QUALITY-ASSURANCE DATA FOR ROUTINE WATER ANALYSIS IN THE LABORATORIES OF THE U.S. GEOLOGICAL SURVEY FOR WATER-YEAR 1982

By Dale B. Peart and Nancy A. Thomas

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QUALITY-ASSURANCE DATA FROM ROUTINE WATER ANALYSIS IN THE LABORATORIES OF THE U.S. GEOLOGICAL SURVEY FOR WATER-YEAR 1982

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ABSTRACT

The U.S. Geological Survey maintains a quality-assurance program based on the analysis of reference samples for its two water-analysis laboratories located in Atlanta, Georgia, and Denver, Colorado. Reference samples containing inorganic constituents are prepared at the U.S. Geological Survey's Ocala, Florida, office and disguised as routine samples, and sent daily to each laboratory through other U.S. Geological Survey offices. The results are permanently stored in the National Water Data Storage and Retrieval System (WATSTORE), the U.S. Geological Survey's data base for all water data. These data are analyzed statistically for precision and bias. The results of these statistical analyses are presented for data collected during the 1982 water year. In addition, one sample containing known concentrations of trihalomethanes was analyzed in both laboratories, and these results also are presented.

INTRODUCTION

The water quality laboratories of the U.S. Geological Survey, located in Atlanta, Georgia, and Denver, Colorado, routinely analyze water, suspended sediments, stream- and lake-bed materials for inorganic constituents, many organic substances including common pesticides, priority pollutants established by the U.S. Environmental Protection Agency (Keith and Telliard, 1979), and some physical properties. Results of the quality-assurance program used to monitor the quality of work performed by these two laboratories are presented in this report. A previous report (Peart and Thomas, 1983) documents results from February through December 1981. Because water data are published on a water year (October through September) rather than a calendar-year basis, this report series has been changed to correspond to that same time period; that is this report will include data from October 1 through December 31, 1981, which has been reported previously in Peart and Thomas, 1983. During the 1982 water year, the following constituents were included in this quality-assurance program:

Inorganic constituents--alkalinity, aluminum, ammonia, ammonia plus organic nitrogen, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, copper, dissolved solids (residue on evaporation), fluoride, iron, lead, lithium, manganese, magnesium, molybdenum, nickel, nitrate plus nitrite, nitrite, organic carbon, orthophosphate, phosphorous, potassium, selenium, silica, silver, sodium, strontium, sulfate, and zinc.

Organic substances--known concentrations of chloroform, bromodichloromethane, methane, dibromochloromethane, and bromoform.

Physical properties--specific conductance.

Analyses of samples for ammonia, ammonia plus organic nitrogen, organic carbon, and orthophosphate were begun in January 1982.

Program Description

Standard Reference Water Samples (SRWS) (Schroder and others, 1980; Skougstad and Fishman, 1975) are used as the principal component of the reference samples used in this program. The SRWS are diluted with deionized water, mixed in varying proportions with other SRWS, or used undiluted. A large range of concentrations of chemical constituents is thereby achieved, increasing the number of unique samples available for quality-assurance purposes. This increase, in turn, decreases the probability that quality-assurance samples will be recognized in the laboratory due to frequency of analyses or unique sample behavior.

In addition to the SRWS, ampuls obtained from the U.S. Environmental Protection Agency that contain known concentrations of various constituents, and synthetic samples made from reagent-grade chemicals are used in preparing reference samples. All samples are prepared in the U.S. Geological Survey's Ocala, Florida, office, and are made to appear as much like real samples as possible. This effort is coordinated with other Geological Survey offices that will be shipping the samples during any given calendar month. When the samples are prepared and appropriate forms are completed, to assure that appropriate constituents have been requested for the sample, they are shipped to selected Geological Survey offices across the country. These Survey offices then ship the quality-assurance samples to the laboratories daily, along with their regular samples.

The analyses requested reflect the frequency of analyses for each chemical constituent in the laboratory. The program goal is to have at least one quality-assurance sample analyzed daily for those constituents that are analyzed daily and, similarly, an appropriate number of quality-assurance samples for those constituents analyzed less frequently.

All constituents in the reference materials are in the dissolved phase. Those constituents in this report that are designated as "total recoverable" are from reference samples that have undergone a digestion process (Skougstad and others, 1979) during analysis, rather than from unfiltered or "whole-water" samples.

Quality-assurance samples pass through each laboratory as routine samples including the application of laboratory quality-control and quality-assurance procedures. The data are then stored in the U.S Geological Survey's National Water Data Storage and Retrieval System (WATSTORE). Having passed through the laboratories in this manner, these quality-assurance samples should reflect the quality of the analytical data for environmental samples that the laboratories produce. Laboratory errors other than those related to analytical chemistry also will be reflected in these data. These errors include logging the sample into the laboratory, transcription errors by the analyst, and keypunching errors. No effort is made to correct nonanalytical errors of this type even when it is quite obvious which corrective measures were appropriate, in order to preserve the laboratories' data as they produce it, regardless of the source of error. Thus, if a data user is capable of detecting errors of this type, he can increase the quality of his data compared to that presented in this report.

Statistical Evaluation

The SRWS initially are analyzed by many other laboratories throughout the United States, using several different analytical methods. These results are compiled by calculating the means, standard deviations, 95-percent confidence limits, and applying a rejection routine (American Society for Testing and Materials, 1980). Resultant means are the values most probably correct or the "most probable values" (MPV). These MPV are used in this quality-assurance program for comparison with laboratory data. For reference samples composed of a mixture of two SRWS or a SRWS and deionized water, MPV for each constituent are averaged according to their respective percentage contribution to determine a new set of MPV for the mixture.

For non-SRWS based samples, for example, ampuls provided by the U.S. Environmental Protection Agency, "true" or "most probable" values were supplied by the respective agency, with corresponding standard deviations. These values were used in determining whether or not the data from the Geological Survey laboratories were acceptable.

Because of an insufficient supply of SRWS for nutrients (ammonia, ammonia plus organic nitrogen, nitrate plus nitrite, nitrite, orthophosphate, phosphorus, and organic carbon), most of the reference materials used during this period were made from reagent chemicals in the Ocala facility. Preparation methods used for these samples are virtually the same as those used in preparing nutrient samples for the SRWS program. However, because of lack of stability data on these samples and no independent analyses of them, the samples were treated as split samples of unknown concentrations and statistical tests were applied to determine if significant differences existed between the performances of the two laboratories.

Initially, the appropriateness of using the mean of two specific-conductance values for an MPV in the case of mixed solution samples was questioned. However, because all SRWS have specific conductances less than 2,100 µmhos/L (micromhos per centimeter at 25° Celsius), it was believed that the departure from linearity would not be significant. A comparison of the means of the analyzed specific-conductance values and the MPV for all the mixtures is presented in Peart and Thomas, 1983. Results of this evaluation indicated that the linearity hypothesis holds true except where the parent samples have widely divergent specific conductances, and no significant bias. We have not used any samples for evaluation purposes where the linearity hypothesis failed to hold true.

Standard deviations were determined by using linear least-squares equations developed by regressing standard deviations achieved in the multilaboratory, multimethod analyses of all the SRWS for which we have data, against the corresponding MPV for those samples. This method allowed an estimation of a most probable standard deviation (MPSD) for each constituent on a sample-by-sample basis to determine whether that analysis was in or out of control. An individual reported value was considered acceptable if it was within two standard deviations of the MPV, which generally was a liberal criterion, because the MPSD's were based on multilaboratory, multimethod data.

In certain situations, the above criterion was impossible to meet. This was true for all values of chromium, molybdenum, and zinc, as well as copper with values of 100 µg/L (micrograms per liter) or greater. These constituents were reported to the nearest 10 µg/L. Regression equations developed from data reported to the nearest 1 µg/L resulted in standard deviations so small that no values reported by the laboratories were acceptable. A minimum standard deviation of 7.5 µg/L was established to allow at least one reportable value to be accepted on each side of the MPV.

The number of standard deviations each constituent deviates from the MPV was calculated by dividing the difference of the reported value and the MPV by the MPSD. This number was used in determining precision and accuracy (bias). The result for each laboratory and constituent is displayed in figures 1 through 90 in the Supplemental Data section at the back of this report. Three symbols are used on the figures to display results from the lower (+), middle (x), and upper (o) one-thirds of the potential analytical range tested in this program. This range does not necessarily correspond with the analytical capabilities of the laboratory instrumentation or methods, but rather with the analytical range we are capable of testing with the available SRWS or other reference samples used. The three parts of this range are based on the MPV of the quality-assurance samples and not the reporting policy; thus, a sample may have a maximum MPV for chromium of 28 µg/L (figs. 27 and 28) and still be reported to the nearest 10 µg/L (that is, 30 µg/L). Not all figures will have all three parts of the analytical range displayed because some flexibility is given to the Ocala, Florida, office in sample selection. Points outside the range of the plots are forced to plot at the limit (±6) with the number of standard deviations indicated adjacent to the point.

Precision and bias are determined by applying binomial-distribution equations to the data according to procedures described by Friedman, Bradford, and Peart, 1983; and Peart and Thomas, 1983. When precision is determined in this manner, it contains an element of accuracy as well, because MPV rather than analyzed means are used as the basis for determining the number of standard deviations each sample deviates that from value. Thus, in this analysis, precision, or lack of it, is based on whether or not the analytical process was in or out of control, and the figures represent control charts.

Traditional determinations of precision (calculation of means and standard deviations) were done for this report. Because standard deviations may vary with concentration in chemical analyses, these determinations were done separately on individual sample mixtures; therefore, they do not give overall appraisals of the analytical processes. Relative standard deviations were calculated and plotted against concentrations in figures 91 through 180 in the Supplemental Data section at the back of this report. These plots allow a data reviewer to estimate the error at any concentration displayed for all constituents.

RESULTS AND DISCUSSION

Initially, 1982 water-year data were presented statistically in three unpublished reports for the following periods: October 1 - December 31, 1981; January 1 - June 30, 1982; July 1 - December 31, 1982. From the latest unpublished report, only the July through September data will be discussed in this report. The linear least-squares equations used to calculate the MPSD changed for each of the periods because of data from newly developed SRWS. Data presented in this report were reanalyzed using the latest set of equations to provide uniform criteria throughout the year. Therefore, data presented in this report may not always correspond to data in the unpublished reports. Results of binomial-distribution tests for these three periods, as well as overall results for the year are shown in tables 1 through 4. In general, if a constituent showed significant lack of precision or bias during one part of the year, the yearly result was the same.

Precision

Precision data for each inorganic constituent is presented in tables 1 and 2. For each constituent, these tables indicate significant lack of precision (by LOP) as well as all acceptable results (by a plus).

Almost all individual aluminum analyses showing LOP were associated with SRWS 73, which had an initially reported range of values from 70 to 1,100 μg/L. The resulting MPV appears to be disproportionately large based on subsequent analyses of this sample, which caused consistent initial rejection of these analyses. Following subsequent chemical analyses of this sample by various methods and after a statistical analysis of the historical data for this sample, it was determined that the original MPV assigned was in error and a new value was determined. Data in this report reflect that change.

Beginning in July, 1981, and continuing through March, 1982, quality-assurance samples were contaminated with iron. Thus, the test for lack of precision for iron and iron, total recoverable, was not made during this period.

Because mercury analyses have exhibited consistent negative bias and LOP and because the Survey is currently undertaking a study of proper preservation techniques for mercury samples, we have serious doubts about our abilities to make valid

Table 1.--*Results of statistical testing for lack of precision in data from the Atlanta Laboratory: inorganic constituents and specific conductance*

[LOP, significant lack of precision; ICP, inductively coupled plasma spectrometry; AA, atomic absorption spectrometry; +, acceptable results; †, samples were contaminated with iron during preparation from July 1981 through March 1982, therefore, all iron data has been deleted for that period. A + or LOP after the † indicate the results after the problem was corrected]

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Alkalinity	+	+	LOP	+
Aluminum	+	LOP	+	LOP
Antimony	+	+	LOP	LOP
Arsenic	+	LOP	LOP	LOP
Barium	+	+	+	+
Barium, total recoverable	+	+	+	+
Beryllium	+	+	+	+
Boron	+	+	+	+
Cadmium	+	+	LOP	+
Cadmium, total recoverable	+	LOP	+	LOP
Calcium(ICP)	LOP	LOP	+	LOP
Calcium(AA)	+	+	+	+
Chloride	+	+	LOP	LOP
Chromium	+	+	+	+
Chromium, total recoverable	+	+	+	+
Cobalt	+	+	+	+
Cobalt, total recoverable	+	+	+	+
Copper	LOP	+	+	LOP
Copper, total recoverable	+	LOP	+	LOP
Dissolved solids	+	+	LOP	LOP
Fluoride	+	+	+	+
Iron		†,+	+	+
Iron, total recoverable		†,LOP	LOP	LOP
Lead	+	+	+	+
Lead, total recoverable	+	+	+	+
Lithium	+	LOP	+	LOP
Magnesium(ICP)	LOP	+	+	+
Magnesium(AA)	+	+	+	LOP
Manganese	+	+	+	+
Manganese, total recoverable	+	+	+	+

Table 1.--*Results of statistical testing for lack of precision in data from the Atlanta Laboratory: inorganic constituents and specific conductance*—Continued

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Molybdenum	+	+	+	+
Nickel	+	+	+	+
Nickel, total recoverable	+	+	+	+
Potassium	+	LOP	+	LOP
Selenium	+	+	+	+
Silica	LOP	+	+	+
Silver	LOP	+	+	LOP
Silver, total recoverable	LOP	+	+	+
Sodium(ICP)	LOP	LOP	LOP	LOP
Sodium(AA)	+	+	+	+
Specific conductance	+	+	+	+
Strontium	+	+	+	+
Sulfate	LOP	+	+	LOP
Zinc	+	+	+	+
Zinc, total recoverable	LOP	LOP	LOP	LOP

statements about the quality of mercury analyses performed in these laboratories. Therefore, we have discontinued our quality-assurance efforts for mercury until the questions regarding preservation have been resolved.

Major ions (calcium, magnesium, and sodium) analyzed by ICP spectrometry in Atlanta failed the precision test fairly consistently. The same constituents in Denver never failed the precision test during this water year. There were no periods in either laboratory where the same consituents, analyzed by AA spectrometry failed the precision criteria.

For constituents that were analyzed as both "dissolved" and "total recoverable" on identical samples, the "total recoverable" analyses failed the precision criteria approximately twice as often as the dissolved analyses in Atlanta and five times as often as the dissolved analyses in Denver. This indicates that significant errors are being introduced because of the extra processing required for the digestion procedure. Other constituents failing the precision criteria at one time or another during the year may have done so because of a combination of factors, such as random errors, samples misidentified during the log-in process, and keypunch errors.

Table 2.--*Results of statistical testing for lack of precision in data from the Denver Laboratory: inorganic constituents and specific conductance*

[LOP, significant lack of precision; ICP, inductively coupled plasma spectrometry; AA, atomic absorption spectrometry; +, acceptable results; †, samples were contaminated with iron during preparation from July 1981 through March 1982, therefore, all iron data has been deleted for that period. A + after the † indicate the results after the problem was corrected]

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Alkalinity	+	+	+	+
Aluminum	+	+	+	+
Antimony	+	LOP	+	LOP
Arsenic	+	+	+	+
Barium	+	+	+	+
Barium, total recoverable	+	LOP	+	LOP
Beryllium	+	+	+	+
Boron	+	+	+	+
Cadmium	+	+	+	+
Cadmium, total recoverable	+	+	+	+
Calcium(ICP)	+	+	+	+
Calcium(AA)	+	+	+	+
Chloride	LOP	LOP	+	LOP
Chromium	+	+	+	+
Chromium, total recoverable	+	+	+	+
Cobalt	+	+	+	+
Cobalt, total recoverble	+	LOP	+	LOP
Copper	+	+	LOP	LOP
Copper, total recoverable	LOP	LOP	LOP	LOP
Dissolved solids	+	+	+	+
Fluoride	+	LOP	+	+
Iron		†,+	+	+
Iron, total recoverable		†,+	+	+
Lead	+	+	+	+
Lead, total recoverable	+	+	+	+
Lithium	+	+	+	+
Magnesium(ICP)	+	+	+	+
Magnesium(AA)	+	+	+	+

Table 2.--*Results of statistical testing for lack of precision in data from the Denver Laboratory: inorganic constituents and specific conductance*—Continued

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Manganese	+	+	+	+
Manganese, total recoverable	+	+	+	+
Molybdenum	+	+	+	+
Nickel	+	+	+	+
Nickel, total recoverable	+	+	+	+
Potassium	+	+	+	+
Selenium	+	+	+	+
Silica	+	+	+	+
Silver	+	+	+	+
Silver, total recoverable	+	LOP	+	+
Sodium(ICP)	+	+	+	+
Sodium(AA)	+	+	+	+
Specific conductance	LOP	LOP	+	LOP
Strontium	+	+	+	+
Sulfate	+	+	+	+
Zinc	+	+	+	+
Zinc, total recoverable	+	LOP	+	LOP

Bias

Results of the statistical tests for bias are shown in tables 3 and 4. Using the method described previously, it is not possible to determine bias where results from less than eight samples were available. This situation occurred from October through March for a few constituents as noted in the tables.

Molybdenum, potassium, and silica have shown a consistent negative bias throughout the year in the Atlanta Laboratory. Zinc has been consistently positive in Atlanta. In Denver, cobalt, nickel, and silver have been consistently negatively biased, with arsenic, chromium, total recoverable, sodium (ICP), zinc, and zinc, total recoverable having a consistently positive bias. No predominant patterns appear regarding bias for ICP analyses versus AA analyses or dissolved versus total recoverable analyses.

The reasons for other constituents showing either consistent or occasional bias are not entirely clear. Several factors may be involved including bias inherent in the

Table 3.--*Results of statistical testing for bias in data from the Atlanta Laboratory: inorganic constituents and specific conductance*

[N,negative; P,positive; ICP, inductively coupled plasma spectrometry; AA, atomic absorption spectrometry; +, acceptable results; †, samples were contaminated with iron during preparation from July 1981 through March 1982, therefore, all iron data has been deleted for that period. A + after the † indicate the results after the problem was corrected; *, too few analyses to determine]

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Alkalinity	+	+	+	+
Aluminum	P	+	P	P
Antimony	+	+	+	+
Arsenic	+	P	P	P
Barium	+	N	+	N
Barium, total recoverable	*	+	+	+
Beryllium	+	P	P	P
Boron	*	+	N	N
Cadmium	+	+	+	N
Cadmium, total recoverable	*	N	+	N
Calcium(ICP)	+	N	+	N
Calcium(AA)	*	+	+	+
Chloride	+	N	+	N
Chromium	+	+	+	+
Chromium, total recoverable	*	P	+	P
Cobalt	+	+	+	+
Cobalt, total recoverble	*	+	+	+
Copper	+	+	+	+
Copper, total recoverable	*	+	+	+
Dissolved solids	+	+	+	+
Fluoride	P	+	P	P
Iron		†,+	P	P
Iron, total recoverable		†,+	P	P
Lead	+	+	+	+
Lead, total recoverable	*	+	+	+
Lithium	+	+	+	+
Magnesium(ICP)	+	N	+	N
Magnesium(AA)	*	+	+	+

Table 3.--*Results of statistical testing for bias in data from the Atlanta Laboratory: inorganic constituents and specific conductance*--Continued

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Manganese	+	P	+	+
Manganese, total recoverable	*	+	+	+
Molybdenum	N	N	N	N
Nickel	+	N	N	N
Nickel, total recoverable	*	+	N	+
Potassium	N	N	N	N
Selenium	+	+	P	P
Silica	N	N	N	N
Silver	N	+	+	N
Silver, total recoverable	*	+	+	+
Sodium(ICP)	+	+	P	P
Sodium(AA)	*	+	+	+
Specific conductance	+	+	+	+
Strontium	+	N	+	+
Sulfate	N	+	+	+
Zinc	P	P	P	P
Zinc, total recoverable	*	P	+	P

analytical method, deterioration of standard calibrating solutions or reagents, improper or inaccurate reagent or standard-solution preparation, undetected problems with analytical instrumentation, undefined matrix effects caused by mixing together two very different SRWS, undetected contamination or, as mentioned above, inaccurate MPV resulting from a very large range of results during the initial analysis of a SRWS. Where bias is statistically significant but precision is good, the bias may have little effect on data interpretation and little practical significance.

