# CHAPTER 3

# Cloudwater and Aerosol Composition at Elevated Sites During the South Coast Air Quality Study

by

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# Introduction

The Suggested Program Plan for SCAQS (Blumenthal et al., 1986) identifies the need to measure cloud and fog in the SoCAB in order to properly understand gas and aerosol processes. There is considerable evidence that the presence of fog or low cloud in the basin is associated with high $SO_4^{2-}$ aerosol loadings and poor visibility in the SoCAB (Blumenthal et al., 1986, and references therein). Previous research sponsored by the CARB at Caltech has identified pre–existing aerosol as a major contributor to the acidity level in fog and cloud. Conversely, evaporated fog and cloud droplets are a major source of aerosol. The primary objectives of Caltech's participation in SCAQS are to assess the role that fog and cloud play in the formation of aerosol in the SoCAB (Objective 3, issue 1 of SCAQS) and to quantify the scavenging of precursor aerosol and gases during droplet formation. The extensive data available from SCAQS on meteorology, emissions, gas and aerosol concentrations will be used to evaluate cloud and fog droplet chemistry models. In this chapter we present the results of cloudwater and aerosol sampling at elevated sites in the SoCAB during SCAQS.

# Methods

During the summer of 1987 cloudwater, aerosol and selected gases were sampled in conjunction with the South Coast Air Quality Study (SCAQS). During the period June 13 to July 17 sites were in operation at San Pedro Hill, Henninger Flats, and Kellogg Hill. A fourth site on Flint Peak, near Pasadena, was set up but could not be used because interference from FM transmitters located near the site disrupted the sampling equipment.

### *Site Descriptions*

The San Pedro Hill site was located at a radar and communications facility operated by the U. S. Air Force and the Federal Aviation Administration. The elevation of the site is 450 m. The distance from the site to the ocean is 2.5 km. Los Angeles Harbor is 6 km east. The sampling equipment was placed at the edge of a flat grassy area. A steep hillside sloped away from the site, giving it unobstructed exposure from 70–270°. A SCAQS meteorological station was located a few hundred meters away from the sampling site.

Henninger Flats is at an elevation of 780 m, 7 km NE of Pasadena, and 45 km NE of the coastline. This site has been used in previous sampling programs (Waldman et al., 1985) and in a fog sampler intercomparison (Hering et al., 1987). A SCAQS meteorological station was also located at Henninger Flats.

Kellogg Hill is 38 km E of downtown Los Angeles at an elevation of 370 m. It lies 50 km NE of the coastline. The sampling equipment was located in a fenced enclosure adjacent to a small building that housed radio transmission equipment. The building partially obstructed the sampler when winds were from the south to west, which is the prevailing daytime wind. The site was unobstructed in the direction of the prevailing night–time winds. Construction activity near the site increased aerosol concentrations of soil dust during the daytime, and may have affected samples collected here.

### *Sampling Procedure*

Each site was equipped with a Caltech Active Strand Collector with an automated fractionating sampler and a cloudwater sensor (see Chapter 1). The CASC collects droplets by inertial impaction on 510 $\mu$m Teflon strands. The 50% collection efficiency cutoff, predicted from impaction theory and based on droplet diameter, is 3.5 μm. Also located at each site was an automated filter pack aerosol sampler. Teflon filters (Gelman Zefluor, 1μm pore size) were used to collect aerosol for inorganic analysis. $HNO_{3(g)}$ was collected on a nylon filter (Gelman Nylasorb) placed behind one Teflon filter. $NH_{3(g)}$ was collected on two oxalic acid impregnated glass fiber filters behind a second Teflon filter. The species that were measured in aerosol, gas and droplet phases are listed in Tables 1 and 2.

During the late afternoon or evening prior to expected cloud impaction, the samplers were cleaned by rinsing the collection strands, sample tubing, and reservoir with distilled, deionized water ($DDH_2O$). After rinsing, the strands were sprayed again with $DDH_2O$, which was collected in the fraction collector as a system blank. Rinsing and blank collection was repeated the following morning whether cloud was collected or not. Three sets of filters were loaded on the aerosol collector. A timer on the collector controlled the times that each filter set was run.

Some samples of cloudwater, fractionated by droplet size, were also collected and analyzed to determine whether any significant difference exists between the chemical composition of small vs. large cloudwater droplets. One of the CASC's was adapted for this purpose by adding an inlet containing four rows of eight 12.7 mm Teflon rods. These rods provide a 50% lower size cut of 16 μm at the sampling velocity of 9 m/s. Each row covers 46% of the cross–sectional area. The four rows together sample 91.5% of the air passing through the collector. The sample collected by impaction on these rods is fed into a sample bottle. Droplets smaller than 15 μm are collected inefficiently on the rods and pass through to be collected on the CASC strands in the main body of the collector.

*Analytical Procedures*

Samples were retrieved in the morning following a cloud event and transported to the lab at Caltech. The samples were weighed to determine their volume and the sample pH was measured with a Radiometer PHM82 pH meter using a combination electrode calibrated against pH 4 and 7 buffers. For selected samples small aliquots of the sample were removed and treated to stabilize reactive species. S(IV) was stabilized as the hydroxymethanesulfonate by adding buffered $CH_2O$ (Dasgupta et al., 1981). $CH_2O$ was stabilized with a solution of $SO_3^{2-}$ (Dong and Dasgupta, 1987). A buffered solution of p–OH phenylacetic acid (POPA) and peroxidase was used to preserve peroxide (Lazrus et al., 1985). Carboxylic acids were preserved by addition of chloroform (Keene and Galloway, 1984). Carbonyls were derivatized with 2,4–dinitrophenylhydrazine in acidic solution (Grosjean and Wright, 1983).

The samples and preserved aliquots were stored in a refrigerator at 4°C until analysis. Major anions were determined by ion chromatography with a Dionex AS4 or AS4A separator column and a micromembrane suppressor. The eluent was 2.8 mM $HCO_3^-$/ 2.2 mM $CO_3^{2-}$. The metallic cations were determined by atomic absorption spectrophotometry. An air/acetylene flame was used for $Na^+$ and $K^+$; $N_2O$/acetylene was used for $Ca^{2+}$ and $Mg^{2+}$ to minimize interferences. $NH_4^+$ was determined by flow injection analysis employing the indophenol blue method.

The stabilized $CH_2O$ was determined by a modification of the Nash method for use with an autoanalyzer (Dong and Dasgupta, 1987) Hydrogen peroxide was added to eliminate S(IV), which interferes by forming an adduct with $CH_2O$. The absorbance of the colored product was measured at 412 nm. S(IV) was analyzed by the pararosaniline method (Dasgupta et al., 1980) adapted for flow injection analysis. Peroxide was determined from the flourescence of the POPA enzyme solution (Lazrus et al., 1985). The method is sensitive to $H_2O_2$ and some organic peroxides, however, the significantly lower

Henry's law coefficients of $CH_3OOH$ and peroxoacetic acid suggest that they will not be important in fog and cloud water (Lazrus et al.,1985). Carboxylic acids were determined by ion exclusion chromatography (Dionex ICE–AS1) with dilute HCl as eluent.

The Teflon and oxalic acid impregnated glass fiber filters were extracted in distilled deionized water ($DDH_2O$) on a shaker table. A small volume of ethanol was added to the filter prior to extraction to more effectively wet the filter surface. The nylon filters were extracted in $HCO_3^-/CO_3^{2-}$ IC eluent. Composition of the extracts was determined by the same procedures used for the fogwater samples, with the exception of additional buffer in the complexing reagent and oxalic acid in the rinse solution of the ammonia analysis to account for the effect of the oxalic acid.

The precision and accuracy of the measurements was determined from the mean and standard deviation of repeated analyses of the same standard (Standard Methods). Detection limits were estimated from analyses of blanks (or the lowest standard). The stated detection limit is defined as the concentration giving a signal 3 times the blank (or low standard) standard deviation. The expected precision, accuracy and detection limits for the major species measured are listed in Table 3. For gas–phase species the variance of the flow measurements is included in the estimates of precision and detection limit.

## Results and Discussion

### *Cloudwater and Aerosol Composition*

During the summer portion of SCAQS, stratus clouds frequently impacted the coastal slopes near San Pedro. This is reflected in the fact that over 240 samples were collected at San Pedro Hill during the study. Clouds were present at this site primarily during the night, although some events lasted until mid–day. On several occasions, the stratus extended as far inland as the slopes of the San Gabriel Mountains and was at the right elevation to be collected at Henninger Flats, where 76 samples were obtained. Stratus were rarely observed at the Kellogg Hill site during this study, where only a couple of samples were obtained. The compositional data for the San Pedro Hill and Henninger Flats samples are presented in Tables 4 and 5.

Samples at both San Pedro Hill and Henninger Flats were consistently acidic. Sample pH values at San Pedro Hill varied from 2.4 to 5.0, while those at Henninger Flats ranged from 2.6 to 4.8. The arithmetic average of the pH at each site was 3.25. Frequency distributions of the sample pH for each site are presented in Figures 2 and 3.

The composition of the cloudwater sampled at both sites was usually dominated by $NO_3^-$, $SO_4^{2-}$, $NH_4^+$, and $H^+$. In some samples $Na^+$ and $Cl^-$ were also found to be important contributors. Concentrations of $Na^+$ and $Cl^-$ were generally both observed at higher levels in the San Pedro Hill cloudwater, consistent with its proximity to the ocean. $NH_4^+$ concentrations averaged higher at Henninger Flats, while $NO_3^-$ concentrations averaged approximately 1200 $\mu$eq/l at both sites. $SO_4^{2-}$ concentrations averaged one–third higher at San Pedro Hill (917 $\mu$eq/l) than at Henninger Flats (689 $\mu$eq/l).

Most of the samples obtained at the two sites were collected during non–overlapping time periods. Often the stratus clouds would impact one site on a given day and not the other. At other times, the clouds were observed to impact the hillside at San Pedro during the period shortly after midnight, while impaction at Henninger Flats did not begin until a few hours later. By this time, clouds were no longer intercepting the slopes of San Pedro Hill. The only event with simultaneous collection at both sites was on July 16. This event, which was associated with drizzle and rainfall in the L.A. Basin, was one of the most extended observed during the study. The sampling capacity of the autosampler carousel was exceeded at both sites at approximately 2300 on the 16th. The event was also one of the least acidic observed at San Pedro Hill. The cloudwater pH there climbed as high as 4.98 during the event, while all of the samples collected at Henninger Flats had a pH less than 4. Like $H^+$ concentrations, concentrations of $NO_3^-$, $SO_4^{2-}$,and $NH_4^+$ were also much higher at Henninger Flats during this event than they were at San Pedro Hill.

The combination of the high sampling rate of the CASC (the CASC has sampled at rates of up to 8.5 ml $min^{-1}$ in past field studies) and the use of the autosampler enabled us to collect samples with a very fine time resolution. During some events, 60 ml samples were collected at San Pedro Hill as quickly as one every 10 minutes. This time resolution enables an examination of rapid fluctuations in the cloudwater composition as a function of changes in wind direction or liquid water content. An example of this resolution is depicted in Figure 4. The diagrams in this figure illustrate the changes in the sample pH, the concentrations of the measured ions, and the estimated liquid water content (based on the collection rate and the theoretical sampling efficiency of the CASC), as a function of time, observed at San Pedro Hill for the period from 0100 to 0315 on June 25, 1987. In just over two hours, the observed levels of all these parameters were seen to change dramatically. Concentrations of all measured species were observed to drop by at least a factor of two between 0130 and 0230. These drops coincided with a doubling of the liquid water content, suggesting that the concentration changes were largely due to dilution. When the liquid water content began to fall after 0230, however, not all of the species' concentrations increased. Levels of $SO_4^{2-}$, $NO_3^-$, and $H^+$ did rise, but $Na^+$, $Cl^-$, $Ca^{2+}$, and $Mg^{2+}$ concentrations remained steady or declined. Analysis of meteorological data from San Pedro Hill, which is part of the SCAQS data set, will enable us to correlate changes in chemical composition with meteorological variables.

The aerosol and gas–phase data for San Pedro Hill, Henninger Flats, and Kellogg Hill are presented in Tables 6 through 8. The major species present are $NH_4^+$, $NO_3^-$, and $SO_4^{2-}$. $Na^+$ and $Cl^-$ are also major components in some samples, particularly at the San Pedro Hill site in the daytime samples, which were collected during onshore flow conditions. The concentration of $NH_4^+$ is greater at the inland sites, Henninger Flats and Kellogg Hill, than at San Pedro Hill. During the daytime concentrations of $HNO_{3(g)}$ are quite high; they often equal or exceed the aerosol $NO_3^-$ concentration. The gas–phase $NH_3$

concentrations are fairly low at Hennigner Flats and San Pedro Hill. Kellogg Hill, which is the closest site to the dairy feedlots in Chino, has the highest $NH_{3(g)}$ concentrations.

### *Blank Concentrations*

In order to determine the efficacy of our collector cleaning procedure the collection strands in the CASC were sprayed with distilled water to generate blanks. The concentrations of major ions in the collector blanks are presented in Table 9. In general the blank concentrations are an order of magnitude less than the measured concentrations of the samples, although there were a few cases of fairly high concentrations in the blanks. Rinsing the strands effectively removed material from the collector; analysis of successive blanks indicates decreased concentrations in the second rinse compared to the first.

### *Size–fractionated Samples*

Clouds began impacting the San Pedro Hill site at approximately 1900 on July 14 and remained there until approximately 1300 on July 15. The event was sampled by the CASC and the autosampler from 1900 until approximately midnight, when the last bottle in the carousel was used. Manual operation of the CASC, with the size–fractionating inlet installed, began at 0400. Samples were collected at half–hour intervals until noon on the 15th. A final one–hour unfractionated sample was collected from 1200 to 1300. The size–fractionating inlet, as discussed earlier, is used to collect the larger droplets in the cloud (those with diameters greater than about 16 $\mu$m), leaving the smaller droplets to be collected on the CASC strands. Figure 5 depicts the fraction of the droplet–size spectrum collected by each portion of the sampler for three different liquid water contents. The droplet–size spectra are typical representations based on the work of Best (1951a). The fraction of the liquid water sampled by each part of the collector is calculated based on impaction theory for droplets on a cylinder. At low liquid water contents, where a higher proportion of the water is typically contained in smaller droplets, most of the droplets will pass through the fractionating inlet and collect on the CASC strands. At higher liquid water contents, however, the preponderance of large droplets will shift the bulk of the collected sample volume to the fractionating inlet. As shown in the figure, considerable overlap in the portions of the droplet spectrum sampled by each part of the collector are expected. Any differences seen in the composition of the two sample fractions, therefore, should be considered as a lower bound on the differences present between more sharply divided portions of the spectrum.

The chemical compositions of the samples collected using the size–fractionating inlet are displayed in Table 10. The samples have been labeled "f" for those fractions collected on the large rods in the front of the collector, and "b" for those collected on the CASC strands in the back. The volume weighted average concentration of each species, obtained by mathematically combining the two fractions for each sampling period, is also presented. The two fraction volumes collected during each sampling interval are compared in Figure 6. The ratio of volumes collected in each fraction was on the order of two or three to one, in favor of the fraction collected on the large rods, for all sampling intervals. During several periods the cloud grew dense enough to produce a light drizzle. Consistent with the predictions in Figure 5, the ratio of volumes collected by each fraction was higher during the periods when the liquid water content was higher.

Comparisons of the ion concentrations in the two fractions collected during each interval suggest that there is a large difference between the average composition of the smaller droplets and that of the larger droplets. Figures 6 through 8 illustrate the case for each of the species measured. For every interval sampled, the concentration of $Na^+$ and $Mg^{2+}$ in the small droplet fraction was observed to be higher than in the large droplet fraction. With the exception of one very low concentration sample, the same was true for $Ca^{2+}$. Concentrations of $SO_4^{2-}$, $NO_3^-$, $NH_4^+$, and $H^+$ were almost always higher in the small droplet fraction (the fact that they were lower in this fraction for the first couple of samples may be due to dilution by residual rinsewater on the CASC strands). Concentrations of $Cl^-$ showed no consistent preference for one fraction over the other, and were generally at similar levels in both fractions. The composition of the fractionated sample collected between 0600 and 0630 is depicted in a pie diagram (Figure 9). In addition to the differences discussed above, this figure illustrates that the total of the ionic species concentrations is much higher in the smaller droplets, on average, than in the larger ones.

Similar results were observed when comparing samples collected by the Caltech Rotating Arm Collector and the CASC at a coastal site in the Santa Barbara Channel. The RAC (Jacob et al., 1984) which has a 50% lower size cut, based on droplet diameter, of about 20 $\mu$m, collected samples with higher concentrations of $Na^+$, $Ca^{2+}$, and $Mg^{2+}$ than were observed in samples collected by the CASC (Collett et al., 1988). The difference in the concentrations was attributed to differences in the portions of the droplet–size spectrum sampled by the two collectors. The CASC, with its theoretical lower size cut of 3.5 $\mu$m, collects almost all of the liquid water contained in cloud droplets, while the higher size cut of the RAC allows it to only collect the larger droplets efficiently. Typically, larger condensation nuclei lead to the formation of larger cloud droplets in the lower portions of a cloud not subjected to significant horizontal entrainment of dry air (Best, 1951b; Mason and Chien, 1962; Hudson, 1984). Since sea salt and soil dust are found to reside in the larger end of the aerosol size spectrum (Seinfeld, 1986), the elements found predominantly in these types of particles (e.g. Cl, Na, Mg, and Ca) will reside there as well. Therefore, as cloud droplets form on the available aerosol nuclei and grow by condensation, it is expected that these elements will be found predominantly in the upper end of the droplet size spectrum.

During the same study, no preference was shown by either collector for higher concentrations of $NO_3^-$, $SO_4^{2-}$, $NH_4^+$, or $Cl^-$. $NO_3^-$, $SO_4^{2-}$, and $NH_4^+$, which make their way into the aerosol phase largely by gas–to–particle conversion processes, are found to reside largely in smaller aerosol particles (Seinfeld, 1986). One might expect then that smaller cloud droplets would be enriched in these ions relative to their larger counterparts. The differences might not be so readily apparent in the droplet phase, however, since all three species may also be introduced by absorption of gas phase precursors, coupled with oxidation of S(IV) to S(VI) in the case of $SO_4^{2-}$. Absorption of $NH_{3(g)}$, and particularly of $HNO_{3(g)}$, was seen to play an important role in determining the composition of cloudwater at the study site (Collett et al., 1988). Since gas phase absorption can make important contributions to the composition of all droplet sizes, it may tend to mask the initial chemical signature given to the droplets by their condensation nuclei.

Observing differences in the chemical composition of small vs. large droplets in the present study is facilitated by the way the droplet size spectrum has been split. While there is still considerable overlap in the portions of the size spectrum collected by the large rods and the small CASC strands, there is more difference than in the Santa Barbara Channel comparison, where the average composition of the large droplets was being compared to the average composition of the whole spectrum. This may at least partially explain why differences in the concentrations of $NO_3^-$, $SO_4^{2-}$, $H^+$, and $NH_4^+$ are evident this time.

The distribution of $Cl^-$ between large and small droplets is somewhat different from the other ions discussed, being found at roughly equivalent concentrations in each fraction. $Cl^-$ is initially associated with $Na^+$ in sea–salt aerosol. If it remained there until nucleation of the aerosol within the cloud, we would expect to see $Cl^-$ concentrations higher in the large droplets, as was observed for $Na^+$. This clearly is not the case, suggesting the possibility that $Cl^-$ was introduced into the droplets in another form. Aerosol samples collected on the afternoon of July 14 at San Pedro Hill show substantial concentrations of $Na^+$, but essentially no $Cl^-$ (see Table 6). High $HNO_{3(g)}$ concentrations also observed during this period could have resulted in acid exchange of $HCl_{(g)}$ for $HNO_{3(g)}$ in the sea salt aerosol. Introduction of $Cl^-$ to the cloudwater droplets that evening as HCl(g) would have produced the type of uniform distribution among all droplet sizes that was observed.

## References

Best, A. C. (1951a) Drop–size distribution in cloud and fog. *Q. Jl. R. met. Soc.* 77,

Best, A. C. (1951b) The size of cloud droplets in layer–type cloud. *Q. Jl. R. met. S* 241.

Blumenthal, D., Watson, J., and Lawson, D. (1986) Southern California Air Qualit (SCAQS) Suggested Program Plan, Sonoma Technology Incorporated Report, Refe No. 10 95050–605.

Collett, J. L., Jr., Munger, J. W., Daube, B. D., Jr., and Hoffmann, M. R. (1988) comparison of two cloudwater/fogwater collectors: the rotating arm active strand collector. submitted to *Atmos. Environ.*

Dasgupta, P. K., DeCesare, K. and Ullrey, J. C. (1980) Determination of atmosph sulfur dioxide without tetrachloromercurate (II) and the mechanism of the Schiff r *Anal. Chem.* **52**, 1912–1922.

Dasgupta, P. K. (1981) Determination of atmospheric sulfur dioxide without tetrachloromercurate(II): Further refinements of a pararosaniline method and a fie application, *J. Air Pollut. Cont. Assoc.* **31**, 779–782.

Dong, S. and Dasgupta, P. K (1987) Fast flourimetric flow injection analysis of formaldehye in atmospheric water, *Environ. Sci. Technol.* **21**. 581.

Grosjean, D. and Wright, B. (1983) Carbonyls in urban fog, ice fog, cloudwater an rainwater, *Atmos. Environ.* 17, 2093–2096.

Hering, S. V., Blumenthal, D. L., Brewer, R. L., Gertler, A., Hoffmann, M., Kadle A., and Pettus, K. (1987) Field intercomparison of five types of fogwater collectors *Environ. Sci. Technol.* 21, 654–663.

Hudson, J. G. (1984) Ambient CCN and FCN measurements, in *Hygroscopic Aero* H. Ruhnke and A. Deepak, Eds., A. Deepak Publishing, Hampton, VA.

Jacob, D. J., Wang, R. F. T., and Flagan, R. C. (1984) Fogwater collector design a characterization, *Environ. Sci. Technol.* 18, 827–833.

Keene, W. C. and Galloway, J. N. (1984) Organic acidity in precipitation of North America, *Atmos. Environ.* **18**, 2491–2497.

Lazrus, A., Kok, G. L., Gitlin, S. N., Lind, J. A., and McLaren, S. E. (1985) Auto flourometric method for hydrogen peroxide in atmospheric precipitation, Anal. *Che* 917–922.

Mason, B. J. and Chien, C. W. (1962) Cloud–droplet growth by condensation in c *Q. Jl. R. met. Soc.* 88, 133–138.

Seinfeld, J. H. (1986) *Atmospheric Chemistry and Physics of Air Pollution*, Wiley–Interscience, New York.

Waldman, J. M., Munger, J. W., Jacob, D. J., and Hoffmann, M. R. (1985) Chemi characterization of stratus cloudwater and its role as a vector for pollutant depositi Los Angeles pine forest. *Tellus* 37, 91–108.

Table 1. Analysis of liquid samples.

| Species | Method |
|---|---|
| pH | Combination Electrode |
| $Cl^-$ | Ion chromatography - $HCO_3^-/CO_3^{2-}$ eluent |
| $NO_3^-$ | " |
| $SO_4^{2-}$ | " |
| $NH_4^+$ | Indophenol blue - Flow Injection Analysis |
| $Na^+$ | Flame Atomic Absorption Spectrometry |
| $K^+$ | " |
| $Ca^{2+}$ | " |
| $Mg^{2+}$ | " |
|  | " |
| S(IV) | Pararosaniline - FIA |
| $CH_2O$ | Nash Method |
| $C_1$ - $C_6$ Carbonyls | DNPH Derivative - HPLC |
| Carboxylic Acids | Ion Chromatography - $B_4O_7^{2-}$ eluent |
|  | Ion Exclusion Chromatography - HCl eluent |
| $H_2O_2$ | POPA - flourescent dimer |

Table 2. Analysis of gas and aerosol samples.

| Species | Filter | Method |
|---|---|---|
| | — (aerosol) — | |
| $SO_4^{2-}$ | Teflon | $H_2O$ extract - IC |
| $NO_3^-$ | Teflon | " |
| $Cl^-$ | Teflon | " |
| $Na^+$ | Teflon | $H_2O$ extract - Flame AAS |
| $Ca^{2+}$ | Teflon | " |
| $Mg^{2+}$ | Teflon | " |
| $NH_4^+$ | Teflon | $H_2O$ extract - indophenol FIA |
| | — (gas) — | |
| $NH_3$ | Oxalic acid - imp. Glass | $H_2O$ extract - indophenol FIA |
| $HNO_3$ | Nylon | $HCO_3^-/CO_3^{2-}$ extract - IC |
| $O_2$ | Base - imp. Quartz | " |

Table 3.

PRECISION, ACCURACY, AND MINIMUM DETECTION LIMIT

Aqueous Phase

| Species | nominal conc. | Acc. | Prec. | RSD | MDL |
|---|---|---|---|---|---|
| | μN | μN | μN | % | μN |
| $NH_4^+$ | 20 | 0.28 | 0.58 | 2.92 | 1.75 |
| $Na^+$ | 10.9 | 0.13 | 0.45 | 4.15 | 1.36 |
| $Ca^{2+}$ | 12.5 | -0.42 | 0.87 | 6.97 | 2.61 |
| $Mg^{2+}$ | 10.25 | 0.30 | 0.48 | 4.66 | 1.43 |
| $Cl^-$ | 20 | 0.26 | 2.04 | 10.20 | 6.12 |
| $NO_3^-$ | 20 | 0.11 | 0.92 | 4.60 | 2.76 |
| $SO_4^{2-}$ | 20 | 0.20 | 0.86 | 4.29 | 2.57 |
| $Cl^-$ | 2 | 0.87 | 2.22 | 111.07 | 6.66 |
| $NO_3^-$ | 2 | 0.31 | 0.35 | 17.71 | 1.06 |
| $SO_4^{2-}$ | 2 | 0.26 | 0.38 | 19.13 | 1.15 |

Gas Phase (4 hour run)

| Species | nominal conc. | Acc. | Prec. | RSD | MDL |
|---|---|---|---|---|---|
| | neq $m^{-3}$ | neq $m^{-3}$ | neq $m^{-3}$ | % | neq/$m^{-3}$ |
| $NH_4^+$ | 69.42 | 0.96 | 2.90 | 4.18 | 8.70 |
| $Na^+$ | 37.84 | 0.44 | 1.95 | 5.16 | 5.86 |
| $Ca^{2+}$ | 43.39 | -1.46 | 3.28 | 7.56 | 9.84 |
| $Mg^{2+}$ | 35.58 | 1.04 | 1.99 | 5.61 | 5.98 |
| $Cl^-$ | 69.42 | 0.90 | 7.40 | 10.65 | 22.19 |
| $NO_3^-$ | 69.42 | 0.38 | 3.83 | 5.52 | 11.49 |
| $SO_4^{2-}$ | 69.42 | 0.69 | 3.66 | 5.27 | 10.97 |
| $NH_3$ | 69.42 | 0.96 | 2.90 | 4.18 | 8.70 |
| $HNO_3$ | 69.42 | 0.38 | 3.83 | 5.52 | 3.69 |
| $Cl^-$ | 6.94 | 3.02 | 7.71 | 111.07 | 23.13 |
| $NO_3^-$ | 6.94 | 1.09 | 1.23 | 17.71 | 3.69 |
| $SO_4^{2-}$ | 6.94 | 0.91 | 1.33 | 19.13 | 3.98 |

# Table 4 San Pedro Hill Cloudwater Data

San Pedro Hill Cloudwater Data

| Date | Sec | Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uN) | K+ (uN) | NH4+ (uN) | Ca2+ (uN) | Mg2+ (uN) | "Fo" (uN) | Cl- (uN) | NO3- (uN) | SO42- (uN) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06/13 | 1 | 06/13 | 1 | 20:43 | 21:22 | 49 | 3.28 | 516 | 21 | 471 | 88 | 119 | 161 | 474 | 855 | 678 | | | | | 0.070 |
| 06/13 | 2 | 06/13 | 2 | 21:22 | 21:52 | 53 | 3.19 | 369 | 14 | 377 | 52 | 166 | 144 | 407 | 743 | 661 | | | | | 0.099 |
| 06/13 | 3 | 06/13 | 3 | 21:52 | 23:19 | 68 | 3.18 | 592 | 21 | 496 | 74 | 178 | 176 | 558 | 904 | 781 | | | | | 0.044 |
| 06/13 | 4 | 06/13 | 4 | 23:19 | 00:20 | 62 | 3.08 | 587 | 22 | 588 | 70 | 184 | 171 | 609 | 957 | 924 | | | | | 0.057 |
| 06/14 | 5 | 06/14 | 5 | 00:20 | 00:56 | 48 | 2.89 | 688 | 24 | 562 | 80 | 214 | 147 | 681 | 1321 | 1215 | | | | | 0.075 |
| 06/14 | 6 | 06/14 | 6 | 00:56 | 01:41 | 56 | 2.80 | 647 | 22 | 555 | 71 | 190 | 139 | 587 | 1608 | 1329 | | | | | 0.070 |
| 06/14 | 7 | 06/14 | 7 | 01:41 | 02:45 | 57 | 2.85 | 706 | 24 | 625 | 78 | 202 | 172 | 762 | 1554 | 1296 | | | | | 0.050 |
| 06/14 | 8 | 06/14 | 8 | 02:45 | 03:13 | 47 | 3.07 | 731 | 23 | 495 | 75 | 214 | 133 | 771 | 962 | 895 | | | | | 0.094 |
| 06/14 | 9 | 06/14 | 9 | 03:13 | 03:46 | 51 | 3.09 | 440 | 15 | 376 | 43 | 119 | 118 | 465 | 796 | 722 | | | | | 0.087 |
| 06/14 | 10 | 06/14 | 10 | 03:46 | 04:09 | 42 | 3.00 | 361 | 13 | 402 | 38 | 95 | 116 | 400 | 893 | 872 | | | | | 0.102 |
| 06/14 | 11 | 06/14 | 11 | 04:09 | 04:31 | 44 | 3.06 | 265 | 10 | 375 | 27 | 64 | 113 | 327 | 819 | 736 | | | | | 0.111 |
| 06/14 | 12 | 06/14 | 12 | 04:31 | 04:59 | 53 | 3.12 | 149 | 6 | 323 | 15 | 47 | 119 | 247 | 702 | 574 | | | | | 0.106 |
| 06/14 | 13 | 06/14 | 13 | 04:59 | 05:40 | 34 | 2.98 | 263 | 11 | 477 | 27 | 82 | 141 | 400 | 993 | 870 | | | | | 0.047 |
| 06/14 | 14 | 06/14 | 14 | 05:40 | 06:16 | 34 | 2.91 | 536 | 20 | 648 | 55 | 155 | 169 | 599 | 1249 | 1125 | | | | | 0.052 |
| 06/14 | 15 | 06/14 | 15 | 06:16 | 07:13 | 18 | 2.82 | 734 | 28 | 744 | 77 | 208 | 181 | 787 | 1569 | 1407 | | | | | 0.017 |
| 06/19 | 4 | 06/19 | 4 | 04:48 | 05:22 | 36 | 3 | 3796 | | 1237 | 460 | 731 | 163 | 1701 | 2137 | 1125 | 25 | | | | 0.055 |
| 06/19 | 5 | 06/19 | 5 | 05:22 | 06:02 | 36 | 3 | 3405 | | 827 | 318 | 634 | 158 | 1672 | 1603 | 1131 | 31 | | | | 0.051 |
| 06/19 | 6 | 06/19 | 6 | 06:02 | 07:04 | 26 | 3 | 3258 | | 665 | 281 | 593 | 130 | 1654 | 1281 | 978 | 27 | | | | 0.023 |
| 06/20 | 1 | 06/20 | 1 | 00:29 | 01:44 | 59 | 3.11 | 2574 | | 555 | 268 | 488 | 150 | 1430 | 1402 | 1094 | 31 | | | | 0.044 |
| 06/20 | 2 | 06/20 | 2 | 01:44 | 02:28 | 62 | 3.14 | 1768 | | 605 | 187 | 410 | 126 | 1384 | 1088 | 1046 | 24 | | | | 0.075 |
| 06/20 | 3 | 06/20 | 3 | 02:28 | 03:25 | 65 | 3.26 | 2318 | | 485 | 173 | 444 | 117 | 1379 | 716 | 783 | 21 | | | | 0.064 |
| 06/20 | 4 | 06/20 | 4 | 03:25 | 04:02 | 65 | 3.35 | 1722 | | 356 | | 388 | 96 | 1421 | 518 | 749 | 21 | | | | 0.098 |
| 06/20 | 5 | 06/20 | 5 | 04:02 | 04:42 | 30 | 3.35 | 1740 | | 347 | | 411 | 140 | 1435 | 498 | 1232 | | | | | 0.042 |
| 06/20 | 6 | 06/20 | 6 | 04:46 | 05:05 | 9 | 3.20 | | | 517 | 272 | 715 | 176 | 1756 | 877 | 1290 | | | | | 0.028 |
| 06/21 | 8 | 06/21 | 8 | 00:14 | 00:55 | 65 | 3.48 | 995 | | 295 | 142 | 253 | 90 | 735 | 915 | 447 | 14 | | | | 0.089 |
| 06/21 | 9 | 06/21 | 9 | 00:55 | 01:17 | 66 | 3.52 | 822 | | 219 | 103 | 199 | 72 | 807 | 477 | 359 | 12 | | | | 0.167 |
| 06/21 | 10 | 06/21 | 10 | 01:17 | 01:42 | 12 | 3.55 | 706 | | 169 | 79 | 192 | 81 | 831 | 377 | 312 | | | | | 0.026 |
| 06/22 | 1 | 06/22 | 1 | 00:24 | 01:13 | 61 | 3.43 | 1257 | | 353 | 243 | 311 | 186 | 978 | 1014 | 507 | 11 | | | | 0.070 |
| 06/22 | 2 | 06/22 | 2 | 01:13 | 01:41 | 62 | 3.37 | 414 | | 311 | 66 | 116 | 105 | 440 | 547 | 428 | 12 | | | | 0.124 |
| 06/22 | 3 | 06/22 | 3 | 01:41 | 02:17 | 62 | 3.31 | 297 | | 327 | 41 | 75 | 109 | 353 | 476 | 381 | 15 | | | | 0.095 |
| 06/22 | 4 | 06/22 | 4 | 02:17 | 02:50 | 61 | 3.34 | 243 | | 355 | 31 | 61 | 97 | 289 | 436 | 354 | 14 | | | | 0.103 |
| 06/22 | 5 | 06/22 | 5 | 02:50 | 03:27 | 62 | 3.36 | 206 | | 376 | 27 | 53 | 100 | 267 | 458 | 368 | 15 | | | | 0.094 |
| 06/22 | 6 | 06/22 | 6 | 03:27 | 04:13 | 62 | 3.26 | 214 | | 461 | 29 | 54 | 127 | 303 | 571 | 465 | | | | | 0.075 |
| 06/22 | 7 | 06/22 | 7 | 04:13 | 05:17 | 60 | 3.09 | 342 | | 640 | 51 | 84 | 146 | 436 | 862 | 665 | 20 | | | | 0.052 |
| 06/22 | 8 | 06/22 | 8 | 05:17 | 05:34 | 13 | 2.89 | 602 | | 1025 | 109 | 168 | 510 | 689 | 1447 | 1121 | | | | | 0.042 |
| 06/22 | 9 | 06/22 | 9 | 06:00 | 07:16 | 60 | 2.84 | 578 | | 1126 | 113 | 161 | 202 | 611 | 1632 | 1478 | 27 | | | | 0.044 |
| 06/22 | 1 | 06/22 | 1 | 23:18 | 23:58 | 66 | 3.32 | 285 | | 371 | 85 | 82 | 97 | 334 | 644 | 480 | | | | | 0.09 |
| 06/22 | 2 | 06/22 | 2 | 23:58 | 00:26 | 62 | 3.44 | 242 | | 349 | 81 | 70 | 102 | 266 | 479 | 370 | | | | | 0.12 |
| 06/23 | 3 | 06/23 | 3 | 00:26 | 01:05 | 62 | 3.31 | 212 | | 354 | 57 | 60 | 92 | 263 | 537 | 459 | | | | | 0.09 |
| 06/23 | 4 | 06/23 | 4 | 01:05 | 01:39 | 62 | 3.36 | 250 | | 348 | 53 | 68 | 76 | 307 | 473 | 391 | | | | | 0.10 |
| 06/23 | 5 | 06/23 | 5 | 01:39 | 02:15 | 62 | 3.49 | 247 | | 309 | 44 | 66 | 76 | 322 | 334 | 284 | | | | | 0.10 |
| 06/23 | 6 | 06/23 | 6 | 02:15 | 02:44 | 61 | 3.51 | 255 | | 270 | 39 | 67 | 57 | 317 | 362 | 333 | | | | | 0.12 |
| 06/23 | 7 | 06/23 | 7 | 02:44 | 03:07 | 62 | 3.54 | 200 | | 231 | 30 | 54 | 55 | 262 | 298 | 285 | | | | | 0.15 |
| 06/23 | 8 | 06/23 | 8 | 03:07 | 03:31 | 62 | 3.48 | 196 | | 229 | 30 | 54 | 56 | 259 | 322 | 318 | | | | | 0.15 |
| 06/23 | 9 | 06/23 | 9 | 03:31 | 03:55 | 62 | 3.54 | 174 | | 234 | 24 | 47 | 58 | 231 | 296 | 269 | | | | | 0.15 |
| 06/23 | 10 | 06/23 | 10 | 03:55 | 04:18 | 62 | 3.50 | 181 | | 264 | 27 | 48 | 60 | 226 | 349 | 320 | | | | | 0.15 |
| 06/23 | 11 | 06/23 | 11 | 04:18 | 04:49 | 62 | 3.50 | 162 | | 295 | 24 | 42 | 71 | 290 | 424 | 352 | | | | | 0.11 |
| 06/23 | 12 | 06/23 | 12 | 04:49 | 05:16 | 62 | 3.62 | 141 | | 280 | 18 | 38 | 25 | 196 | 277 | 224 | | | | | 0.13 |

