	0.66	2.88	8.06	8.86	2.74	1.14
Fall	1999.75	5.01	5.11	7.82	1.30	1.07	5.31	0.20	0.72	5.08	3.94	5.84	1.10
Winter	2000.00	4.69	5.17	6.73	0.90	1.32	6.35	0.15	0.61	3.77	3.87	7.00	1.10
Spring	2000.25	6.97	4.95	11.14	1.90	1.23	5.00	0.33	2.27	8.08	7.94	5.56	1.01
Summer	2000.50	7.71	4.85	14.00	1.30	0.66	2.57	0.18	2.22	8.79	9.63	2.93	0.98
Fall	2000.75	6.79	4.93	11.80	1.05	0.66	3.57	0.15	2.05	9.25	5.45	4.12	1.02
Winter	2001.00	7.19	4.95	11.19	1.40	1.81	9.22	0.23	1.16	6.21	7.34	10.61	1.04
Spring	2001.25	6.99	4.96	10.96	2.69	1.56	6.40	0.38	2.99	8.85	7.42	7.14	1.07
Summer	2001.50	6.00	4.97	10.67	1.10	0.49	1.44	0.23	3.83	6.98	8.15	1.69	1.06
Fall	2001.75	5.38	5.12	7.62	1.20	1.56	7.35	0.31	0.94	5.50	3.79	8.94	1.04
Winter	2002.00	4.28	5.20	6.32	0.60	0.74	4.79	0.10	0.55	3.06	3.21	5.61	1.10
Spring	2002.25	6.89	5.02	9.53	1.90	1.56	6.96	0.33	4.44	7.48	10.02	7.53	0.99
Summer	2002.50	5.73	5.07	8.51	1.70	0.74	2.31	0.56	4.55	7.02	6.81	2.48	1.13
Fall	2002.75	5.83	5.08	8.24	0.90	1.73	9.01	0.28	2.11	5.33	5.37	10.41	1.05
Winter	2003.00	3.35	5.32	4.79	1.05	0.99	4.31	0.10	0.72	2.37	2.61	5.16	1.18
Spring	2003.25	4.93	5.14	7.28	1.45	0.82	2.96	0.26	2.44	4.50	5.65	3.47	1.12
Summer	2003.50	11.19	4.81	15.35	2.84	2.30	9.79	0.82	13.31	15.31	15.92	10.32	1.07
Fall	2003.75	3.92	5.28	5.22	1.10	0.99	5.48	0.18	0.83	3.27	2.71	6.49	1.11
Winter	2004.00	4.33	5.17	6.71	1.10	0.82	4.31	0.20	0.55	2.48	4.47	5.05	1.14
Spring	2004.25	6.77	4.99	10.21	4.79	1.48	5.00	0.43	2.61	6.89	8.23	6.04	1.16
Summer	2004.50	5.43	5.02	9.62	1.05	0.33	1.39	0.18	1.83	5.19	6.65	1.69	1.06
Fall	2004.75	4.87	5.12	7.60	0.95	0.99	5.26	0.20	1.22	4.79	3.92	6.43	1.07
Winter	2005.00	4.11	5.14	7.31	0.70	0.49	3.09	0.13	0.72	3.23	3.79	4.09	1.12
Spring	2005.25	5.28	5.07	8.43	1.60	1.07	4.61	0.23	1.94	5.85	5.39	5.61	1.06
Summer	2005.50	7.80	4.85	14.13	1.50	0.74	2.65	0.38	3.33	7.62	10.39	3.13	1.07
Fall	2005.75	4.21	5.23	5.90	1.00	0.66	4.05	0.33	1.05	3.48	3.40	4.68	1.12
Winter	2006.00	4.33	5.31	4.94	1.80	1.07	5.61	0.36	1.44	2.42	3.47	6.52	1.23
Spring	2006.25	6.22	5.19	6.46	3.04	1.73	6.48	1.07	8.43	7.48	7.29	7.73	1.21
Summer	2006.50	7.02	4.91	12.39	1.40	0.49	1.48	0.28	4.38	6.92	10.18	1.89	1.08
Fall	2006.75	4.73	5.13	7.50	1.30	1.15	5.87	0.31	1.05	4.69	3.86	6.88	1.11
Winter	2007.00	3.77	5.28	5.24	1.30	1.23	6.66	0.26	0.61	3.00	2.86	7.65	1.13
Spring	2007.25	3.83	5.19	6.46	1.50	0.74	2.70	0.31	1.50	3.58	4.57	3.24	1.16
Summer	2007.50	7.01	4.90	12.50	1.70	0.74	2.70	1.46	3.77	7.42	10.21	3.47	1.08
Fall	2007.75	4.21	5.17	6.75	1.05	0.82	3.96	0.21	1.44	4.00	3.98	4.91	1.10
Winter	2008.00	4.57	5.22	6.05	1.25	1.73	9.14	0.28	0.50	2.96	3.57	10.95	1.08
Spring	2008.25	6.34	5.02	9.59	3.29	1.65	4.92	0.97	3.88	8.17	8.08	6.15	1.09
Summer	2008.50	6.01	4.96	10.84	1.50	0.49	1.74	0.28	4.10	7.44	7.68	2.17	1.10
Fall	2008.75	3.50	5.29	5.14	0.80	0.74	4.48	0.21	1.11	3.46	2.31	5.16	1.14
Winter	2009.00	4.13	5.22	6.08	1.15	1.15	6.26	0.31	0.44	3.15	3.66	7.56	1.07
Spring	2009.25	4.29	5.19	6.41	1.90	0.99	4.18	0.26	1.16	4.67	4.19	4.82	1.09
Summer	2009.50	6.66	5.18	12.27	2.55	0.74	0.38	1.96	3.33	7.19	7.76	2.62	1.21
Fall	2009.75	3.25	5.49	5.11	0.85	0.66	0.15	4.22	0.50	2.58	2.07	4.85	1.21
Winter	2010.00	2.76	5.56	4.72	1.30	0.41	0.15	2.09	0.33	1.65	2.44	2.37	1.40
Spring	2010.25	4.39	5.36	5.56	2.65	1.48	0.28	6.00	3.11	4.21	5.21	6.97	1.16
Summer	2010.50	5.63	5.00	10.00	1.75	0.82	2.96	0.36	4.88	5.85	7.10	3.47	1.26
Fall	2010.75	3.09	5.25	5.62	0.65	0.41	1.91	0.18	0.50	2.31	2.61	2.45	

