

Data Quality Assurance Report for

**Shenandoah Watershed Study,
Virginia Trout Stream Sensitivity Study,
And Related Projects**

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1 Data Quality Assurance Metrics for 2009

Quality assurance results are derived from analysis sessions pertaining to samples collected during the calendar year 2009. These results are based on analyses of field replicates, trip blanks, laboratory QC samples, and certified reference materials.

Quality assurance of analysis of stream-water samples was obtained by conductivity and charge ratio analysis, use of minimum detection and lower quantification limits, bias analysis, precision analysis, blank analysis, and analysis of reference samples. This section describes the results of these analyses and lists the minimum detection limits and lower quantification limits used during the period.

Conductivity ratio was in-control for all samples analyzed. Charge ratio was in-control for some sample groups but not others, particularly those with heterogeneous sampling environments. Detection limits compared favorably with objectives for most characteristics. Precision analysis based on field replicates was observed to be in-control except for calcium and nitrate. Blank analysis indicated a lack of contamination, but a probable low level bias for many characteristics. Analysis of CRMs indicated no systemic bias. Results from participation in the Environment Canada collaborative study indicated several high cation values.

During 2010 several actions were taken to address these issues. Post-preserved lab blanks continued to be collected for comparison with trip blanks. Alternative regression models for standard curves were examined.

In 2011, additional actions will be taken. The calibration curve model selection process will continue to be evaluated, injection volumes will be increased, and MDL standard solution numbers will be increased. These actions may lead to additional designed experiments or to changes in methods and protocols.

1.1 Charge ratio analysis

Charge ratio for samples is defined as the sum of anions divided by the sum of base cations and is a characteristic listed in EPA STORET. We calculate the sum of anions (SAA) as

$$\text{SAA} = [\text{SO}_4^{2-}] + [\text{Cl}^-] + [\text{NO}_3^-] + [\text{ANC}]$$

We calculate the sum of base cations (SBC) as

$$\text{SBC} = [\text{Ca}^{2+}] + [\text{Mg}^{2+}] + [\text{Na}^+] + [\text{K}^+] + [\text{NH}_4^+]$$

or as

$$\text{SBC} = [\text{Ca}^{2+}] + [\text{Mg}^{2+}] + [\text{Na}^+] + [\text{K}^+]$$

for cases where NH4 is not measured. Over the period of record several different instruments and methods have been used to measure anions, cations and ANC, and so analysis of charge ratio statistics requires a division of the data into groups corresponding to the different methods used. In addition, different station groups may have different natural ranges of these characteristics. The methods used during this reporting period are listed in Table 1.

Table 1: Methods used to calculate charge ratio

Charge ratio characteristic name	Description
IONRATIO_MET_IC2_AUTO	sum of anions by IC2 and titration by Metrohm auto-titrator/ sum of cations by IC2, collected by automated sampler
IONRATIO_MET_IC2_GRAB	sum of anions by IC2 and titration by Metrohm auto-titrator/ sum of cations by IC2, collected by hand

To calculate SAA and SBC when one or more of the characteristics had a censored value, we substituted either one half of the minimum detection limit (MDL) or one half of the sum of the MDL plus the lower quantitation limit (LQL), depending on whether the value determined was below the MDL or below the LQL, respectively.

The capability of a process to operate within specified limits is often quantified using the indices C_p or C_{pk} , also known as process capability ratios (Montgomery, 1997). The formulas for C_p and C_{pk} are:

$$C_p = \frac{USL - LSL}{6\sigma}$$

$$C_{pk} = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right)$$

where μ is the sample mean, σ the sample standard deviation, and USL and LSL are the upper specification limit and lower specification limit, respectively. When a process is “on target”, or no target is specified, the C_p is appropriate. When a target is specified or the process is off-target, the C_{pk} provides a better metric of the process’s ability to remain within specification limits and on-target. For an off-target process, the C_p provides a metric of the process’s ability to operate within limits corresponding to the on-target process. Generally, a C_p or C_{pk} in excess of 1.3 is desired to meet the objectives of the Six Sigma philosophy (Montgomery, 1997). Values less than 1.3 indicate a need for process improvement, assuming sufficient observations have been made.

Lower and upper specification limits for charge ratio have been given in the literature (Morrison, 1991) as 0.85 and 1.15 for the Maine Region and 0.80 and 1.10 for the Catskills Region, respectively. We report statistics for SHEN and VTSSS based on the Catskills Region limits and for MIDN based on the Maine Region limits because they more-closely approximate the range we observe in the samples. These limits are stated as representing a 99% confidence interval for acceptable individual results. A 99% confidence interval is a less stringent quality requirement than that of the Six Sigma philosophy; it corresponds approximately to a five-sigma philosophy. A value of approximately 1.1 in the C_p or C_{pk} provides the same level of assurance that a process is in-control with respect to a 99% confidence interval requirement as the value of 1.3 does for the Six Sigma requirement.

We report both the C_p and the C_{pk} because of the uncertainty in what the target value should be. Confidence intervals for the C_p and the C_{pk} can be large for small sample size. Figures 1-2 graphically illustrate the frequency with which charge ratio fell within the target specification limits for the various measurement methods, and give a confidence interval for the C_p and the C_{pk} .

Figure 1 shows charge ratio distributions for 34 grab samples collected in MIDN parks where charge ratio was determined using auto-titration of ANC and using ion chromatography for all ions. The upper part of Figure 1 is for 22 samples collected at either the Fredericksburg/Spotsylvania National Battlefield Park (FRSP) or the

Richmond National Battlefield Park (RICH). Charge ratio at these two parks was out of control because of a number of high charge ratio samples and a high standard deviation. The lower part of Figure 1 is for 12 grab samples collected at five other MIDN parks. These results are well within control.

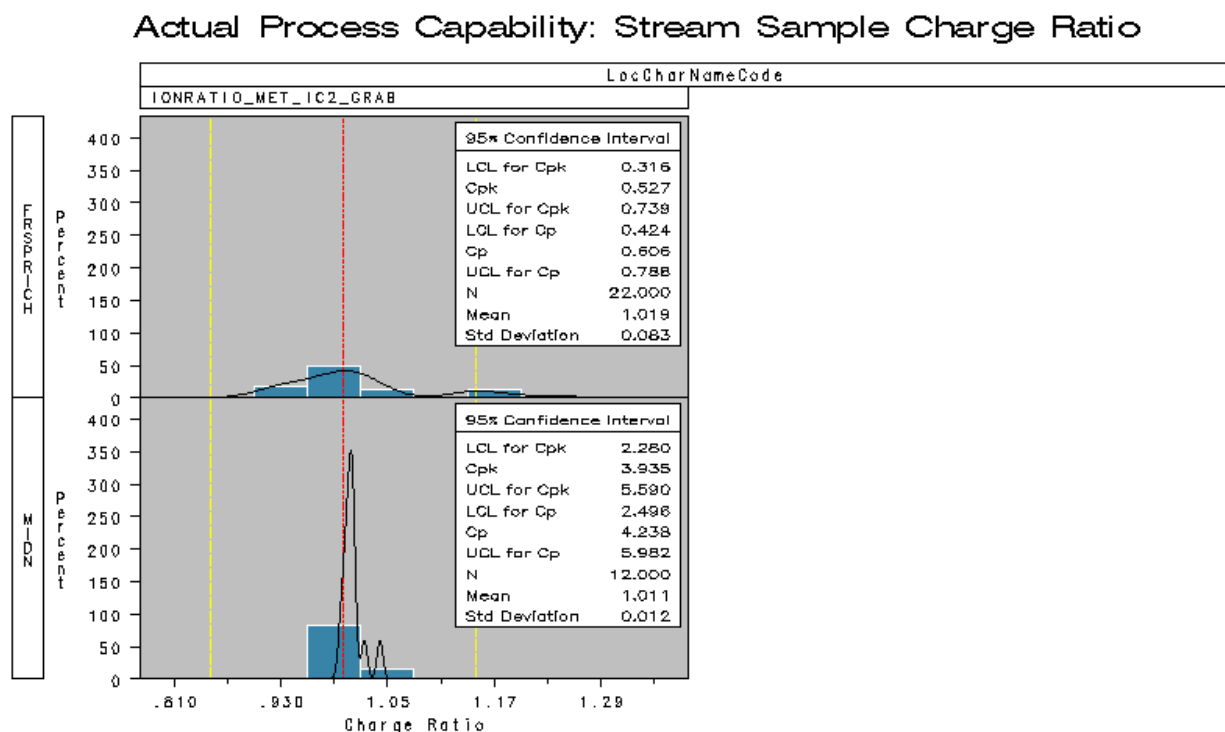


Figure 1: Distributions of charge balance ratio where charge concentrations were determined using auto-titration of ANC and using ion chromatography for all ions. Upper plot: grab samples associated with FRSP and RICH. Lower plot: grab samples associated with other MIDN parks.