Table 4  San Pedro Hill Cloudwater Data (continued)

San Pedro Hill Cloudwater Data

| Date | Seq | Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uM) | K+ (uM) | NH4+ (uM) | Ca2+ (uM) | Mg2+ (uM) | "Fo" (uM) | Cl- (uM) | NO3- (uM) | SO42- (uM) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06/23 | 13 | 06/23 | 13 | 05:16 | 05:41 | 61 | 3.55 | 136 |  | 239 | 19 | 37 | 24 | 189 | 320 | 283 |  |  |  |  | 0.14 |
| 06/23 | 14 | 06/23 | 14 | 05:41 | 06:07 | 62 | 3.56 | 123 |  | 223 | 17 | 33 | 21 | 173 | 301 | 288 |  |  |  |  | 0.13 |
| 06/23 | 15 | 06/23 | 15 | 06:07 | 06:29 | 62 | 3.58 | 131 |  | 233 | 20 | 35 | 25 | 177 | 307 | 277 |  |  |  |  | 0.16 |
| 06/23 | 16 | 06/23 | 16 | 06:29 | 06:54 | 62 | 3.58 | 130 |  | 226 | 21 | 36 | 27 | 184 | 297 | 269 |  |  |  |  | 0.14 |
| 06/23 | 17 | 06/23 | 17 | 06:54 | 07:20 | 62 | 3.52 | 148 |  | 272 | 23 | 40 | 36 | 203 | 323 | 293 |  |  |  |  | 0.13 |
| 06/23 | 18 | 06/23 | 18 | 07:20 | 07:43 | 62 | 3.47 | 169 |  | 308 | 28 | 45 | 43 | 218 | 388 | 371 |  |  |  |  | 0.15 |
| 06/23 | 19 | 06/23 | 19 | 07:43 | 08:06 | 62 | 3.43 | 171 |  | 293 | 30 | 47 | 44 | 226 | 392 | 358 |  |  |  |  | 0.15 |
| 06/23 | 20 | 06/23 | 20 | 08:06 | 10:27 | 62 | 3.15 | 452 |  | 528 | 95 | 131 | 104 | 505 | 1024 | 606 |  |  |  |  | 0.02 |
| 06/23 | 1 | 06/23 | 1 | 19:55 | 20:47 | 30 | 2.53 | 2941 |  | 1659 | 527 | 561 | 586 | 1574 | 5623 | 3246 | 35 |  |  |  | 0.03 |
| 06/23 | 8 | 06/23 | 8 | 22:30 | 23:18 | 61 | 2.64 | 3148 |  | 1510 | 560 | 601 | 497 | 1548 | 5240 | 2846 | 26 |  |  |  | 0.07 |
| 06/23 | 9 | 06/23 | 9 | 23:18 | 00:21 | 53 | 2.57 | 2953 |  | 1725 | 505 | 577 | 470 | 1613 | 5267 | 2934 | 22 |  |  |  | 0.05 |
| 06/24 | 10 | 06/24 | 10 | 00:36 | 01:09 | 61 | 2.62 | 1289 |  | 1520 | 240 | 313 | 259 | 924 | 3617 | 2291 | 26 |  |  |  | 0.10 |
| 06/24 | 11 | 06/24 | 11 | 01:09 | 01:33 | 61 | 2.82 | 446 |  | 789 | 78 | 134 | 147 | 492 | 1770 | 1341 | 18 |  |  |  | 0.14 |
| 06/24 | 12 | 06/24 | 12 | 01:33 | 02:04 | 61 | 2.79 | 276 |  | 726 | 45 | 82 | 116 | 393 | 1586 | 1329 | 19 |  |  |  | 0.11 |
| 06/24 | 13 | 06/24 | 13 | 02:04 | 02:31 | 61 | 2.81 | 236 |  | 843 | 38 | 68 | 133 | 339 | 1667 | 1254 | 23 |  |  |  | 0.13 |
| 06/24 | 14 | 06/24 | 14 | 02:31 | 03:03 | 61 | 2.77 | 225 |  | 1443 | 48 | 68 | 133 | 386 | 2171 | 1493 | 30 |  |  |  | 0.11 |
| 06/24 | 15 | 06/24 | 15 | 03:03 | 03:38 | 61 | 2.71 | 295 |  | 2147 | 55 | 84 | 152 | 466 | 2715 | 2053 | 31 |  |  |  | 0.10 |
| 06/24 | 16 | 06/24 | 16 | 03:38 | 04:12 | 61 | 2.75 | 298 |  | 2859 | 60 | 86 | 160 | 505 | 2757 | 2501 | 49 |  |  |  | 0.10 |
| 06/24 | 17 | 06/24 | 17 | 04:12 | 04:42 | 61 | 2.75 | 284 |  | 2441 | 48 | 79 | 157 | 476 | 2618 | 2205 | 46 |  |  |  | 0.11 |
| 06/24 | 18 | 06/24 | 18 | 04:42 | 05:03 | 61 | 2.86 | 350 |  | 1465 | 50 | 96 | 115 | 441 | 1049 | 1561 | 31 |  |  |  | 0.16 |
| 06/24 | 19 | 06/24 | 19 | 05:03 | 05:17 | 62 | 2.94 | 249 |  | 966 | 30 | 65 | 84 | 360 | 1291 | 1119 | 29 |  |  |  | 0.25 |
| 06/24 | 20 | 06/24 | 20 | reservoir |  | 66 | 2.84 | 189 |  | 1748 | 33 | 57 | 113 | 309 | 2073 | 1538 |  |  |  |  |  |
| 06/24 | 20B | 06/24 | 20B | reservoir |  | 64 | 2.83 | 194 |  | 1916 | 34 | 58 | 118 | 318 | 2108 | 1587 | 47 |  |  |  |  |
| 06/24 | 21 | 06/24 | 21 | 06:41 | 07:08 | 60 | 2.81 | 189 |  | 2088 | 36 | 56 | 130 | 400 | 2895 | 1853 | 43 |  |  |  | 0.12 |
| 06/24 | 22 | 06/24 | 22 | 07:08 | 07:56 | 60 | 2.76 | 230 |  | 2150 | 45 | 68 | 162 | 397 | 2340 | 1951 | 45 |  |  |  | 0.07 |
| 06/24 | 23 | 06/24 | 23 | 07:56 | 08:21 | 60 | 2.78 | 257 |  | 1448 | 46 | 71 | 157 | 390 | 2000 | 1540 | 46 |  |  |  | 0.13 |
| 06/24 | 24 | 06/24 | 24 | 08:21 | 08:32 | 20 | 2.78 | 294 |  | 1310 | 88 | 104 | 148 | 409 | 2100 | 1521 | 51 |  |  |  | 0.10 |
| 06/24 | 25 | 06/24 | 25 | 08:32 | 08:56 | 61 | 2.77 | 454 |  | 1272 | 107 | 136 | 141 | 539 | 2074 | 1588 | 36 |  |  |  | 0.14 |
| 06/24 | 26 | 06/24 | 26 | 08:56 | 09:14 | 61 | 2.88 | 273 | 16 | 462 |  | 67 | 98 | 478 | 1526 | 1224 | 29 |  |  |  | 0.19 |
| 06/24 | 27 | 06/24 | 27 | 09:14 | 09:33 | 61 | 2.92 | 385 | 15 | 595 |  | 91 | 80 | 477 | 1434 | 1125 | 30 |  |  |  | 0.18 |
| 06/24 | 28 | 06/24 | 28 | 09:33 | 10:42 | 60 | 2.65 | 1790 | 55 | 1457 |  | 377 | 229 | 1365 | 3521 | 2358 | 34 |  |  |  | 0.05 |
| 06/24 | 29 | 06/24 | 29 | 10:42 | 11:19 | 17 | 2.60 | 1803 | 59 | 1341 |  | 406 | 240 | 1396 | 3602 | 2452 |  |  |  |  | 0.02 |
| 06/24 | 1 | 06/24 | 1 | 19:39 | 23:02 | 11 | 2.66 | 1618 | 307 | 9383 | 1143 | 1151 | 393 | 2086 | 8191 | 5796 |  |  |  |  | 0.00 |
| 06/25 | 3 | 06/25 | 3 | 00:37 | 01:04 | 66 | 2.63 | 594 | 27 | 1855 | 200 | 135 | 211 | 400 | 3658 | 2438 | 35 |  |  |  | 0.14 |
| 06/25 | 4 | 06/25 | 4 | 01:04 | 01:33 | 66 | 2.67 | 810 | 30 | 1915 | 239 | 173 | 210 | 488 | 3481 | 2422 | 37 |  |  |  | 0.13 |
| 06/25 | 5 | 06/25 | 5 | 01:33 | 01:53 | 67 | 2.73 | 708 | 25 | 1242 | 193 | 159 | 151 | 440 | 2646 | 1815 | 31 |  |  |  | 0.19 |
| 06/25 | 6 | 06/25 | 6 | 01:53 | 02:07 | 67 | 2.72 | 395 | 14 | 724 | 77 | 81 | 82 | 270 | 1471 | 1105 | 24 |  |  |  | 0.27 |
| 06/25 | 7 | 06/25 | 7 | 02:07 | 02:20 | 67 | 3.09 | 244 | 11 | 470 | 43 | 53 | 46 | 176 | 832 | 662 | 16 |  |  |  | 0.29 |
| 06/25 | 8 | 06/25 | 8 | 02:20 | 02:31 | 67 | 3.11 | 205 | 8 | 410 | 38 | 50 | 33 | 157 | 845 | 711 | 16 |  |  |  | 0.34 |
| 06/25 | 9 | 06/25 | 9 | 02:31 | 02:42 | 67 | 3.11 | 270 | 10 | 429 | 55 | 61 | 44 | 184 | 870 | 741 | 17 |  |  |  | 0.34 |
| 06/25 | 10 | 06/25 | 10 | 02:42 | 02:56 | 67 | 3.04 | 177 | 7 | 509 | 30 | 40 | 34 | 132 | 891 | 660 | 30 |  |  |  | 0.27 |
| 06/25 | 11 | 06/25 | 11 | 02:56 | 03:12 | 67 | 2.87 | 158 | 7 | 1078 | 32 | 37 | 101 | 174 | 1805 | 1120 | 30 |  |  |  | 0.23 |
| 06/25 | 12 | 06/25 | 12 | 03:12 | 03:14 | 10 | 2.88 | 142 | 7 | 1031 | 33 | 37 | 62 | 162 | 1837 | 1095 |  |  |  |  | 0.29 |
| 06/25 | 13 | 06/25 | 13 | 03:16 | 03:41 | 68 | 2.74 | 171 | 10 | 1270 | 36 | 44 | 132 | 230 | 2583 | 1528 | 34 |  |  |  | 0.15 |
| 06/25 | 14 | 06/25 | 14 | 03:45 | 03:53 | 18 | 2.66 | 273 | 15 | 1753 | 57 | 66 | 146 | 276 | 3270 | 1896 |  |  |  |  | 0.13 |
| 06/25 | 15 | 06/25 | 15 | 03:57 | 04:06 | 26 | 2.67 | 289 | 13 | 1708 | 52 | 66 | 132 | 265 | 3020 | 1828 | 28 |  |  |  | 0.16 |
| 06/25 | 16 | 06/25 | 16 | 04:09 | 04:17 | 20 | 2.65 | 315 | 14 | 1631 | 60 | 72 | 152 | 281 | 4000 | 1854 |  |  |  |  | 0.14 |
| 06/25 | 17 | 06/25 | 17 | 04:20 | 04:27 | 23 | 2.70 | 224 | 13 | 1064 | 55 | 65 | 140 | 272 | 2823 | 1688 | 22 |  |  |  | 0.18 |
| 06/25 | 18 | 06/25 | 18 | 04:30 | 04:37 | 21 | 2.73 | 289 | 13 | 1423 | 54 | 69 | 135 | 295 | 2490 | 1702 | 23 |  |  |  | 0.17 |
| 06/25 | 19 | 06/25 | 19 | 04:39 | 04:45 | 13 | 2.71 | 434 | 18 | 1735 | 88 | 86 | 148 | 364 | 2888 | 2106 |  |  |  |  | 0.12 |
| 06/25 | 20 | 06/25 | 20 | 04:48 | 04:52 | 10 | 2.67 | 541 | 20 | 1779 | 113 | 105 | 132 | 386 | 3089 | 2185 |  |  |  |  | 0.14 |

Table 4 San Pedro Hill Cloudwater Data (continued)

San Pedro Hill Cloudwater Data

| Date | Sec | Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uN) | K+ (uN) | NH4+ (uN) | Ca2+ (uN) | Mg2+ (uN) | 'Fo' (uN) | Cl- (uN) | NO3- (uN) | SO42- (uN) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06/25 | 21 | 06/25 | 21 | 04:55 | 05:04 | 19 | 2.65 | 611 | 22 | 1684 | 115 | 110 | 152 | 407 | 3233 | 2222 | | | | | 0.12 |
| 06/25 | 22A | 06/25 | 22A | reservoir | | 67 | 2.74 | 512 | 18 | 1955 | 90 | 91 | 135 | 476 | 2575 | 2234 | 25 | | | | |
| 06/25 | 22B | 06/25 | 22B | reservoir | | 44 | 2.76 | 520 | 18 | 1736 | 88 | 96 | 127 | 468 | 2362 | 2058 | 24 | | | | |
| 06/25 | 23 | 06/25 | 23 | 05:17 | 07:33 | 17 | 2.64 | 1266 | 44 | 2373 | 270 | 256 | 216 | 838 | 3435 | 3229 | | | | | 0.01 |
| 06/26 | 1 | 06/26 | 1 | 01:48 | 02:08 | 33 | 2.99 | 315 | 19 | 1979 | 164 | 86 | 129 | 213 | 2462 | 1528 | | | | | 0.09 |
| 06/26 | 2 | 06/26 | 2 | 02:08 | 02:19 | 39 | 3.26 | 113 | 7 | 1704 | 41 | 30 | 68 | 89 | 1445 | 1045 | | | | | 0.20 |
| 06/26 | 3 | 06/26 | 3 | 02:19 | 02:30 | 40 | 3.33 | 87 | 4 | 906 | 19 | 18 | 26 | 77 | 822 | 713 | | | | | 0.20 |
| 06/26 | 4 | 06/26 | 4 | 02:30 | 02:57 | 37 | 3.30 | 168 | 8 | 1035 | 43 | 39 | 33 | 84 | 1054 | 762 | | | | | 0.08 |
| 06/26 | 5 | 06/26 | 5 | 02:57 | 03:06 | 33 | 3.27 | 83 | 5 | 1363 | 22 | 24 | 23 | 43 | 912 | 645 | | | | | 0.20 |
| 06/26 | 6 | 06/26 | 6 | 03:06 | 03:15 | 36 | 3.36 | 49 | 4 | 1124 | 13 | 16 | 26 | 51 | 1015 | 747 | | | | | 0.23 |
| 06/26 | 7 | 06/26 | 7 | 03:15 | 03:24 | 32 | 3.39 | 67 | 5 | 1119 | 23 | 23 | 49 | 88 | 1096 | 810 | | | | | 0.20 |
| 06/26 | 8 | 06/26 | 8 | 03:24 | 03:39 | 64 | 3.42 | 103 | 7 | 1415 | 22 | 26 | 59 | 87 | 1113 | 823 | | | | | 0.24 |
| 06/26 | 9 | 06/26 | 9 | 03:39 | 03:53 | 68 | 3.48 | 41 | 4 | 879 | 17 | 16 | 39 | 55 | 814 | 590 | | | | | 0.27 |
| 06/26 | 10 | 06/26 | 10 | 03:53 | 04:04 | 39 | 3.48 | 98 | 5 | 593 | 19 | 24 | 26 | 106 | 572 | 534 | | | | | 0.20 |
| 06/26 | 11 | 06/26 | 11 | 04:04 | 04:24 | 66 | 3.51 | 114 | 7 | 479 | 27 | 30 | 22 | 94 | 489 | 461 | | | | | 0.19 |
| 06/26 | 12 | 06/26 | 12 | 04:24 | 04:43 | 65 | 3.47 | 59 | 4 | 423 | 12 | 17 | 23 | 58 | 454 | 387 | | | | | 0.19 |
| 06/26 | 13 | 06/26 | 13 | 04:43 | 05:00 | 69 | 3.43 | 41 | 3 | 478 | 11 | 13 | 29 | 51 | 560 | 393 | | | | | 0.23 |
| 06/26 | 14 | 06/26 | 14 | 05:00 | 05:14 | 64 | 3.40 | 28 | 3 | 585 | 9 | 11 | 39 | 49 | 718 | 482 | | | | | 0.26 |
| 06/26 | 15 | 06/26 | 15 | 05:14 | 05:27 | 63 | 3.38 | 33 | 3 | 709 | 8 | 10 | 46 | 47 | 750 | 496 | | | | | 0.27 |
| 06/26 | 16 | 06/26 | 16 | 05:27 | 05:45 | 69 | 3.24 | 46 | 3 | 943 | 10 | 13 | 64 | 64 | 1051 | 680 | | | | | 0.21 |
| 06/26 | 17 | 06/26 | 17 | 05:45 | 05:58 | 68 | 3.28 | 36 | 3 | 886 | 9 | 10 | 58 | 78 | 955 | 643 | | | | | 0.29 |
| 06/26 | 18 | 06/26 | 18 | 05:58 | 06:12 | 69 | 3.28 | 31 | 3 | 787 | 8 | 11 | 65 | 65 | 966 | 663 | | | | | 0.27 |
| 06/26 | 19 | 06/26 | 19 | 06:12 | 06:26 | 63 | 3.26 | 36 | 3 | 1026 | 13 | 12 | 70 | 66 | 1055 | 748 | | | | | 0.25 |
| 06/26 | 20A | 06/26 | 20A | reservoir | | 65 | 3.06 | 165 | 8 | 1977 | 38 | 43 | 123 | 196 | 1626 | 1553 | | | | | |
| 06/26 | 20B | 06/26 | 20B | reservoir | | 69 | 3.00 | 160 | 10 | 1818 | 46 | 49 | 146 | 223 | 1998 | 1971 | | | | | |
| 07/01 | 1 | 07/01 | 1 | 20:34 | 21:57 | 29 | 3.18 | 912 | | 638 | 215 | 248 | 88 | 745 | 1138 | 836 | | | | | 0.02 |
| 07/01 | 4 | 07/01 | 4 | 22:07 | 22:10 | 8 | 3.15 | 618 | | 613 | 159 | 176 | 79 | 544 | 936 | 775 | | | | | 0.15 |
| 07/01 | 8 | 07/01 | 8 | 22:33 | 22:39 | 13 | 3.15 | 386 | | 522 | 97 | 108 | 67 | 366 | 722 | 658 | | | | | 0.12 |
| 07/01 | 10 | 07/01 | 10 | 22:51 | 22:56 | 10 | 3.18 | 336 | | 496 | 79 | 90 | 52 | 339 | 682 | 585 | | | | | 0.11 |
| 07/01 | 11 | 07/01 | 11 | 22:59 | 23:08 | 17 | 3.19 | 372 | | 566 | 88 | 89 | 66 | 378 | 704 | 666 | | | | | 0.11 |
| 07/01 | 13 | 07/01 | 13 | 23:19 | 23:24 | 11 | 3.23 | 348 | | 545 | 80 | 90 | 54 | 351 | 605 | 609 | | | | | 0.12 |
| 07/01 | 20 | 07/01 | 20 | reservoir | | | | 385 | | 242 | 57 | 90 | 46 | 453 | 401 | 435 | | | | | |
| 07/02 | 1 | 07/02 | 1 | 20:00 | 21:10 | 60 | 3.19 | 528 | | 494 | 95 | 133 | 109 | 510 | 713 | 836 | | | | | 0.05 |
| 07/02 | 2 | 07/02 | 2 | 21:10 | 22:46 | 34 | 3.30 | 379 | | 394 | 79 | 93 | 98 | 400 | 535 | 492 | | | | | 0.02 |
| 07/03 | 3 | 07/03 | 3 | 00:06 | 00:55 | 62 | 2.91 | 683 | | 2132 | 286 | 202 | 221 | 438 | 3206 | 1546 | | | | | 0.07 |
| 07/03 | 4 | 07/03 | 4 | 00:55 | 01:32 | 61 | 2.99 | 345 | | 2309 | 125 | 96 | 210 | 327 | 2325 | 1464 | | | | | 0.09 |
| 07/03 | 5 | 07/03 | 5 | 01:32 | 02:48 | 52 | 2.60 | 515 | | 2770 | 209 | 158 | 236 | 532 | 4131 | 2562 | | | | | 0.04 |
| 07/03 | 6 | 07/03 | 6 | 02:51 | 03:50 | 61 | 2.47 | 487 | | 2568 | 167 | 149 | 271 | 562 | 4656 | 3028 | | | | | 0.06 |
| 07/03 | 7 | 07/03 | 7 | 03:50 | 04:35 | 62 | 2.61 | 392 | | 2156 | 118 | 110 | 219 | 488 | 3278 | 2305 | | | | | 0.08 |
| 07/03 | 8 | 07/03 | 8 | 04:35 | 05:12 | 60 | 2.67 | 377 | | 1725 | 98 | 105 | 179 | 454 | 2748 | 1903 | | | | | 0.09 |
| 07/03 | 9 | 07/03 | 9 | 05:12 | 05:46 | 61 | 2.64 | 405 | | 1557 | 100 | 115 | 176 | 479 | 2994 | 1959 | | | | | 0.10 |
| 07/03 | 10 | 07/03 | 10 | 05:46 | 06:22 | 60 | 2.63 | 308 | | 1682 | 72 | 83 | 180 | 440 | 2924 | 2030 | | | | | 0.09 |
| 07/03 | 11 | 07/03 | 11 | 06:22 | 06:53 | 59 | 2.61 | 315 | | 1195 | 71 | 83 | 159 | 365 | 2874 | 1691 | | | | | 0.11 |
| 07/03 | 12 | 07/03 | 12 | 06:53 | 07:25 | 58 | 2.58 | 355 | | 1037 | 82 | 95 | 180 | 381 | 2973 | 1687 | | | | | 0.10 |
| 07/03 | 13 | 07/03 | 13 | 07:25 | 08:16 | 58 | 2.48 | 446 | | 1426 | 110 | 124 | 256 | 491 | 3823 | 2340 | | | | | 0.06 |
| 07/03 | 14 | 07/03 | 14 | 08:16 | 09:08 | 20 | 2.42 | 672 | | 1693 | 186 | 192 | 298 | 656 | 4631 | 2957 | | | | | 0.02 |
| 07/07 | 1 | 07/07 | 1 | 00:54 | 01:29 | 66 | 3.33 | 647 | | 1108 | 127 | 145 | 135 | 582 | 1301 | 810 | 20 | 4 | | | 0.11 |
| 07/07 | 2 | 07/07 | 2 | 01:29 | 01:47 | 57 | 3.31 | 388 | | 544 | 61 | 88 | 84 | 406 | 812 | 588 | 15 | 9 | | | 0.18 |
| 07/07 | 3 | 07/07 | 3 | 01:47 | 02:02 | 58 | 3.34 | 235 | | 320 | 28 | 53 | 72 | 284 | 554 | 455 | 14 | 18 | | | 0.21 |

# Table 4 San Pedro Hill Cloudwater Data (continued)

San Pedro Hill Cloudwater Data

| Date | Seq | Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uM) | K+ (uM) | NH4+ (uM) | Ca2+ (uM) | Mg2+ (uM) | "Fo" (uM) | Cl- (uM) | NO3- (uM) | SO42- (uM) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/07 | 4 | 07/07 | 4 | 02:02 | 02:24 | 61 | 3.25 | 280 | | 347 | 32 | 65 | 80 | 341 | 669 | 523 | 18 | 13 | | | 0.16 |
| 07/07 | 5 | 07/07 | 5 | 02:24 | 03:06 | 62 | 3.14 | 647 | | 433 | 56 | 135 | 109 | 734 | 780 | 722 | 22 | 54 | | | 0.08 |
| 07/07 | 6 | 07/07 | 6 | 03:06 | 03:40 | 61 | 3.51 | 503 | | 266 | 36 | 106 | 72 | 591 | 332 | 384 | 13 | 61 | | | 0.10 |
| 07/07 | 7 | 07/07 | 7 | 03:40 | 04:21 | 23 | 3.44 | 719 | | 296 | 57 | 156 | 80 | 821 | 488 | 454 | 12 | 72 | | | 0.03 |
| 07/08 | 1 | 07/08 | 1 | 00:48 | 01:59 | 65 | 2.81 | 1365 | | 2458 | 508 | 335 | 185 | 1055 | 3419 | 2647 | | | | | 0.05 |
| 07/08 | 2 | 07/08 | 2 | 01:59 | 02:26 | 57 | 2.87 | 798 | | 1875 | 213 | 208 | 174 | 623 | 2446 | 1878 | | | | | 0.12 |
| 07/08 | 3 | 07/08 | 3 | 02:26 | 02:48 | 60 | 2.93 | 498 | | 926 | 126 | 123 | 86 | 363 | 1557 | 1123 | | | | | 0.15 |
| 07/08 | 4 | 07/08 | 4 | 02:48 | 03:10 | 61 | 3.02 | 467 | | 683 | 100 | 111 | 115 | 355 | 1211 | 932 | | | | | 0.15 |
| 07/08 | 5 | 07/08 | 5 | 03:10 | 03:31 | 59 | 3.08 | 287 | | 431 | 54 | 65 | 89 | 290 | 915 | 686 | | | | | 0.16 |
| 07/08 | 6 | 07/08 | 6 | 03:31 | 03:54 | 56 | 3.12 | 314 | | 424 | 56 | 70 | 40 | 353 | 901 | 606 | | | | | 0.14 |
| 07/08 | 7 | 07/08 | 7 | 03:54 | 04:18 | 60 | 3.04 | 274 | | 428 | 45 | 61 | 51 | 294 | 1088 | 687 | | | | | 0.14 |
| 07/08 | 8 | 07/08 | 8 | 04:18 | 04:19 | 4 | 3.91 | 59 | | 88 | 20 | 15 | | 71 | 172 | 143 | | | | | 0.25 |
| 07/08 | 9 | 07/08 | 9 | 04:19 | 04:52 | 1 | 3.91 | | | | | | | | | | | | | | 0.00 |
| 07/08 | 10 | 07/08 | 10 | 04:52 | 04:52 | 59 | 3.00 | 303 | | 481 | 51 | 68 | 59 | 331 | 1208 | 697 | | | | | |
| 07/08 | 17 | 07/08 | 17 | unknown | | 58 | 2.86 | 888 | | 808 | 166 | 208 | 116 | 760 | 2142 | 1190 | | | | | |
| 07/13 | 1 | 07/13 | 1 | 02:48 | 03:25 | 36 | 3.79 | 223 | | 210 | 52 | 57 | 39 | 264 | 217 | 230 | 10 | 47 | 15 | 6 | 0.05 |
| 07/13 | 2 | 07/13 | 2 | 03:25 | 04:07 | 9 | 3.83 | 204 | | 240 | 45 | 57 | 42 | 242 | 174 | 230 | | | 17 | 6 | 0.01 |
| 07/14 | 1 | 07/14 | 1 | 01:56 | 02:14 | 39 | 3.65 | 82 | | 220 | 32 | 28 | 40 | 120 | 180 | 292 | 9 | | 16 | 8 | 0.12 |
| 07/14 | 2 | 07/14 | 2 | 02:14 | 02:24 | 37 | 3.75 | 68 | | 167 | 17 | 19 | 19 | 95 | 136 | 217 | | | | | 0.21 |
| 07/14 | 3 | 07/14 | 3 | 02:24 | 02:33 | 35 | 3.68 | 97 | | 198 | 23 | 28 | 39 | 163 | 154 | 243 | 8 | | 14 | 8 | 0.22 |
| 07/14 | 4 | 07/14 | 4 | 02:33 | 02:41 | 38 | 3.78 | 149 | | 161 | 21 | 35 | 1 | 174 | 135 | 218 | | | | | 0.27 |
| 07/14 | 5 | 07/14 | 5 | 02:41 | 02:53 | 59 | 3.83 | 134 | | 140 | 16 | 30 | 48 | 171 | 146 | 231 | 5 | | 13 | 6 | 0.28 |
| 07/14 | 6 | 07/14 | 6 | 02:53 | 03:02 | 38 | 3.86 | 147 | | 129 | 17 | 34 | 28 | 170 | 113 | 194 | | | | | 0.23 |
| 07/14 | 7 | 07/14 | 7 | 03:02 | 03:12 | 38 | 3.83 | 133 | | 153 | 15 | 31 | 28 | 153 | 120 | 219 | 6 | | 13 | 6 | 0.21 |
| 07/14 | 8 | 07/14 | 8 | 03:12 | 03:22 | 37 | 3.80 | 87 | | 191 | 13 | 24 | 29 | 123 | 128 | 236 | | | | | 0.21 |
| 07/14 | 9 | 07/14 | 9 | 03:22 | 03:30 | 36 | 3.81 | 77 | | 186 | 13 | 22 | 30 | 113 | 130 | 227 | 9 | | 12 | 6 | 0.25 |
| 07/14 | 10 | 07/14 | 10 | 03:30 | 03:38 | 44 | 3.91 | 98 | | 148 | 16 | 26 | 26 | 132 | 112 | 182 | | | | | 0.31 |
| 07/14 | 11 | 07/14 | 11 | 03:38 | 03:47 | 36 | 3.82 | 97 | | 154 | 13 | 25 | 32 | 135 | 127 | 204 | 7 | | 14 | 6 | 0.22 |
| 07/14 | 12 | 07/14 | 12 | 03:47 | 03:56 | 39 | 3.81 | 85 | | 150 | 13 | 24 | 29 | 123 | 129 | 202 | | | | | 0.24 |
| 07/14 | 13 | 07/14 | 13 | 03:56 | 04:07 | 46 | 3.79 | 65 | | 159 | 13 | 19 | 30 | 100 | 132 | 196 | 18 | | 15 | 7 | 0.24 |
| 07/14 | 14 | 07/14 | 14 | 04:07 | 04:19 | 38 | 3.61 | 64 | | 224 | 19 | 19 | 35 | 100 | 209 | 291 | | | | | 0.18 |
| 07/14 | 15 | 07/14 | 15 | 04:19 | 04:33 | 40 | 3.34 | 84 | | 568 | 34 | 27 | 52 | 124 | 547 | 572 | 27 | | 18 | 11 | 0.16 |
| 07/14 | 16 | 07/14 | 16 | 04:33 | 04:45 | 38 | 3.32 | 89 | | 659 | 39 | 28 | 62 | 135 | 592 | 622 | | | | | 0.18 |
| 07/14 | 17 | 07/14 | 17 | 04:45 | 04:55 | 38 | 3.32 | 79 | | 683 | 40 | 25 | 64 | 134 | 549 | 618 | 38 | | 22 | 14 | 0.21 |
| 07/14 | 18 | 07/14 | 18 | 04:55 | 05:06 | 39 | 3.33 | 78 | | 748 | 42 | 25 | 71 | 147 | 559 | 670 | | | | | 0.20 |
| 07/14 | 19 | 07/14 | 19 | 05:06 | 05:17 | 38 | 3.32 | 96 | | 977 | 50 | 29 | 79 | 180 | 597 | 757 | 8 | | 34 | 18 | 0.19 |
| 07/14 | 20 | 07/14 | 20 | reservoir | | 65 | 3.14 | 204 | | 694 | 55 | 57 | 79 | 240 | 600 | 820 | 28 | | 27 | 31 | |
| 07/14 | 21 | 07/14 | 21 | reservoir | | 29 | 3.13 | 207 | | 669 | 53 | 59 | 80 | 239 | 592 | 814 | | | | | |
| 07/14 | 1 | 07/14 | 1 | 19:06 | 19:54 | 40 | 3.26 | 164 | | 391 | 77 | 47 | 72 | 154 | 589 | 473 | 15 | 31 | 43 | 22 | 0.05 |
| 07/14 | 2 | 07/14 | 2 | 19:54 | 20:21 | 38 | 3.23 | 162 | | 391 | 44 | 41 | 120 | 206 | 541 | 521 | | | | | 0.08 |
| 07/14 | 3 | 07/14 | 3 | 20:21 | 20:39 | 37 | 3.41 | 147 | | 313 | 33 | 36 | 64 | 161 | 364 | 413 | 10 | 53 | 35 | 13 | 0.11 |
| 07/14 | 4 | 07/14 | 4 | 20:39 | 20:54 | 39 | 3.47 | 132 | | 254 | 29 | 32 | 49 | 137 | 305 | 355 | | | | | 0.15 |
| 07/14 | 5 | 07/14 | 5 | 20:54 | 21:11 | 40 | 3.48 | 121 | | 215 | 22 | 29 | 41 | 125 | 251 | 306 | | | | | 0.13 |
| 07/14 | 6 | 07/14 | 6 | 21:11 | 21:26 | 41 | 3.50 | 122 | | 184 | 18 | 28 | 39 | 152 | 243 | 293 | 6 | 62 | 20 | 9 | 0.15 |
| 07/14 | 7 | 07/14 | 7 | 21:26 | 21:39 | 39 | 3.53 | 96 | | 182 | 15 | 25 | 41 | 123 | 221 | 272 | | | | | 0.17 |
| 07/14 | 8 | 07/14 | 8 | 21:39 | 21:51 | 39 | 3.54 | 140 | | 197 | 22 | 32 | 37 | 138 | 245 | 295 | | | | | 0.18 |
| 07/14 | 9 | 07/14 | 9 | 21:51 | 22:03 | 37 | 3.58 | 177 | | 194 | 27 | 38 | 36 | 173 | 238 | 272 | 6 | 62 | 20 | 9 | 0.17 |
| 07/14 | 10 | 07/14 | 10 | 22:03 | 22:14 | 38 | 3.67 | 180 | | 173 | 22 | 38 | 29 | 174 | 199 | 244 | | | | | 0.20 |
| 07/14 | 11 | 07/14 | 11 | 22:14 | 22:26 | 41 | 3.62 | 193 | | 169 | 24 | 42 | 29 | 186 | 209 | 268 | | | | | 0.19 |

