THE WASTEWATER TECHNOLOGY CENTRE INTERLABORATORY STUDY FOR TOTAL CYANIDE:

PHASE 1: LOW LEVEL TOTAL CYANIDE

Prepared for:

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i. Acknowledgements

This report was prepared by Peter Child and James Ford of Investigative Science Incorporated on behalf of the Wastewater Technology Centre. The technical aspects of the study including study design, sample preparation and distribution was carried out by a project team comprised of Jim Fraser, Mohammad Foroutan and Peter Fowlie of Wastewater Technology Centre and Peter Child of Investigative Science Incorporated. The authors wish to acknowledge the contributions of Marrianne Austen and Kiejo Aspila to the study.

ii. Abbreviations and Key Terms

The following abbreviations and key terms are used in this report. They have specific definitions which are summarized below as well as explained more fully in the body of the report.

Milli-Q Water:	Eighteen megohm quality water generated by a Millipore Milli-Q system.
Effluent:	Final effluent from a gold mine. Taken from the outfall of the tailings system.
Standard Solutions:	The nine solutions or samples (labelled L1 through L9) sent to each participating laboratory.
Target Values:	The theoretical cyanide concentrations of the Standard Solution as calculated by weights and measures.
Expected Values:	The accepted or "correct" cyanide concentrations of the Standard Solutions statistically determined using data from the most precise participating laboratories.
mg/L:	Milligrams per litre, equal to Parts per million (ppm).
SCN:	Thiocyanate

1.0 EXECUTIVE SUMMARY

This study was carried out on behalf of the Conservation and Protection Laboratory Managers Committee of Environment Canada to evaluate the capability of Environment Canada labs to determine total cyanide in standards and industrial wastewaters. This is part of an ongoing program to prepare and distribute reference materials from industrial wastewaters and containing parameters of interest to Federal laboratories.

At the present time there are 12 Environment Canada laboratories. In order to allow comparison with other labs and to increase the sample size, a provincial government laboratory and non-government labs from the mining and commercial sectors were invited to participate. As a result, 33 laboratories across Canada participated in the study. Several laboratories submitted results determined by two different analytical methods.

The study was carried out in 2 phases; the first for low levels of cyanide (less than 5 ppm) and the second, for high levels (0-60 ppm). In the low level study, sample matrices included reagent water and gold mining tailing pond effluent. In the high level study, the matrices included Municipal STP influent and steel industry biox effluent. In both cases the desired concentrations of cyanide were achieved by spiking with potassium ferricyanide. This report deals with the low level phase of the study.

All samples were prepared at the Wastewater Technology Centre laboratories. Target concentrations were developed by precise weight and volume measurements and all operations were subject to witness. During bottling of the standard samples, sets of samples were collected for immediate laboratory analysis (to develop empirical standard concentrations). These same samples were also analyzed over the period of the study to test sample stability over time.

The five techniques used to evaluate the data in this study include;

- Frequency analysis to check the distribution of results to confirm that parametric statistics (example: standard deviation, t-test) can be used.
- Comparison of the reported results to the Expected Values using a paired t-test.
- A two step flagging procedure to eliminate Grubbs outliers and flag imprecise data.
- Regression analysis to assess accuracy and precision.
- Ranking analysis to determine if any of the laboratories are consistently biased.

Since the standard solutions were prepared with reagent grade chemicals and are not traceable to a known standard, the Expected Value for each standard solution was calculated using the best data returned by participating laboratories rather than the Target Value (calculated from weights and measures). This Expected Value was used as the mean for statistical comparisons.

Examination of the distribution of the submitted results showed that the results were normally distributed. The use of normal statistics was found to be justified.

The key findings of this study are:

- 2.8% of results fell outside 3 standard deviations of the mean expected value and were flagged as Grubbs outliers. These results were contributed by 5 laboratories.
- 23% of results fell outside 1 standard deviation of the mean expected value. 61% of labs had at least 1 result flagged in this manner.
- 30% of labs submitted results which were identified as significantly different from the expected by the t-test.
- 75% of labs displayed good or satisfactory precision as judged by the regression correlation coefficient. 25% displayed poor precision.
- 72% of labs displayed no bias in the regression slope test. 85% displayed no bias in the Youden Rank Sum test.
- 14% of labs were judged to be biased high and 14% biased low by the regression slope test. 6% were biased high and 6% biased low by the Rank Sum test.
- 83% of labs displayed regression Y-intercepts which were judged to be good or satisfactory. 17% were judged to be poor, indicating problems with precision, method failure at high concentrations or inappropriate blank correction.
- 2 of 36 participating labs displayed serious method failure with these samples.
- There was no evidence of a difference between methods with respect to accuracy or precision. However, 4 of the 36 laboratories showed a possible positive interference from thiocyanate in sample L5. These laboratories all reported using autoanalyzer methods.
- There was no evidence of a general matrix effect although some labs did appear to have difficulty with the effluent matrix.

In summary, between 23% and 25% of the participants in this study displayed poor precision as judged by the outlier flagging test and regression correlation coefficient test, respectively. Between 12% and 28% of the participants were judged to be biased, or inaccurate, by the Youden Rank Sum test and regression slope test, respectively. In view of the fact that the Rank Sum test does not detect bias in labs displaying imprecision, the 28% assessment is expected to more closely reflect the actual situation.

2.0 INTRODUCTION

This study was carried out on behalf of the Conservation and Protection Laboratory Managers Committee of Environment Canada to evaluate the capability of Environment Canada labs to determine total cyanide in standards and industrial wastewaters. This is part of an ongoing program to prepare and distribute reference materials from industrial wastewaters and containing parameters of interest to Federal laboratories.

At the present time there are 12 Environment Canada laboratories. In order to allow comparison with other labs and to increase the sample size, non-government labs from the mining and commercial sectors were invited to participate. As a result, 33 laboratories across Canada participated in the study.

The study was carried out in 2 phases; the first for low levels of cyanide (less than 5 ppm) and the second, for high levels (0-60 ppm). In the low level study, sample matrices included reagent water and gold mining tailing pond effluent. In the high level study, the matrices included Municipal STP influent and steel industry biox effluent. In both cases the desired concentrations of cyanide were achieved by spiking with potassium ferricyanide.

This report was prepared in 2 independent sections to reflect the 2 phases of the study.

3.0 TECHNICAL APPROACH

3.1 STUDY DESIGN

Current and proposed environmental guidelines for acceptable cyanide concentrations in aqueous effluent are regulating the levels to the one mg/L range. Many laboratories now perform this analysis on various aqueous matrices and the relative precision and accuracy of these laboratories in producing analytical data in the low concentration range in effluents is not well defined.

The study was designed to test the laboratory's proficiency in both pure water and industrial effluent matrices using ferricyanide ($Fe(CN)_6$) as the spike. The pure water matrix samples minimize potential interference whereas the effluent matrix samples provide the participating laboratories with samples containing interferences normally found in environmental analysis. In addition, one of the pure water samples was spiked with thiocyanate to provide a positive control on proper sample digestion and distillation procedures. Thiocyanate would be detected by methods employing UV digestion if proper corrections are not made.

A total of nine samples were sent to each laboratory using ferricyanide ($Fe(CN)_6$) as the spike. Four samples having target concentrations of 0.1 to 3.0 mg/L CN^- in pure water, four samples covering the range of 0.2 to 3.1 mg/L CN^- in gold mine effluent, and one sample containing 0.5 mg/L CN^- in pure water with an additional 1.0 mg/L CN^- (as thiocyanate) were prepared. The effluent matrix samples were 0.1 mg/L greater in concentration as the gold mine effluent used contained this background level of detectable cyanide.

Table 3.1 summarizes the target cyanide concentrations in the samples prepared for the study. The actual values determined in this study are summarized in Table 4.2.

The participating laboratories were each given a unique identification code number (CN001 through CN036). These code numbers were used in all subsequent correspondence to ensure the confidentiality of the results.

The samples were initially sent to the participants on November 24, 1991 by overnight courier. Unfortunately the courier failed to make delivery and returned the samples. They were then re-sent by overnight courier on December 5, 1991. The nine samples were numbered randomly (as in table 3.1). The results were requested by December 31, 1991. A sample of the correspondence and results request form are included in Appendix 1.

On January 6, 1992, a summary of the raw results were returned to each participant with a request that they check the results for data entry errors. The laboratories were advised at the outset that changes to results, other than data entry errors, could not be made at this time. One laboratory requested corrections and these were made.

3.2 PREPARATION OF STANDARDS AND SAMPLES

3.2.1 OVERVIEW

A set of nine 30 litre standard cyanide solutions was prepared in 50 litre carboys for the study. Of these, four were prepared in an effluent matrix and five in a pure water matrix. Initially a stock solution of 1000 mg/L CN^- was prepared with aliquots of this stock solution used to make up the nine standard solutions. The samples were bottled directly from the standard solution carboys.

In the preparation of the standard solutions and the samples, all weights, measurements, and records were witnessed by an observer to prevent mistakes by the analyst.

3.2.2 EQUIPMENT AND REAGENTS

The cyanide for the preparation of the stock solution was potassium ferricyanide ($K_4Fe(CN)_6 \cdot 3H_2O$) provided by Fisher (Certified ACS potassium ferricyanide, Cat. No. P-236, Lot 712095). Impurities in the reagent were 0.015% by weight and were accounted for in the preparation of the stock solution. No certified traceable source of pure cyanide salt (example: National Bureau of Standards, Canadian Standards Association, U.S. Environmental Protection Agency) could be found.

The thiocyanate used for the positive digestion/distillation check was prepared in a stock solution using potassium thiocyanate (KSCN) provided by Fisher (Certified ACS potassium thiocyanate, Cat. No. P-317, Lot 781716).

To stabilize the stock solutions and samples sodium hydroxide (NaOH) was added to bring the pH to 12. The sodium hydroxide was purchased from Fisher (Certified ACS sodium hydroxide, Cat. No. S-320. Lot 736976-60).

All water used for stock solution preparation and dilution of standards was 18 megohm produced by a Millipore Milli-Q water purification system. The effluent was final effluent from the tailings system outfall of an undisclosed gold mine.

Stock solutions were prepared using a balance and volumetric glassware. The balance calibration was checked with standard weights on November 18, 1991 and found to be accurate to ± 0.001 gram. Volumetric dispensing of the stock solution to the standard solutions was done using volumetric pipettes.

The standard solutions were prepared in new 50 litre polypropylene carboys. The carboys were first washed with dilute sulphuric acid and triple rinsed with 18 megohm water. The samples were dispensed from the carboys through Tygon tubing into new 500 mL rectangular Nalgene bottles (high density polyethylene, Nalgene product number: 2007-0016).

3.2.3 PREPARATION OF STOCK WATER, CYANIDE, AND THIOCYANATE SOLUTIONS

The stock water or effluent was prepared in batches as required by putting 130 litres of water or effluent into a 200 litre plastic carboy and adding 480 ml of 20 % NaOH solution. This stock water was at pH 12 and was used as dilution water to make up the standard solutions. The density of the stock water was measured at 0.9962 g/mL.

The stock cyanide concentrate containing 1000 mg/L CN^- was prepared as follows: Into a 2 litre volumetric flask, 1 litre of water and 20 ml of 1 N NaOH were added and the pH tested with pH paper (pH 12.5). To this, 5.4126 g of $K_4Fe(CN)_6 \cdot 3H_2O$ was added and the volume brought up to below the 2 litre line. The pH was checked again and was stable at 12.5. The solution was made up to volume.

The target stock thiocyanate concentration was 1000 mg/L as CN. Into a 100 ml volumetric flask containing 50 ml of water, 0.1673 g of KSCN was added. The solution was made up to volume.

3.2.4 PREPARATION OF STANDARD SOLUTIONS

A set of nine cyanide solutions were prepared for the study with target concentrations shown in Table 3.1. The quantities of reagents used to prepare the standard solutions are also summarized in this table. All were prepared using the stock water, effluent, cyanide, and thiocyanate solutions discussed in section 3.2.3.

The standards were prepared in new clean 50 litre polypropylene carboys according to the following general protocol:

1) The carboys were washed with dilute sulphuric acid solution and rinsed three times with 18 megohm water.

2) Approximately 30 Kg of stock water was weighed into each carboy and this calibration level was marked for further reference. The exact weight of water was measured for each calibration level.

3) Stock water (Milli-Q water with NaOH to pH 12) was added to the carboy up to the calibration line (approximately 30 Kg). The exact weight of stock water was calculated using the measured density and calibrated mark on the carboy.

4) The required amount of 1000 mg/L CN^- stock solution (see section 3.2.3) was added directly to the carboy using a volumetric pipette.

5) The contents were stirred for 1 minute with an electric mixer.

6) Each addition, weight or volume, was checked by a second analyst and the record initialled.

7) The target concentration (determined from recorded weights and measures) was calculated using the exact stock water weight and stock solution volume added.

8) The solutions were bottled immediately and stored at room temperature until shipping.

Table 3.1

TARGET CONCENTRATIONS AND REAGENT QUANTITIES USED

Sample Number (random)	Matrix	Target Concentration (mg/L)		Cyanide Stock† (ml)	Thiocyanate Stock‡ (ml)	Stock Water (kg)
		Cyanide	SCN			
L1	Water	0.297		9.0	0	30.094
L2	Effluent	1.097		30.0	0	29.971
L3	Water	2.979		0.0	0	30.094
L4	Effluent	0.1997		3.0	0	29.971
L5	Water	0.499	1.0	15.0	30	29.971
L6	Effluent	0.397		9.0	0	30.094
L7	Water	0.0997		3.0	0	29.971
L8	Water	0.997		30.0	0	29.971
L9	Effluent	3.079		90.0	0	30.094

†: 1000 mg/L Stock Cyanide Solution
‡: 1000 mg/L Stock Thiocyanate Solution

3.2.5 BOTTLING OF STANDARD SAMPLES

The samples were dispensed from the 50 litre carboys directly into new rectangular 500 mL Nalgene bottles through Tygon tubing immediately after preparation. All solutions were mechanically stirred for 1 minute prior to bottling. The bottled samples were capped and stored at room temperature until shipping. The samples were not shipped until December 5, 1991 due to a mistake by the courier. The filling sequence was recorded and three samples per sequence (starting, middle, and end) were retained for internal analysis.

3.3 VERIFICATION OF STANDARD CONCENTRATIONS

3.3.1 OVERVIEW

Verification of the standard concentrations was done using procedures to assure accurate target concentrations by weights and measures as well as by actual analysis of standard samples. Target concentrations were developed by precise weight and volume measurements (see Table 3.1) and all operations were subject to witness. During bottling of the standard samples, sets of samples were collected for immediate laboratory analysis (to develop empirical standard concentrations). These same samples were also analyzed over the period of the study to test sample stability over time.

No traceable source of pure cyanide salts were available for the study so Fisher Certified ACS potassium ferricyanide was used. The impurity content provided by the supplier (0.015%) was factored into the calculations for making up the cyanide standard solution but no independent verification of the purity was undertaken.

3.3.2 WITNESS SYSTEM

To reduce the chance of measurement, reading, or recording error a qualified witness observed all acts of weights and measures during the preparation of the stock and standard solutions. Laboratory notes were initialled by the witness throughout the procedure.

3.3.3 INTERNAL ANALYSIS OF STOCK REAGENTS

Internal analysis was performed on the stock reagents used. Analysis of the Stock Water (Milli-Q water with NaOH to pH 12) showed no detectable cyanide (less than 0.005 mg/L). Duplicate analysis of the Stock Effluent (Gold mine effluent with NaOH to pH 12) showed a cyanide concentration of 0.102 $\pm$0.007 mg/L.

3.3.4 INTERNAL ANALYSIS OF FRESH STANDARD SOLUTIONS DURING BOTTLING

During the bottling of the standard solutions three 500 mL samples were collected for internal analysis. The samples collected were the first in the bottling series (bottle 1), one in the middle of the series (bottle 26), and one at the end of the series (bottle 54, 55, or 56). Each of these samples was analyzed for cyanide concentration. The purpose of this was to determine if the standard solutions were homogenous in the carboys so that there was no systematic difference between the first and last bottles dispensed.

There were no systematic differences in cyanide concentration between the first and last samples bottled in each Standard Solution. This means the standard solutions in the carboys were homogenous and there is no bias between the first and last bottles dispensed. The

analysis data is shown in Appendix 2.

3.3.5 INTERNAL ANALYSIS OF STANDARD SOLUTIONS FOR STABILITY

To determine if the standard samples were stable for the duration of the project, the samples retained for internal analysis were analyzed weekly for cyanide concentration. Each standard solution was tested six (6) times between the start of the project (November 25, 1991) and the date results were due from the participating laboratories (December 31, 1991).

There were no trends in cyanide concentration among the six samples analyzed for each Standard Solution. This means the cyanide concentration in the bottled standard samples did not change over the duration of the study. The analysis data and graphs for the sample stability are in Appendix 3.

3.4 DATA EVALUATION

3.4.1 OVERVIEW

The purpose of assessing the data in this project is to identify values which differ significantly from the values expected and to characterize the status of laboratory analysis in general. Since the standard solutions were prepared with reagent grade chemicals and are not traceable to a known standard, the Expected Value for each standard solution was calculated using the best data returned by participating laboratories rather than the Target Value (calculated from weights and measures). This Expected Value is used as the mean for statistical comparisons. Its rationalization and calculation is described in section 3.4.5 of this report.