As explained earlier, the nutrients which include ammonia; ammonia plus organic nitrogen; organic carbon; nitrate plus nitrite nitrogen; nitrite-nitrogen; phosphorus; and phosphorus, ortho were treated as split samples of unknown concentrations. The means and standard deviations for each nutrient mixture used in the $\underline{t}$ statistic are documented in table 5. Results in table 6 show that both laboratories are performing similarly on all nutrient constituents except phosphorus, in which the means are similar but the standard deviations are significantly different.

Table 4.--*Results of statistical testing for bias in data from the Denver Laboratory: inorganic constituents and specific conductance*

[N,negative; P,positive; ICP, inductively coupled plasma spectrometry; AA, atomic absorption spectrometry; +, acceptable results; †, samples were contaminated with iron during preparation from July 1981 through March 1982, therefore, all iron data has been deleted for that period. A + after the † indicate the results after the problem was corrected; *,too few analyses to determine]

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Alkalinity	+	P	+	P
Aluminum	N	+	+	+
Antimony	P	P	+	P
Arsenic	P	P	P	P
Barium	N	N	+	N
Barium, total recoverable	+	+	+	+
Beryllium	+	+	+	+
Boron	*	+	+	N
Cadmium	N	N	+	N
Cadmium, total recoverable	N	N	+	N
Calcium(ICP)	+	+	+	+
Calcium(AA)	+	+	+	+
Chloride	+	+	+	+
Chromium	+	P	+	P
Chromium, total recoverable	P	P	P	P
Cobalt	N	N	N	N
Cobalt, total recoverble	N	N	+	N
Copper	+	+	+	+
Copper, total recoverable	+	+	+	+
Dissolved solids	N	N	+	N
Fluoride	P	P	+	P
Iron		†,+	+	P
Iron, total recoverable		†,+	+	+
Lead	+	+	+	N
Lead, total recoverable	+	+	+	N
Lithium	+	+	+	+
Magnesium(ICP)	P	P	+	P
Magnesium(AA)	+	+	+	P

Table 4.--*Results of statistical testing for bias in data from the Denver Laboratory: inorganic constituents and specific conductance*—Continued

Constituent (dissolved except as indicated)	Oct. - Dec. 1981	Jan. - June 1982	July - Sept. 1982	Summary Oct. - Sept. 1981 1982
Manganese	+	P	+	P
Manganese, total recoverable	+	+	+	+
Molybdenum	N	+	N	N
Nickel	N	N	N	N
Nickel, total recoverable	N	N	+	N
Potassium	+	+	+	+
Selenium	+	P	P	P
Silica	+	N	+	N
Silver	N	N	N	N
Silver, total recoverable	N	N	+	N
Sodium(ICP)	P	P	P	P
Sodium(AA)	P	P	+	P
Specific conductance	+	P	P	P
Strontium	+	+	+	+
Sulfate	P	P	+	P
Zinc	P	P	P	P
Zinc, total recoverable	P	P	P	P

Organic Substances

Two ampuls provided by the U.S. Environmental Protection Agency that contained trihalomethanes were given to each laboratory for analysis. The Denver Laboratory correctly identified the only four compounds present in the sample: bromoform, dichlorobromomethane, chloroform, and chlorodibromomethane. The Atlanta Laboratory failed to correctly identified any compounds as being present. Quantitative results for the Denver Laboratory were within the 95-percent confidence limits of the true values for the four compounds.

SUMMARY AND CONCLUSIONS

Reference samples with known MPV most probable values are disguised as regular samples and submitted with real samples by selected offices of the U.S. Geological Survey to the two water-quality laboratories operated by the Survey and located in Atlanta, Georgia, and Denver, Colorado. The data generated are stored in the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE). These data are then statistically analyzed for precision and bias, using a binomial-probability-distribution equation.

Table 5.--*Comparison of results for nutrient samples*

[N, number of observations; Mean and Standard deviation reported in milligrams per liter]

Constituent	Mix	Atlanta N	Atlanta Mean	Atlanta Standard deviation	Denver N	Denver Mean	Denver Standard deviation
Ammonia	1	14	0.13	0.046	14	0.13	0.039
	2	48	.53	.141	54	.59	.147
	3	12	.90	.180	12	1.0	.070
	4	6	1.1	.084	6	1.1	.041
	5	25	1.7	.458	24	1.6	.406
	6	10	1.5	.063	10	1.6	.063
	7	22	.44	.167	38	.55	.392
	8	14	.28	.050	22	.38	.031
	9	18	2.9	.408	26	3.1	.248
	10	24	2.9	.688	30	4.1	.900
	11	24	2.5	.568	19	2.8	.549
	12	20	.63	.104	33	.72	.086
	13	24	1.0	.147	20	1.1	.155
	14	20	1.1	.102	24	1.5	.260
	15	19	.89	.331	32	1.0	.266
	16	10	.80	.166	18	1.2	.034
	17	14	.25	.156	12	.19	.124
	18	20	.58	.027	20	.44	.172
Ammonia plus organic nitrogen	1	14	0.52	0.267	15	1.2	0.512
	2	47	1.5	.736	54	2.1	.379
	3	12	1.4	.623	12	1.5	.258
	4	6	1.3	.308	6	1.4	.519
	5	25	1.9	1.13	24	2.4	.418
	6	10	1.5	.287	10	2.4	.414
	7	22	1.5	.561	38	1.9	.548
	8	14	1.3	.313	22	1.9	.344
	9	18	2.9	.408	26	3.1	.248
	10	23	3.4	.491	29	4.3	.589
	11	24	4.0	4.61	18	3.7	.745
	12	20	1.7	1.00	33	2.2	.383
	13	24	2.4	.482	19	3.3	.967
	14	20	2.3	.296	24	3.1	.512
	15	18	1.8	.751	32	2.9	.561
	16	10	2.4	.302	18	3.1	.440
	17	14	.53	.287	12	.87	.277
	18	20	1.5	.340	20	1.2	.556
Carbon - organic	1	10	3.2	1.50	10	2.9	1.58
	2	32	9.2	2.12	41	8.3	3.76
	3	6	6.2	1.98	6	8.6	2.93

Table 5.--*Comparison of results for nutrient samples*--Continued

Constituent	Mix	Atlanta N	Atlanta Mean	Atlanta Standard deviation	Denver N	Denver Mean	Denver Standard deviation
Carbon - organic (Cont.)	4	6	5.0	3.44	6	3.8	4.26
	5	16	2.8	1.58	18	2.9	1.88
	6	10	2.1	1.80	10	1.8	1.03
	7	20	7.0	1.92	38	6.8	3.00
	8	7	5.4	2.86	16	5.8	2.74
	9	11	3.9	.660	20	2.0	1.45
	10	25	7.7	3.71	30	8.1	3.20
	11	20	3.8	1.29	15	3.7	1.23
	12	11	3.5	1.93	18	3.1	.785
	13	24	6.7	1.68	20	4.2	2.17
	14	9	9.0	6.06	12	10.	4.79
	15	15	6.8	1.09	25	6.4	1.65
	16	6	3.1	.755	10	2.7	.715
	17	14	1.9	.594	12	3.2	1.88
	18	14	9.0	.834	18	9.6	.314
Nitrate plus nitrite nitrogen	1	14	1.9	1.75	14	1.5	1.51
	2	48	3.3	.891	54	3.2	.325
	3	12	1.4	.300	12	1.5	.078
	4	6	1.6	.055	6	1.5	.075
	5	25	2.6	.756	24	2.5	.316
	6	10	2.6	.048	10	2.4	.084
	7	22	1.6	.637	38	1.7	.535
	8	14	1.3	.027	22	1.2	.050
	9	18	4.9	.615	26	2.8	.033
	10	24	4.7	.809	30	5.1	1.20
	11	24	4.9	.253	18	4.7	.290
	12	20	1.8	.486	33	1.8	.397
	13	24	2.2	.062	20	2.2	.045
	14	20	2.2	.060	24	2.2	.072
	15	18	2.2	.088	32	2.1	.367
	16	10	2.2	.032	18	2.1	.070
	17	14	3.2	1.79	12	4.4	.145
	18	20	3.2	.643	20	1.5	.943
	19	4	3.6	.050	4	3.4	.058
	20	8	3.2	.198	8	2.7	.969
	21	4	2.7	.058	2	2.6	.000
	22	8	2.6	.099	6	2.6	.052
	23	8	4.3	.835	6	3.9	.122
	24	6	1.9	.126	7	1.7	.700
	25	4	2.6	.058	4	2.5	.000
	26	4	1.1	.000	4	1.0	.000
	27	6	2.4	.055	6	2.2	.110

Table 5.--*Comparison of results for nutrient samples*—Continued

Constituent	Mix	Atlanta N	Atlanta Mean	Atlanta Standard deviation	Denver N	Denver Mean	Denver Standard deviation
Nitrate plus nitrite nitrogen (Cont.)	28	4	1.5	0.050	5	1.4	0.045
	29	6	.72	.038	8	.66	.032
	30	4	3.1	.100	4	3.1	.096
	31	10	2.0	.808	11	2.1	.457
	32	2	1.9	.778	3	0.56	.129
	33	3	1.0	.450	6	1.2	.041
	34	3	2.6	.058	2	2.5	.212
	35	3	3.0	.361	2	3.3	.071
Nitrite - nitrogen	1	6	0.33	0.227	5	0.28	0.277
	2	6	1.3	.490	4	1.3	.352
	3	3	.68	.082	3	.71	.010
	4	3	.78	.044	3	.73	.000
	5	18	1.2	.386	18	1.2	.372
	6	10	1.3	.067	10	1.2	.000
	7	3	.27	.046	4	.32	.005
	10	15	2.4	.141	20	2.6	.679
	11	10	2.3	.115	6	2.3	.052
	12	4	.25	.119	2	.21	.000
	13	21	.29	.097	17	.35	.006
	14	3	.33	.006	3	.34	.006
	16	3	.33	.007	3	.34	.006
	17	14	.38	.214	12	.56	.015
	18	3	1.4	.058	1	1.4	----
Phosphorus	1	10	0.33	0.084	9	0.29	0.092
	2	47	1.6	.436	53	1.5	.727
	3	12	.43	.085	12	.45	.058
	4	6	.47	.014	6	.45	.016
	5	25	.73	.197	24	.81	.097
	6	10	.72	.020	10	.70	.033
	7	22	.80	.287	38	.87	.122
	8	14	.68	.017	22	.64	.493
	9	25	1.5	.402	22	1.4	.493
	10	25	1.4	.351	30	1.2	.575
	11	20	1.5	.137	15	1.5	.717
	12	12	1.8	.340	17	2.0	.895
	13	24	2.4	.325	20	2.5	.695
	14	20	2.5	.119	24	1.9	.862
	15	18	2.5	.156	32	2.4	.602
	16	6	2.7	.098	8	2.3	.497
	17	14	.38	.098	12	.43	.035
	18	20	1.6	.114	20	1.1	.418

Table 5.--*Comparison of results for nutrient samples*—Continued

Constituent	Mix	Atlanta N	Atlanta Mean	Atlanta Standard deviation	Denver N	Denver Mean	Denver Standard deviation
Phosphorus (Cont.)	24	4	0.71	0.015	7	0.62	0.277
	26	4	.49	.021	4	.50	.082
	27	3	.66	.020	2	.66	.021
	28	4	.54	.355	4	.62	.242
	29	6	.23	.005	8	.23	.036
	30	4	.60	.015	4	.65	.026
	31	1	.07	----	4	.81	.072
	33	3	.30	.064	6	.20	.134
	34	3	.64	.015	2	.64	.000
	35	3	1.5	.058	2	1.6	.141
Phosphorus, ortho	1	6	0.33	0.106	4	0.28	0.118
	2	12	.91	.411	6	1.1	.327
	3	6	.36	.127	6	.45	.061
	4	6	.43	.012	6	.40	.013
	5	19	.71	.206	18	.74	.094
	6	10	.68	.026	10	.68	.044
	7	6	.61	.008	6	.61	.005
	10	16	1.3	.290	20	1.3	.192
	11	11	1.4	.082	6	1.2	.117
	12	4	1.5	.412	3	1.2	.471
	13	24	1.8	.383	20	1.8	.129
	14	6	1.9	.137	6	1.8	.117
	15	4	2.0	.050	4	1.9	.100
	17	14	.40	.099	12	.39	.072
	18	6	1.1	.041	2	1.0	.000

Recurring problems with lack of precision existed in Atlanta for arsenic; calcium(ICP); iron, total recoverable; sodium(ICP); and zinc, total recoverable; and in Denver for chloride; copper, total recoverable; and specific conductance.

Significant bias recurred in Atlanta for arsenic; beryllium; fluoride; molybdenum; nickel; potassium; silica; and zinc; and in Denver for antimony; arsenic; barium; cadmium; cadmium, total recoverable; chromium, total recoverable; cobalt; cobalt, total recoverable; dissolved solids; fluoride; magnesium(ICP); molybdenum; nickel; nickel, total recoverable; selenium; silver; silver, total recoverable; sodium(ICP); sodium(AA); specific conductance; sulfate; zinc; and zinc, total recoverable.

The quality-assurance samples were contaminated with iron during preparation beginning in July, 1981, and continuing through March, 1982. Therefore, no evaluation of iron or iron, total-recoverable data was made for this period.

Table 6.--*Results of statistic evaluation for nutrients*

[A, no significant difference; B, significant difference]

Constituent	Comparison of means	Comparison of standard deviations
Ammonia	A	A
Ammonia plus organic N	A	A
Carbon, organic	A	A
Nitrate plus nitrite N	A	A
Nitrite N	A	A
Phosphorus	A	B
Phosphorus, ortho	A	A

Both laboratories are performing similarly on all nutrient constituents except phosphorus, in which the means are similar but the standard deviations are significantly different.

Results of analyses of ampuls (provided by the U.S. Environmental Protection Agency) containing four trihalomethanes each were acceptable in the Denver Laboratory; the Atlanta laboratory failed to identify any compounds as being present.

Factors that need to be considered for data interpretation for this period in conjunction with the results presented in this report include the following:

1. Nonanalytical errors were not corrected by this project in order to preserve the data as the laboratory produced it. Thus, if the data reviewer in the U.S. Geological Survey's office that collected the sample, is familiar with the collection site or the historical data from that site, many errors of this type could be easily corrected. For example, if two samples from different sites are submitted to the laboratory on the same day and happen to get misidentified, so that the analytical data are misreported for these samples, the collecting office very often can detect this situation and correct it, based on historical data from these sites.

2. No quality-assurance samples had any constituents reanalyzed except those requested by the laboratory quality-assurance group. U.S. Geological Survey data reviewers in the offices where the samples were collected are expected to scrutinize incoming new data for discrepancies and make requests for reanalysis; these requests may help detect analytical and nonanalytical errors, so data quality should improve, compared to that stated in this report.

3. Figures included in this report may be used to determine analytical conditions at any given time. Where they show that an analytical process may have been in control for the majority of the year and out of control for a short period, but long enough so that the statistical tests applied indicated lack of precision or significant bias results for the year, the data from that period when the analytical process was in control can be considered precise and unbiased.

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Supplemental Data Section

 (page 23 follows)

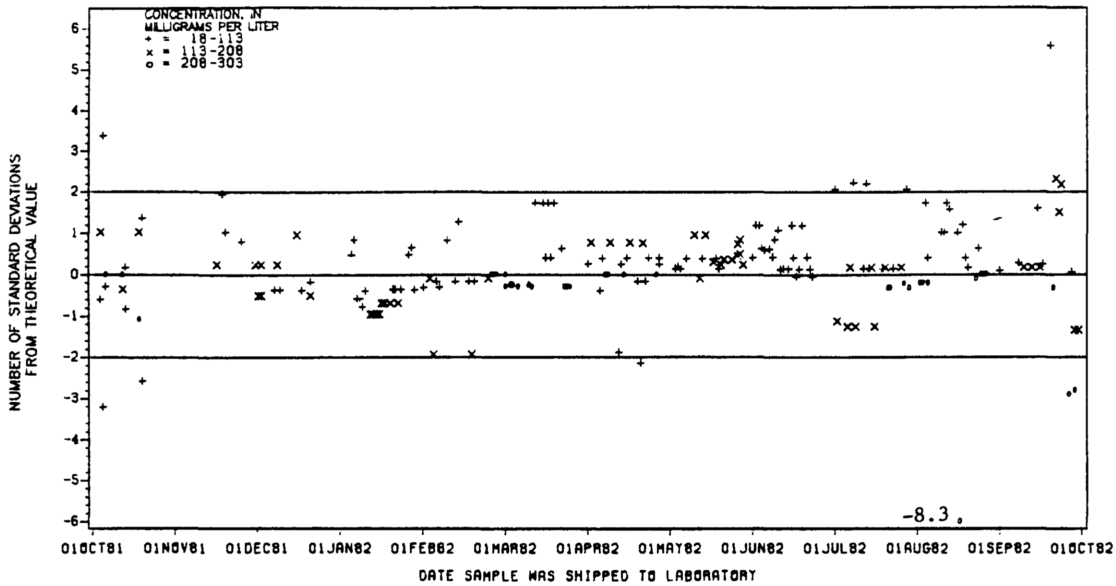

Figure 1.-- Alkalinity, dissolved, data from the Atlanta laboratory.