# Table 4 San Pedro Hill Cloudwater Data (continued)

San Pedro Hill Cloudwater Data

| Date | Seq | Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uN) | K+ (uN) | NH4+ (uN) | Ca2+ (uN) | Mg2+ (uN) | "Fo" (uN) | Cl- (uN) | NO3- (uN) | SO42- (uN) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/14 | 12 | 07/14 | 12 | 22:26 | 22:36 | 38 | 3.58 | 185 | | 176 | 28 | 41 | 37 | 192 | 235 | 302 | 8 | 53 | 17 | 7 | 0.21 |
| 07/14 | 13 | 07/14 | 13 | 22:36 | 22:46 | 40 | 3.63 | 177 | | 145 | 23 | 39 | 28 | 165 | 192 | 259 | | | | | 0.23 |
| 07/14 | 14 | 07/14 | 14 | 22:46 | 22:56 | 40 | 3.69 | 174 | | 138 | 22 | 38 | 26 | 168 | 172 | 230 | | | | | 0.22 |
| 07/14 | 15 | 07/14 | 15 | 22:56 | 23:06 | 41 | 3.73 | 193 | | 131 | 25 | 42 | 39 | 186 | 167 | 212 | 10 | 62 | 16 | 7 | 0.23 |
| 07/14 | 16 | 07/14 | 16 | 23:06 | 23:17 | 38 | 3.68 | 191 | | 152 | 28 | 43 | 30 | 173 | 197 | 240 | | | | | 0.20 |
| 07/14 | 17 | 07/14 | 17 | 23:17 | 23:37 | 38 | 3.41 | 216 | | 264 | 42 | 51 | 53 | 190 | 383 | 390 | | | | | 0.11 |
| 07/14 | 18 | 07/14 | 18 | 23:37 | 23:49 | 38 | 3.25 | 267 | | 377 | 66 | 65 | 73 | 272 | 602 | 550 | 14 | 49 | 29 | 11 | 0.18 |
| 07/14 | 19 | 07/14 | 19 | 23:49 | 00:07 | 42 | 3.38 | 225 | | 299 | 44 | 53 | 53 | 187 | 449 | 407 | | | | | 0.20 |
| 07/14 | 20A | 07/14 | 20A | reservoir | | | 3.44 | 52 | | 205 | 17 | 18 | 25 | 57 | 325 | 284 | | | | | |
| 07/14 | 20B | 07/14 | 20B | reservoir | | | 3.43 | 40 | | 201 | 10 | 13 | 30 | 87 | 316 | 285 | 13 | 19 | 21 | 8 | |
| 07/15 | 2 | 07/15 | 2 | 13:18 | 13:38 | 18 | 2.98 | 242 | | 764 | 199 | 79 | 147 | 315 | 857 | 1417 | | | | | 0.05 |
| 07/15 | 3 | 07/15 | 3 | 19:45 | 20:50 | 54 | 3.28 | 224 | | 754 | 197 | 76 | 130 | 181 | 565 | 1074 | | | | | 0.05 |
| 07/15 | 4 | 07/15 | 4 | 20:50 | 21:18 | 12 | 3.23 | 172 | | 746 | 158 | 61 | 222 | 245 | 621 | 995 | | | | | 0.02 |
| 07/15 | 5 | 07/15 | 5 | 22:00 | 22:43 | 55 | 3.05 | 271 | | 1141 | 236 | 100 | 248 | 357 | 1013 | 1583 | | | | | 0.07 |
| 07/15 | 6 | 07/15 | 6 | 22:43 | 23:09 | 55 | 3.00 | 145 | | 828 | 134 | 51 | 99 | 139 | 927 | 1214 | | | | | 0.12 |
| 07/15 | 7 | 07/15 | 7 | 23:09 | 23:33 | 56 | 3.07 | 89 | | 538 | 81 | 34 | 81 | 117 | 674 | 876 | | | | | 0.13 |
| 07/15 | 8 | 07/15 | 8 | 23:33 | 23:56 | 55 | 3.08 | 79 | | 482 | 68 | 30 | 93 | 120 | 685 | 805 | | | | | 0.13 |
| 07/15 | 9 | 07/15 | 9 | 23:56 | 00:55 | 55 | 2.64 | 198 | | 2161 | 235 | 71 | 213 | 217 | 2797 | 2438 | | | | | 0.05 |
| 07/16 | 10 | 07/16 | 10 | 00:55 | 01:11 | 55 | 2.86 | 157 | | 1225 | 165 | 58 | 154 | 218 | 1528 | 1438 | | | | | 0.19 |
| 07/16 | 11 | 07/16 | 11 | 01:11 | 01:25 | 56 | 3.04 | 101 | | 606 | 90 | 36 | 108 | 158 | 880 | 872 | | | | | 0.22 |
| 07/16 | 12 | 07/16 | 12 | 01:25 | 01:38 | 56 | 3.14 | 65 | | 427 | 55 | 24 | 78 | 112 | 640 | 643 | | | | | 0.24 |
| 07/16 | 13 | 07/16 | 13 | 01:38 | 01:53 | 59 | 3.12 | 55 | | 507 | 52 | 22 | 82 | 110 | 699 | 684 | | | | | 0.22 |
| 07/16 | 14 | 07/16 | 14 | 01:53 | 02:10 | 55 | 3.14 | 29 | | 404 | 29 | 13 | 70 | 61 | 591 | 630 | | | | | 0.18 |
| 07/16 | 15 | 07/16 | 15 | 02:10 | 02:28 | 56 | 3.16 | 22 | | 391 | 21 | 10 | 57 | 40 | 547 | 548 | | | | | 0.17 |
| 07/16 | 16 | 07/16 | 16 | 02:28 | 02:44 | 56 | 3.27 | 28 | | 330 | 31 | 12 | 48 | 47 | 448 | 438 | | | | | 0.19 |
| 07/16 | 17 | 07/16 | 17 | Reservoir | | 68 | 3.93 | 24 | | 328 | 14 | 8 | 22 | 47 | 190 | 219 | | | | | |
| 07/16 | 2 | 07/16 | 2 | 15:35 | 16:07 | 55 | 3.56 | 84 | | 284 | | | 36 | 84 | 249 | 259 | | | | | 0.10 |
| 07/16 | 3 | 07/16 | 3 | 16:07 | 16:19 | 55 | 3.74 | 33 | | 160 | | | 29 | 50 | 147 | 215 | | | | | 0.26 |
| 07/16 | 4 | 07/16 | 4 | 16:19 | 16:45 | 25 | 3.67 | 33 | | 142 | | | 29 | 44 | 167 | 203 | | | | | 0.05 |
| 07/16 | 5 | 07/16 | 5 | 17:40 | 18:30 | 55 | 3.50 | 92 | | 207 | | | 51 | 98 | 280 | 277 | | | | | 0.06 |
| 07/16 | 6 | 07/16 | 6 | 18:30 | 19:02 | 27 | 3.64 | 83 | | 187 | 27 | 22 | 43 | 70 | 231 | 248 | | | | | 0.05 |
| 07/16 | 7 | 07/16 | 7 | 19:14 | 19:37 | 56 | 3.51 | 75 | | 242 | 47 | 28 | 47 | 88 | 295 | 329 | | | | | 0.14 |
| 07/16 | 8 | 07/16 | 8 | 19:37 | 19:49 | 56 | 3.55 | 52 | | 126 | | | 18 | 55 | 145 | 295 | | | | | 0.26 |
| 07/16 | 9 | 07/16 | 9 | 19:49 | 20:03 | 26 | 3.86 | 35 | | 98 | 13 | 11 | 15 | 39 | 116 | 170 | | | | | 0.10 |
| 07/16 | 10 | 07/16 | 10 | 20:03 | 20:18 | 56 | 4.06 | 24 | | 80 | 9 | 7 | 13 | 30 | 96 | 114 | | | | | 0.21 |
| 07/16 | 11 | 07/16 | 11 | 20:18 | 20:33 | 55 | 4.14 | 20 | | 70 | 8 | 7 | 10 | 28 | 84 | 93 | | | | | 0.21 |
| 07/16 | 12 | 07/16 | 12 | 20:33 | 20:50 | 56 | 4.15 | 20 | | 66 | 9 | 7 | 10 | 27 | 77 | 104 | | | | | 0.18 |
| 07/16 | 13 | 07/16 | 13 | 20:50 | 21:04 | 56 | 4.30 | 19 | | 56 | 8 | 6 | 8 | 25 | 53 | 74 | | | | | 0.23 |
| 07/16 | 14 | 07/16 | 14 | 21:04 | 21:25 | 56 | 4.48 | 16 | | 66 | | | 11 | 23 | 43 | 58 | | | | | 0.15 |
| 07/16 | 15 | 07/16 | 15 | 21:25 | 21:43 | 55 | 4.58 | 10 | | 80 | | | | 21 | 37 | 69 | | | | | 0.17 |
| 07/16 | 16 | 07/16 | 16 | 21:43 | 22:04 | 56 | 4.32 | 8 | | 71 | | | | 14 | 35 | 77 | | | | | 0.15 |
| 07/16 | 17 | 07/16 | 17 | 22:04 | 22:23 | 56 | 4.46 | 9 | | 53 | | | | 11 | 34 | 60 | | | | | 0.16 |
| 07/16 | 18 | 07/16 | 18 | 22:23 | 22:40 | 55 | 4.98 | 6 | | 47 | 3 | 1 | | 13 | 28 | 39 | | | | | 0.18 |
| 07/16 | 19 | 07/16 | 19 | 22:40 | 22:53 | 56 | 4.75 | 11 | | 44 | 5 | 3 | | 14 | 30 | 55 | | | | | 0.24 |
| 07/17 | 20 | 07/17 | 20 | reservoir | | 33 | 3.80 | 49 | | 504 | | | 33 | 79 | 300 | 376 | | | | | |
| 07/17 | 21 | 07/17 | 21 | reservoir | | 34 | 4.65 | 45 | | 134 | | | 7 | 56 | 60 | 98 | | | | | |
| | | | | Number | | 240 | 242 | 241 | 63 | 242 | 225 | 231 | 236 | 242 | 242 | 242 | 80 | 16 | 21 | 21 | 227 |
| | | | | Minimum | | | 2.42 | 6 | 3 | 44 | 3 | 1 | 1 | 11 | 28 | 39 | 5 | 4 | 12 | 6 | 0.00 |
| | | | | Maximum | | | 4.98 | 3796 | 307 | 9383 | 1143 | 1151 | 586 | 2096 | 8191 | 5796 | 51 | 72 | 43 | 31 | 0.34 |
| | | | | Aritn. Avg | | | 3.25 | 404 | 19 | 775 | 82 | 107 | 103 | 369 | 1185 | 917 | 23 | 42 | 21 | 10 | 0.14 |

# Table 5 Henninger Flats Cloudwater Data

**Henninger Flats Cloudwater Data**

| Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uN) | NH4+ (uN) | Ca2+ (uN) | Mg2+ (uN) | Cl- (uN) | NO3- (uN) | SO42- (uN) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 06/20 | 1 | 05:00 | 06:19 | 65 | 3.59 | 272 | 1009 | 73 | 71 | 181 | 974 | 455 | 75 | | | | 0.05 |
| 06/20 | 2 | 06:19 | 06:56 | 45 | 3.39 | 180 | 805 | 39 | 48 | 169 | 877 | 447 | 75 | | | | 0.07 |
| 06/20 | 3 | 06:56 | 07:36 | 24 | 3.19 | 192 | 921 | 46 | 52 | 177 | 1220 | 537 | 80 | | | | 0.03 |
| 06/20 | 5 | 08:08 | 08:47 | 64 | 3.04 | 387 | 1461 | 90 | 103 | 308 | 1841 | 845 | 91 | | | | 0.09 |
| 06/20 | 6 | 08:47 | 09:30 | 45 | 2.92 | 571 | 1743 | 117 | 155 | 452 | 2329 | 996 | 66 | | | | 0.06 |
| 06/20 | 7 | 09:30 | 11:03 | 43 | 2.75 | 1652 | 3509 | 454 | 435 | 975 | 4034 | 2028 | 68 | | | | 0.03 |
| 06/21 | 1 | 01:28 | 02:30 | 7 | 3.75 | 314 | 603 | 118 | 86 | 161 | 787 | 36 | | | | | 0.01 |
| 06/21 | 5 | 02:49 | 05:06 | 44 | 3.15 | 801 | 2411 | 249 | 257 | 486 | 2796 | 1371 | 76 | | | | 0.02 |
| 06/21 | 6 | 05:06 | 05:53 | 43 | 3.04 | 454 | 1743 | 75 | 129 | 314 | 1982 | 1061 | 67 | | | | 0.05 |
| 06/21 | 7 | 05:53 | 06:20 | 44 | 2.97 | 330 | 1467 | 93 | 86 | 258 | 1802 | 934 | 65 | | | | 0.09 |
| 06/21 | 8 | 06:20 | 06:34 | 45 | 3.04 | 243 | 1161 | 63 | 63 | 215 | 1420 | 773 | 54 | | | | 0.18 |
| 06/21 | 9 | 06:34 | 06:50 | 44 | 3.06 | 193 | 945 | 46 | 54 | 202 | 1270 | 705 | 53 | | | | 0.15 |
| 06/21 | 10 | 06:50 | 07:08 | 44 | 3.04 | 183 | 954 | 42 | 49 | 195 | 1252 | 704 | 58 | | | | 0.14 |
| 06/21 | 11 | 07:08 | 07:41 | 44 | 2.91 | 254 | 1229 | 60 | 67 | 223 | 1254 | 842 | 62 | | | | 0.08 |
| 06/21 | 12 | 07:41 | 08:12 | 44 | 2.87 | 339 | 1487 | 85 | 91 | 266 | 1986 | 1094 | 64 | | | | 0.08 |
| 06/21 | 13 | 08:12 | 08:39 | 44 | 2.84 | 434 | 1708 | 111 | 113 | 295 | 2233 | 1243 | 66 | | | | 0.09 |
| 06/21 | 14 | 08:39 | 09:19 | 44 | 2.77 | 624 | 2122 | 188 | 157 | 400 | 3143 | 1642 | 75 | | | | 0.06 |
| 06/21 | 15 | 09:19 | 10:03 | 18 | 2.62 | 1553 | 3172 | 520 | 400 | 666 | 5472 | 2606 | 109 | | | | 0.02 |
| 07/09 | 1 | 23:47 | 01:38 | 36 | 3.88 | 127 | 1502 | 129 | 51 | 198 | 802 | 582 | | | | | 0.02 |
| 07/10 | 2 | 01:38 | 03:09 | 35 | 3.58 | 157 | 1760 | 167 | 63 | 214 | 1181 | 937 | | | | | 0.02 |
| 07/10 | 3 | 03:09 | 05:07 | 29 | 3.28 | 125 | 1530 | 127 | 52 | 197 | 1377 | 810 | | | | | 0.01 |
| 07/10 | 4 | 05:22 | 05:58 | 35 | 3.12 | 195 | 1295 | 159 | 99 | 200 | 1665 | 802 | | | | | 0.06 |
| 07/10 | 5 | 05:58 | 07:07 | 35 | 3.07 | 92 | 996 | 96 | 46 | 124 | 1327 | 438 | | | | | 0.03 |
| 07/10 | 6 | 07:07 | 07:31 | 35 | 3.21 | 50 | 796 | 47 | 20 | 101 | 923 | 368 | | | | | 0.08 |
| 07/10 | 7 | 07:31 | 08:08 | 34 | 3.16 | 55 | 843 | 49 | 20 | 111 | 993 | 412 | | | | | 0.05 |
| 07/10 | 8 | 08:08 | 08:31 | 36 | 3.15 | 65 | 954 | 61 | 24 | 112 | 1144 | 608 | | | | | 0.09 |
| 07/10 | 9 | 08:31 | 09:05 | 35 | 3.15 | 77 | 1103 | 71 | 30 | 117 | 1053 | 544 | | | | | 0.06 |
| 07/10 | 10 | 09:05 | 09:19 | 36 | 3.24 | 66 | 912 | 70 | 31 | 108 | 984 | 642 | | | | | 0.14 |
| 07/10 | 11 | 09:19 | 09:33 | 36 | 3.26 | 48 | 671 | 55 | 21 | 91 | 747 | 429 | | | | | 0.14 |
| 07/10 | 12 | 09:33 | 09:46 | 36 | 3.31 | 58 | 700 | 62 | 23 | 92 | 735 | 408 | | | | | 0.16 |
| 07/10 | 13 | 09:46 | 10:00 | 36 | 3.28 | 58 | 743 | 64 | 24 | 93 | 854 | 545 | | | | | 0.14 |
| 07/10 | 14 | 10:00 | 10:14 | 36 | 3.25 | 56 | 761 | 65 | 26 | 104 | 786 | 431 | | | | | 0.14 |
| 07/10 | 15 | 10:14 | 10:26 | 36 | 3.26 | 56 | 704 | 66 | 24 | 100 | 786 | 431 | | | | | 0.17 |
| 07/10 | 16 | 10:26 | 10:44 | 36 | 3.20 | 70 | 880 | 87 | 29 | 109 | 941 | 524 | | | | | 0.11 |
| 07/10 | 17 | 10:44 | 10:59 | 36 | 3.20 | 59 | 845 | 80 | 25 | 104 | 917 | 497 | | | | | 0.14 |
| 07/10 | 18 | 10:59 | 11:15 | 35 | 3.15 | 75 | 970 | 102 | 31 | 127 | 1096 | 591 | | | | | 0.12 |
| 07/10 | 19 | 11:15 | 11:30 | 35 | 3.17 | 67 | 937 | 96 | 31 | 112 | 1152 | 691 | | | | | 0.13 |
| 07/10 | 20 | reservoir | | 63 | 2.88 | 92 | 1545 | 159 | 47 | 140 | 2065 | 1094 | | | | | |
| 07/16 | 1 | 00:17 | 01:42 | 50 | 2.95 | 83 | 2597 | 146 | 46 | 66 | 1153 | 916 | | | | | 0.03 |
| 07/16 | 2 | 01:43 | 02:17 | 9 | 2.73 | 149 | 4085 | 234 | 75 | 68 | 1908 | 1474 | | | | | 0.07 |
| 07/16 | 4 | 02:48 | 03:50 | 62 | 2.83 | 77 | 3301 | 126 | 41 | 55 | 1307 | 1103 | | | | | 0.06 |
| 07/16 | 5 | 03:50 | 04:59 | 62 | 2.84 | 58 | 3108 | 90 | 29 | 59 | 1211 | 908 | | | | | 0.05 |
| 07/16 | 6 | 04:59 | 05:24 | 62 | 2.95 | 40 | 2219 | 61 | 19 | 43 | 979 | 772 | | | | | 0.14 |
| 07/16 | 7 | 05:24 | 05:43 | 63 | 3.05 | 33 | 1395 | 42 | 14 | 44 | 635 | 426 | | | | | 0.19 |
| 07/16 | 8 | 05:43 | 06:08 | 62 | 3.12 | 25 | 1397 | 32 | 11 | 40 | 641 | 464 | | | | | 0.14 |
| 07/16 | 9 | 06:08 | 06:24 | 63 | 3.14 | 28 | 1172 | 31 | 11 | 44 | 1164 | 842 | | | | | 0.22 |
| 07/16 | 10 | 06:24 | 06:36 | 64 | 3.46 | 50 | 724 | 43 | 17 | 41 | 683 | 480 | | | | | 0.30 |
| 07/16 | 11 | 06:36 | 06:45 | 64 | 3.65 | 50 | 597 | 40 | 17 | 38 | 478 | 310 | | | | | 0.40 |
| 07/16 | 12 | 06:45 | 06:55 | 64 | 3.65 | 41 | 571 | 31 | 14 | 54 | 464 | 294 | | | | | 0.36 |
| 07/16 | 13 | 06:55 | 07:05 | 64 | 3.69 | 31 | 562 | 23 | 11 | 59 | 482 | 315 | | | | | 0.36 |
| 07/16 | 14 | 07:05 | 07:14 | 64 | 4.78 | 23 | 502 | 19 | 9 | 25 | 452 | 281 | | | | | 0.40 |
| 07/16 | 15 | 07:14 | 07:24 | 65 | 3.84 | 15 | 492 | 12 | 6 | 22 | 413 | 259 | | | | | 0.36 |
| 07/16 | 16 | 07:24 | 07:35 | 64 | 3.70 | 13 | 447 | 11 | 5 | 26 | 397 | 238 | | | | | 0.33 |
| 07/16 | 17 | 07:35 | 07:45 | 65 | 3.77 | 10 | 393 | 8 | 3 | 18 | 332 | 177 | | | | | 0.37 |

# Table 5  Henninger Flats Cloudwater Data (continued)

Henninger Flats Cloudwater Data

| Date | Seq | Start | Stop | Vol (ml) | pH | Na+ (uN) | NH4+ (uN) | Ca2+ (uN) | Mg2+ (uN) | Cl- (uN) | NO3- (uN) | SO42- (uN) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | LWC ml/m3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/16 | 18 | 07:45 | 07:54 | 64 | 3.80 | 6 | 324 | 7 | 3 | 18 | 284 | 139 | | | | | 0.40 |
| 07/16 | 15 | 07:54 | 08:06 | 65 | 3.81 | 5 | 329 | 8 | 2 | 18 | 288 | 137 | | | | | 0.30 |
| 07/16 | 20A | reservoir | | 63 | 2.68 | 80 | 2118 | 397 | 77 | 115 | 1643 | 787 | | | | | |
| 07/16 | 20B | reservoir | | 31 | 2.83 | 52 | 1515 | 242 | 50 | 103 | 1164 | 648 | | | | | |
| | | | | | | | | | | | | | | | | | |
| 07/16 | 2 | 16:56 | 17:49 | 61 | 3.03 | 273 | 2435 | 985 | 171 | 301 | 3319 | 2028 | | | | | 0.07 |
| 07/16 | 3 | 17:49 | 18:16 | 61 | 3.30 | 139 | 1235 | 518 | 86 | 155 | 1416 | 993 | | | | | 0.13 |
| 07/16 | 4 | 18:16 | 18:40 | 62 | 3.29 | 85 | 1149 | 265 | 65 | 98 | 1167 | 796 | | | | | 0.15 |
| 07/16 | 5 | 18:40 | 19:03 | 62 | 3.29 | 77 | 1016 | 234 | 59 | 90 | 1055 | 758 | | | | | 0.15 |
| 07/16 | 6 | 19:03 | 19:28 | 63 | 3.20 | 64 | 1092 | 189 | 50 | 81 | 1030 | 824 | | | | | 0.14 |
| 07/16 | 7 | 19:28 | 19:51 | 63 | 3.25 | 50 | 1020 | 136 | 41 | 80 | 1011 | 906 | | | | | 0.15 |
| 07/16 | 8 | 19:51 | 20:14 | 63 | 3.26 | 51 | 999 | 128 | 38 | 80 | 979 | 874 | | | | | 0.15 |
| 07/16 | 9 | 20:14 | 20:35 | 63 | 3.26 | 50 | 848 | 125 | 36 | 76 | 929 | 741 | | | | | 0.17 |
| 07/16 | 10 | 20:35 | 20:53 | 63 | 3.24 | 35 | 786 | 101 | 31 | 54 | 840 | 565 | | | | | 0.20 |
| 07/16 | 11 | 20:53 | 21:11 | 64 | 3.22 | 31 | 741 | 87 | 28 | 48 | 1029 | 660 | | | | | 0.20 |
| 07/16 | 12 | 21:11 | 21:28 | 64 | 3.27 | 23 | 639 | 56 | 20 | 39 | 827 | 447 | | | | | 0.21 |
| 07/16 | 13 | 21:28 | 21:44 | 64 | 3.32 | 27 | 516 | 66 | 22 | 40 | 751 | 366 | | | | | 0.22 |
| 07/16 | 14 | 21:44 | 22:00 | 65 | 3.41 | 18 | 398 | 43 | 16 | 22 | 604 | 274 | | | | | 0.23 |
| 07/16 | 15 | 22:00 | 22:16 | 65 | 3.52 | 12 | 356 | 33 | 12 | 29 | 496 | 221 | | | | | 0.23 |
| 07/16 | 16 | 22:16 | 22:34 | 65 | 3.48 | 20 | 404 | 38 | 13 | 32 | 560 | 241 | | | | | 0.20 |
| 07/16 | 17 | 22:34 | 22:55 | 64 | 3.49 | 17 | 387 | 32 | 12 | 32 | 513 | 212 | | | | | 0.17 |
| 07/16 | 18 | 22:55 | 23:27 | 64 | 3.48 | 13 | 411 | 32 | 12 | 38 | 549 | 235 | | | | | 0.11 |
| 07/17 | 19 | reservoir | | 40 | 3.94 | 3 | 273 | 15 | 7 | 27 | 231 | 155 | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | N | | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 17 | | | | 72 |
| | | Arith. Avg. | | 3765 | 3.25 | 166 | 1203 | 118 | 57 | 142 | 1206 | 689 | 71 | | | | 0.14 |
| | | Min | | | 2.62 | 3 | 273 | 7 | 2 | 18 | 231 | 36 | 53 | | | | 0.01 |
| | | Max | | | 4.78 | 1652 | 4085 | 985 | 435 | 975 | 5472 | 2606 | 109 | | | | 0.40 |

Table 6  San Pedro Hill Aerosol Data

| Date | Seq | START | STOP | Na+ | NH4+ | Ca2+ | Mg2+ | Cl- | NO3- | SO42- | NH3 | HNO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | neq / m3 | | | | | | | | |
| 06/19 | A | 01:00 | 05:00 | 170 | 119 | 25.1 | 44.3 | 90.2 | 142 | 113 | -0.9 | 15.5 |
| 06/19 | B | 06:00 | 09:00 | 188 | 74 | 15.9 | 42.4 | 105.4 | 81 | 124 | -1.2 | 26.6 |
| 06/19 | C | 09:00 | 12:00 | 181 | 93 | 22.1 | 46.3 | 88.9 | 103 | 133 | -1.2 | 27.1 |
| 06/19 | D | 20:00 | 00:00 | 115 | 94 | 24.8 | 33.5 | 51.5 | 102 | 104 | 14.5 | 28.4 |
| 06/20 | A | 02:00 | 06:00 | 60 | 73 | 17.2 | 29.5 | 60.2 | 94 | 93 | 2.9 | 10.7 |
| 06/20 | B | 08:00 | 12:00 | 168 | 89 | 17.8 | 45.2 | 72.3 | 99 | 127 | -0.9 | 23.6 |
| 06/23 | A | 20:00 | 00:00 | 110 | NA | 19.9 | 26.2 | 34.1 | 187 | 294 | -0.9 | 123.7 |
| 06/24 | A | 00:00 | 03:00 | 24 | NA | 14.4 | 2.5 | 7.9 | 51 | 37 | -1.2 | -0.5 |
| 06/24 | B | 03:00 | 06:00 | 67 | NA | 27.2 | 18.6 | 86.9 | 435 | 475 | -1.2 | 12.9 |
| 06/24 | C | 07:30 | 08:00 | 13 | 318 | 16.1 | 6.7 | 0.0 | 43 | 340 | -7.5 | 106.8 |
| 06/24 | D | 10:00 | 14:00 | 171 | 194 | 18.4 | 19.1 | 8.8 | 108 | 267 | -0.9 | 140.5 |
| 06/24 | E | 14:00 | 18:00 | 173 | 162 | 34.9 | 48.8 | 39.5 | 147 | 188 | 38.4 | 131.8 |
| 06/24 | F | 20:00 | 00:00 | 59 | 447 | 17.5 | 26.0 | 7.6 | 211 | 317 | -0.9 | 46.7 |
| 06/25 | A | 01:15 | 05:00 | 32 | 297 | 17.0 | 6.3 | NA | 32 | 338 | 0.6 | 17.3 |
| 06/25 | B | 05:00 | 09:00 | 5 | 17 | 15.3 | 0.0 | NA | 7 | 22 | 19.1 | -0.1 |
| 06/25 | C | 07:57 | 10:30 | 90 | 261 | 47.3 | 15.4 | 0.0 | 68 | 314 | -1.5 | 162.7 |
| 06/25 | D | 11:00 | 15:00 | 99 | 197 | 30.4 | 26.3 | 0.0 | 81 | 255 | 6.8 | 133.0 |
| 06/25 | E | 16:00 | 20:00 | NA | NA | NA | NA | NA | NA | NA | 0.0 | 92.3 |
| 06/25 | F | 22:00 | 02:00 | 83 | 624 | 34.9 | 17.2 | 7.5 | 385 | 291 | 10.6 | 41.3 |
| 07/06 | A | 20:00 | 00:00 | 122 | NA | 23.8 | 26.4 | 64.4 | 189 | 131 | -0.9 | NA |
| 07/07 | A | 00:00 | 04:00 | 70 | NA | 18.0 | 14.5 | 67.2 | 136 | 125 | -0.9 | 21.1 |
| 07/07 | C | 09:00 | 12:00 | | | | | | | | 0.0 | 35.9 |
| 07/07 | E | 09:00 | 12:00 | NA | NA | NA | NA | NA | NA | NA | 49.2 | 38.5 |
| 07/07 | D | 14:00 | 18:00 | NA | NA | NA | NA | NA | NA | NA | 0.0 | 26.7 |
| 07/12 | A | 20:00 | 00:00 | 15 | 55 | 19.9 | 3.6 | 0.0 | 20 | 85 | 16.0 | 49.1 |
| 07/13 | A | 00:00 | 03:00 | 0 | 1 | 18.7 | 1.8 | 0.0 | 6 | 4 | -1.2 | -2.3 |
| 07/13 | B | 03:00 | 06:00 | 17 | 94 | 55.9 | 8.6 | 20.7 | 38 | 70 | 21.4 | 79.0 |
| 07/13 | C | 08:00 | 12:00 | 69 | 375 | 32.9 | 18.8 | 0.7 | 90 | 182 | 104.8 | 158.2 |
| 07/13 | D | 12:00 | 15:00 | 76 | 132 | 25.6 | 17.3 | 2.9 | 89 | 135 | 61.5 | 80.3 |
| 07/13 | E | 15:00 | 18:00 | 44 | 79 | 17.7 | 10.9 | 0.0 | 34 | 79 | 36.8 | 38.5 |
| 07/13 | F | 20:10 | 00:00 | 21 | 68 | 27.4 | 11.5 | 0.0 | 20 | 94 | 28.8 | 22.0 |
| 07/14 | A | 02:00 | 06:00 | 14 | 161 | 6.8 | 1.7 | 0.0 | 6 | 180 | -0.9 | 6.3 |
| 07/14 | B | 08:00 | 12:00 | 61 | 430 | 25.4 | 17.7 | 0.0 | 41 | 448 | 2.9 | 166.0 |
| 07/14 | C | 14:00 | 18:00 | 73 | NA | 28.9 | 16.6 | 10.8 | 57 | 179 | 45.4 | 79.9 |
| 07/14 | D | 20:00 | 00:00 | 11 | 0 | 15.8 | 3.7 | 12.7 | NA | 42 | -0.9 | 3.4 |
| 07/15 | A | 02:00 | 04:00 | 7 | 0 | 5.6 | 0.0 | NA | 23 | 32 | -1.9 | 5.9 |
| 07/15 | B | 04:00 | 06:00 | 0 | NA | 0.0 | 0.0 | NA | 86 | 96 | -1.9 | 0.9 |
| 07/15 | C | 06:00 | 08:00 | 20 | NA | 7.1 | 0.9 | 19.9 | 124 | 166 | -1.9 | NA |
| 07/15 | D | 08:00 | 10:00 | 7 | NA | 19.0 | 0.0 | 35.0 | 46 | 82 | -1.9 | NA |
| 07/15 | E | 10:00 | 11:30 | 0 | NA | 0.0 | 0.0 | NA | 16 | 75 | -2.5 | NA |
| 07/15 | F | 14:00 | 18:00 | 24 | NA | 17.8 | 7.3 | 16.3 | 36 | 101 | 19.9 | NA |
| 07/15 | G | 20:00 | 00:00 | 14 | NA | 38.8 | 8.3 | 26.8 | 137 | 200 | -0.9 | NA |