Table 7: Tahoma Woods NADP Site Seasonal Precipitation Data

Season	Year	Cond	pH	H ⁺	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NH ₄ ⁺	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	[+]/[-]
		(uS/cm)	Tahoma										
Fall	1999.75	2.99	5.33	4.67	0.60	0.33	1.65	0.13	0.55	2.23	1.84	1.92	1.32
Winter	2000.00	3.97	5.26	5.52	0.90	0.82	4.39	0.13	0.72	2.77	2.79	4.80	1.21
Spring	2000.25	6.78	5.05	8.95	1.75	2.63	12.31	0.43	1.94	8.44	4.52	13.91	1.04
Summer	2000.50	10.12	4.78	16.41	1.45	2.47	12.44	0.46	1.33	14.58	4.77	13.88	1.04
Fall	2000.75	7.05	4.89	12.94	0.95	0.66	3.31	0.15	0.83	10.54	3.60	3.98	1.04
Winter	2001.00	6.02	5.08	8.36	2.00	1.73	8.70	0.28	1.39	5.79	5.36	9.73	1.08
Spring	2001.25	6.95	4.99	10.35	1.90	1.73	7.22	0.41	1.83	9.44	5.44	8.10	1.02
Summer	2001.50	5.41	5.01	9.73	1.30	0.49	1.83	0.28	1.88	7.87	3.69	2.31	1.12
Fall	2001.75	5.39	5.09	8.13	1.10	1.07	5.26	0.26	1.66	6.48	3.26	6.23	1.09
Winter	2002.00	4.21	5.28	5.25	1.00	1.48	7.79	0.20	0.83	2.92	2.65	9.39	1.11
Spring	2002.25	5.45	5.21	6.18	1.35	1.89	9.44	0.38	1.66	5.33	4.13	10.89	1.03
Summer	2002.50	5.41	5.24	5.77	1.25	1.73	5.79	6.01	2.38	5.79	5.32	7.36	1.24
Fall	2002.75	10.34	4.79	16.11	2.00	1.15	5.61	0.28	7.21	12.85	14.50	6.15	0.97
Winter	2003.00	3.28	5.34	4.59	0.75	0.82	4.00	0.13	0.83	2.00	2.00	4.85	1.26
Spring	2003.25	4.61	5.27	5.40	1.70	1.32	5.87	0.38	2.94	4.35	4.94	6.88	1.09
Summer	2003.50	7.91	5.13	7.43	3.94	1.32	2.96	1.53	19.46	11.79	17.10	3.67	1.13
Fall	2003.75	4.89	5.23	5.87	1.50	1.65	8.44	0.36	1.83	4.54	3.56	9.85	1.09
Winter	2004.00	3.68	5.30	5.05	0.85	0.90	5.31	0.18	0.78	2.02	2.89	6.26	1.17
Spring	2004.25	4.82	5.20	6.37	1.70	1.23	6.09	0.46	3.49	5.60	5.11	6.97	1.09
Summer	2004.50	3.52	5.26	5.55	0.75	0.33	1.74	0.31	1.66	3.94	3.29	2.17	1.10
Fall	2004.75	5.61	5.15	7.08	1.45	2.22	10.96	0.41	0.89	5.00	3.48	13.77	1.03
Winter	2005.00	6.51	5.00	10.05	1.25	1.48	7.53	0.26	1.33	2.75	3.11	14.36	1.08
Spring	2005.25	3.95	5.29	5.13	2.50	0.82	3.13	0.28	2.27	3.87	3.24	5.05	1.16
Summer	2005.50	6.83	5.00	10.00	1.90	1.32	5.05	0.54	4.71	8.62	7.39	5.98	1.07
Fall	2005.75	5.55	5.12	7.60	1.50	1.56	7.61	0.33	0.94	4.02	2.92	11.17	1.08
Winter	2006.00	3.81	5.32	4.75	2.40	0.99	5.13	0.20	0.28	2.02	1.63	7.28	1.26
Spring	2006.25	5.56	5.12	7.66	2.25	0.90	2.92	0.51	3.77	5.44	6.61	4.85	1.07
Summer	2006.50	5.54	5.07	8.55	2.79	0.66	2.22	0.77	2.94	5.04	4.39	5.53	1.20
Fall	2006.75	4.03	5.21	6.17	0.85	1.23	6.09	0.33	0.67	4.00	2.10	7.59	1.12
Winter	2007.00	4.56	5.34	4.58	1.90	2.63	13.09	0.36	0.44	3.46	1.87	15.74	1.09
Spring	2007.25	5.15	5.12	7.66	1.85	1.48	6.57	0.56	2.11	4.79	5.36	7.70	1.13
Summer	2007.50	6.60	4.99	10.33	1.80	1.07	4.13	0.84	5.99	7.96	7.66	5.92	1.12
Fall	2007.75	4.55	5.19	6.40	1.30	1.32	6.96	0.38	1.77	5.08	2.95	8.44	1.10
Winter	2008.00	3.35	5.36	4.38	1.00	0.99	6.09	0.21	0.39	1.79	1.65	7.53	1.19
Spring	2008.25	5.76	5.19	6.49	2.00	2.14	9.88	0.44	2.44	6.90	4.11	12.81	0.98
Summer	2008.50	6.12	4.98	10.57	1.30	0.91	4.44	0.56	0.67	7.73	4.23	4.88	1.18
Fall	2008.75	3.48	5.27	5.33	0.80	0.82	4.09	0.31	1.16	2.88	2.82	5.28	1.24
Winter	2009.00	3.00	5.32	4.78	0.90	0.82	4.44	0.21	0.50	2.35	1.73	12.75	1.08
Spring	2009.25	4.89	5.32	4.81	3.14	2.47	11.01	0.51	1.77	6.21	2.92	2.40	1.14
Summer	2009.50	5.67	5.06	8.77	1.55	0.66	2.18	0.46	7.76	8.73	7.61	2.40	1.14
Fall	2009.75	4.35	5.27	5.42	1.35	1.81	9.44	0.36	1.00	3.81	2.40	11.12	1.12
Winter	2010.00	2.94	5.36	4.37	1.90	0.91	4.35	0.18	0.78	1.98	2.08	5.05	1.37
Spring	2010.25	5.09	5.34	4.59	3.44	2.55	11.31	0.51	3.33	5.67	4.79	12.98	1.10
Summer	2010.50	6.39	5.03	9.44	1.55	1.56	6.92	0.46	3.94	7.62	6.73	7.98	1.07
Fall	2010.75	4.02	5.26	5.45	1.00	1.48	7.31	0.31	0.55	3.31	2.15	9.00	1.11
Winter	2011.00	3.52	5.34	4.53	0.75	1.65	7.57	0.26	0.67	2.48	1.90	8.94	1.16
Spring	2011.25	4.12	5.32	4.75	1.70	1.81	7.05	1.05	3.38	4.29	3.27	8.18	1.25
Summer	2011.50	6.42	5.04	9.23	1.45	1.89	6.96	0.74	5.77	8.52	7.13	8.04	1.10
Fall	2011.75	4.68	5.29	5.15	0.95	2.88	12.53	0.38	0.89	3.94	1.97	14.61	1.11
Winter	2012.00	5.42	5.40	4.00	1.70	4.11	18.92	0.59	0.83	3.75	2.24	22.43	1.06
Spring	2012.25	2.91	5.37	4.27	1.40	0.91	3.39	0.28	1.94	2.63	2.26	4.03	1.37