In addition to identifying outlying data and laboratories, the analysis techniques provide useful information as to why certain data or laboratories deviate significantly from the Expected Values. The interpretation of the statistical analysis is used to constructively review the performance of the participating laboratories.

The five techniques used in this study are: Frequency analysis to check the distribution of results to confirm that parametric statistics (example: standard deviation, t-test) can be used; Comparison of the reported results to the Expected Values using a paired t-test; A two step flagging procedure to eliminate Grubbs outliers and flag imprecise data; Regression analysis to compare each laboratory's results with the Expected Values; Ranking analysis to determine if any of the laboratories are consistently biased. Each technique is described below,

3.4.2 FREQUENCY DISTRIBUTION OF DATA

Round robin analytical data is usually distributed normally (ie. the data are distributed on a normal or "bell" curve) but there are cases such as consistent high or low end method failure where the data may appear skewed or even bi-modal. Frequency distribution is used to subjectively determine if the data are distributed normally.

To test the frequency distribution the data sets for each standard sample are arithmetically adjusted about a single mean. The frequency distribution of the entire data set is then plotted and visually interpreted. Calculations are done after Chapman and Schaufele, 1970.

3.4.3 COMPARISON WITH EXPECTED VALUES

The reported values for each standard solution from each laboratory are compared to the Expected Values using a paired t-test. The paired t-test is a statistical test used for normally distributed data where the two groups of data being compared are dependent on each other. In the case of the round robin data we are comparing $L1_{expected}$ to $L1_{measured}$ and $L2_{expected}$ to $L2_{measured}$ and so on.

The t statistic then is used to determine if the data submitted by the participating laboratory is significantly different from the Expected Values (ie. the values deemed "correct"). Calculations were done after Malik and Mullen, 1973.

To compare measured and expected values using the paired t-test, the authors arbitrarily adopted a probability of 10 percent (α=0.10) for this study. This means that laboratories whose data are shown to be significantly different from the Expected Values would likely be so nine times out of ten. Only one time out of ten would this difference be attributable to random variation. In the experience of the authors the 10 percent criteria is acceptable for the purposes of this study.

This test determines which laboratories submit data which is different than the expected results by a test which weighs the data's variability against it's deviation from the Expected Values. The advantage of this is it is an objective test which determines if a given laboratory's measured results are different from the Expected Values. The disadvantage is that a laboratory with a lot of variability in its data (ie. data which is not precise) will not tend to be detected whereas a laboratory with very precise data which is marginally different from the expected will be detected. These characteristics of the paired t-test are considered when the results are interpreted.

3.4.4 FLAGGING PROCEDURE

The flagging procedure is done in two stages. In the flagging procedure the variability of the data is estimated using the standard deviation statistic calculated as a function of Quattro Pro 3.0® (Borland International). An explanation and definition of the statistic can be found in most introductory statistics texts such as Ostle and Mensing, 1975.

The first stage was to remove all invalid data generally referred to as Grubbs outliers (reference 1) and defined as all results which are more than three (3) standard deviations from the mean. Once the Grubbs outliers are removed, the means and standard deviations for each Standard Solutions are recalculated.

In the second stage of the flagging procedure the recalculated means and standard deviations are used to identify the data which lies outside one (1) standard deviation from the mean. The criteria of 1 standard deviation is arbitrary but considered reasonable by the authors for the purposes of this study.

To determine the Expected Values for each Standard Solution (the value deemed as correct) the outliers (ie. the data which lie outside one standard deviation from the mean) are removed from the data set and the means are recalculated. These means, which represent the results obtained by the central core of unflagged labs, are used as the Expected Values.

3.4.4 REGRESSION ANALYSIS

Linear regression analysis is done for the results of each participating laboratory. The

analysis is done using the linear regression function (calculated using least squares) of Quattro Pro 3.0® (Borland International). An explanation and definition of the statistic can be found in most introductory statistics texts such as Ostle and Mensing, 1975.

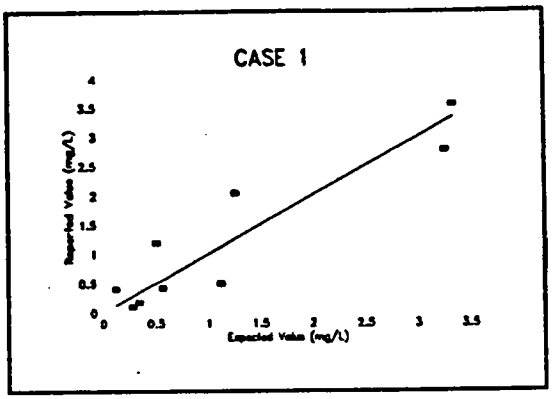
This analysis tests the performance of the laboratory by comparing the reported results of the laboratory to the Expected Values. Regression analysis provides both a visual representation of the data as well as descriptive statistics such as slope, regression coefficient, and $Y_{intercept}$. The results of regression analysis can be used to diagnose some of the typical problems found in laboratory performance studies. These problems, illustrated in Figure 3.1, include:

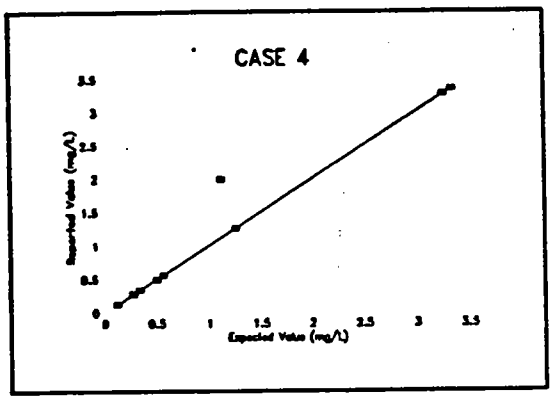
- Lack of precision (case 1)
- Calibration problems (high bias illustrated in case 2)
- Analytical blank problems (combined with high bias in case 3)
- Single sample outlier problems (case 4)
- Method failure (case 5)

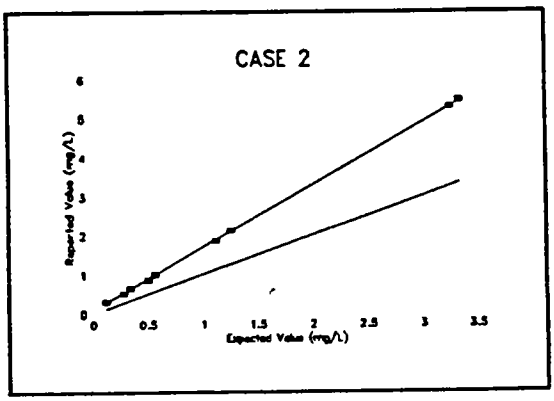
Case 6 in Figure 3.1 represents the ideal situation; perfect accuracy and precision. It should be noted that in Figure 3.1, the line passing through the data points represents the best fit regression line, while the other indicates the expected values.

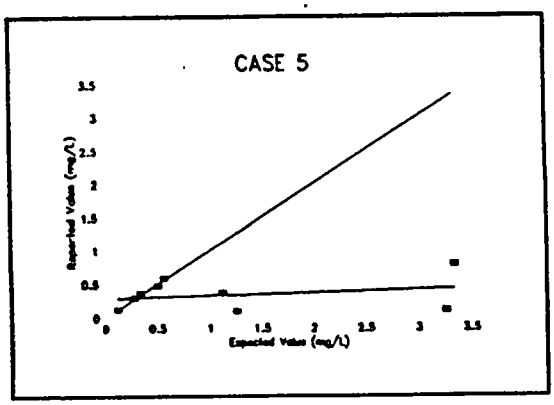
Figure 3.1

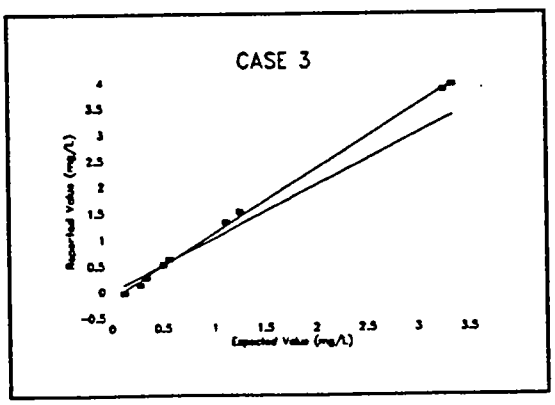
TYPICAL PROBLEMS ENCOUNTERED IN LABORATORY PERFORMANCE STUDIES

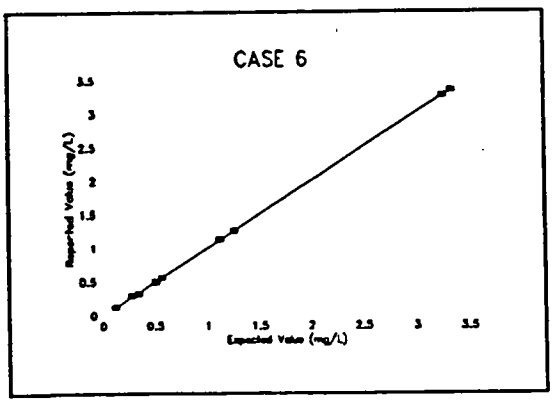












Using the descriptive statistics generated by regression analysis the precision of a laboratory is reflected in how close the reported data are to the regression line. This "quality of fit" is quantified by the regression coefficient R^2. For the purposes of this study the authors have arbitrarily chosen the following criteria: A regression coefficient (R^2) of greater than 0.995 to indicate good precision; An R^2 between 0.995 and 0.990 to indicate satisfactory precision; An R^2 of less than 0.990 to indicate poor precision.

The accuracy of each laboratory is reflected in the slope of the best fit line. The slope of the ideal line is 1.0 therefore lines which deviate significantly from this may indicate a calibration problem. For the purposes of this study the authors have arbitrarily chosen the following criteria: Laboratories with slopes falling between 0.85 and 1.15 are considered unbiased. Laboratories with slopes greater than 1.15 are designated as biased high. Laboratories with slopes less than 0.85 are designated as biased low.

A problem with the analytical blank may manifest itself as a deviation of the $Y_{intercept}$ from the origin. For the purposes of this study the authors have arbitrarily chosen the following criteria: A $Y_{intercept}$ within 0.01 of the origin (10 percent of the lowest measured concentration) is considered good; A $Y_{intercept}$ within 0.10 is considered satisfactory; A $Y_{intercept}$ greater than 0.10 from the origin is considered poor.

3.4.5 RANKING OF DATA TO DETECT BIAS

A Rank Sum Test (Youden and Steiner, 1975) is used to determine if any of the participating laboratories are consistently biased (ie. does a specific laboratory overestimate or underestimate all the Standard Solutions in a systematic manner). To calculate this statistic, the data from each laboratory for each Standard Solution are ranked. The rank 1 is given to the lowest result, a rank of 2 to the next lowest and so on. The rankings are then summed for each laboratory. The presumption is that a laboratory which ranked 1 for most or all standard solutions has a pronounced systematic bias towards underestimating the concentration.

The criterion for detecting bias is suggested by Youden as 5 percent. This criterion was adopted in the present study. This means that laboratories identified as biased by the test would be expected to be biased 19 times out of 20.

This statistic is useful in determining laboratories which are consistently producing either high or low results. Youden's rank test is non-parametric and can therefore be used without having normally distributed data. This makes it useful if the data are skewed or bi-modal in distribution. Like the paired t-test, however, Youden's rank test loses sensitivity if a laboratory's data is imprecise. It is, therefore, most useful for detecting slight biases in results from labs displaying a high degree of precision.

A summary of the strengths and weaknesses of the methods used to evaluate the results is given in Table 3.2

TABLE 3.2

SUMMARY OF DATA EVALUATION METHODS

Method	Features	Weaknesses	Requires Normal Data?
Paired t-Test	-looks at pooled sample set -tests differences from expected values -detects small consistent differences in precise data missed by regression slope or rank sum bias assessments	-tends to flag minor biases in very precise data -doesn't detect large bias in imprecise data	yes
Outlier Analysis	-gives information on each individual result -recognizes differences between measured and expected values	-cannot distinguish inaccuracy from imprecision -flagging criteria depends upon entire group, therefore, if the entire group performs poorly, the flagging criteria are less strict	yes
Regression Analysis	-looks at pooled sample set -can distinguish imprecision from inaccuracy -indicates magnitude of biases -informative graphical format	-strongly affected by outliers	yes
Rank Sum Test	-detects bias -looks at pooled sample set -doesn't require normally distributed results	-may not detect bias in imprecise results or in cases where measured result line crosses the expected line -doesn't give magnitude of biases detected	no

4.0 RESULTS AND DISCUSSION

4.1 SUMMARY OF PARTICIPATING LABORATORIES

Thirty six laboratories participated in the study providing a total of 324 data for analysis. The geographical breakdown of the laboratory locations are in Table 4.1.

Table 4.1

INTERLABORATORY STUDY FOR LOW LEVEL TOTAL CYANIDE
PARTICIPATING LABORATORY LOCATIONS

LOCATION	NUMBER OF PARTICIPANTS
Southern Ontario	14
Northern Ontario	7
Quebec	4
United States	3
British Columbia	2
Manitoba	1
Northwest Territories	1

A list of the participating laboratories is in Appendix 4. It should be noted that this listing is not in order of laboratory code.

4.2 ASSESSMENT OF LABORATORY PERFORMANCE

4.2.1 OVERVIEW

The performance of each participating laboratory was assessed by considering the results of the statistical analyses. Although the various procedures used estimate the variability differently, they all tend to reflect the overall accuracy of a laboratory.

The purpose of the tests are to both determine the accuracy of each laboratory and to provide information as to why any specific laboratory had difficulty. This permits constructive comments as to potentially correctable problems such as calibration error, inappropriate blank correction, or method failure.

The laboratory performance is discussed by subject (for example: distribution, flags, regression, ranking) in the following subsections. These discussions provide an overview of the study results. In addition, laboratory specific performance information is given in section 6.0. A complete table of the raw results is in Appendix 5.

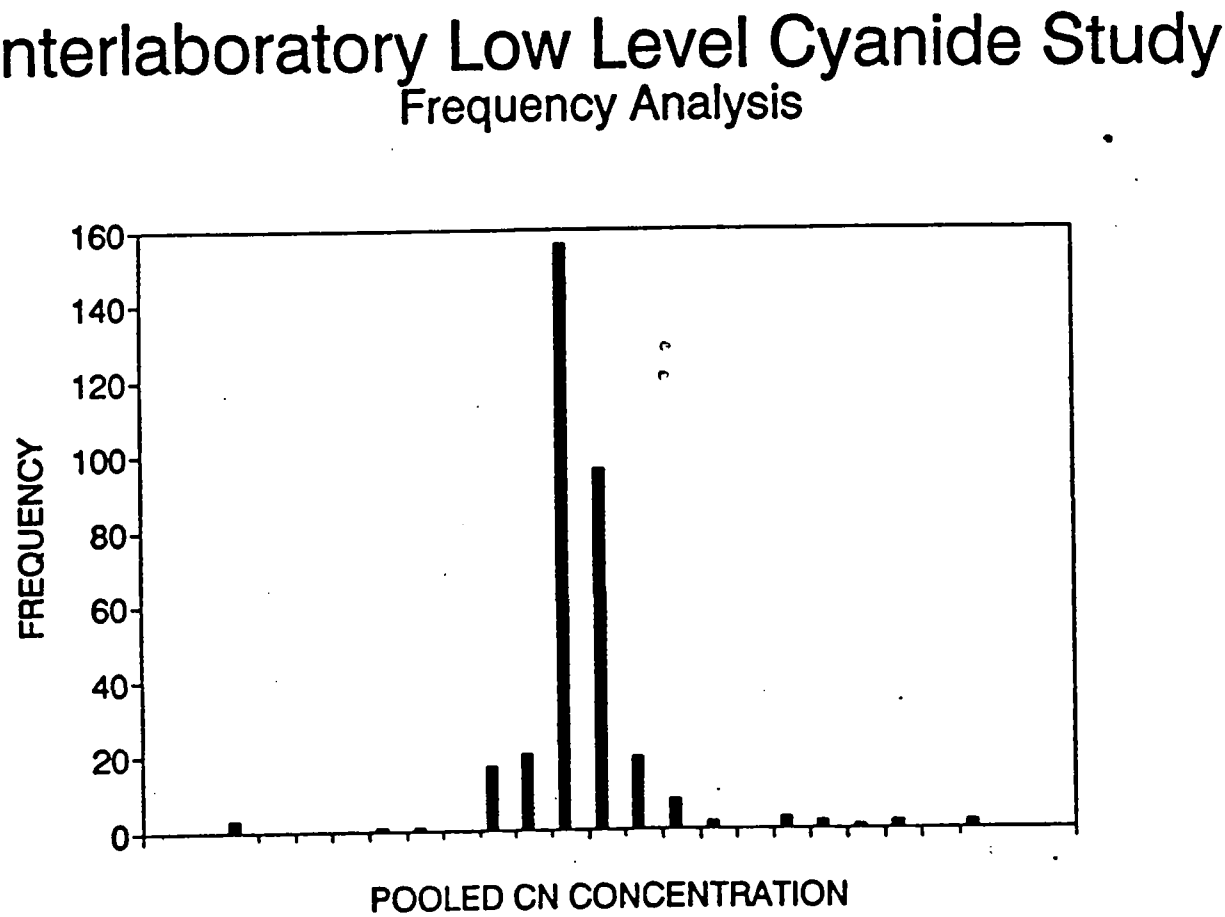
4.2.2 DATA DISTRIBUTION

The overall distribution of the data was checked by developing a frequency distribution after arithmetically adjusting each standard sample result around a single mean. The purpose of this is to determine if there are any unusual skews in the data or if the data is bi-modal. Such non-normal distributions would indicate if there was a general method failure at the high end or near zero through the overall study. In addition, normally distributed data are necessary for the use of the paired t-test and standard deviation statistics.

