

2011

**Data Quality Assurance Report
Shenandoah Watershed Study,
Virginia Trout Stream Sensitivity Study,
And Related Projects**

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Table of Contents

1. Data Quality Assurance Results for 2010.....	3
2. Method Detection Limit Analysis	3
3. Charge Ratio Analysis.....	4
4. Conductivity Ratio Analysis	5
5. Analysis of Quality Control Check Samples.....	8
Blanks.....	8
Internal Quality Control Check Samples	8
External Quality Control Check Samples.....	8
6. Analysis of Field Duplicates.....	15
7. Collaborative Study Results for Precision and Systemic Bias.....	15
8. Corrective Actions	19
9. Citations	19

Tables and Figures

Figure 2-1: Method Detection Limits Summary	4
Figure 3-1: Charge Ratio Distributions for Sample Sets	6
Figure 4-1: Conductivity Ratio Distributions for Sample Sets	7
Table 5-1: Data Quality Objectives and Results for Blank Analyses	9
Table 5-2: Data Quality Objectives and Results for Internal Quality Control Check Samples.....	11
Table 5-3: Data Quality Objectives and Results for External Quality Control Check Samples	13
Table 6-1: Results Summary for Field Duplicates	16
Table 7-1: SWAS-VTSSS Program Inter-Laboratory Performance	17
Table 7-2: Rating Key for Environment Canada Proficiency Testing Program	18

1. Data Quality Assurance Results for 2011

This report provides data quality assurance results for the Shenandoah Watershed Study and Virginia Trout Stream Sensitivity Study (SWAS-VTSSS) program for samples collected in calendar year 2011. Results are reported here for quality assurance metrics associated with analysis of designated SWAS-VTSSS primary sampling sites in the western Virginia mountain region, including analysis of routine quarterly and weekly samples, and episodic (storm-flow) samples. Data quality assurance results are also reported here for analysis of TIME samples collected in western Virginia, Maryland, and West Virginia.

The data quality assurance results reported here include method detection limits analysis, charge and conductivity ratio analysis, and precision and bias analysis. These results are evaluated in relation to data quality objectives established by Morrison (1991) and Paulsen (1997).

Additional evaluation of SWAS-VTSSS data quality is provided through participation in an interlaboratory performance evaluation program administered by Environment Canada. Results for SWAS-VTSSS laboratory participation in this program are also reported here.

Section 8 of this report describes corrective actions taken or planned to improve data quality.

2. Method Detection Limit Analysis

Method Detection Limits (MDLs) are calculated at least annually using results from analyses of prepared low-level reference samples that consist of analytes in concentrations of 2-3 times the target MDL. Target MDLs are derived from the method detection limit objectives specified in Paulsen (1997). The calculated MDL is a function of the standard deviation of n analyzed samples, the number of samples, and the t -distribution, as follows: $MDL = s \cdot t$, where s is the standard deviation and t is the 99th quantile from a t -distribution with $n-1$ degrees of freedom. MDLs associated with each analysis are provided with SWAS-VTSSS data reported to SWAS-VTSSS program sponsoring agencies and scientific collaborators.

MDL objectives and results for 2011 are reported in Table 2-1. Results are reported for all analytes for which a zero concentration value can be obtained. MDL objectives were met for all analytes except calcium ion and dissolved organic carbon.

Table 2-1: Method Detection Limits Summary¹

Variable	MDL Objective ¹	Reporting Units	Start ²	End ³	MDL Attained
Ammonium	1.0	µeq/L	1/3/2011	12/28/2011	0.096
Calcium Ion	1.0	µeq/L	1/3/2011	12/28/2011	1.27
Chloride	1.0	µeq/L	1/3/2011	12/28/2011	0.111
Dissolved Organic Carbon	0.1	mg/L	1/25/2011	12/12/2011	0.103
Magnesium Ion	1.0	µeq/L	1/3/2011	12/28/2011	0.485
Nitrate	0.5	µeq/L	1/3/2011	12/28/2011	0.12
Organic Monomeric Aluminum	10.0	µg/L	1/25/2011	10/31/2011	3.125
Potassium Ion	1.0	µeq/L	1/3/2011	12/28/2011	0.078
Silica	0.84	µmol/L	1/3/2011	12/28/2011	0.589
Sodium Ion	1.0	µeq/L	1/3/2011	12/28/2011	0.058
Sulfate	1.0	µeq/L	1/3/2011	12/28/2011	0.444
Total Monomeric Aluminum	10.0	µg/L	1/25/2011	12/12/2011	3.125

¹ Method detection limit objectives are based on Paulsen (1997).

² Start date for sample collection period.

³ End date for sample collection period.

3. Charge Ratio Analysis

The charge or ion-balance ratio for individual water samples, defined as the sum of anions divided by the sum of cations, should equal 1. Deviation from 1 indicates either analytical error or failure either to account for or to measure all ions in the sample. In practice, charge ratios tend to differ from 1 due to the presence of unquantified or unspciated charged solutes such as organic ions or aluminum ions. Paulsen (1997) describes a range of specification limits for acceptable results given different types of surface waters. We have adopted lower and upper

specification limits of 0.80 and 1.15, as closest to the range generally observed in SWAS-VTSSS samples.

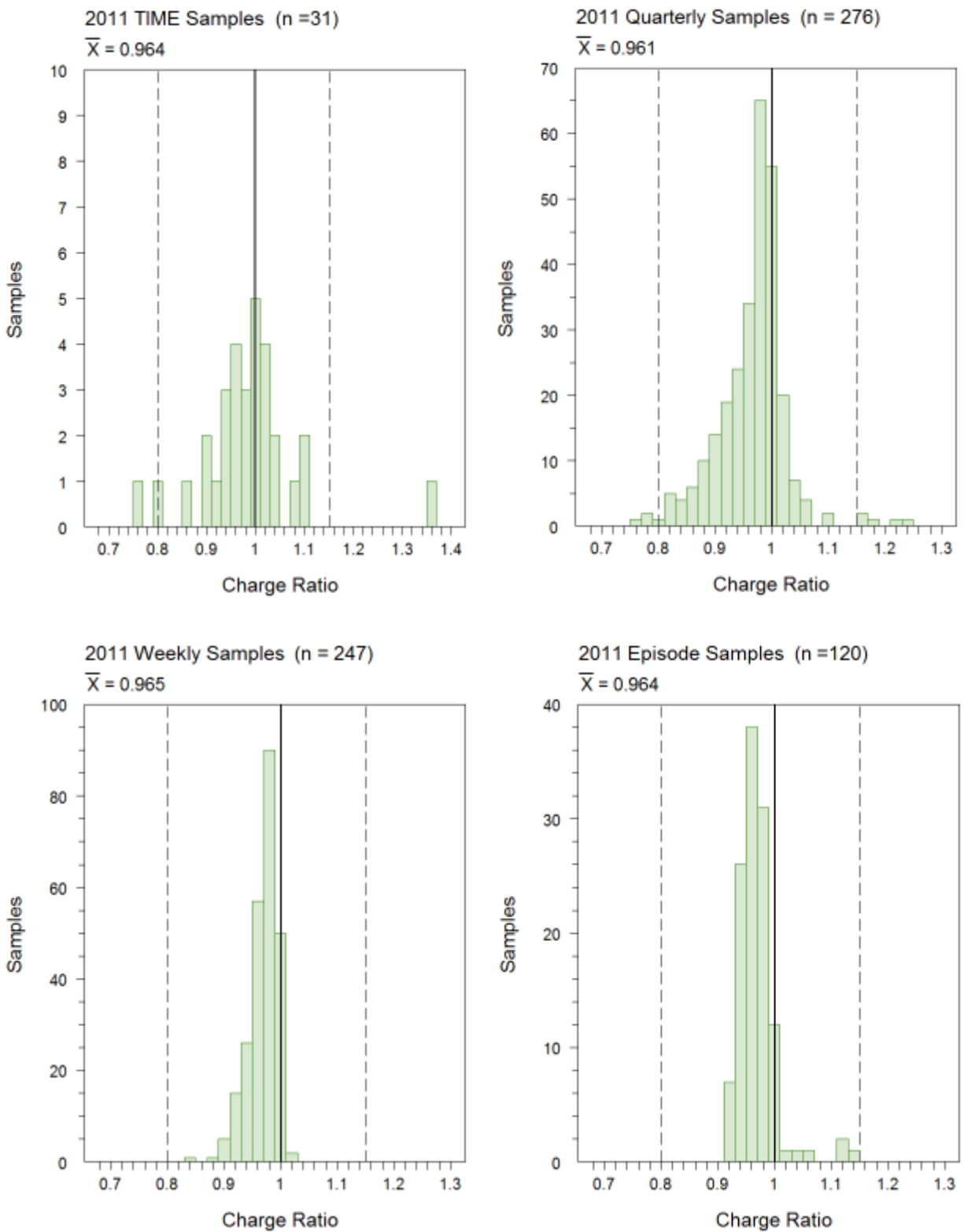
Charge ratio objectives (specification limits) and results for 2011 are depicted in Figure 3-1 for different subsets of SWAS-VTSSS project and TIME project samples collected in 2011. Most results are within the specification limits. The distributions of all sample sets show an anion deficit (charge ratio < 1), probably reflecting the presence of organic ions. An examination of the records with the greatest charge ratio discrepancy reveals that a small subset of sites are disproportionately represented, suggesting the presence of unquantified ions rather than analytical error.