Figure 2 shows the distributions of charge ratio for 649 samples analyzed using auto-titration of ANC and using ion chromatography for all ions. In the upper part of Figure 2, grab samples (right side) and auto-sampler samples (left side) collected in SHEN had charge balance ratios well within the specification limits. The lower part of Figure 2 is for 229 grab samples associated with the VTSSS project outside of SHEN. Although the mean is close to the target mean, the wide variance in these results leads to sub-standard values of C_p and C_{pk} . The VTSSS sites span a large geographic area. It is not unreasonable to assume that these sites experience natural variation in charge balance between sites that is higher than for the collection of Catskill sites EPA used to set the

specification limits. Several sites in particular had low charge ratio. These results were not removed because the analyses for those results were in-control.

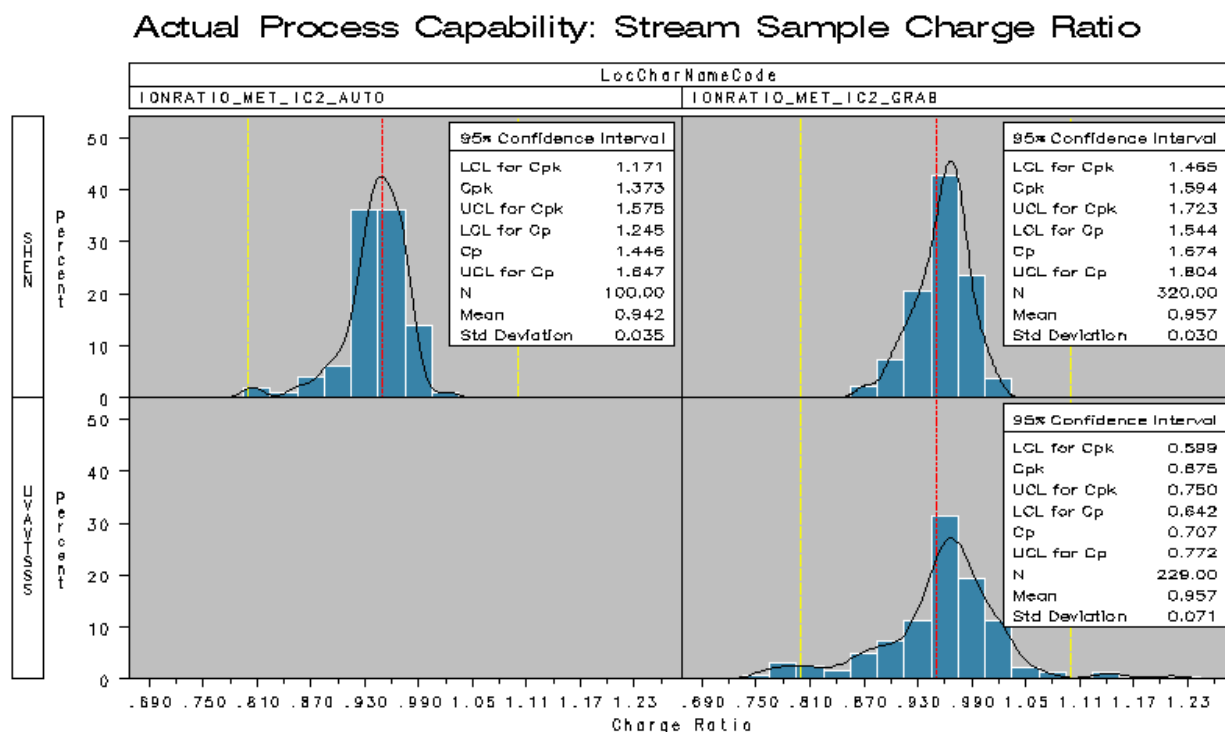


Figure 2: Distributions of charge balance ratio where charge concentrations were determined using auto-titration of ANC and using ion chromatography for all ions. Upper left: auto-sampler samples, SHEN. Upper right: grab samples, SHEN. Lower right: grab samples, VTSSS outside of SHEN.

1.2 Conductivity ratio analysis

Conductivity ratio for samples is defined as the calculated conductance divided by the measured conductance. Calculated conductance is determined by summing the products of the concentrations of the ions and their respective equivalent conductance factors.

The Catskills Region of EPA's LTEM project specified an acceptable range of 0.85 to 1.15 for the ratio of samples with measured conductance between 5 and 30 $\mu\text{S}/\text{cm}$ (Morrison 1991). Specifications were not given for samples exceeding 30 $\mu\text{S}/\text{cm}$.

Other regions allowed up to a 30% difference (ratio of 0.70 to 1.30) for samples in the same measured conductivity range.

Samples with an expected charge ratio of 0.95 cannot be expected to have a corresponding conductivity ratio of 1.00. Using a simple assumption of an equal average conductivity factor for the missing ions as for the measured ions, a sample with a charge ratio of 0.95 would have a conductivity ratio of 0.975. Therefore, for SHEN and VTSSS we use 0.975 as the center of the specification range with lower and upper specification limits of 0.825 and 1.125 respectively.

Figure 3 shows the conductivity ratio distribution for 34 MIDN grab samples where conductivity ratio was determined using auto-titration of ANC and a temperature-correcting conductivity meter. The C_{pk} value for MIDN indicates that the measurement process was in control.

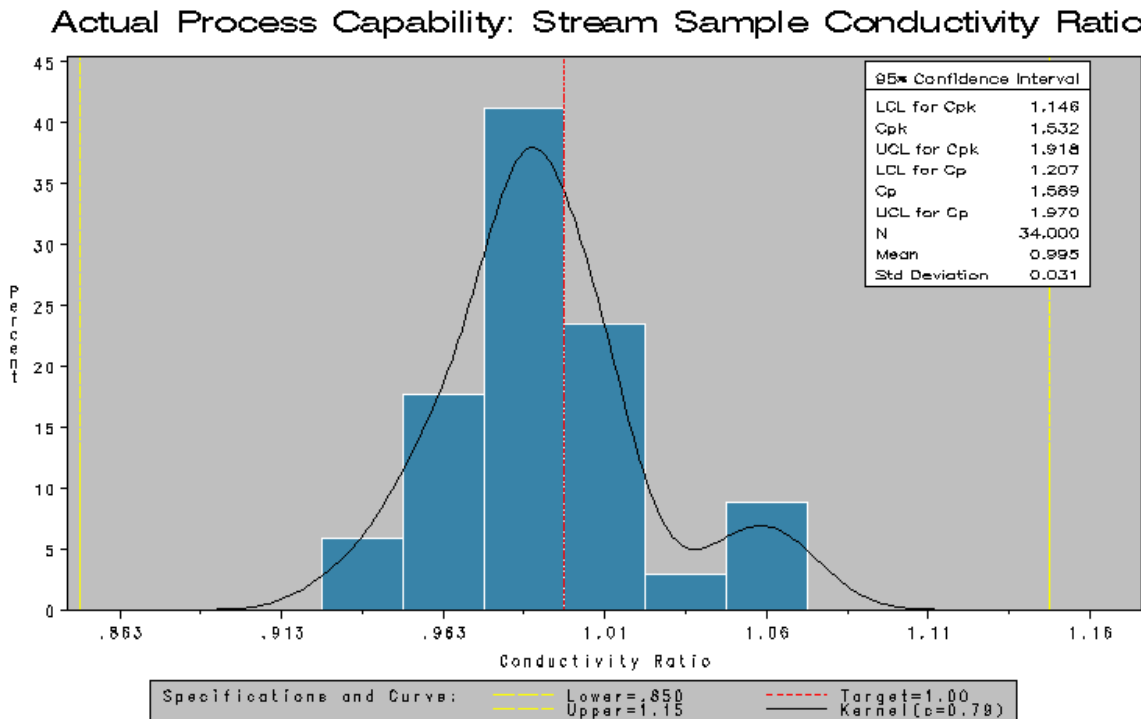


Figure 3: Distribution of conductivity ratio for MIDN.