Data acquired from <http://nadp.sws.uiuc.edu/nadpdata>

Each entry is a volume weighted average concentration of a three month period (Eqn. 2). Winter 199x is defined as Dec 199x-1 through Feb 199x. Spring is defined as Mar 199x through May 199x. Summer is defined as June 199x through Aug 199x.

Fall is defined as Sept 199x through Nov 199x.

The column headed "[+]/[-]" is the ratio of cation to anion concentration.

Table 9: pH Evaporation Correction Comparison						
Season	Year	MIR pH		pH	ABS (MIR pH - Tahoma pH)	
		Not-Corrected	Corrected	Tahoma	Not Corrected	Corrected
Winter	2000.00	5.35	6.05	5.26	0.088374548	0.787344552
Spring	2000.25	5.11	5.69	5.05	0.057348132	0.638637126
Summer	2000.50	5.17	5.17	4.78	0.38638925	0.38638925
Fall	2000.75	4.94	4.94	4.89	0.05167682	0.05167682
Winter	2001.00			5.08		
Spring	2001.25			4.99		
Summer	2001.50	4.84	4.93	5.01	0.16743857	0.080521537
Fall	2001.75	5.04	5.38	5.09	0.054607649	0.289505249
Winter	2002.00	5.30	5.42	5.28	0.016431227	0.144034361
Spring	2002.25	4.74	4.91	5.21	0.467445035	0.299906263
Summer	2002.50	7.51	4.90	5.24	2.266463825	0.342732752
Fall	2002.75	5.04	5.13	4.79	0.249690745	0.33579471
Winter	2003.00	4.90	4.90	5.34	0.434542316	0.434542316
Spring	2003.25	5.13	5.31	5.27	0.137596604	0.040844874
Summer	2003.50	5.10	5.13	5.13	0.033644463	0.002831396
Fall	2003.75	5.28	5.38	5.23	0.049610313	0.144189803
Winter	2004.00	5.24	5.36	5.30	0.058280966	0.065064385
Spring	2004.25	4.99	5.28	5.20	0.201088315	0.087229849
Summer	2004.50	5.12	5.28	5.26	0.13737234	0.023827666
Fall	2004.75	5.27	5.35	5.15	0.11862461	0.195667914
Winter	2005.00	5.56	5.71	5.00	0.562149927	0.714617249
Spring	2005.25	5.26	5.36	5.29	0.034072307	0.064999296
Summer	2005.50	5.15	5.23	5.00	0.146132894	0.231566521
Fall	2005.75	5.22	5.41	5.12	0.10410582	0.288024467
Winter	2006.00	5.26	5.47	5.32	0.067762489	0.147783952
Spring	2006.25	5.12	5.22	5.12	0.007114895	0.108277619
Summer	2006.50	5.02	5.02	5.07	0.05144199	0.04613218
Fall	2006.75	5.68	5.94	5.21	0.470295871	0.730528903
Winter	2007.00	5.58	5.79	5.34	0.243332044	0.455157557
Spring	2007.25	5.48	5.53	5.12	0.360497481	0.418452597
Summer	2007.50	5.82	5.90	4.99	0.834723428	0.91185838
Fall	2007.75	5.03	5.04	5.19	0.168074981	0.149665867
Winter	2008.00	5.00	5.23	5.36	0.355416154	0.127590768
Spring	2008.25	4.86	5.00	5.19	0.329596058	0.184521169
Summer	2008.50	5.51	5.53	4.98	0.533741661	0.558750205
Fall	2008.75	5.37	5.42	5.27	0.099836409	0.151027294
Winter	2009.00	5.58	5.65	5.32	0.259579174	0.329815205
Spring	2009.25	5.25	5.39	5.32	0.068438405	0.074076566
Summer	2009.50	5.71	5.73	5.06	0.649038769	0.668829283
Fall	2009.75	5.73	5.88	5.27	0.46711659	0.613114352
Winter	2010.00	5.97	6.50	5.36	0.611060158	1.13924396
Spring	2010.25	5.26	5.52	5.34	0.079807416	0.18035256
Summer	2010.50	5.41	5.45	5.03	0.385414334	0.421514487
Fall	2010.75	5.28	5.46	5.26	0.020254021	0.192259935
Winter	2011.00	5.39	5.49	5.34	0.050258869	0.148077856
Spring	2011.25	5.20	5.26	5.32	0.126892656	0.059878813
Summer	2011.50	5.00	5.09	5.04	0.035853743	0.057202866
Fall	2011.75	5.70	5.78	5.29	0.413925581	0.491301827
Winter	2012.00	5.78	5.80	5.40	0.384865437	0.398483799
Spring	2012.25	5.53	5.57	5.37	0.156321078	0.196702635
sum of difference:					12.06278053	13.46685686