4. Conductivity Ratio Analysis

The conductivity ratio for individual water samples, defined as the calculated conductance divided by the measured conductance, should equal 1. Calculated conductance is determined by summing the products of the concentrations of the ions and their respective conversion factors. As with charge ratios, deviation from 1 for conductivity ratios indicates either analytical error or failure either to account for or to measure all ions in the sample. In practice, conductivity ratios also tend to differ from 1 due to the presence of unquantified or unspiciated charged solutes such as organic ions or aluminum ions. Morrison (1991) identifies acceptable ranges adopted by a number of surface water monitoring projects in the eastern U.S. for samples with measured conductance ≤ 30 $\mu\text{eq/L}$. We have adopted lower and upper specification limits of 0.85 and 1.15, as closest to the range generally observed in SWAS-VTSSS samples.

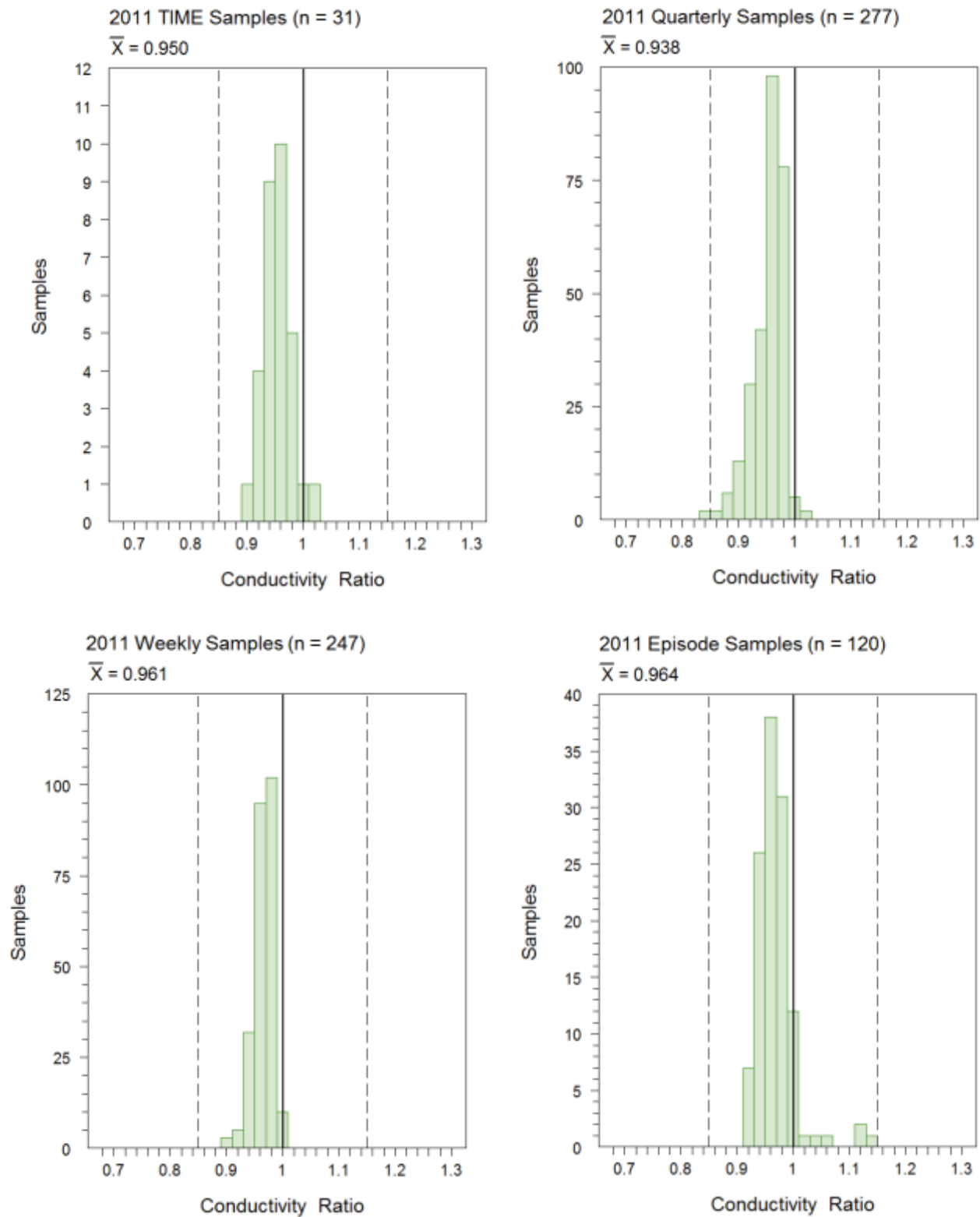
Conductivity ratio objectives (specification limits) and results for 2011 are depicted in Figure 4-1 for different subsets of SWAS-VTSSS samples collected in 2011. Most results are within the specification limits.

Figure 3-1: Charge Ratio Distributions for Sample Sets¹



¹ Upper and lower specification limits are indicated by the dashed lines.

Figure 4-1: Conductivity Ratio Distributions for Sample Sets¹



¹ Upper and lower specification limits are indicated by the dashed lines.

5. Analysis of Quality Control Check Samples

Several different types of quality control check samples (QCCS) are used by the SWAS-VTSSS program. These include blanks, internal reference samples, and external reference samples.

Blanks

Blanks are deionized water. The target value for blanks is 0. Data quality objectives are based on Paulsen (1997). Blanks are analyzed for all procedures except for pH.

1. Laboratory blanks: deionized water analyzed prior to sample analysis.
2. Post-preservation blanks: deionized water added to sample bottles, which remain in the laboratory and are subject to conditions similar to actual samples.
3. Trip blanks: deionized water added to sample bottles, which are transported to sampling sites and are subject to conditions similar to actual samples.

Table 5-1 provides data quality objectives and results for blank analysis conducted in 2011. Deviations for blank analyses were greatest for calcium ion, sulfate, and silica.

Internal Quality Control Check Samples

Internal QCCSs are prepared in the laboratory. Data quality objectives are based on Paulsen (1997). Calibration and detection limit quality control check samples are analyzed for all procedures except for pH, conductivity, and ANC.

1. Calibration quality control check samples: mid-range concentration reference samples analyzed before and after analytical sessions and periodically throughout the sessions.
2. Detection limit quality control check samples: reference samples with analyte concentrations of 4-6 times the method detection limit objective analyzed prior to analytical sessions.
3. Laboratory QCCS: a reference sample for pH, conductivity, and ANC analyzed before analytical sessions and periodically throughout the session for pH and ANC.

Table 5-2 provides data quality objectives and results for internal QCCS analysis conducted in conjunction with analyses for samples collected in 2011.

External Quality Control Check Samples

External QCCSs are prepared outside of the program laboratory by external providers of quality control samples. All external QCCSs used by the program in 2011 were obtained from the Environment Canada Proficiency Testing Program. Table 5-3 provides data quality objectives and results for external QCCS analysis conducted in 2011. Deviations for external QCCS analyses were greatest for calcium ion, chloride, ammonium, sulfate, and dissolved organic carbon.

Table 5-1: Data Quality Objectives and Results for Blank Analyses¹

SAMPLE_ID	Units	LSL	USL	N	Mean	SD	Min	Max	%Low	%High
LABORATORY BLANKS ²										
Acid Neutralizing Capacity	µeq/L	-5	5	63	2.50	0.86	0.44	6.56	0	1.6
Ammonium	µeq/L	-1.11	1.11	7	0.00	0.00	0	0	0	0
Calcium Ion	µeq/L	-1	1	7	0.45	0.66	0	1.55	0	28.6
Chloride	µeq/L	-0.85	0.85	8	0.13	0.02	0.1	0.16	0	0
Magnesium Ion	µeq/L	-0.82	0.82	7	0.19	0.26	0	0.65	0	0
Nitrate	µeq/L	-0.48	0.48	8	0.02	0.06	0	0.18	0	0
Potassium Ion	µeq/L	-1.02	1.02	7	0.02	0.06	0	0.16	0	0
Silica	µmol/L	-0.83	0.83	8	0.53	0.31	0	0.94	0	25.0
Sodium Ion	µeq/L	-0.87	0.87	7	0.05	0.06	0	0.15	0	0
Specific conductance	µS/cm	-1	1	65	0.10	0.00	0.1	0.1	0	0
Sulfate	µeq/L	-1.04	1.04	8	0.00	0.00	0	0	0	0
Total Monomeric Aluminum	µg/L	-10	10	9	1.00	0.45	0.29	1.65	0	0
POST PRESERVATION BLANKS ³										
Acid Neutralizing Capacity	µeq/L	-5	5	4	2.07	0.56	1.53	2.58	0	0
Ammonium	µeq/L	-1.11	1.11	4	0.00	0.00	0	0	0	0
Calcium Ion	µeq/L	-1	1	4	0.29	0.24	0	0.52	0	0
Chloride	µeq/L	-0.85	0.85	4	0.26	0.06	0.22	0.35	0	0
Dissolved Organic Carbon	mg/L	-0.1	0.1	4	0.03	0.04	0	0.09	0	0
Magnesium Ion	µeq/L	-0.82	0.82	4	0.08	0.15	0	0.3	0	0
Nitrate	µeq/L	-0.48	0.48	4	0.11	0.13	0	0.26	0	0
Potassium Ion	µeq/L	-1.02	1.02	4	0.00	0.00	0	0	0	0