Figure 4 shows the distributions of conductivity ratio for 649 SHEN and non-SHEN VTSSS samples analyzed using auto-titration of ANC and a temperature-correcting conductivity meter. The C_{pk} for these groups all exceed 1.1, indicating satisfactory performance.

Actual Process Capability: Stream Sample Conductivity Ratio

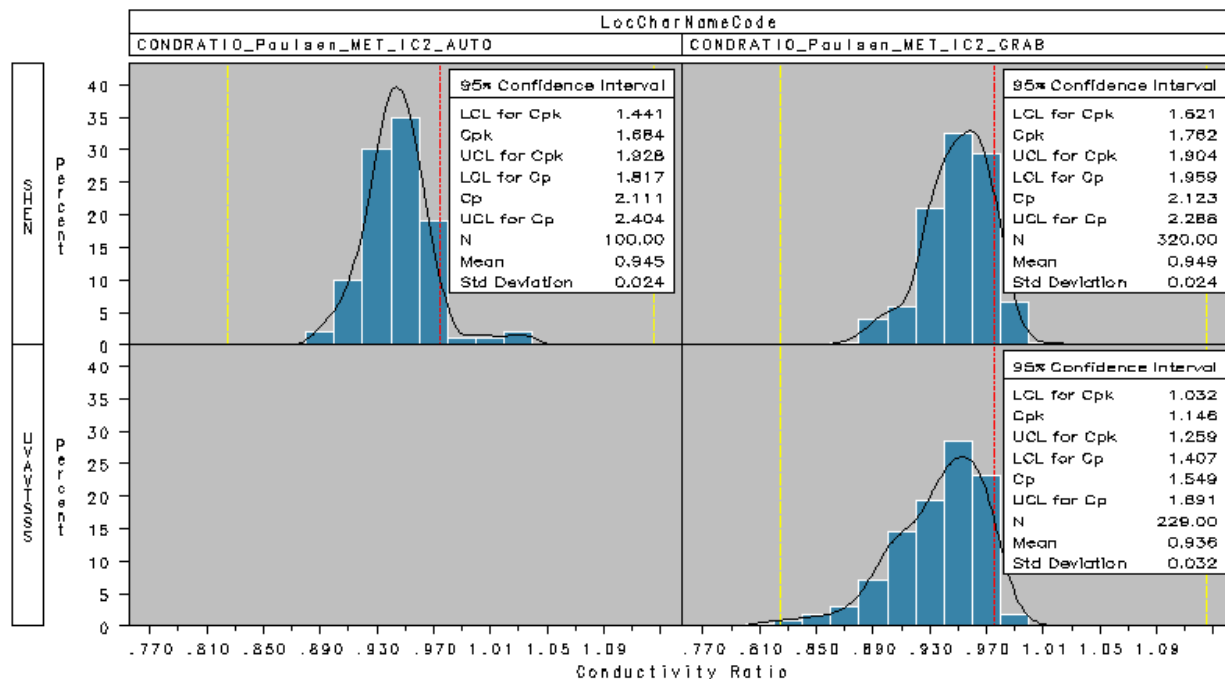


Figure 4: Distribution of conductivity ratio for SHEN and non-SHEN VTSSS samples.

1.3 Minimum detection and lower quantification limits

MDLs and LQLs for the reporting period were calculated following the *Shenandoah Watershed Study Standard Operating Procedure: Laboratory Procedures and Quality Assurance Project Plan (SOP #4)*. Most characteristics had two MDLs calculated during the reporting period. The MDL is a function of the standard deviation of the analyzed MDL standard solutions, 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. The LQL is defined as 3.18 times the MDL.

Table 2 summarizes detection limits used by the UVA lab during the reporting period, and compares them with detection limit objectives suggested in Table 4 of Paulsen (1997). In the last column we calculate the probability that the MDL is less than the MDL specification, given the statistical uncertainty in the estimate of the MDL. The detection limits for most characteristics other than calcium and silica were statistically below their objective values (MDL spec). For these two MDLs, the LQL was still far below actual measured field sample values. Those MDLs also had relatively low

values of N. Measures to address this problem in the future will be discussed in Section 2.2.

Table 2: Detection limit summary

MDL ID	Start Date	End Date	N	Stdev	MDL spec	MDL	LQL	Prob MDL < MDL spec
Aluminum, Organic + Inorganic Monomeric (reactive aluminum) ID: 2009_AL_TOT_TCON_ALUMINUM	01/01/2009	08/31/2010	21	1.678	10	4.241	13.487	1
Aluminum, Organic + Inorganic Monomeric (reactive aluminum) ID: 2010_AL_TOT_TCON_ALUMINUM	08/31/2010	09/08/2010	3	1.084	10	7.552	24.016	1
Calcium ID: 2009_IONS_IC_CALCIUM	01/01/2009	03/31/2010	13	0.337	0.998	0.903	2.872	0.845
Calcium ID: 2010_IONS_IC_CALCIUM	04/01/2010	08/11/2010	8	0.555	0.998	1.663	5.29	0.0003
Carbon, organic ID: 2009_PHOEN_8000_DOC	01/01/2009	03/31/2010	5	0.03	0.1	0.111	0.352	0.2098
Carbon, organic ID: 2010_PHOEN_8000_DOC	04/01/2010	09/28/2010	3	0.016	0.1	0.112	0.355	0.1051
Chloride ID: 2009_IONS_IC_CHLORIDE	01/01/2009	03/31/2010	13	0.057	0.846	0.153	0.488	1
Chloride ID: 2010_IONS_IC_CHLORIDE	04/01/2010	08/11/2010	8	0.033	0.846	0.099	0.313	1
Magnesium ID: 2009_IONS_IC_MAGNESIUM	01/01/2009	03/31/2010	13	0.211	0.823	0.567	1.802	1
Magnesium ID: 2010_IONS_IC_MAGNESIUM	04/01/2010	08/11/2010	8	0.102	0.823	0.305	0.969	1
Nitrogen, Nitrate (NO3) as NO3 ID: 2009_IONS_IC_NITRATE	01/01/2009	03/31/2010	13	0.082	0.483	0.221	0.702	1
Nitrogen, Nitrate (NO3) as NO3 ID: 2010_IONS_IC_NITRATE	04/01/2010	08/11/2010	8	0.021	0.483	0.064	0.203	1
Nitrogen, ammonium (NH4) as NH4 ID: 2009_IONS_IC_AMMONIUM	01/01/2009	03/31/2010	13	0.115	1.108	0.308	0.98	1
Nitrogen, ammonium (NH4) as NH4 ID: 2010_IONS_IC_AMMONIUM	04/01/2010	08/11/2010	8	0.067	1.108	0.201	0.64	1
Potassium ID: 2009_IONS_IC_POTASSIUM	01/01/2009	03/31/2010	13	0.097	1.024	0.261	0.829	1

MDL ID	Start Date	End Date	N	Stddev	MDL spec	MDL	LQL	Prob MDL < MDL spec
Potassium ID: 2010_IONS_IC_POTASSIUM	04/01/2010	08/11/2010	8	0.047	1.024	0.139	0.443	1
Silica ID: 2009_SILICA_TCON_SILICA	01/01/2009	08/18/2010	28	0.299	0.83	0.74	2.354	0.944
Silica ID: 2010_SILICA_TCON_SILICA	08/19/2010	08/19/2010	2	0.101	0.83	3.22	10.239	0
Sodium ID: 2009_IONS_IC_SODIUM	01/01/2009	03/31/2010	13	0.042	0.87	0.113	0.359	1
Sodium ID: 2010_IONS_IC_SODIUM	04/01/2010	08/11/2010	8	0.063	0.87	0.19	0.603	1
Sulfur, sulfate (SO4) as SO4 ID: 2009_IONS_IC_SULFATE	01/01/2009	03/31/2010	13	0.225	1.04	0.604	1.92	1
Sulfur, sulfate (SO4) as SO4 ID: 2010_IONS_IC_SULFATE	04/01/2010	08/11/2010	8	0.202	1.04	0.605	1.925	1

1.4 Precision analysis based on field replicates

Precision was monitored by collecting replicate field samples (Table 3). The sampling locations are rotated randomly so that all seasons are sampled at each site over time.