NA indicates sample not analyzed

Table 7  Henninger Flats Aerosol Data

| Date | Seq | START | STOP | Na+ | NH4+ | Ca2+ | Mg2+ | Cl- | NO3- | SO42- | NH3 | HNO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | neq / m3 | | | | | | | | |
| 06/19 | A | 01:00 | 05:00 | 8 | 3 | 0.1 | 0.0 | 0.0 | 9 | 5 | -0.9 | 12.8 |
| 06/19 | B | 06:00 | 09:00 | 0 | 5 | 0.0 | 0.0 | 0.0 | 8 | 5 | -1.2 | 10.9 |
| 06/19 | C | 09:00 | 12:00 | 1 | 4 | 1.4 | 1.4 | 0.0 | 7 | 7 | -1.2 | 17.5 |
| 06/24 | A | 02:00 | 06:00 | 33 | 77 | 24.3 | 11.8 | 2.3 | 51 | 74 | 2.9 | 65.4 |
| 06/24 | B | 06:00 | 10:00 | 36 | 117 | 12.5 | 13.9 | 0.0 | 63 | 102 | -0.9 | 161.5 |
| 06/24 | C | 10:00 | 14:00 | 134 | 838 | 71.3 | 53.6 | 28.7 | 442 | 533 | 78.5 | 812.2 |
| 06/24 | A | 17:00 | 20:00 | 107 | 551 | 63.9 | 23.2 | 0.0 | 193 | 446 | 24.5 | 479.1 |
| 06/24 | B | 20:00 | 00:00 | 59 | 239 | 28.3 | 13.8 | NA | 114 | 189 | 30.7 | 47.4 |
| 06/25 | B | 14:00 | 18:00 | 106 | 645 | 92.9 | 27.3 | 22.5 | 287 | 479 | 98.6 | 897.0 |
| 06/25 | C | 20:00 | 00:00 | 38 | 284 | 32.8 | 9.4 | 0.0 | 83 | 234 | 18.4 | 78.4 |
| 06/25 | A | 02:00 | 06:00 | 54 | 250 | 34.7 | 14.8 | NA | 77 | 217 | 10.6 | 69.4 |
| 06/26 | A | 02:00 | 06:00 | 44 | 188 | 34.6 | 12.9 | 21.2 | 65 | 174 | 20.7 | 112.7 |
| 07/06 | A | 20:00 | 00:00 | 56 | 193 | 30.9 | 13.7 | 0.0 | 123 | 141 | -0.9 | 63.1 |
| 07/07 | A | 02:00 | 06:00 | 29 | 75 | 16.4 | 7.6 | 0.0 | 46 | 66 | -0.9 | 28.4 |
| 07/07 | B | 08:00 | 12:00 | 75 | 421 | 46.3 | 22.4 | 0.0 | 202 | 311 | 6.8 | 277.8 |
| 07/12 | A | 20:00 | 00:00 | 21 | 93 | 33.5 | 9.3 | 7.8 | 28 | 81 | 26.8 | 72.9 |
| 07/13 | A | 02:00 | 06:00 | 4 | 27 | 2.9 | 4.0 | 0.0 | 12 | 33 | 9.1 | 17.4 |
| 07/13 | B | 08:00 | 12:00 | 21 | 183 | 27.9 | 13.7 | 0.0 | 99 | 96 | 91.7 | 251.2 |
| 07/14 | A | 20:00 | 00:00 | 35 | 151 | 27.7 | 13.2 | NA | 76 | 116 | 23.8 | |
| 07/15 | A | 02:00 | 06:00 | 15 | 111 | 10.7 | 4.0 | 0.0 | 30 | 95 | 1.4 | |
| 07/15 | B | 08:00 | 12:00 | 54 | 543 | 38.8 | 14.8 | NA | 254 | 313 | 58.5 | |

NA indicates sample not analyzed

Table 8  Kellogg Hill Aerosol Data

| Date | Seq | START | STOP | Na+ | NH4+ | Ca2+ | Mg2+ | Cl- | NO3- | SO42- | NH3 | HNO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | neq / m3 | | | | | | | | |
| 06/19 | A | 01:00 | 05:00 | 183 | 178 | 73.4 | 60.3 | 72.1 | 190 | 136 | 283.0 | 9.5 |
| 06/19 | B | 06:00 | 09:00 | 168 | 273 | 95.8 | 60.8 | 62.7 | 226 | 191 | 192.2 | 16.0 |
| 06/19 | C | 09:00 | 12:00 | 8 | 9 | 62.3 | 12.0 | 0.0 | 10 | 7 | -1.2 | 6.1 |
| 06/24 | A | 02:00 | 06:00 | 140 | 581 | 64.6 | 41.9 | 15.6 | 452 | 291 | -0.9 | 59.8 |
| 06/24 | B | 06:00 | 10:00 | 145 | 767 | 153.6 | 59.8 | 15.8 | 582 | 359 | 26.8 | 152.2 |
| 06/24 | C | 10:00 | 13:50 | 149 | 875 | 192.8 | 61.6 | 0.0 | 567 | 451 | 131.9 | 624.0 |
| 06/24 | D | 20:00 | 00:00 | 124 | 250 | 78.3 | 35.8 | 0.0 | 234 | 203 | 34.6 | 52.7 |
| 06/24 | E | 02:00 | 06:00 | 125 | 594 | 109.3 | 25.6 | 0.0 | 392 | 372 | 26.8 | 63.1 |
| 06/25 | B | 20:00 | 00:00 | 84 | 279 | 51.3 | 28.2 | 10.9 | 191 | 167 | 58.5 | 52.3 |
| 06/25 | C | 02:00 | 06:00 | 62 | 549 | 40.1 | 11.1 | 12.0 | 372 | 271 | 34.6 | 43.4 |
| 06/25 | D | 08:00 | 12:00 | 66 | 838 | 116.3 | 32.2 | 0.2 | 496 | 441 | 154.9 | 385.8 |
| 06/25 | A | 08:00 | 12:00 | 115 | 784 | 179.0 | 48.8 | NA | 629 | 415 | 279.2 | 360.8 |
| 07/06 | | 20:00 | 00:00 | 95 | 258 | 88.4 | 20.6 | 6.8 | 232 | 155 | 65.4 | 48.2 |
| 07/07 | | 08:00 | 12:00 | 108 | 383 | 160.6 | 39.4 | 10.8 | 300 | 249 | 46.9 | 210.7 |
| 07/07 | | 02:00 | 06:00 | 140 | 494 | 103.3 | 41.8 | 25.6 | 423 | 220 | 35.3 | 37.8 |
| 07/12 | A | 20:10 | 00:00 | 44 | 139 | 60.1 | 16.9 | 1.3 | 91 | 94 | 146.4 | 44.0 |
| 07/13 | A | 01:00 | 05:00 | 70 | 177 | 58.4 | 21.7 | 12.4 | 124 | 108 | 102.5 | 8.8 |
| 07/13 | B | 07:00 | 11:00 | 54 | 368 | 269.7 | 53.1 | 4.9 | 309 | 149 | 339.3 | 197.4 |

NA indicates sample not analyzed

## Table 9 Collector Blank Analyses

| Date | Site | Description | Na+ (uM) | NH4+ (uM) | Ca2+ (uM) | Mg2+ (uM) | Cl- (uM) | NO3- (uM) | SO42- (uM) |
|---|---|---|---|---|---|---|---|---|---|
| 06/13 | SPH | reservoir only after rinse | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 06/13 | SPH | first after rinse | 2 | 4 | 3 | 1 | 7 | 0 | 0 |
| 06/13 | SPH | second after rinse | 1 | 3 | 1 | 0 | 6 | 0 | 0 |
| 06/18 | SPH | reservoir only after rinse | 7 | 2 |  | 2 | 13 | 9 | 9 |
| 06/18 | SPH | blank #1 after rinsing | 50 | 16 |  | 10 | 49 | 22 | 21 |
| 06/18 | SPH | blank #2 after rinsing | 27 | 10 |  | 6 | 32 | 17 | 18 |
| 06/20 | SPH | clear bottle left in fridge | 0 | 0 | 0 | 0 | 6 | 0 | 9 |
| 06/21 | SPH | blank after rinsing | 78 | 16 | 14 | 20 | 68 | 48 | 26 |
| 06/22 | SPH | blank after rinsing | 40 | 54 | 13 | 12 | 33 | 77 | 71 |
| 06/23 | SPH | reservoir only after rinse | 5 | 7 | 1 | 2 | 8 | 15 | 11 |
| 06/24 | SPH |  |  | 64 | 4 |  | 6 | 44 | 52 |
| 06/25 | SPH | blank after cleaning |  |  | 5 |  | 23 | 80 | 74 |
| 07/02 | SPH | blank after rinsing | 211 | 83 | 39 | 54 | 134 | 228 | 144 |
| 07/06 | SPH | blank after rinsing |  | 30 | 4 | 5 | 20 | 47 | 46 |
| 07/07 | SPH | unused bottle |  | 0 | 0 | 0 | 0 | 0 | 0 |
| 07/07 | SPH | blank after rinsing |  | 11 | 3 | 5 | 25 | 20 | 16 |
| 07/12 | SPH | blank after rinsing | 2 | 3 | 4 | 2 | 5 | 7 | 6 |
| 07/13 | SPH | blank after rinsing | 3 | 7 | 1 | 2 | 8 | 12 | 8 |
| 07/13 | SPH | blank at 2000 | 24 | 17 | 10 | 9 | 16 | 33 | 20 |
| 07/14 | SPH | blank after rinsing | 15 | 27 | 8 | 6 | 3 | 22 | 42 |
| 07/14 | SPH | blank after rinsing | 5 | 11 | 4 | 2 | 1 | 11 | 15 |
| 07/15 | SPH | blank on large rods | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  |  |  |  |  |  |  |  |  |  |
| 06/09 | HF | blank after rinsing | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| 06/09 | HF | blank after rinsing | 1 | 3 | 0 | 0 | 0 | 0 | 0 |
| 06/14 | HF | blank after rinsing | 7 | 27 | 7 | 3 | 7 | 0 | 32 |
| 06/15 | HF | blank after rinsing | 2 | 6 | 2 | 1 | 0 | 0 | 0 |
| 06/18 | HF | rinse blank | 3 | 15 | 2 | 1 | 11 | 20 | 11 |
| 06/19 | HF | sitting overnight w/o rinse | 67 | 80 | 30 | 19 | 18 | 133 | 72 |
| 06/19 | HF | after 100 ml rinse | 18 | 27 | 10 | 5 | 10 | 44 | 24 |
| 06/20 | HF | reservoir only after rinse | 13 | 25 | 1 | 3 | 8 | 38 | 20 |
| 06/20 | HF | system after rinse | 33 | 50 | 9 | 8 | 14 | 75 | 36 |
| 06/22 | HF | post cleaning strands, left in fridge | 5 | 19 | 2 | 2 | 3 | 23 | 19 |
| 06/23 | HF | blank after rinsing | 8 | 29 | 0 | 5 | 27 | 48 | 23 |
| 06/24 | HF | blank after rinsing | 0 | 0 | 0 | 0 | 7 | 0 | 0 |
| 06/25 | HF | reservoir only after rinse | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| 06/30 | HF | blank #1 after rinsing | 9 | 17 | 8 | 4 | 7 | 47 | 14 |
| 06/30 | HF | blank #2 after rinsing | 5 | 10 | 4 | 1 | 8 | 23 | 8 |
| 07/02 | HF | blank after rinsing | 3 | 13 | 5 | 1 | 23 | 19 | 12 |
| 07/04 | HF | blank after rinsing | 1 | 9 | 2 | 0 | 6 | 15 | 7 |
| 07/07 | HF | blank after rinsing | 27 | 28 | 13 | 8 | 8 | 73 | 21 |
| 07/08 | HF | blank after rinsing | 147 | 314 |  |  | 74 | 419 | 206 |
| 07/09 | HF | reservoir only after rinse | 1 | 0 | 0 | 0 | 6 | 6 | 0 |
| 07/09 | HF | system after rinse | 10 | 3 | 1 | 0 | 9 | 12 | 0 |
| 07/09 | HF | system after rinse | 6 | 3 | 1 | 0 | 7 | 10 | 6 |
| 07/10 | HF | blank after rinsing | 0 | 3 | 1 | 0 | 6 | 8 | 0 |
| 07/11 | HF | rinse of bottle sitting in fridge | 0 | 0 | 0 | 0 | 24 | 0 | 0 |
| 07/12 | HF | before rinsing, sat 2 days w/o sampling | 19 | 117 | 39 | 15 | 10 | 102 | 98 |
| 07/12 | HF | after rinsing | 1 | 4 | 2 | 0 | 4 | 6 | 6 |
| 07/13 | HF | collector only, left in fridge overnight | 1 | 7 | 3 | 1 | 6 | 14 | 6 |
| 07/14 | HF | blank after rinsing | 3 | 11 | 6 | 1 | 5 | 18 | 8 |
| 07/14 | HF | blank after rinsing | 3 | 11 | 6 | 2 | 4 | 17 | 10 |
| 07/15 | HF | blank after rinsing | 2 | 104 | 2 | 1 | 6 | 17 | 0 |
| 07/15 | HF | blank after rinsing | 1 | 60 | 2 | 0 | 8 | 21 | 0 |
| 07/17 | HF | blank after rinsing | 1 | 10 | 1 | 0 | 4 | 11 | 0 |

## Table 10 Size-fractionated sample concentrations

| Date | f/b | Seq | Start | Stop | Vol (ml) | pH | Na+ (uN) | NH4+ (uN) | Ca2+ (uN) | Mg2+ (uN) | Cl- (uN) | NO3- (uN) | SO42- (uN) | S(IV) (uM) | CH2O (uM) | H2O2 (uM) | HFo (uM) | HAc (uM) | -/+ | Rate ml/min |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07/15 | f | 21 | 04:00 | 04:30 | 70 | 3.40 | 18 | 190 | 7 | 5 | 38 | 356 | 251 | | | | | | 1.04 | 2.3 |
| 07/15 | f | 22 | 04:33 | 05:00 | 68 | 3.34 | 30 | 251 | 12 | 8 | 66 | 396 | 355 | | 10 | 10 | 19 | 11 | 1.08 | 2.5 |
| 07/15 | f | 23 | 05:00 | 05:30 | 71 | 3.27 | 48 | 323 | 22 | 13 | 75 | 465 | 461 | | 16 | 0 | 21 | 13 | 1.06 | 2.4 |
| 07/15 | f | 24 | 05:30 | 06:00 | 71 | 3.26 | 53 | 615 | 55 | 16 | 70 | 618 | 595 | | 27 | 0 | 40 | 19 | 1.00 | 2.4 |
| 07/15 | f | 25 | 06:00 | 06:30 | 74 | 3.29 | 64 | 899 | 40 | 19 | 65 | 706 | 732 | | 29 | 0 | 37 | 18 | 0.98 | 2.5 |
| 07/15 | f | 26 | 06:30 | 07:00 | 112 | 3.42 | 87 | 391 | 22 | 21 | 81 | 399 | 436 | | 15 | 0 | 26 | 11 | 1.02 | 3.7 |
| 07/15 | f | 27 | 07:00 | 07:30 | 121 | 3.42 | 55 | 202 | 12 | 14 | 72 | 276 | 343 | | 13 | 0 | 17 | 9 | 1.04 | 4.0 |
| 07/15 | f | 28 | 07:30 | 08:00 | 136 | 3.44 | 36 | 191 | 8 | 10 | 58 | 219 | 328 | | 13 | 4 | 19 | 9 | 0.99 | 4.5 |
| 07/15 | f | 29 | 08:00 | 08:30 | 122 | 3.49 | 25 | 192 | 6 | 7 | 42 | 223 | 288 | | 13 | 10 | 18 | 10 | 1.02 | 4.0 |
| 07/15 | f | 30 | 08:30 | 09:00 | 116 | 3.52 | 23 | 166 | 8 | 7 | 40 | 204 | 271 | | 13 | 16 | 20 | 9 | 1.02 | 3.9 |
| 07/15 | f | 31 | 09:00 | 09:30 | 114 | 3.56 | 45 | 164 | 17 | 13 | 48 | 188 | 242 | | | | | | 0.93 | 3.8 |
| 07/15 | f | 32 | 09:30 | 10:00 | 110 | 3.64 | 39 | 138 | 13 | 11 | 122 | 178 | 214 | | | | | | 1.19 | 3.7 |
| 07/15 | f | 33 | 10:00 | 10:30 | 56 | 3.42 | 27 | 234 | 20 | 10 | 35 | 192 | 228 | | | | | | 0.68 | 1.9 |
| 07/15 | f | 34 | 10:30 | 11:00 | 64 | 3.40 | 48 | 275 | 54 | 19 | 84 | 337 | 418 | | 18 | 49 | 33 | 13 | 1.06 | 2.1 |
| 07/15 | f | 35 | 11:30 | 12:00 | 40 | 3.54 | 161 | 274 | 217 | 57 | 116 | 341 | 564 | | | | | | 1.02 | 1.3 |
| 07/15 | f | 36 | 12:00 | 13:00 | 30 | 3.38 | 478 | 432 | 515 | 175 | 326 | 730 | 1087 | | | | | | 1.06 | 0.5 |
| | | | Samples from rear strands: Small droplets | | | | | | | | | | | | | | | | | |
| 07/15 | b | 21 | 04:00 | 04:30 | 43 | 3.56 | 7 | 171 | 4 | 2 | 25 | 233 | 192 | | | | | | 0.98 | 1.4 |
| 07/15 | b | 22 | 04:33 | 05:00 | 29 | 3.42 | 11 | 267 | 5 | 3 | 57 | 326 | 301 | | 11 | 9 | 16 | 10 | 1.03 | 1.1 |
| 07/15 | b | 23 | 05:00 | 05:30 | 28 | 3.28 | 12 | 376 | 6 | 4 | 57 | 478 | 433 | | 13 | 0 | 18 | 11 | 1.05 | 0.9 |
| 07/15 | b | 24 | 05:30 | 06:00 | 31 | 3.10 | 13 | 804 | 8 | 3 | 100 | 823 | 684 | | 26 | 0 | 34 | 17 | 0.99 | 1.0 |
| 07/15 | b | 25 | 06:00 | 06:30 | 28 | 3.08 | 14 | 1479 | 7 | 4 | 118 | 1152 | 1016 | | 55 | 0 | 38 | 22 | 0.98 | 0.9 |
| 07/15 | b | 26 | 06:30 | 07:00 | 38 | 3.24 | 11 | 845 | 4 | 2 | 88 | 728 | 692 | | 25 | 0 | 32 | 20 | 0.98 | 1.3 |
| 07/15 | b | 27 | 07:00 | 07:30 | 39 | 3.35 | 13 | 424 | 4 | 4 | 76 | 401 | 432 | | 17 | 0 | 18 | 9 | 1.02 | 1.3 |
| 07/15 | b | 28 | 07:30 | 08:00 | 38 | 3.38 | 12 | 341 | 3 | 3 | 52 | 303 | 393 | | 16 | 3 | 19 | 9 | 0.96 | 1.3 |
| 07/15 | b | 29 | 08:00 | 08:30 | 30 | 3.42 | 16 | 317 | 7 | 5 | 51 | 281 | 397 | | 17 | 6 | 19 | 10 | 1.01 | 1.0 |
| 07/15 | b | 30 | 08:30 | 09:00 | 32 | 3.47 | 18 | 260 | 9 | 7 | 52 | 242 | 352 | | 14 | 11 | 23 | 10 | 1.02 | 1.1 |
| 07/15 | b | 31 | 09:00 | 09:30 | 22 | 3.49 | 10 | 242 | 5 | 3 | 34 | 187 | 280 | | | | | | 0.86 | 0.7 |
| 07/15 | b | 32 | 09:30 | 10:00 | 35 | 3.59 | 14 | 205 | 7 | 5 | 105 | 184 | 250 | | | | | | 1.11 | 1.2 |
| 07/15 | b | 33 | 10:00 | 10:30 | 16 | 3.46 | 21 | 282 | 15 | 8 | 50 | 256 | 350 | | | | | | 0.97 | 0.5 |
| 07/15 | b | 34 | 10:30 | 11:00 | 30 | 3.25 | 35 | 488 | 22 | 14 | 123 | 462 | 606 | | 21 | 39 | 40 | 17 | 1.06 | 1.0 |
| 07/15 | b | 35 | 11:30 | 12:00 | 16 | 3.24 | 29 | 478 | 30 | 12 | 96 | 408 | 654 | | | | | | 1.03 | 0.5 |
| 07/15 | b | 36 | 12:00 | 13:00 | 14 | 2.96 | 76 | 685 | 73 | 30 | 172 | 705 | 1143 | | | | | | 1.03 | 0.2 |
| | | | Combined Values | | | | | | | | | | | | | | | | | "LWC" (ml/m3 |
| 07/15 | | 21 | 04:00 | 04:30 | 112 | 3.45 | 14 | 182 | 6 | 4 | 33 | 309 | 229 | | | | | | 1.02 | 0.21 |
| 07/15 | | 22 | 04:33 | 05:00 | 97 | 3.36 | 24 | 256 | 10 | 6 | 63 | 376 | 339 | | 10 | | | | 1.06 | 0.20 |
| 07/15 | | 23 | 05:00 | 05:30 | 99 | 3.27 | 38 | 338 | 18 | 10 | 70 | 469 | 453 | | 15 | | | | 1.06 | 0.18 |
| 07/15 | | 24 | 05:30 | 06:00 | 102 | 3.20 | 41 | 672 | 41 | 12 | 79 | 680 | 622 | | 27 | | | | 0.99 | 0.19 |
| 07/15 | | 25 | 06:00 | 06:30 | 101 | 3.22 | 50 | 1057 | 31 | 15 | 79 | 827 | 809 | | 36 | | | | 0.98 | 0.19 |
| 07/15 | | 26 | 06:30 | 07:00 | 150 | 3.37 | 67 | 532 | 18 | 16 | 83 | 483 | 501 | | 18 | | | | 1.00 | 0.28 |
| 07/15 | | 27 | 07:00 | 07:30 | 160 | 3.40 | 45 | 256 | 10 | 12 | 73 | 307 | 365 | | 14 | | | | 1.04 | 0.30 |
| 07/15 | | 28 | 07:30 | 08:00 | 174 | 3.43 | 31 | 224 | 7 | 8 | 57 | 238 | 342 | | 14 | | | | 0.99 | 0.32 |
| 07/15 | | 29 | 08:00 | 08:30 | 151 | 3.48 | 23 | 216 | 6 | 7 | 44 | 234 | 318 | | 13 | | | | 1.01 | 0.28 |
| 07/15 | | 30 | 08:30 | 09:00 | 147 | 3.51 | 22 | 186 | 8 | 7 | 42 | 212 | 288 | | 13 | | | | 1.02 | 0.28 |
| 07/15 | | 31 | 09:00 | 09:30 | 136 | 3.55 | 39 | 177 | 15 | 11 | 46 | 188 | 248 | | | | | | 0.92 | 0.25 |
| 07/15 | | 32 | 09:30 | 10:00 | 145 | 3.63 | 33 | 154 | 12 | 10 | 118 | 180 | 223 | | | | | | 1.17 | 0.27 |
| 07/15 | | 33 | 10:00 | 10:30 | 71 | 3.43 | 26 | 244 | 19 | 10 | 38 | 206 | 255 | | | | | | 0.74 | 0.13 |
| 07/15 | | 34 | 10:30 | 11:00 | 94 | 3.35 | 44 | 344 | 44 | 17 | 97 | 377 | 478 | | 19 | | | | 1.06 | 0.18 |
| 07/15 | | 35 | 11:30 | 12:00 | 57 | 3.43 | 123 | 332 | 164 | 44 | 110 | 360 | 590 | | | | | | 1.03 | 0.11 |
| 07/15 | | 36 | 12:00 | 13:00 | 44 | 3.20 | 351 | 512 | 374 | 129 | 277 | 722 | 1105 | | | | | | 1.05 | 0.04 |

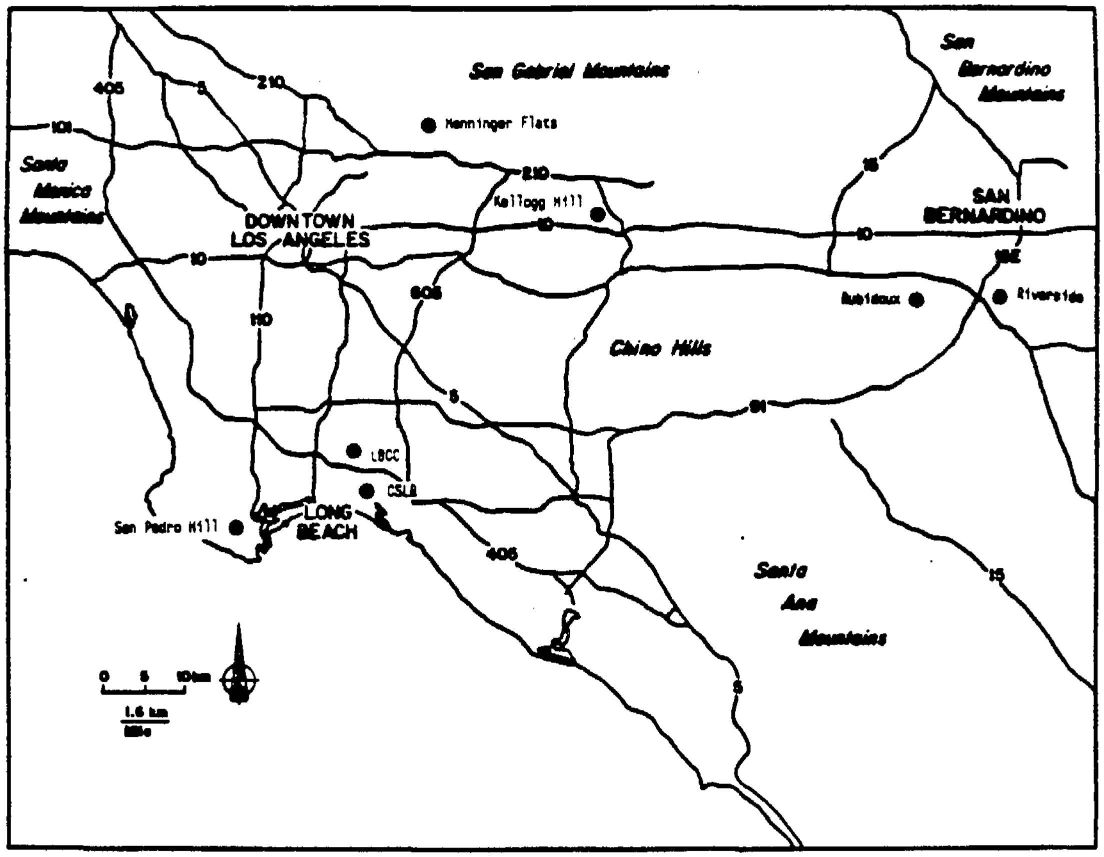

Figure 1. Map of the Los Angeles area showing the seven sites used for sampling cloud and fogwater, aerosol, and selected gases during the summer and winter portions of the South Coast Air Quality Study (SCAQS). Sites are depicted by a bold dot. Also shown on the map are major freeways and mountains.

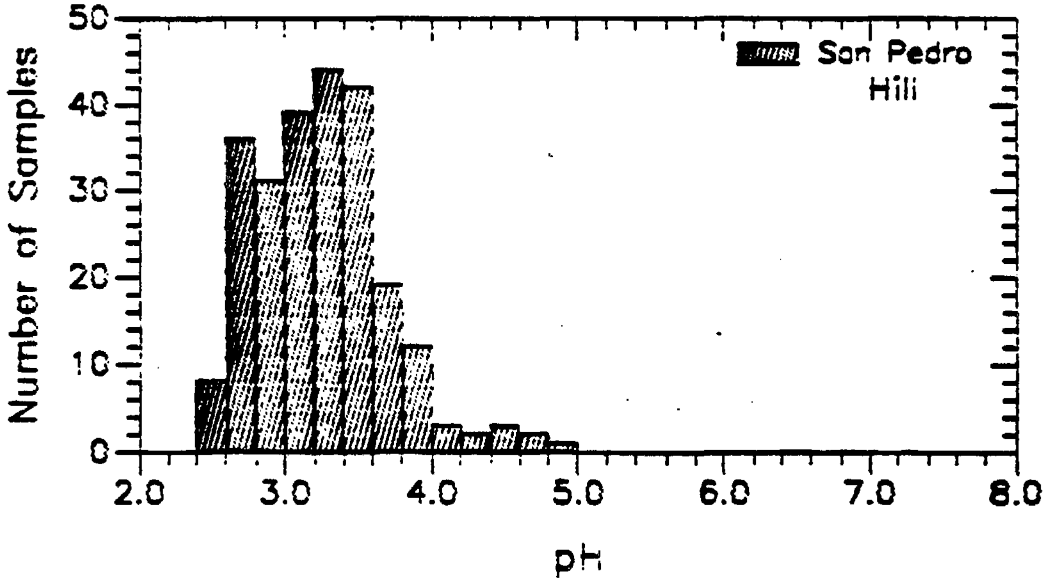

Figure 2. pH distribution of intercepted stratus cloudwater samples collected at San Pedro Hill during the summer of 1987.

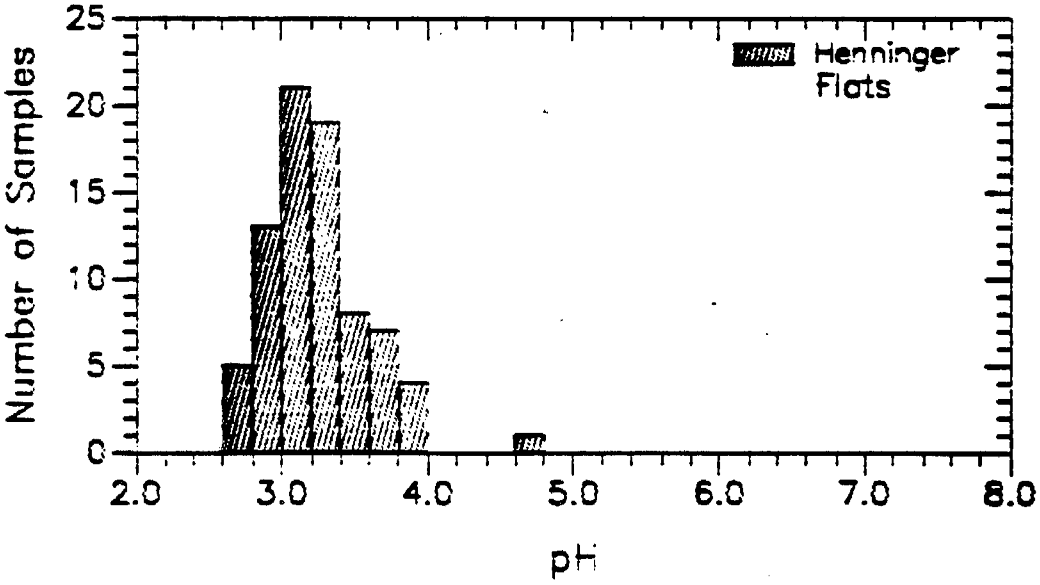

Figure 3. pH distribution of intercepted stratus cloudwater samples collected at Henninger Flats during the summer of 1987.