The frequency analysis is shown in Figure 4.1. The shape of the distribution indicates the data is normally distributed. There are small peaks at the low and high ends of the distribution but these are accounted for by five outlying results from laboratories CN001, CN005, CN007, and CN011. There is no indication of a skewed or bi-modal distribution. No general method failure is suspected and the use of normal statistics is justified.

FIGURE 4.1

DISTRIBUTION OF STUDY RESULTS



4.2.3 COMPARISON WITH EXPECTED VALUES

In this study the Expected cyanide Values are produced from the data submitted by the participating laboratories. The process is to use the full raw data set to calculate means and standard deviations (SD) for each Standard Solution. The Grubbs outliers (data more than 3 SD's from the mean) are then removed and the means and SD's are recalculated giving the valid data set. In the valid data set all data more than 1 SD from the mean are then rejected and the means again recalculated. These means are the Expected Values. The Expected values and Target Values (values calculated from weights and measures) are in Table 4.2.

Table 4.2

INTERLABORATORY STUDY FOR LOW LEVEL TOTAL CYANIDE
TARGET AND EXPECTED VALUES FOR THE STANDARD SOLUTIONS

SAMPLE NUMBER	TARGET VALUE (mg/L) as CN^-	EXPECTED VALUE (mg/L) as CN^-
L1	0.297	0.3283
L2	1.097	1.2485
L3	2.979	3.2488
L4	0.1997	0.2676
L5	0.499	0.5530
L6	0.397	0.4948
L7	0.0997	0.1111
L8	0.997	1.1094
L9	3.079	3.3314

The reported values for each standard solution from each laboratory were compared to the Expected Values using a paired t-test. This test shows which of the laboratories results varied significantly from the Expected Values. Laboratories were considered to be significantly different from the Expected Values at the ten percent level ($\alpha = 0.10$). An alpha value of 0.10 represents 5% chance of concluding that the reported lab results are significantly greater than, or significantly less than the expected when in fact they are not.

Thirty percent, or 11 of the 36, participating laboratories reported results which were

significantly different than the expected results. Table 4.3 shows the laboratories whose results differed significantly from the expected values. The percentages listed are the probabilities that the measured results are different from the expected values.

Table 4.3

INTERLABORATORY STUDY FOR LOW LEVEL TOTAL CYANIDE
LABORATORIES WITH RESULTS SIGNIFICANTLY DIFFERENT THAN THE EXPECTED VALUES (Limit $\alpha = 0.10$)

LABORATORY CODE	PROBABILITY OF BEING DIFFERENT FROM THE EXPECTED
CN001	98%
CN004a	95%
CN004b	95%
CN005	95%
CN006	95%
CN012	90%
CN015	90%
CN035a	95%
CN035b	95%
CN036a	98%
CN036b	95%

NSD: Not Significantly different from Expected Values at $\alpha = 0.10$

4.2.4 ASSIGNING FLAGS

Assigning flags was done in two stages. The first stage removed the invalid data (Grubbs outliers) falling outside three standard deviations of the mean. This resulted in the removal of nine of the 324 results or 2.8 percent of the total. Table 4.4 shows the sample results classified as Grubbs outliers.

Table 4.4

SUMMARY OF RESULTS LYING OUTSIDE 3 STANDARD DEVIATIONS OF THE MEAN (GRUBBS OUTLIERS)

LABORATORY CODE	SAMPLE NUMBERS OUTSIDE OF 3 Std. Dev. OF THE MEAN
CN001	L8
CN005	L2, L5, L9
CN007	L4, L6
CN011	L1, L2, L3, L7
CN029	L7

All of the sample numbers (ie. L1 to L9) are evenly represented in the invalid data pool therefore no particular sample seemed to cause analytical difficulty. A table of the full data set with the invalid data removed is in Appendix 6.

The second stage of flagging was to identify results falling outside 1 standard deviation. This was done by tabulating the data with the Grubbs outliers removed (see appendix 6), recalculating the means and standard deviations for each of the Standard Solutions, and flagging all data which lie outside one standard deviation of the mean. This resulted in 75 of the remaining 313 data or 23 percent of the total being identified as outliers. Table 4.5 shows the laboratories and sample numbers which are outside 1 standard deviation of the mean.

Table 4.5

SUMMARY OF RESULTS LYING OUTSIDE 1 STANDARD DEVIATION OF THE MEAN

LABORATORY CODE	SAMPLE NUMBERS FALLING OUTSIDE 1 STD. DEV. OF THE MEAN
CN001	L1-L9
CN003	L8
CN005	L1, L2, L3, L4, L5, L6, L8, L9
CN006	L2
CN007	L1, L2, L3, L4, L6, L7, L8, L9
CN009	L5, L7, L8
CN010	L7, L8
CN011	ALL
CN013	L7
CN014	L1, L2, L3, L4, L8, L9
CN015	L7
CN017	L1, L5, L8
CN018	L2
CN019	L5, L7
CN021	L1, L3, L4, L9
CN025	L3, L8
CN026	L7
CN027	L6
CN029	L1, L2, L7
CN031	L1, L2, L3, L7, L8
CN032	L1, L5, L7
CN033	L3

A total of 22 of the 36 labs earned at least one flagged result. The sample numbers (ie. L1 to L9) are evenly represented in the outlier data pool therefore no particular sample seemed to cause analytical difficulty. A table of the full data set with the outliers marked is in Appendix 7.

4.2.5 REGRESSION ANALYSIS

Linear regression analysis was done for each participating laboratory. The results submitted by the laboratory were regressed against the Expected Values. A best fit line, slope, and $Y_{intercept}$ were calculated for the submitted results. A summary of the findings are given below and the actual regression curves are included in the lab-specific summaries in Section 6.0.

This analysis is very useful in trouble-shooting analytical problems. Inferences can be made about precision, calibration problems, blank problems, and overall accuracy. In addition, the graphical representation of the data on the regression plot provides an intuitive picture of the overall laboratory performance.

The precision of each laboratory is reflected in how well the data fit on the regression line. This "quality of fit" is quantified by the regression coefficient R^2. In this study we have assumed that a regression coefficient (R^2) of greater than 0.995 indicates good precision and an R^2 between 0.995 and 0.990 indicates satisfactory precision. An R^2 of less than 0.990 indicates poor precision.

Table 4.6 shows the participating laboratories with regression coefficients in descending order of R^2.

Table 4.6

REGRESSION COEFFICIENTS OF PARTICIPATING LABORATORIES

LABORATORY CODE	REGRESSION COEFFICIENT	INFERENCE
CN008	0.9996	Good Precision
CN002	0.9994	"
CN015	0.9994	"
CN035a	0.9993	"
CN024	0.9992	"
CN036b	0.9991	"
CN036a	0.9990	"
CN035b	0.9989	"
CN026	0.9985	"
CN004a	0.9985	"
CN010	0.9984	"
CN004b	0.9982	"
CN006	0.9981	"
CN014	0.9981	"
CN028	0.9980	"
CN012	0.9979	"
CN001	0.9976	"
CN027	.09968	"
CN022	0.9959	"
CN032	0.9956	"
CN021	0.9945	Satisfactory Precision
CN003	0.9939	"
CN019	0.9914	"
CN023	0.9912	"
CN031	0.9911	"

LABORATORY CODE	REGRESSION COEFFICIENT	INFERENCE
CN025	0.9905	"
CN016	0.9905	"
CN018	0.9826	Poor Precision
CN017	0.9829	"
CN033	0.9822	"
CN009	0.9781	"
CN013	0.9702	"
CN029	0.9463	"
CN005	0.9241	"
CN011	0.1073	"
CN007	0.0037	"

Twenty seven of the 36 laboratories (75%) displayed good or satisfactory precision according to these criteria. Nine of 63 labs displayed poor precision. Of the latter group, 2 labs displyed serious method failure, as characterized by R^2 values of less than 0.2.

The accuracy of each laboratory is reflected in the slope of the best fit line. The slope of the ideal line is 1.0. Lines which deviate significantly from this may usually reflect bias caused by a calibration problem. Laboratories with slopes within 0.15 of 1 (ie between 1.15 and 0.85) are considered unbiased in this study. Laboratories with slopes above 1.15 were flagged as biased high. Laboratories with slopes less than 0.85 were flagged as biased low.

Table 4.7 lists the laboratories, regression slopes and bias assessments.

Table 4.7

REGRESSION SLOPES AND BIAS ASSESSMENTS OF PARTICIPATING LABORATORIES

LABORATORY CODE	REGRESSION SLOPE	INFERENCE
CN002	1.0000	No Bias Detected
CN022	0.9923	"
CN016	1.0080	"
CN008	0.9884	"
CN029	0.9651	"
CN009	0.9630	"
CN024	0.9563	"
CN035b	1.0440	"
CN026	1.0490	"
CN036a	1.0530	"
CN004b	1.0610	"
CN036b	1.0650	"
CN028	1.0660	"
CN035a	1.0670	"
CN018	1.0720	"
CN015	1.0780	"
CN004a	1.0796	"
CN023	1.0800	"
CN003	0.8954	"
CN033	0.8894	"
CN027	1.1110	"
CN019	0.8870	"
CN013	0.8815	"
CN017	0.8726	"

LABORATORY CODE	REGRESSION SLOPE	INFERENCE
CN012	1.1288	"
CN032	0.8626	"
CN025	0.8285	Biased Low
CN031	0.8259	Biased Low
CN010	0.8248	Biased Low
CN006	1.1890	Biased High
CN014	1.3730	Biased High
CN021	1.4760	Biased High
CN001	1.4779	Biased High
CN005	1.6870	Biased High
CN011	0.1170	Biased Low
CN007	0.0621	Biased Low

No bias was detected in 26 of 36 laboratories (72 percent of the participants) listed in Table 4.7. Bias was detected in 10 laboratories. There were an equal number of high and low biases in the flagged group. In 2 laboratories, major difficulties were noted.

Deviation of the $Y_{intercept}$ from the origin may indicate an analytical blank problem, poor precision or method failure at high concentrations. In this study, a $Y_{intercept}$ less than ± 0.01 mg/L is considered good and those within ± 0.10 mg/L are considered satisfactory. A $Y_{intercept}$ greater than 0.10 mg/L is designated as poor.

Table 4.8 lists the laboratories and regression Y intercepts sorted from the best (ie. closest to the origin) to the most deviant.

Table 4.8

REGRESSION Y INTERCEPTS OF PARTICIPATING LABORATORIES LISTED IN DESCENDING ORDER

LABORATORY CODE	REGRESSION Y-INTERCEPT	INFERENCE
CN004b	0.0013	Good
CN036b	0.0031	"
CN004a	0.0032	"
CN035a	0.0055	"
CN002	-0.0081	"
CN033	0.0093	"
CN008	-0.0097	"
CN035b	0.0113	Satisfactory
CN016	-0.0117	"
CN032	0.0129	"
CN015	-0.0147	"
CN031	0.0154	"
CN036a	0.0155	"
CN006	-0.0185	"
CN010	0.0189	"
CN029	0.0207	"
CN028	-0.0304	"
CN009	0.0324	"
CN012	-0.0367	"
CN024	-0.0402	"
CN022	-0.0424	"
CN026	-0.0431	"
CN023	-.0503	"

LABORATORY CODE	REGRESSION Y-INTERCEPT	INFERENCE
CN001	0.0536	"
CN019	0.0551	"
CN025	0.0585	"
CN027	-0.0688	"
CN017	0.0696	"
CN003	0.0750	"
CN013	0.0760	"
CN018	-0.1165	Poor
CN011	0.1471	"
CN014	-0.1596	"
CN005	0.1837	"
CN021	-0.2644	"
CN007	1.1780	"

Thirty or the 36 participants (83%) displayed good or satisfactory intercept values. Six labs fell into the poor category. To establish the source of the problems in these cases, an examination of the regression curves is recommended to determine whether the errant Y-intercept values are the result of imprecision, method failure at high concentrations or inappropriate blank correction.

4.2.6 RANKING FOR BIAS

The Rank Sum Test (Youden et al, 1975) was used to determine if any of the participating laboratories were consistently biased (ie. did a specific laboratory overestimate or underestimate all the standard solutions in a systematic manner). This test complements the regression slope analysis but does not require a normal distribution of results in order to be valid. In this test, the data from each laboratory for each standard solution are ranked. The rank 1 is given to the lowest result, a rank of 2 to the next lowest and so on. The rankings are then summed for each laboratory giving the Rank Sum statistic. Laboratories with unusually low or high rank sums are designated as biased low or biased high, respectively.

The results of the Rank Sum test are shown in ascending order in Table 4.9 with the Laboratory code, the Rank Sum, and inference.

Table 4.9

RANK SUM TEST RESULTS FOR PARTICIPATING LABORATORIES

LABORATORY CODE	RANK SUM	INFERENCE
CN011	41	Biased Low
CN010	69	"
CN033	80	No Bias Detected
CN024	86	"
CN032	88	"
CN031	103	"
CN025	110	"
CN018	111	"
CN017	112	"
CN019	115	"
CN022	121	"
CN008	134	"
CN009	139	"
CN016	139	"

LABORATORY CODE	RANK SUM	INFERENCE
CN026	141	"
CN023	148	"
CN002	149	"
CN013	170	"
CN007	171	"
CN003	171	"
CN021	174	"
CN027	185	"
CN029	192	"
CN028	196	"
CN035b	199	"
CN004b	210	"
CN014	215	"
CN036a	215	"
CN015	216	"
CN036b	219	"
CN035a	223	"
CN012	238	"
CN004a	238	"
CN006	252	"
CN005	310	Biased High
CN001	314	"

No bias was detected by the rank sum test in 32 (89 percent of the total) of the participating laboratories. Laboratories CN011 and CN010 were assessed as biased low, meaning they consistently underestimated the concentration of the standard solutions and would do so more that 95 times out of 100. Laboratories CN005 and CN001 were assessed as biased high, meaning that they consistently overestimated the concentration of the standard solutions and would do so more than 95 times out of 100.

4.3 PERFORMANCE vs METHOD OF ANALYSIS

The participating laboratories were requested to submit the method of cyanide analysis used in their laboratories. The two general methods used were 1) manual determination, and 2) autoanalyzer. For each of these general methods one of four specific methods was used. These are:

- Colourimetric determination using isonicotinic/barbituric acid
- Colourimetric determination using pyridine/barbituric acid
- Colourimetric determination of tetracyano-nickelate complex
- Ion specific electrode

Table 4.10 summarizes the methods used by each of the participating laboratories.

Table 4.10

ANALYTICAL METHODS USED BY PARTICIPATING LABORATORIES

LABORATORY CODE	MANUAL OR AUTOANALYZER	DETAILS OF METHOD
CN001	Autoanalyzer	None given
CN002	Manual	Pyr/barb
CN003	Autoanalyzer	Isonic/barb
CN004a	Autoanalyzer	Pyr/barb
CN004b	Autoanalyzer	Pyr/barb
CN005	Autoanalyzer	Pyr/barb
CN006	Autoanalyzer	None given
CN007	Autoanalyzer	None given
CN008	Autoanalyzer	None given
CN009	Autoanalyzer	None given
CN010	Manual	Isonic/barb
CN011	Manual	Pyr/barb
CN012	Manual	Isonic/barb
CN013	Manual	Isonic/barb
CN014	Manual	Isonic/barb

LABORATORY CODE	MANUAL OR AUTOANALYZER	DETAILS OF METHOD
CN015	Manual	Ion spec. elect.
CN016	Manual	Pyr/barb
CN017	Autoanalyzer	Pyr/barb
CN018	Autoanalyzer	None given
CN019	Autoanalyzer	None given
CN021	Manual	None given
CN022	Manual	None given
CN023	Manual	Ion spec. elect.
CN024	Manual	Pyr/barb
CN025	Manual	Isonic/barb
CN026	Manual	Isonic/barb
CN027	Manual	Tetra-nickel
CN028	Manual	Isonic/barb
CN029	Manual	Pyr/barb
CN031	Manual	Ion spec. elect.
CN032	Manual	Tetra-Nickel
CN033	Manual	Pyr/barb
CN035a	Autoanalyzer	Pyr/barb
CN035b	Autoanalyzer	Pyr/barb
CN036a	Autoanalyzer	Pyr/barb
CN036b	Autoanalyzer	Pyr/barb

Isonic/barb: Colourimetric determination using isonicotinic/barbituric acid
Pyr/barb: Colourimetric determination using pyridine/barbituric acid
Tetra-nickel: Colourimetric determination of tetracyano-nickelate complex
Ion spec elect: Ion specific electrode

Paired t-tests were performed to compare the following methods:

Autoanalyzer	vs	Manual Methods
Ion Specific Electrode	vs	Other Methods
Tetracyano-nickelate	vs	Other Methods
Isonicotinic/barbituric acid	vs	Pyridine/barbituric acid

The tests showed no significant difference between any of the pairs indicating that there was no detectable difference in the performance of the various methods used in the study..