Table 3: Number of field replicates collected by sample group

Sample group	n
MIDN	9
SHEN	47
Non-SHEN VTSSS	16

During the 2009 period, 72 replicate samples were analyzed. We used specification limits given in the last column of Table 4, adapted from Paulsen (1997), to assess performance.

Table 4: Quality Assurance Objectives: Analytical Detection Limits, Precision, and Accuracy Objectives (from Paulsen, 1997)

Variable	Reporting Units	Detection Limit	Concentration Range	Precision ¹ and Accuracy ² Objectives	$\times\sqrt{2}$ for duplicate differences and RPD
pH, field, closed system or equilibrated	pH units	na	≤ 5.75 > 5.75	± 0.075 ± 0.15	± 0.106 ± 0.21
ANC	$\mu\text{eq/L}$	na	≤ 100 > 100	± 5 $\pm 5\%$	± 7 $\pm 7\%$
Conductivity	$\mu\text{S/cm}$	na	≤ 50 > 50	± 1.0 $\pm 2\%$	± 1.4 $\pm 3\%$
Color	PCU	na	≤ 50 > 50	± 5 $\pm 10\%$	± 7 $\pm 14\%$
Cl^-	$\mu\text{eq/L}$	1.0	≤ 20 > 20	± 1.0 $\pm 5\%$	± 1.4 $\pm 7\%$
NO_3^-	$\mu\text{eq/L}$	0.5	≤ 10 > 10	± 0.5 $\pm 5\%$	± 0.7 $\pm 7\%$
SO_4^{2-}	$\mu\text{eq/L}$	1.0	≤ 20 > 20	± 1.0 $\pm 5\%$	± 1.4 $\pm 7\%$
Ca, Mg, Na, K	$\mu\text{eq/L}$	1.0	≤ 20 > 20	± 1.0 $\pm 5\%$	± 1.4 $\pm 7\%$
Al, total dissolved, and total and organic monomeric	$\mu\text{g/L}$	10	≤ 100 > 100	± 10 $\pm 10\%$	± 14 $\pm 14\%$
DOC and DIC	mg/L	0.1	≤ 1 > 1	± 0.1 $\pm 10\%$	± 0.14 $\pm 14\%$
NH_4	$\mu\text{eq/L}$	1.0	≤ 20 > 20	± 1.0 $\pm 5\%$	± 1.4 $\pm 7\%$
SiO_2	mg/L	0.05 (0.84 $\mu\text{M/L}$)	≤ 1 (17 $\mu\text{M/L}$) > 1 (17 $\mu\text{M/L}$)	± 0.05 (0.84 $\mu\text{M/L}$) $\pm 5\%$	± 0.07 (1.17 $\mu\text{M/L}$) $\pm 7\%$

¹ The precision objectives are based on the standard deviation of repeated measurements at lower concentrations, and as percent relative standard deviation at higher concentrations. If the difference between duplicates or the relative percent difference (RPD) is used to estimate precision, modify the above objectives so that they are also based on the difference and RPD. The objectives are modified by multiplying by $\sqrt{2}$.

² Accuracy is estimated as the difference between measured and target values of samples of known concentration at lower concentrations, and as percent difference at higher concentrations.

Table 5 gives precision results for all characteristics including the number of times the precision objective in Table 4 was exceeded (defects). Under the null hypothesis that even when a process is in control, a small percentage of results will fall outside of the specification limits, we calculate the probability of getting k or more defects. If this probability is large, then the number of defects seen does not suggest the null hypothesis should be rejected. Because of the number of tests we use a threshold of 0.005 for the acceptance criterion for individual tests and 0.05 for group tests (ALL). We assume results are independent and use a common individual probability of 0.01 (one out of a hundred) that an individual result could be outside of the specification limits even when the process is in control. Table 5 indicates that excluding nitrate and calcium, precision of all analyses performed in the UVA lab during the period was in-control ($p=0.3079$).

Table 5: Precision results summary

Characteristic	Defect s (k)	total	Percent defective	Probability of k or more outside of specification limits given acceptable individual probability of 0.01
ANC	0	68	0.00%	0.4951
Calcium	5	68	7.35%	0.0006
Chloride	1	68	1.47%	0.4951
Conductivity	0	68	0.00%	0.4951
DOC	0	12	0.00%	0.1136
Potassium	1	68	1.47%	0.4951
Magnesium	0	68	0.00%	0.4951
Sodium	0	68	0.00%	0.4951
Ammonium	0	7	0.00%	0.0679
Nitrate	6	19	31.58%	0.0000
pH	3	68	4.41%	0.0310
Phosphate	0	0	N/A	N/A
Silica	0	68	0.00%	0.4951
Sulfate	3	68	4.41%	0.0310
Monomeric aluminum, organic fraction	0	1	0.00%	0.0100
Total monomeric aluminum	0	5	0.00%	0.0490
ALL	19	724	2.62%	0.0002
ALL minus nitrate, calcium	8	637	1.26%	0.3079

1.5 Blank analysis

Blanks are sample bottles filled with de-ionized water. **Trip blanks** are carried to sample site locations, returned, and analyzed to test for system-wide contamination. One trip blank was analyzed during each quarterly sampling window. During 2009 four trip blanks were analyzed. **Post-preserved blanks** are equivalent to trip blanks, except they do not leave the lab. During 2009 four of these were analyzed also. Post-preserved blank analysis was initiated in 2009 because of poor trip blank results in previous years.

Lab blanks were also analyzed for DOC. Samples analyzed for DOC are filtered through a 0.45 um membrane filter directly into an autosampler vial. Lab blanks for DOC were prepared by either filtering de-ionized water into an autosampler vial or by dispensing de-ionized water directly into an autosampler vial. Concentrations of DOC in lab blanks are used to assess contamination, but are not expected to be zero because low background levels of DOC are present even in laboratory grade de-ionized water.

Except for DOC, ANC, pH, and conductivity, blank results should be less than the MDL. Results above the MDL indicate contamination or some bias in the measurement process, although that bias may only be applicable at low levels.

Given the number of tests we again use a criterion value of 0.005 for the probability threshold, above which we accept the hypothesis of an in-control measurement process. Table 6 indicates a significant number of results above MDL for results obtained from the ion chromatograph (IC2), for both trip blanks and post-preserved blanks. The equivalency of these results indicates that the problem does not stem from sample collection.

The results obtained for the other procedures (Technicon (TC) and Phoenix 8000) are indicative of an in-control measurement process. We conclude that the trip blanks were contamination-free, but that the current ion chromatograph procedure has a low-level bias. Additional work is planned to isolate the source of this problem.

Table 6: Blank analysis summary

Quality Control Sample Type	Analytical procedure	N	Total Censored	< MDL	< LQL	≥ LQL	# of defects (k)	% defective	Probability $K \geq k$ under H_0
Trip Blank	By IC2	32	27	14	13	5	18	56.25%	0.0000
Trip Blank	Phoenix 8000 - DOC	4	4	4	0	0	0	0.00%	0.0119
Trip Blank	By TC - Silica	4	4	3	1	0	1	25.00%	0.0119
Trip Blank	By TC - Aluminum	6	6	6	0	0	0	0.00%	0.0179
Post-preservative Blank	By IC2	32	25	14	11	7	18	56.25%	0.0000
Post-preservative Blank	Phoenix 8000 - DOC	4	4	4	0	0	0	0.00%	0.0119
Post-preservative Blank	By TC - Silica	4	4	4	0	0	0	0.00%	0.0119
Post-preservative Blank	By TC - Aluminum	6	6	6	0	0	0	0.00%	0.0179
Lab Blank	Phoenix 8000 - DOC	8	8	8	0	0	0	0.00%	0.0237
Trip blank summary	Phoenix 8000 plus TC	14	14	13	1	0	1	7.14%	0.0412
	All except pH, ANC, conductivity	46	41	27	14	5	19	41.30%	0.0000

1.6 Precision analysis based on reference samples

Reference samples were analyzed during all analysis sessions for pH, alkalinity, conductivity, cations, anions, aluminum, DOC, and silica. Analysis results for reference samples are summarized in **Appendix 1 - Lab QC results**. Appendix 1 contains one table listing the reference samples used. Some of these were certified reference materials (CRMs), and some were quality control check samples or low-level samples to be used for detection limit computation (LAB). Appendix 1 contains a second table containing summary analysis results, including the C_p statistic for characteristics for which specification limits could be ascertained.