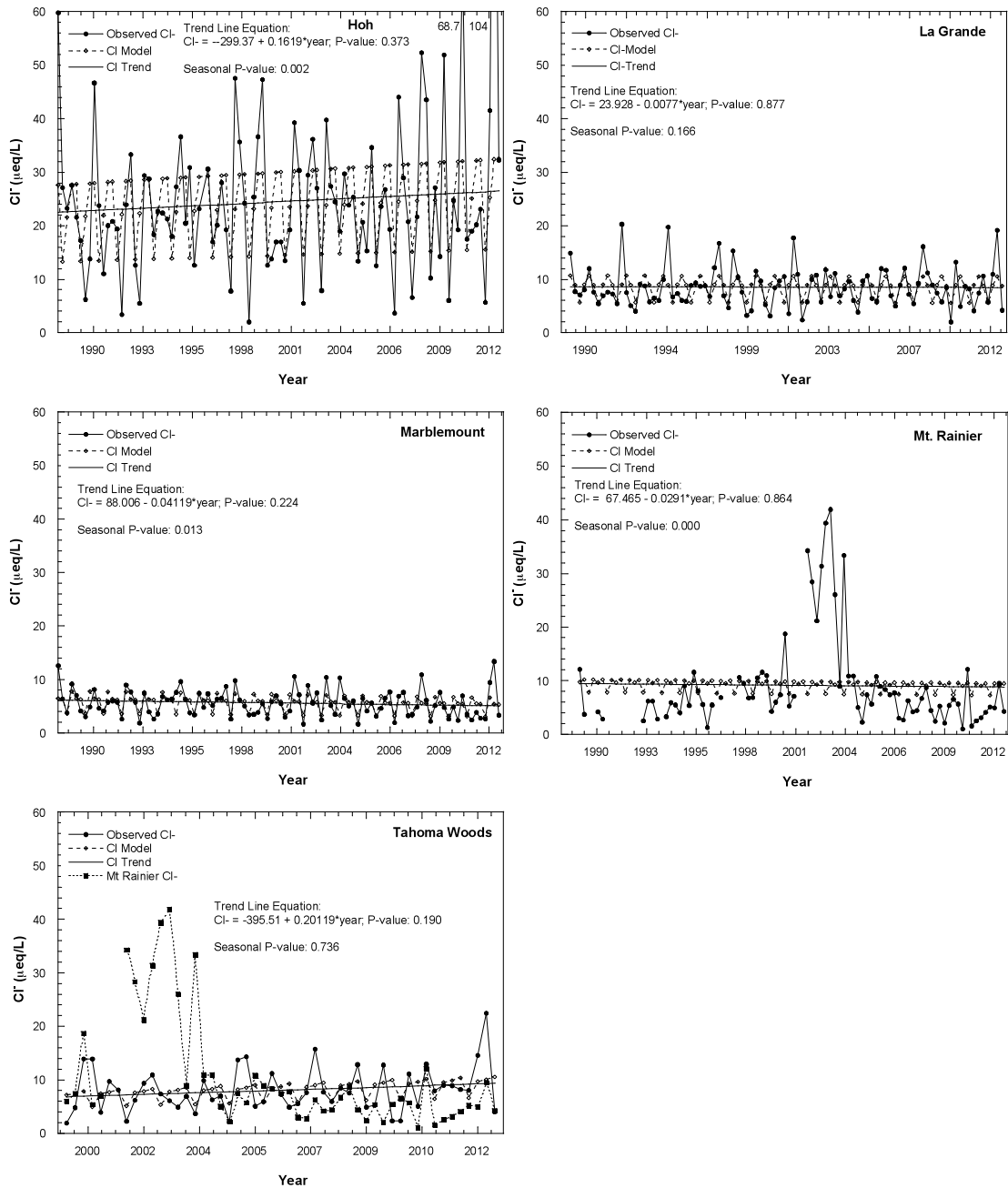


Figure 1: Observed, Modeled and Trend including Trend Line Equation for Cl⁻ precipitation concentrations at 4 NADP sites and at Mt. Rainier.

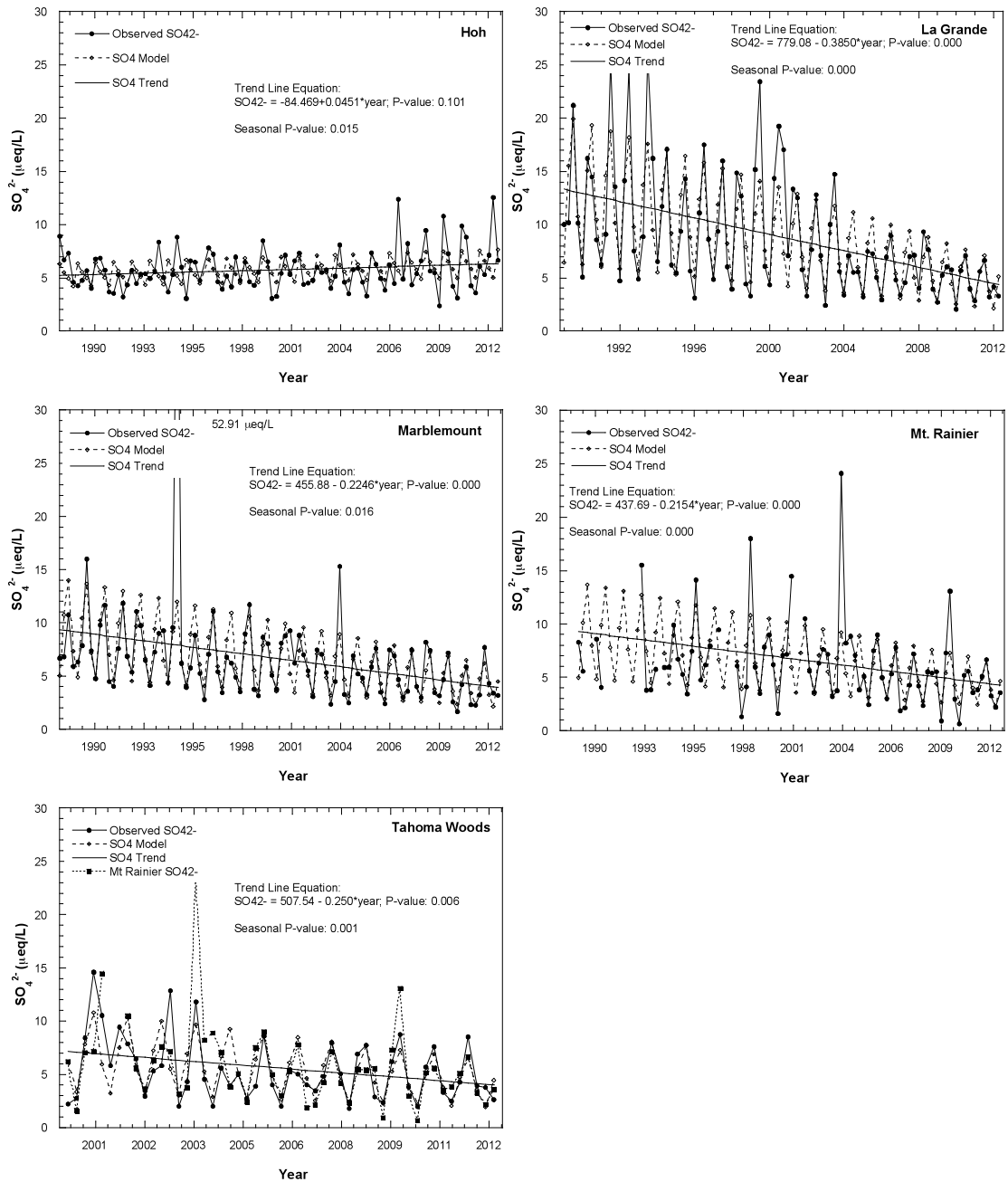


Figure 2: Observed, Modeled and Trend including Trend Line Equation for SO₄²⁻ precipitation concentrations at 4 NADP sites and at Mt. Rainier.