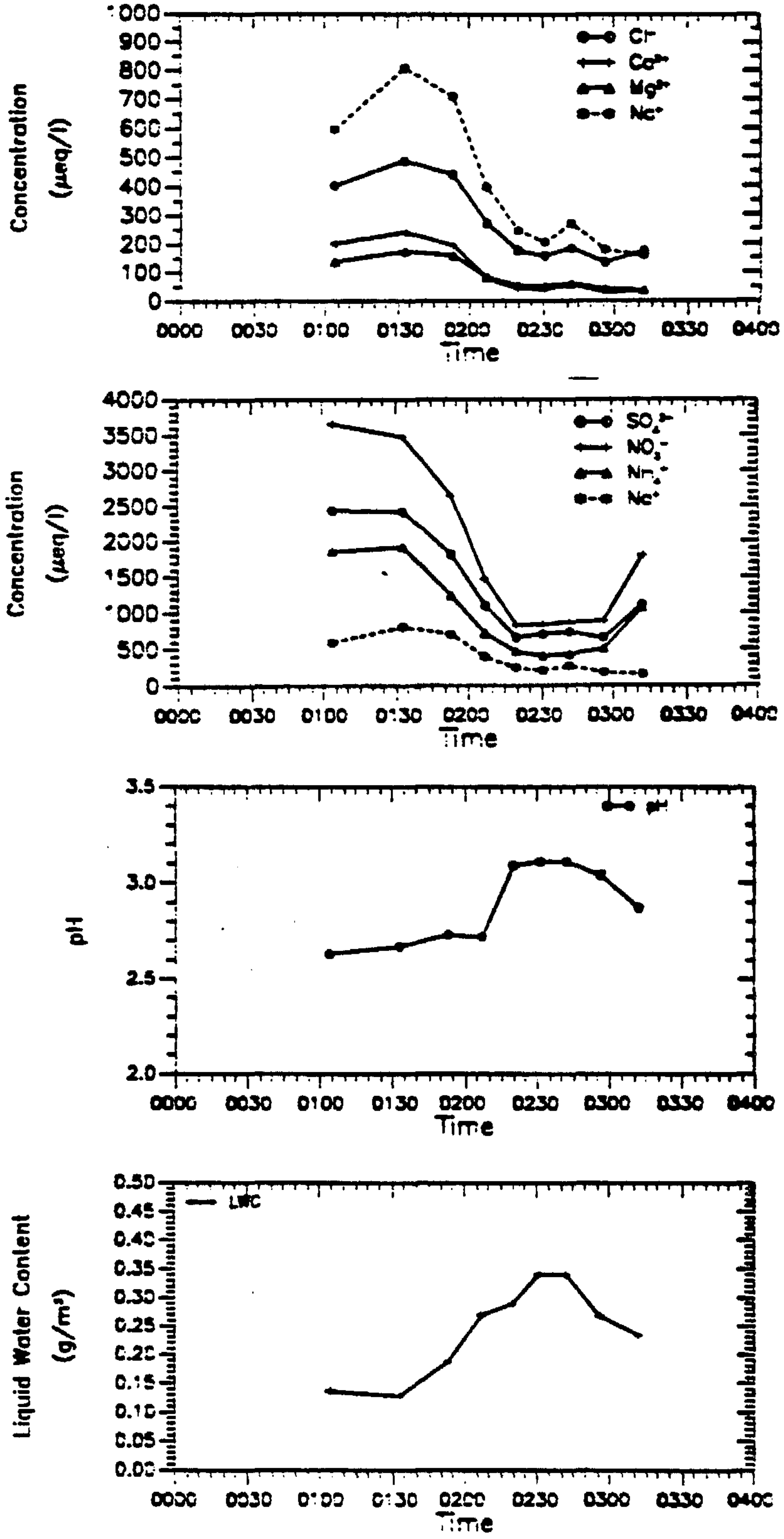

Figure 4. Time trace indicating rapid changes of observed species concentrations, pH, and liquid water content during the morning of June 25, 1987, at San Pedro Hill. Samples were collected as rapidly as one every ten minutes by the CASC and the autosampler during this period.

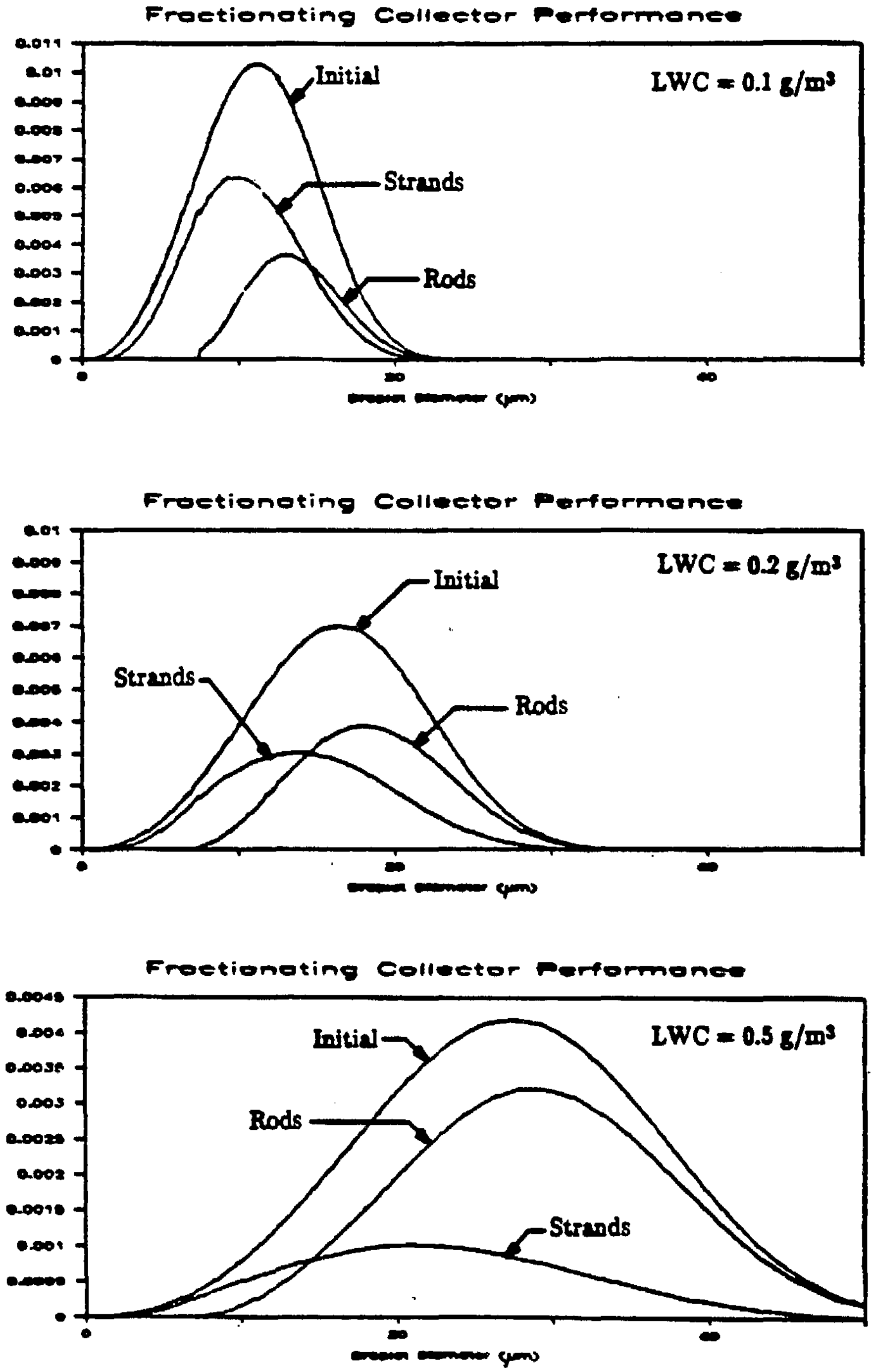

Figure 5. Performance of the fractionating collector is illustrated for three different liquid water contents. Shown for each liquid water content are the initial droplet distribution (based on Best's formula; Best, 1951), the portion of the droplet spectrum collected on the large rods in the fractionating inlet, and the portion collected by the CASC strands in the main body of the collector. The collection efficiencies are based on impaction theory and the percentage of airflow through the collector sampled by each collection surface.

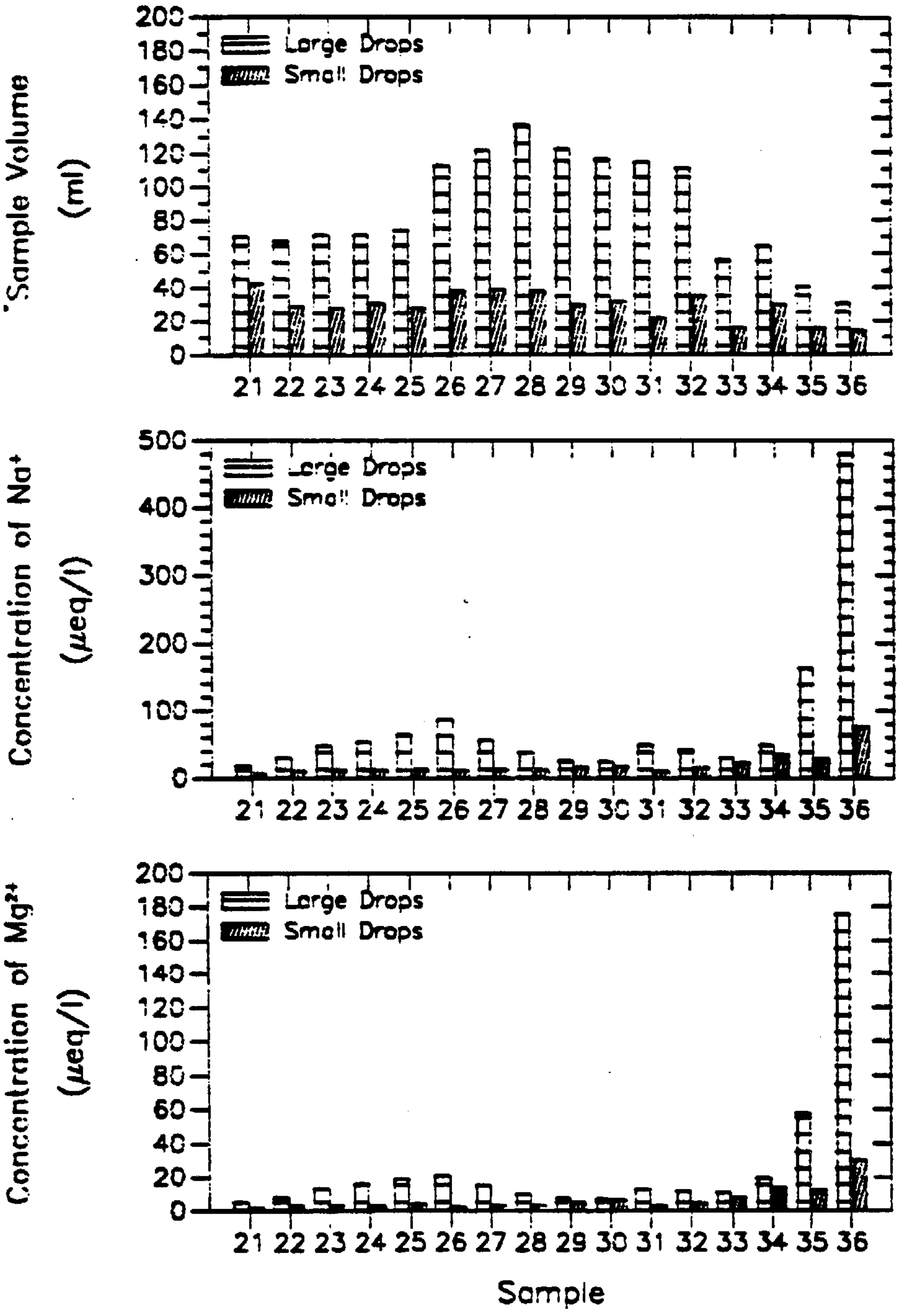

Figure 6. Comparison of sample volumes, $Na^+$ concentrations, and $Mg^{2+}$ concentrations for the samples collected by the fractionating collector on the morning of July 15, 1987. Samples collected on the large rods in the sampler inlet are labeled "large drops", while those collected by the CASC strands are labeled "small drops."

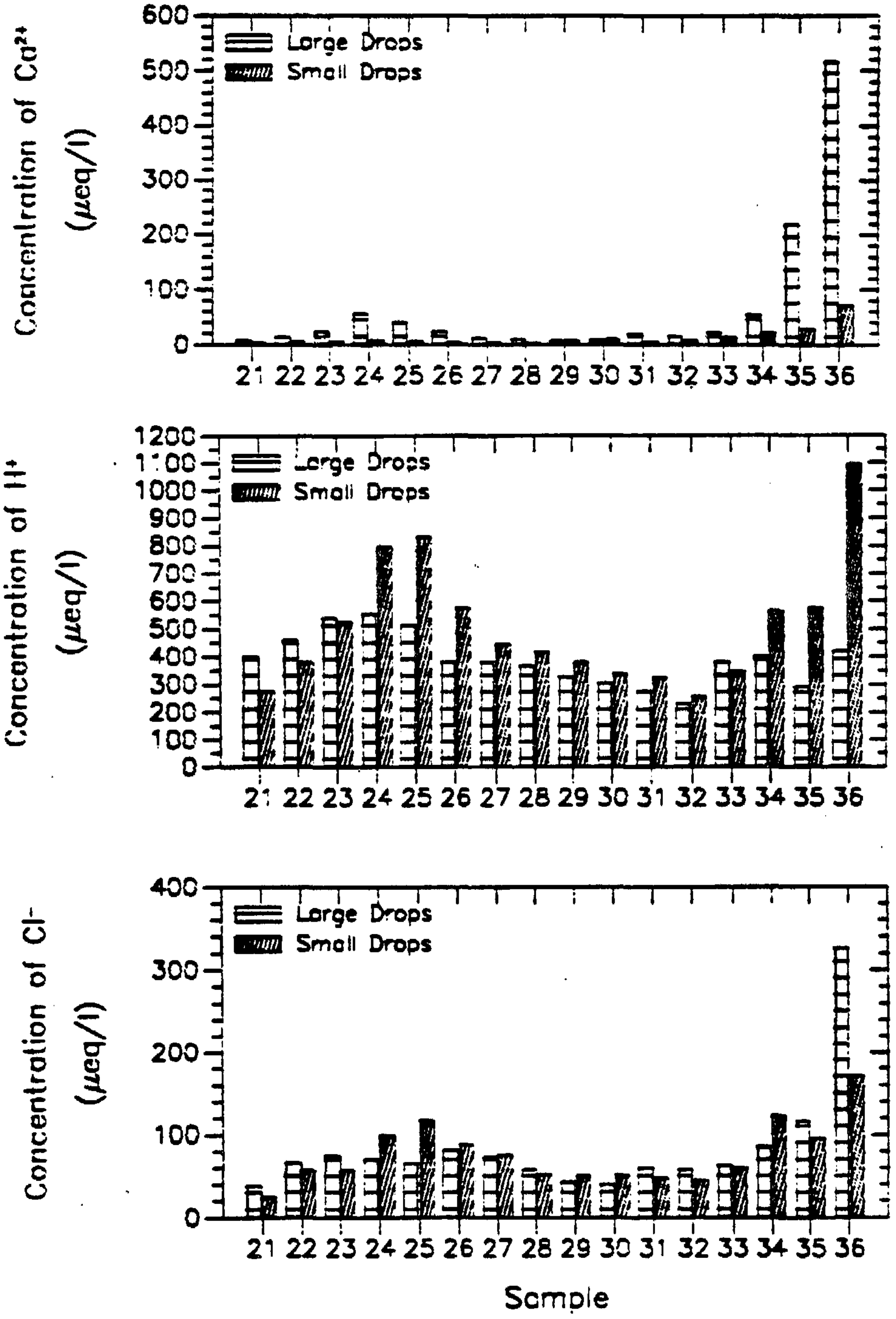

Figure 7. Comparison of $Ca^{2+}$ concentrations, $H^+$ concentrations, and $Cl^-$ concentrations for the samples collected by the fractionating collector on the morning of July 15, 1987. Samples collected on the large rods in the sampler inlet are labeled "large drops", while those collected by the CASC strands are labeled "small drops."

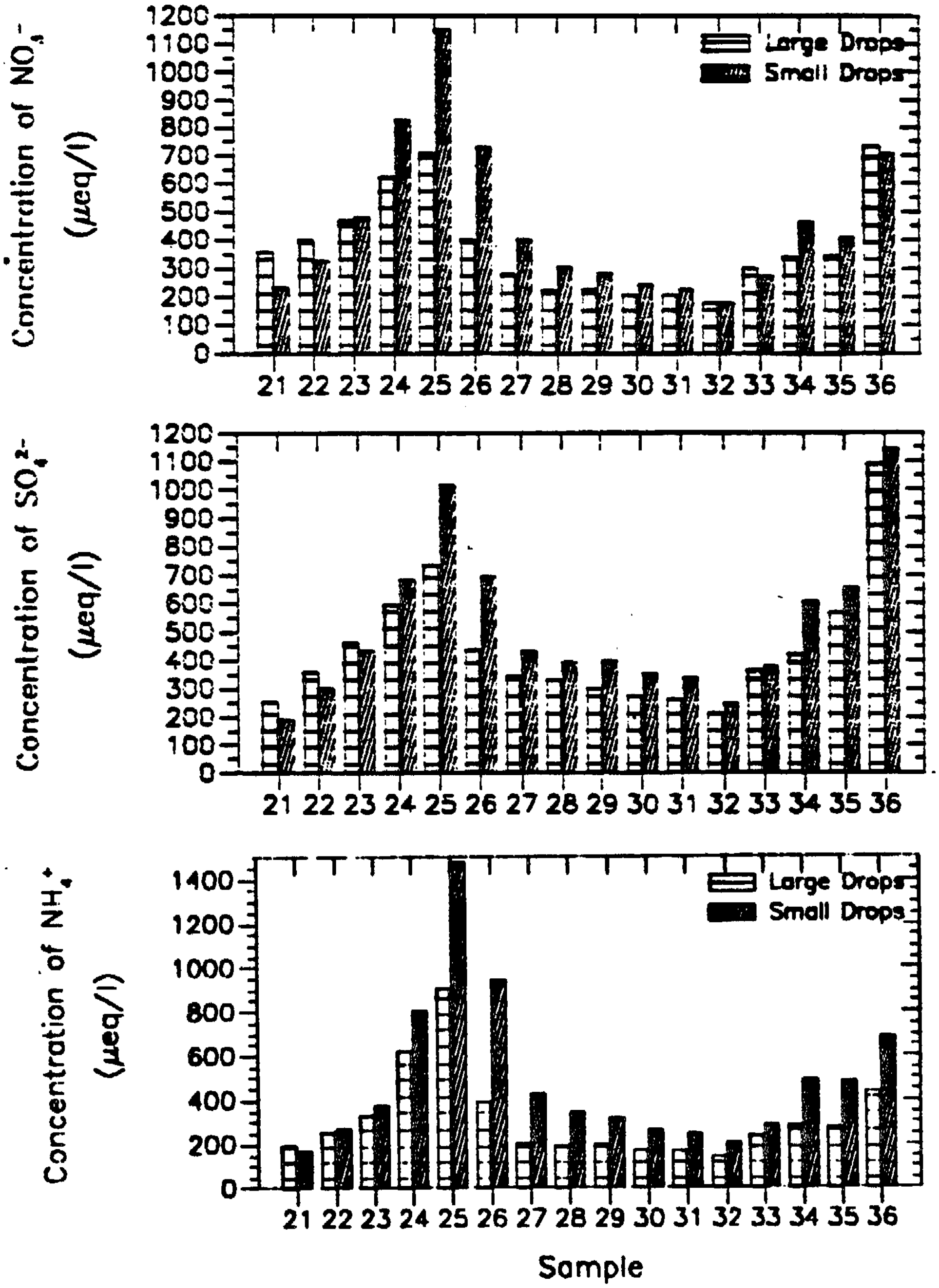

Figure 8. Comparison of $NO_3^-$ concentrations, $SO_4^{2-}$ concentrations, and $NH_4^+$ concentrations for the samples collected by the fractionating collector on the morning of July 15, 1987. Samples collected on the large rods in the sampler inlet are labeled "large drops", while those collected by the CASC strands are labeled "small drops."

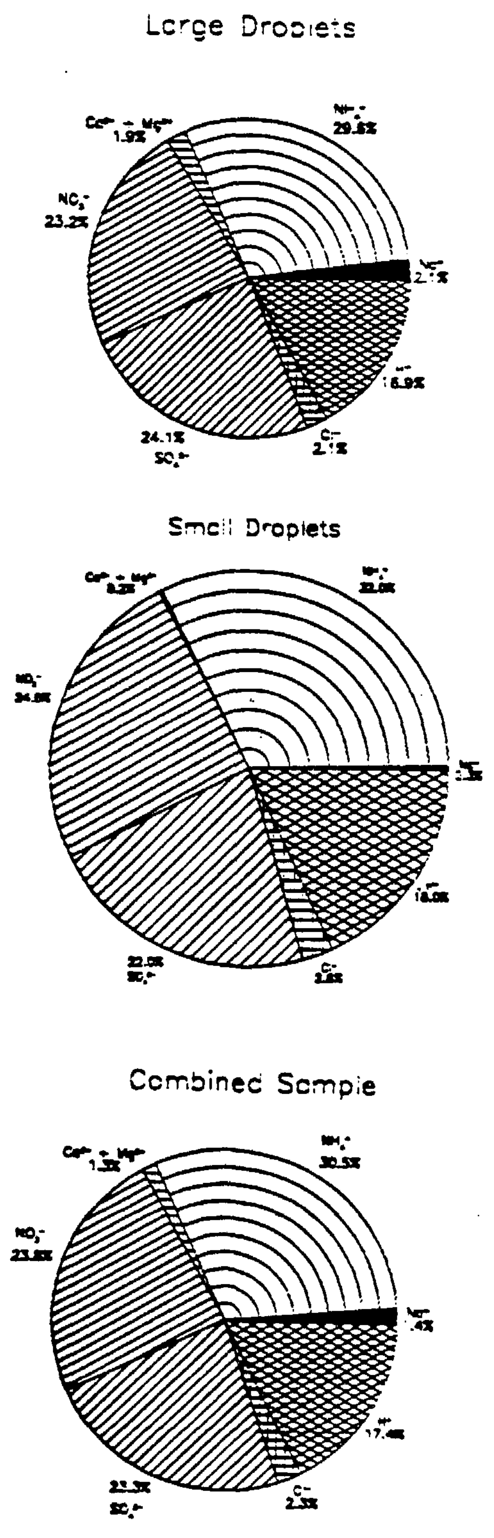

Figure 9. Illustration of the composition of the cloudwater sampled between 0600 and 0630 on July 15, 1987, using the fractionating collector. The fraction labeled "large droplets" was collected on the large rods in the inlet. The fraction labeled "small droplets" was collected on the CASC strands in the main body of the collector. The "combined sample" represents the volume weighted average composition of the two fractions. The area of each diagram is proportional to the total of the measured ionic species concentrations in that fraction of the sample.

# CHAPTER 4

# CHEMICAL COMPOSITION OF COASTAL STRATUS CLOUDS:

## Dependence on Droplet Size and Distance from the Coast

by

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# Abstract

The aerosol at elevated sites in the South Coast air basin is a mixture of sea salt and pollution–derived secondary aerosol. The influence of sea salt declines with increasing distance from the coast. Nitric acid appears to react with the NaCl in sea–salt aerosol to release $HCl_{(g)}$ and form $NaNO_3$ in the aerosol. At inland sites aerosol concentrations differ during onshore and offshore flow. The highest concentrations are observed during the day when the onshore flow transports pollutants to the sites, while lower concentrations were observed at night when drainage flows from nearby mountains influenced the sites. Variations in liquid water content are a major influence on cloudwater concentration.

Comparisons of the ionic concentrations in two size–segregated fractions collected during each sampling interval suggest that there is a large difference between the average composition of the smaller droplets and that of the larger droplets. For each time interval, the concentration of $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ in the large droplet fraction was observed to be higher than in the small droplet fraction. The concentrations of $SO_4^{2-}$, $NO_3^-$, $NH_4^+$, and $H^+$ were higher in the small droplet fraction. Chloride concentrations were nearly equal in both fractions. Differences in the composition of size–fractionated cloudwater samples suggest that large droplets are formed from sea salt and soil dust, which are large aerosol, and small droplets are formed on small secondary aerosol composed of primarily ammonium sulfate and ammonium nitrate. The concentrations of several components that exist partly in the gas phase (e.g. $Cl^-$, HCOOH, and $CH_3COOH$) appear to be independent of droplet size.

# Introduction

Coastal stratus clouds are a major feature of the Los Angeles weather pattern. Cass (1979) noted a correlation between episodes of high $SO_4^{2-}$ concentrations and the presence of cloud or fog. Previous studies by Waldman et al. (1985) and Richards et al. (1983) have indicated that stratus clouds above Los Angeles have high concentrations of $NO_3^-$ and $SO_4^{2-}$.

The size–dependent composition of aerosol is well known. Soil dust and sea salt generally make up the large aerosol, while nitrate and sulfate, partially neutralized by ammonium, make up much of the sub–micron aerosol. If droplet size is dependent on the size of the condensation nucleus then the composition of droplets could depend on size as well. In Japan, Naruse and Maruyama (1971) observed a correlation between droplet size and nucleus mass. The larger droplets contained large sea–salt nuclei, while the smaller drops contained ammonium sulfate aerosol. Hudson and Rogers (1984) indirectly determined nucleus size by measuring the critical supersaturation of nuclei from different size droplets. They found that the largest drops contained nuclei with low $SS_{cr}$ (i.e. large mass). Noone et al. (1988) have recently provided evidence that solute concentration within cloud droplets can be a function of droplet size in coastal stratus clouds (Cheeka Peak Research Station, Washington). They reported that cloud droplets in the size range of 18 to 23 $\mu$m had solute mass 2.7 times that of droplets in the size range of 9 to 18 $\mu$m. Their results were consistent with the suggestion by Andreae et al. (1986) that in marine air the larger droplets are nucleated on dust or sea salt, while the smaller droplets form on excess (non–sea–salt) sulfate derived from the photoxidation of dimethyl sulfide. Collett et al. (1988) attributed differences in the composition of cloudwater samples collected by two collectors with different 50% lower droplet size cuts to size–dependent differences in droplet composition. Some of the theoretical aspects of size–dependent variations in droplet composition have been discussed by Perdue and Beck (1988).

In addition to an anticipated dependence of the chemical composition of the coastal stratus on droplet size, we also expected to see significant variations in composition as a function of distance from the coast. In order to acheive these objectives we developed a cloudwater sampler capable of size fractionation and we established cloudwater and aerosol sampling stations at three elevated sites in the Los Angeles air basin during a period of prolonged cloud cover. This effort overlapped in time with the Southern California Air Quality Study (SCAQS) of 1987.

## Methods

· ***Site Descriptions***

Three sites, San Pedro Hill, Henninger Flats, and Kellogg Hill (see Fig. 1), were operational during the period of June 13 to July 17, 1987. The San Pedro Hill site (elev. 450 m) was located at a radar and communications facility operated by the U. S. Air Force and the Federal Aviation Administration. San Pedro Hill is the easternmost hill of ridge that forms the Palos Verdes Peninsula. The distance from the site to the ocean was 2.5 km; Los Angeles Harbor was 6 km east. The sampling equipment was placed at the edge of a flat grassy area. A steep hillside sloped away from the site, giving it unobstructed exposure from 70–270°.

Henninger Flats (elev. 780 m) is on a level bench partway up Mount Wilson in the San Gabriel Mountains, 7 km NE of Pasadena, and 45 km NE of the coastline. This site has been used in previous sampling programs (Waldman et al., 1985) and for a cloud/fog collector intercomparison (Hering et al., 1987). The Flats is an experimental forest area that has been planted with pine trees; the sampling equipment was located in a clearing a few hundred meters back from the edge. Because it is partially sheltered by the surrounding trees, cloud interception at the samplers is slightly delayed.

Kellogg Hill is 38 km E of downtown Los Angeles at an elevation of 370 m. It lies 50 km NE of the coastline. The sampling equipment was located in a fenced enclosure adjacent to a small building that housed radio transmission equipment. The building partially obstructed the sampler when winds were from the south to west, which is the prevailing daytime wind. The site was unobstructed in the direction of the prevailing night–time winds. Construction activity near the site increased aerosol concentrations of soil dust during the daytime.

· *Sampling Procedure*

Each site was equipped with a Caltech Active Strand Collector (CASC) with an automated fractionating sampler and a cloudwater sensor, shown in Figure 2 (Daube et al., 1987). The CASC collects droplets by inertial impaction on 510 $\mu$m Teflon strands. The 50% collection efficiency cutoff, predicted from impaction theory and based on droplet diameter, is 3.5 $\mu$m (Friedlander, 1977). A protective rain shield, which had its opening facing downward, was attached to the front of the collector to exclude large ($d > 200$ $\mu$m) sedimenting droplets. The cloudwater sensor, which is a miniature version of the CASC connected to a resistance grid, was used to turn the collector on when fog was present. The cloudwater collected by the CASC was directed to the fractionating sampler. In the fractionating sampler, cloudwater accumulated in a reservoir until a liquid level sensor determined that 60 ml had been collected. The reservoir was then drained to a 60 ml polyethylene sample bottle held in a carousel. The carousel had a capacity of 20 bottles. When all 20 bottles had been filled, the level sensor was deactivated. Any further sample collected was retained in the reservoir. If its capacity was exceeded the sample drained out through an overflow tube. The reservoir and sample bottles were housed in a refrigerator. A printer recorded the times that the sampler came on and off and when the bottles were filled. Also located at each site was an automated filter pack aerosol sampler. Open-faced Teflon filters (Gelman Zefluor, 1$\mu$m pore size) were used to collect aerosol for inorganic analysis. $HNO_{3(g)}$ was collected on a nylon filter (Gelman Nylasorb) placed behind one Teflon filter. $NH_{3(g)}$ was collected on two oxalic acid impregnated glass fiber filters behind a second Teflon filter. A rain shield above the filter holders excluded debris and sedimenting droplets.

During the late afternoon or evening prior to an expected cloud event, the samplers were cleaned by rinsing the collection strands, sample tubing, and reservoir with distilled, deionized water ($DDH_2O$). After rinsing, the strands were sprayed again with $DDH_2O$, which was collected in the fraction collector as a system blank. Rinsing and blank collection were repeated the following morning whether cloud was collected or not. Three sets of filters were loaded on the aerosol collector. A timer on the collector controlled the times that each filter set was run.

At San Pedro Hill, a size–fractionating inlet was used on the CASC for the period of 15–16 July, 1987. The rain shield was not used in conjunction with the size–fractionating inlet. Four rows of eight 12.7 mm Teflon rods, which have a 50% lower size cut of 16 $\mu$m (diameter) at the sampling velocity of 9 m $s^{-1}$ are arranged at the front of the inlet. Each row covers 46% of the cross–sectional area. Large droplets impact on the rods, while most droplets smaller than 15 $\mu$m pass through to be collected on the CASC strands in the main body of the collector. Water from the rods and strands is collected in separate bottles, which were manually emptied at the end of each sampling interval.

- ***Analytical Procedures***

Samples were retrieved in the morning following a cloud event and transported to the lab at Caltech. The samples were weighed to determine their volume and the sample pH was measured with a Radiometer PHM82 pH meter using a combination electrode calibrated against pH 4 and 7 buffers. For selected samples small aliquots were removed and treated to stabilize reactive species. $CH_2O$ was stabilized by addition of $SO_3^{2-}$ (Dong and Dasgupta, 1987). Likewise, in a separate aliquot S(IV) was stabilized with $CH_2O$. Hydrogen peroxide was reacted with p–hydroxyphenylacetic acid in the presence of peroxidase to form a stable dimer (Lazrus et al., 1985). Carboxylic acids were preserved by addition of chloroform (Keene and Galloway, 1984).

The samples and preserved aliquots were stored in a refrigerator at 4 °C until analysis. Major anions were determined by ion chromatography with a Dionex AS4 or AS4A separator column and a micromembrane suppressor. The eluent was 2.8 mM $HCO_3^-$/ 2.2 mM $CO_3^{2-}$. The metallic cations were determined by atomic absorption spectrophotometry. An air/acetylene flame was used for $Na^+$ and $K^+$; $N_2O$/acetylene was used for $Ca^{2+}$ and $Mg^{2+}$ to minimize interferences. $NH_4^+$ was determined by flow injection analysis employing the indophenol blue method.

The stabilized $CH_2O$ was determined by a modification of the Nash method for use with an autoanalyzer (Dong and Dasgupta, 1987) Hydrogen peroxide was added to eliminate S(IV), which interferes by forming an adduct with $CH_2O$. The absorbance of the colored product was measured at 412 nm. S(IV) was analyzed by the pararosaniline method (Dasgupta et al., 1980) adapted for flow injection analysis. Carboxylic acids were determined by ion exclusion chromatography (Dionex ICE–AS1) with dilute HCl as the eluent and by normal ion chromatography using $Na_2B_4O_7$ as the eluent.

The Teflon and oxalic acid–impregnated glass fiber filters were extracted in distilled deionized water ($DDH_2O$) on a shaker table. A small volume of ethanol was added to the filter prior to extraction to more effectively wet the filter surface. The nylon filters were extracted in $HCO_3^-/CO_3^{2-}$ IC eluent. Composition of the extracts was determined by the same procedures used for the fogwater samples, with the exception of additional buffer in the complexing reagent and oxalic acid in the rinse solution of the ammonia analysis to account for the effect of the oxalic acid. Complete details of the analytical procedures and estimates of their precision and accuracy are presented elsewhere (Munger, 1989).

## Results

### · *Aerosol Composition*

The aerosol and gas–phase data for San Pedro Hill, Henninger Flats, and Kellogg Hill are summarized in Table 1. The samples are separated into day and night samples to account for the diurnal variation in wind direction at the sites. Onshore winds prevailed during the day; offshore drainage flows prevailed at night. The major species present were $NH_4^+$, $NO_3^-$, and $SO_4^{2-}$. In many of the daytime samples $HNO_3$ was equal to or greater than the $NO_3^-$. In general, the concentrations of N(–III), N(V), and $SO_4^{2-}$ increased with distance from the coast.

$Na^+$, $Cl^-$ and $Mg^{2+}$ decreased away from the coast. The highest concentrations of $NH_3$ were observed at Kellogg Hill.

Day and nighttime concentrations at San Pedro Hill were similar. At Henninger Flats and Kellogg Hill there was a tendency towards higher concentrations in the daytime samples. This apparent trend was not statistically significant, however, because of the large degree of variability in the daytime concentrations.