1.7 Systemic bias analysis based on CRMs

We used the sign test of the SAS procedure PROC UNIVARIATE to assess whether or not the measurement process was biased with respect to other labs, using the results and target values for the CRMs listed in **Appendix 1 - Lab QC results**. The test statistic M is calculated as

$$M = \frac{n^+ - n^-}{2}$$

where n^+ is the number of observations greater than μ_0 and n^- is the number of observations less than μ_0 , where an observation is the sign of the difference between the lab results and the CRM target value. In this case we chose $\mu_0=0$. See the SAS documentation for details of the computation of the p-value. Given the number of tests, we would take a p-value less than 0.005 as evidence of systemic bias. However, for small N, the potential for either a Type I or Type II error is such that we would not want to place too much weight on any results where N is much less than 10. Table 7 indicates that no characteristics were of concern.

Table 7: Systemic bias analysis

EPA STORET Characteristic Name	N	M	p-value
Aluminum, Organic + Inorganic Monomeric (reactive aluminum)	1	-0.5	1.0000
Calcium	11	-1.5	0.5488
Carbon, organic	5	-1.5	0.3750
Chloride	12	2	0.3877

EPA STORET Characteristic Name	N	M	p-value
Magnesium	11	-1.5	0.5488
Nitrogen, Nitrate (NO3) as NO3	11	-0.5	1.0000
Nitrogen, ammonium (NH4) as NH4	4	-2	0.1250
Potassium	9	-3.5	0.0391
Silica	6	-2	0.2188
Sodium	12	4	0.0386

1.8 Collaborative study results for precision and systemic bias

The project laboratory participates in the Environment Canada Proficiency Testing (EC PT) Program administered by the Information and Quality Management Group of Environment Canada's Emergencies, Operational Analytical Laboratories and Research Support Division (EOALRSD). Environmental programs in both the United States and Canada participate in these accredited studies which are designed for laboratories analyzing acid rain and surface waters. The PT program provides an objective, third-party evaluation of the laboratory's performance. The purpose of the PT studies is to provide a useful means of quantifying laboratory performance and data quality. The report for each study includes an assessment of systemic bias and precision.

Each study consists of ten samples, which are analyzed by the project laboratory by the same methods as the project samples and usually included in analysis sessions along with project samples. The test results are then reported to Environment Canada. Performance summaries for PT studies in which the project laboratory has participated to date are reported in Table 8.

The project laboratory's reported test results for each sample and each parameter are compared to the value assigned by Environment Canada. The assigned value is the median of test results from all laboratories participating in the PT study. Systemic bias is indicated when a laboratory's test results are consistently and significantly higher or lower than the assigned values for a given parameter. The two components of systemic bias are the Bias Blank and Bias % Slope. For most parameters a Bias % Slope of greater than the absolute value of 5 is considered significant. Precision performance is indicated using flags. A result is flagged with a "warning flag" if its value is 2 - 3 robust standard deviations from the assigned value. A result is flagged with an "action flag" if its value is more than 3 robust standard deviations from the assigned value.

Table 8: Project Laboratory Performance in Environment Canada PT Program Studies

Study Date	pH - manual	pH- titrator	specific conductance	Alkalinity – manual (2-point)	Alkalinity – titrator (11 point)	chloride	nitrate	sulfate	ammonia	reactive silica	sodium	potassium	calcium	magnesium	Dissolved organic carbon	
10-MAY-94	A	N	A	N	N	A	A	A	A	A	A	A	A	A	N	
15-JAN-95	A	N	1	A	N	2	A	A	A	3	A	A	A	4	N	
05-SEP-95	A	N	A	A	N	A	A	A	N	A	A	A	A	A	N	
01-SEP-96	A	N	A	A	N	A	A	A	A	A	5	A	A	A	N	
02-SEP-97	A	N	A	A	N	A	A	A	A	A	A	A	A	A	N	
01-SEP-98	A	N	A	A	N	A	A	A	6	A	A	A	A	A	N	
01-SEP-99	A	N	A	A	N	A	A	A	7	A	A	A	A	A	N	
28-AUG-00	A	N	A	A	N	A	A	A	A	8	A	A	A	A	N	
27-AUG-01	A	N	A	A	N	A	A	A	9	10	A	A	A	11	N	
03-SEP-02	A	N	12	A	N	A	A	A	A	13	A	A	A	A	N	
01-JUN-04	A	N	A	A	N	A	A	A	A	A	A	A	A	A	N	
01-DEC-05	A	N	A	A	N	A	A	A	A	A	A	A	A	A	N	
01-DEC-06	14	A	A	A	A	A	A	A	A	A	A	A	A	A	N	
01-DEC-07	N	A	15	N	A	A	A	A	A	A	A	A	A	A	A	
01-DEC-08	N	A	A	N	A	A	16	A	17	A	A	A	A	A	A	
01-DEC-09	N	A	A	N	A	A	A	A	A	A	A	18	A	19	A	
Defects	1	0	3	0	0	1	1	0	4	4	1	1	0	3	0	19
Total	13	4	16	12	4	16	16	16	15	16	16	16	16	16	3	195

Notes:

A) Acceptable

N) No 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.

2 Corrective actions

This section describes corrective actions that have been taken since the end of this reporting period (31 December 2009) and corrective actions, if any, that are anticipated as a result of this report, including plans for determining appropriate corrective actions.

2.1 Corrective actions taken during 2010

Corrective actions taken in 2010 were based on the quality assurance report for the 2008 reporting period.

We continued to collect trip blanks and post-preserved blanks during 2010.

In 2010 alternative regression models for standard curves were examined. This preliminary examination did not lead to an explanation for detectable concentrations in trip Blanks and post-preserved blanks. Therefore regression models used in 2010 were the same as for 2009.

2.2 Corrective actions planned for 2011

Corrective actions to be taken in 2011 are based on this quality assurance report. Following we describe the issues and the planned remedial actions.

2.2.1 Charge ratio variability –VTSSS

Looking over the period of record, the charge ratio for certain sites outside of SHEN is consistently high which indicates the probability of unmeasured ions, instead of indicating analytical problems. Comparing these sites to others with charge ratios closer to one may not be informative of overall data quality. This may indicate a need to establish project-specific charge ratio specification limits. This is unchanged from the 2009 data report.

2.2.2 Calcium and nitrate precision

Calcium and nitrate analyses did not meet precision objectives during this reporting period. Precision is assessed by using field replicates in which two samples bottles are collected, one after the other, by the field collector.

In 2011, the appropriateness of using field replicates to assess precision will be examined. The assumption that the two replicate bottles contain the same analyte concentrations will be tested by analyzing replicate aliquots from each bottle. Aliquot replicates will be compared with bottle replicates to determine if the source of poor precision is the analytical technique or the field replicate collection process.

2.2.3 Blank bias

Regression models will continue to be evaluated in 2011 to determine the most appropriate model.

Also, the volume of sample injected into the IC will be increased for the cations (ammonium, calcium, magnesium, potassium, sodium). This will result in a higher signal-to-noise ratio. This should lead to better precision and accuracy, especially at

lower concentrations, since the signal for low concentrations is small relative to the background noise. This should also lead to a lower MDL.

2.2.4 Minimum detection limits

In 2011 an increased priority will be placed on analyzing a sufficient number of MDL standard solutions so that the calculation of MDL values will be based on the appropriate number of analyses. This will mean that the reported MDL will better reflect the true MDL achieved by the laboratory process.

3 Appendices

Appendix 1, Lab QC Results, is provided as a separate file.

4 References

- Hirsch, R.M. and Slack, J.R., 1984. A nonparametric trend test for seasonal data with serial dependence. *Water Resources Research*, 20(6), 727-732.
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- Rantz, S. E., *et al.*, 1982. Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge. *U.S. Geol. Surv. Water-Supply Paper 2175*, U.S. Geological Survey, Washington, DC.