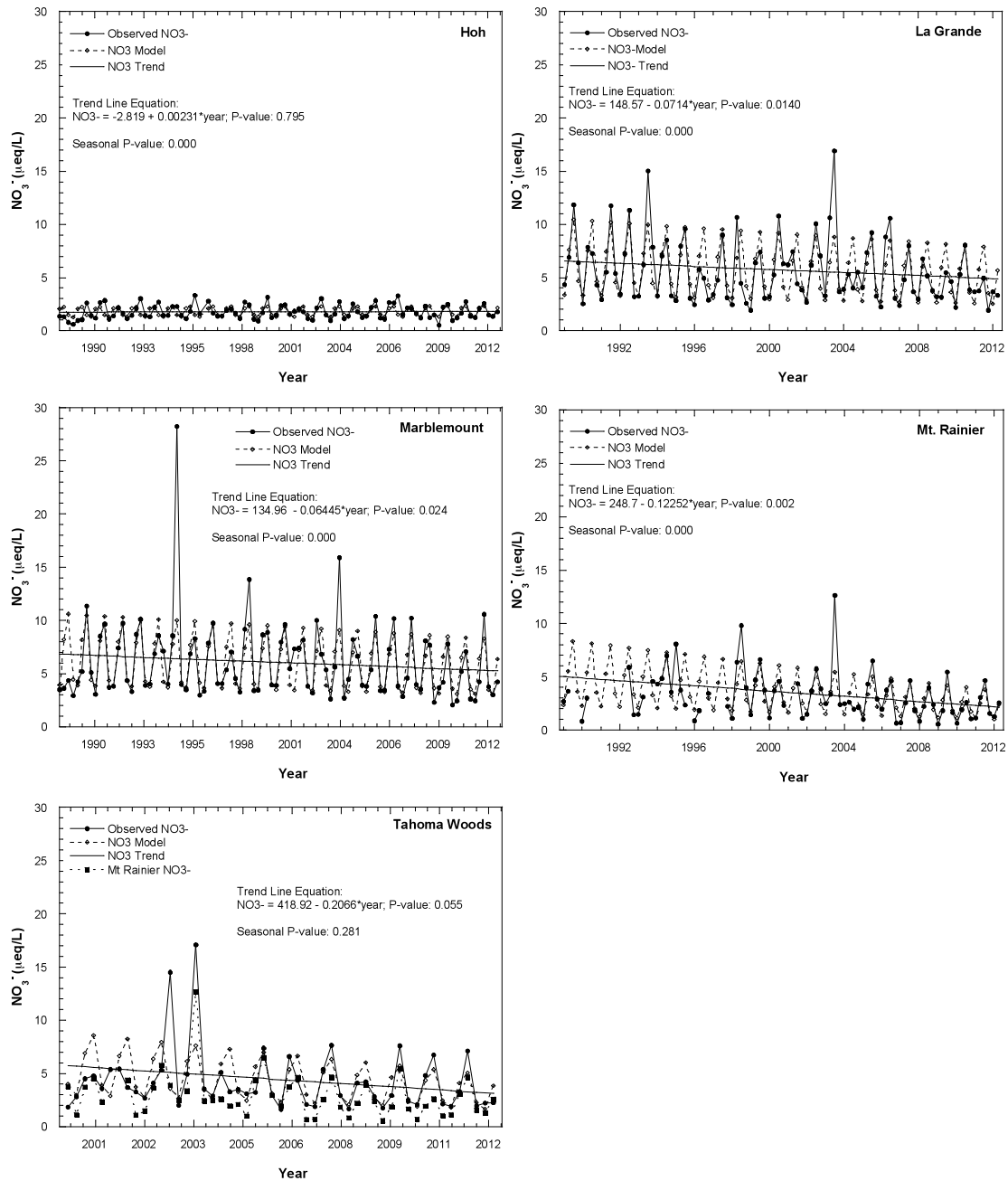


Figure 3: Observed, Modeled and Trend including Trend Line Equation for NO_3^- precipitation concentrations at 4 NADP sites and at Mt. Rainier.