Most of the samples showed a large $Cl^-$ deficit when compared to the sea salt $Na^+$:$Cl^-$ ratio (see Figure 3A). The averages in Table 1 indicate that the $Cl^-$ deficit is generally greater in the daytime.

Concentrations of the acidic anions, $NO_3^- + SO_4^{2-}$, exceeded those of $NH_4^+$ in all but one sample from San Pedro Hill (Figure 4A). The overall acid–base balance of the atmosphere is indicated in Figure 4B which plots total acids against total bases (acids = $Cl^- + NO_3^- + SO_4^{2-} + HNO_3$; bases = $NH_4^+ + Na^+ + Ca^{2+} + Mg^{2+} + NH_3$). The difference between the two sums is equivalent to total atmospheric alkalinity, as defined by Jacob et al. (1986). Most of the data plot along the 1:1 line, which indicates neutrality. The samples with excess acids are from Henninger Flats and Kellogg Hill. Kellogg Hill also had the only samples with excess bases.

- ***Cloudwater Composition***

The weather pattern during June and July 1987 was ideal for cloudwater collection. Clouds formed nearly every night. During the sampling period, 242 samples from 18 cloud events were collected at San Pedro Hill. Because the sampling carousel could only hold 20 time–resolved samples, long cloud events with high liquid water content (LWC) were not sampled to the end.

Concentration data for the San Pedro Hill cloudwater samples are summarized in Table 2. Typical LWC values, as estimated from collection rate and the theoretical collection efficiency of the CASC, were $\simeq 0.1$ g $m^{-3}$. Cloudwater at San Pedro Hill was consistently acidic. The overall range of pH was 2.4 – 5.0; the volume–weighted average pH was 3.15. The major anions were $NO_3^-$ and $SO_4^{2-}$; on an equivalent basis $NO_3^-$ was in slight excess. In addition to $H^+$, the major cations were $NH_4^+$ and $Na^+$. Their ranking varied from event to event. Concentrations of $CH_2O$ were typically 20 – 30 $\mu$M, while the concentrations of formate and acetate were found to be in the range of 12 – 43 $\mu$M and 6 – 31 $\mu$M, respectively. Hydrogen peroxide concentrations were found in the range of 4 – 72 $\mu$M while S(IV) was usually absent in samples for which it was determined. In addition to formaldehyde other aldehydes such as acetaldehyde (1 – 5 $\mu$M), glyoxal (1 – 10 $\mu$M), and methylglyoxal (4 – 8 $\mu$M) were identified and quantified in cloudwater collected at San Pedro Hill during this sampling program (Igawa et al., 1988).

Clouds intercepted Henninger Flats less frequently than at San Pedro Hill. Because of the difference in their elevations, clouds did not usually intercept both sites simultaneously. At Henninger Flats, 76 samples from 5 cloud events were obtained during the sampling period. Cloudwater from Henninger Flats was similar in chemical composition to that from San Pedro Hill (see Table 4). The range of pH was comparable at the two sites, but Henninger Flats had a slightly higher pH on the average. Henninger Flats had higher concentrations of $NH_4^+$ and lower $SO_4^{2-}$ and $Na^+$. Because of the lower $SO_4^{2-}$, the ratio of $NO_3^-$ to $SO_4^{2-}$ was greater at Henninger Flats. Stratus clouds did not penetrate far enough inland at low elevation to permit sampling at Kellogg Hill.

In the majority of the samples, $Cl^-$ and $Na^+$ were present at the sea water ratio (see Figure 3B). A $Cl^-$ deficit (or $Na^+$ excess) was consistently observed in samples with $Na^+ > 750$ $\mu$N. The apparent $Cl^-$ deficit in the average concentrations is due to the influence of the high concentration samples.

### · *Temporal Variations*

Concentration vs. time profiles for 4 representative periods are shown in Figures 5 – 8. Gaps in the LWC trace indicate non–continuous sampling when the 20 bottles had been filled. Concentrations for the period 0400 –1300 on July 15 at San Pedro Hill are derived from the volume–weighted average of the two size–fractioned samples. Concentrations tended to decrease as LWC increased, and then increase again at the end of the event as LWC decreased. Some depletion was also apparent during long periods of stable LWC, such as the samples after 0700 on July 15 at San Pedro Hill and the second set of samples from Henninger Flats on July 16.

Most of the samples obtained at the two sites were collected during non-overlapping time periods. Often the stratus clouds would intercept one site on a given day and not the other. At other times, the clouds were observed to intercept the hillside at San Pedro during the period shortly after midnight, while interception at Henninger Flats did not begin until a few hours later. By this time, clouds were no longer intercepting the slopes of San Pedro Hill. The only event with simultaneous collection at both sites was on the night of July 16–17. This event, which was associated with drizzle in the L.A. Basin, was one of the most persistent during the study. Clouds were present at both sites the previous night, though the bottles at San Pedro Hill were full by 0244 on 16 July when continuous cloud interception began at Henninger Flats. The clouds did not completely clear during the day of July 16. Continuous cloud cover returned to both sites around 1740 the evening of July 16 and filled all 20 bottles by approximately 2300 on 16 July. The clouds continued without interruption until 0500 at both sites and was intermittent until mid–morning. This event had the lowest overall concentrations of major ions and the highest pH observed at San Pedro Hill. The pH and ion concentrations at Henninger Flats were close to their average values.

- ***Size–fractionated Samples***

The size–fractionated cloud samples were collected during an extended cloud event at San Pedro Hill. Clouds initially intercepted the site at approximately 1900 on July 14 and remained until approximately 1300 on July 15. Twenty samples were collected between 1900 and 0000. Collection of size–fractionated samples began at 0400 and continued until 1200. A final one–hour unfractionated sample was collected from 1200 to 1300.

The overall concentration in the clouds when the size–fractionated samples were collected is indicated in Figure 6. The major ions are comparable to those at the beginning of the event and in the subsequent event. The sea salt ions were less than in the preceding and following samples. Figures 9 – 12 illustrate the major ions, sea salts and collection rates in the two fractions. The concentrations of all species increased concurrently around 0600 without appreciable change in collection rate. The sharp increase in the collection rate for large drops subsequent to this corresponded to a period of drizzle. Concentrations gradually decreased over the next several hours until the final samples when they rose again as LWC dropped.

## Discussion

### · *Inter–site and Temporal Variations*

The differences in chemical composition at the three sites are consistent with their location. San Pedro Hill, being the closest to the ocean, is the most affected by sea salt. During the day, prevailing winds carry emissions of $NO_x$ and $SO_2$ and their oxidation products, $HNO_3$ and $SO_4^{2-}$, inland where they impact Henninger Flats and Kellogg Hill. Higher N(–III) levels are obtained near the dairy feedlots in Chino (see Figure 1). As noted above, the ratio of $SO_4^{2-}$ to $NO_3^-$ in cloudwater is higher at San Pedro Hill than at Henninger Flats. Local oil refinery emissions, which affect San Pedro Hill at night, when offshore winds prevail, may directly influence this ratio.

Aerosol concentrations at Henninger Flats and Kellogg Hill were generally less at night than during the day. Henninger Flats was frequently above the inversion at night, which could explain the low concentrations there. In addition, downslope flow from the adjacent mountains, which rise to 1800 m, could flush the site with cleaner air at night. Kellogg Hill, which is also near the San Gabriel Mountains, may also be affected by this mechanism. San Pedro Hill, on the other hand, is far from any higher ground and will not be affected by clean–air drainage flows. The offshore winds that influence the site at night may have been influenced by primary emissions and secondary pollutants from the SCAB. A sea breeze during the day would normally be expected to bring relatively clean air to the San Pedro Hill site. However, as Cass and Shair (1984) have pointed out, pollutants accumulate off the coast of Los Angeles due to the daily sea breeze/land breeze cycle. Thus, the onshore flow of the sea breeze returns pollutants that were carried out to sea by the previous nights offshore flow.

· ***Acid–Base Balance***

The routine observation of pH 3 cloudwater clearly indicates that the airmass in the portion of the SCAB affected by stratus has excess acidity. The acid–base balance at San Pedro Hill and Henninger Flats (Fig. 4B) is generally consistent with this observation. Previous observations by Jacob et al. (1985) noted that coastal areas are generally deficient in acid–neutralizing capacity. Further inland, near the major sources of $NH_3$ (e.g. cattle feed lots and other agricultural activities), samples with excess alkalinity were collected. In the presence of excess acidity, sea salt aerosol readily loses $HCl_{(g)}$ if the humidity is <99% (Clegg and Brimblecombe, 1985). Apparent loss of $Cl^-$ from aerosol samples has been frequently observed along the California coast (Jacob et al., 1985; Munger et al., 1988). Due to the reaction between $HNO_{3(g)}$ and $NaCl_{(s)}$, $NO_3^-$ replaces $Cl^-$ in the NaCl–dominated aerosol and releases $HCl_{(g)}$. The emitted gas–phase HCl should be included in the acid base balance because it is efficiently scavenged by cloud droplets. Infact, unlike the aerosol samples most of the cloudwater samples did not have a $Cl^-$ deficit.

· ***Size–fractionated Cloudwater Samples***

Figure 14 illustrates the theoretical performance of the size–fractionating inlet. The initial droplet–size spectra are theoretical curves generated from Best's formula (1951). The fraction of the liquid water retained on the rods and the strands is calculated from impaction theory for droplets on a cylinder (Friedlander, 1977). Collection efficiency curves are shown for the strands and rods in Figure 14. The fraction of air sampled by the collector is a function the diameter and spacing of the collector elements as shown in the following relationship:

$$F_s = 1 - [1 - \frac{D_c}{\Delta C}]^n$$

where $F_s$ is the fraction of incoming air that is sampled, $D_c$ is the diameter of an individual collection element, $\Delta C$ is the spacing of the elements, and n is the number of rows. The CASC contains 6 rows of 510 $\mu$m strands, spaced 1.8 mm apart, which yields an 86% sampling efficiency. The size–fractionating inlet contains 4 rows of 12.7 mm rods, spaced 25.4 mm apart, and samples 91% of the incoming air.

At low liquid water contents, where a higher proportion of the water is present in droplets too small to be collected by the rods, most of the water will be collected on the strands. With increasing LWC the mass median diameter increases and more sample is collected on the rods. Because the rods do not have a sharp lower size cut–off, there is considerable overlap in the portions of the droplet spectrum sampled by the rods and strands. Any differences observed in the composition of the two sample fractions, therefore, should be considered as a lower bound on the actual differences present if the droplets could be separated more cleanly.

Comparisons of the ionic concentrations in the two fractions collected during each interval suggest that there is a large difference between the average composition of the smaller droplets and that of the larger droplets. For every interval sampled, the concentration of $Na^+$ and $Mg^{2+}$ in the large droplet fraction was observed to be higher than in the small droplet fraction. With the exception of one very low concentration sample, the same was true for $Ca^{2+}$. Concentrations of $SO_4^{2-}$, $NO_3^-$, $NH_4^+$, and $H^+$ (Figure 9) were almost always higher in the small droplet fraction. Neither fraction had consistently higher $Cl^-$ concentrations (Figure 10); $Cl^-$ was nearly equal in both fractions. The $Cl^-$:$Na^+$ ratio in the two fractions differs, however. In the large–droplet fraction, $Na^+$ and $Cl^-$ are close to the seawater ratio, while the fine–droplet fraction has an excess of $Cl^-$ relative to seawater. As noted above, $Cl^-$ is removed from the sea salt aerosol by reaction with $HNO_3$. Gas–phase HCl should be scavenged equally by all droplets.

Comparison of the organic acid concentrations (Fig. 12) in the two fractions indicates that there was little difference; this result would be expected if the clouds were in equilibrium with the surrounding air and the droplet pH did not vary appreciably with size. The calculated equilibrium partial pressures of each fraction are comparable (i.e. $C_{aq} = K_{h,i}P_i$). Over the observed cloudwater pH range of 3 to 3.6, the majority of the organic acid will be in the gas phase (Munger et al., 1989). The behavior of HCOOH and $CH_3COOH$ is discussed by Munger et al. (1989). In addition, the $CH_2O$ concentrations in the initial fractionated samples are equivalent, which is also consistent with equilibrium considerations. However, beginning at 5:30 there was a spike in [$CH_2O$], [HCOOH], and [$CH_3CO_2H$] as well as the major inorganic ions. The organic acids appear to maintain their apparent equilbrium between the gas and aqueous phases, while the $CH_2O$ showed a pronounced increase in the small–droplet fraction. This difference disappears over the subsequent three hours. The sharpness of the pulse suggests the passage of a plume or a major wind shift. The $CH_2O$ data imply that the precursor nuclei for the smaller droplets contain formaldehyde that is not in equilibrium with the gas phase. The presence of $\alpha$–hydroxymethanesulfonate (HMSA) and other aldehyde–bisulfite adducts could account for this apparent non–equilibrium behavior (Munger et al., 1986). At pH 3.5, the kinetics of aldehyde–bisulfite adduct dissociation is quite slow (Betterton et al., 1988), thus HMSA in the precursor aerosol would be retained in the droplet and measured analytically as $CH_2O$. The presence of detectable S(IV) during this period is consistent with this argument. Of special interest in this regard, S(IV) and $H_2O_2$ were not found to be present simultaneously in either size fraction.

The differences in concentration between the size fractions are consistent with the suggestion that large nuclei produce large droplets and small nuclei produce small droplets (Best, 1951; Mason and Chien; 1962; Hudson, 1984; Jensen and Charlson, 1984; Noone et al., 1988). For the size–dependent aerosol composition to be preserved in the droplets requires nucleation scavenging to be the dominant scavenging process. Because $Na^+$, $Ca^{2+}$ and $Mg^{2+}$ are associated with sea salt and soil dust (Seinfeld, 1986) they are found predominantly in the large droplets; while $NH_4^+$, $SO_4^{2-}$, and to some extent $NO_3^-$, which are mostly found in secondary aerosol, would be in the small droplets (Seinfeld, 1986). However, $NO_3^-$, which can exist in the gas phase or on large aerosol by exchange with $Cl^-$, would also be found to a substantial extent in large droplets. However, the cloudwater concentrations of these ions may be altered by absorption of precursor gas phase species followed by chemical reaction. For example, $NH_{3(g)}$ can be absorbed by the droplets and protonated to form $NH_4^+$; $HNO_{3(g)}$ can be absorbed, followed by deprotonation to yield $NO_3^-$; $SO_{2(g)}$ can be absorbed and oxidized to $SO_4^{2-}$. The first two processes are extremely rapid, while the oxidation of S(IV) to S(VI) in cloudwater is also rapid in the presence $H_2O_2$ or a metal catalyst (Hoffmann and Jacob, 1984). Since S(IV) and $H_2O_2$ were not found concurrently in the time– and size–resolved samples, the rapid oxidation of S(IV) to S(VI) by $H_2O_2$ was likely to have taken place (McArdle and Hoffmann, 1983).

## Summary

Aerosol composition at elevated sites in the South Coast air basin was a mixture of sea salt and pollution–derived secondary aerosol. The influence of sea salt declined with increasing distance from the coast. Abundant $HNO_3$ reacted with the NaCl in sea–salt aerosol to give $HCl_{(g)}$ and $NaNO_3$ in the aerosol. At inland sites aerosol concentrations differ during onshore and offshore flow. The highest concentrations were observed during the day when the onshore flow transports pollutants to the sites, while lower concentrations were observed at night when drainage flows from nearby mountains influenced the sites. Variations in liquid water content are a major influence on cloudwater concentration. Steady declines in concentration were also observed during periods of steady LWC. These may be due to removal by drizzle, dilution by advection, or entrainment of cleaner air from aloft.

Differences in the composition of size–fractionated cloudwater samples suggest that large droplets are formed from sea salt and soil dust, which are large aerosol, and small droplets are formed on small secondary aerosol composed of ammonium sulfate and nitrate. Components that exist partly in the gas phase (e.g. $Cl^-$, HCOOH, and $CH_3COOH$) did not appear to be size segregated. The exchange of $HNO_3$ for HCl on sea salt provides a means for $Cl^-$ to associate with small droplets. Because $Cl^-$ is removed from the sea salt aerosol during the day, the large droplets that form from them are deficient in $Cl^-$. Chloride is retained in the air mass and some ends up in the small droplets that formed on secondary aerosol.

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# References

Andreae, M. O., Charlson, R. J., Bruynseels, F., Storms, H., Van Grieken, R. and Maenhaut, W. (1986) Internal mixture of sea salt, silicates, and excess sulfate in marine aerosols. *Science*, **295**, 683–685.

Best, A. C. (1951a) Drop–size distribution in cloud and fog. *Q. J. R. Met. Soc.* 77, 418–426.

Best, A. C. (1951b) The size of cloud droplets in layer–type cloud. *Q. J. R. Met. Soc.* **77**, 241–248.

Betterton, E., Erel, Y., and Hoffmann, M. R. (1988) Aldehyde–bisulfite adducts. Prediction of some of their thermodynamic and kinetic properties. *Environ. Sci. Technol.* **22**, 92–98.

Cass, G. R., and Shair, F. H. 1984. Sulfate accumulation in a sea breeze/land breeze circulation system. *J. Geophys. Res.* **89**, 1429–1438.

Clegg, S. L. and Brimblecombe, P. (1985) Potential degassing of hydrogen chloride from acidified sodium chloride droplets. *Atmos. Environ.* **19**, 465–470.

Collett, J. L., Jr., Munger, J. W., Daube, B. D., Jr., and Hoffmann, M. R. (1988) A comparison of two cloudwater/fogwater collectors: the rotating arm collector and the Caltech active strand collector. submitted to *Atmos. Environ.*

Dasgupta, P. K., DeCesare, K. and Ullrey, J. C. (1980) Determination of atmospheric sulfur dioxide without tetrachloromercurate (II) and the mechanism of the Schiff reaction, *Anal. Chem.* **52**, 1912–1922.

Daube, B. C., Jr., Flagan, R. C., and Hoffmann, M. R. (1987) *Active Cloudwater Collector* United States Patent # 4,697,462, Oct. 6, 1987.

Dong, S. and Dasgupta, P. K (1987) Fast flourimetric flow injection analysis of formaldehye in atmospheric water, *Environ. Sci. Technol.* **21**. 581.

Friedlander, S. K. (1977) *Smoke, Dust and Haze, Fundamentals of Aerosol Behavior.* John Wiley and Sons, New York.

Hering, S. V., Blumenthal, D. L., Brewer, R. L., Gertler, A., Hoffmann, M., Kadlecek, J. A., and Pettus, K. (1987) Field intercomparison of five types of fogwater collectors. *Environ. Sci. Technol.* 21, 654–663.

Hoffmann, M. R. and Jacob, D. J. (1984) Kinetics and mechanisms of the catalytic oxidation of dissolved sulfur dioxide in aqueous solution: an application to nighttime fogwater chemistry, in ***Acid Precipitation: $SO_2$, NO, and $NO_x$ Oxidation Mechanisms: Atmospheric Considerations***, J. G. Calvert, ed., Butterworth Publishers, Boston, 101–172.

Hudson, J. G. and Rogers, C. F. (1984) Interstitial CCN measurements related to mixing in clouds. *Proc. 9th Int. Cloud. Physics. Conf.* August 21–28, TalinnUSSR.

Hudson, J. G. (1984) Ambient CCN and FCN measurements, in ***Hygroscopic Aerosols***, L. H. Ruhnke and A. Deepak, eds., A. Deepak Publishing, Hampton, VA.

Igawa, M., Munger, J. W. and Hoffmann, M. R. (1989) Analysis of aldehydes in cloud and fogwater samples by HPLC with a postcolumn reaction detector. *Environ. Sci. Technol.* in press.

Jacob, D. J., Waldman, J. M., Munger, J. W., and Hoffmann, M. R. (1985) Chemical composition of fogwater collected along the California coast. *Environ. Sci.* Technol. 19, 730–736.

Jacob, D. J., Munger, J. W., Waldman, J. M., and Hoffmann, M. R. (1986) The $H_2SO_4$–$HNO_3^-NH_3$ system at high humidities and in fogs: I. Spatial and temporal patterns in the San Joaquin Valley of California. *J. Geophys. Res.* 91, 1073–1088.

Jensen, J. B. and Charlson, R. J. (1984) On the efficiency of nucleation scavenging.

*Tellus*, **36B**, 367–375.

Keene, W. C. and Galloway, J. N. (1984) Organic acidity in precipitation of North America, *Atmos. Environ.* **18**, 2491–2497.

McArdle, J. V. and Hoffmann, M. R. (1983) Kinetics and mechanism of the oxidation of aquated sulfur dioxide by hydrogen peroxide at low pH. *J. Phys. Chem.*, **87**, 5425–5429.

Mason, B. J. (1971) ***The Physics of Clouds***, 2nd Ed., Oxford University Press, London.

Mason, B. J. and Chien, C. W. (1962) Cloud-droplet growth by condensation in cumulus. Q. *J. R. Met. Soc.* 88, 133–138.

Munger, J. W., Tiller, C. T., and Hoffmann, M. R. (1986) Determination of hydroxymethanesulfonate in fog water. *Science*, **231**, 247–249.

Munger, J. W., Collett, J., Jr., Daube, B. C., Jr., and Hoffmann, M. R. (1989) Carboxylic acids and carbonyl compounds in Southern California fogs. *Tellus*, in press.

Munger, J. W., Collett, J., Jr., Daube, B. C., Jr., and Hoffmann, M. R. (1988) Chemical composition of intercepted stratus cloud along the Santa Barbara Channel coast. (submitted to *Environ. Sci. Technol.*)

Naruse, H. and Maruyama, H. (1971) On the hygroscopic nuclei in cloud droplets, *Papers in Meteor. and Geophys.* **22**, 1–21.

Noone, K. J., Charlson, R. J., Covert, D. S., Ogren, J. A., and Heintzenberg, J. (1988) Cloud droplets: solute concentration is size dependent. *J. Geophys. Res.* **93**, 9477–9482.

Perdue, E. M. and Beck, K. C. (1988) Chemical consequences of mixing atmospheric droplets of varied pH. *J. Geophys. Res.* **93**, 691–698.

Richards, L. W., Anderson, J. A., Blumenthal, D. L., McDonald, J. A., Kok, G. L., and Lazrus, A. L. (1983) Hydrogen peroxide and sulfur (IV) in Los Angeles cloud water, *Atmos. Environ.* 17, 911–914.

Seinfeld, J. H. (1986) ***Atmospheric Chemistry and Physics of Air Pollution***, Wiley Interscience, New York.

Shair, F. H., Sasaki, E. J., Carlan, D. E., Cass, G. R., Goodin, W. R., Edinger, J. G. and Schacher, G. E. (1982) Transport and dispersion of airborne pollutants associated with the land breeze–sea breeze system. *Atmos. Environ.* **16**, 2043–2053.

Waldman, J. M., Munger, J. W., Jacob, D. J., and Hoffmann, M. R. (1985) Chemical characterization of stratus cloudwater and its role as a vector for pollutant deposition in a Los Angeles pine forest. *Tellus* 37, 91–108.

# Table 1. Summary Statistics for Aerosol Samples Collected at Three Elevated in the Los Angeles Basin (6–13 to 7–17–88)

## San Pedro Hill

| | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $NH_3$ | $HNO_3$ | N(–3) | N(v) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | neq m$^{-3}$ | | | | | | | nmole m$^{-3}$ | | | |
| ***Day*** | | | | | | | | | | | |
| N | 18 | 13 | 18 | 18 | 16 | 18 | 18 | 18 | 14 | 13 | 14 |
| Min | 0 | 17 | 0 | 0 | 0 | 7 | 22 | 0 | 0 | 36 | 7 |
| Max | 188 | 430 | 47 | 49 | 105 | 147 | 448 | 105 | 166 | 479 | 279 |
| Avg | 81 | 186 | 22 | 19 | 25 | 69 | 179 | 19 | 91 | 206 | 164 |
| $\sigma$ | 65 | 122 | 10 | 16 | 33 | 37 | 106 | 28 | 57 | 131 | 74 |
| ***Night*** | | | | | | | | | | | |
| N | 19 | 12 | 19 | 19 | 16 | 18 | 19 | 19 | 17 | 10 | 17 |
| Min | 0 | 0 | 0 | 0 | 0 | 6 | 32 | 0 | 0 | 71 | 12 |
| Max | 170 | 624 | 56 | 44 | 90 | 435 | 475 | 29 | 124 | 635 | 448 |
| Avg | 52 | 169 | 22 | 15 | 34 | 127 | 162 | 5 | 28 | 212 | 155 |
| $\sigma$ | 46 | 183 | 12 | 13 | 31 | 118 | 121 | 9 | 31 | 180 | 129 |

## Henninger Flats

| | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $NH_3$ | $HNO_3$ | N(–3) | N(v) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | neq m$^{-3}$ | | | | | | | nmole m$^{-3}$ | | | |
| ***Day*** | | | | | | | | | | | |
| N | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 |
| Min | 0 | 4 | 0 | 0 | 0 | 7 | 5 | 0 | 11 | 4 | 19 |
| Max | 134 | 838 | 93 | 54 | 29 | 442 | 533 | 99 | 897 | 916 | 1255 |
| Avg | 59 | 367 | 39 | 19 | 6 | 173 | 255 | 40 | 363 | 407 | 526 |
| $\sigma$ | 46 | 284 | 31 | 15 | 11 | 136 | 195 | 40 | 317 | 310 | 450 |
| ***Night*** | | | | | | | | | | | |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 10 | 12 | 10 |
| Min | 4 | 3 | 0 | 0 | 0 | 9 | 5 | 0 | 13 | 3 | 22 |
| Max | 59 | 284 | 35 | 15 | 21 | 123 | 234 | 31 | 113 | 302 | 186 |
| Avg | 33 | 141 | 23 | 10 | 3 | 59 | 119 | 12 | 57 | 153 | 118 |
| $\sigma$ | 18 | 87 | 12 | 5 | 6 | 35 | 70 | 11 | 29 | 93 | 56 |

## Table 1. (continued)

### Kellogg Hill

| | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $NH_3$ | $HNO_3$ | N(–3) | N(v) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\|\longrightarrow$ neq m$^{-3}$ $\longleftarrow\|$ | | | | | | | $\|\longrightarrow$ nmole m$^{-3}$ $\longleftarrow\|$ | | | |
| ***Day*** | | | | | | | | | | | |
| N | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Min | 8 | 9 | 62 | 12 | 0 | 10 | 7 | 0 | 6 | 8 | 16 |
| Max | 149 | 875 | 270 | 62 | 16 | 629 | 451 | 339 | 624 | 1063 | 1191 |
| Avg | 92 | 575 | 162 | 44 | 5 | 413 | 296 | 140 | 277 | 714 | 690 |
| $\sigma$ | 48 | 302 | 60 | 16 | 6 | 204 | 156 | 120 | 185 | 353 | 358 |
| ***Night*** | | | | | | | | | | | |
| N | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| Min | 44 | 139 | 40 | 11 | 0 | 91 | 94 | 0 | 9 | 279 | 133 |
| Max | 183 | 594 | 109 | 61 | 72 | 452 | 372 | 283 | 63 | 620 | 512 |
| Avg | 112 | 343 | 75 | 33 | 20 | 266 | 201 | 89 | 40 | 432 | 306 |
| $\sigma$ | 43 | 167 | 21 | 16 | 24 | 118 | 80 | 82 | 19 | 128 | 128 |

# Table 2. Concentrations in Cloudwater Samples Collected at San Pedro Hill (6–13 to 7–17–87).

| | V(mL) | pH | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $CH_2O$ | –/+ | LWC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ‖⟶ | | | $\mu N$ | | ⟵ | ‖ | $\mu M$ | | g $m^{-3}$ |
| *14 June 1987* | | | | | | | | | | | | |
| N | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 0 | 15 | 15 |
| Min | 18 | 2.80 | 149 | 323 | 15 | 47 | 247 | 702 | 574 | — | 1.09 | 0.02 |
| Max | 68 | 3.28 | 734 | 744 | 88 | 214 | 787 | 1608 | 1407 | — | 1.19 | 0.11 |
| Avg | 48 | 3.02 | 506 | 501 | 58 | 149 | 538 | 1062 | 939 | — | 1.14 | 0.07 |
| Vol Wt. Avg | | 3.02 | 468 | 466 | 54 | 139 | 502 | 991 | 880 | — | — | 0.06 |
| *19 June 1987* | | | | | | | | | | | | |
| N | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Min | 26 | 3.18 | 3258 | 665 | 281 | 593 | 1654 | 1281 | 978 | 25 | 0.73 | 0.02 |
| Max | 36 | 3.33 | 3796 | 1237 | 460 | 731 | 1701 | 2137 | 1131 | 31 | 0.75 | 0.06 |
| Avg | 33 | 3.25 | 3486 | 909 | 353 | 652 | 1676 | 1674 | 1078 | 27 | 0.74 | 0.04 |
| Vol Wt. Avg | | 3.25 | 3553 | 980 | 375 | 670 | 1682 | 1784 | 1102 | — | — | 0.04 |
| *20 June 1987* | | | | | | | | | | | | |
| N | 6 | 6 | 5 | 6 | 4 | 6 | 6 | 6 | 6 | 4 | 6 | 6 |
| Min | 9 | 3.11 | 1722 | 347 | 173 | 388 | 1379 | 498 | 749 | 21 | 0.73 | 0.03 |
| Max | 65 | 3.35 | 2574 | 605 | 272 | 715 | 1756 | 1402 | 1290 | 31 | 1.84 | 0.10 |
| Avg | 48 | 3.24 | 2024 | 478 | 225 | 476 | 1468 | 850 | 1032 | 24 | 1.06 | 0.06 |
| Vol Wt. Avg | | 3.24 | 1812 | 470 | 127 | 444 | 1434 | 815 | 964 | — | — | 0.06 |
| *21 June 1987* | | | | | | | | | | | | |
| N | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| Min | 12 | 3.48 | 706 | 169 | 79 | 192 | 735 | 377 | 312 | 12 | 1.00 | 0.03 |
| Max | 66 | 3.55 | 995 | 295 | 142 | 253 | 837 | 915 | 447 | 14 | 1.07 | 0.17 |
| Avg | 47 | 3.52 | 841 | 228 | 108 | 215 | 793 | 590 | 373 | 13 | 1.04 | 0.09 |
| Vol Wt. Avg | | 3.51 | 866 | 238 | 113 | 216 | 787 | 606 | 382 | — | — | 0.09 |
| *22 June 1987* | | | | | | | | | | | | |
| N | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 9 |
| Min | 13 | 2.84 | 206 | 311 | 27 | 53 | 267 | 436 | 354 | 11 | 0.94 | 0.04 |
| Max | 62 | 3.43 | 1257 | 1126 | 243 | 311 | 978 | 1632 | 1478 | 27 | 1.09 | 0.12 |
| Avg | 56 | 3.21 | 462 | 552 | 79 | 120 | 485 | 827 | 641 | 16 | 1.01 | 0.08 |
| Vol Wt. Avg | | 3.23 | 424 | 467 | 70 | 110 | 447 | 704 | 540 | — | — | 0.07 |

# Table 2. (continued)

| | V(mL) | pH | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $CH_2O$ | −/+ | LWC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | $\|\longrightarrow \mu N \longleftarrow\|$ | | | | $\mu M$ | | $g\ m^{-3}$ |
| ***23 June 1987*** | | | | | | | | | | | | |
| N | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 0 | 20 | 20 |
| Min | 61 | 3.15 | 123 | 223 | 17 | 33 | 173 | 277 | 224 | — | 0.95 | 0.02 |
| Max | 66 | 3.62 | 452 | 528 | 95 | 131 | 505 | 1024 | 608 | — | 1.27 | 0.16 |
| Avg | 62 | 3.47 | 200 | 293 | 38 | 55 | 257 | 407 | 342 | — | 1.08 | 0.12 |
| Vol Wt. Avg | | 3.49 | 185 | 277 | 34 | 50 | 241 | 371 | 324 | — | — | 0.10 |
| ***24 June 1987*** | | | | | | | | | | | | |
| N | 24 | 24 | 24 | 24 | 20 | 24 | 24 | 24 | 24 | 22 | 24 | 22 |
| Min | 17 | 2.53 | 189 | 462 | 30 | 56 | 309 | 1291 | 1119 | 18 | 1.09 | 0.02 |
| Max | 66 | 2.94 | 3148 | 2859 | 560 | 601 | 1613 | 5623 | 3246 | 51 | 1.51 | 0.25 |
| Avg | 56 | 2.76 | 794 | 1495 | 134 | 179 | 666 | 2627 | 1871 | 34 | 1.18 | 0.11 |
| Vol Wt. Avg | | 2.78 | 553 | 1340 | 99 | 133 | 552 | 2226 | 1669 | — | — | 0.09 |
| ***25 June 1987*** | | | | | | | | | | | | |
| N | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 15 | 23 | 21 |
| Min | 10 | 2.63 | 142 | 410 | 30 | 37 | 132 | 832 | 660 | 16 | 0.89 | 0.00 |
| Max | 68 | 3.11 | 1618 | 9383 | 1143 | 1151 | 2096 | 8191 | 5796 | 37 | 1.42 | 0.34 |
| Avg | 42 | 2.78 | 468 | 1702 | 138 | 135 | 402 | 2708 | 1874 | 26 | 1.18 | 0.18 |
| Vol Wt. Avg | | 2.81 | 323 | 1072 | 73 | 73 | 254 | 2062 | 1365 | — | — | 0.11 |
| ***26 June 1987*** | | | | | | | | | | | | |
| N | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 0 | 21 | 19 |
| Min | 32 | 2.99 | 28 | 423 | 8 | 10 | 43 | 454 | 387 | — | 0.79 | 0.08 |
| Max | 69 | 3.51 | 315 | 1979 | 164 | 86 | 223 | 2462 | 1971 | — | 1.36 | 0.29 |
| Avg | 55 | 3.31 | 89 | 1058 | 27 | 25 | 90 | 1044 | 794 | — | 1.11 | 0.21 |
| Vol Wt. Avg | | 3.34 | 67 | 931 | 20 | 19 | 71 | 915 | 660 | — | — | 0.21 |
| ***01 July 1987*** | | | | | | | | | | | | |
| N | 6 | 6 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 0 | 6 | 6 |
| Min | 8 | 3.15 | 336 | 242 | 57 | 90 | 339 | 401 | 435 | — | 0.95 | 0.02 |
| Max | 29 | 3.23 | 912 | 638 | 215 | 248 | 745 | 1138 | 836 | — | 1.02 | 0.15 |
| Avg | 15 | 3.18 | 480 | 517 | 111 | 129 | 454 | 741 | 652 | — | 0.98 | 0.10 |
| Vol Wt. Avg | | 3.18 | 440 | 555 | 108 | 120 | 415 | 754 | 671 | — | — | 0.04 |