Appendix 1: LIMS QC results, 2009

QCs used during the period

Lab QC Type	Lab QC Name	Lab QC Comment
CRM	84_SW08	ENVIRONMENT CANADA PT STUDY 84: SAMPLE SW08
CRM	87_SW01	ENVIRONMENT CANADA PT STUDY 87: SAMPLE SW01
CRM	87_SW02	ENVIRONMENT CANADA PT STUDY 87: SAMPLE SW02
CRM	87_SW03	ENVIRONMENT CANADA PT STUDY 93: SAMPLE SW03
CRM	87_SW04	ENVIRONMENT CANADA PT STUDY 87: SAMPLE SW04
CRM	87_SW06	ENVIRONMENT CANADA PT STUDY 87: SAMPLE SW06
CRM	87_SW08	ENVIRONMENT CANADA PT STUDY 87: SAMPLE SW08
CRM	91_SW01	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW01
CRM	91_SW03	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW03
CRM	91_SW06	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW06
CRM	91_SW07	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW07
CRM	91_SW08	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW08
CRM	91_SW09	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW09
CRM	91_SW10	ENVIRONMENT CANADA PT STUDY 91: SAMPLE SW10
CRM	93_RN01	ENVIRONMENT CANADA PT STUDY 93: SAMPLE RN01
CRM	93_RN03	ENVIRONMENT CANADA PT STUDY 93: SAMPLE RN03
CRM	93_RN04	ENVIRONMENT CANADA PT STUDY 93: SAMPLE RN04
CRM	93_RN07	ENVIRONMENT CANADA PT STUDY 93: SAMPLE RN07
CRM	93_RN08	ENVIRONMENT CANADA PT STUDY 93: SAMPLE RN08
CRM	FN13	NATURAL AUDIT SAMPLE PROVIDED BY LOCKHEED ENGINEERING AND SCIENCES COMPANY
CRM	FN16	NATURAL AUDIT SAMPLE PROVIDED BY LOCKHEED ENGINEERING AND SCIENCES COMPANY
CRM	QCP3	INORGANIC VENTURES QCP RAIN SAMPLE 3 (LOT # X-RN01015)
LAB	ALCALQCCS	ALUMINUM CALIBRATION QUALITY CONTROL CHECK SAMPLE
LAB	ALDETQCCS	ALUMINUM DETECTION LIMIT QUALITY CONTROL CHECK SAMPLE
LAB	ANCALQCCS	ANION CALIBRATION QUALITY CONTROL CHECK SAMPLE
LAB	ANDETQCCS	ANION DETECTION LIMIT QUALITY CONTROL CHECK SAMPLE
LAB	CACALQCCS	CATION CALIBRATION QUALITY CONTROL CHECK SAMPLE
LAB	CADETQCCS	CATION DETECTION LIMIT QUALITY CONTROL CHECK SAMPLE

Lab QC Type	Lab QC Name	Lab QC Comment
LAB	DIW	DE-IONIZED WATER
LAB	DOCDLQCCS	DOC DETECTION LIMIT QUALITY CONTROL CHECK SAMPLE
LAB	DOC_2.5	2.5 MG/L DOC
LAB	DOC_5.0	5.0 MG/L DOC
LAB	DOC_CAL_QCCS_HI	DOC CALIBRATION QUALITY CONTROL CHECK SAMPLE - HIGH
LAB	DOC_CAL_QCCS_LO	DOC CALIBRATION QUALITY CONTROL CHECK SAMPLE - LOW
LAB	PH 4.60 QCS	LABORATORY-PREPARED PH 4.60 QUALITY CHECK STANDARD
LAB	PH-COND_QC	
LAB	SICALQCCS	SILICA CALIBRATION QUALITY CONTROL CHECK SAMPLE
LAB	SIDETQCCS	SILICA DETECTION LIMIT QUALITY CONTROL CHECK SAMPLE
LAB	SILICA_MIDSTD	SILICA STANDARD 3 FOR QC

QC Analysis results

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
CRM	84_SW08	UVA_SILICA_TCON	Silica		10	35.16	0.39	34.56	35.80	35.50	33.70	37.30	1.52	10.23949
CRM	87_SW01	UVA_IONS_IC	Chloride		12	8.25	0.22	7.95	8.82	8.46	7.61	9.31	1.31	0.487796
CRM	87_SW01	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		12	18.34	0.14	18.08	18.56	18.32	17.40	19.23	2.12	0.702091
CRM	87_SW01	UVA_IONS_IC	Nitrogen, ammonium (NH4) as NH4		12	5.52	0.12	5.29	5.74	8.56	7.45	9.67	3.06	0.980274
CRM	87_SW01	UVA_IONS_IC	Sodium		12	7.16	0.07	7.08	7.34	7.40	6.53	8.27	3.99	0.603472
CRM	87_SW01	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		12	27.09	0.29	26.55	27.56	27.35	25.98	28.72	1.60	1.924622
CRM	87_SW02	UVA_IONS_IC	Calcium		10	19.24	2.49	16.64	25.35	17.20	16.20	18.20	0.13	5.289737
CRM	87_SW02	UVA_IONS_IC	Chloride		10	58.24	0.31	57.94	58.84	58.00	55.10	60.80	3.05	0.487796
CRM	87_SW02	UVA_IONS_IC	Magnesium		10	16.75	0.66	16.09	18.28	16.50	15.60	17.30	0.43	1.80201
CRM	87_SW02	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		10	14.01	0.12	13.88	14.24	16.10	15.30	16.90	2.20	0.702091
CRM	87_SW02	UVA_IONS_IC	Potassium		10	3.24	0.06	3.17	3.36	3.38	2.36	4.40	5.39	0.828857
CRM	87_SW02	UVA_IONS_IC	Sodium		10	61.22	0.41	60.77	61.85	59.60	56.60	62.60	2.42	0.603472
CRM	87_SW02	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		10	35.48	0.25	35.18	36.00	35.80	34.00	37.60	2.36	1.924622
CRM	87_SW03	UVA_PHOEN_8000	Carbon, organic		2	3.08	0.08	3.02	3.14	3.16	2.84	3.48	1.27	0.354854
CRM	87_SW04	UVA_PHOEN_8000	Carbon, organic		2	7.00	0.04	6.97	7.03	7.14	6.43	7.85	5.83	0.354854
CRM	87_SW06	UVA_PHOEN_8000	Carbon, organic		4	5.29	0.26	5.08	5.67	5.14	4.63	5.65	0.65	0.354854

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
CRM	87_SW08	UVA_PHOEN_8000	Carbon, organic		3	0.68	0.03	0.66	0.72	0.70	0.60	0.80	1.06	0.354854
CRM	91_SW01	UVA_IONS_IC	Calcium		4	45.39	0.54	44.97	46.18	45.40	43.13	47.67	1.41	5.289737
CRM	91_SW01	UVA_IONS_IC	Chloride		4	33.96	0.50	33.58	34.69	33.60	31.92	35.28	1.12	0.487796
CRM	91_SW01	UVA_IONS_IC	Magnesium		4	18.65	0.44	18.13	19.06	18.90	17.96	19.85	0.72	1.80201
CRM	91_SW01	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		4	23.91	0.17	23.78	24.15	24.20	22.99	25.41	2.32	0.702091
CRM	91_SW01	UVA_IONS_IC	Sodium		4	35.08	0.49	34.77	35.81	33.60	31.92	35.28	1.13	0.603472
CRM	91_SW01	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		4	33.89	0.28	33.54	34.20	34.30	32.59	36.02	2.06	1.924622
CRM	91_SW03	UVA_SILICA_TCON	Silica		15	40.87	0.76	40.05	42.62	42.26	40.15	44.37	0.93	10.23949
CRM	91_SW06	UVA_IONS_IC	Calcium		13	220.90	2.83	217.22	225.04	221.60	210.52	232.68	1.31	5.289737
CRM	91_SW06	UVA_IONS_IC	Chloride		13	32.34	0.42	31.98	33.65	31.90	30.31	33.50	1.27	0.487796
CRM	91_SW06	UVA_IONS_IC	Magnesium		13	101.18	1.32	99.08	102.53	101.20	96.14	106.26	1.28	1.80201
CRM	91_SW06	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		13	18.69	0.27	18.43	19.48	18.30	17.39	19.22	1.15	0.702091
CRM	91_SW06	UVA_IONS_IC	Potassium		13	16.30	0.15	16.09	16.71	16.70	15.68	17.72	2.23	0.828857
CRM	91_SW06	UVA_IONS_IC	Sodium		13	69.46	0.93	68.59	71.84	67.40	64.03	70.77	1.21	0.603472
CRM	91_SW06	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		13	153.55	1.79	151.40	158.98	153.90	146.21	161.60	1.44	1.924622
CRM	91_SW07	UVA_IONS_IC	Calcium		16	154.23	1.43	151.63	157.23	159.00	151.00	167.00	1.86	5.289737
CRM	91_SW07	UVA_IONS_IC	Chloride		16	28.39	0.39	27.99	29.74	28.10	26.70	29.50	1.20	0.487796
CRM	91_SW07	UVA_IONS_IC	Magnesium		16	71.89	0.48	71.24	73.42	72.90	69.30	76.60	2.53	1.80201
CRM	91_SW07	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		16	65.29	0.33	64.75	66.01	71.30	67.70	74.80	3.61	0.702091
CRM	91_SW07	UVA_IONS_IC	Potassium		16	4.88	0.08	4.78	5.09	5.12	4.10	6.14	4.23	0.828857
CRM	91_SW07	UVA_IONS_IC	Sodium		16	22.02	0.13	21.78	22.24	21.60	20.50	22.70	2.75	0.603472