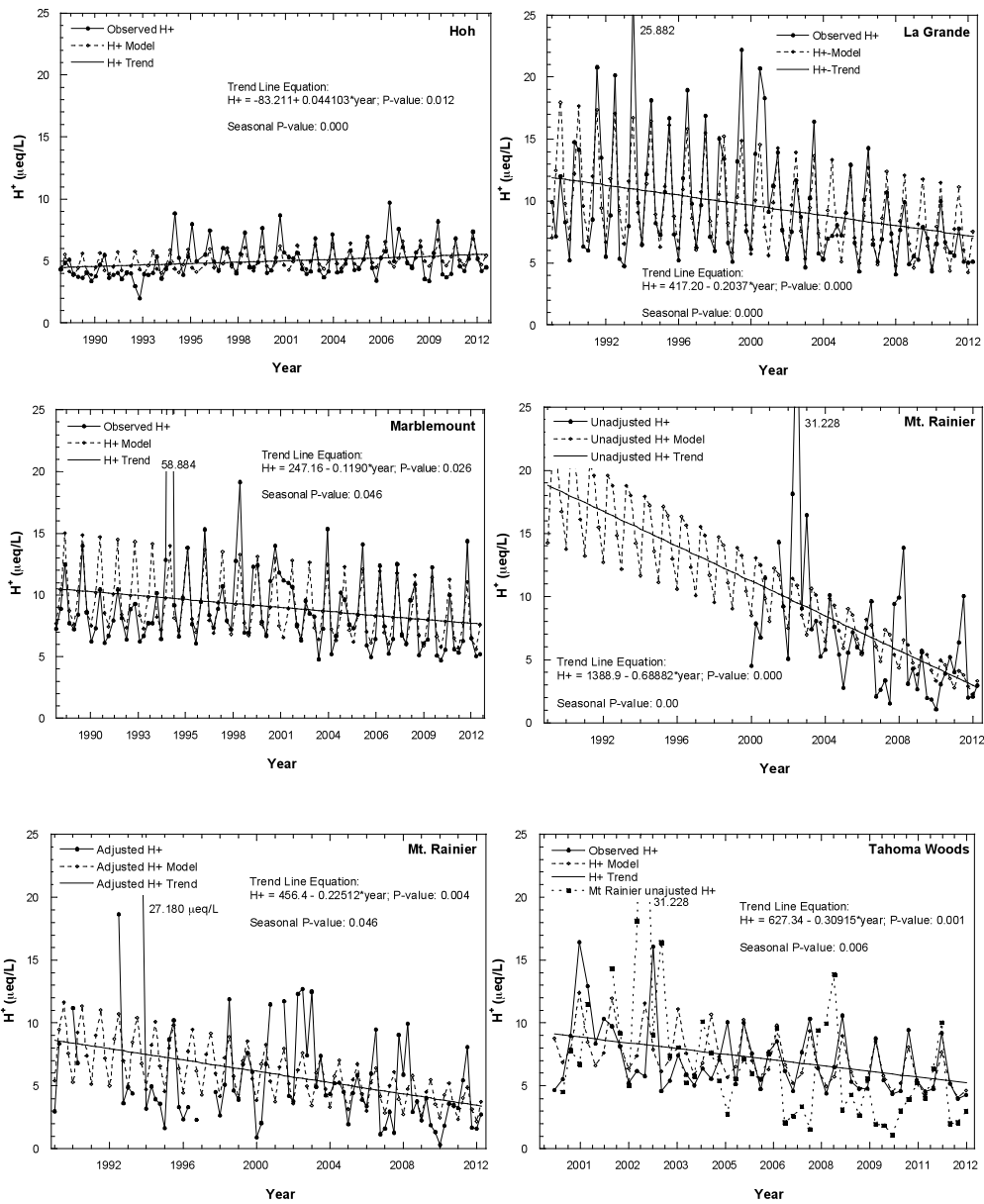


Figure 4a: Observed, Modeled and Trend including Trend Line Equation for H⁺ precipitation concentrations at 4 NADP sites and at Mt. Rainier.

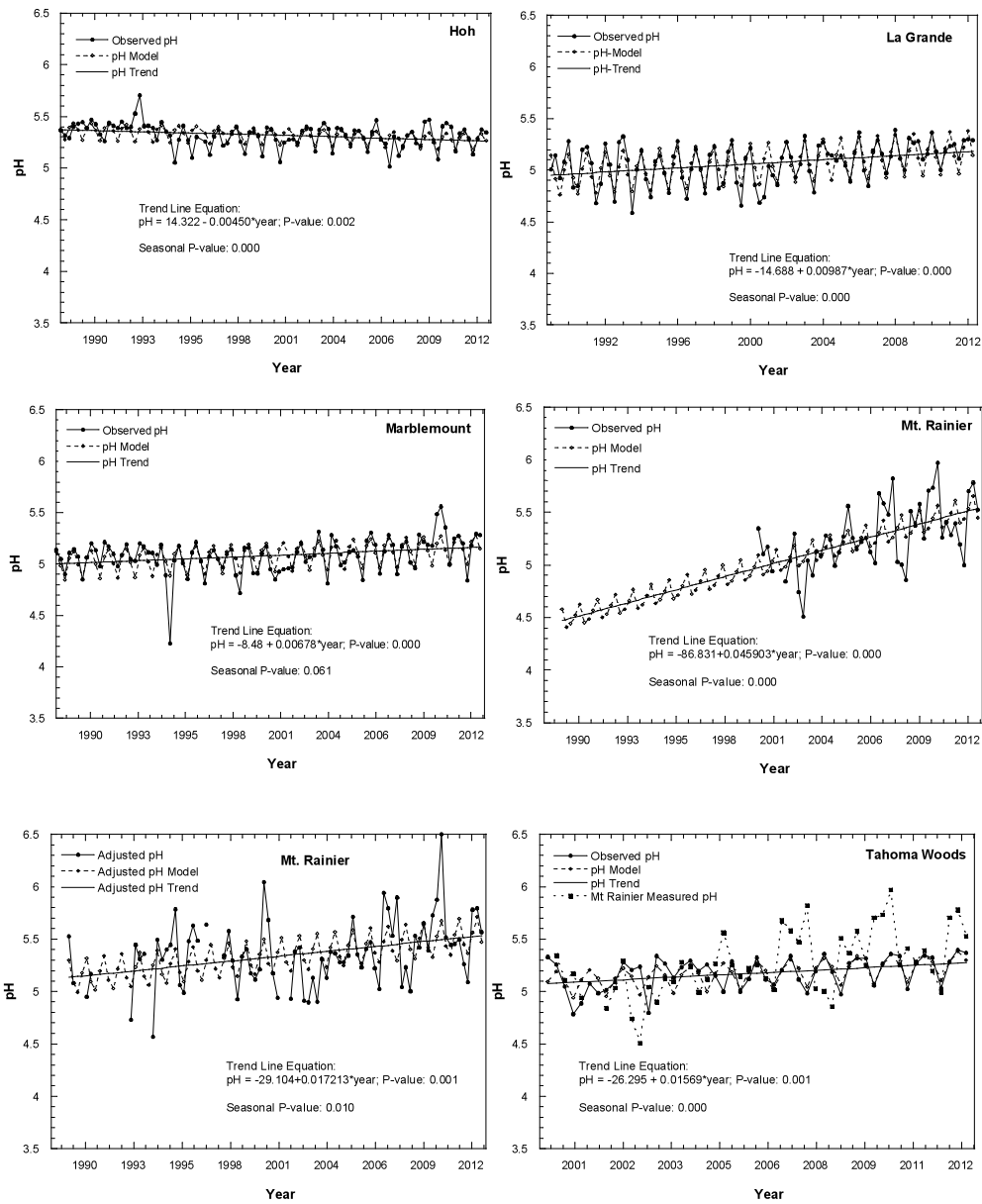


Figure 4b: Observed, Modeled and Trend including Trend Line Equation for pH values of precipitation at 4 NADP sites and at Mt. Rainier.