## Table 2. (continued)

| | V(mL) | pH | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $CH_2O$ | −/+ | LWC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\|\longrightarrow$ | | | $\mu N$ | | $\longleftarrow\|$ | | $\mu M$ | | g $m^{-3}$ |
| *03 July 1987* | | | | | | | | | | | | |
| N | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 0 | 14 | 14 |
| Min | 20 | 2.42 | 308 | 394 | 71 | 83 | 327 | 535 | 492 | — | 0.98 | 0.02 |
| Max | 62 | 3.30 | 683 | 2770 | 286 | 202 | 656 | 4656 | 3028 | — | 1.26 | 0.11 |
| Avg | 55 | 2.72 | 443 | 1652 | 128 | 124 | 466 | 2987 | 1900 | — | 1.16 | 0.07 |
| Vol Wt. Avg | | 2.66 | 415 | 1675 | 119 | 116 | 445 | 2994 | 1892 | — | — | 0.06 |
| *07 July 1987* | | | | | | | | | | | | |
| N | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Min | 23 | 3.14 | 235 | 266 | 28 | 53 | 284 | 332 | 384 | 12 | 1.07 | 0.03 |
| Max | 66 | 3.51 | 719 | 1108 | 127 | 156 | 821 | 1301 | 810 | 22 | 1.19 | 0.21 |
| Avg | 55 | 3.33 | 489 | 473 | 57 | 107 | 537 | 706 | 562 | 16 | 1.13 | 0.12 |
| Vol Wt. Avg | | 3.31 | 412 | 470 | 52 | 91 | 453 | 713 | 555 | — | — | 0.10 |
| *08 July 1987* | | | | | | | | | | | | |
| N | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 0 | 9 | 9 |
| Min | 4 | 2.81 | 59 | 88 | 20 | 15 | 71 | 172 | 143 | — | 1.07 | 0.00 |
| Max | 65 | 3.91 | 1365 | 2458 | 508 | 335 | 1055 | 3419 | 2647 | — | 1.27 | 0.25 |
| Avg | 53 | 3.09 | 485 | 866 | 130 | 117 | 415 | 1435 | 1044 | — | 1.15 | 0.13 |
| Vol Wt. Avg | | 2.99 | 481 | 855 | 119 | 116 | 409 | 1435 | 1052 | — | — | 0.11 |
| *13 July 1987* | | | | | | | | | | | | |
| N | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 2 | 2 |
| Min | 9 | 3.79 | 204 | 210 | 45 | 57 | 242 | 174 | 230 | 10 | 0.93 | 0.01 |
| Max | 36 | 3.83 | 223 | 240 | 52 | 57 | 264 | 217 | 230 | — | 1.10 | 0.05 |
| *14 July 1987* | | | | | | | | | | | | |
| N | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 11 | 21 | 19 |
| Min | 29 | 3.13 | 64 | 129 | 13 | 19 | 95 | 112 | 182 | 5 | 0.94 | 0.12 |
| Max | 65 | 3.91 | 207 | 977 | 55 | 59 | 240 | 600 | 820 | 38 | 1.17 | 0.31 |
| Avg | 40 | 3.61 | 106 | 351 | 26 | 29 | 146 | 285 | 382 | 15 | 1.02 | 0.22 |
| Vol Wt. Avg | | 3.63 | 97 | 295 | 22 | 26 | 138 | 235 | 319 | — | — | 0.21 |
| *14 July 1987* | | | | | | | | | | | | |
| N | 19 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 8 | 21 | 19 |
| Min | 37 | 3.23 | 40 | 131 | 10 | 13 | 57 | 167 | 212 | 6 | 0.95 | 0.05 |
| Max | 42 | 3.73 | 267 | 391 | 77 | 65 | 272 | 602 | 550 | 15 | 1.08 | 0.23 |
| Avg | 39 | 3.50 | 160 | 227 | 30 | 38 | 162 | 307 | 327 | 10 | 1.01 | 0.17 |
| Vol Wt. Avg | | 3.52 | 175 | 210 | 29 | 40 | 173 | 277 | 311 | — | — | 0.14 |

## Table 2. (continued)

| | V(mL) | pH | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $CH_2O$ | −/+ | LWC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\|\longrightarrow$ | | | $\mu$N | | | $\longleftarrow\|$ | $\mu$M | | g $m^{-3}$ |
| *16 July 1987* | | | | | | | | | | | | |
| N | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 0 | 16 | 15 |
| Min | 12 | 2.64 | 22 | 328 | 14 | 8 | 40 | 190 | 219 | — | 0.93 | 0.02 |
| Max | 68 | 3.93 | 271 | 2161 | 236 | 100 | 357 | 2797 | 2438 | — | 1.12 | 0.24 |
| Avg | 51 | 3.12 | 119 | 727 | 110 | 43 | 155 | 854 | 992 | — | 1.06 | 0.14 |
| Vol Wt. Avg | | 3.06 | 93 | 639 | 87 | 35 | 131 | 819 | 888 | — | — | 0.11 |
| *17 July 1987* | | | | | | | | | | | | |
| N | 20 | 20 | 20 | 20 | 9 | 9 | 20 | 20 | 20 | 0 | 20 | 18 |
| Min | 25 | 3.50 | 6 | 44 | 3 | 1 | 11 | 28 | 39 | — | 0.92 | 0.05 |
| Max | 56 | 4.98 | 92 | 504 | 47 | 28 | 98 | 300 | 376 | — | 1.23 | 0.26 |
| Avg | 49 | 4.09 | 35 | 136 | 14 | 10 | 43 | 125 | 161 | — | 1.09 | 0.16 |
| Vol Wt. Avg | | 3.94 | 28 | 101 | 6 | 4 | 35 | 100 | 138 | — | — | 0.14 |
| *All Samples 6–14 to 7–17–88* | | | | | | | | | | | | |
| N | 240 | 242 | 241 | 242 | 225 | 231 | 242 | 242 | 242 | 80 | 241 | 227 |
| Min | 1 | 2.42 | 6 | 44 | 3 | 1 | 11 | 28 | 39 | 5 | 0.73 | 0.00 |
| Max | 69 | 4.98 | 3796 | 9383 | 1143 | 1151 | 2096 | 8191 | 5796 | 51 | 1.84 | 0.34 |
| Avg | 49 | 3.25 | 404 | 775 | 82 | 107 | 369 | 1185 | 917 | 23 | 1.09 | 0.14 |
| Vol Wt. Avg | | 3.15 | 263 | 632 | 51 | 65 | 256 | 941 | 736 | — | — | 0.103 |

# Table 3. Concentrations of Organic Acids, S(IV), HCHO, and $H_2O_2$ Cloudwater Samples Collected at San Pedro Hill

| V(mL) | pH | Time (hrs) | S(IV) | $CH_2O$ | $H_2O_2$ | $HCO_2H$* | $CH_3COOH$* | +/- |
|---|---|---|---|---|---|---|---|---|
| | | | $\|\longrightarrow$ | | $\mu M$ | | $\longleftarrow\|$ | |
| *7–15–88 Size–fractionated Sample from the Front Rods of the CASC* | | | | | | | | |
| 68 | 3.34 | 4:33–5:00 | 0 | 10 | 10 | 19 | 11 | 1.08 |
| 71 | 3.27 | 5:00–5:30 | 0 | 16 | 0 | 21 | 13 | 1.06 |
| 71 | 3.26 | 5:30–6:00 | 0 | 27 | 0 | 40 | 19 | 1.00 |
| 74 | 3.29 | 6:00–6:30 | 6 | 29 | 0 | 37 | 18 | 0.98 |
| 112 | 3.42 | 6:30–7:00 | 6 | 16 | 0 | 26 | 11 | 1.02 |
| 121 | 3.42 | 7:00–7:30 | 6 | 13 | 0 | 17 | 9 | 1.04 |
| 136 | 3.44 | 7:30–8:00 | 0 | 13 | 4 | 19 | 9 | 0.99 |
| 122 | 3.49 | 8:00–8:30 | 0 | 13 | 10 | 18 | 10 | 1.02 |
| 116 | 3.52 | 8:30–9:00 | 0 | 13 | 16 | 20 | 9 | 1.02 |
| 64 | 3.40 | 10:30–11:00 | 0 | 18 | 49 | 33 | 13 | 1.06 |
| *7–15–88 Size–fractionated Sample from the Back Strings of the CASC* | | | | | | | | |
| 29 | 3.42 | 4:33–5:00 | 0 | 11 | 9 | 16 | 10 | 1.03 |
| 28 | 3.28 | 5:00–5:30 | 0 | 13 | 0 | 18 | 11 | 1.05 |
| 31 | 3.10 | 5:30–6:00 | 6 | 26 | 0 | 34 | 17 | 0.99 |
| 28 | 3.08 | 6:00–6:30 | 10 | 55 | 0 | 38 | 22 | 0.98 |
| 38 | 3.24 | 6:30–7:00 | 5 | 25 | 0 | 32 | 20 | 0.98 |
| 39 | 3.35 | 7:00–7:30 | 0 | 17 | 0 | 18 | 9 | 1.02 |
| 38 | 3.38 | 7:30–8:00 | 0 | 16 | 3 | 19 | 9 | 0.96 |
| 30 | 3.42 | 8:00–8:30 | 0 | 17 | 6 | 19 | 10 | 1.01 |
| 32 | 3.47 | 8:30–9:00 | 0 | 14 | 11 | 23 | 10 | 1.02 |
| 30 | 3.25 | 10:30–11:00 | 0 | 21 | 39 | 40 | 17 | 1.06 |

*Samples Collected from 7–7–87 to 7–14–87*

| Parameter | V(mL) | pH | S(IV) | $CH_2O$ | $H_2O_2$ | HCOOH* | $CH_3COOH$* |
|---|---|---|---|---|---|---|---|
| | | | $\|\longrightarrow$ | | $\mu M$ | | $\longleftarrow\|$ |
| N | 21 | 21 | — | 20 | 16 | 21 | 21 |
| Min | 9 | 3.14 | — | 5 | 4 | 12 | 6 |
| Max | 59 | 3.83 | — | 38 | 72 | 43 | 31 |
| Avg. | 38 | 3.58 | — | 13 | 42 | 20 | 10 |

* This represents the total RCOOH (i.e. [RCOOH] + [$RCO_2^-$]) unless otherwise noted.

# Table 4. Concentrations in Cloudwater Samples Collected at Henninger Flats during the Period of 6–20 to 7–17–87.

| | V(mL) | pH | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $CH_2O$ | −/+ | LWC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ‖⟶ $\mu$N ⟵‖ | | | | | | | $\mu$M | | g $m^{-3}$ |
| *20 June 1987* | | | | | | | | | | | | |
| N | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Min | 24 | 2.75 | 180 | 805 | 39 | 48 | 169 | 877 | 447 | 66 | 0.90 | 0.03 |
| Max | 65 | 3.59 | 1652 | 3509 | 454 | 435 | 975 | 4034 | 2028 | 91 | 1.04 | 0.09 |
| Avg | 48 | 3.15 | 542 | 1575 | 136 | 144 | 377 | 1879 | 885 | 76 | 0.99 | 0.05 |
| Vol Wt. Avg | | 3.09 | 442 | 1418 | 106 | 118 | 327 | 1715 | 796 | 78 | — | 0.05 |
| *21 June 1987* | | | | | | | | | | | | |
| N | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11 | 12 | 12 |
| Min | 7 | 2.62 | 183 | 603 | 42 | 49 | 161 | 787 | 36 | 53 | 0.76 | 0.01 |
| Max | 45 | 3.75 | 1553 | 3172 | 520 | 400 | 666 | 5472 | 2606 | 109 | 1.09 | 0.18 |
| Avg | 39 | 3.01 | 485 | 1583 | 138 | 129 | 308 | 2116 | 1084 | 68 | 0.98 | 0.08 |
| Vol Wt. Avg | | 2.96 | 340 | 1368 | 89 | 90 | 259 | 1773 | 963 | 62 | — | 0.05 |
| *10 July 1987* | | | | | | | | | | | | |
| N | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 0 | 20 | 19 |
| Min | 29 | 2.88 | 48 | 671 | 47 | 20 | 91 | 735 | 368 | — | 0.81 | 0.01 |
| Max | 63 | 3.88 | 195 | 1760 | 167 | 99 | 214 | 2065 | 1094 | — | 1.08 | 0.17 |
| avg | 37 | 3.24 | 82 | 1022 | 91 | 36 | 128 | 1076 | 589 | — | 0.96 | 0.10 |
| Vol Wt. Avg | | 3.22 | 68 | 864 | 76 | 29 | 111 | 949 | 526 | — | — | 0.05 |
| *16 July 1987* | | | | | | | | | | | | |
| N | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 0 | 20 | 18 |
| Min | 9 | 2.68 | 5 | 324 | 7 | 2 | 18 | 284 | 137 | — | 0.46 | 0.01 |
| Max | 65 | 4.78 | 149 | 4085 | 397 | 77 | 115 | 1908 | 1474 | — | 1.33 | 0.40 |
| Avg | 58 | 3.36 | 43 | 1392 | 80 | 23 | 48 | 804 | 549 | — | 0.78 | 0.24 |
| Vol Wt. Avg | | 3.48 | 27 | 740 | 27 | 10 | 35 | 525 | 346 | — | — | 0.14 |
| *17 June 1987* | | | | | | | | | | | | |
| N | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 0 | 18 | 17 |
| Min | 40 | 3.03 | 3 | 273 | 15 | 7 | 22 | 231 | 159 | — | 0.95 | 0.07 |
| Max | 65 | 3.94 | 273 | 2435 | 985 | 171 | 301 | 3319 | 2028 | — | 1.18 | 0.23 |
| Avg | 62 | 3.35 | 55 | 817 | 171 | 40 | 73 | 967 | 628 | — | 1.05 | 0.17 |
| Vol Wt. Avg | | 3.31 | 46 | 752 | 136 | 34 | 63 | 897 | 572 | — | — | 0.15 |

## Table 4. (continued)

***All Samples 6–20 to 7–17–88***

|  | V(mL) | pH | $Na^+$ | $NH_4^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $NO_3^-$ | $SO_4^{2-}$ | $CH_2O$ | −/+ | LWC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | μN |  |  |  |  |  |  | μM |  | g $m^{-3}$ |
| N | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 17 | 76 | 72 |
| Min | 7 | 2.62 | 3 | 273 | 7 | 2 | 18 | 231 | 36 | 53 | 0.46 | 0.01 |
| Max | 65 | 4.78 | 1652 | 4085 | 985 | 435 | 975 | 5472 | 2606 | 109 | 1.33 | 0.40 |
| Avg | 50 | 3.25 | 166 | 1203 | 118 | 57 | 142 | 1206 | 689 | 71 | 0.94 | 0.14 |
| Vol Wt. Avg |  | 3.29 | 82 | 845 | 74 | 31 | 86 | 855 | 511 | — | — | 0.09 |

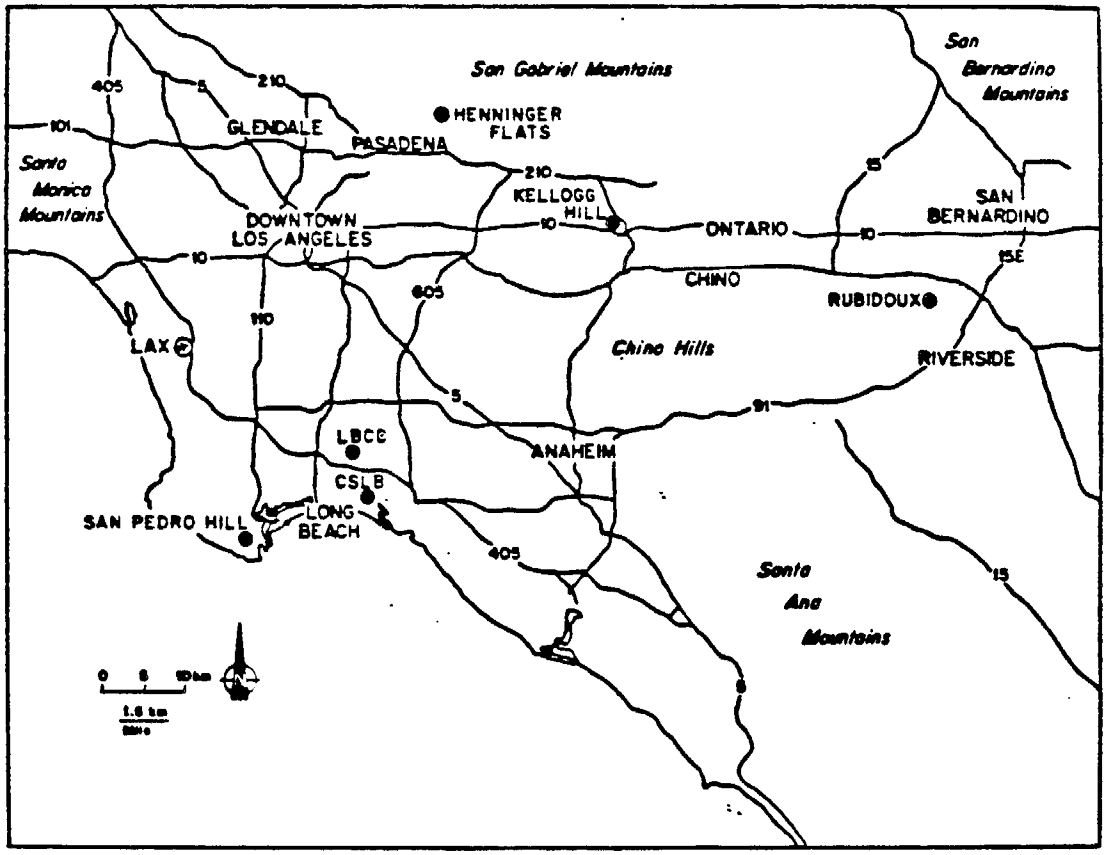


Figure 1
Map of the South Coast Air Basin. Major freeways and selected cities are shown. Sampling sites are indicated by •.

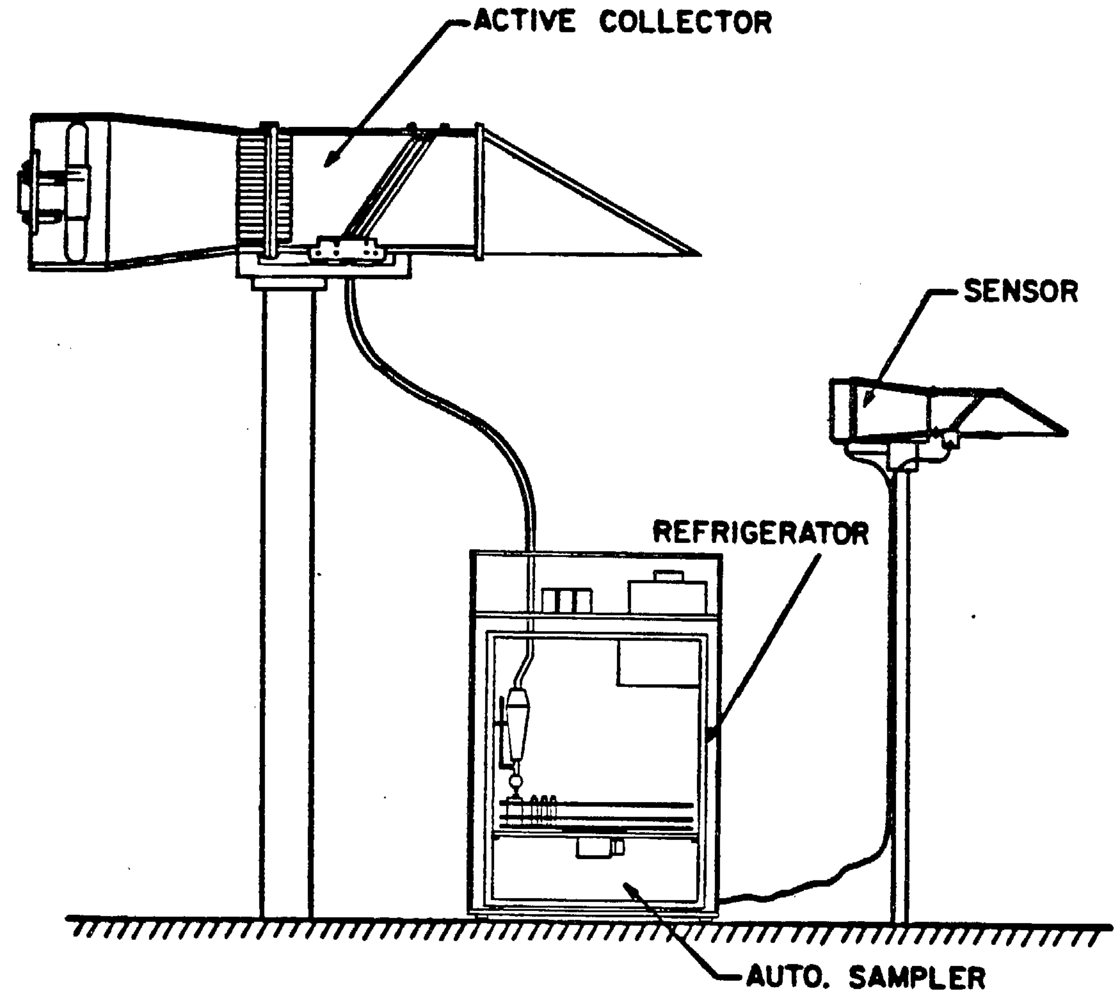


Figure 2
Diagram of the automated cloudwater collector system. Depicted in the figure are the CASC, a cloudwater sensor, and the fractionating collector, housed in a refrigerator.

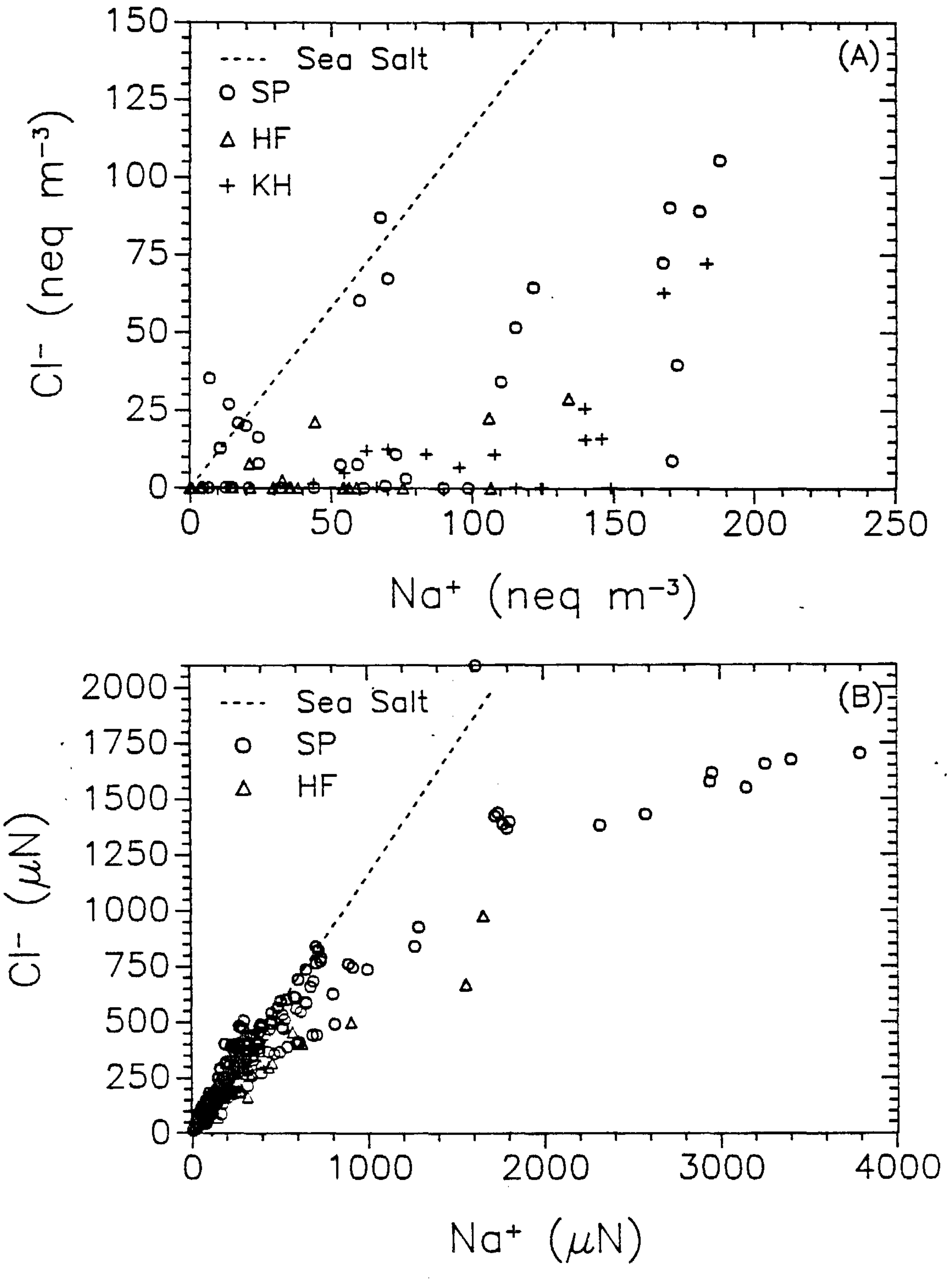


Figure 3

A) $Cl^-$ concentrations in aerosol samples, plotted against $Na^+$. --- indicates the sea–salt ratio. B) Same as A, but for cloudwater.

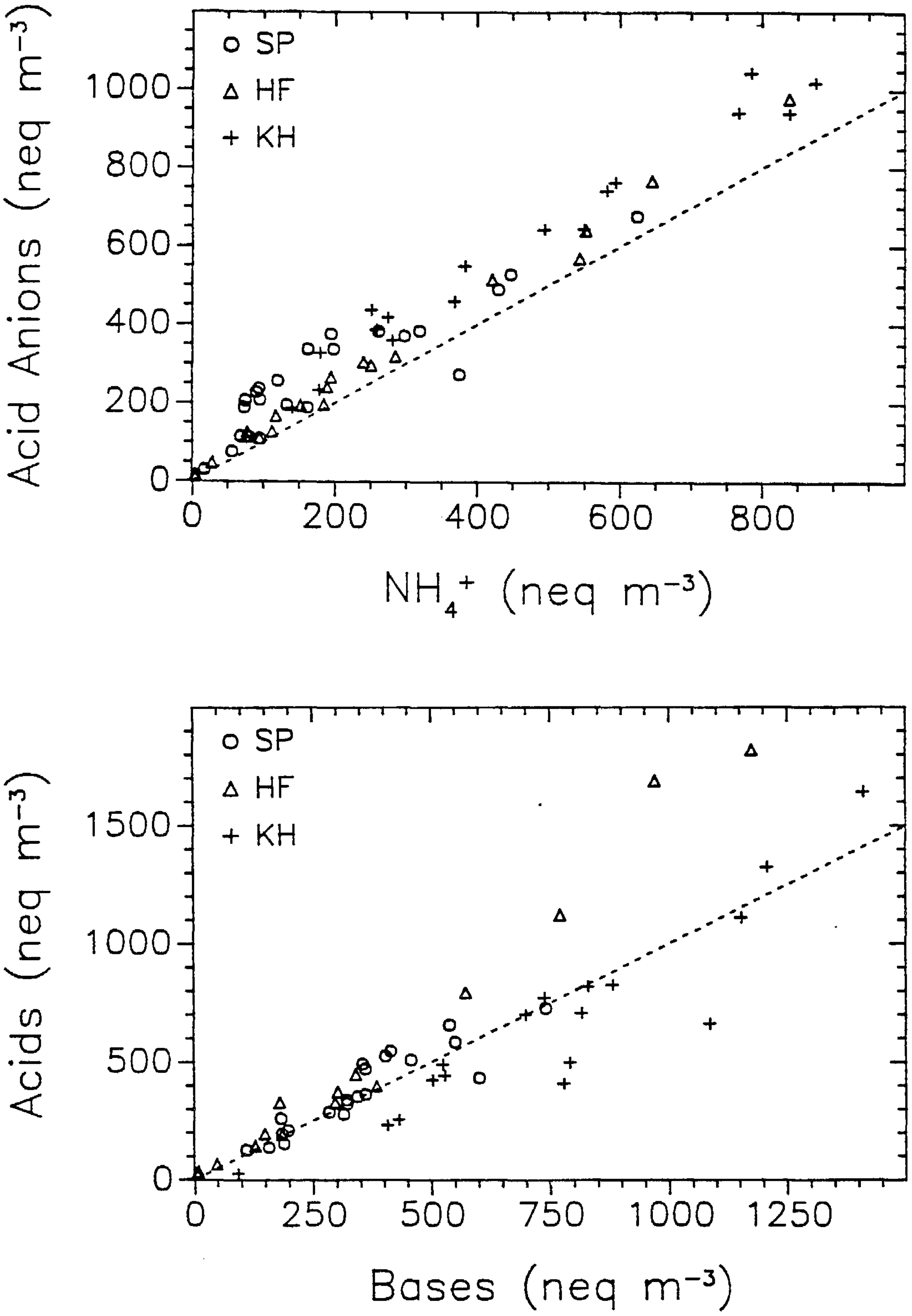


Figure 4

A) The sum, $NO_3^- + SO_4^{2-}$, plotted vs $NH_4^+$ in aerosol samples.

B) Total anions ($Cl^- + NO_3^- + SO_4^{2-} + HNO_3$) plotted vs total cations ($Na^+ + Ca^{2+} + Mg^{2+} + NH_4^+ + NH_3$) in aerosol samples

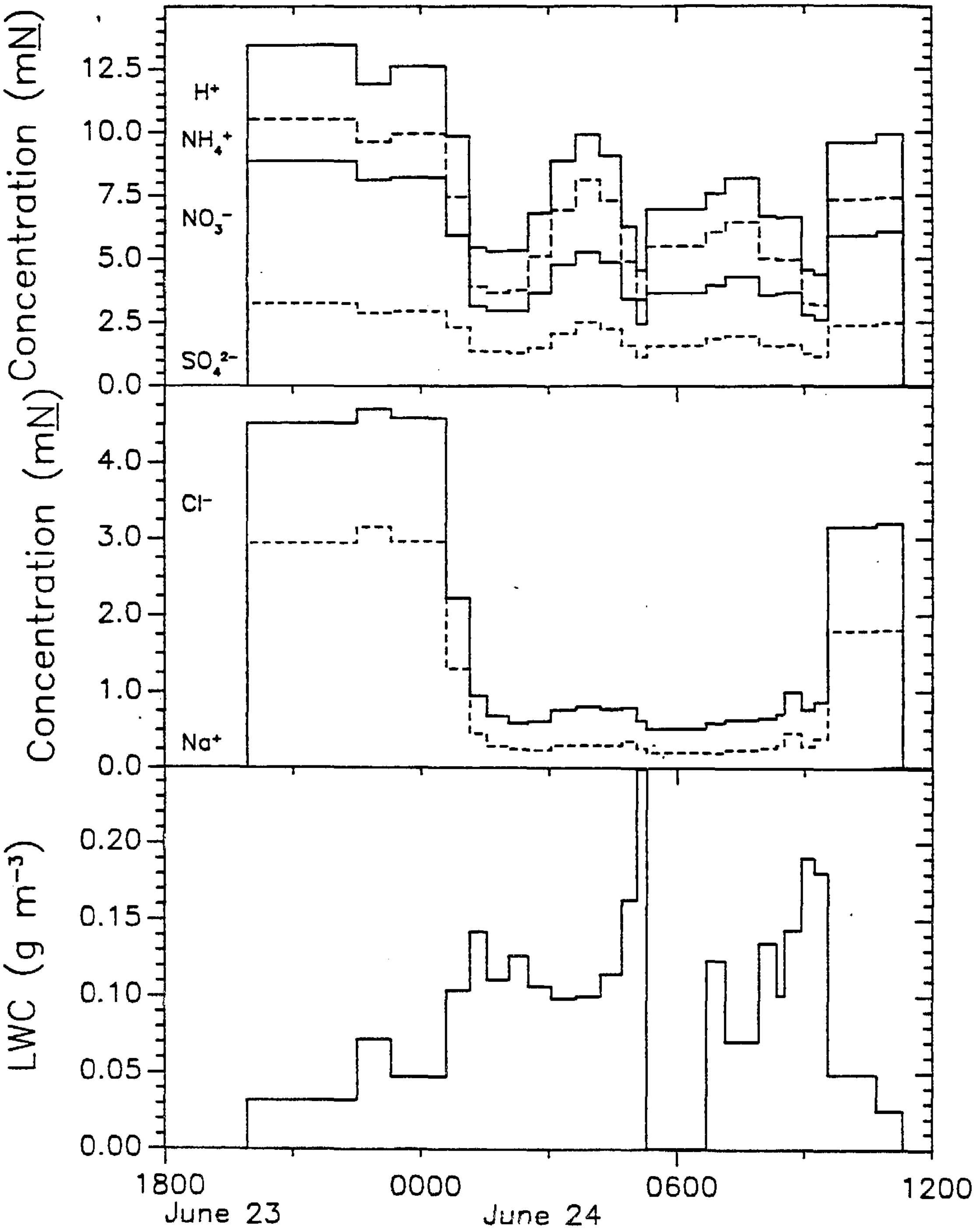


Figure 5

Concentrations of major ions and sea salts and LWC in cloudwater samples collected at San Pedro Hill on June 23 and 24, 1987. LWC is estimated from the sample collection rate and its theoretical efficiency.