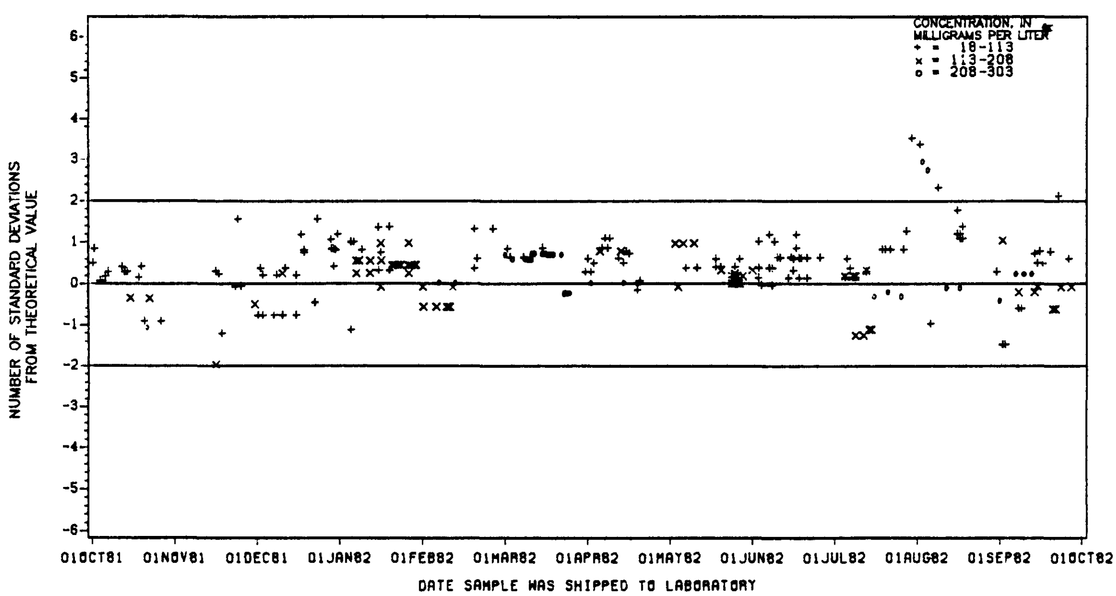

Figure 2.-- Alkalinity, dissolved, data from the Denver laboratory.

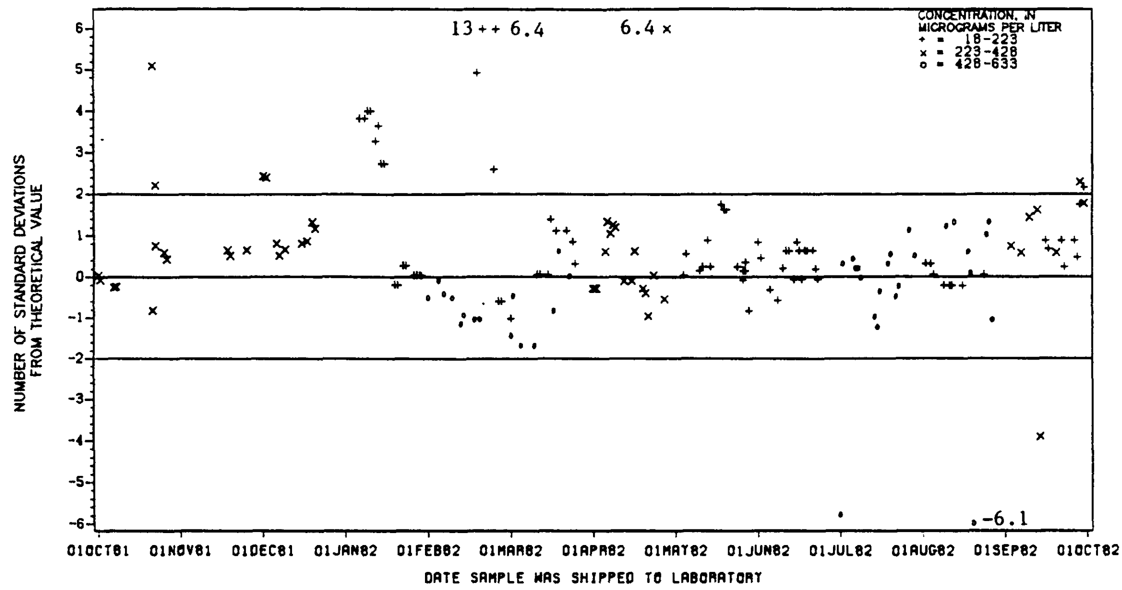

Figure 3.-- Aluminum, dissolved, data from the Atlanta laboratory.

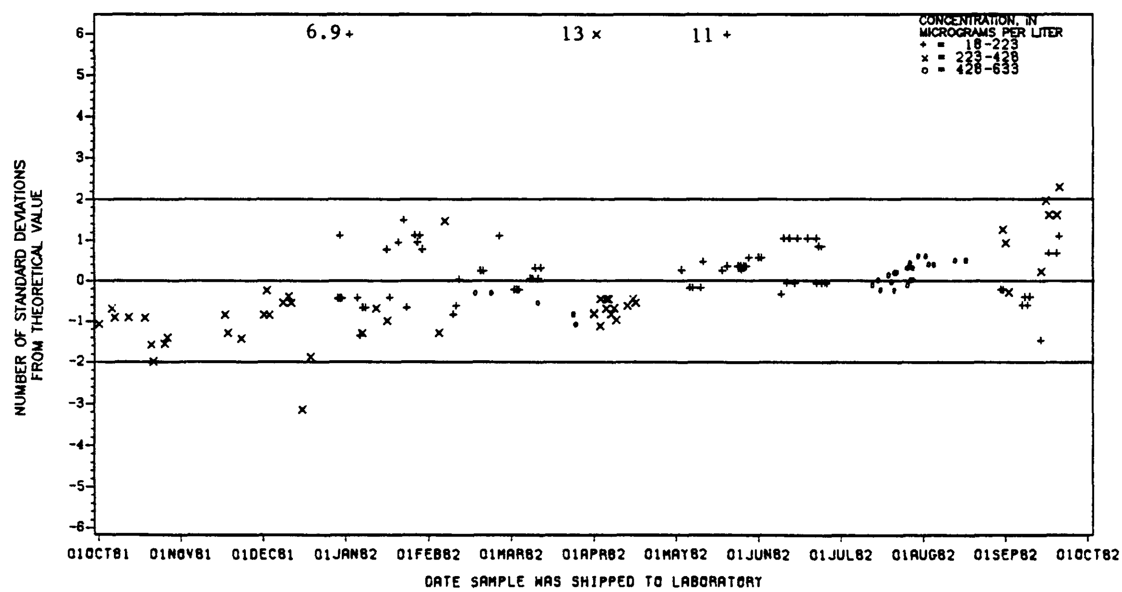

Figure 4.-- Aluminum, dissolved, data from the Denver laboratory.

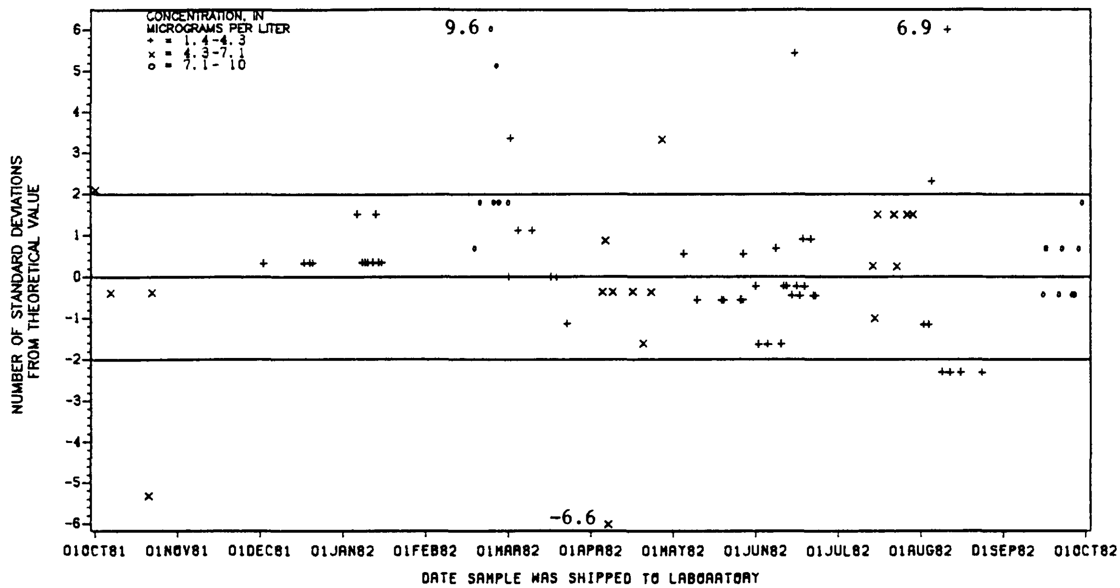

Figure 5.-- Antimony, dissolved, data from the Atlanta laboratory.

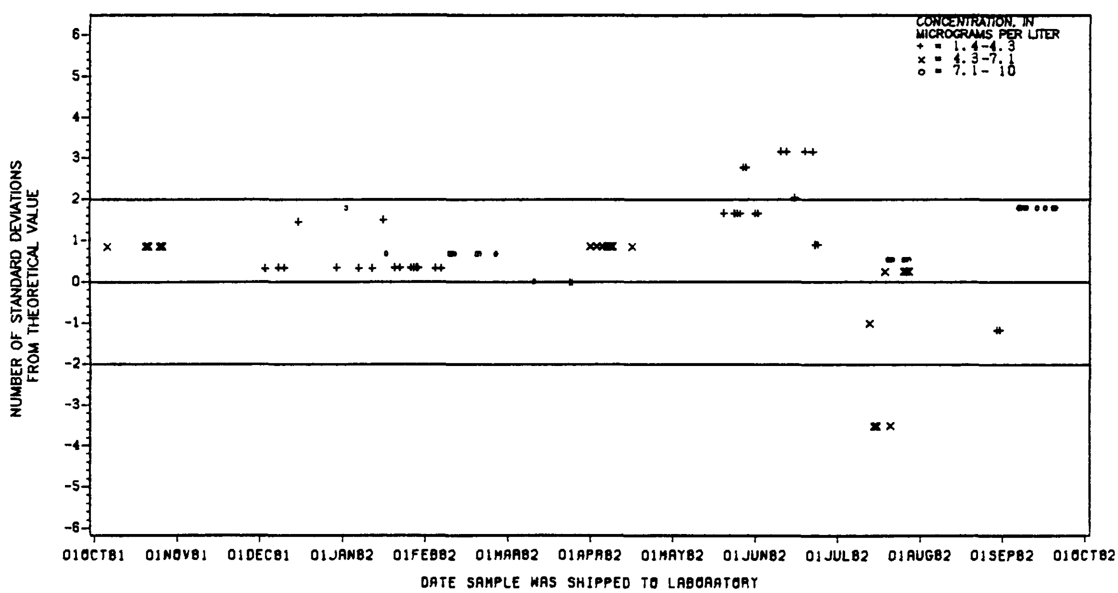

Figure 6.-- Antimony, dissolved, data from the Denver laboratory.

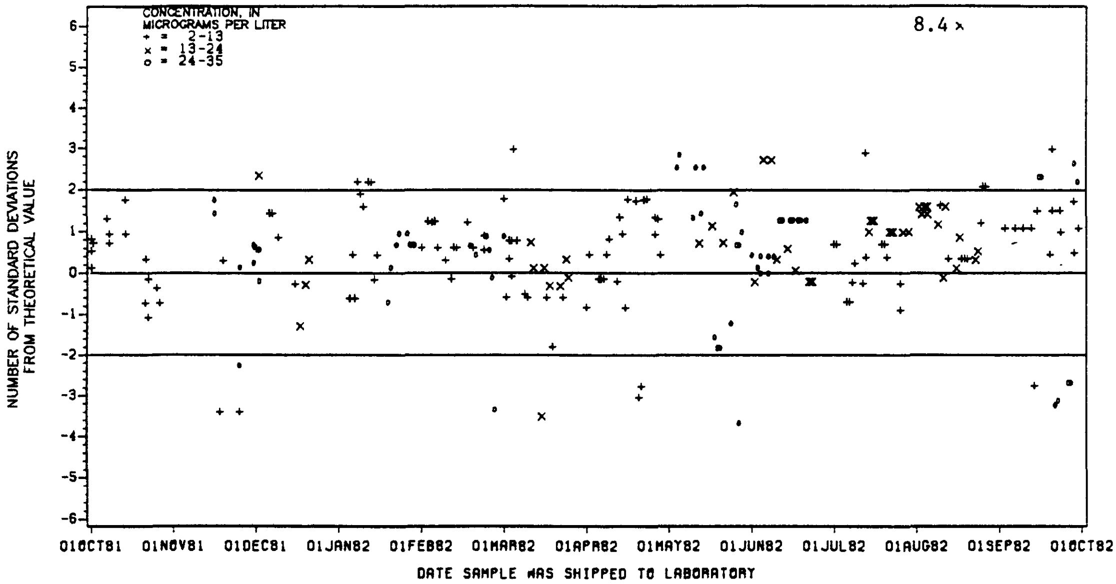

Figure 7.-- Arsenic, dissolved, data from the Atlanta laboratory.

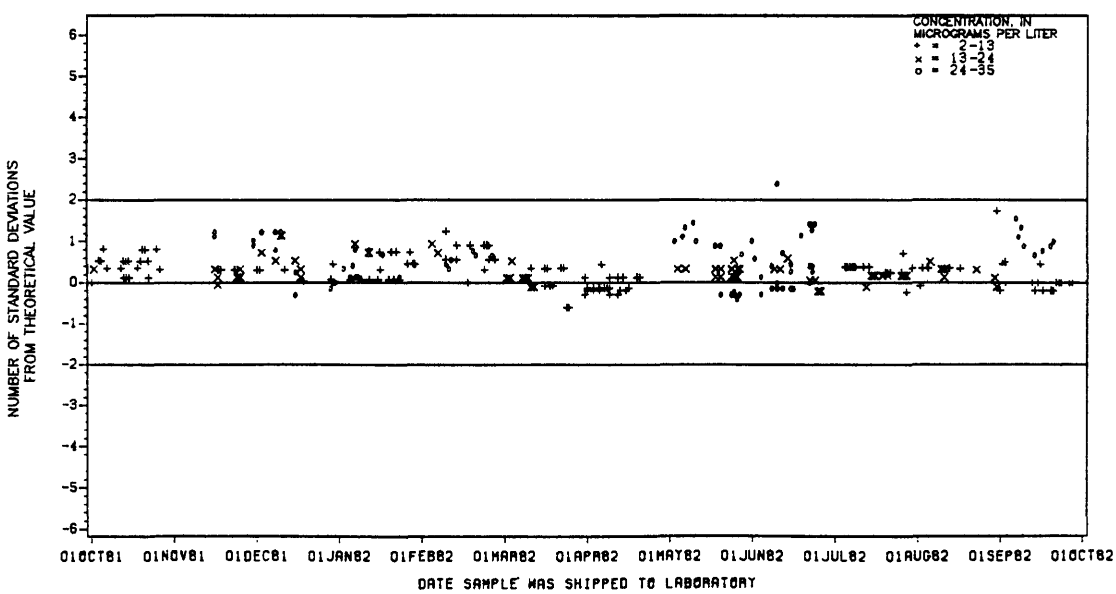

Figure 8.-- Arsenic, dissolved, data from the Denver laboratory.

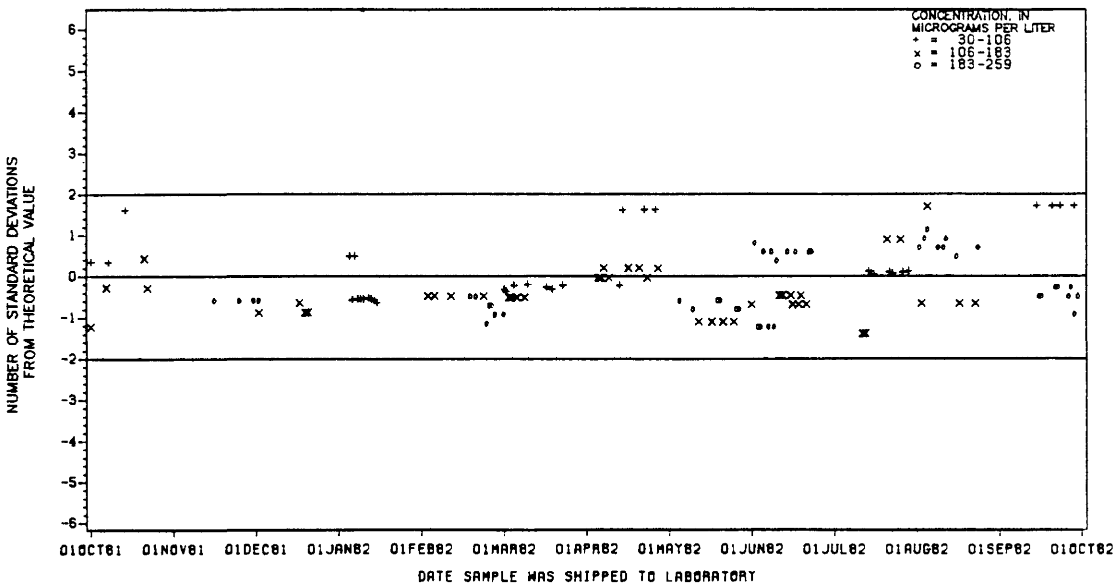

Figure 9.-- Barium, dissolved, data from the Atlanta laboratory.

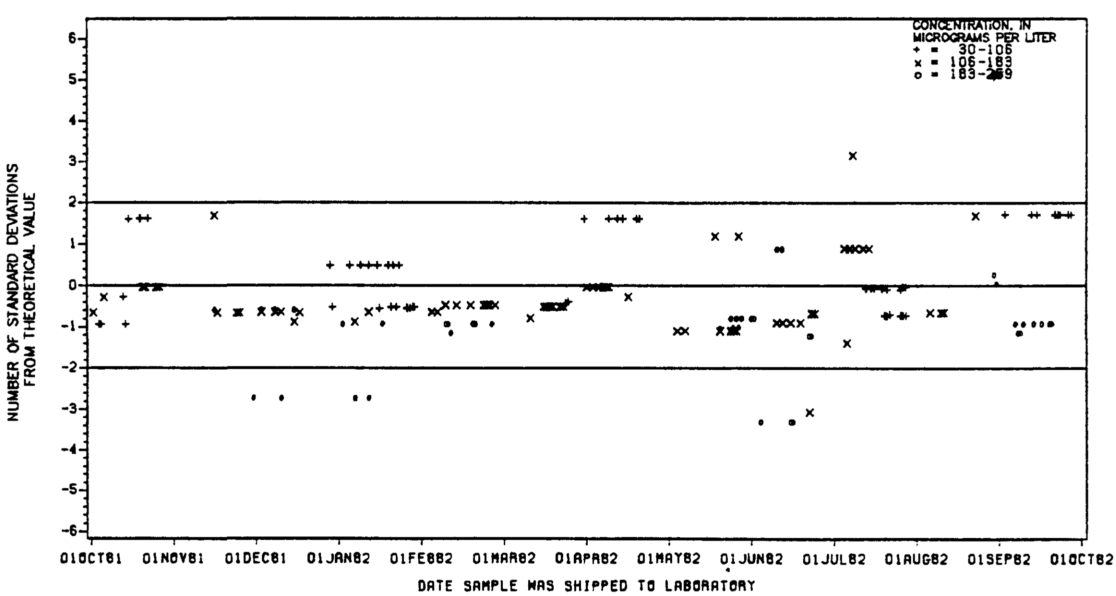

Figure 10.-- Barium, dissolved, data from the Denver laboratory.