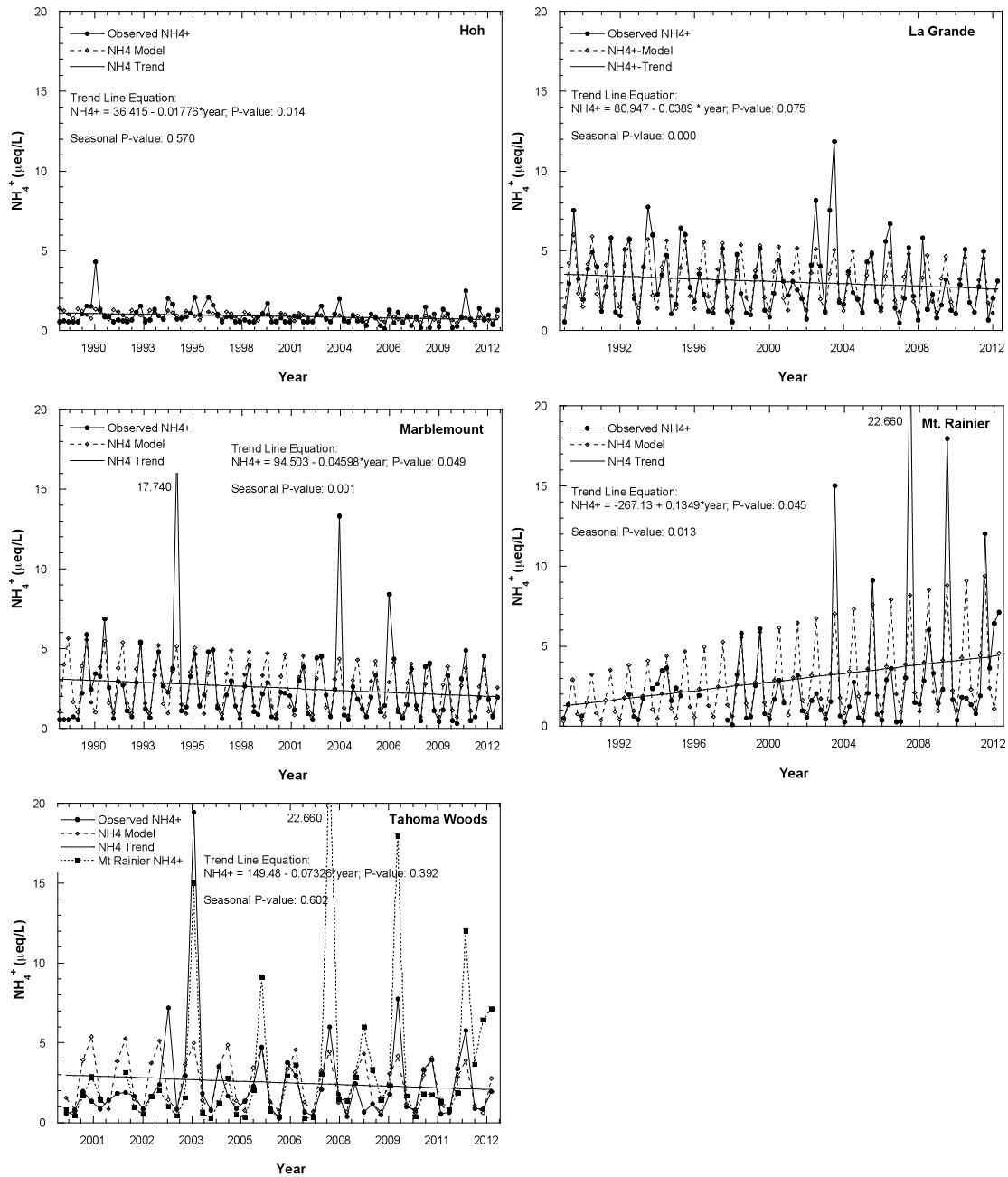


Figure 5: Observed, Modeled and Trend including Trend Line Equation for NH_4^+ precipitation concentrations at 4 NADP sites and at Mt. Rainier.

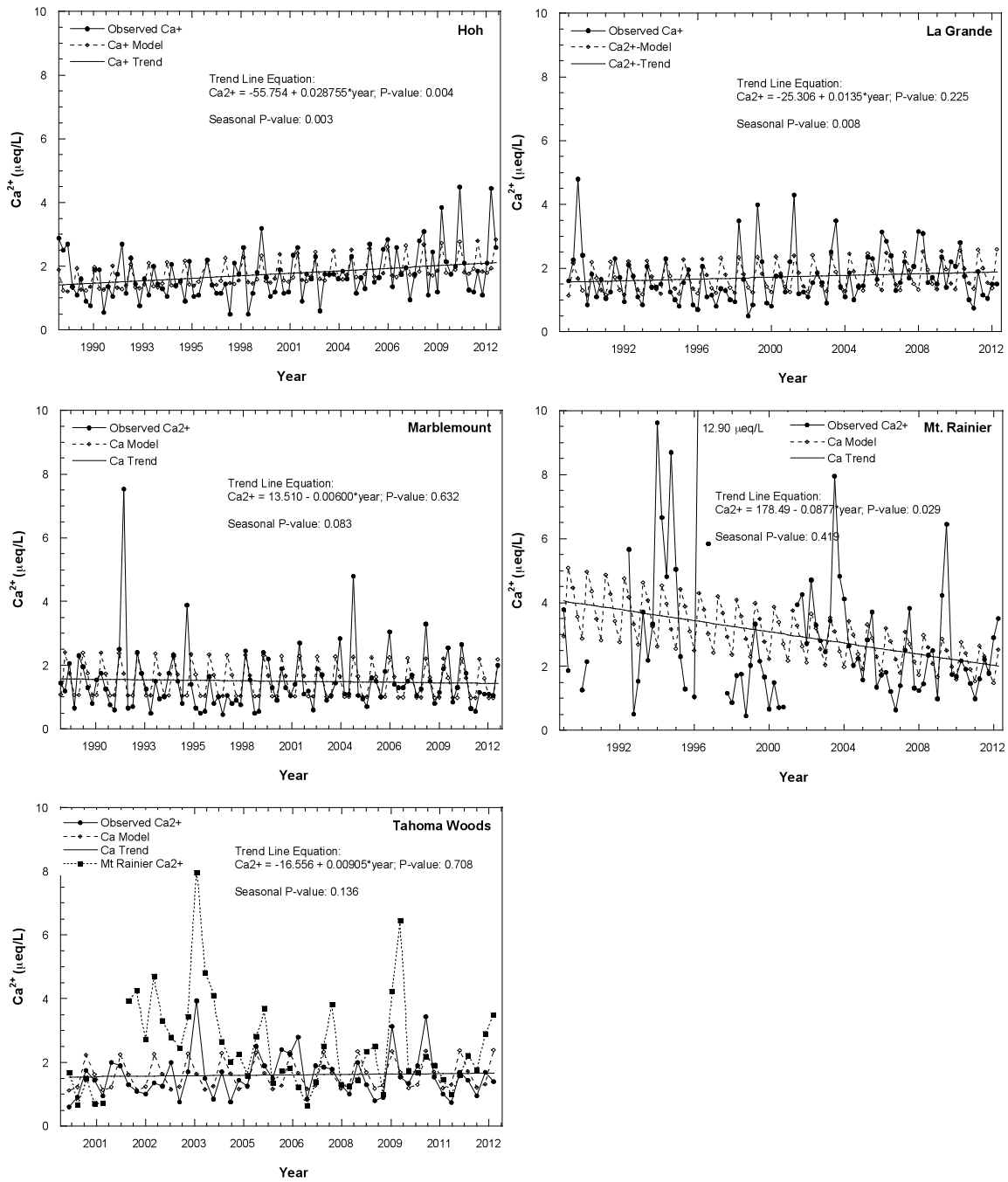


Figure 6: Observed, Modeled and Trend including Trend Line Equation for Ca^{2+} precipitation concentrations at 4 NADP sites and at Mt. Rainier.