SAMPLE_ID	Units	LSL	USL	N	Mean	SD	Min	Max	%Low	%High
Silica	μmol/L	-0.83	0.83	4	0.39	0.20	0.13	0.56	0	0
Sodium Ion	μeq/L	-0.87	0.87	4	0.00	0.00	0	0	0	0
Specific Conductance	μS/cm	-1	1	4	0.45	0.06	0.4	0.5	0	0
Sulfate	μeq/L	-1.04	1.04	4	0.75	0.59	0	1.32	0	50.0
Total Monomeric Aluminum	μg/L	-10	10	4	0.89	0.28	0.48	1.1	0	0
TRIP BLANKS ⁴										
Acid Neutralizing Capacity	μeq/L	-5	5	4	1.81	0.51	1.35	2.29	0	0
Ammonium	μeq/L	-1.11	1.11	4	0.00	0.00	0	0	0	0
Calcium Ion	μeq/L	-1	1	4	0.49	0.49	0.05	1	0	0
Chloride	μeq/L	-0.85	0.85	4	0.26	0.04	0.21	0.31	0	0
Dissolved Organic Carbon	mg/L	-0.1	0.1	4	0.03	0.04	0	0.09	0	0
Magnesium Ion	μeq/L	-0.82	0.82	4	0.18	0.21	0	0.39	0	0
Nitrate	μeq/L	-0.48	0.48	4	0.11	0.13	0	0.26	0	0
Potassium Ion	μeq/L	-1.02	1.02	4	0.00	0.00	0	0	0	0
Silica	μmol/L	-0.83	0.83	4	0.27	0.24	0	0.56	0	0
Sodium Ion	μeq/L	-0.87	0.87	4	0.04	0.07	0	0.14	0	0
Specific Conductance	μS/cm	-1	1	4	0.45	0.06	0.4	0.5	0	0
Sulfate	μeq/L	-1.04	1.04	4	0.75	0.59	0	1.31	0	50.0
Total Monomeric Aluminum	μg/L	-10	10	4	1.06	0.69	0.29	1.74	0	0

¹ Data quality objectives, lower specification limits (LSL) and upper specification limits (USL), are based on Paulsen (1997). The target value for blanks is 0.

² Laboratory blanks are deionized water; analyzed prior to sample analysis for all procedures except for pH.

³ Post-preservation blanks are deionized water added to sample bottles, which remain in the laboratory and are subject to conditions similar to actual samples; analyzed for all procedures except for pH.

⁴ Trip blanks are deionized water added to sample bottles, which are transported to sampling sites and are subject to conditions similar to actual samples; analyzed for all procedures except for pH.

Table 5-2: Data Quality Objectives and Results for Internal Quality Control Check Samples¹

SAMPLE_ID	Units	Target	LSL	USL	N	Mean	SD	Min	Max	%Low	%High
CALIBRATION QCCS²											
1536273167-Total Monomeric Aluminum	µg/L	50	40	60	33	52.25	1.41	49.7	55.71	0	0
1589085299-Ammonium	µeq/L	16.62	15.8	17.45	61	16.72	0.06	16.62	16.84	0	0
1589085299-Calcium Ion	µeq/L	29.94	28.4	31.44	61	29.83	0.64	28.91	32.02	0	3.3
1589085299-Magnesium Ion	µeq/L	24.69	23.5	25.92	61	24.48	0.15	24.16	24.85	0	0
1589085299-Potassium Ion	µeq/L	30.72	29.2	32.26	61	30.80	0.09	30.62	30.98	0	0
1589085299-Sodium Ion	µeq/L	26.1	24.8	27.41	61	26.15	0.07	25.97	26.29	0	0
1607051116-Silica	µmol/L	42.63	40.5	44.76	45	43.38	0.35	42.43	44.03	0	0
294015784-Dissolved Organic Carbon	mg/L	3	2.7	3.3	26	2.93	0.04	2.85	3	0	0
604979034-Dissolved Organic Carbon	mg/L	1.5	1.35	1.65	27	1.45	0.04	1.38	1.55	0	0
835178633-Chloride	µeq/L	25.38	24.1	26.65	61	25.59	0.12	25.31	25.87	0	0
835178633-Nitrate	µeq/L	14.49	13.8	15.21	61	14.63	0.14	14.32	14.99	0	0
835178633-Sulfate	µeq/L	31.2	29.6	32.76	61	31.32	0.25	30.73	31.94	0	0
DETECTION LIMIT QCCS³											
1430223312-Dissolved Organic Carbon	mg/L	0.5	0.4	0.6	7	0.48	0.02	0.44	0.51	0	0
1551398954-Silica	µmol/L	4.26	3.43	5.09	9	4.58	0.25	4.08	4.94	0	0
2038668014-Total Monomeric Aluminum	µg/L	40	30	50	9	40.60	0.44	39.71	41.03	0	0
310620753-Ammonium	µeq/L	5.54	4.43	6.65	8	5.61	0.07	5.54	5.76	0	0
310620753-Calcium Ion	µeq/L	4.99	3.99	5.99	8	4.33	0.19	4.13	4.67	0	0
310620753-Magnesium Ion	µeq/L	4.12	3.29	4.94	8	3.67	0.12	3.5	3.85	0	0
310620753-Potassium Ion	µeq/L	5.12	4.1	6.14	8	5.01	0.07	4.95	5.17	0	0
310620753-Sodium Ion	µeq/L	4.35	3.48	5.22	8	4.24	0.04	4.19	4.29	0	0

SAMPLE_ID	Units	Target	LSL	USL	N	Mean	SD	Min	Max	%Low	%High
324900038-Chloride	µeq/L	4.23	3.38	5.08	8	4.16	0.04	4.13	4.24	0	0
324900038-Nitrate	µeq/L	2.42	1.93	2.9	8	2.43	0.04	2.37	2.49	0	0
324900038-Sulfate	µeq/L	5.2	4.16	6.24	8	5.20	0.14	4.98	5.46	0	0
LABORATORY QCCS ⁴											
1575259953-Acid Neutralizing Capacity	µeq/L	-25	-30	-20	204	-24.12	0.93	-27.17	-21.44	0	0
1575259953-pH		4.6	4.53	4.68	204	4.60	0.02	4.53	4.65	0	0

¹ Data quality objectives, lower specification limits (LSL) and upper specification limits (USL), are based on Paulsen (1997).

² Calibration Quality Control Check Samples are mid-range calibration standards; analyzed before and after sample analysis and periodically throughout analytical runs for all procedures except pH, conductivity, and ANC.

³ Detection Limit Quality Control Check Samples consist of analytes at a concentration of 4 – 6 times the method detection limit objective; analyzed prior to sample analysis for all procedures except pH, conductivity, and ANC.

⁴ Laboratory Quality Control Check Samples are laboratory-prepared reference samples; analyzed before and after sample analysis and periodically throughout analytical runs for pH and ANC.