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
CRM	91_SW07	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		16	90.30	0.48	89.39	91.43	90.50	86.00	95.00	3.10	1.924622
CRM	91_SW08	UVA_SILICA_TCON	Silica		14	60.95	1.03	59.73	63.25	63.21	60.05	66.37	1.02	10.23949
CRM	91_SW09	UVA_IONS_IC	Calcium		14	130.01	2.14	125.67	133.07	131.20	124.70	137.80	1.02	5.289737
CRM	91_SW09	UVA_IONS_IC	Chloride		14	49.32	0.37	48.78	50.39	49.40	46.90	51.80	2.19	0.487796
CRM	91_SW09	UVA_IONS_IC	Magnesium		14	52.58	0.85	51.02	53.55	51.80	49.30	54.40	1.00	1.80201
CRM	91_SW09	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		14	5.47	0.25	5.29	6.31	5.40	4.90	5.90	0.66	0.702091
CRM	91_SW09	UVA_IONS_IC	Nitrogen, ammonium (NH4) as NH4		14	3.02	0.28	2.73	3.54	3.35	2.20	4.50	1.36	0.980274
CRM	91_SW09	UVA_IONS_IC	Potassium		14	13.26	0.09	13.15	13.46	13.30	12.30	14.30	3.69	0.828857
CRM	91_SW09	UVA_IONS_IC	Sodium		14	101.21	1.17	100.27	104.57	98.70	93.80	103.70	1.41	0.603472
CRM	91_SW09	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		14	102.19	0.74	101.60	104.65	101.50	96.40	106.60	2.28	1.924622
CRM	93_RN01	UVA_SILICA_TCON	Silica		10	40.92	0.43	40.47	41.57	41.90	39.80	44.00	1.62	10.23949
CRM	93_RN03	UVA_PHOEN_8000	Carbon, organic		5	4.88	0.07	4.83	5.00	5.13	4.62	5.64	2.50	0.354854
CRM	93_RN04	UVA_IONS_IC	Calcium		15	30.97	2.37	28.80	36.18	30.00	28.50	31.50	0.21	5.289737
CRM	93_RN04	UVA_IONS_IC	Chloride		15	5.15	0.13	4.95	5.35	5.08	4.23	5.92	2.19	0.487796
CRM	93_RN04	UVA_IONS_IC	Magnesium		15	11.74	0.46	11.13	12.67	12.30	11.50	13.20	0.62	1.80201
CRM	93_RN04	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		15	33.10	0.20	32.89	33.47	32.80	31.20	34.50	2.74	0.702091
CRM	93_RN04	UVA_IONS_IC	Nitrogen, ammonium (NH4) as NH4		15	6.43	0.05	6.32	6.52	14.10	13.00	15.20	7.89	0.980274
CRM	93_RN04	UVA_IONS_IC	Sodium		15	3.06	0.05	2.99	3.16	3.05	2.18	3.92	5.71	0.603472

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
CRM	93_RN04	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		15	39.85	0.24	39.54	40.32	39.90	37.90	41.90	2.82	1.924622
CRM	93_RN07	UVA_IONS_IC	Calcium		15	147.37	1.39	145.56	150.88	149.00	142.00	157.00	1.80	5.289737
CRM	93_RN07	UVA_IONS_IC	Chloride		15	6.75	0.14	6.52	6.98	6.49	5.64	7.33	1.96	0.487796
CRM	93_RN07	UVA_IONS_IC	Magnesium		15	38.98	0.32	38.23	39.47	39.50	37.50	41.50	2.10	1.80201
CRM	93_RN07	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		15	46.66	0.21	46.36	46.95	47.80	45.40	50.20	3.84	0.702091
CRM	93_RN07	UVA_IONS_IC	Potassium		15	5.19	0.05	5.09	5.26	5.12	4.10	6.14	7.08	0.828857
CRM	93_RN07	UVA_IONS_IC	Sodium		15	24.45	0.15	24.14	24.75	24.10	22.90	25.30	2.69	0.603472
CRM	93_RN07	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		15	109.59	0.42	108.63	110.25	110.00	104.00	115.00	4.36	1.924622
CRM	93_RN08	UVA_IONS_IC	Calcium		8	166.44	1.33	164.89	168.09	170.00	162.00	179.00	2.12	5.289737
CRM	93_RN08	UVA_IONS_IC	Chloride		8	45.98	0.27	45.63	46.38	46.00	43.70	48.30	2.89	0.487796
CRM	93_RN08	UVA_IONS_IC	Magnesium		8	60.16	0.47	59.48	60.87	60.20	57.20	63.20	2.12	1.80201
CRM	93_RN08	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		8	4.25	0.04	4.21	4.33	5.49	5.01	5.97	3.90	0.702091
CRM	93_RN08	UVA_IONS_IC	Potassium		8	5.35	0.05	5.26	5.46	5.58	4.56	6.60	6.30	0.828857
CRM	93_RN08	UVA_IONS_IC	Sodium		8	71.33	0.39	70.81	72.09	69.20	65.70	72.60	2.98	0.603472
CRM	93_RN08	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		8	63.44	0.49	62.85	64.51	62.60	59.50	65.70	2.09	1.924622
CRM	FN13	UVA_AL_TOT_TCON	Aluminum, Organic + Inorganic Monomeric (reactive aluminum)		10	36.72	0.72	35.89	37.84	58.00	48.00	68.00	4.64	24.01578
CRM	FN13	UVA_IONS_IC	Calcium		10	108.18	1.23	106.47	109.72	99.26	94.29	104.22	1.34	5.289737
CRM	FN13	UVA_IONS_IC	Chloride		10	10.22	0.07	10.14	10.34	11.91	11.06	12.76	4.01	0.487796