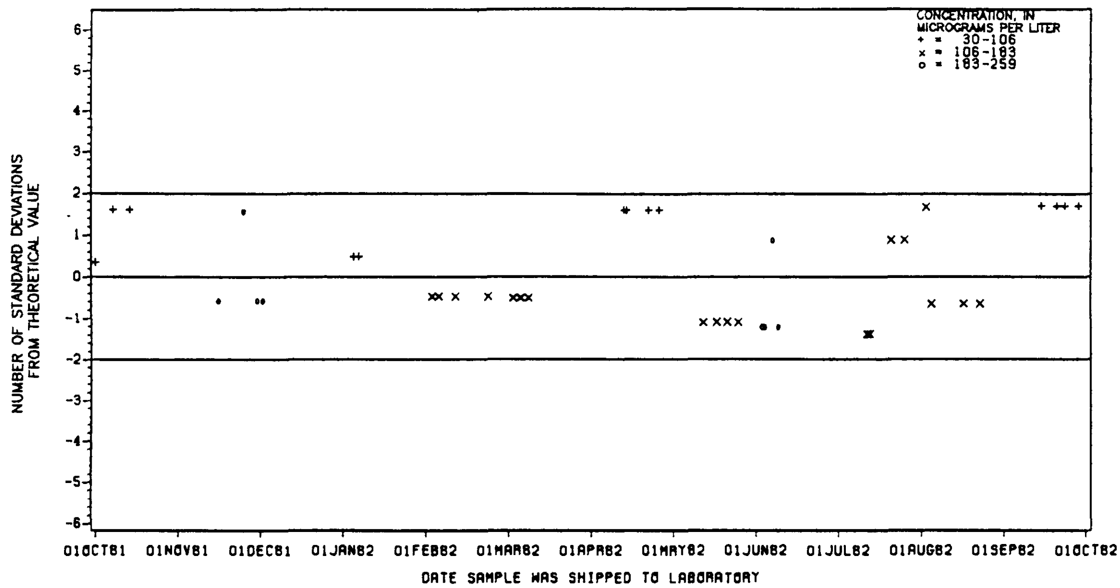

Figure 11.-- Barium, total recoverable, data from the Atlanta laboratory.

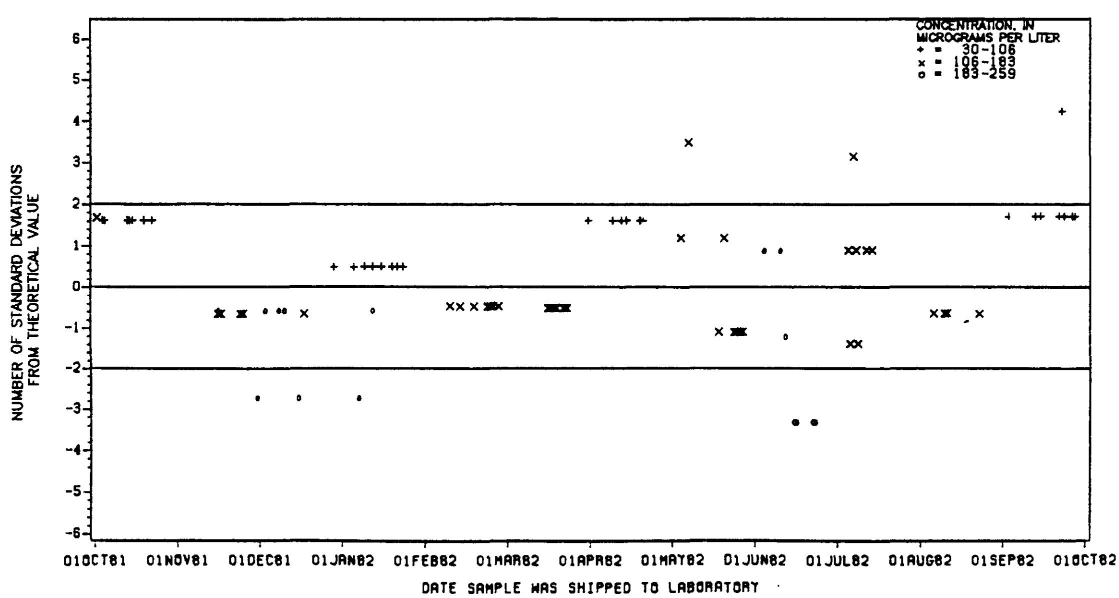

Figure 12.-- Barium, total recoverable, data from the Denver laboratory.

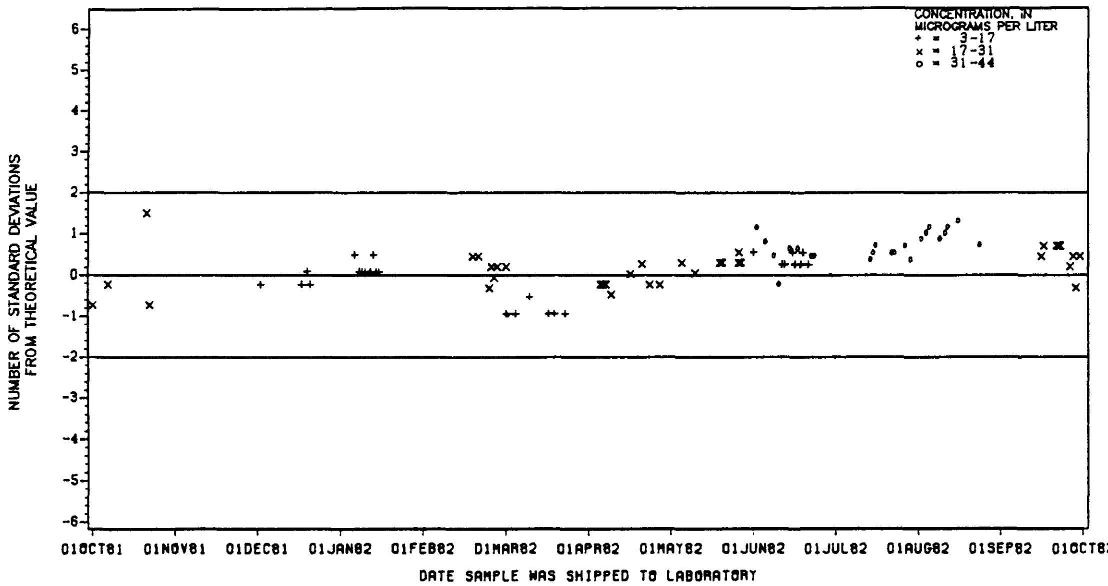

Figure 13.-- Beryllium, dissolved, data from the Atlanta laboratory.

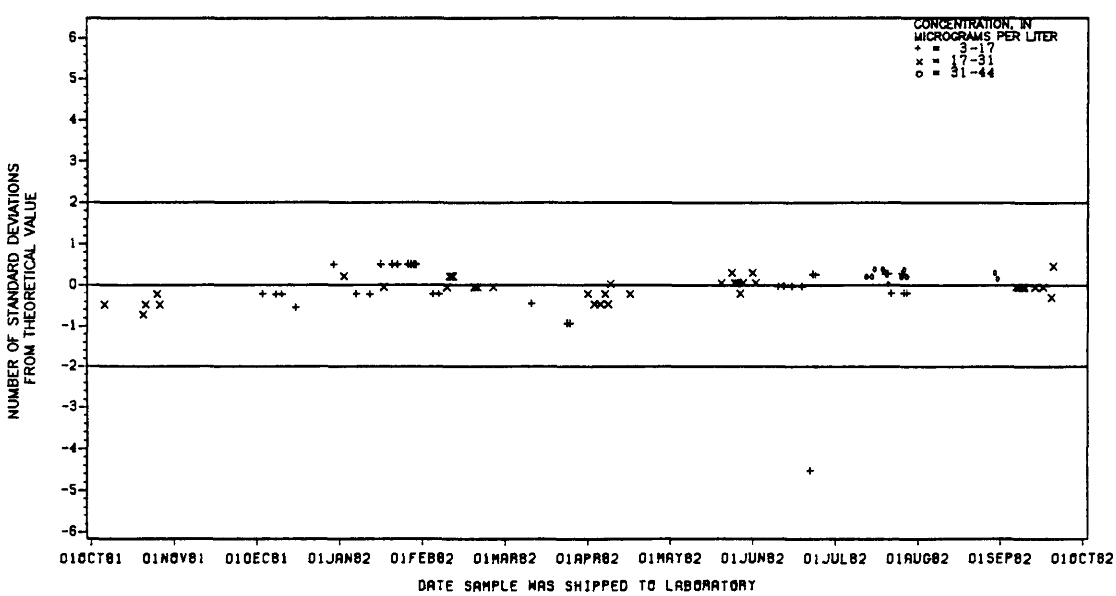

Figure 14.-- Beryllium, dissolved, data from the Denver laboratory.

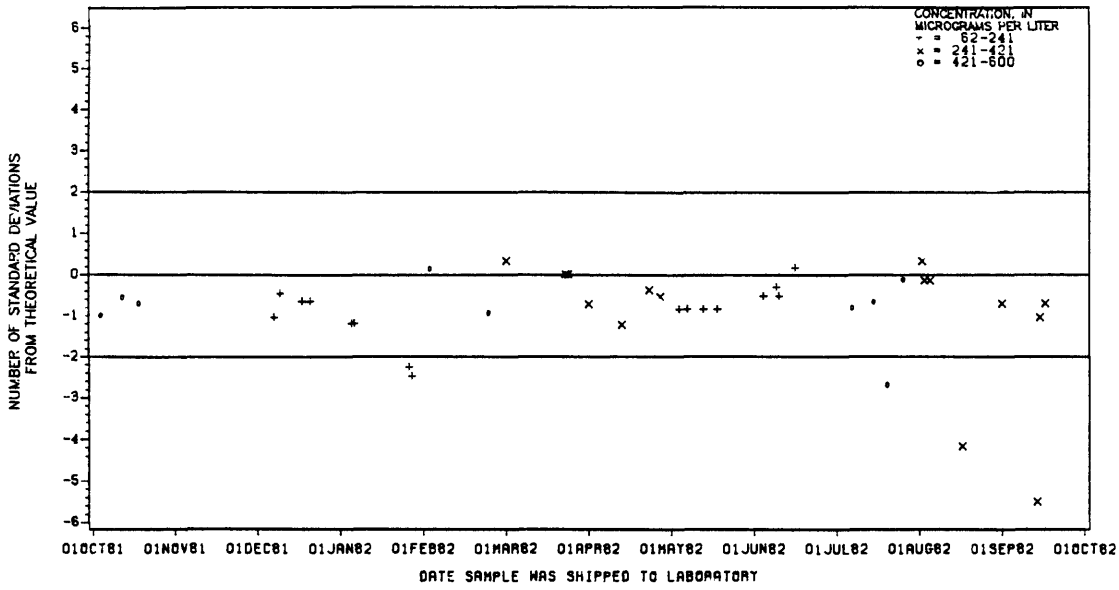

Figure 15.-- Boron, dissolved, data from the Atlanta laboratory.

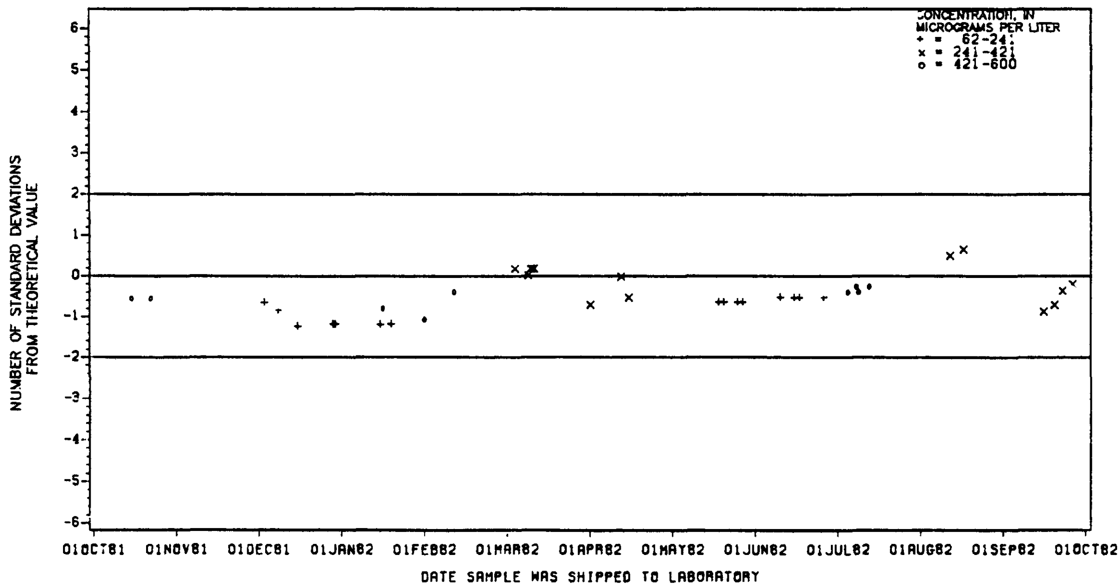

Figure 16.-- Boron, dissolved, data from the Denver laboratory.

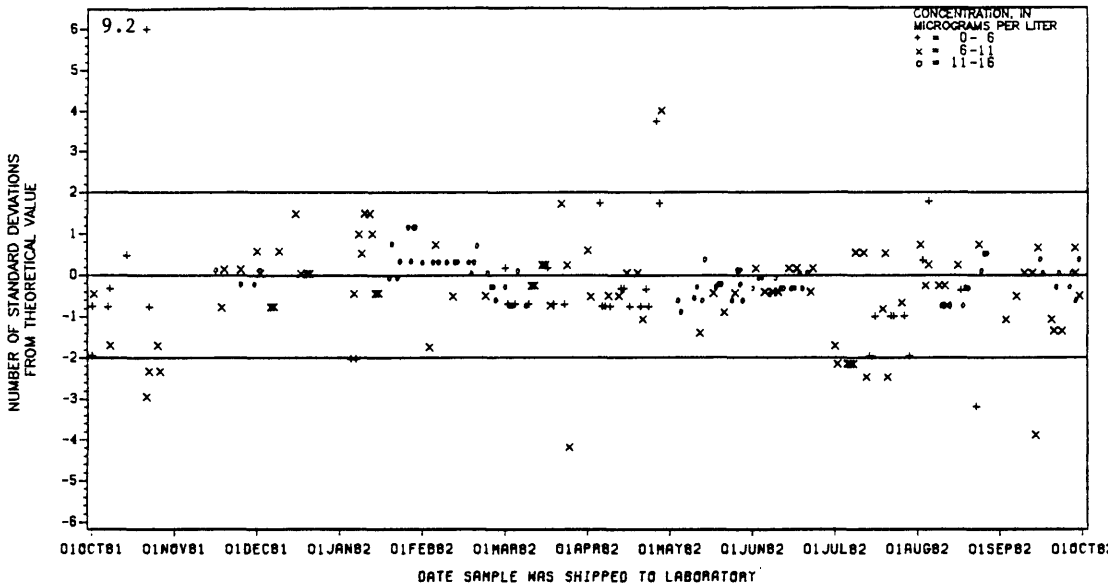

Figure 17.-- Cadmium, dissolved, data from the Atlanta laboratory.

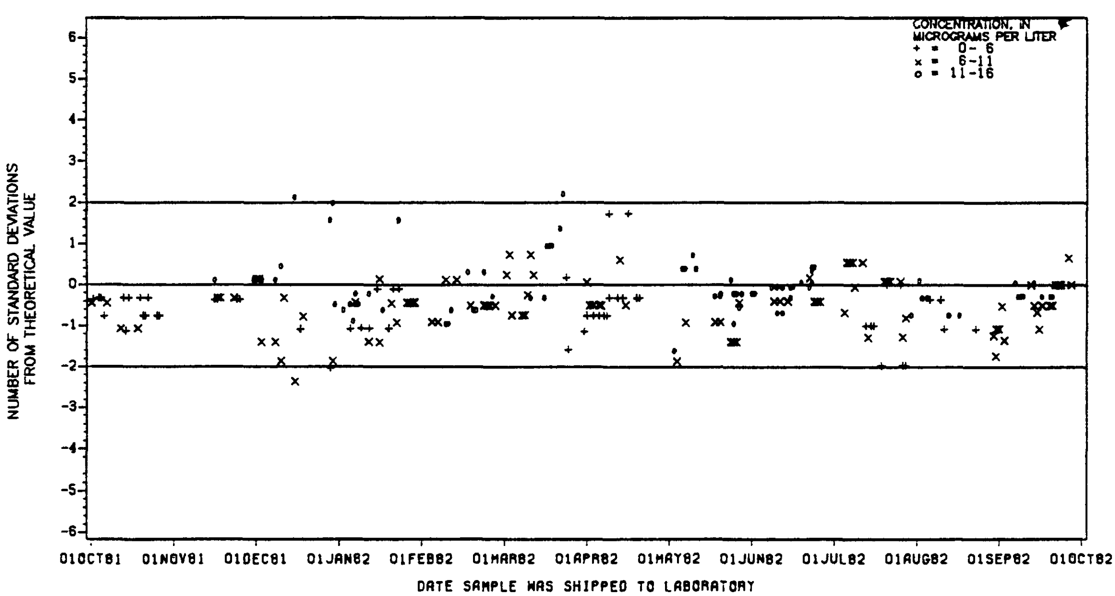

Figure 18.-- Cadmium, dissolved, data from the Denver laboratory.

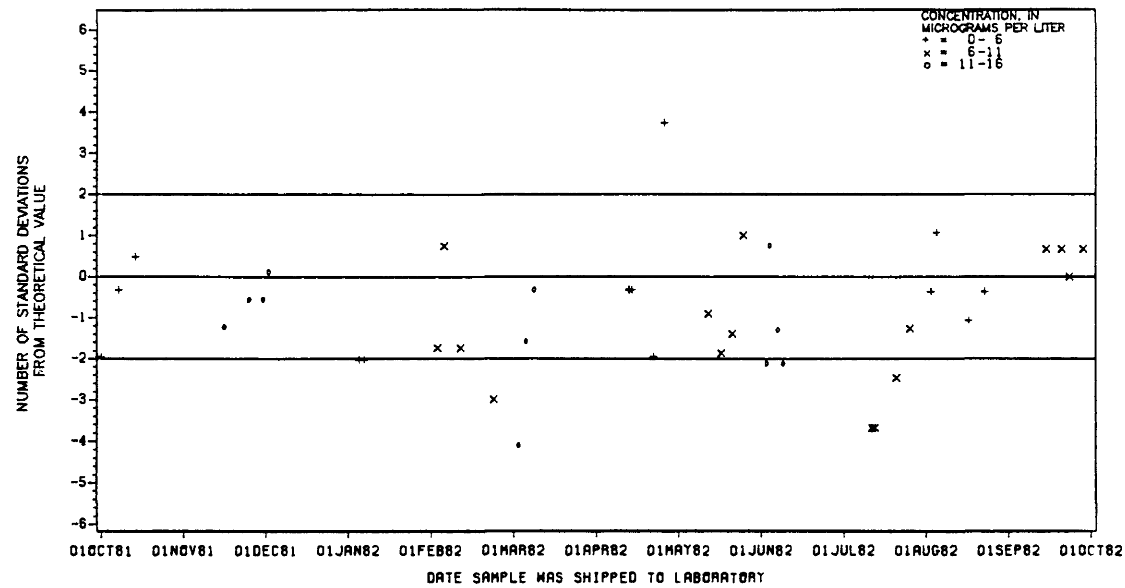

Figure 19.-- Cadmium, total recoverable, data from the Atlanta laboratory.