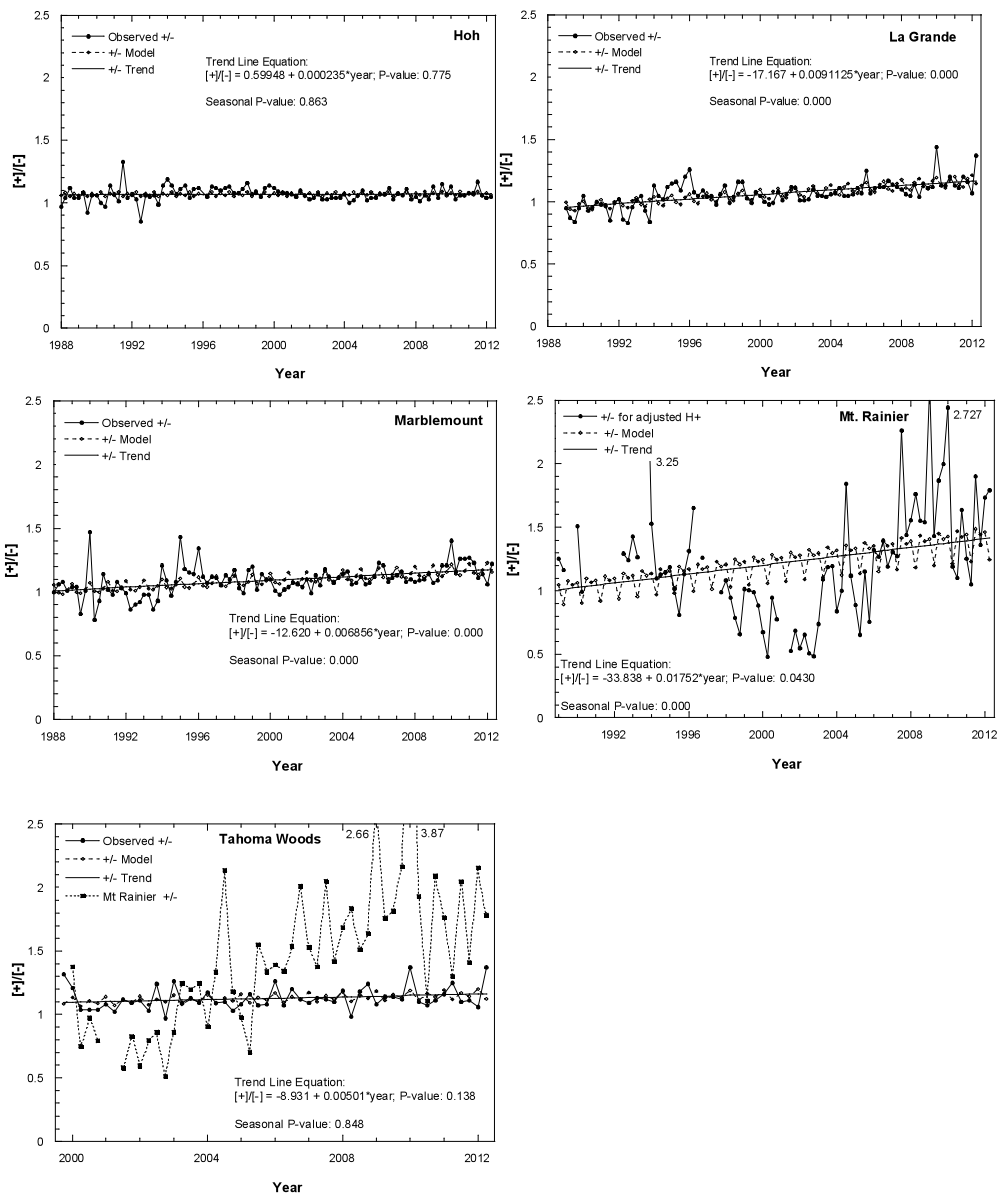


Figure 7: Observed, Modeled and Trend including Trend Line Equation for [H⁺]/[OH⁻] charge ratio in precipitation at 4 NADP sites and at Mt. Rainier.

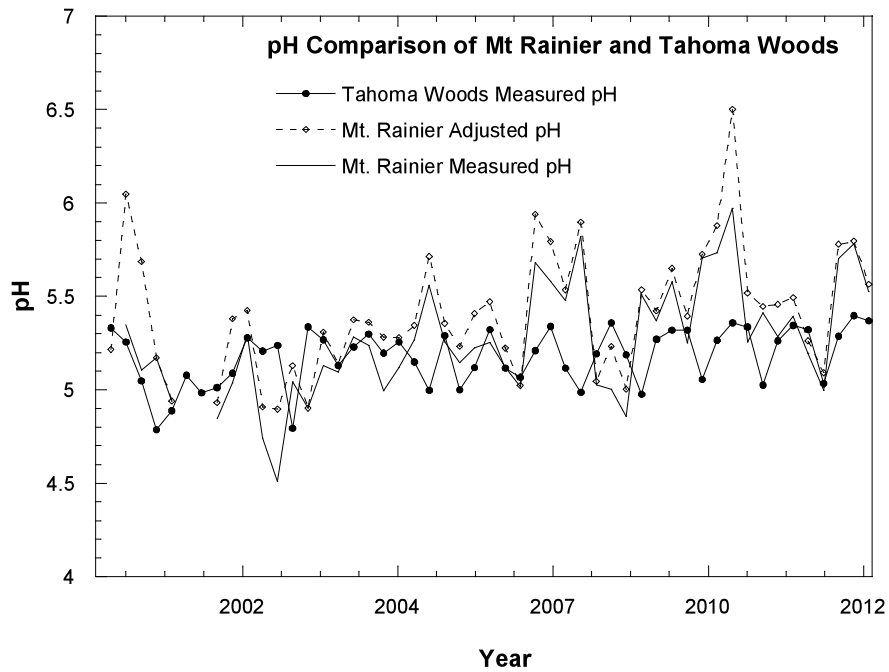


Figure 8: Comparison of Measured Tahoma Woods, Measured Mt. Rainier, and Corrected Mt. Rainier pH.