Table 5-3: Data Quality Objectives and Results for External Quality Control Check Samples^{1,2}

SAMPLE_ID	Units	Target	LSL	USL	N	Mean	SD	Min	Max	%Low	%High
1028560529-Silica	µmol/L	30.2	28.7	31.7	17	29.98	0.30	29.24	30.52	0	0
1043652504-Ammonium	µeq/L	0.43	-0.68	1.54	10	0.70	0.40	0.29	1.41	0	0
1043652504-Calcium Ion	µeq/L	135.7	129	142.5	10	136.72	0.99	134.4	137.9	0	0
1043652504-Chloride	µeq/L	11	10.2	11.8	10	11.39	0.06	11.32	11.53	0	0
1043652504-Magnesium Ion	µeq/L	76.5	75.6	77.3	10	77.01	0.33	76.34	77.5	0	10.0
1043652504-Potassium Ion	µeq/L	4.2	3.17	5.22	10	4.23	0.03	4.18	4.26	0	0
1043652504-Sodium Ion	µeq/L	6.53	5.66	7.4	10	6.58	0.05	6.51	6.65	0	0
1043652504-Sulfate	µeq/L	125.8	120	132.1	10	125.08	0.57	124.6	126.3	0	0
1103680110-Dissolved Organic Carbon	mg/L	6.22	5.6	6.84	3	6.24	0.07	6.17	6.31	0	0
1105597272-Silica	µmol/L	96.95	92.1	101.8	11	95.54	0.51	94.69	96.18	0	0
1133206360-Silica	µmol/L	0.36	-0.48	1.19	3	0.48	0.21	0.34	0.72	0	0
1150111047-Ammonium	µeq/L	2.1	1	3.21	3	2.35	0.11	2.25	2.46	0	0
1150111047-Calcium Ion	µeq/L	194.6	185	204.3	3	191.93	1.20	190.7	193.1	0	0
1150111047-Magnesium Ion	µeq/L	86.4	82.1	90.7	3	86.25	0.44	85.78	86.66	0	0
1150111047-Nitrate	µeq/L	7.7	7.21	8.18	3	7.87	0.06	7.83	7.94	0	0
1150111047-Potassium Ion	µeq/L	12.4	11.4	13.5	3	12.43	0.09	12.36	12.53	0	0
1150111047-Sodium Ion	µeq/L	108.8	103	114.2	3	111.79	0.25	111.5	112	0	0
1150111047-Sulfate	µeq/L	115.7	110	121.4	3	115.19	0.31	114.9	115.5	0	0
1310267086-Dissolved Organic Carbon	mg/L	0.32	0.22	0.42	4	0.45	0.03	0.41	0.48	0	75.0
257817781-Ammonium	µeq/L	19.8	18.7	20.9	7	16.79	0.25	16.52	17.13	100.0	0
257817781-Calcium Ion	µeq/L	7.78	6.79	8.78	7	8.23	0.51	7.63	9	0	14.3
257817781-Chloride	µeq/L	4.23	3.38	5.08	7	4.67	0.07	4.55	4.74	0	0
257817781-Magnesium Ion	µeq/L	2.55	1.73	3.37	7	2.72	0.13	2.58	2.95	0	0

SAMPLE_ID	Units	Target	LSL	USL	N	Mean	SD	Min	Max	%Low	%High
257817781-Nitrate	µeq/L	16.2	15.4	17.1	7	16.76	0.20	16.41	16.99	0	0
257817781-Potassium Ion	µeq/L	0.95	-0.08	1.97	7	1.08	0.02	1.06	1.11	0	0
257817781-Sodium Ion	µeq/L	2.87	2	3.74	7	3.06	0.02	3.02	3.08	0	0
257817781-Sulfate	µeq/L	27	25.7	28.4	7	28.22	0.25	27.82	28.54	0	28.6
481906401-Dissolved Organic Carbon	mg/L	6.98	6.28	7.68	4	7.07	0.04	7.02	7.11	0	0
638339277-Ammonium	µeq/L	2.79	1.68	3.9	12	2.56	0.08	2.32	2.62	0	0
638339277-Calcium Ion	µeq/L	130.7	124	137.3	12	130.29	1.26	127.7	132.3	0	0
638339277-Chloride	µeq/L	5.36	4.51	6.2	12	5.49	0.07	5.35	5.6	0	0
638339277-Magnesium Ion	µeq/L	33.99	32.3	35.69	12	33.94	0.26	33.54	34.34	0	0
638339277-Nitrate	µeq/L	2.14	1.66	2.62	12	2.25	0.04	2.17	2.31	0	0
638339277-Potassium Ion	µeq/L	4.71	3.69	5.73	12	4.65	0.02	4.63	4.71	0	0
638339277-Sodium Ion	µeq/L	24.36	23.1	25.58	12	25.08	0.06	25	25.22	0	0
638339277-Sulfate	µeq/L	78.42	74.5	82.34	12	79.05	0.50	78.23	79.83	0	0
73408571-Ammonium	µeq/L	19.8	18.7	20.9	4	16.66	0.13	16.56	16.85	100.0	0
73408571-Calcium Ion	µeq/L	7.58	6.59	8.58	4	8.02	0.85	7.24	9.05	0	25.0
73408571-Chloride	µeq/L	4.23	3.38	5.08	4	4.40	0.28	4.18	4.8	0	0
73408571-Magnesium Ion	µeq/L	2.72	1.89	3.54	4	2.48	0.06	2.42	2.55	0	0
73408571-Nitrate	µeq/L	16.3	15.5	17.1	4	16.45	0.28	16.11	16.69	0	0
73408571-Potassium Ion	µeq/L	0.99	-0.03	2.01	4	0.96	0.06	0.91	1.05	0	0
73408571-Sodium Ion	µeq/L	3.03	2.16	3.9	4	2.92	0.04	2.88	2.96	0	0
73408571-Sulfate	µeq/L	27.9	26.5	29.3	4	27.83	0.40	27.37	28.17	0	0

¹ Data quality objectives, lower specification limits (LSL) and upper specification limits (USL) are based on Paulsen (1997).

² External Quality Control Samples are provided through the Environment Canada Proficiency Testing Program; analyzed for all procedures except pH, conductivity, and ANC.

6. Analysis of Field Duplicates

Sample duplicates were collected from one weekly sampling site each week, with site selected on a rotating basis. Additional duplicates (for about 5% of sample sites) were collected from quarterly sampling sites during each quarter and from TIME project sampling sites. Data quality objectives and upper and lower specification limits for differences between duplicates are adapted from Paulsen (1997).

Table 6-1 lists data quality objectives and summarizes results for 72 duplicate sample pairs collected in 2011. Most of the results met data quality objectives for differences between duplicate sample pairs. For nitrate the objective was met for 90.3% of the duplicate pairs; for calcium ion the objective was met for 95.8% of the duplicate pairs; and for sulfate the objective was met for 94.4% of the duplicate pairs.

Appendix 1 provides a complete listing of duplicate sample pair results.

7. Collaborative Study Results for Precision and Systemic Bias

The SWAS-VTSSS program laboratory participates in the Environment Canada Proficiency Testing Program administered by the Information and Quality Management Group of Environment Canada's Emergencies, Operational Analytical Laboratories and Research Support Division. Public and private laboratories, primarily in the United States and Canada, participate in this program which is designed for laboratories analyzing rain and natural soft water samples. Each study consists of ten samples, which are analyzed by the SWAS-VTSSS program laboratory by the same methods as the project samples, usually concurrently with project samples.

The Proficiency Testing program provides an objective, third-party evaluation of the laboratory's performance. The report for each study includes an assessment of systemic bias and precision.

The project laboratory's reported test results for each sample and each parameter are compared to the value assigned by Environment Canada. Over the years of participation, the Environment Canada Proficiency Testing program has evolved and therefore updated its methods for evaluation of systemic bias and precision. Currently the Proficiency Testing program is accredited by the American Association for Laboratory Accreditation and conforms to the ISO/IEC 17043:2010 Conformity assessment – General requirements for proficiency testing. Details of how the systemic bias and precision were evaluated for a particular study are given in the Final Report for each Proficiency Testing study.

Performance summaries for Proficiency Testing studies in which the project laboratory has participated to date are reported in Table 7-1. The rating key for the Environment Canada Proficiency Testing program is provided in Table 7-2.

Table 6-1: Results Summary for Field Duplicates¹

Variable	Reporting Units	Concentration Range ²	Data Quality Objective ³	Total ⁴	Attainment
pH	pH units	≤ 5.75 > 5.75	±0.106 ±0.21	72	100%
ANC	µeq/L	≤ 100 > 100	±7 ±7%	72	100%
Conductivity	µS/cm	≤ 50 > 50	±1.4 ±3%	72	100%
Cl ⁻	µeq/L	≤ 20 > 20	±1.4 ±7%	72	100%
NO ₃ ⁻	µeq/L	≤ 10 > 10	±0.7 ±7%	72	90.3%
SO ₄ ²⁻	µeq/L	≤ 20 > 20	±1.4 ±7%	72	94.4%
Ca ²⁺	µeq/L	≤ 20 > 20	±1.4 ±7%	72	95.8%
Mg ²⁺	µeq/L	≤ 20 > 20	±1.4 ±7%	72	100%
Na ⁺	µeq/L	≤ 20 > 20	±1.4 ±7%	72	100%
K ⁺	µeq/L	≤ 20 > 20	±1.4 ±7%	72	100%
DOC	mg/L	≤ 1 > 1	±0.14 ±14%	15	100%
NH ₄ ⁺	µeq/L	≤ 20 > 20	±1.4 ±7%	72	98.6%
SiO ₂	µmol/L	≤ 17 > 17	±1.17 ±7%	72	100%

¹ Field duplicate values are provided in Appendix 1

² Precision objectives are based absolute differences at lower concentrations and relative percent deviation at higher concentrations. Precision objectives for pH are based on absolute differences at both lower and higher values.

³ Data quality objectives for precision are based on Paulsen (1997).

⁴ Total number of duplicate pairs.