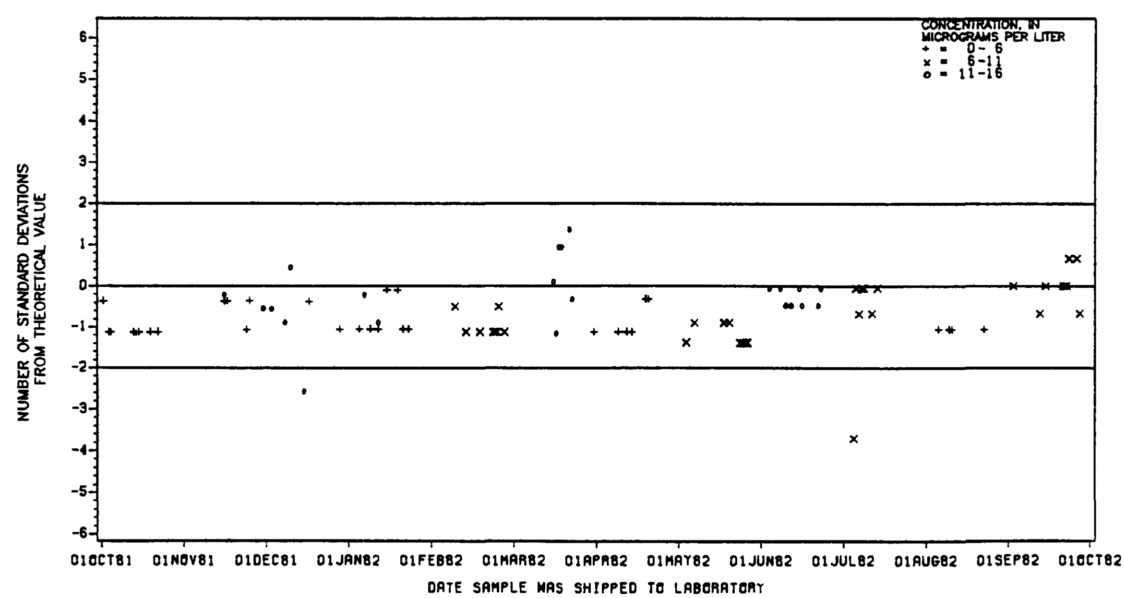

Figure 20.-- Cadmium, total recoverable, data from the Denver laboratory.

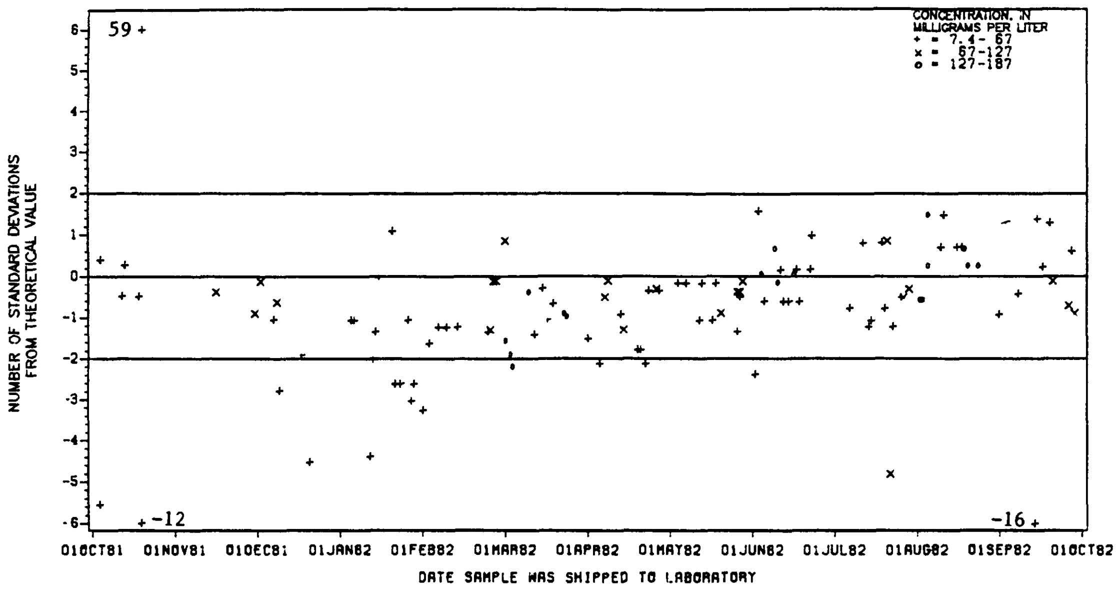

Figure 21.-- Calcium(inductively coupled plasma emission spectrometry), dissolved, data from the Atlanta laboratory.

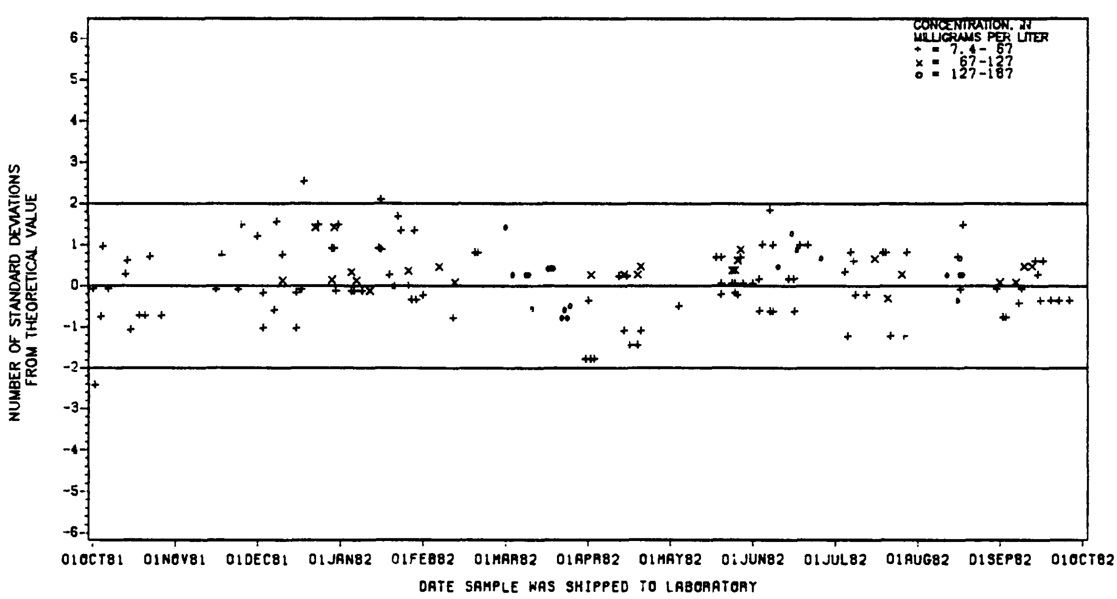

Figure 22.-- Calcium(inductively coupled plasma emission spectrometry), dissolved, data from the Denver laboratory.

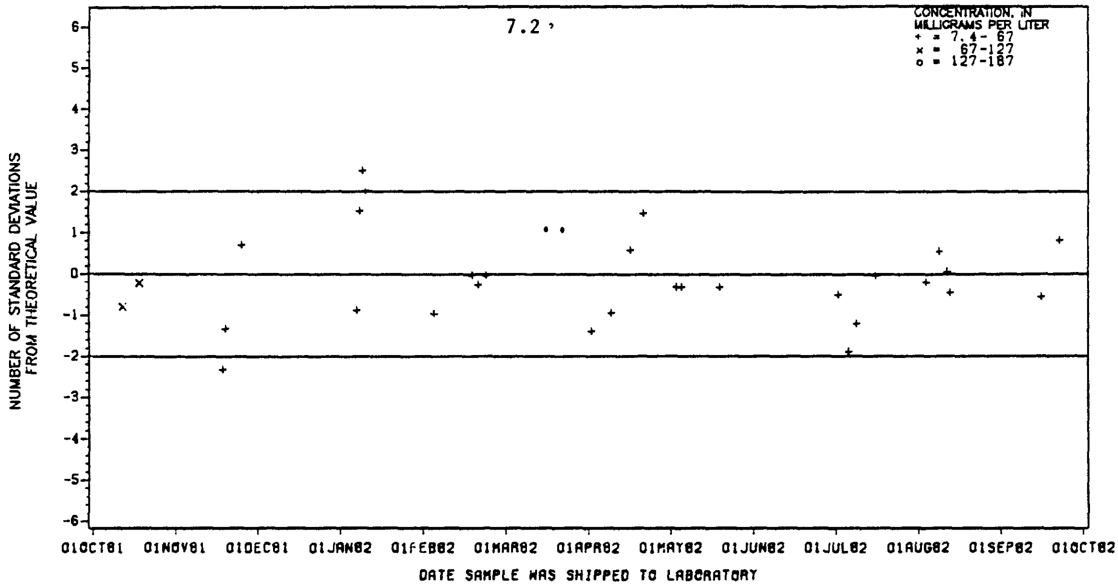

Figure 23.-- Calcium(atomic absorption spectrometry), dissolved, data from the Atlanta laboratory.

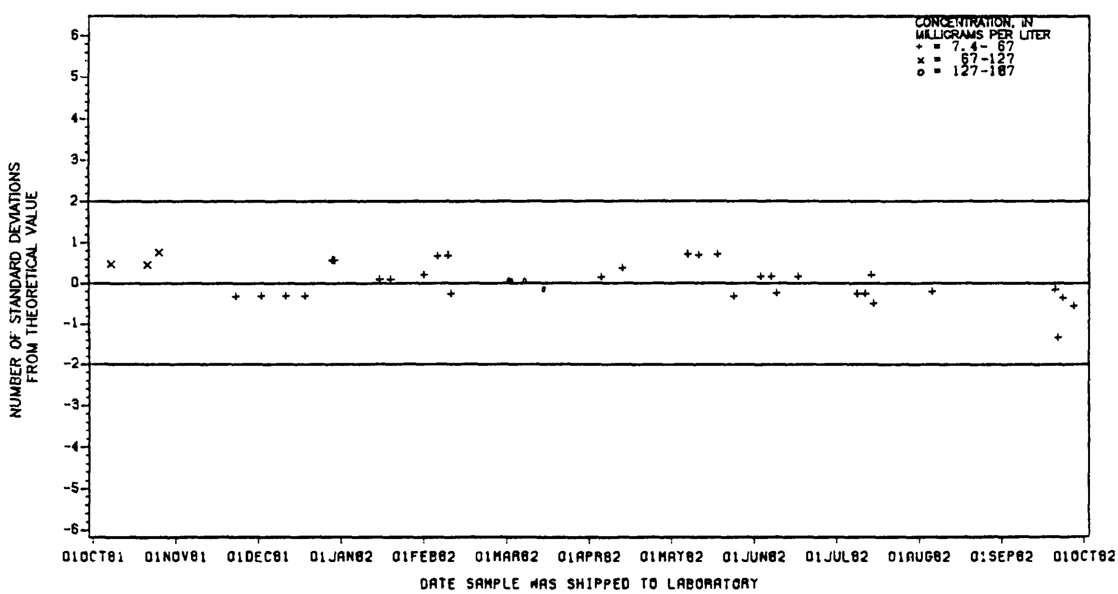

Figure 24.-- Calcium(atomic absorption spectrometry), dissolved, data from the Denver laboratory.

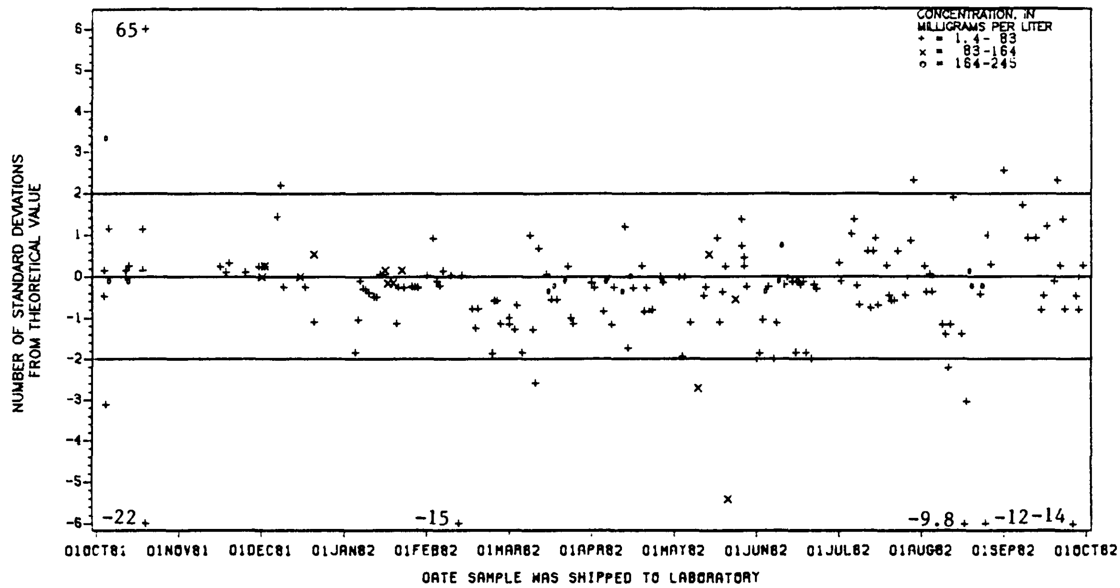

Figure 25.-- Chloride, dissolved, data from the Atlanta laboratory.

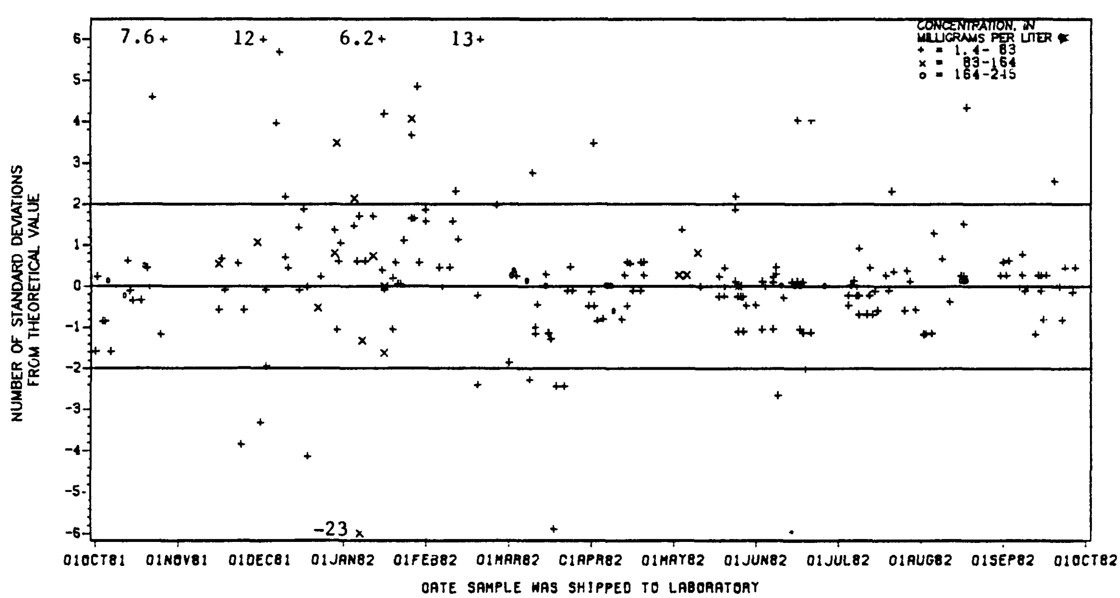

Figure 26.-- Chloride, dissolved, data from the Denver laboratory.

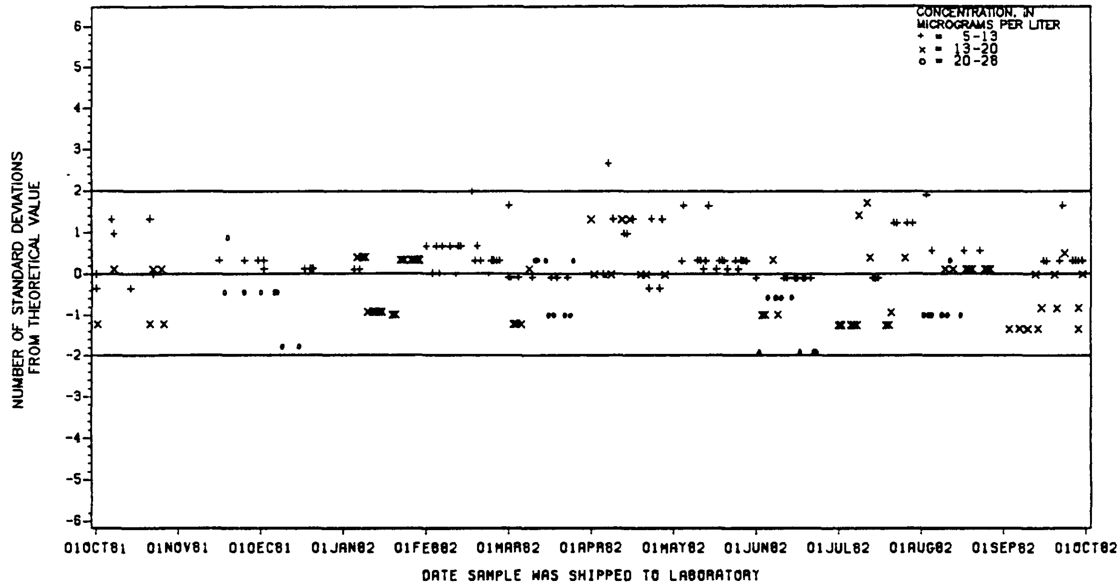

Figure 27.-- Chromium, dissolved, data from the Atlanta laboratory.

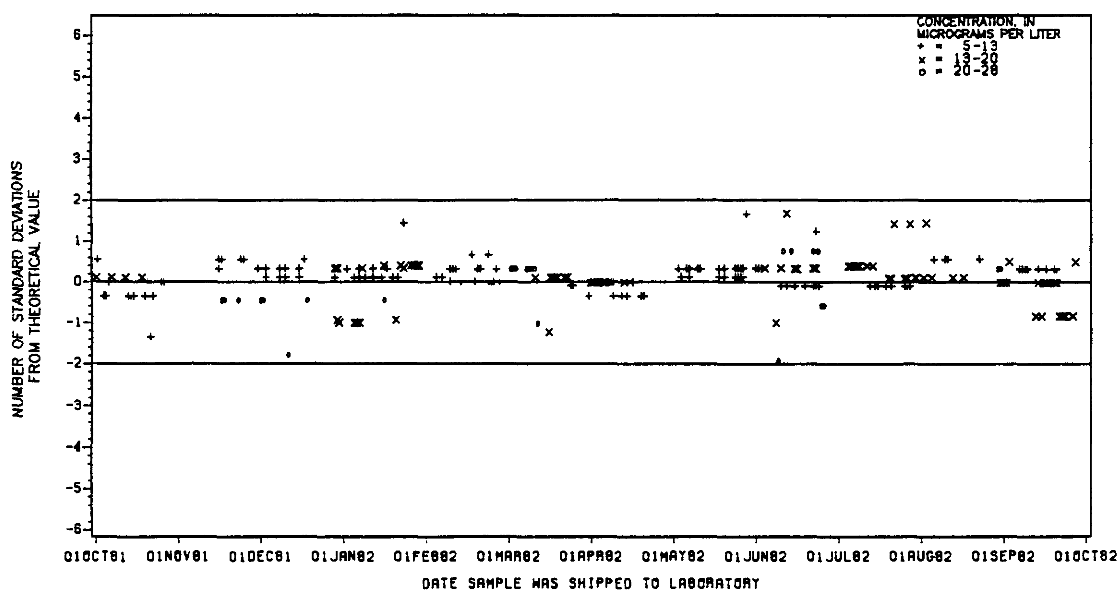

Figure 28.-- Chromium, dissolved, data from the Denver laboratory.