4.4 PERFORMANCE vs PRESENCE OF THIOCYANATE

Sample L5 contained 1 mg/L thiocyanate (SCN) combined with a 0.5 mg/L CN^- (as ferricyanide) in pure water. This was done to determine if any of the laboratories suffered from a positive interference as the result of the presence of thiocyanate.

If the thiocyanate had been read as cyanide, it would have resulted in a measured value of greater than the expected value of 0.553 mg/L. The data indicate that 4 of the participating laboratories (CN001, CN009, CN017 and CN019) exhibited behaviour consistent with a positive thiocyanate interference. This was judged by comparing the results for sample L5 against the 95% confidence interval for that sample calculated from the raw results with all outliers removed (see Appendix 7). These laboratories all reported using autoanalyzer methods.

4.5 PERFORMANCE WITH EFFLUENTS vs WATER MATRIX

The standard samples analyzed by the participating laboratories were provided in both effluent and pure water matrices. The water matrix samples (L1, L3, L5, L7, L8) were a matrix of Milli-Q water at pH 12. The effluent matrix samples (L2, L4, L6, L9) were a matrix of final gold mine effluent from the outfall of the tailings system adjusted to pH 12.

The means and standard deviations of the raw data set and of the data set with the laboratories having Grubbs outliers (CN001, CN005, CN007, CN011, CN029) removed were calculated to determine if there was a trend towards more variability in effluent samples. These calculations are summarized in the Table 4.11 below.

Table 4.11

WATER vs EFFLUENT MATRIX EFFECTS

		RAW DATA			GRUBBS REMOVED		
SAMPLE NUMBER	MATRIX	MEAN	SD	COEFF. VAR.	MEAN	SD	COEFF. VAR.
L1	Water	0.34	0.07	21	0.32	0.03	11
L2	Effluent	1.22	0.36	29	1.24	0.15	12
L3	Water	3.22	0.80	25	3.28	0.45	14
L4	Effluent	0.38	0.67	174	0.26	0.05	18
L5	Water	0.59	0.19	31	0.57	0.10	17
L6	Effluent	0.52	0.19	36	0.49	0.07	14
L7	Water	0.11	0.03	24	0.11	0.01	13
L8	Water	1.12	0.18	16	1.08	0.11	10
L9	Effluent	3.41	0.90	27	3.40	0.45	13.2

SD: Standard deviation.
COEFF VAR: Coefficient of variation; equals (100 x standard deviation)/mean
GRUBBS REMOVED: The data set with laboratories having Grubbs outliers (ie. data outside of 3 SD's of the mean) removed.

The coefficient of variation of the raw data without Grubbs outlying labs removed shows a substantial difference between effluent and water matrices. The coefficient of variation for effluent matrices was 66% while that for water was 24%. Once the Grubbs outlying laboratories were removed from the data set, however, the difference between the matrices disappeared. The coefficient of variation for effluent matrices became 14 while that for water became 13. The effect of removing the most imprecise laboratories from the data set indicates that there is no general matrix effect on low level cyanide analysis in this study. As is evident from an examination of the laboratory specific summaries given in Section 6.0, some labs did appear to have trouble determining cyanide accurately in the effluent matrix. This effect will be explored in more detail in the following phase of this study.

5.0 SUMMARY AND CONCLUSIONS

The key findings of this study are:

- 2.8% of results fell outside 3 standard deviations of the mean expected value and were flagged as Grubbs outliers. These results were contributed by 5 laboratories.
- 23% of results fell outside 1 standard deviation of the mean expected value. 61% of labs had at least 1 result flagged in this manner.
- 30% of labs submitted results which were identified as significantly different from the expected by the t-test.
- 75% of labs displayed good or satisfactory precision as judged by the regression correlation coefficient. 25% displayed poor precision.
- 72% of labs displayed no bias in the regression slope test. 85% displayed no bias in the Youden Rank Sum test.
- 14% of labs were judged to be biased high and 14% biased low by the regression slope test. 6% were biased high and 6% biased low by the Rank Sum test.
- 83% of labs displayed regression Y-intercepts which were judged to be good or satisfactory. 17% were judged to be poor, indicating problems with precision, method failure at high concentrations or inappropriate blank correction.
- 2 of 36 participating labs displayed serious method failure with these samples.
- There was no evidence of a difference between methods with respect to accuracy or precision.
- 4 of the 36 laboratories showed a possible positive interference from thiocyanate in sample L5. These laboratories all reported using autoanalyzer methods.
- There was no evidence of a general matrix effect although some labs did appear to have difficulty with the effluent matrix.
  the big message is calibration. High end failure shown by a slope problem

In summary, 25% of the participants in this study displayed poor precision as judged by the regression correlation coefficient test. Between 12% and 28% of the participants were judged to be biased, or inaccurate, by the Youden Rank Sum test and regression slope test, respectively. In view of the fact that the Rank Sum test does not detect bias in labs displaying imprecision, the 28% assessment is expected to more closely reflect the actual situation.

Precision generally depends on several factors including the method itself, general

laboratory practice and the skill of the analyst. As a results, it is sometimes difficult to improve the overall level of precision of any given method.

Problems in accuracy are usually the result of inaccurate standards and are often correctable by simply purchasing or preparing better standards. It is therefore expected that the majority of laboratories assessed as biased in this study should be able to cure the problem relatively easily. Laboratories with serious precision problems will have considerably more work to do to rectify the situation.

6.0 LABORATORY SPECIFIC REPORTS

The following pages are reports for each of the participating laboratories giving a summary of their results and statistical analysis, the inferences which can be made form these analyses, and recommendations for corrective action. These reports provide each laboratory with the essential results pertaining to their specific situation on one page.

REPORT FOR LABORATORY CN001

RESULTS:

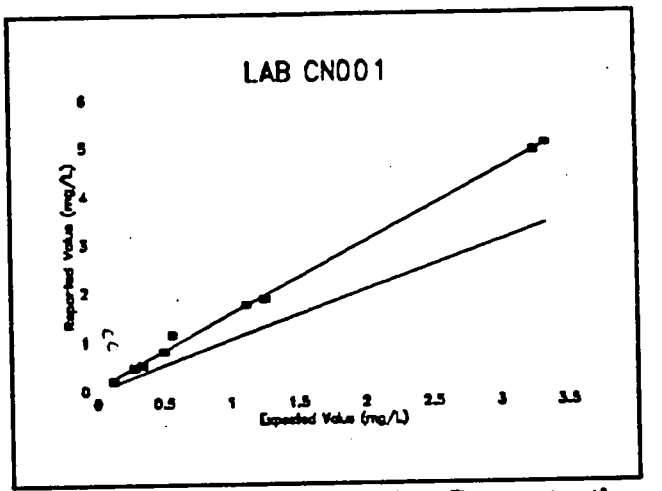
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN001 Value (mg/L)	0.49	1.82	4.84	0.43	1.10	0.77	0.16	1.70	5.00

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 98 percent (ie. 98 times out of 100 your laboratory would not produce the expected results).

The flagging procedure indicated that sample L8 was outside 3 standard deviations of the mean expected value. All samples were outside 1 standard deviation of the mean expected values.

The regression coefficient (R^2=0.9976) indicated good precision and a satisfactory Y-intercept (Y_{int}=0.0536). The slope of the regression line (m=1.4779, see figure) indicates a high bias. The rank sum test also indicates a high bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method may have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis but appears to be biased high probably as a result of a calibration problem. This is indicated by the good regression coefficient combined with the major difference in regression slopes between your results and the expected values.

REPORT FOR LABORATORY CN002

RESULTS:

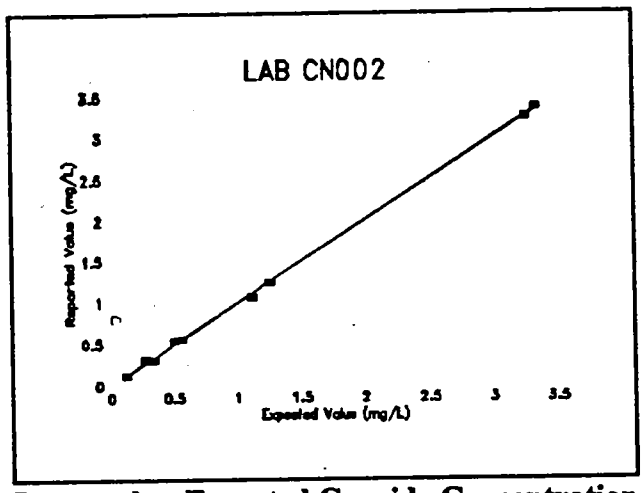
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN002 Value (mg/L)	0.29	1.23	3.23	0.30	0.55	0.52	0.10	1.05	3.35

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9994) and a good Y-intercept (Y_{int}=-0.0081). The slope of the regression line (m=1.000) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has both good precision and good accuracy in low level cyanide analysis.

REPORT FOR LABORATORY CN003

RESULTS:

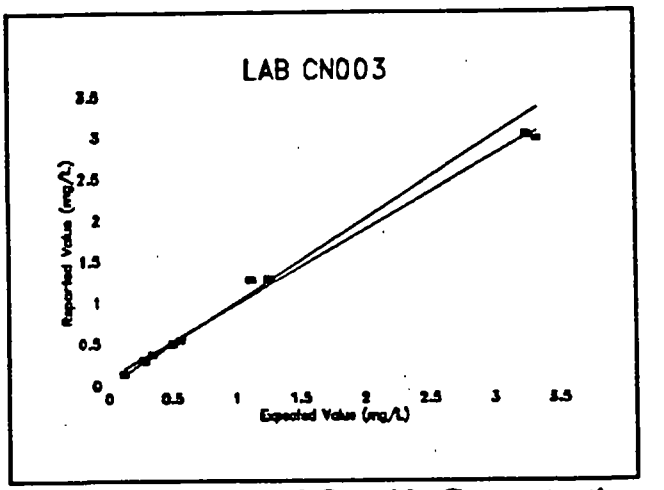
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN003 Value (mg/L)	0.35	1.27	3.01	0.28	0.52	0.48	0.12	1.26	2.96

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L8 was outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9939) and a satisfactory Y-intercept (Y_{int}=0.0750). No bias was detected by either the slope of the regression line (m=0.8954) or the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has satisfactory precision in low level cyanide analysis. Sample L8 is the only result classified as an outlier. Although the slope of the regression line does not detect any bias, it does indicate that your laboratory may have a problem underestimating cyanide concentrations above 3 mg/L. In this study, the underestimation of the high concentrations causes the y intercept to be greater than zero.

REPORT FOR LABORATORY CN004A

RESULTS:

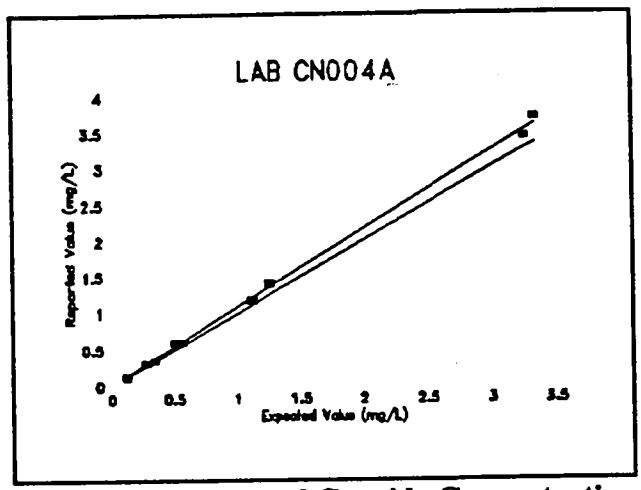
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN004A Value (mg/L)	0.34	1.40	3.42	0.30	0.59	0.58	0.11	1.16	3.68

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9985) and a good Y-intercept (Y_{int}=0.0032). The slope of the regression line (m=1.0796) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a slight high bias exists in your results. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN004B

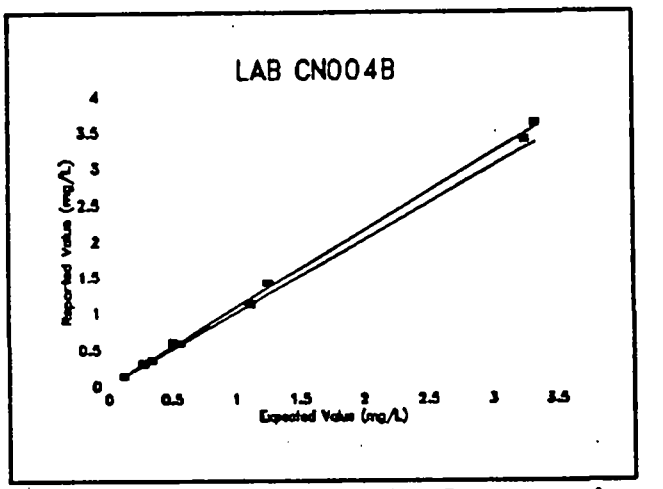
RESULTS:

Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN004B Value (mg/L)	0.34	1.40	3.37	0.29	0.56	0.57	0.12	1.11	3.61

STATISTICAL SUMMARY:

Your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).

No samples were outside 3 standard deviations of the mean expected values. No samples were outside 1 standard deviation of the mean expected values.



Reported vs Expected Cyanide Concentration

Regression analysis (see figure) showed a good linear regression coefficient (R^2=0.9982), good $Y_{intercept}$ (Y_{int}=0.0013), and a good slope of the regression line (m=1.0610).

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis but may have a minor calibration problem. This is evident by the difference in regression slopes between yourself and the expected values.

REPORT FOR LABORATORY CN005

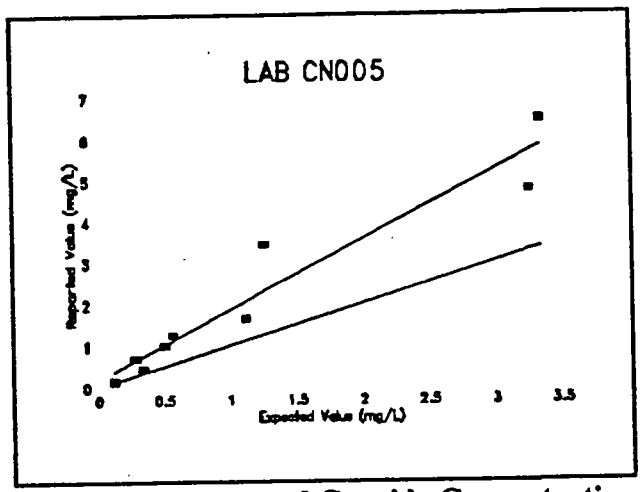
RESULTS:

Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN005 Value (mg/L)	0.43	3.43	4.74	0.67	1.25	0.99	0.13	1.63	6.44

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).

The flagging procedure indicated that samples L2, L5 and L8 were outside 3 standard deviations of the mean expected value. All samples except L7 were outside 1 standard deviation of the mean expected values.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The regression coefficient (R^2=0.9241) indicated poor precision and a poor Y-intercept (Y_{int}=0.1837). The slope of the regression line (m=1.687, see figure) indicates a high bias. The rank sum test also indicates a high bias.

The analytical method used worked equally well with samples in water and effluent matrices. The method does not appear to have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has poor precision in low level cyanide analysis and appears to be biased high. This is indicated by the low regression coefficient combined with the major difference in regression slopes between your results and the expected values.

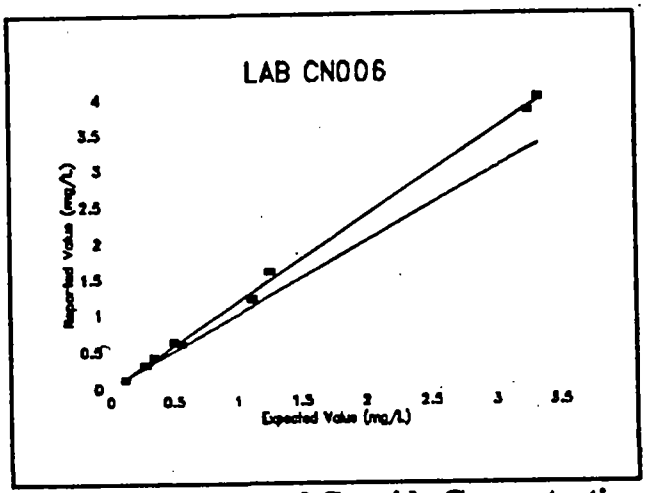
REPORT FOR LABORATORY CN006

RESULTS:

Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN006 Value (mg/L)	0.40	1.58	3.80	0.30	0.58	0.61	0.10	1.20	3.98

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L2 was outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9981) and a satisfactory Y-intercept (Y_{int}=-0.0185). The slope of the regression line (m=1.1890) indicated a high bias. No bias was detected by the rank sum test.