Table 7-1: SWAS-VTSSS Program Inter-Laboratory Performance¹

Study Number and date	pH - manual	pH- titrator	specific conductance	ANC – manual	ANC – titrator	chloride	nitrate	sulfate	ammonium	silica	sodium ion	potassium ion	calcium ion	magnesium ion	DOC	% Score
L36: May 1994	A		A			A	A	A	A	A	A	A	A	A		16.7
L38: Jan 1995	A		1	A		2	A	A	A	3	A	A	A	4		25.8
L39: Sep 1995	A		A	A		A	A	A		A	A	A	A	A		0.0
FP69: Sep 1996	A		A	A		A	A	A	A	A	5	A	A	A		0.8
FP71: Sep 1997	A		A	A		A	A	A	A	A	A	A	A	A		0.0
FP73: Sep 1998	A		A	A		A	A	A	6	A	A	A	A	A		0.8
FP75: Sep 1999	A		A	A		A	A	A	7	A	A	A	A	A		0.8
FP77: Aug 2000	A		A	A		A	A	A	A	8	A	A	A	A		0.4
FP79: Aug 2001	A		A	A		A	A	A	9	10	A	A	A	11		2.1
FP81: Sep 2002	A		12	A		A	A	A	A	13	A	A	A	A		6.7
PT84: Jun 2004	A		A	A		A	A	A	A	A	A	A	A	A		0.0
PT87: Dec 2005	A		A	A		A	A	A	A	A	A	A	A	A		0.0
PT89: Dec 2006	14	A	A	A	A	A	A	A	A	A	A	A	A	A		5.6
PT91: Dec 2007		A	15		A	A	A	A	A	A	A	A	A	A	A	5.4
PT93: Dec 2008		A	A		A	A	16	A	17	A	A	A	A	A	A	0.8
PT95: Dec 2009		A	A		A	A	A	A	A	A	A	18	A	19	A	0.9
PT97: Dec 2010		A	A		A	A	A	A	A	16	A	A	A	A	A	0.4
PT99: Dec 2011		A	A		A	A	A	A	A	A	A	A	A	A	A	0.0

¹ Environment Canada Proficiency Testing Program; score is the sum of the % of reported parameters that were biased plus the % of the reported parameters that were flagged. A perfect score would be 0.0. See rating key below.

Table 7-2: Rating Key for Environment Canada Proficiency Testing Program

A = Acceptable results

- 1) Although no results are flagged, ranking indicates a slight bias low.
- 2) Although no results are flagged, ranking indicates a slight bias low. After these results were submitted, the ion chromatography column used for chloride analyses was replaced.
- 3) Acceptable, except for high on one out of ten samples.
- 4) Although no results are flagged, ranking indicates a slight bias high.
- 5) Flagged very high on one out of ten samples. This was due to a calculation error made after analysis.
- 6) Two out of 10 samples flagged: one extremely low, one low.
- 7) Two out of 10 samples flagged: both very low.
- 8) Flagged extremely low on one sample out of 10.
- 9) Three out of 10 samples flagged: one extremely low, one very low, and one low.
- 10) Satisfactory, except for low on one out of 10 samples.
- 11) Flagged extremely high on one sample out of 10.
- 12) Four out of 10 samples flagged low. Ranking indicates a low bias: -4.64%, blank -0.3536.
- 13) Two out of 10 samples flagged: one very low, one low.
- 14) Ranking indicates a high bias: 8.50%, blank: -0.4069.
- 15) Ranking indicates a low bias: -9.10%, blank: 0.3390. Four out of 10 samples flagged as low: three action flags and one warning flag.
- 16) Action flag (high) on one out of 10 samples.
- 17) Warning flag (low) on one out of 10 samples.
- 18) Warning flag (high) on one out of 10 samples.
- 19) Action flag (high) on two out of 10 samples.

8. Corrective Actions

The following steps are planned to improve SWAS-VTSSS program data quality:

1. Modifications of ion-chromatography procedures, including more frequent replacement of instrument tubing, have been implemented to improve analysis of major ions: Poor precision can be caused by contaminated tubing, especially for calcium and magnesium. This may be the cause of the difficulty in attaining the MDL and precision objectives and the deviations for blank, internal QCCS and external QCCS results.
2. The outdated spectrophotometer instrument used for analysis of silica has been replaced: A more-modern instruments should provide more precise analyses and lower detection limits.
3. Additional sources of external QCCS material or methods of handling external QCCS material will be investigated in order to obtain reference samples with more-stable concentrations of nitrogen species.
4. Analysis of lab duplicates will be initiated to determine if the source of the differences between duplicate sample pairs is due to differences between the two samples or imprecision in analysis.

9. Citations

Morrison, Marilyn, 1991, *Data User's Guide to the United States Environmental Protection Agency's Long-term Monitoring Project: Quality Assurance Plan and Data Dictionary*, Environmental Research Laboratory, EPA, Corvallis, OR.

Paulsen, Steve, 1997, *Environmental Monitoring and Assessment Program: Integrated Quality Assurance Project Plan for Surface Waters Research Activities*, National Health and Environmental Effects Research Laboratory, Western Ecology Division, EPA, Corvallis, OR.

Appendix 1: Analysis Results for Duplicate Pairs

ANC (acid neutralizing capacity)	µeq/L
Cond (specific conductance)	µS/cm
SO ₄ (sulfate)	µeq/L
NO ₃ (nitrate)	µeq/L
Cl (chloride)	µeq/L
Ca (calcium ion)	µeq/L
Mg (magnesium ion)	µeq/L
K (potassium ion)	µeq/L
Na (sodium ion)	µeq/L
NH ₄ (ammonium)	µeq/L
SiO ₂ (silica)	µmol/L
DOC (dissolved organic carbon)	mg/L

Sample	pH_1	pH_2	ANC_1	ANC_2	Cond_1	Cond_2
DR01-2/14/2011-1:40:00 PM	5.44	5.46	2.98	2.66	19.5	19.4
VT04-7/27/2011-1:15:00 PM	6.6	6.6	59.61	59.14	14.2	14.4
VT15-10/28/2011-1:35:00 PM	6.2	6.22	29.11	31.41	13.5	13.9
WOR1-5/9/2011-1:25:00 PM	5.98	6.08	24.79	23.98	16.6	16.8
PAIN-8/15/2011-10:30:00 AM	5.9	6.05	15.76	14.89	18.6	18.8
STAN-12/18/2011-1:15:00 PM	6.28	6.1	76.65	78.04	17.4	17.3
WOR1-10/30/2011-12:15:00 PM	6.05	6.14	34.23	34.08	17.7	17.8
STAN-8/29/2011-12:30:00 PM	6.92	6.92	107.23	106.86	20.1	20.2
VT54-7/25/2011-10:14:00 AM	6.59	6.63	103.5	102.89	32.7	32.6
NFDR-2/22/2011-1:20:00 PM	6.44	6.52	47.53	47.76	21.9	22
NFDR-4/12/2011-2:35:00 PM	6.5	6.51	51.84	51.68	21.6	21.8
VT02-1/31/2011-11:35:00 AM	6.44	6.26	35.61	35.46	14.7	14.7
WOR1-11/28/2011-12:00:00 PM	5.91	5.96	23.66	23.66	16.6	16.7
PINE-12/12/2011-4:45:00 PM	6.96	7.1	168.99	168.91	30.1	30.3
VT24-4/26/2011-10:30:00 AM	6.03	6.02	17	17.23	12.2	12.2
VT53-10/26/2011-11:50:00 AM	6.01	6.04	23.73	23.41	20.4	20.5
VA 555-5/18/2011-3:23:00 PM	6.14	6.2	29.55	29.67	11.4	11.4
PAIN-6/6/2011-1:10:00 PM	5.87	5.82	7.32	7.56	19.2	19.3
PINE-10/17/2011-6:00:00 PM	7.13	7.14	195.73	195.28	32	32
NFDR-1/11/2011-12:05:00 PM	6.47	6.48	46.83	47.29	22	21.9
VT01-4/25/2011-11:45:00 AM	6.8	6.74	84.46	85.12	18.4	18.4
PAIN-1/17/2011-12:10:00 PM	5.67	5.74	7.76	8.14	20.2	20.2
STAN-10/24/2011-2:00:00 PM	6.91	6.81	87.51	91.53	17.5	17.7
NFDR-6/1/2011-2:40:00 PM	6.61	6.59	72.16	71.51	23.5	23.4
VT75-1/31/2011-2:45:00 PM	7.02	6.99	117.37	116.86	23.5	23.7
WV 796-5/16/2011-1:45:00 PM	5.47	5.49	17.34	17.36	12.7	12.7
PINE-4/26/2011-1:10:00 PM	7.08	7.07	193.21	192.52	31.9	31.8
VT61-4/29/2011-1:48:00 PM	7.38	7.2	251.34	250.59	39.8	39.6
VT51-7/28/2011-12:55:00 PM	7.53	7.44	401.17	402.12	52.8	53.2
PAIN-7/18/2011-10:20:00 AM	6.06	6.06	15.26	13.05	19.8	19.8