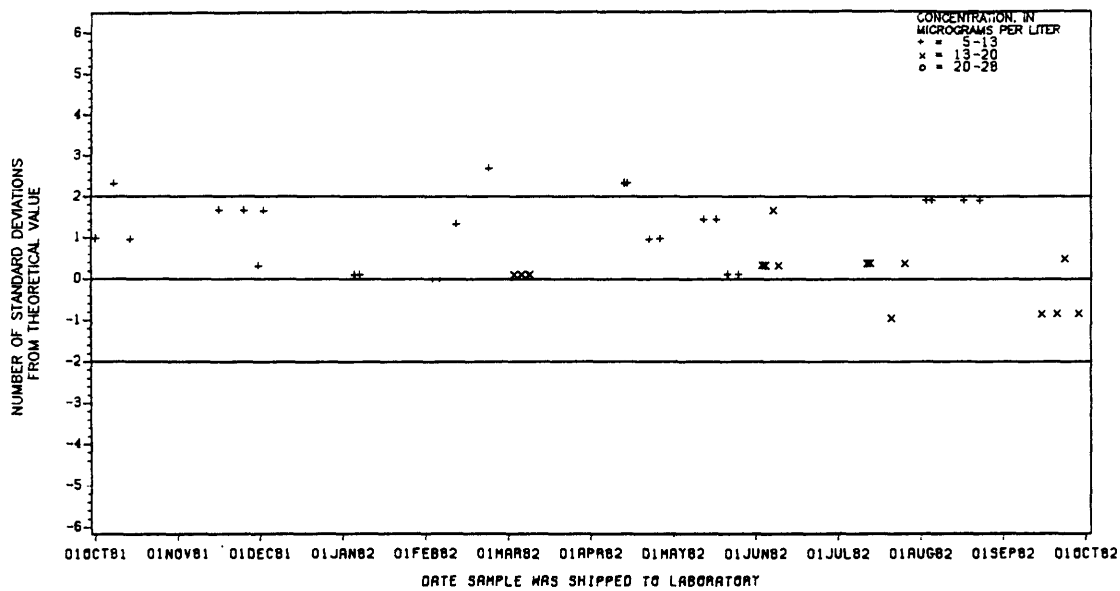

Figure 29.-- Chromium, total recoverable, data from the Atlanta laboratory.

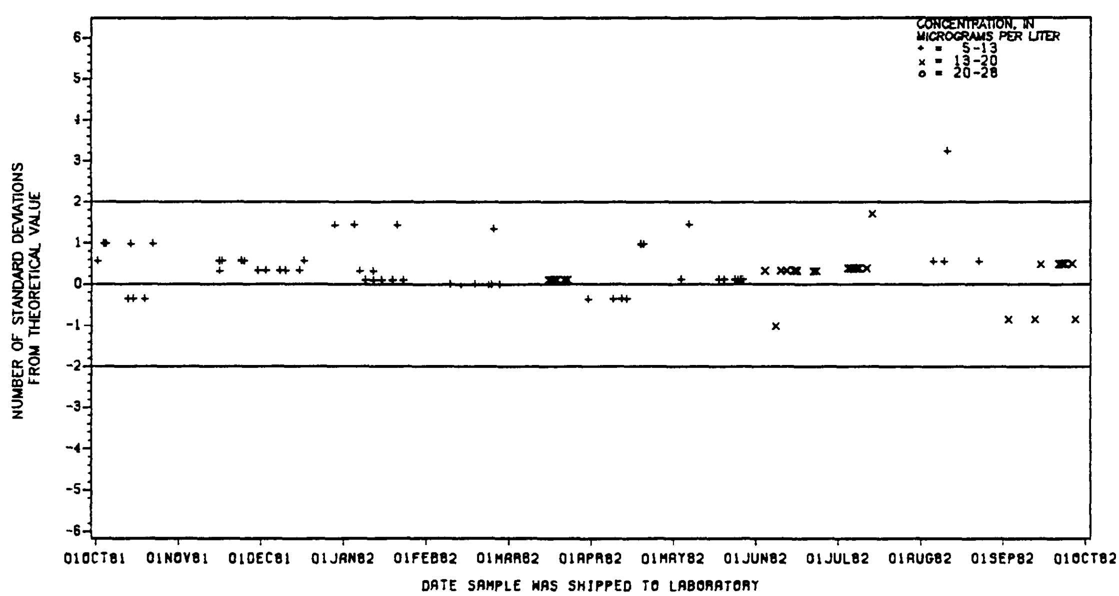

Figure 30.-- Chromium, total recoverable, data from the Denver laboratory.

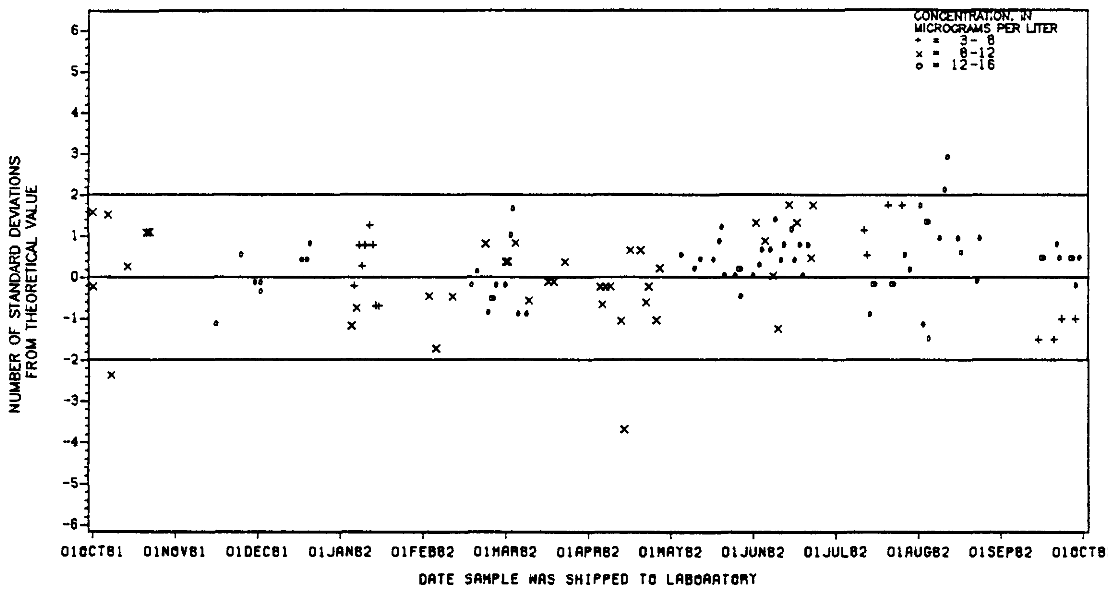

Figure 31.-- Cobalt, dissolved, data from the Atlanta laboratory.

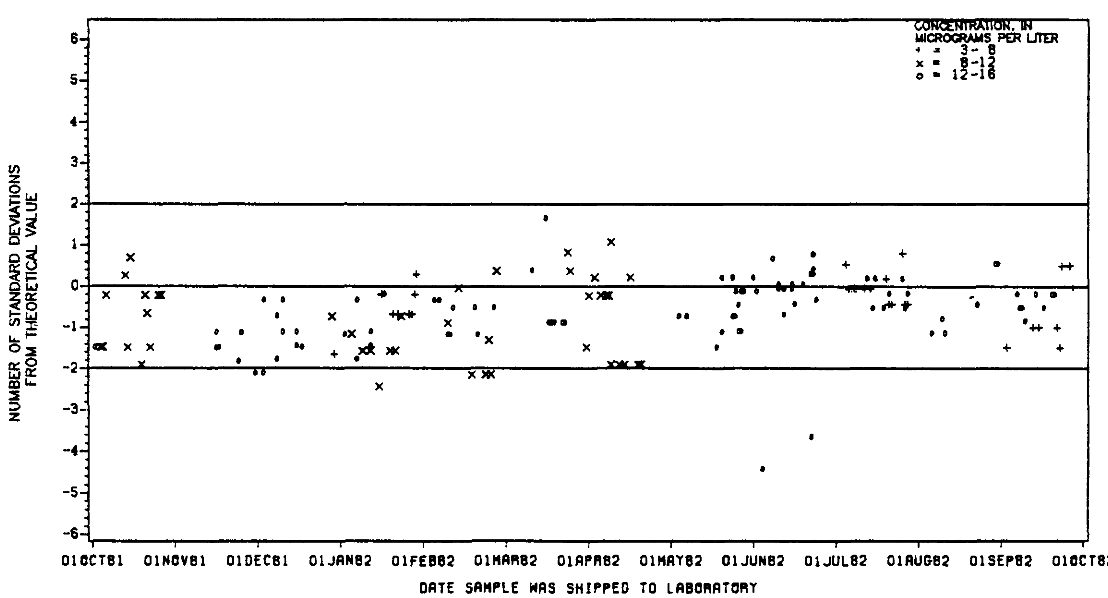

Figure 32.-- Cobalt, dissolved, data from the Denver laboratory.

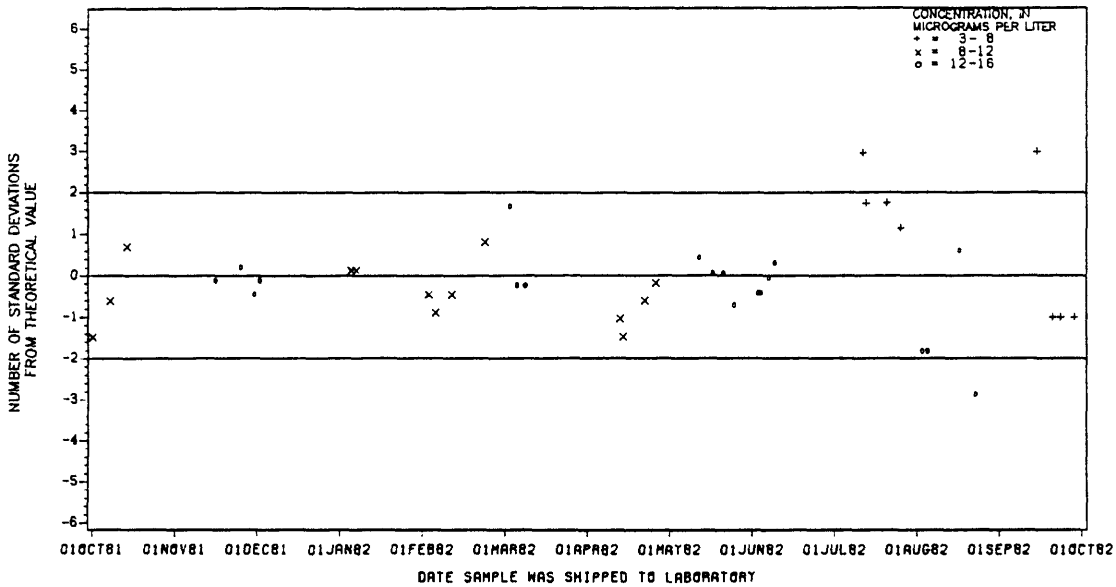

Figure 33.-- Cobalt, total recoverable, data from the Atlanta laboratory.

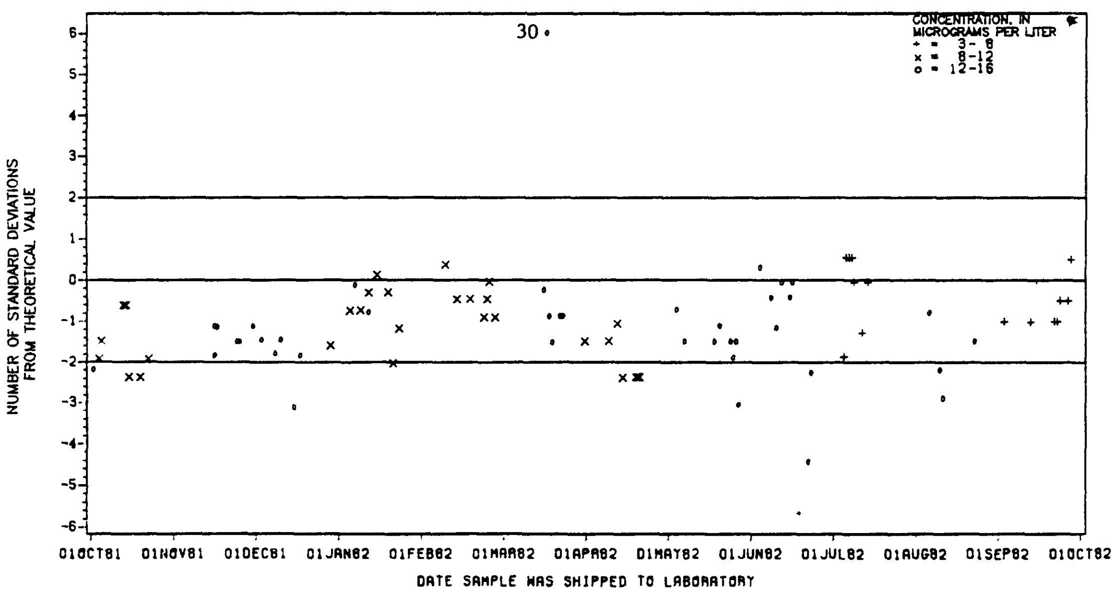

Figure 34.-- Cobalt, total recoverable, data from the Denver laboratory.

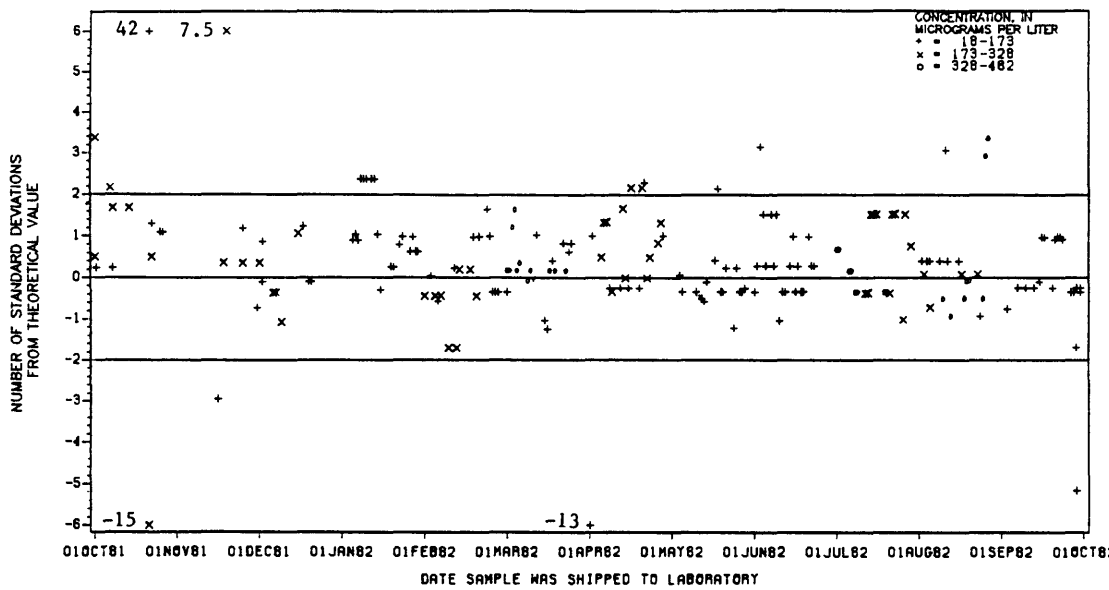

Figure 35.-- Copper, dissolved, data from the Atlanta laboratory.

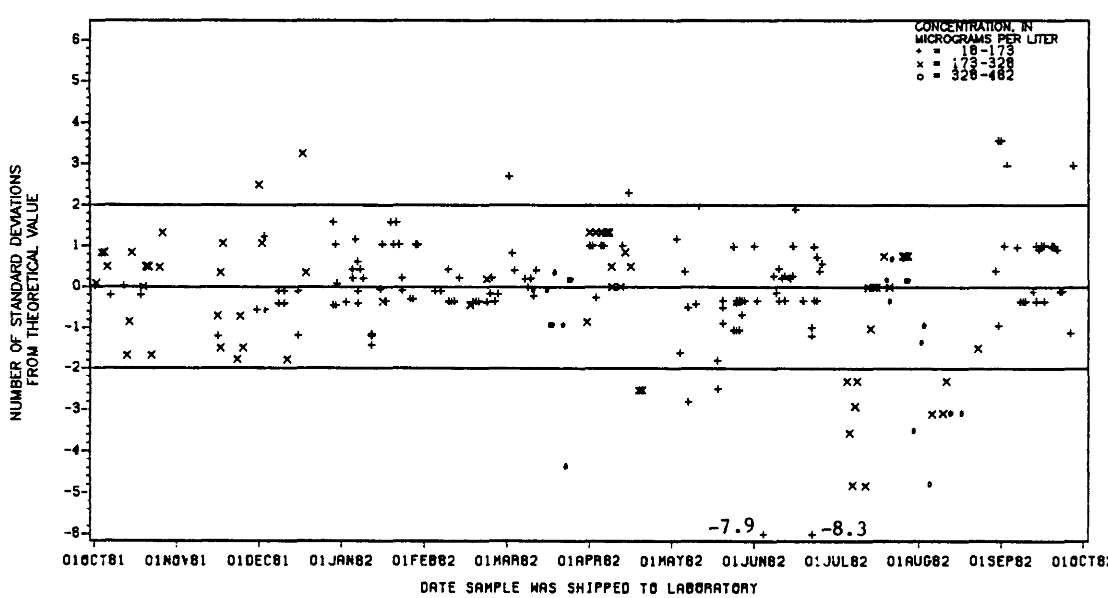

Figure 36.-- Copper, dissolved, data from the Denver laboratory.