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. A high bias was detected by the regression slope. This is confirmed by a visual examination of the figure. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN007

RESULTS:

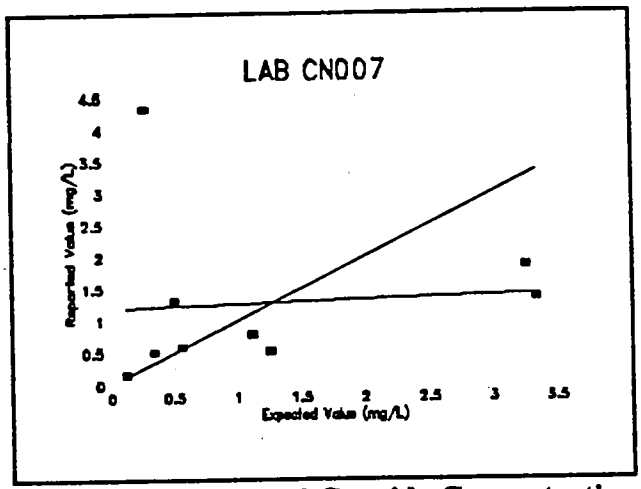
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN007 Value (mg/L)	0.50	0.51	1.83	4.31	0.58	1.30	0.14	0.77	1.33

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure indicated that samples L4 and L6 were outside 3 standard deviations of the mean expected value. All samples except L5 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated poor precision and very little relationship between the measured results and the expected values (R^2=0.0037). A poor Y-intercept (Y_{int}=1.1780) is also indicated. The slope of the regression line (m=0.0621) indicated a low bias. No bias was detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method did not appear to have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has a serious problem with the analysis of low level cyanide. The regression results and the attached figure indicate a high degree of imprecision. The failure of the paired t-test to establish a significant difference between your results and the expected values may be attributed to the recognized weakness of this test in recognizing differences in data sets with large standard deviations. This should not be taken to indicate that the reported results are correct. The regression slope suggests a low bias in your results. It is more likely, however, that the observed slope is the result of imprecision rather than a consistent low bias.

REPORT FOR LABORATORY CN008

RESULTS:

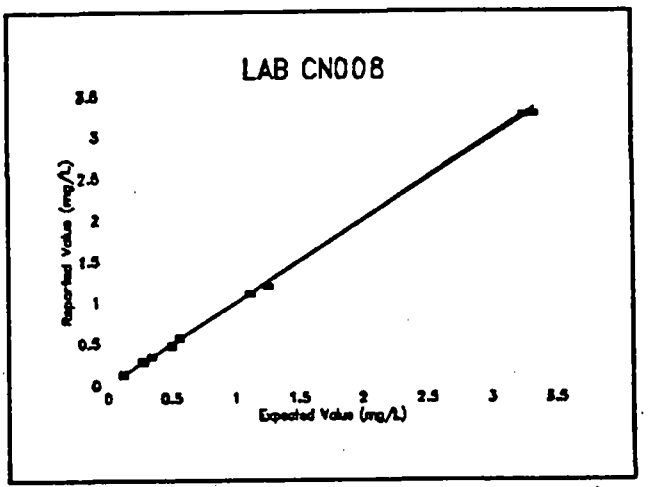
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN008 Value (mg/L)	0.33	1.18	3.24	0.27	0.55	0.45	0.11	1.09	3.26

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9996) and a good Y-intercept (Y_{int}=-0.0097). The slope of the regression line (m=0.9984) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has both good precision and good accuracy in low level cyanide analysis.

REPORT FOR LABORATORY CN009

RESULTS:

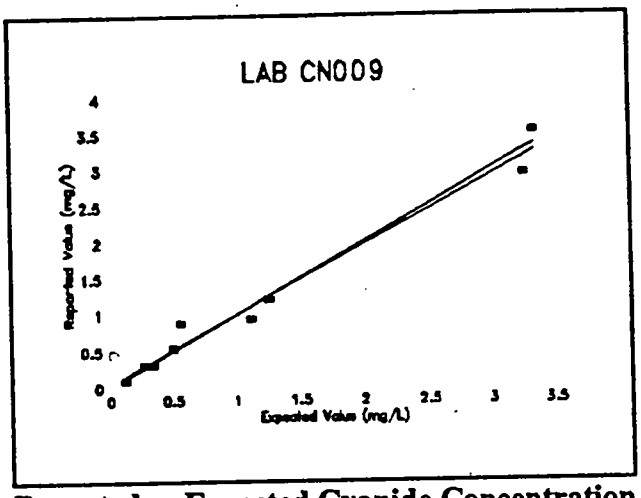
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN009 Value (mg/L)	0.29	1.19	2.92	0.29	0.86	0.52	0.09	0.92	3.51

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L5, L7 and L8 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated poor precision (R^2=0.9781) and a satisfactory Y-intercept (Y_{int}=0.0324). The slope of the regression line (m=0.9630) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method may have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has no detectable biases but exhibited poor precision in this study. This is indicated by the low regression coefficient and the three values falling outside the 1 standard deviation limit. This is confirmed by a visual inspection of the above figure.

REPORT FOR LABORATORY CN010

RESULTS:

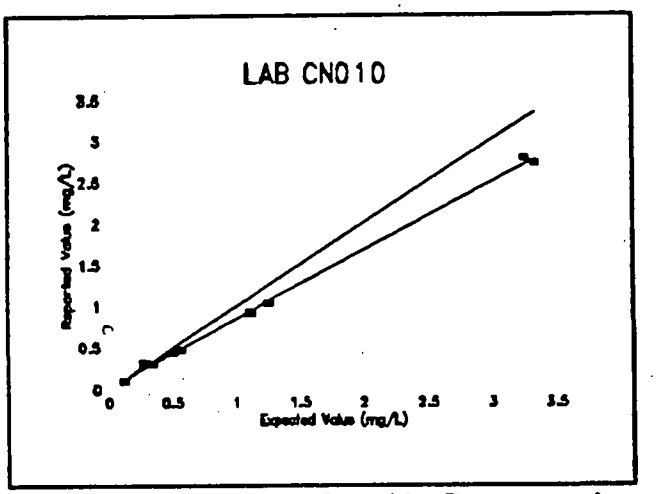
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN010 Value (mg/L)	0.29	1.03	2.77	0.30	0.46	0.43	0.09	0.91	2.71

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L7 and L8 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9984) and a satisfactory Y-intercept (Y_{int}=0.0189). The slope of the regression line (m=0.8248) indicates a low bias. A low bias was also detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. A low bias was, however, detected by both the regression slope and the rank sum test. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN011

RESULTS:

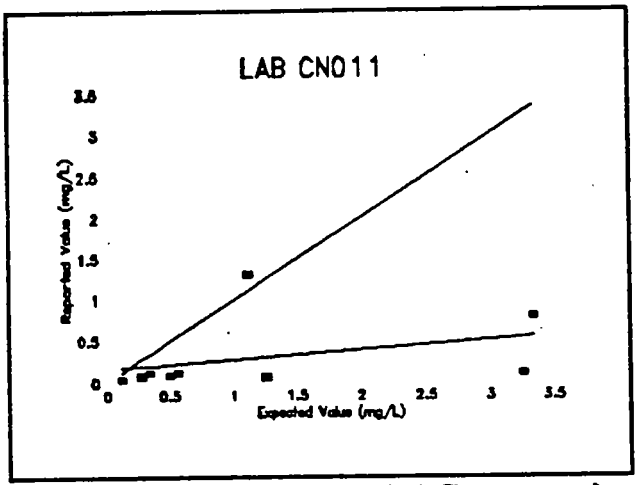
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN011 Value (mg/L)	0.10	0.05	0.09	0.06	0.10	0.08	0.02	1.30	0.77

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure indicated that samples L1, L2, L3 and L7 were outside 3 standard deviations of the mean expected value. All samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicates poor precision and very little relationship between the measured results and the expected values (R^2=0.1073). A poor Y-intercept (Y_{int}=0.1471) is also indicated. The slope of the regression line (m=0.1170) indicated severe low bias. Low bias was also detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method did not appear to have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has a serious problem with the analysis of low level cyanide. The regression slope and rank sum tests, as well as a visual inspection of the above figure, suggest a low bias in your results. This may be the results of a calibration standard problem, however, the high degree of imprecision evident in the results confounds diagnosis of the problem. The failure of the paired t-test to establish a significant difference between your results and the expected values may be attributed to the recognized weakness of this test in recognizing differences in data sets with large standard deviations. This should not be taken to indicate that the reported results are correct.

REPORT FOR LABORATORY CN012

RESULTS:

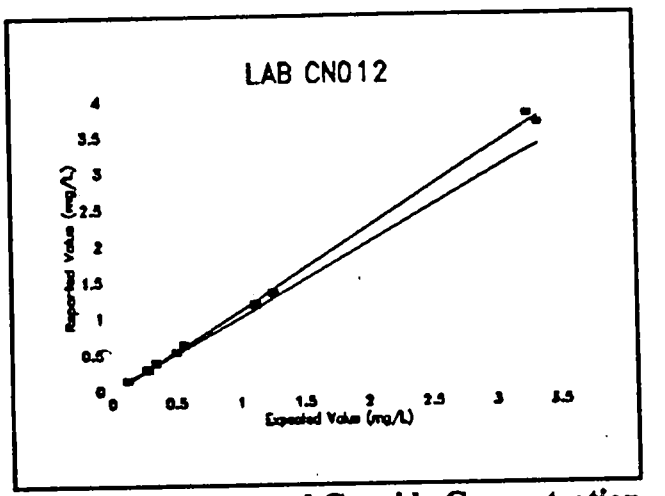
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN012 Value (mg/L)	0.36	1.32	3.76	0.27	0.61	0.51	0.12	1.16	3.63

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 90 percent (ie. 90 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9979) and a satisfactory Y-intercept (Y_{int}=-0.0367). The slope of the regression line (m=1.1288) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a slight high bias exists in your results. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN013

RESULTS:

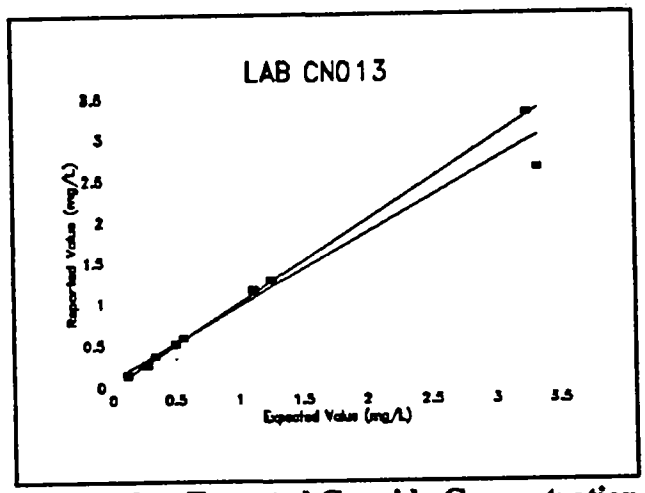
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN013 Value (mg/L)	0.35	1.26	3.29	0.25	0.57	0.50	0.13	1.14	2.62

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L7 was outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated poor precision (R^2=0.9702) and a satisfactory Y-intercept (Y_{int}=0.0760). No bias was detected by either the slope of the regression line (m=0.8815) or the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

Statistical analysis of your data indicates that your laboratory may have a precision problem in low level cyanide analysis. This imprecision is evident from the low regression correlation coefficient and the deviation in the regression slope from the expected. The results do not indicate any systematic bias in your results.

REPORT FOR LABORATORY CN014

RESULTS:

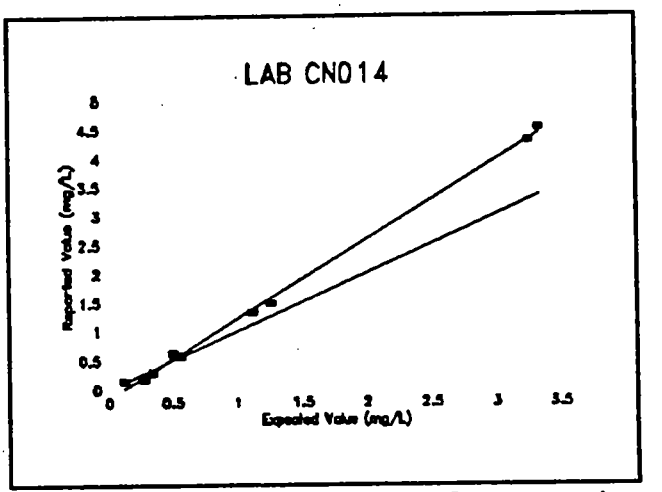
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN014 Value (mg/L)	0.27	1.46	4.27	0.15	0.57	0.60	0.12	1.31	4.49

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value, however, samples L1, L2, L3, L4, L8 and L9 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9981) but a poor Y-intercept (Y_{int}=−0.1596). The slope of the regression line (m=1.3730) indicated a high bias. No bias was detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. A high bias was detected by the regression slope. This is confirmed by a visual examination of the figure. This is most likely the result of a calibration standard problem. The crossing of the regression line over the expected line and the resulting large negative Y-intercept evident in the above figure may indicate an inappropriate blank correction.

REPORT FOR LABORATORY CN015

RESULTS:

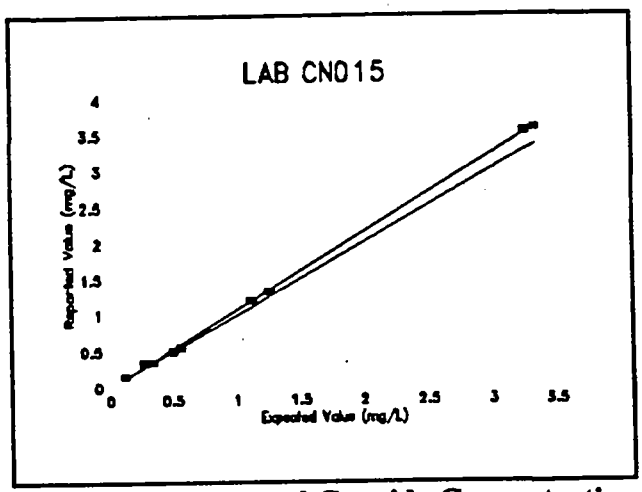
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN015 Value (mg/L)	0.33	1.31	3.52	0.33	0.54	0.49	0.14	1.19	3.56

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 90 percent (ie. 90 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L7 was outside 1 standard deviation of the mean expected value.

Regression analysis (see figure) indicated good precision (R^2=0.9994) and a satisfactory Y-intercept (Y_{int}=-0.0147). The slope of the regression line (m=1.0780) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a slight high bias exists in your results. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN016

RESULTS:

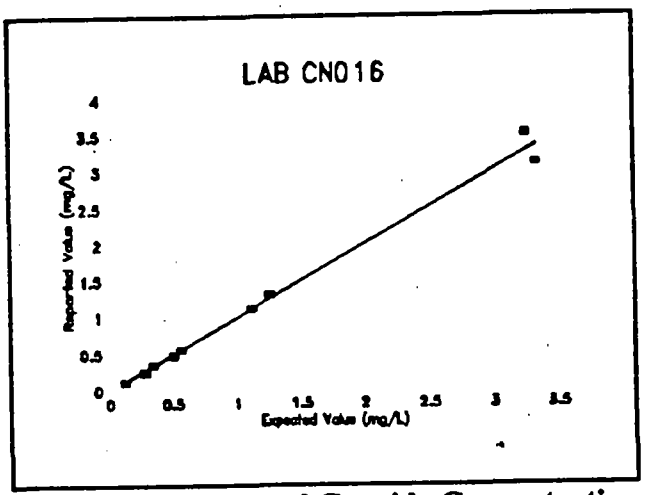
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN016 Value (mg/L)	0.33	1.30	3.50	0.23	0.54	0.47	0.10	1.10	3.10

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9905) and a satisfactory Y-intercept (Y_{int}=-0.0117). The slope of the regression line (m=1.0080) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good accuracy in low level cyanide analysis. The results also indicate that your laboratory may have a problem with precision in samples containing the higher levels of cyanide, such as in samples L3 and L9 in this study. This can be seen in the above figure and is reflected in the correlation coefficient and Y-intercept.

REPORT FOR LABORATORY CN017

RESULTS:

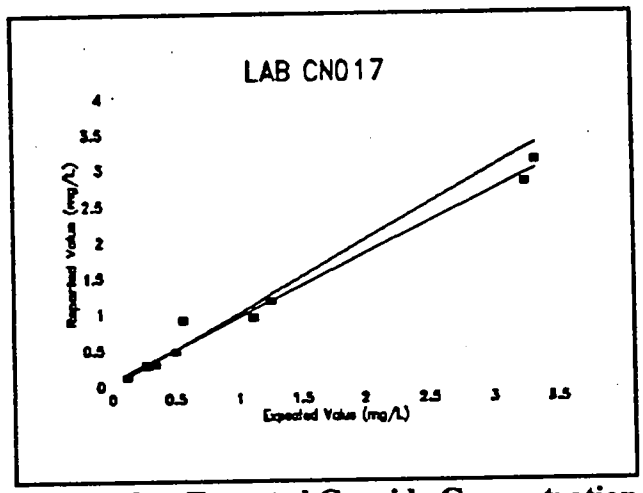
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN017 Value (mg/L)	0.28	1.15	2.79	0.27	0.89	0.46	0.10	0.93	3.09

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L1, L5 and L8 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated poor precision (R^2=0.9829) and a satisfactory Y-intercept (Y_{int}=0.0696). No bias was detected by either the slope of the regression line (m=0.8726) or the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method may have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory may have a precision problem in low level cyanide analysis. This is indicated by the three samples falling outside 1 standard deviation, the low correlation coefficient and a visual inspection of the above graph. Although no biases were detected by either the regression slope of the rank sum tests, the slope of the regression line indicates a tendency to underestimate cyanide concentrations.