Sample	SO4_1	SO4_2	NO3_1	NO3_2	CA_1	CA_2
DR01-2/14/2011-1:40:00 PM	106.21	106.15	0.26	0.26	24.53	26.55
VT04-7/27/2011-1:15:00 PM	35.37	37.64	5.78	1.37	24.26	25.27
VT15-10/28/2011-1:35:00 PM	60.33	60.41	0.55	0	36.28	37.73
WOR1-5/9/2011-1:25:00 PM	80.63	80.73	0	0.32	27.77	28.49
PAIN-8/15/2011-10:30:00 AM	88.58	88.75	0	5.32	25.63	26.27
STAN-12/18/2011-1:15:00 PM	45.95	46.09	0.5	0.55	59.05	60.4
WOR1-10/30/2011-12:15:00 PM	81.89	81.67	0	0	29.67	30.32
STAN-8/29/2011-12:30:00 PM	39.41	39.67	0	0	71.68	73.24
VT54-7/25/2011-10:14:00 AM	94.82	111.44	10.19	19.93	105.34	107.48
NFDR-2/22/2011-1:20:00 PM	95.65	95.63	0.18	0	62.98	64.11
NFDR-4/12/2011-2:35:00 PM	85.49	89.98	0.19	0.21	66.64	67.47
VT02-1/31/2011-11:35:00 AM	42.81	43.41	26.36	27.06	40.62	41.11
WOR1-11/28/2011-12:00:00 PM	81.11	81.32	0	0	26.99	27.31
PINE-12/12/2011-4:45:00 PM	72.79	72.79	3.36	0.35	114.85	116.11
VT24-4/26/2011-10:30:00 AM	59.13	59.16	0.19	0.19	40.1	40.5
VT53-10/26/2011-11:50:00 AM	105.39	105.54	0	0	31.39	31.69
VA 555-5/18/2011-3:23:00 PM	42.37	42.52	0.33	0.33	36.63	36.96
PAIN-6/6/2011-1:10:00 PM	106.99	106.67	0.33	0.33	27.12	27.35
PINE-10/17/2011-6:00:00 PM	71.44	71.89	0	0.35	126.64	127.61
NFDR-1/11/2011-12:05:00 PM	81.42	87.05	0	0	65.32	65.82
VT01-4/25/2011-11:45:00 AM	29.55	30.89	20.36	24.4	72.82	73.36
PAIN-1/17/2011-12:10:00 PM	116.43	116.53	0.31	0	31.37	31.57
STAN-10/24/2011-2:00:00 PM	42.16	42.17	0	0	62.37	62.75
NFDR-6/1/2011-2:40:00 PM	89.26	88.92	0	0.33	74.15	74.54
VT75-1/31/2011-2:45:00 PM	42.15	45.94	2.3	2.29	89.58	90
WV 796-5/16/2011-1:45:00 PM	55.09	54.84	0.34	0.37	64.84	65.11
PINE-4/26/2011-1:10:00 PM	70.08	70.7	0.19	0.22	122.77	123.23
VT61-4/29/2011-1:48:00 PM	84.42	84.47	0.24	0	145.17	145.71
VT51-7/28/2011-12:55:00 PM	77.63	77.01	0	0	206.17	206.73
PAIN-7/18/2011-10:20:00 AM	102.23	102.56	0	0	26.01	26.06

Sample	MG_1	MG_2	NA_1	NA_2	K_1	K_2
DR01-2/14/2011-1:40:00 PM	46.64	46.58	26.2	26.14	38.7	38.67
VT04-7/27/2011-1:15:00 PM	17.33	16.74	71.22	70.39	13.23	13.03
VT15-10/28/2011-1:35:00 PM	38.03	38.26	19.84	22.75	12.94	13.93
WOR1-5/9/2011-1:25:00 PM	42.44	42.4	20.55	20.53	35.82	35.82
PAIN-8/15/2011-10:30:00 AM	43.74	44.78	23.18	23.53	46.79	47.04
STAN-12/18/2011-1:15:00 PM	24.86	25.1	60.25	60.51	8.77	8.81
WOR1-10/30/2011-12:15:00 PM	46.69	47	22.26	22.25	37.99	37.95
STAN-8/29/2011-12:30:00 PM	28.89	28.78	71.51	70.55	12.69	12.78
VT54-7/25/2011-10:14:00 AM	98.01	99.31	45.83	45.95	29.11	29.21
NFDR-2/22/2011-1:20:00 PM	36.22	36.29	74.02	74	7.25	7.26
NFDR-4/12/2011-2:35:00 PM	36.99	37.15	69.24	69.07	8.99	8.95
VT02-1/31/2011-11:35:00 AM	22.02	22.02	47.96	47.84	10.77	10.71
WOR1-11/28/2011-12:00:00 PM	42.27	42.52	22.31	22.34	35.33	35.37
PINE-12/12/2011-4:45:00 PM	94.83	94.91	68.4	68.36	4.72	4.7
VT24-4/26/2011-10:30:00 AM	24.99	25.08	15.59	15.6	11.99	11.97
VT53-10/26/2011-11:50:00 AM	50.74	50.97	31.95	31.98	41.58	41.59
VA 555-5/18/2011-3:23:00 PM	29.73	29.79	14.74	14.74	11.74	11.75
PAIN-6/6/2011-1:10:00 PM	45.34	45.45	24.35	24.18	44.84	44.73
PINE-10/17/2011-6:00:00 PM	101.53	101.66	70.24	70.11	6.24	6.27
NFDR-1/11/2011-12:05:00 PM	37.03	37.16	71.49	71.53	6.94	6.95
VT01-4/25/2011-11:45:00 AM	29.74	29.87	52.01	52.01	9.44	9.35
PAIN-1/17/2011-12:10:00 PM	53.59	53.75	23.88	23.94	37.71	37.7
STAN-10/24/2011-2:00:00 PM	26.25	26.12	59.23	59.53	10.68	10.7
NFDR-6/1/2011-2:40:00 PM	40.6	40.59	75.75	75.51	10.56	10.57
VT75-1/31/2011-2:45:00 PM	68.33	68.45	50.27	50.27	3.5	3.5
WV 796-5/16/2011-1:45:00 PM	25.79	25.8	7.22	7.29	2.92	2.97
PINE-4/26/2011-1:10:00 PM	97.9	98.06	71.56	71.6	7.08	7.08
VT61-4/29/2011-1:48:00 PM	125.5	125.65	93.41	93.39	10.94	10.95
VT51-7/28/2011-12:55:00 PM	179.99	180.41	110.2	110	25.28	25.36
PAIN-7/18/2011-10:20:00 AM	45.66	45.59	27.34	26.24	49.06	48

Sample	NH4_1	NH4_2	SIO2_1	SIO2_2	DOC_1	DOC_2
DR01-2/14/2011-1:40:00 PM	0	0	90.45	90.25		
VT04-7/27/2011-1:15:00 PM	0	0	174.16	174.16		
VT15-10/28/2011-1:35:00 PM	0.13	0.15	88.18	88.18		
WOR1-5/9/2011-1:25:00 PM	0	0	77.54	77.54		
PAIN-8/15/2011-10:30:00 AM	0	0	99.07	99.07		
STAN-12/18/2011-1:15:00 PM	0	0	137.71	137.51		
WOR1-10/30/2011-12:15:00 PM	0	0	83.16	83.16	0.6	0.58
STAN-8/29/2011-12:30:00 PM	0	0	153.62	153.62		
VT54-7/25/2011-10:14:00 AM	0	2.94	110.84	110.84		
NFDR-2/22/2011-1:20:00 PM	0	0	155.17	155.37		
NFDR-4/12/2011-2:35:00 PM	0	0	147.21	147.21		
VT02-1/31/2011-11:35:00 AM	0	0	118.15	117.95		
WOR1-11/28/2011-12:00:00 PM	0	0	82.41	82.22		
PINE-12/12/2011-4:45:00 PM	0	0	187.15	186.77	0.59	0.56
VT24-4/26/2011-10:30:00 AM	0	0	78.18	78.18		
VT53-10/26/2011-11:50:00 AM	0	0	111.49	111.49		
VA 555-5/18/2011-3:23:00 PM	0	0	65.84	65.66	1.15	1.12
PAIN-6/6/2011-1:10:00 PM	0	0	93.93	93.19	0.79	0.78
PINE-10/17/2011-6:00:00 PM	0	0	201.68	201.68	0.93	0.94
NFDR-1/11/2011-12:05:00 PM	0	0	151.27	152.46		
VT01-4/25/2011-11:45:00 AM	1.19	0.41	123.32	123.32		
PAIN-1/17/2011-12:10:00 PM	0	0	83.09	82.89		
STAN-10/24/2011-2:00:00 PM	0.2	0	137.56	137.56		
NFDR-6/1/2011-2:40:00 PM	0	0	173.56	173.56		
VT75-1/31/2011-2:45:00 PM	0	0	117.57	117.38		
WV 796-5/16/2011-1:45:00 PM	0	0	40.86	41.04	5.89	5.93
PINE-4/26/2011-1:10:00 PM	0	0	206.33	206.33	0.62	0.61
VT61-4/29/2011-1:48:00 PM	0	0	247.64	247.64		
VT51-7/28/2011-12:55:00 PM	0	0.42	200.66	197.18		
PAIN-7/18/2011-10:20:00 AM	0	0	98.02	98.02		