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
CRM	FN13	UVA_IONS_IC	Magnesium		10	40.59	0.75	39.12	41.64	38.74	36.80	40.67	0.87	1.80201
CRM	FN13	UVA_IONS_IC	Potassium		10	8.17	0.07	8.07	8.24	8.95	7.92	9.97	5.19	0.828857
CRM	FN13	UVA_IONS_IC	Sodium		10	24.66	0.18	24.46	24.98	25.39	24.12	26.66	2.29	0.603472
CRM	FN13	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		10	119.75	0.41	119.01	120.67	115.09	109.34	120.85	4.66	1.924622
CRM	FN13	UVA_SILICA_TCON	Silica		11	18.45	0.75	17.94	20.62	17.75	16.86	18.63	0.39	10.23949
CRM	FN16	UVA_IONS_IC	Calcium		10	300.35	4.88	289.04	307.98	285.96	271.66	300.25	0.98	5.289737
CRM	FN16	UVA_IONS_IC	Chloride		10	28.01	0.17	27.86	28.27	27.67	26.28	29.05	2.74	0.487796
CRM	FN16	UVA_IONS_IC	Magnesium		10	134.10	1.27	131.98	135.76	131.33	124.77	137.90	1.72	1.80201
CRM	FN16	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		10	4.23	0.27	3.87	4.61	5.93	5.45	6.42	0.59	0.702091
CRM	FN16	UVA_IONS_IC	Potassium		10	19.19	0.10	19.02	19.31	19.29	18.27	20.31	3.49	0.828857
CRM	FN16	UVA_IONS_IC	Sodium		10	44.98	0.44	44.42	45.47	44.13	41.93	46.34	1.65	0.603472
CRM	FN16	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		10	177.67	1.05	176.67	179.93	174.33	165.62	183.05	2.77	1.924622
CRM	FN16	UVA_SILICA_TCON	Silica		13	36.50	0.46	35.86	37.70	37.30	35.44	39.17	1.35	10.23949
CRM	QCP3	UVA_IONS_IC	Calcium		5	9.36	0.18	9.10	9.62	9.93	8.93	10.93	1.80	5.289737
CRM	QCP3	UVA_IONS_IC	Chloride		5	34.03	0.18	33.84	34.31	33.56	31.88	35.24	3.09	0.487796
CRM	QCP3	UVA_IONS_IC	Magnesium		5	20.37	0.08	20.27	20.47	20.90	19.86	21.95	4.40	1.80201
CRM	QCP3	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		5	33.83	0.23	33.57	34.19	33.01	31.36	34.66	2.37	0.702091
CRM	QCP3	UVA_IONS_IC	Nitrogen, ammonium (NH4) as NH4		5	32.73	0.41	32.02	33.00	33.63	31.95	35.31	1.37	0.980274
CRM	QCP3	UVA_IONS_IC	Potassium		5	13.78	0.07	13.73	13.90	13.95	12.93	14.97	4.89	0.828857
CRM	QCP3	UVA_IONS_IC	Sodium		5	26.39	0.07	26.34	26.51	25.97	24.67	27.27	6.11	0.603472

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
CRM	QCP3	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		5	104.06	0.68	103.49	105.21	102.60	97.47	107.73	2.53	1.924622
LAB	ALCALQCCS	UVA_AL_TOT_TCON	Aluminum, Organic + Inorganic Monomeric (reactive aluminum)		38	52.73	1.36	49.54	56.16	50.00	40.00	60.00	2.44	24.01578
LAB	ANCALQCCS	UVA_IONS_IC	Chloride		112	25.48	0.17	24.95	25.96	25.38	24.11	26.65	2.45	0.487796
LAB	ANCALQCCS	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		112	14.31	0.14	13.99	14.75	14.49	13.77	15.21	1.72	0.702091
LAB	ANCALQCCS	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		112	30.69	0.25	30.17	31.59	31.20	29.64	32.76	2.08	1.924622
LAB	ANDETQCCS	UVA_IONS_IC	Chloride		17	4.11	0.05	4.06	4.22	4.23	3.38	5.08	6.02	0.487796
LAB	ANDETQCCS	UVA_IONS_IC	Nitrogen, Nitrate (NO3) as NO3		17	2.51	0.04	2.41	2.58	2.42	1.93	2.90	3.88	0.702091
LAB	ANDETQCCS	UVA_IONS_IC	Sulfur, sulfate (SO4) as SO4		17	5.44	0.19	5.01	5.64	5.20	4.16	6.24	1.87	1.924622
LAB	CACALQCCS	UVA_IONS_IC	Calcium		109	30.59	0.70	29.15	33.21	29.94	28.44	31.44	0.72	5.289737
LAB	CACALQCCS	UVA_IONS_IC	Magnesium		109	23.90	0.34	22.99	25.03	24.69	23.46	25.92	1.20	1.80201
LAB	CACALQCCS	UVA_IONS_IC	Nitrogen, ammonium (NH4) as NH4		109	16.31	0.19	15.81	16.60	16.62	15.79	17.45	1.48	0.980274
LAB	CACALQCCS	UVA_IONS_IC	Potassium		109	30.78	0.12	30.46	31.23	30.72	29.18	32.26	4.31	0.828857
LAB	CACALQCCS	UVA_IONS_IC	Sodium		109	25.90	0.14	25.56	26.39	26.10	24.80	27.41	3.19	0.603472
LAB	CADETQCCS	UVA_IONS_IC	Magnesium		17	3.61	0.19	3.35	4.03	4.12	3.29	4.94	1.46	1.80201

Lab QC Type	Lab QC Name	NPSTORET Procedure ID	EPA STORET Name	Lab Statistic Name	n	Mean	Std Dev	Min	Max	Lab Target Value	Lab Target LSL	Lab Target USL	C _p	Lower Quant Limit
LAB	CADETQCCS	UVA_IONS_IC	Nitrogen, ammonium (NH4) as NH4		17	5.29	0.13	5.00	5.43	5.54	4.43	6.65	2.82	0.980274
LAB	CADETQCCS	UVA_IONS_IC	Potassium		17	4.84	0.06	4.73	4.96	5.12	4.10	6.14	5.49	0.828857
LAB	CADETQCCS	UVA_IONS_IC	Sodium		17	4.18	0.06	4.07	4.30	4.35	3.48	5.22	4.66	0.603472
LAB	DIW	UVA_ANC_PH_M809	Not Applicable	ANC Titration R- squared	132	1.00	0.00	1.00	1.00	.	.	.	.	.
LAB	DIW	UVA_ANC_PH_M809	Not Applicable	ANC Titration slope	132	0.01	0.00	0.01	0.01	.	.	.	.	.
LAB	DOC_2.5	UVA_PHOEN_8000	Carbon, organic		8	2.26	0.04	2.20	2.34	2.50	2.25	2.75	1.86	0.354854
LAB	DOC_5.0	UVA_PHOEN_8000	Carbon, organic		7	4.50	0.06	4.43	4.60	5.00	4.50	5.50	2.96	0.354854
LAB	DOC_CAL_QCCS_HI	UVA_PHOEN_8000	Carbon, organic		23	2.88	0.06	2.83	3.03	3.00	2.70	3.30	1.74	0.354854
LAB	DOC_CAL_QCCS_LO	UVA_PHOEN_8000	Carbon, organic		26	1.46	0.06	1.41	1.65	1.50	1.35	1.65	0.85	0.354854
LAB	PH 4.60 QCS	UVA_ANC_PH_M809	Not Applicable	ANC Titration R- squared	1151	1.00	0.00	1.00	1.00	.	.	.	.	.
LAB	PH 4.60 QCS	UVA_ANC_PH_M809	Not Applicable	ANC Titration slope	1151	0.01	0.00	0.01	0.01	.	.	.	.	.
LAB	PH-COND_QC	UVA_ANC_PH_M809	Not Applicable	ANC Titration R- squared	1107	1.00	0.00	1.00	1.00	.	.	.	.	.
LAB	PH-COND_QC	UVA_ANC_PH_M809	Not Applicable	ANC Titration slope	1107	0.01	0.00	0.01	0.01	.	.	.	.	.
LAB	SICALQCCS	UVA_SILICA_TCON	Silica		60	41.25	0.32	40.52	42.21	42.63	40.50	44.76	2.20	10.23949
LAB	SILICA_MIDSTD	UVA_SILICA_TCON	Silica		4	106.26	1.03	105.00	107.34	106.57	101.24	111.90	1.72	10.23949

<i>Lab QC Type</i>	<i>Lab QC Name</i>	<i>NPSTORET Procedure ID</i>	<i>EPA STORET Name</i>	<i>Lab Statistic Name</i>	<i>n</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Min</i>	<i>Max</i>	<i>Lab Target Value</i>	<i>Lab Target LSL</i>	<i>Lab Target USL</i>	<i>C_p</i>	<i>Lower Quant Limit</i>
STATISTIC	Titrator	UVA_ANC_PH_M809	Not Applicable	ANC Titration R- squared	94	1.00	0.00	1.00	1.00	.	.	.	.	.
STATISTIC	Titrator	UVA_ANC_PH_M809	Not Applicable	ANC Titration slope	94	0.01	0.00	0.01	0.01	.	.	.	.	.