REPORT FOR LABORATORY CN018

RESULTS:

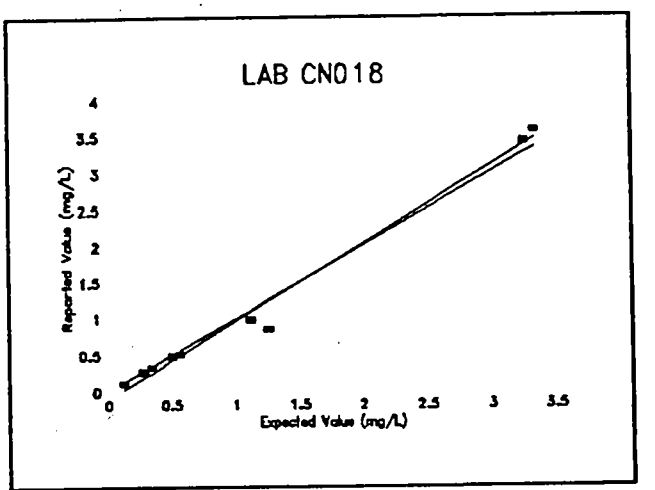
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN018 Value (mg/L)	0.32	0.84	3.41	0.26	0.50	0.47	0.10	0.97	3.56

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L2 was outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated poor precision (R^2=0.9862) and a poor Y-intercept (Y_{int}=-0.1165). No bias was detected by either the slope of the regression line (m=1.0720) or the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that the accuracy of your laboratory is good but there may be a precision problem in the analysis. This is indicated by the sample result falling outside 1 standard deviation and by the low regression correlation coefficient.

REPORT FOR LABORATORY CN019

RESULTS:

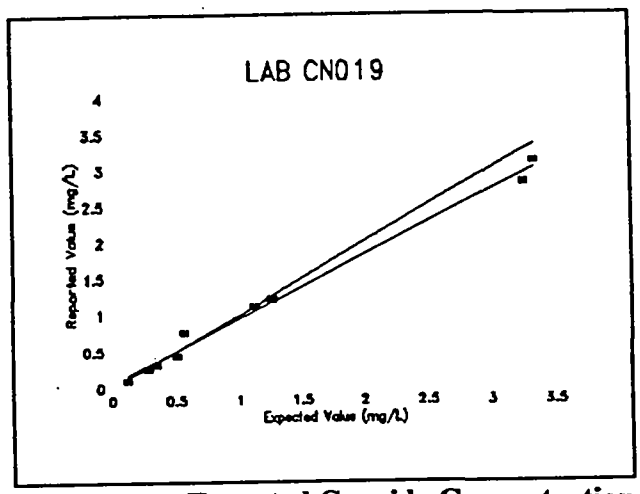
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN019 Value (mg/L)	0.29	1.20	2.80	0.24	0.74	0.42	0.09	1.10	3.10

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L5 and L7 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9914) and a satisfactory Y-intercept (Y_{int}=0.0551). No bias was detected by either the slope of the regression line (m=0.8870) or the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method may have been influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has satisfactory precision in low level cyanide analysis as indicated by the regression coefficient. The precision indicators would likely have been better but for a possible overestimation of sample L5; the sample spiked with both cyanide and thiocyanate. The L5 result was flagged as a outlier and may indicate a positive interference from thiocyanate. The slope of the regression line and a visual inspection of the figure may indicate a tendency to underestimate cyanide concentrations.

REPORT FOR LABORATORY CN021

RESULTS:

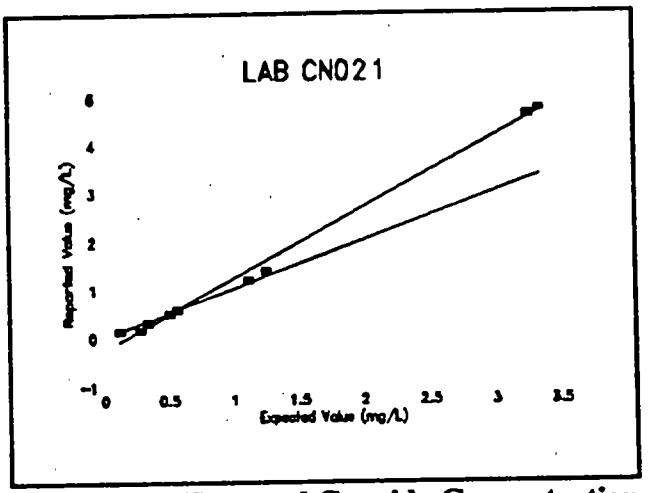
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN021 Value (mg/L)	0.28	1.35	4.60	0.13	0.56	0.48	0.11	1.17	4.72

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value, however, samples L1, L3, L4 and L9 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9945) but a poor Y-intercept (Y_{int}=-0.2644). The slope of the regression line (m=1.4760) indicated a high bias. No bias was detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. A high bias was detected by the regression slope. This is confirmed by a visual examination of the figure and is most likely the result of a calibration standard problem. The crossing of the regression line over the expected line and the resulting large negative Y-intercept evident in the above figure may indicate an inappropriate blank correction.

REPORT FOR LABORATORY CN022

RESULTS:

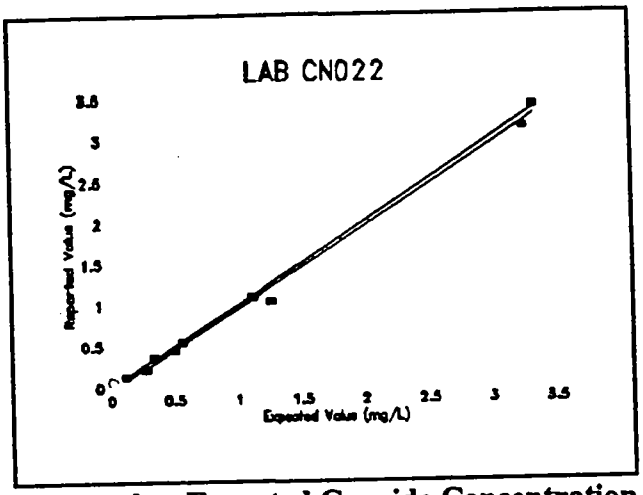
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN022 Value (mg/L)	0.34	1.03	3.12	0.20	0.53	0.44	0.11	1.08	3.37

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9959) and a satisfactory Y-intercept (Y_{int}=-0.0424). The slope of the regression line (m=0.9923) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good accuracy and good precision in low level cyanide analysis.

REPORT FOR LABORATORY CN023

RESULTS:

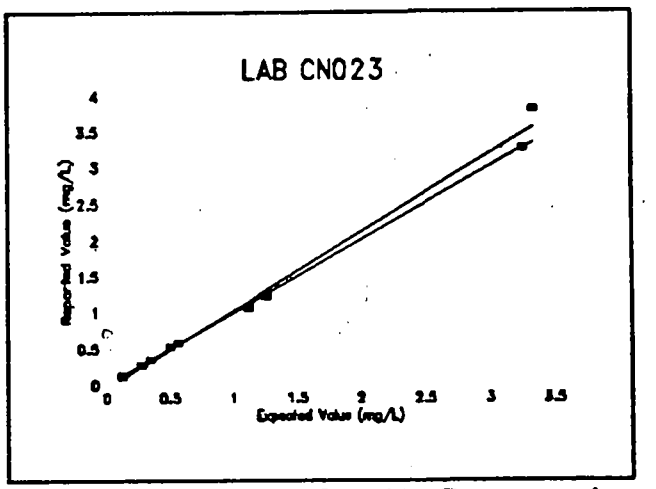
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN023 Value (mg/L)	0.34	1.21	3.25	0.26	0.56	0.51	0.11	1.05	3.80

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9912) and a satisfactory Y-intercept (Y_{int}=-0.0503). The slope of the regression line (m=1.0800) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory displays good accuracy and satisfactory precision in low level cyanide analysis.

REPORT FOR LABORATORY CN024

RESULTS:

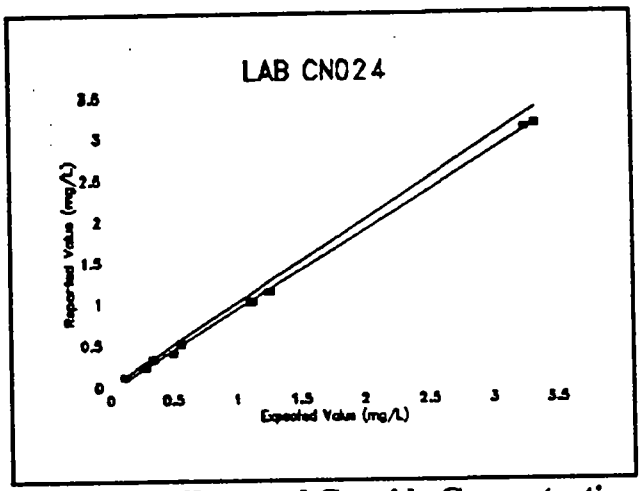
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN024 Value (mg/L)	0.32	1.11	3.10	0.21	0.50	0.38	0.10	1.00	3.14

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9992) and a satisfactory Y-intercept (Y_{int}=-0.0402). The slope of the regression line (m=0.9563) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good accuracy and good precision in low level cyanide analysis. Although no bias was detected by either the regression slope or the rank sum test, a visual inspection of the above graph may indicate a slight tendency to underestimate cyanide concentrations.

REPORT FOR LABORATORY CN025

RESULTS:

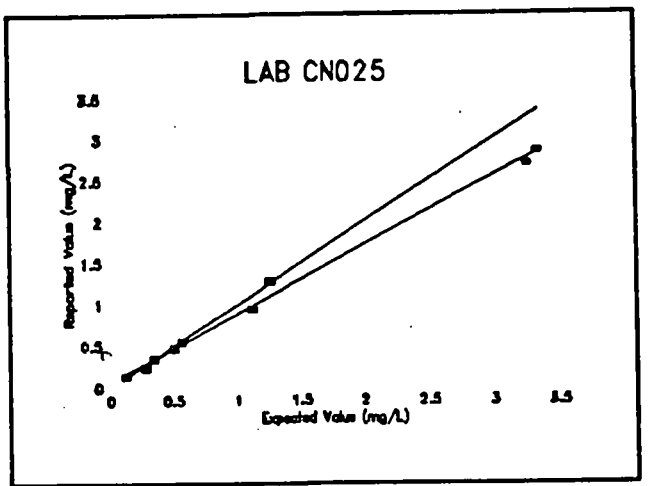
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN025 Value (mg/L)	0.33	1.27	2.68	0.23	0.53	0.46	0.12	0.93	2.84

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L3 and L8 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9905) and a satisfactory Y-intercept (Y_{int}=0.0585). The slope of the regression line (m=0.8285) indicates a low bias. No bias was detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has satisfactory precision in low level cyanide analysis as indicated by the regression coefficient. A low bias was detected by the regression slope. This may be the result of a calibration standard problem or may reflect an underestimation of the higher cyanide concentrations.

REPORT FOR LABORATORY CN026

RESULTS:

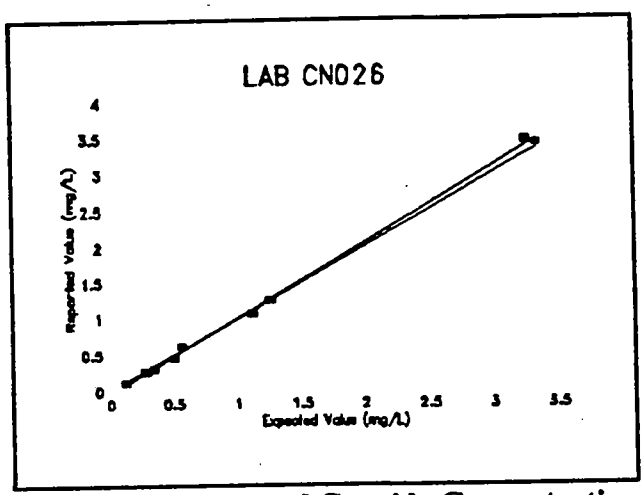
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN026 Value (mg/L)	0.29	1.24	3.44	0.26	0.61	0.45	0.09	1.06	3.40

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L7 was outside 1 standard deviation of the mean expected value.

Regression analysis (see figure) indicated good precision (R^2=0.9985) and a satisfactory Y-intercept (Y_{int}=-0.0431). The slope of the regression line (m=1.0490) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has both good precision and good accuracy in low level cyanide analysis.

REPORT FOR LABORATORY CN027

RESULTS:

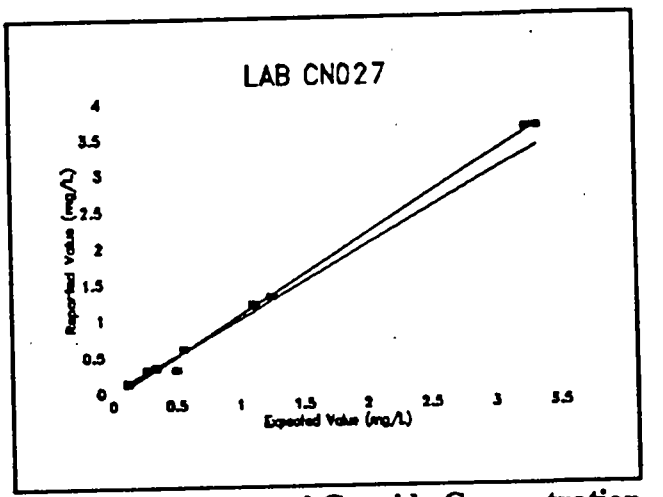
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN027 Value (mg/L)	0.32	1.30	3.60	0.29	0.58	0.29	0.11	1.18	3.59

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L6 was outside 1 standard deviation of the mean expected value.

Regression analysis (see figure) indicated good precision (R^2=0.9968) and a satisfactory Y-intercept (Y_{int}=-0.0688). The slope of the regression line (m=1.1110) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory displays good precision in low level cyanide analysis. Although no bias was detected by either the regression slope or the rank sum test, a visual inspection of the above graph indicates a slight tendency to overestimate cyanide concentrations.

REPORT FOR LABORATORY CN028

RESULTS:

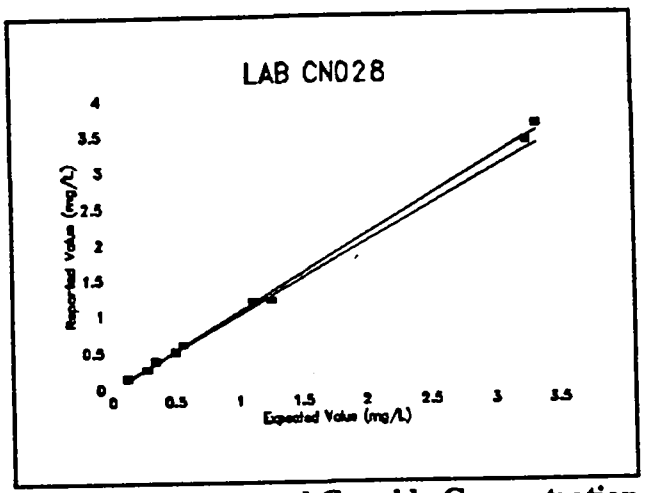
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN028 Value (mg/L)	0.36	1.19	3.37	0.24	0.58	0.48	0.12	1.17	3.61

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected value.

Regression analysis (see figure) indicated good precision (R^2=0.9980) and a satisfactory Y-intercept (Y_{int}=-0.0304). The slope of the regression line (m=1.0660) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory displays both good precision and good accuracy in low level cyanide analysis.

REPORT FOR LABORATORY CN029

RESULTS:

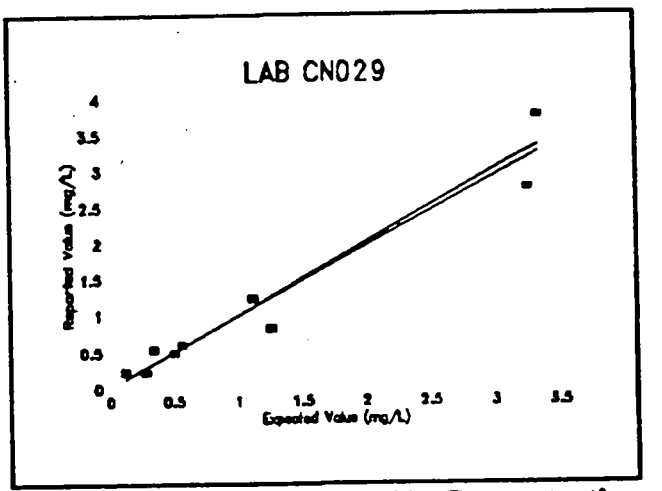
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN029 Value (mg/L)	0.52	0.81	2.74	0.21	0.58	0.48	0.21	1.21	3.74

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected one sample (L7) outside 3 standard deviations of the mean expected value. Samples L1, L2 and L7 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated poor precision (R^2=0.9463) and a satisfactory Y-intercept (Y_{int}=0.0207). The slope of the regression line (m=0.9651) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has no detectable biases but exhibited poor precision in this study. This is indicated by the low regression coefficient and the three values falling outside the 1 standard deviation limit. This is confirmed by a visual inspection of the above figure.