Sample	pH_1	pH_2	ANC_1	ANC_2	Cond_1	Cond_2
PINE-3/8/2011-3:20:00 PM	6.92	6.93	149.68	150.34	30.3	30.2
PINE-11/14/2011-4:00:00 PM	6.74	6.89	201.95	202.16	31.5	31.6
WOR1-7/12/2011-9:45:00 AM	6.43	6.49	76.11	74.53	21.4	21.7
PAIN-11/7/2011-11:45:00 AM	5.83	5.9	10.97	11.23	20.8	20.7
STAN-11/21/2011-1:30:00 PM	6.7	6.67	89.55	89	17.6	17.6
STAN-7/5/2011-2:40:00 PM	6.69	6.7	104.67	105.09	19.2	19.3
PINE-9/19/2011-3:30:00 PM	7.09	7.22	327.34	325.04	42	41.8
PINE-1/25/2011-1:15:00 PM	7.07	7.03	160.12	159.97	27.2	27.3
PINE-7/25/2011-11:00:00 AM	6.92	6.92	360.29	361.2	43.4	43.4
WV 754-5/29/2011-11:50:00 AM	6.52	6.57	54.14	53.62	20.9	21.1
VT26-10/26/2011-2:00:00 PM	5.23	5.25	1.61	0.29	13.6	13.6
PINE-6/27/2011-3:30:00 PM	6.93	6.86	291.34	286.6	38.7	38.6
PINE-8/22/2011-12:45:00 PM	6.99	7.03	367.47	366.27	43.7	43.9
PINE-6/14/2011-10:30:00 AM	7.14	7.15	271.88	272.13	36.8	37.2
STAN-5/3/2011-11:40:00 AM	6.91	6.75	73.93	74.67	17.3	17.6
VT37-10/26/2011-2:55:00 PM	6.34	6.33	32.4	32.68	15.5	15.7
DR01-3/28/2011-11:50:00 AM	5.42	5.42	3.38	3.05	20.7	20.7
STAN-2/1/2011-10:40:00 AM	6.81	6.85	77.95	78.42	17.4	17.3
VT07-7/28/2011-12:55:00 PM	4.95	4.99	3.33	3.12	17.8	17.5
VT07-2/3/2011-2:40:00 PM	5.07	5.08	-1.64	-2.66	17.5	17.5
STAN-9/26/2011-3:15:00 PM	6.95	6.9	111.59	111.41	20	20.1
PAIN-12/5/2011-11:15:00 AM	5.46	5.63	7	7.07	20.3	20.2
VT50-10/26/2011-2:30:00 PM	4.71	4.72	-14.09	-14.36	24	24
PAIN-4/18/2011-2:40:00 PM	5.24	5.25	3.26	3.37	21.1	21
WV 015-5/20/2011-11:20:00 AM	4.6	4.6	-20.08	-20.24	58	57.9
DR01-1/3/2011-12:55:00 PM	5.45	5.49	4.8	5.01	18.7	18.8
DR01-5/16/2011-2:05:00 PM	5.4	5.47	4.4	4.02	18.9	18.8
WOR1-3/21/2011-12:50:00 PM	5.86	6.07	20.74	21.39	16.8	16.7
PAIN-2/28/2011-2:50:00 PM	5.56	5.66	6.52	6.37	20	19.9
STAN-8/1/2011-1:30:00 PM	6.49	6.51	113.29	112.05	20.2	19.9

Sample	SO4_1	SO4_2	NO3_1	NO3_2	CA_1	CA_2
PINE-3/8/2011-3:20:00 PM	83.94	83.97	0.18	0.18	110.94	111.15
PINE-11/14/2011-4:00:00 PM	63.51	63.7	0	0	124.17	124.32
WOR1-7/12/2011-9:45:00 AM	64.78	70.13	0	0	40	40.04
PAIN-11/7/2011-11:45:00 AM	115.93	115.9	0	0.35	30.78	30.8
STAN-11/21/2011-1:30:00 PM	42.38	42.6	0	0	63.73	63.75
STAN-7/5/2011-2:40:00 PM	43.27	43.04	0	0	69.62	69.62
PINE-9/19/2011-3:30:00 PM	51.63	51.54	0	0.36	171.22	171.11
PINE-1/25/2011-1:15:00 PM	60.45	60.41	0	0.31	99.87	99.77
PINE-7/25/2011-11:00:00 AM	36.54	36.34	0	0	181.19	180.71
WV 754-5/29/2011-11:50:00 AM	92.98	93.31	0.33	0	68.56	68.35
VT26-10/26/2011-2:00:00 PM	70.77	70.48	0	0	38.06	37.9
PINE-6/27/2011-3:30:00 PM	48.43	47.8	0.35	0	156.79	156.08
PINE-8/22/2011-12:45:00 PM	36.39	37.28	0	0.36	181.47	180.59
PINE-6/14/2011-10:30:00 AM	51.73	51.87	0	0.34	149.02	148.26
STAN-5/3/2011-11:40:00 AM	48.64	48.35	0.23	0.24	60.27	59.95
VT37-10/26/2011-2:55:00 PM	71.94	71.85	4.86	4.55	38.55	38.34
DR01-3/28/2011-11:50:00 AM	107.9	107.78	0.2	0.19	28.06	27.89
STAN-2/1/2011-10:40:00 AM	43.3	43.23	0	0	59.96	59.53
VT07-7/28/2011-12:55:00 PM	72.91	72.9	0.38	0	56.34	55.92
VT07-2/3/2011-2:40:00 PM	78.31	78.62	0.26	2.34	57.21	56.59
STAN-9/26/2011-3:15:00 PM	38.64	38.84	0.34	0	75.66	74.83
PAIN-12/5/2011-11:15:00 AM	111.19	110.86	0.42	0	30.54	30.2
VT50-10/26/2011-2:30:00 PM	120.74	120.71	0.63	0.6	29.35	29.02
PAIN-4/18/2011-2:40:00 PM	108.58	107.94	0.18	0.19	30.52	30.17
WV 015-5/20/2011-11:20:00 AM	202.31	202.75	0.36	1.43	114.26	112.85
DR01-1/3/2011-12:55:00 PM	101.21	101.06	0.3	0.31	23.22	22.93
DR01-5/16/2011-2:05:00 PM	99.68	99.31	0.33	0.33	22.76	22.47
WOR1-3/21/2011-12:50:00 PM	84.94	84.91	0.19	0.19	28.12	27.76
PAIN-2/28/2011-2:50:00 PM	113.64	113.67	0.18	0.18	30.06	29.64
STAN-8/1/2011-1:30:00 PM	42.01	41.94	0	0	71.13	70.09

Sample	MG_1	MG_2	NA_1	NA_2	K_1	K_2
PINE-3/8/2011-3:20:00 PM	92.54	92.78	66.43	66.57	5.06	5.05
PINE-11/14/2011-4:00:00 PM	100	100.27	72.83	72.95	5.4	5.47
WOR1-7/12/2011-9:45:00 AM	61.96	62.4	24.63	24.64	51.46	51.43
PAIN-11/7/2011-11:45:00 AM	51.78	51.63	25.2	25.13	45.86	45.66
STAN-11/21/2011-1:30:00 PM	26.48	26.06	61.96	61.94	10.27	10
STAN-7/5/2011-2:40:00 PM	28.37	28.14	66.75	66.8	11.76	11.77
PINE-9/19/2011-3:30:00 PM	135.08	135.2	101.1	99.9	8.58	7.5
PINE-1/25/2011-1:15:00 PM	82.69	82.82	65.78	65.9	3.95	3.96
PINE-7/25/2011-11:00:00 AM	137.81	137.43	109.88	109.63	9.09	8.87
WV 754-5/29/2011-11:50:00 AM	60.44	60.52	29.25	29.21	17.28	17.33
VT26-10/26/2011-2:00:00 PM	27.95	27.72	13.81	13.77	6.38	6.36
PINE-6/27/2011-3:30:00 PM	122.67	122.2	93.54	93.26	7.51	7.48
PINE-8/22/2011-12:45:00 PM	137.75	137.36	115.47	115.47	9.35	9.28
PINE-6/14/2011-10:30:00 AM	117.56	117.57	89.08	89.11	6.89	6.82
STAN-5/3/2011-11:40:00 AM	24.96	24.93	58.77	59.03	9.69	9.76
VT37-10/26/2011-2:55:00 PM	46.55	46.76	23.21	23.25	17.28	17.29
DR01-3/28/2011-11:50:00 AM	47.93	47.84	29.47	29.54	39.03	39.06
STAN-2/1/2011-10:40:00 AM	25.17	25.04	60.56	60.7	8.22	8.28
VT07-7/28/2011-12:55:00 PM	24.88	24.76	17.87	17.75	7.92	7.86
VT07-2/3/2011-2:40:00 PM	27.98	28.06	17.22	17.23	7.12	7.14
STAN-9/26/2011-3:15:00 PM	30.48	30.06	67.82	68.13	12.96	13
PAIN-12/5/2011-11:15:00 AM	49.96	49.72	24.51	24.34	42.54	42.48
VT50-10/26/2011-2:30:00 PM	44.49	44.42	17.2	17.21	13.05	13.06
PAIN-4/18/2011-2:40:00 PM	47.81	47.94	22.01	22.15	42.41	42.49
WV 015-5/20/2011-11:20:00 AM	62.61	62.26	170.73	170.44	12.79	12.78
DR01-1/3/2011-12:55:00 PM	43.47	43.43	26.52	26.56	36.38	36.39
DR01-5/16/2011-2:05:00 PM	39.87	39.8	26.42	26.42	42.33	42.15
WOR1-3/21/2011-12:50:00 PM	43.81	43.74	20.34	20.32	34.7	34.69
PAIN-2/28/2011-2:50:00 PM	49.36	49.28	23.93	23.92	40.54	40.48
STAN-8/1/2011-1:30:00 PM	28.57	28.04	72.76	72.52	12.94	12.66