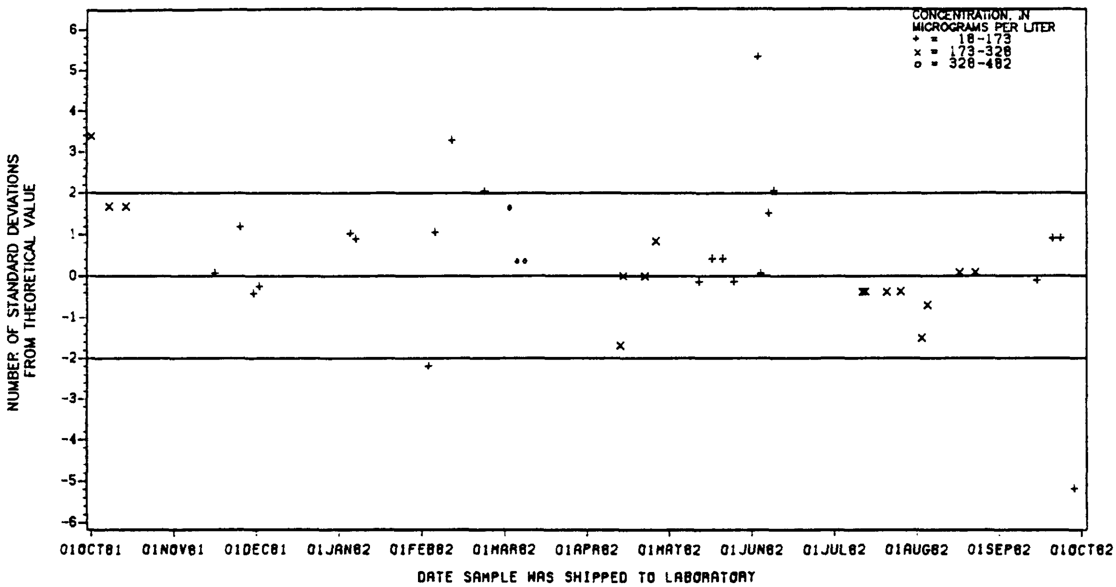

Figure 37.-- Copper, total recoverable, data from the Atlanta laboratory.

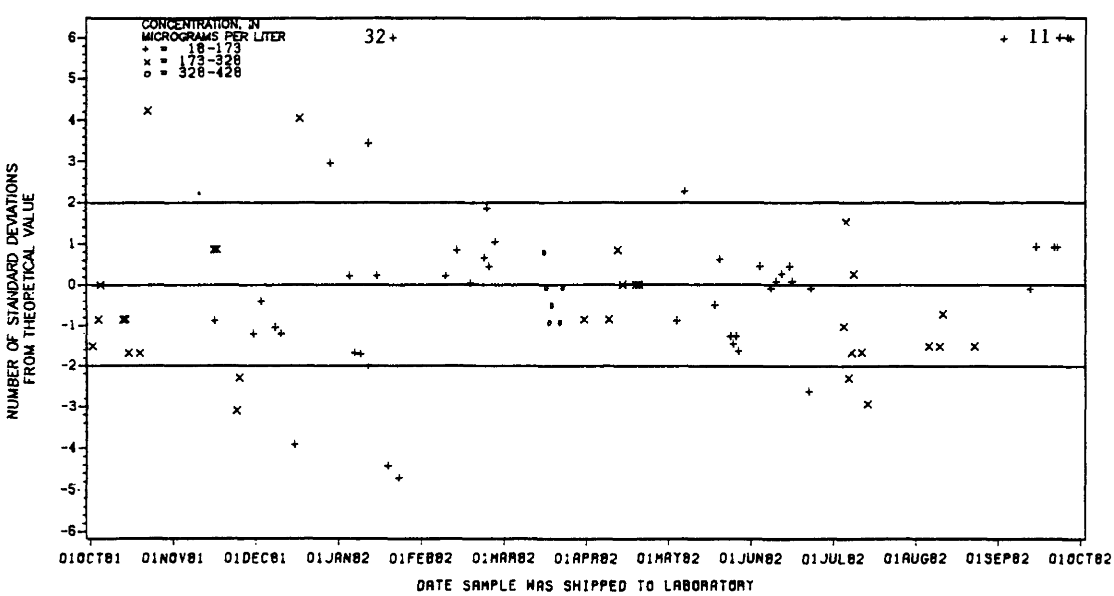

Figure 38.-- Copper, total recoverable, data from the Denver laboratory.

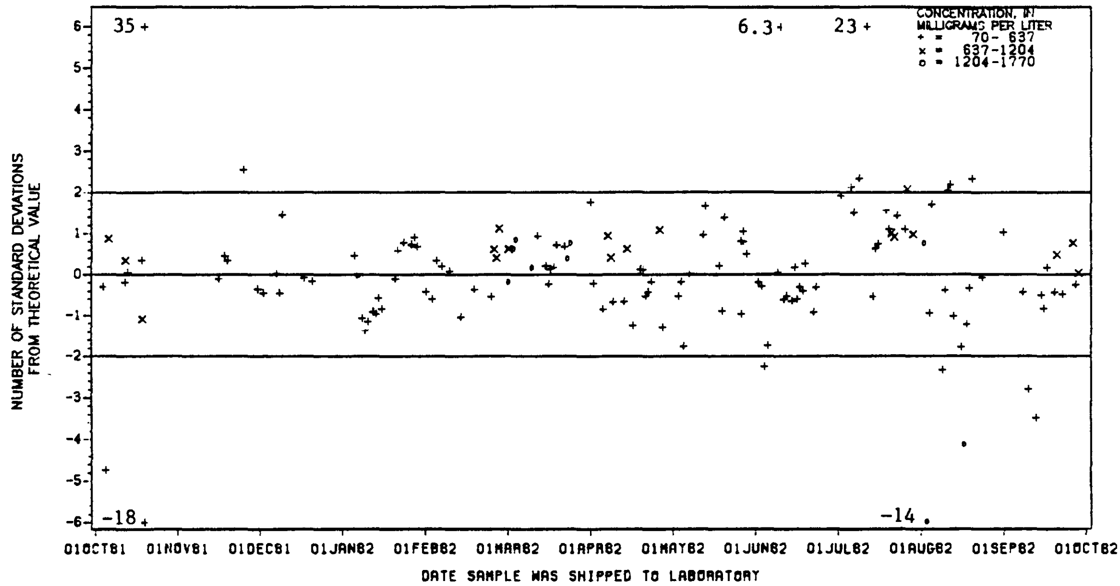

Figure 39.-- Dissolved solids, data from the Atlanta laboratory.

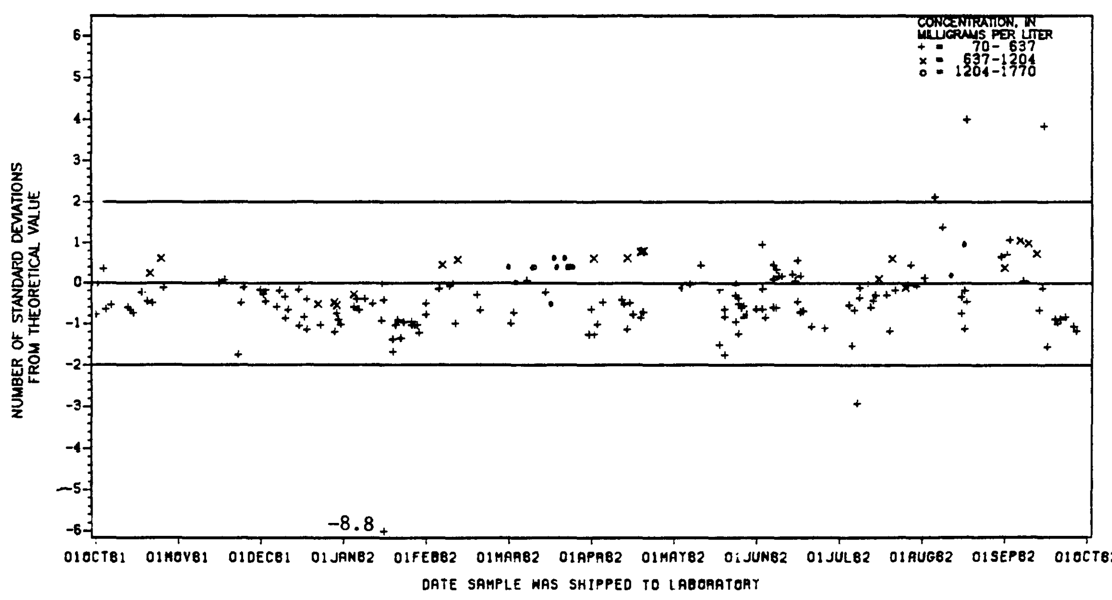

Figure 40.-- Dissolved solids, data from the Denver laboratory.

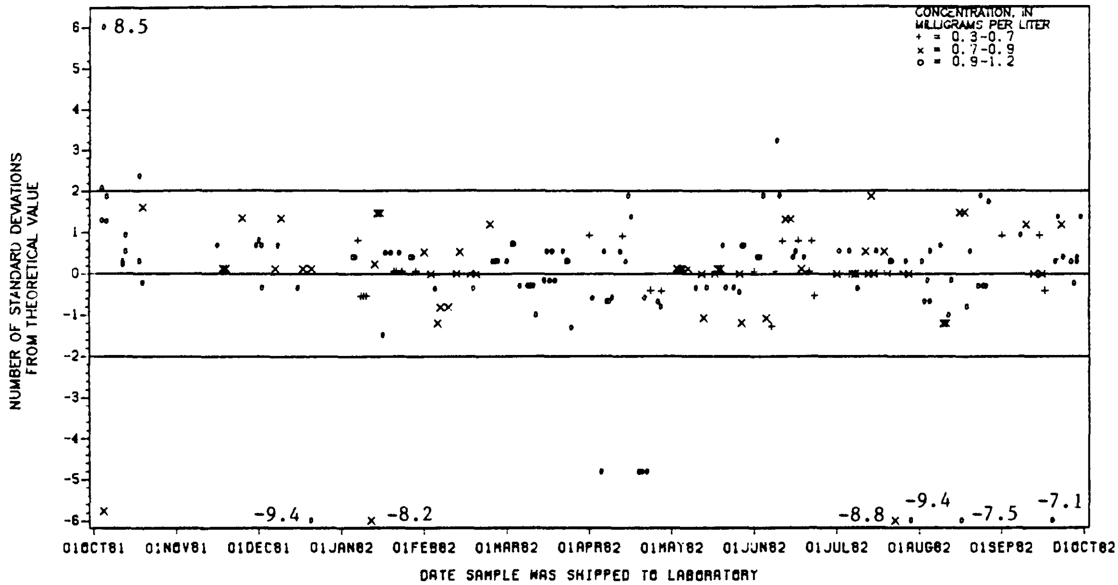

Figure 41.-- Fluoride, dissolved, data from the Atlanta laboratory.

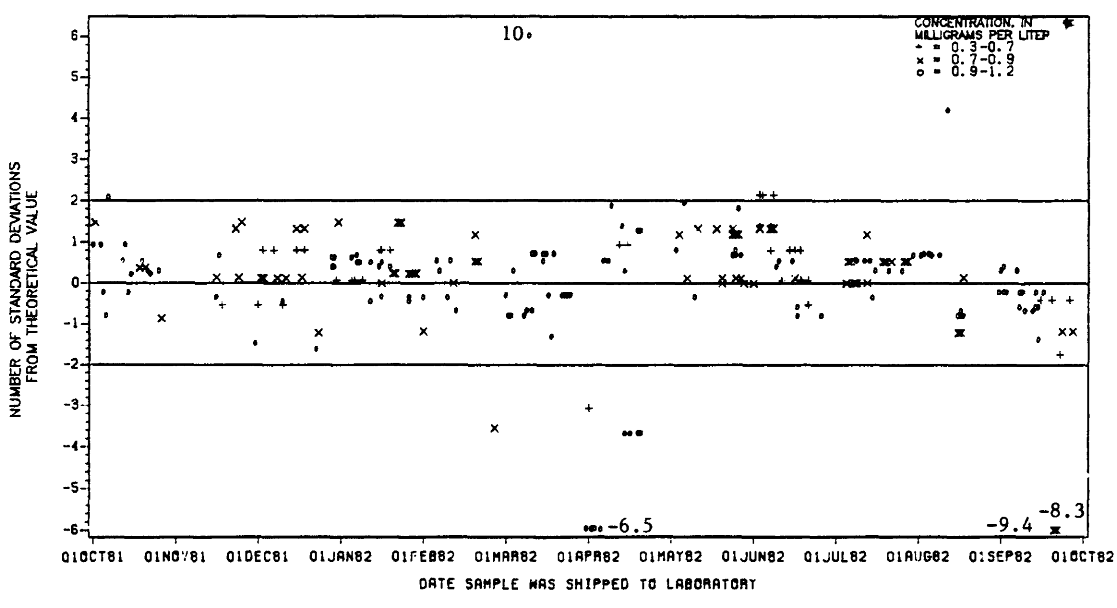

Figure 42.-- Fluoride, dissolved, data from the Denver laboratory.

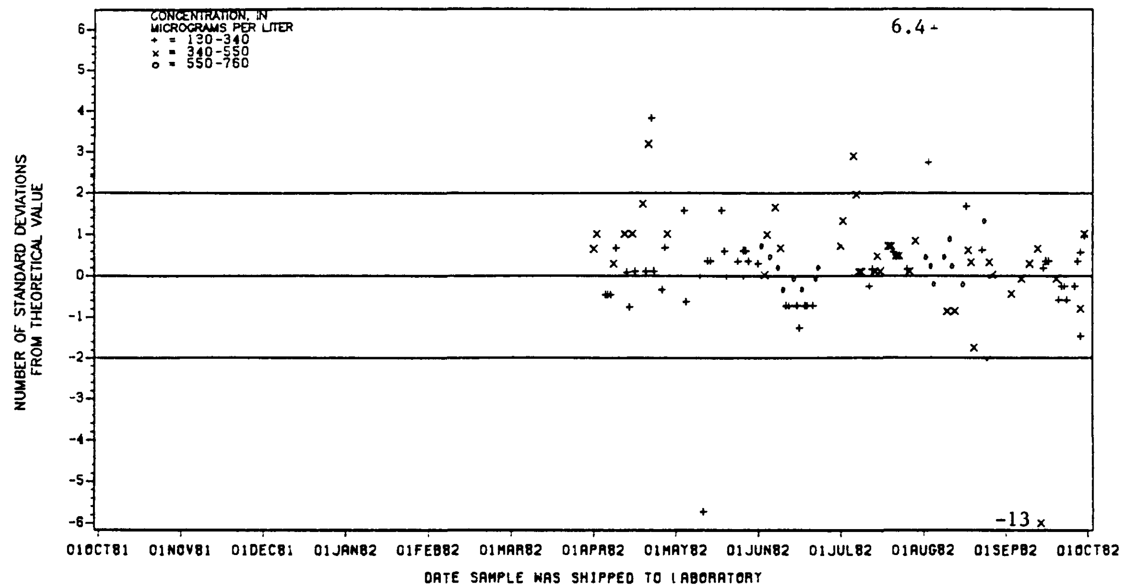

Figure 43.-- Iron, dissolved, data from the Atlanta laboratory.

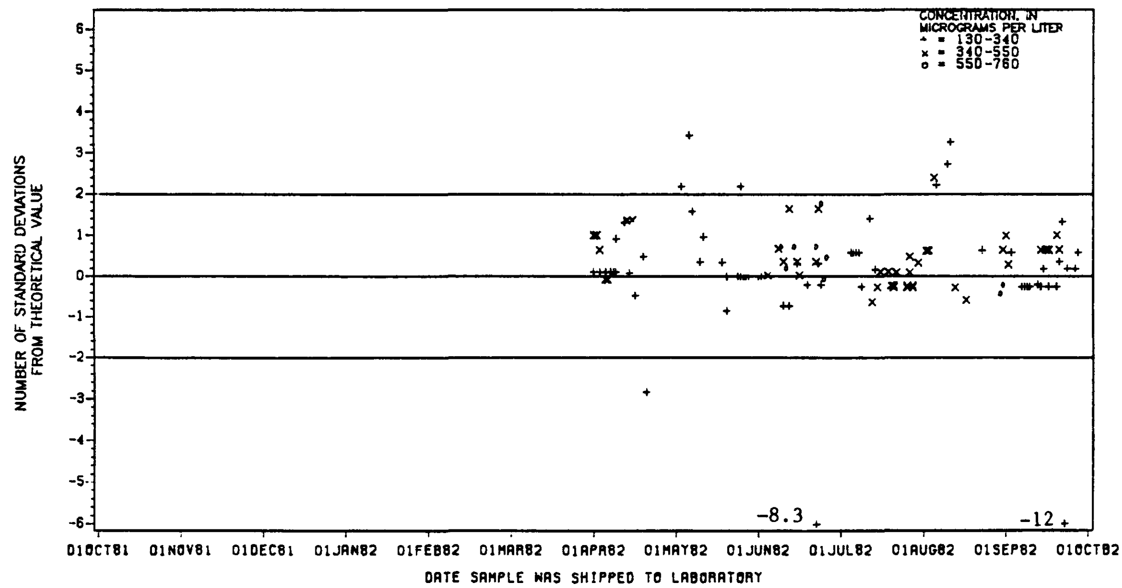

Figure 44.-- Iron, dissolved, data from the Denver laboratory.

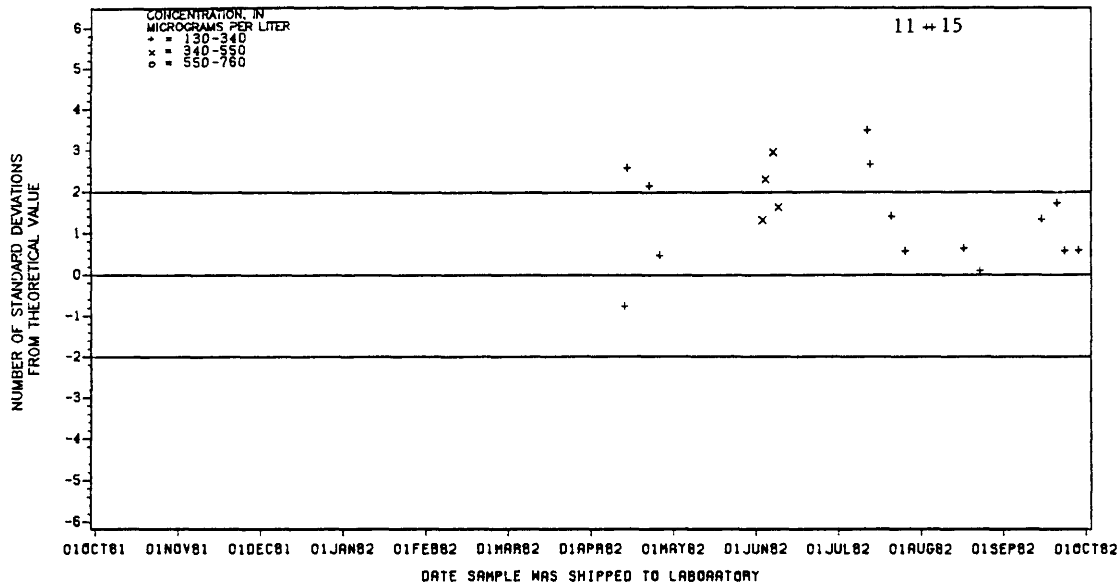

Figure 45.-- Iron, total recoverable, data from the Atlanta laboratory.