REPORT FOR LABORATORY CN031

RESULTS:

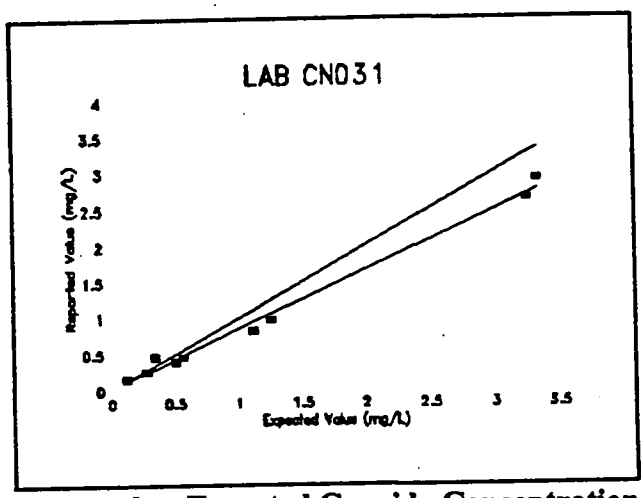
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN031 Value (mg/L)	0.45	0.96	2.63	0.25	0.44	0.38	0.15	0.81	2.90

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L1, L2, L3, L7 and L8 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated satisfactory precision (R^2=0.9911) and a satisfactory Y-intercept (Y_{int}=0.0154). The slope of the regression line (m=0.8259) indicates a low bias. No bias was detected by the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has satisfactory precision in low level cyanide analysis as indicated by the regression coefficient. A low bias was, however, detected by the regression slope. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN032

RESULTS:

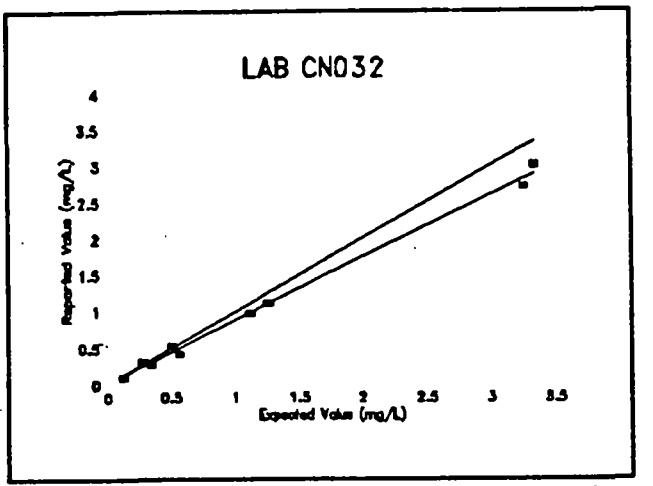
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN032 Value (mg/L)	0.27	1.10	2.70	0.30	0.41	0.51	0.09	0.96	3.00

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Samples L1, L5 and L7 were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9956) and a satisfactory Y-intercept (Y_{int}=0.0129). No bias was detected by either the slope of the regression line (m=0.8626) or the rank sum test.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, a visual inspection of the above figure indicates a tendency to underestimate cyanide concentrations. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN033

RESULTS:

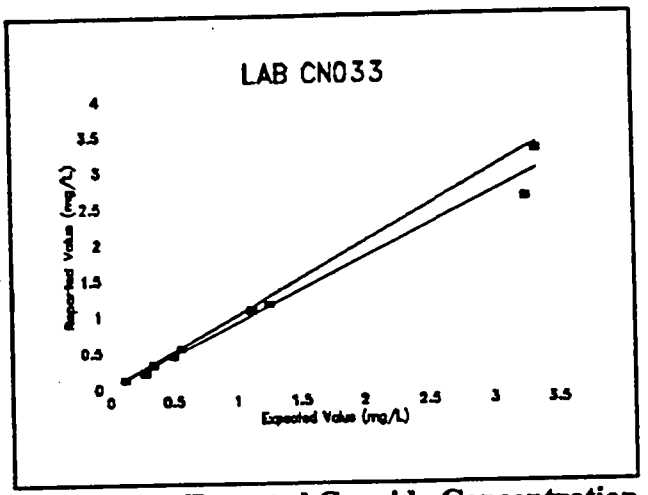
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN033 Value (mg/L)	0.31	1.14	2.59	0.20	0.53	0.43	0.10	1.05	3.25

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were not statistically different from the expected results.

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. Sample L3 was outside 1 standard deviation of the mean expected value.

Regression analysis (see figure) indicated poor precision (R^2=0.9822) but a good Y-intercept (Y_{int}=0.0093). The slope of the regression line (m=0.8894) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory displayed poor precision in this study. This is indicated by the low regression coefficient. A visual inspection of the above figure, however, suggests that this is largely the result of the one outlying value detected (sample L3).

REPORT FOR LABORATORY CN035A

RESULTS:

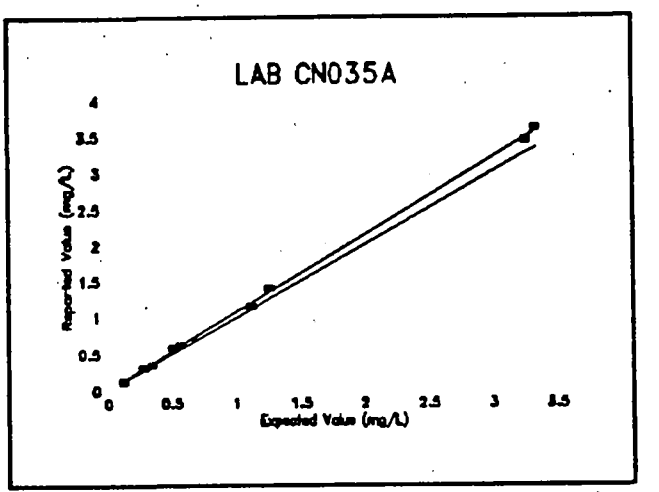
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN035A Value (mg/L)	0.34	1.38	3.43	0.30	0.60	0.56	0.11	1.14	3.60

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9993) and a good Y-intercept (Y_{int}=0.0055). The slope of the regression line (m=1.0670) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line repfesents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a slight high bias exists in your results. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN035B

RESULTS:

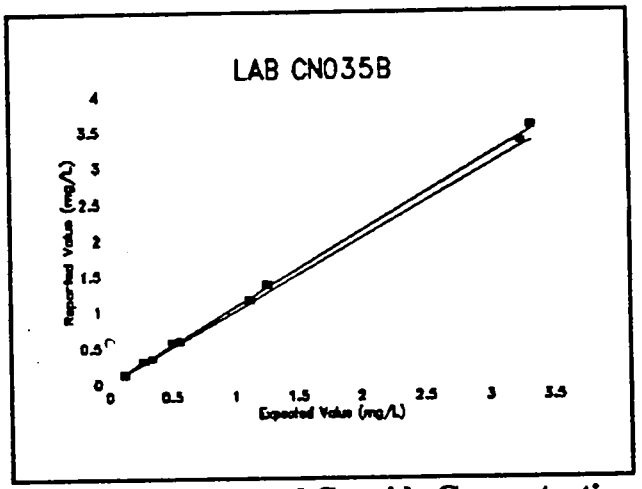
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN035B Value (mg/L)	0.33	1.36	3.33	0.30	0.57	0.57	0.11	1.14	3.55

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9989) and a satisfactory Y-intercept (Y_{int}=0.0113). The slope of the regression line (m=1.0440) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a very slight high bias exists in your results. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN036A

RESULTS:

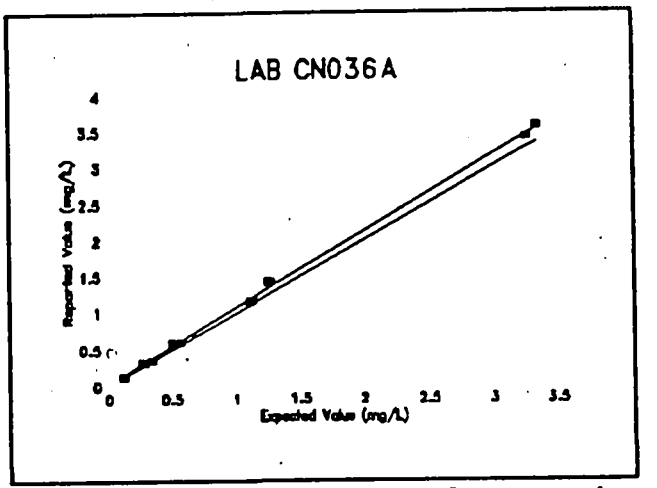
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN036A Value (mg/L)	0.33	1.41	3.39	0.31	0.58	0.58	0.11	1.14	3.55

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 98 percent (ie. 98 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9990) and a satisfactory Y-intercept (Y_{int}=0.0155). The slope of the regression line (m=1.0530) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a very slight high bias exists in your results. This is most likely the result of a calibration standard problem.

REPORT FOR LABORATORY CN036B

RESULTS:

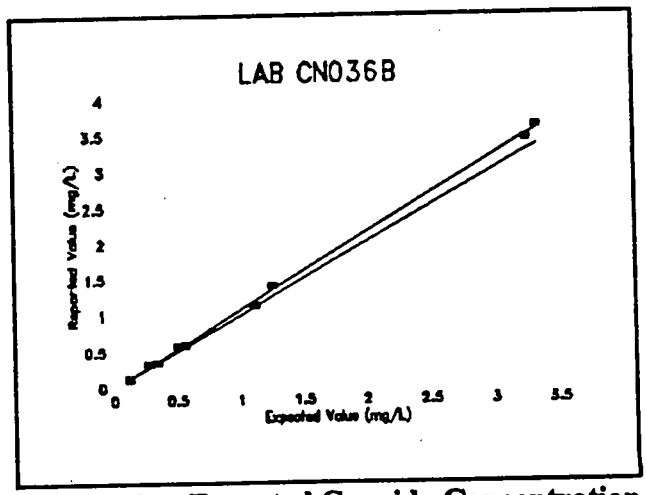
Sample Number	L1	L2	L3	L4	L5	L6	L7	L8	L9
Expected Value (mg/L)	0.3283	1.2485	3.2488	0.2676	0.5530	0.4948	0.1111	1.1094	3.3314
CN036B Value (mg/L)	0.33	1.38	3.42	0.32	0.58	0.56	0.11	1.12	3.60

STATISTICAL SUMMARY:

The paired t-test showed that your laboratory's results were statistically different from the expected results with a probability of 95 percent (ie. 95 times out of 100 your laboratory would not produce the expected results).

The flagging procedure detected no samples outside 3 standard deviations of the mean expected value. No samples were outside 1 standard deviation of the mean expected values.

Regression analysis (see figure) indicated good precision (R^2=0.9991) and a good Y-intercept (Y_{int}=0.0031). The slope of the regression line (m=1.0650) indicated no bias.



Reported vs Expected Cyanide Concentration

(Note: Dark boxes indicate reported results. Line passing through the boxes is the best regression fit. The second line represents the expected values.)

The analytical method used worked equally well with samples in water and effluent matrices. The method was not influenced by the presence of thiocyanate in sample L5.

INFERENCE:

The statistical analysis of your data indicates that your laboratory has good precision in low level cyanide analysis as indicated by the regression coefficient. Although no bias was detected by either the regression slope or the rank sum test, the t-test results and a visual examination of the figure, suggest that a very slight high bias exists in your results. This is most likely the result of a calibration standard problem.

7.0 REFERENCES

Chapman, D.G. and R.A. Schaufele, 1970 Elementary Probability Models and Statistical Inference. Xerox College Publishing Company, Mass. U.S.A.

Grubbs, F.E., 1969 Procedures for Detecting Outlying Observations in Samples. Technometrics 11: 1-21

Malik, H.J. and K. Mullen, 1973 A First Course in Probability and Statistics. Addison-Wesley Pub. Co., Mass. U.S.A.

Ostle, B. and R.W. Mensing, 1975 Statistics in Research. 3rd ed. Iowa state University Press, Iowa, U.S.A.

Youden, W.J. and E.H. Steiner, 1975 Statistical Manual of the Association of Official Analytical Chemists. AOAC, Va., U.S.A.

8.0 APPENDICES

APPENDIX 1
Initial Correspondence and Results Reporting Form

Date

Participant Address

Dear:

The Wastewater Technology Centre invites you to participate in an interlaboratory comparison study for total cyanide scheduled to begin in November 1991. The samples will be prepared from spiked reagent water and industrial effluents from the gold mining and iron and steel sectors.

We anticipate that the program will be operated in two phases, the first; a study of cyanide levels in the 0 to 100 ppm range, and the second; a study involving low levels in the 0 to 1 ppm range. Each phase will be comprised of 10 to 15 samples. We expect that the first phase samples will be distributed in November 1991, while the second phase will likely take place in January 1992.

The aim of the study is to assist laboratories in assessing their analytical performance on real industrial effluents. As such, all analyses should be carried out according to the normal routine in your laboratory. We will, however, request details of the method of analysis used. The results will be evaluated both statistically and graphically in a manner that will be informative to the analyst.

Should you wish to participate in this program, please return the attached form to Mr. Peter Fowlie by telefax at (416) 336 4765 before October 20, 1992.
Thank you for your consideration and we look forward to your participation in this program.

Yours truly,
WASTEWATER TECHNOLOGY CENTRE,

Peter Fowlie, Laboratory Manager

Wastewater Technology Centre
operated by RockCliffe Research Management Inc.

Centre Technique des Eaux Usées
dirigé par Gestion de Recherche RockCliffe Inc.

867, chemin Lakeshore Road
P.O. Box / C.P. 5068, Burlington
Ontario, Canada, L7R 4L7
(416) 336-4855
Fax/Fac (416) 336-4765

November 24, 1991

LAB CODE: CNO01

Dear

Enclosed please find samples for determination of Total Cyanide as part of an interlaboratory comparison study carried out by the Wastewater Technology Centre (WTC).

The samples are based on industrial effluent or laboratory water and contain cyanide in concentrations ranging from 0 to 3 ppm. Each bottle is labelled with a sample number ranging from 1 to 9. Please refer to this sample number when recording your results.

On each bottle label you will also find a bottle number which may range from 1 to 60. This indicates the order in which the bottles were filled. You do not need to refer to this number when recording your results.

Your results should be recorded on the attached sheets. Please include a brief description of the methods used including the date of analysis.

Your laboratory has been assigned a unique code number to ensure the confidentiality of your results. This code will be used in all future correspondence with your laboratory and in the subsequent reports.

Your results should be faxed or mailed to the address indicated on the results sheets by Tuesday, December 31, 1991. A summary of the results from all participating labs, identified only by their code numbers, will be mailed to you shortly afterwards. At this time you will have an opportunity to check any data entry errors that may have occurred at our end. We regret that we will not be able to change the results submitted to us from your laboratory at this time. A final report of the entire interlaboratory comparison will be mailed to you on completion of the study.

Should you require any assistance please contact Dr. Peter Child at (416)336-6428 or Mr. Jim Fraser at (416)336-4719.

Yours sincerely,

Peter Child, Ph.D., C.Chem.

RESULTS REPORT FORM

LAB CODE:CNOO1

TOTAL CYANIDE:

Results:

Units	Sample Number								
	L1	L2	L3	L4	L5	L6	L7	L8	L9
mg/L									

Date Analysis Completed:

Methods:

Please provide a short description of the methods used.