Sample	NH4_1	NH4_2	SIO2_1	SIO2_2	DOC_1	DOC_2
PINE-3/8/2011-3:20:00 PM	0	0	182.31	180.72		
PINE-11/14/2011-4:00:00 PM	0	0	199.3	198.53	0.57	0.58
WOR1-7/12/2011-9:45:00 AM	0	0	90.88	90.7		
PAIN-11/7/2011-11:45:00 AM	0	0	105	105.19		
STAN-11/21/2011-1:30:00 PM	0	0	132.97	132.78		
STAN-7/5/2011-2:40:00 PM	0	0	151.83	151.83		
PINE-9/19/2011-3:30:00 PM	0	0	268.55	268.17	0.71	0.7
PINE-1/25/2011-1:15:00 PM	0	0	173.42	172.25	0.38	0.38
PINE-7/25/2011-11:00:00 AM	0	0	290.53	290.9	0.74	0.72
WV 754-5/29/2011-11:50:00 AM	0	0	79.05	78.86	0.55	0.53
VT26-10/26/2011-2:00:00 PM	0	0	84.45	84.45		
PINE-6/27/2011-3:30:00 PM	0	0	262.83	262.83		
PINE-8/22/2011-12:45:00 PM	0	0	289.01	289.39		
PINE-6/14/2011-10:30:00 AM	0	0	255.08	255.08		
STAN-5/3/2011-11:40:00 AM	0.35	0	131	130.81		
VT37-10/26/2011-2:55:00 PM	0	0	79.26	79.26		
DR01-3/28/2011-11:50:00 AM	0	0	89.66	89.85		
STAN-2/1/2011-10:40:00 AM	0	0	129.69	130.09		
VT07-7/28/2011-12:55:00 PM	0	0	62.18	62.18		
VT07-2/3/2011-2:40:00 PM	0	0	53.32	53.51		
STAN-9/26/2011-3:15:00 PM	0	0	149.36	149.36		
PAIN-12/5/2011-11:15:00 AM	0	0	96.03	96.03		
VT50-10/26/2011-2:30:00 PM	0	0	82.72	82.72		
PAIN-4/18/2011-2:40:00 PM	0	0	82.49	82.49		
WV 015-5/20/2011-11:20:00 AM	0	0	70.11	69.92	1.11	1.08
DR01-1/3/2011-12:55:00 PM	0	0	92.18	92.18		
DR01-5/16/2011-2:05:00 PM	0	0	97.97	98.15		
WOR1-3/21/2011-12:50:00 PM	0	0	75.94	75.94		
PAIN-2/28/2011-2:50:00 PM	0	0	81.47	81.07		
STAN-8/1/2011-1:30:00 PM	0	0	157.34	156.51		

Sample	pH_1	pH_2	ANC_1	ANC_2	Cond_1	Cond_2
STAN-3/14/2011-6:00:00 PM	6.14	6.13	62.8	62.11	16.8	16.7
PAIN-9/12/2011-9:45:00 AM	5.95	6.09	15.98	16.58	20.1	20.2
PAIN-6/22/2011-10:45:00 AM	5.82	5.81	12.67	12.6	19.3	19.4
VT22-1/25/2011-3:15:00 PM	6.72	6.73	85.09	85.48	18.7	18.8
WOR1-12/28/2011-4:00:00 PM	6.04	5.98	21.56	21.08	16.6	16.7
VT11-5/5/2011-3:40:00 PM	6.05	5.96	14.16	15.05	10.1	10
VT23-7/25/2011-1:00:00 PM	7.16	7.12	192.33	192.94	27.7	27.7
MAIA97-132-5/18/2011-11:20:00	5.87	5.87	18.03	18.42	16.7	16.8
PAIN-10/10/2011-10:30:00 AM	5.98	5.95	16.77	16.45	20.3	20.6
WOR1-2/7/2011-12:35:00 PM	5.97	6	20.42	20.44	16.8	16.7
VT28-4/26/2011-1:50:00 PM	5.27	5.26	1.23	0.35	10.2	10.2

Sample	SO4_1	SO4_2	NO3_1	NO3_2	CA_1	CA_2
STAN-3/14/2011-6:00:00 PM	50.08	49.03	0.19	0.19	57.09	56
PAIN-9/12/2011-9:45:00 AM	108.56	108.91	0.34	0	26.6	26.09
PAIN-6/22/2011-10:45:00 AM	104.1	104.29	0.33	0.34	27.02	26.46
VT22-1/25/2011-3:15:00 PM	52.28	52.03	0.3	0	54.6	53.42
WOR1-12/28/2011-4:00:00 PM	81.81	82.08	0.66	0.67	29.11	28.46
VT11-5/5/2011-3:40:00 PM	41.25	34.54	0.25	0.35	24.6	23.95
VT23-7/25/2011-1:00:00 PM	25.64	26.51	0	0	91.96	89.26
MAIA97-132-5/18/2011-11:20:00	81.5	80.67	0.33	0.32	44.84	42.82
PAIN-10/10/2011-10:30:00 AM	113.01	112.92	0	0	29.26	27.22
WOR1-2/7/2011-12:35:00 PM	82.94	83.61	0.26	0.26	35.27	29.08
VT28-4/26/2011-1:50:00 PM	46.33	46.34	0.25	0.26	19.39	19.46

Sample	MG_1	MG_2	NA_1	NA_2	K_1	K_2
STAN-3/14/2011-6:00:00 PM	24.26	23.89	54.51	54.39	9.37	9.35
PAIN-9/12/2011-9:45:00 AM	47.37	47.48	27.21	27.34	50.47	50.5
PAIN-6/22/2011-10:45:00 AM	45.22	45.3	24.72	24.75	46.42	46.4
VT22-1/25/2011-3:15:00 PM	39.57	39.58	65.16	65.33	8.71	8.75
WOR1-12/28/2011-4:00:00 PM	44.29	44.4	20.94	20.94	33.95	33.99
VT11-5/5/2011-3:40:00 PM	26.32	25.92	12.5	12.49	11.59	11.6
VT23-7/25/2011-1:00:00 PM	55.52	54.46	99.14	98.69	21.5	21.32
MAIA97-132-5/18/2011-11:20:00	49.78	49.19	20.16	20.27	17.63	17.72
PAIN-10/10/2011-10:30:00 AM	49.91	50.27	26.68	26.93	48.59	49.08
WOR1-2/7/2011-12:35:00 PM	45.76	45.75	21.09	21.08	31.69	31.72
VT28-4/26/2011-1:50:00 PM	21.55	21.46	11.62	11.55	7.15	7.15

Sample	NH4_1	NH4_2	SIO2_1	SIO2_2	DOC_1	DOC_2
STAN-3/14/2011-6:00:00 PM	0	0	124.9	124.9	0.55	0.55
PAIN-9/12/2011-9:45:00 AM	0	0	114.26	114.45		
PAIN-6/22/2011-10:45:00 AM	0	0	92.85	92.67		
VT22-1/25/2011-3:15:00 PM	0	0	164.56	163.96		
WOR1-12/28/2011-4:00:00 PM	0	0	80.25	80.25		
VT11-5/5/2011-3:40:00 PM	0	0	58.74	58.92		
VT23-7/25/2011-1:00:00 PM	0.24	0	238.99	238.21		
MAIA97-132-5/18/2011-11:20:00	0	0	69.19	69.19	0.81	0.8
PAIN-10/10/2011-10:30:00 AM	0	0	112.28	113.41		
WOR1-2/7/2011-12:35:00 PM	0	0	74.13	73.62		
VT28-4/26/2011-1:50:00 PM	0	0	61.81	62		