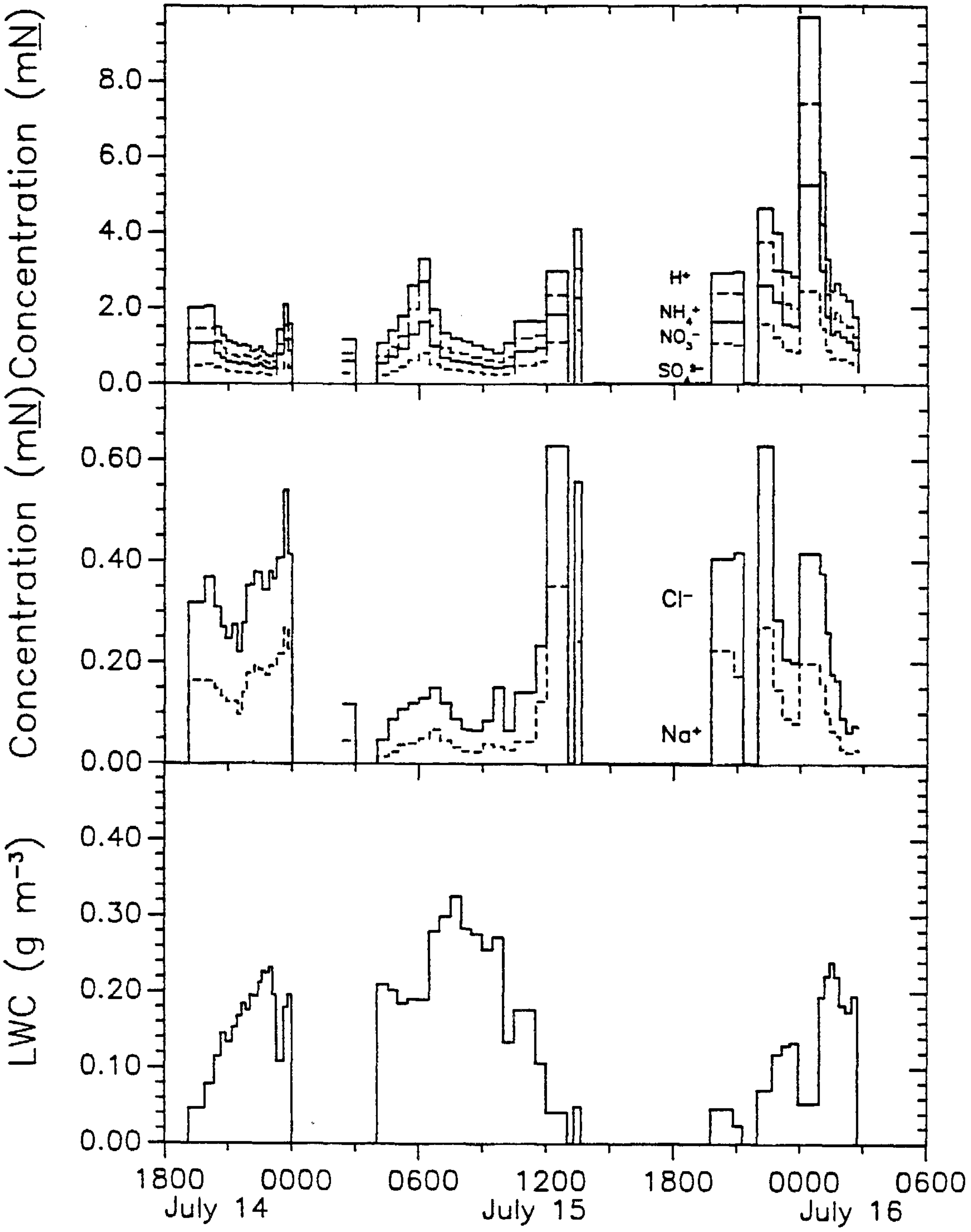


Figure 6

Concentrations of major ions and sea salts and LWC in cloudwater samples collected at San Pedro Hill over the period July 14 – July 16, 1987. LWC is estimated from the sample collection rate and its theoretical efficiency.

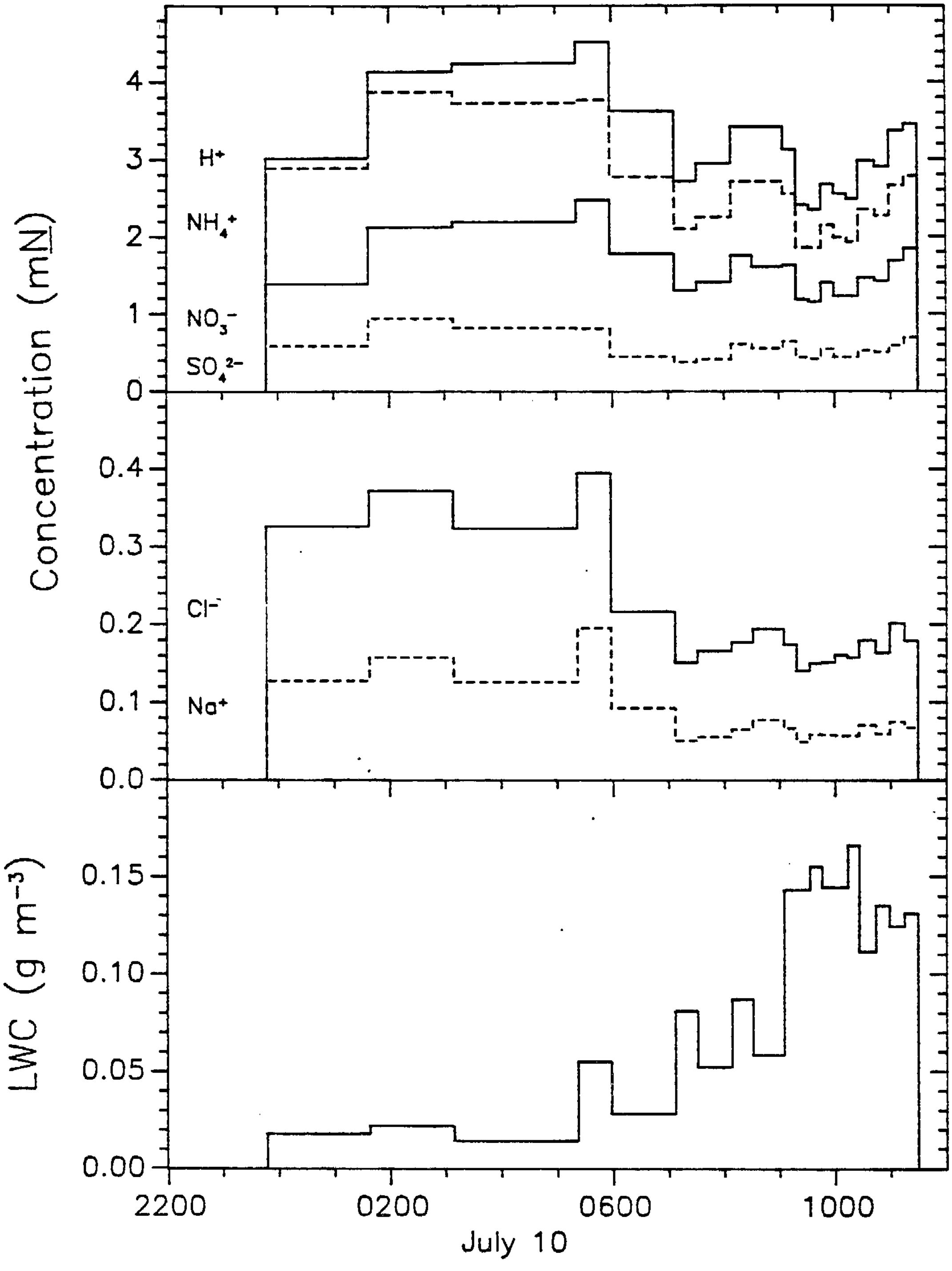


Figure 7

Concentrations of major ions and sea salts and LWC in cloudwater samples collected at Henninger Flats on July 10, 1987. LWC is estimated from the sample collection rate and its theoretical efficiency.

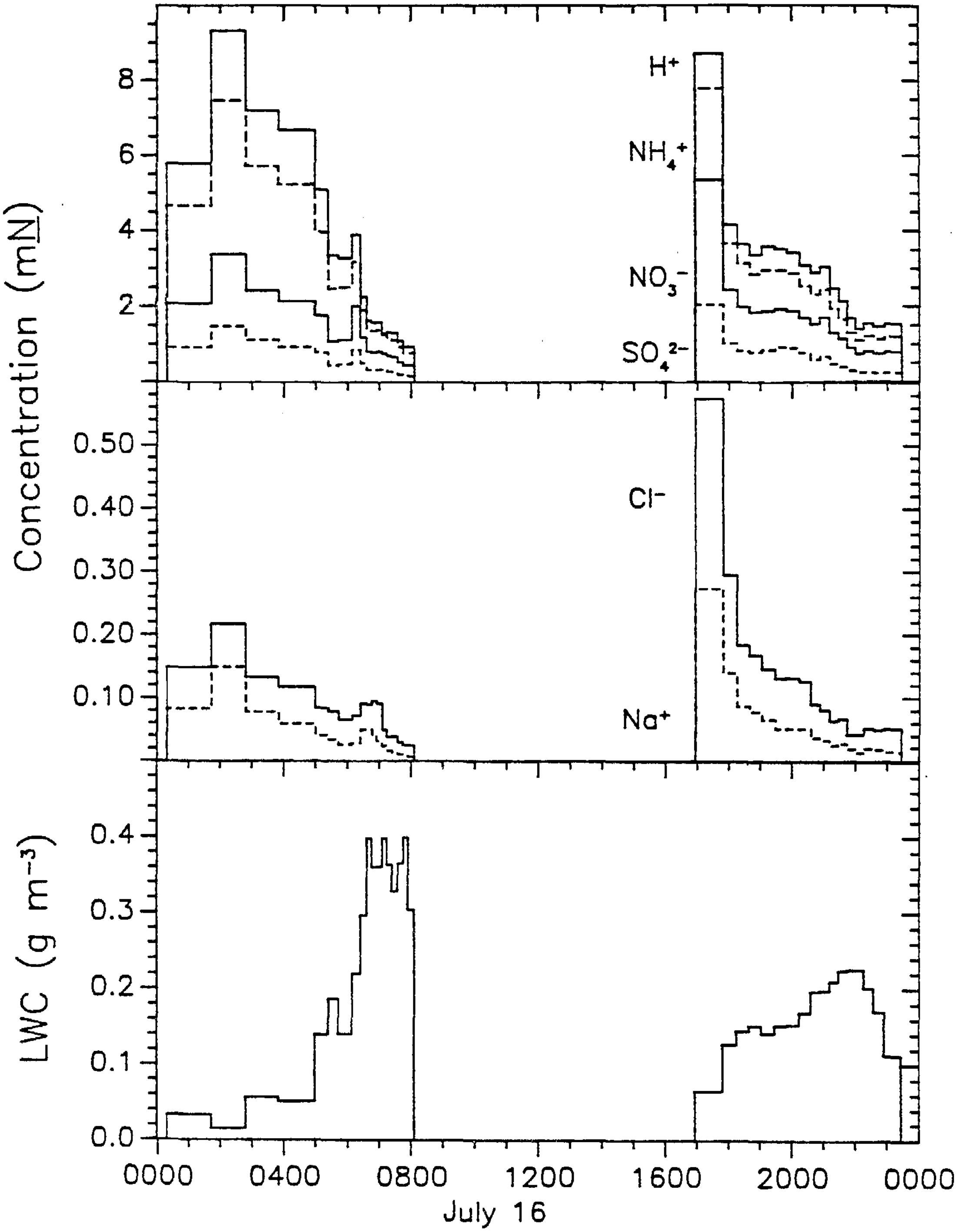


Figure 8

Concentrations of major ions and sea salts and LWC in cloudwater samples collected at Henninger Flats on July 16, 1987. LWC is estimated from the sample collection rate and its theoretical efficiency.

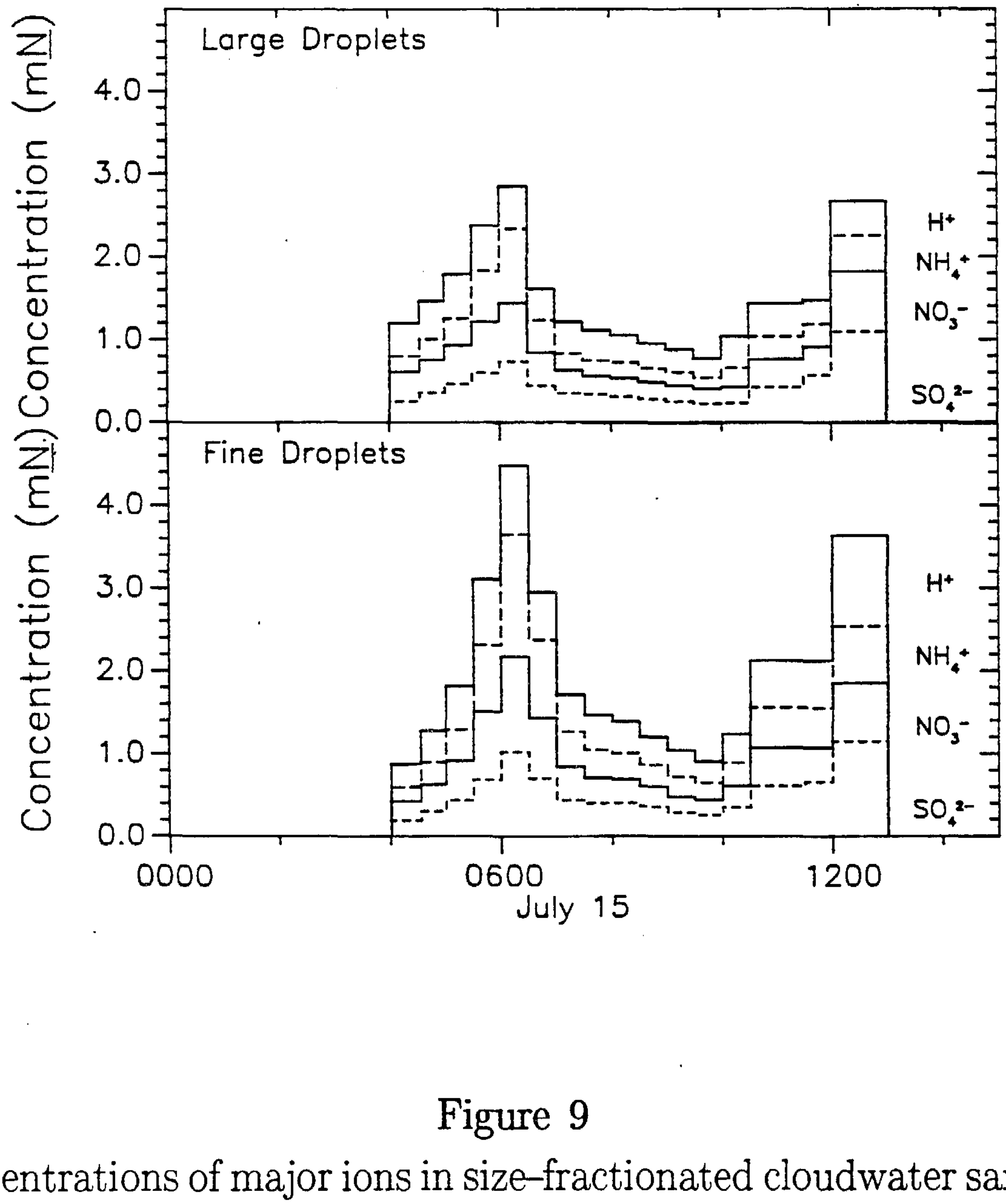


Figure 9

Concentrations of major ions in size-fractionated cloudwater samples collected at San Pedro Hill on the morning of July 15, 1987.

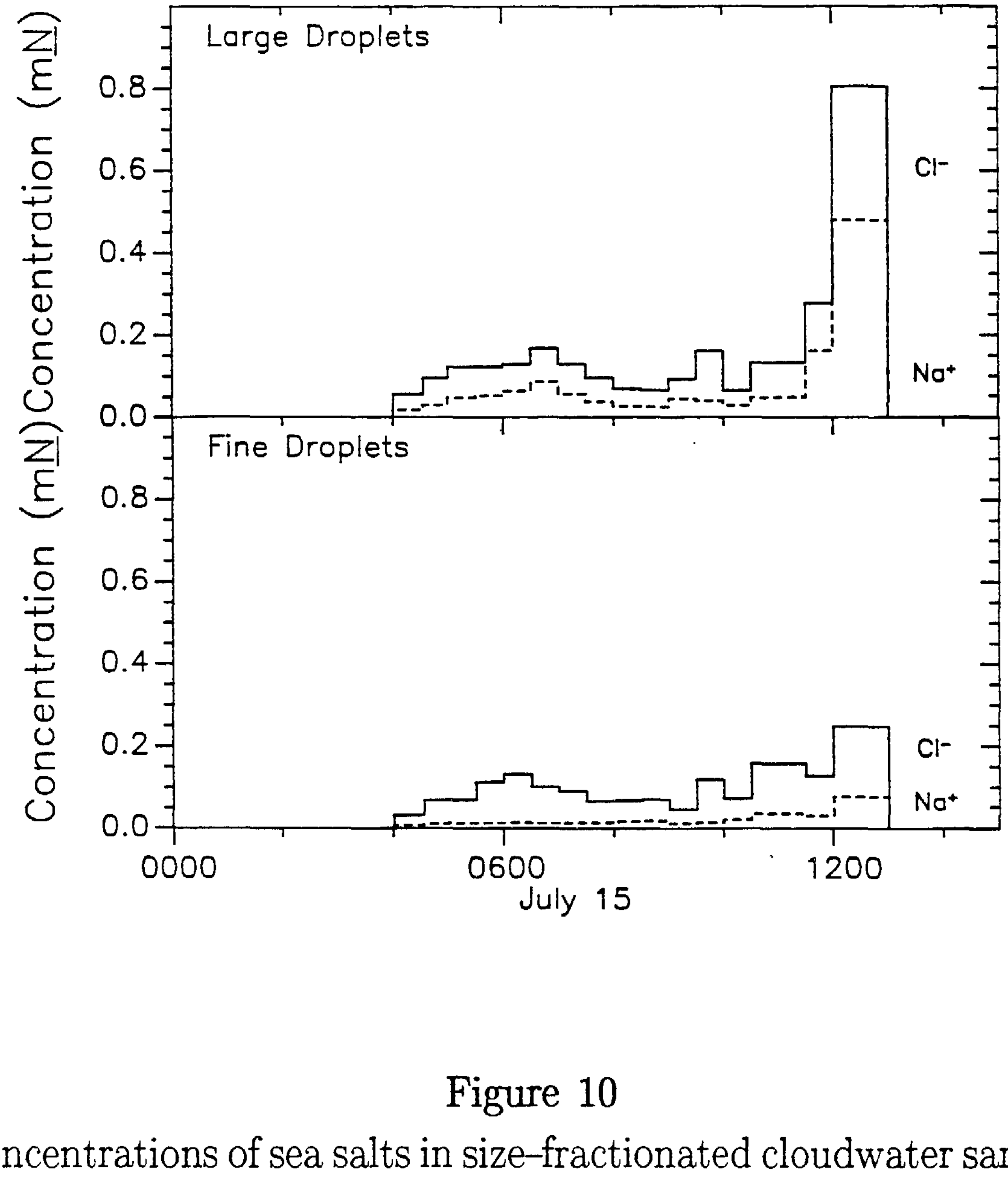


Figure 10
Concentrations of sea salts in size-fractionated cloudwater samples collected at San Pedro Hill on the morning of July 15, 1987.

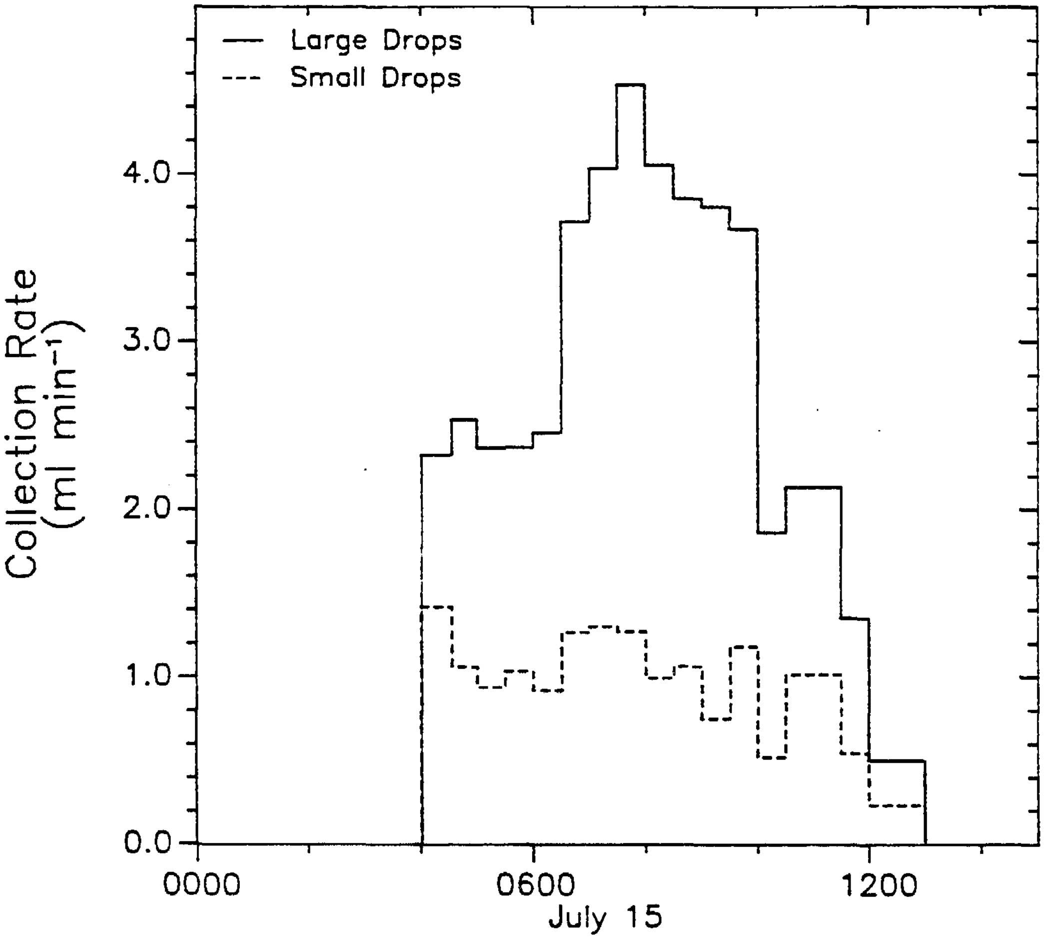


Figure 11

Collection rate for size-fractionated cloudwater samples collected at San Pedro Hill on the morning of July 15, 1987.

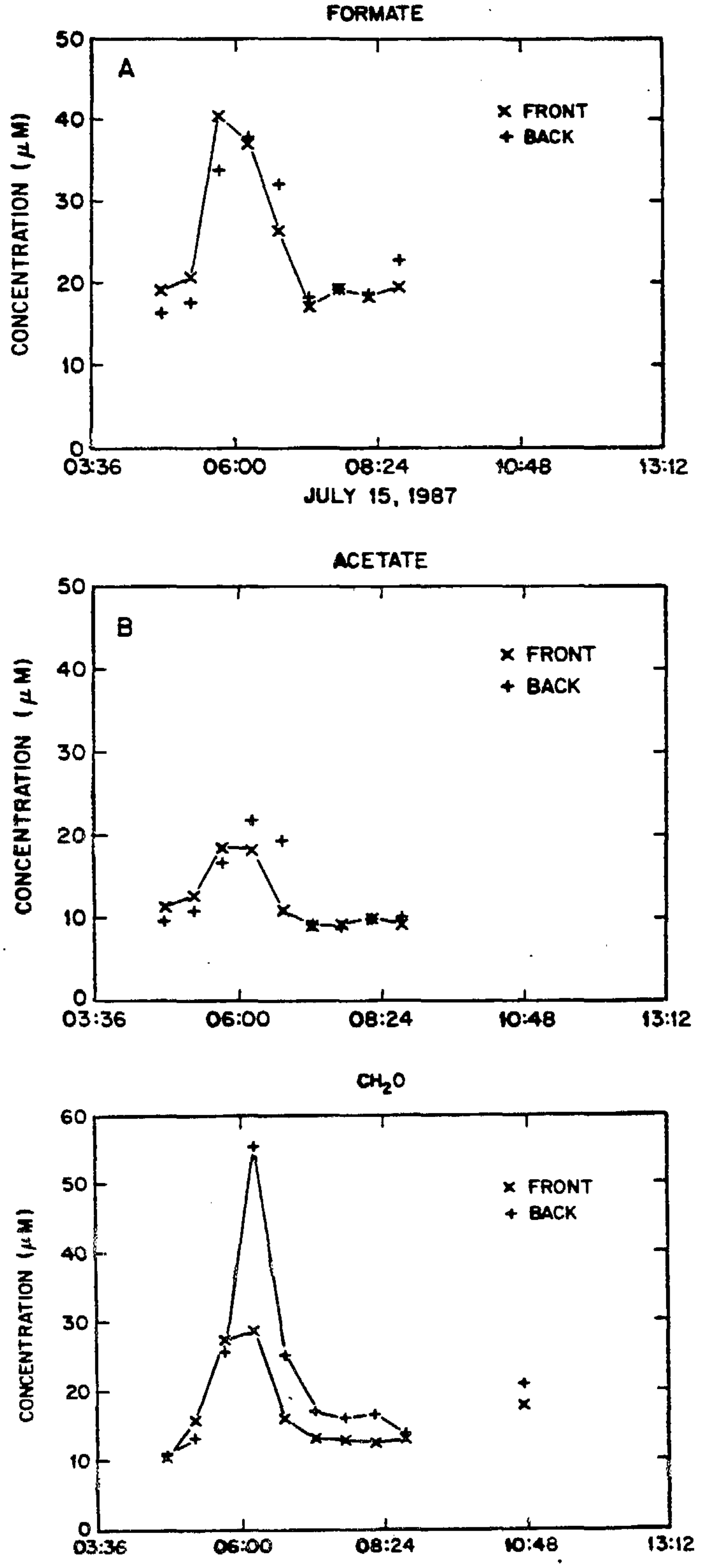


Figure 12

Formate (A), acetate (B), and formaldehyde (C) in size-fractionated cloudwater samples from San Pedro Hill. Large droplets are collected in the front fraction;are collected in the back fraction.

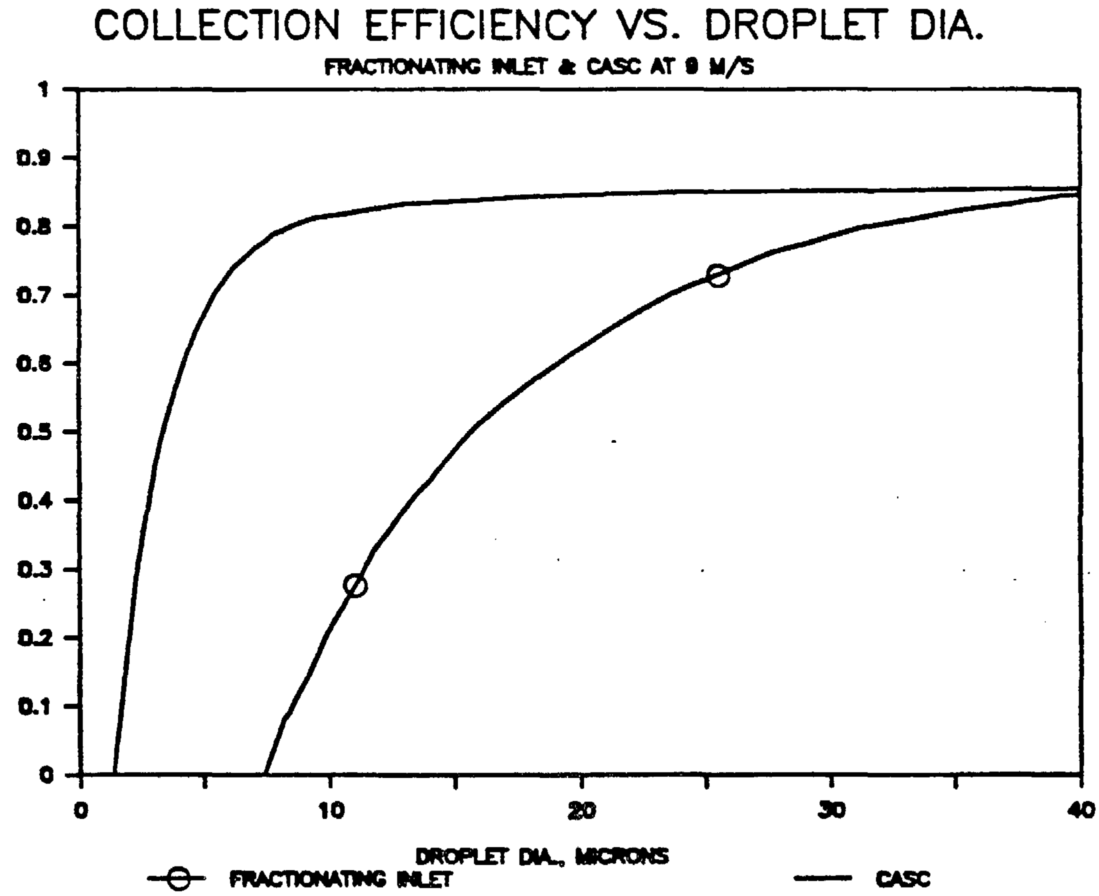
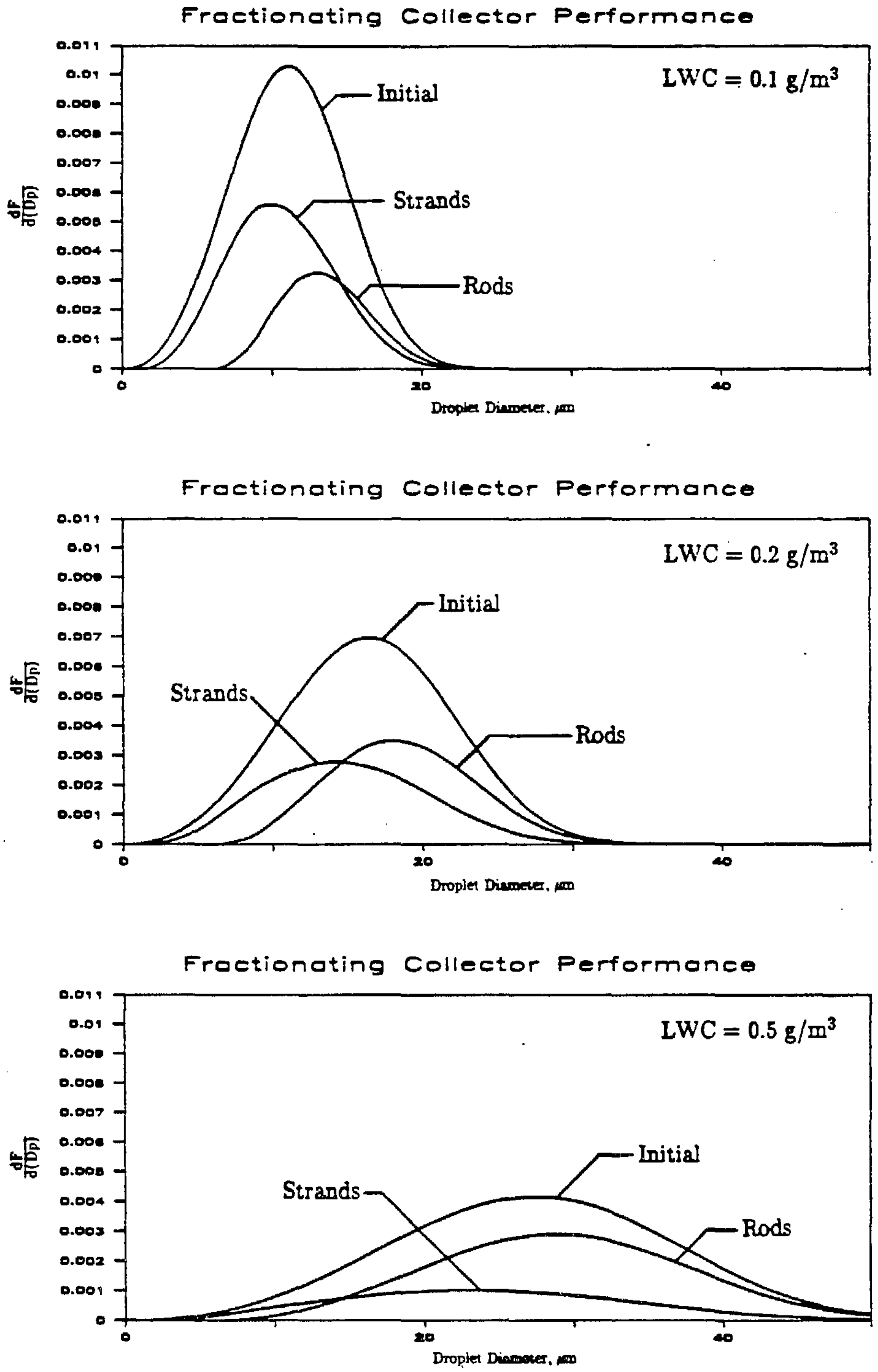


Figure 13

Theoretical collection efficiency vs droplet diameter for collection on the rods of the fractionating inlet and the strands of the CASC.

 
Fractionating Collector Performance

Fractionating Collector Performance

Fractionating Collector Performance

Figure 14

Collection of water on the fractionating inlet rods and CASC strands under three LWC conditions. Initial droplet-size distributions are given by Best's parameterized curves.