Please return this form before Tuesday, December 31, 1991 to Dr. Peter Child by Fax at (416) 336-4765 or by mail to: Wastewater Technology Centre, 867 Lakeshore Road, Burlington, Ontario, L7R 4A6

APPENDIX 2

Analysis of Cyanide in Test Samples Collected During the Bottling Run

WTC3 LOW LEVEL CYANIDE STUDY
ANALYSIS OF CYANIDE IN TEST SAMPLES COLLECTED DURING THE BOTTLING RUN

SAMPLE NUMBER	TARGET CONC. (mg/L)	MATRIX	BOTTLE NUMBER			MEAN	STANDARD DEVIATION	|BOTTLE #-MEAN|-1SD			|BOTTLE #-MEAN|-2SD		
			Start	Middle	End			Start	Middle	End	Start	Middle	End
L3	3	Water	3.3550	3.0150	3.0700	3.1467	0.1490	0.0593	-0.0173	-0.0723	-0.0897	-0.1664	-0.2214
L9	3	Effluent	3.3050	2.9700	3.3800	3.2183	0.1782	-0.0916	0.0701	-0.0166	-0.2698	-0.1082	-0.1948
L8	1	Water	1.0950	1.0750	1.0400	1.0700	0.0227	0.0023	-0.0177	0.0073	-0.0205	-0.0405	-0.0155
L2	1	Effluent	1.1800	1.0450	1.3100	1.1783	0.1082	-0.1065	0.0251	0.0235	-0.2147	-0.0831	-0.0847
L5	0.5	Water	0.4900	0.5615	0.5260	0.5258	0.0292	0.0066	0.0065	-0.0290	-0.0225	-0.0227	-0.0582
L6	0.5	Effluent	0.4010	0.4340	0.5010	0.4453	0.0416	0.0027	-0.0303	0.0141	-0.0389	-0.0719	-0.0275
L1	0.2	Water	0.2995	0.3330	0.3130	0.3152	0.0138	0.0019	0.0041	-0.0116	-0.0119	-0.0097	-0.0254
L4	0.2	Effluent	0.1980	0.2150	0.2400	0.2170	0.0180	0.0030	-0.0160	0.0050	-0.0150	-0.0340	-0.0130
L7	0.1	Water	0.1165	0.1355	0.1220	0.1247	0.0080	0.0002	0.0029	-0.0053	-0.0078	-0.0051	-0.0133

APPENDIX 3

Analysis of Bottled Standards for Cyanide over the Six Week Period of the Study

WTC3 LOW LEVEL CYANIDE STUDY
ANALYSIS OF BOTTLED STANDARDS FOR CYANIDE OVER THE SIX WEEK PERIOD OF THE STUDY

SAMPLE NUMBER	TARGET CONC. (mg/L)	MATRIX	TIME SERIES ANALYSIS OF [CN]							MEAN	STANDARD DEVIATION
			Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6		
L9	3.1	Effluent	3.2180	3.1900	2.8900	2.9300	3.7500	3.0800	3.4700	3.2183	0.2821
L3	3	Water	3.1470	3.0720	3.1050	2.7100	3.4000	3.1800	3.1300	3.1063	0.1898
L2	1.1	Effluent	1.1780	1.0950	1.0300	1.0650	1.1900	1.0800	1.1200	1.1083	0.0543
L8	1	Water	1.0700	1.0370	0.9650	0.9850	1.1600	1.0250	1.0300	1.0389	0.0589
L5	0.5	Water	0.5260	0.5580	0.5610	0.5290	0.5830	0.5660	0.4345	0.5368	0.0458
L6	0.4	Effluent	0.4450	0.4270	0.4235	0.4080	0.4480	0.4620	0.3590	0.4246	0.0315
L1	0.3	Water	0.3150	0.3430	0.3385	0.3160	0.3740	0.3240	0.3335	0.3349	0.0188
L4	0.2	Effluent	0.2170	0.2360	0.2350	0.1840	0.2900	0.2115	0.2010	0.2249	0.0315
L7	0.1	Water	0.1250	0.1080	0.1115	0.1200	0.0930	0.1165	0.1005	0.1106	0.0103

SAMPLE NUMBER	TARGET CONC. (mg/L)	MATRIX	TIME SERIES ANALYSIS OF [CN], (|[CN]-MEAN|-1SD)						
			Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
L9	3.1	Effluent	-0.2818	-0.2538	0.0462	0.0062	0.2497	-0.1438	-0.0303
L3	3	Water	-0.1491	-0.1555	-0.1885	0.2065	0.1039	-0.1161	-0.1661
L2	1.1	Effluent	0.0154	-0.0410	0.0240	-0.0110	0.0274	-0.0260	-0.0426
L8	1	Water	-0.0277	-0.0570	0.0150	-0.0050	0.0623	-0.0450	-0.0500
L5	0.5	Water	-0.0350	-0.0246	-0.0216	-0.0380	0.0004	-0.0166	0.0565
L6	0.4	Effluent	-0.0111	-0.0291	-0.0304	-0.0149	-0.0081	0.0059	0.0341
L1	0.3	Water	0.0010	-0.0107	-0.0152	0.0000	0.0203	-0.0080	-0.0175
L4	0.2	Effluent	-0.0238	-0.0204	-0.0214	0.0094	0.0338	-0.0181	-0.0076
L7	0.1	Water	0.0040	-0.0077	-0.0095	-0.0010	0.0073	-0.0045	-0.0002

SAMPLE NUMBER	TARGET CONC. (mg/L)	MATRIX	TIME SERIES ANALYSIS OF [CN], (|[CN]-MEAN|-2SD)						
			Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
L9	3.1	Effluent	-0.5638	-0.5358	-0.2358	-0.2758	-0.0324	-0.4258	-0.3124
L3	3	Water	-0.3389	-0.3453	-0.3783	0.0167	-0.0859	-0.3059	-0.3559
L2	1.1	Effluent	-0.0389	-0.0954	-0.0304	-0.0654	-0.0269	-0.0804	-0.0969
L8	1	Water	-0.0866	-0.1159	-0.0439	-0.0639	0.0034	-0.1039	-0.1089
L5	0.5	Water	-0.0808	-0.0703	-0.0673	-0.0838	-0.0453	-0.0623	0.0107
L6	0.4	Effluent	-0.0427	-0.0607	-0.0619	-0.0464	-0.0397	-0.0257	0.0026
L1	0.3	Water	-0.0178	-0.0285	-0.0340	-0.0188	0.0015	-0.0268	-0.0363
L4	0.2	Effluent	-0.0551	-0.0519	-0.0529	-0.0221	0.0021	-0.0496	-0.0391
L7	0.1	Water	-0.0063	-0.0181	-0.0198	-0.0113	-0.0031	-0.0148	-0.0108

APPENDIX 4
List of Participating Laboratories

Mr. Ken Little
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West Vancouver, BC
Canada, V7V 1N8

APPENDIX 5
Complete Table of Results (Raw Data)

WTC3 ROUND ROBIN STUDY FOR TOTAL CYANIDE: RAW DATA

SAMPLE NUMBER	TARGET	CN001	CN002	CN003	CN004A	CN004B	CN005	CN006	CN007	CN008	CN009	CN010	CN011	CN012	CN013	CN014	CN015	CN016	CN017
L1	0.297	0.49	0.291	0.36	0.338	0.337	0.425	0.4	0.498	0.325	0.29	0.29	0.103	0.36	0.35	0.27	0.33	0.33	0.26
L2	1.097	1.62	1.23	1.27	1.396	1.4	2.43	1.58	0.513	1.18	1.19	1.03	0.0467	1.32	1.26	1.46	1.31	1.3	1.15
L3	2.979	4.84	3.23	3.01	3.422	3.371	4.74	3.8	1.63	3.24	2.92	2.77	0.0911	3.76	3.29	4.27	3.62	3.5	2.79
L4	0.1997	0.43	0.3	0.28	0.299	0.268	0.667	0.3	4.31	0.268	0.29	0.3	0.0811	0.27	0.26	0.15	0.325	0.23	0.27
L5	0.499	1.1	0.645	0.62	0.585	0.559	1.25	0.58	0.58	0.552	0.86	0.46	0.1	0.81	0.67	0.67	0.638	0.64	0.69
L6	0.397	0.77	0.521	0.48	0.582	0.571	0.966	0.61	1.3	0.454	0.52	0.43	0.077	0.61	0.5	0.6	0.486	0.47	0.46
L7	0.0997	0.16	0.104	0.119	0.113	0.118	0.126	0.1	0.14	0.113	0.09	0.09	0.0226	0.12	0.13	0.12	0.14	0.1	0.097
L8	0.997	1.7	1.06	1.28	1.156	1.109	1.63	1.2	0.768	1.09	0.92	0.91	1.3	1.16	1.14	1.31	1.19	1.1	0.93
L9	3.079	5	3.35	2.98	3.682	3.611	6.44	3.96	1.33	3.26	3.51	2.71	0.744	3.63	2.62	4.49	3.56	3.1	3.09

SAMPLE NUMBER	TARGET	CN018	CN019	CN021	CN022	CN023	CN024	CN025	CN026	CN027	CN028	CN029	CN031	CN032	CN033	CN036A	CN036B	CN036A	CN036B
L1	0.297	0.316	0.29	0.28	0.341	0.34	0.318	0.332	0.297	0.321	0.36	0.521	0.45	0.27	0.309	0.3381	0.3316	0.331	0.332
L2	1.097	0.836	1.2	1.35	1.03	1.21	1.113	1.27	1.243	1.295	1.19	0.812	0.96	1.1	1.14	1.38	1.361	1.41	1.38
L3	2.979	3.41	2.8	4.6	3.12	3.25	3.095	2.68	3.443	3.6	3.37	2.74	2.63	2.7	2.69	3.428	3.33	3.382	3.416
L4	0.1997	0.258	0.24	0.13	0.202	0.26	0.211	0.226	0.257	0.29	0.237	0.208	0.26	0.3	0.202	0.2968	0.2972	0.309	0.315
L5	0.499	0.496	0.74	0.56	0.533	0.56	0.501	0.534	0.607	0.56	0.56	0.583	0.44	0.41	0.526	0.6012	0.574	0.578	0.578
L6	0.397	0.467	0.42	0.48	0.439	0.51	0.383	0.456	0.447	0.293	0.46	0.479	0.38	0.51	0.426	0.564	0.5678	0.575	0.562
L7	0.0997	0.1	0.091	0.11	0.114	0.11	0.102	0.116	0.093	0.11	0.124	0.213	0.15	0.09	0.102	0.1129	0.1109	0.111	0.114
L8	0.997	0.971	1.1	1.17	1.08	1.05	1.001	0.933	1.055	1.18	1.17	1.21	0.81	0.96	1.05	1.136	1.144	1.142	1.121
L9	3.079	3.56	3.1	4.72	3.37	3.08	3.14	2.84	3.4	3.59	3.61	3.74	2.9	3	3.25	3.598	3.554	3.551	3.595

APPENDIX 6
Table of Results with Invalid Data (Grubbs outliers) Removed

RAW DATA WITH GRUBBS OUTLIERS REMOVED (+/- 3 Std. Dev.) AND MEANS AND +/- 1 STD. DEV. CALCULATED

Sample Number	Spike Level (mg/L)	CN001	CN002	CN003	CN004A	CN004B	CN005	CN006	CN007	CN008	CN009	CN010	CN011	CN012	CN013	CN014	CN015	CN016	CN017	CN018	CN019	CN02
L1	0.297	0.49	0.291	0.35	0.338	0.337	0.425	0.4	0.498	0.325	0.29	0.29		0.36	0.35	0.27	0.33	0.33	0.28	0.315	0.29	0.2
L2	1.097	1.82	1.23	1.27	1.396	1.4		1.58	0.513	1.18	1.19	1.03		1.32	1.26	1.46	1.31	1.3	1.15	0.836	1.2	1.3
L3	2.979	4.84	3.23	3.01	3.422	3.371	4.74	3.8	1.83	3.24	2.92	2.77		3.76	3.29	4.27	3.62	3.5	2.79	3.41	2.8	4.
L4	0.1997	0.43	0.3	0.28	0.299	0.268	0.667	0.3		0.268	0.29	0.3	0.0811	0.27	0.25	0.15	0.326	0.23	0.27	0.268	0.24	0.1
L5	0.499	1.1	0.645	0.52	0.585	0.559		0.58	0.58	0.552	0.88	0.46	0.1	0.61	0.57	0.57	0.536	0.54	0.49	0.496	0.74	0.5
L6	0.397	0.77	0.521	0.48	0.582	0.571	0.966	0.61		0.454	0.52	0.43	0.077	0.51	0.5	0.6	0.485	0.47	0.46	0.467	0.42	0.4
L7	0.0997	0.16	0.104	0.119	0.113	0.118	0.126	0.1	0.14	0.113	0.09	0.09		0.12	0.13	0.12	0.14	0.1	0.097	0.1	0.091	0.1
L8	0.997		1.05	1.28	1.156	1.109	1.63	1.2	0.768	1.09	0.92	0.91	1.3	1.16	1.14	1.31	1.19	1.1	0.93	0.971	1.1	1.1
L9	3.079	5	3.35	2.96	3.682	3.611		3.98	1.33	3.26	3.51	2.71	0.744	3.63	2.62	4.49	3.56	3.1	3.09	3.58	3.1	4.7

RAW DATA WITH GRUBBS OUTLIERS REMOVED (+/- 3 Std. Dev.) AND MEANS AND +/- 1 STD. DEV. CALCULATED

Sample Number	Spike Level (mg/L)	CN022	CN023	CN024	CN025	CN026	CN027	CN028	CN029	CN031	CN032	CN033	CN035A	CN035B	CN036A	CN036B	NUMBER OF DATA	MEAN	STANDARD DEVIATION	MEAN + 1 SD	MEAN - 1 SD
L1	0.297	0.341	0.34	0.318	0.332	0.287	0.321	0.36	0.521	0.45	0.27	0.309	0.3381	0.3316	0.331	0.332	35	0.3434	0.0625	0.4059	0.2810
L2	1.097	1.03	1.21	1.113	1.27	1.243	1.298	1.19	0.812	0.96	1.1	1.14	1.38	1.361	1.41	1.38	34	1.2281	0.2279	1.4541	0.9982
L3	2.979	3.12	3.25	3.096	2.68	3.443	3.6	3.37	2.74	2.63	2.7	2.69	3.428	3.33	3.392	3.416	35	3.3113	0.6114	3.9228	2.6999
L4	0.1997	0.202	0.28	0.211	0.226	0.257	0.29	0.237	0.208	0.25	0.3	0.202	0.2968	0.2972	0.309	0.316	35	0.2711	0.0910	0.3621	0.1801
L5	0.499	0.533	0.58	0.501	0.534	0.507	0.58	0.58	0.583	0.44	0.41	0.526	0.6012	0.574	0.578	0.578	35	0.5763	0.1508	0.7262	0.4245
L6	0.397	0.439	0.51	0.383	0.456	0.447	0.293	0.48	0.479	0.38	0.51	0.425	0.564	0.5676	0.575	0.562	35	0.4990	0.1358	0.6347	0.3632
L7	0.0997	0.114	0.11	0.102	0.115	0.093	0.11	0.124		0.15	0.09	0.102	0.1129	0.1109	0.111	0.114	34	0.1129	0.0166	0.1296	0.0963
L8	0.997	1.08	1.05	1.001	0.933	1.056	1.18	1.17	1.21	0.81	0.96	1.05	1.135	1.144	1.142	1.121	35	1.1001	0.1537	1.2538	0.9465
L9	3.079	3.37	3.08	3.14	2.84	3.4	3.59	3.61	3.74	2.9	3	3.26	3.598	3.554	3.551	3.595	35	3.3207	0.7659	4.0766	2.5648
															TOTAL DATA		313				

APPENDIX 7
Table of Results with Outliers marked

WTC3 ROUND ROBIN STUDY FOR TOTAL CYANIDE: Data tables for outlier removal and expected mean calculation

RAW DATA WITH OUTLIERS (+/- 1 Std. Dev.) REMOVED AND EXPECTED MEANS CALCULATED

Sample Number	Spike Level (mg/L)	CN001	CN002	CN003	CN004A	CN004B	CN005	CN006	CN007	CN008	CN009	CN010	CN011	CN012	CN013	CN014	CN015	CN016	CN017	CN018
L1	0.297		0.291	0.36	0.338	0.337		0.4		0.326	0.29	0.29		0.36	0.35		0.33	0.33		0.316
L2	1.097		1.23	1.27	1.396	1.4				1.18	1.19	1.03		1.32	1.26		1.31	1.3	1.15	
L3	2.979		3.23	3.01	3.422	3.371		3.8		3.24	2.92	2.77		3.76	3.29		3.62	3.6	2.79	3.41
L4	0.1997		0.3	0.28	0.299	0.288		0.3		0.268	0.29	0.3		0.27	0.25		0.326	0.23	0.27	0.258
L5	0.499		0.545	0.52	0.585	0.569		0.58	0.58	0.552		0.46		0.61	0.57	0.57	0.538	0.54		0.496
L6	0.397		0.521	0.48	0.582	0.571		0.61		0.454	0.52	0.43		0.51	0.5	0.5	0.485	0.47	0.46	0.467
L7	0.0997		0.104	0.119	0.113	0.118	0.128	0.1		0.113				0.12		0.12		0.1	0.097	0.1
L8	0.997		1.05		1.156	1.109		1.2		1.09				1.16	1.14		1.19	1.1		0.971
L9	3.079		3.35	2.96	3.682	3.611		3.96		3.26	3.61	2.71		3.63	2.62		3.56	3.1	3.09	3.56

RAW DATA WITH OUTLIERS (+/- 1 Std. Dev.) REMOVED AND EXPECTED MEANS CALCULATED

Sample Number	Spike Level (mg/L)	CN019	CN021	CN022	CN023	CN024	CN025	CN026	CN027	CN028	CN029	CN031	CN032	CN033	CN035A	CN035B	CN036A	CN036B	NUMBER OF DATA	MEAN	STANDARD DEVIATION
L1	0.297	0.29		0.341	0.34	0.318	0.332	0.267	0.321	0.36				0.309	0.3361	0.3318	0.331	0.332	26	0.3283	0.0265
L2	1.097	1.2	1.35	1.03	1.21	1.113	1.27	1.243	1.296	1.19			1.1	1.14	1.38	1.381	1.41	1.38	27	1.2485	0.1062
L3	2.979	2.8		3.12	3.25	3.096		3.443	3.6	3.37	2.74		2.7		3.428	3.33	3.382	3.416	27	3.2488	0.3009
L4	0.1997	0.24		0.202	0.26	0.211	0.226	0.257	0.29	0.237	0.208	0.26	0.3	0.202	0.2068	0.2972	0.309	0.316	30	0.2676	0.0360
L5	0.499		0.56	0.533	0.56	0.501	0.534	0.607	0.58	0.58	0.563	0.44		0.525	0.6012	0.574	0.578	0.576	29	0.5530	0.0399
L6	0.397	0.42	0.48	0.439	0.51	0.383	0.456	0.447		0.46	0.479	0.38	0.51	0.425	0.564	0.5676	0.575	0.582	31	0.4948	0.0606
L7	0.0997		0.11	0.114	0.11	0.102	0.116		0.11	0.124				0.102	0.1129	0.1109	0.111	0.114	24	0.1111	0.0079
L8	0.997	1.1	1.17	1.08	1.05	1.001		1.055	1.18	1.17	1.21		0.96	1.05	1.135	1.144	1.142	1.121	25	1.1094	0.0675
L9	3.079	3.1		3.37	3.08	3.14	2.84	3.4	3.59	3.61	3.74	2.9	3	3.25	3.598	3.554	3.551	3.595	30	3.3314	0.3200
																	TOTAL DATA		249		