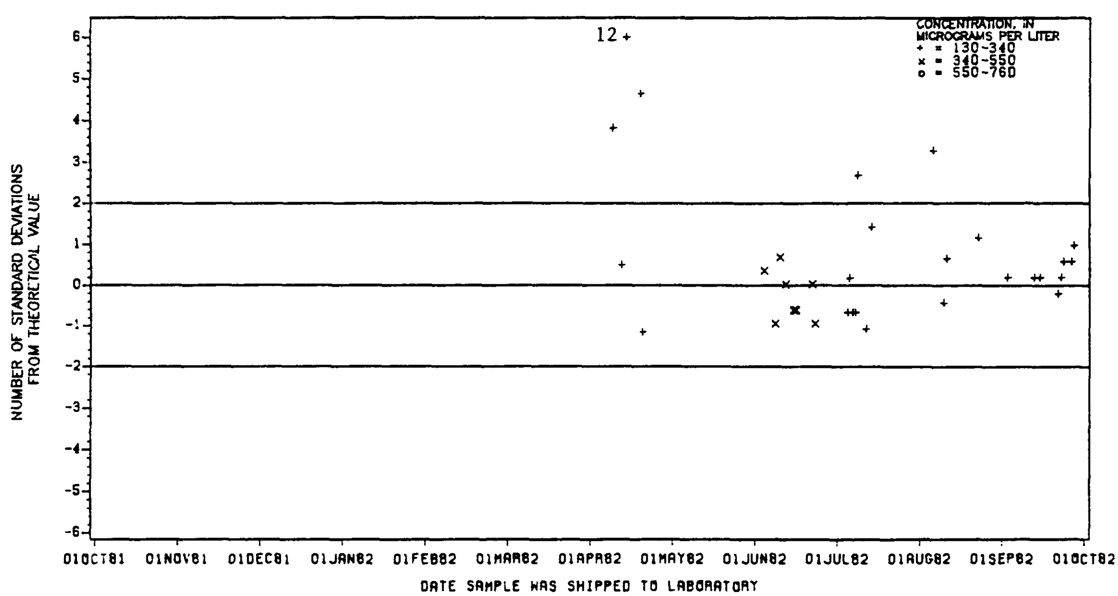

Figure 46.-- Iron, total recoverable, data from the Denver laboratory.

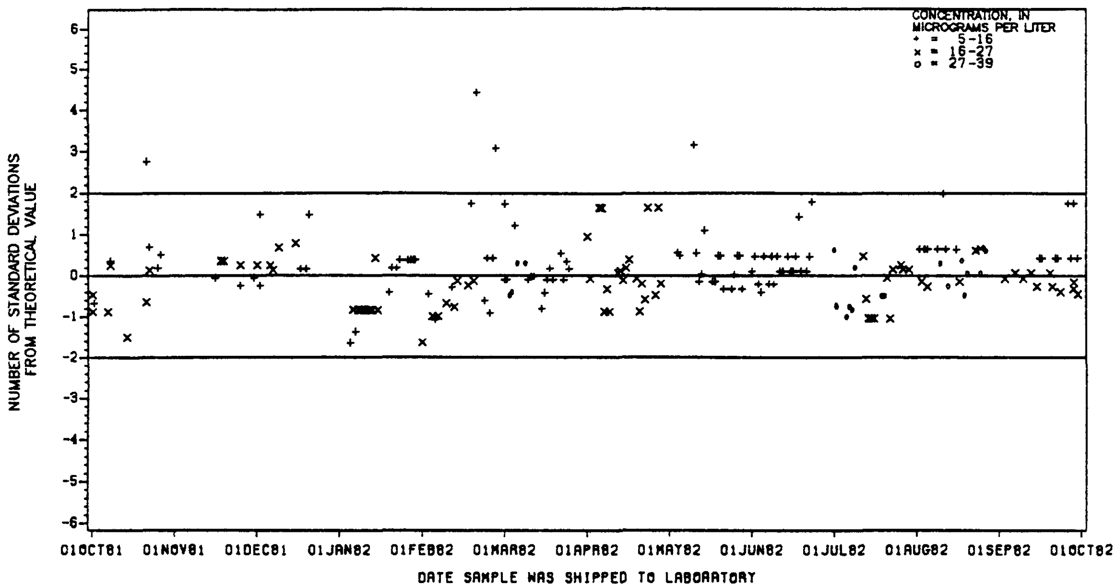

Figure 47.-- Lead, dissolved, data from the Atlanta laboratory.

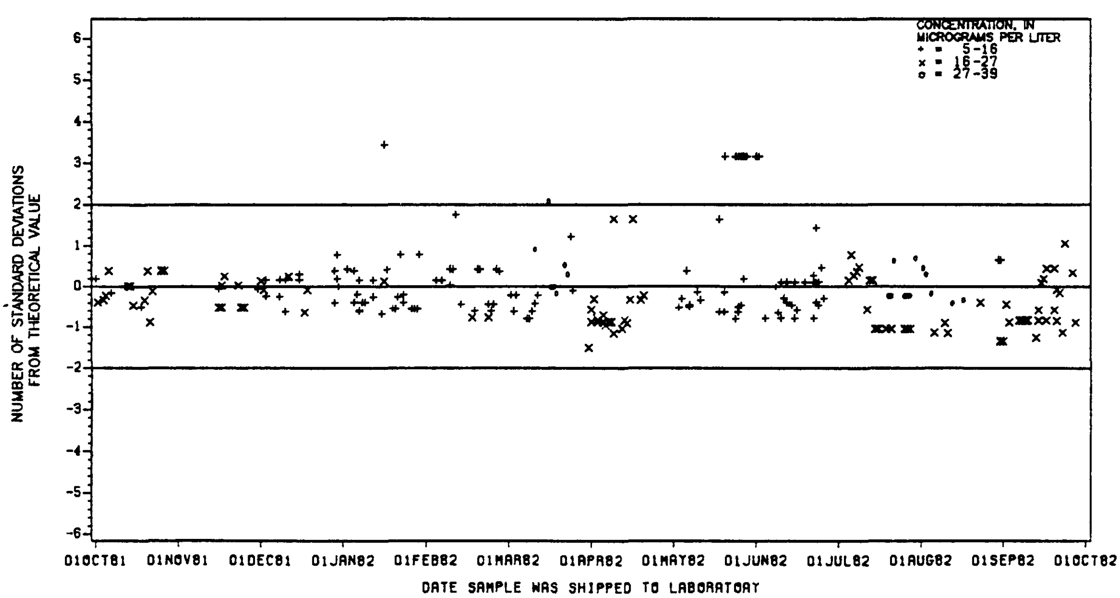

Figure 48.-- Lead, dissolved, data from the Denver laboratory.

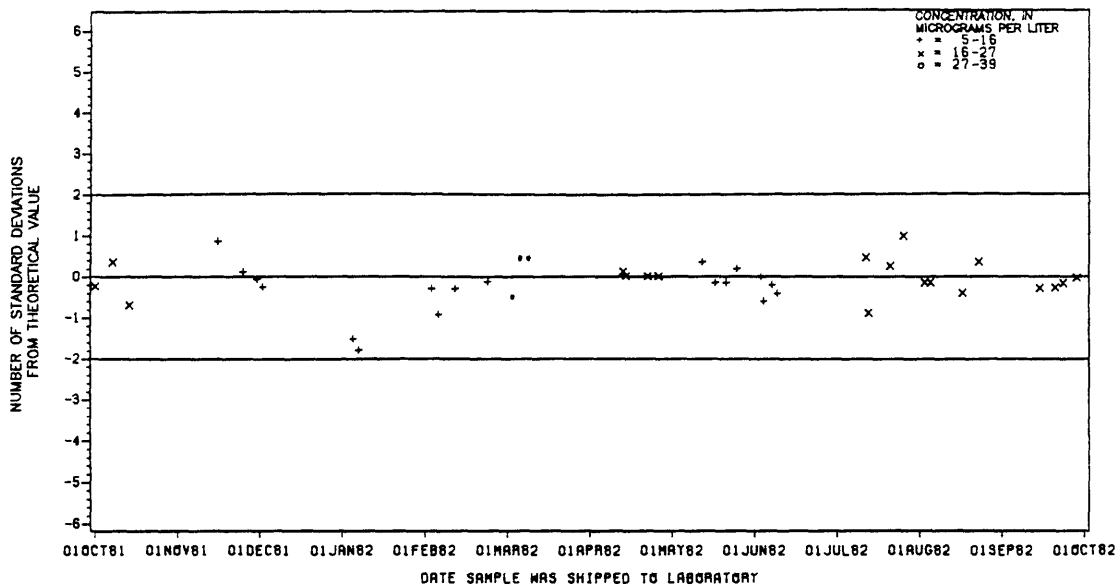

Figure 49.-- Lead, total recoverable, data from the Atlanta laboratory.

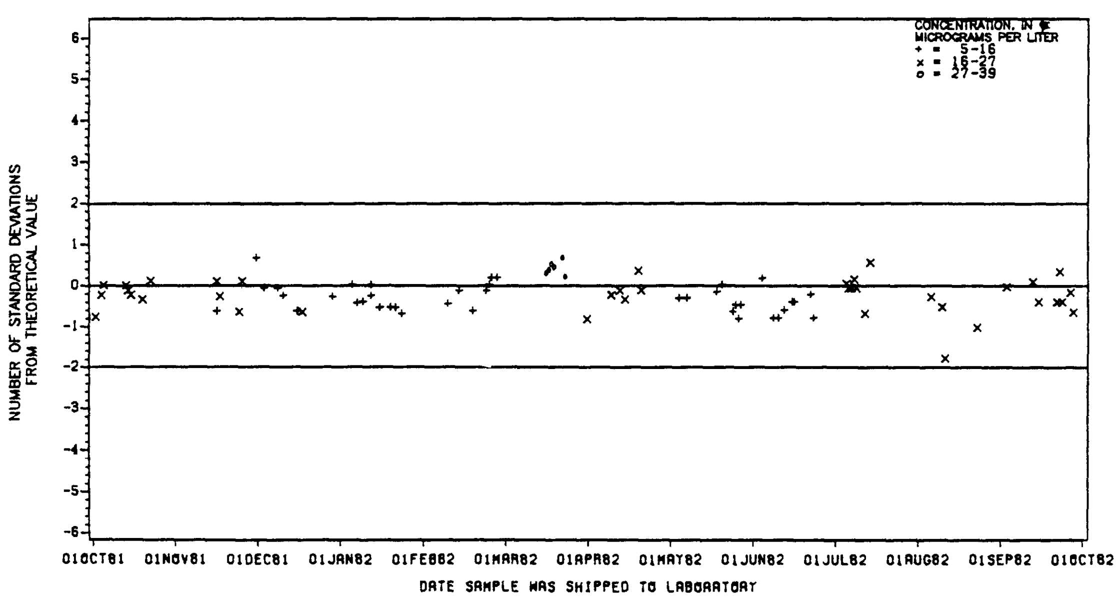

Figure 50.-- Lead, total recoverable, data from the Denver laboratory.

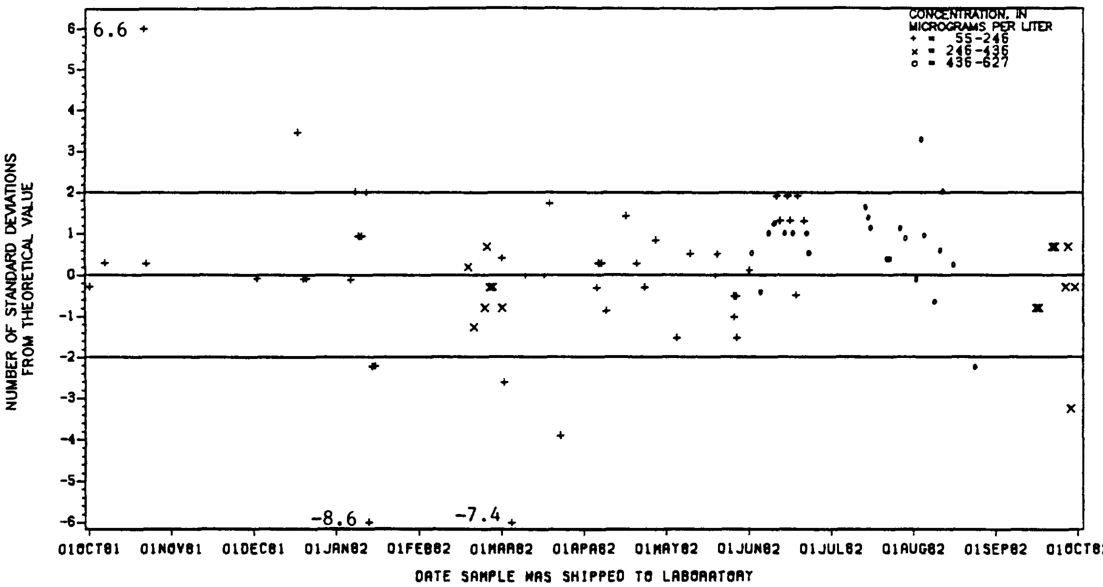

Figure 51.-- Lithium, dissolved, data from the Atlanta laboratory.

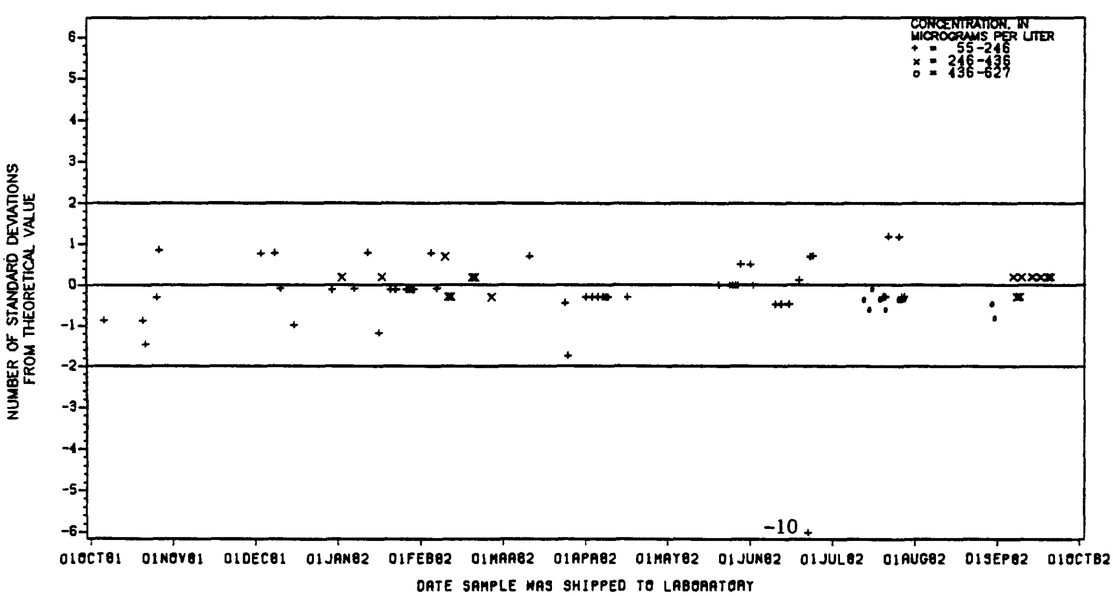

Figure 52.-- Lithium, dissolved, data from the Denver laboratory.

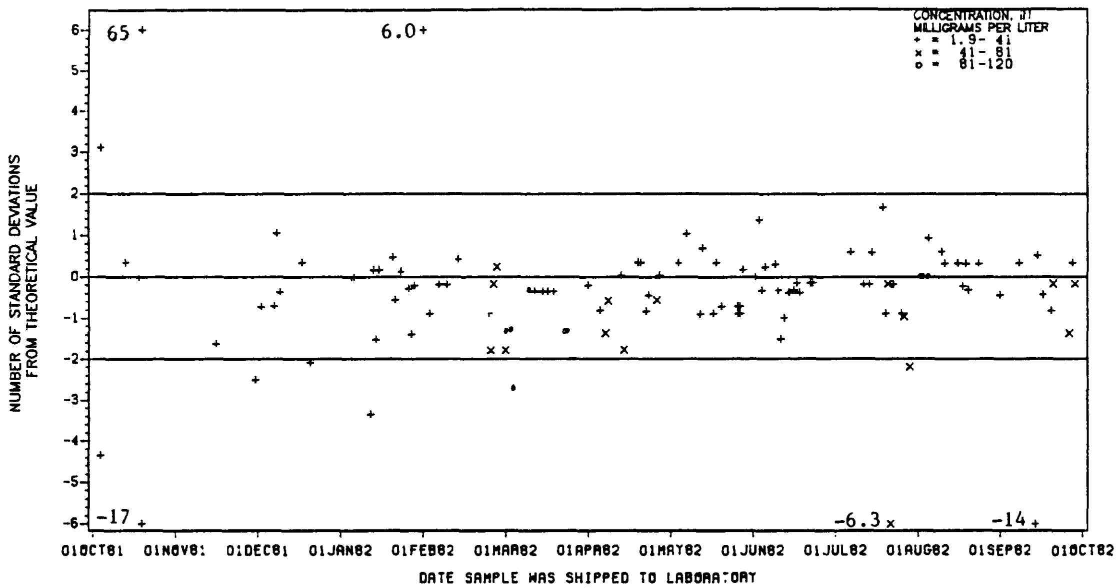

Figure 53.-- Magnesium, dissolved(inductively coupled plasma emission spectrometry), data from the Atlanta laboratory.

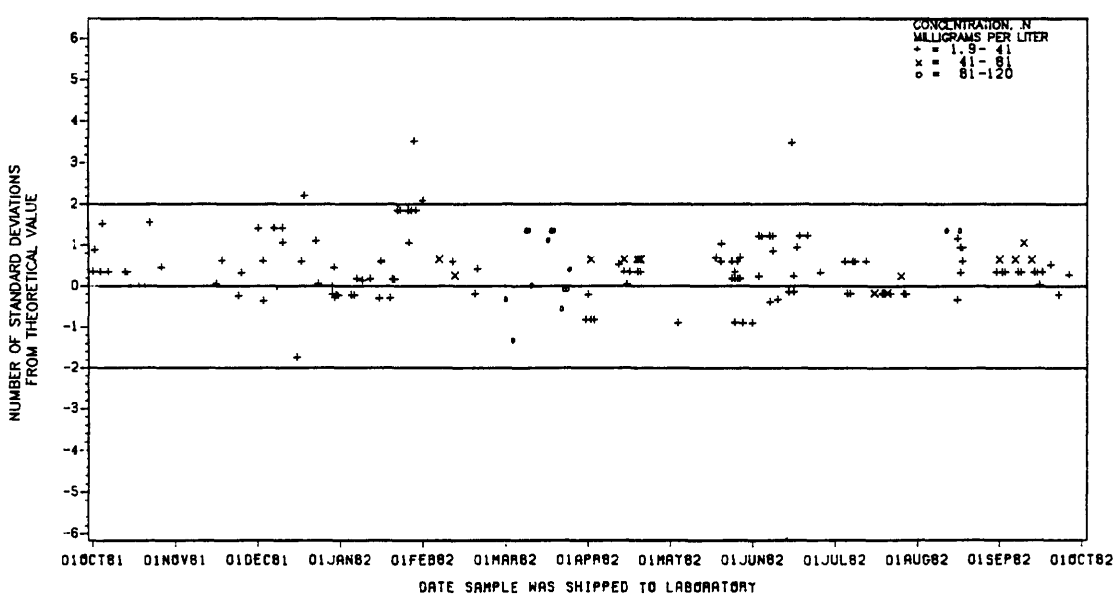

Figure 54.-- Magnesium, dissolved(inductively coupled plasma emission spectrometry), data from the Denver laboratory.

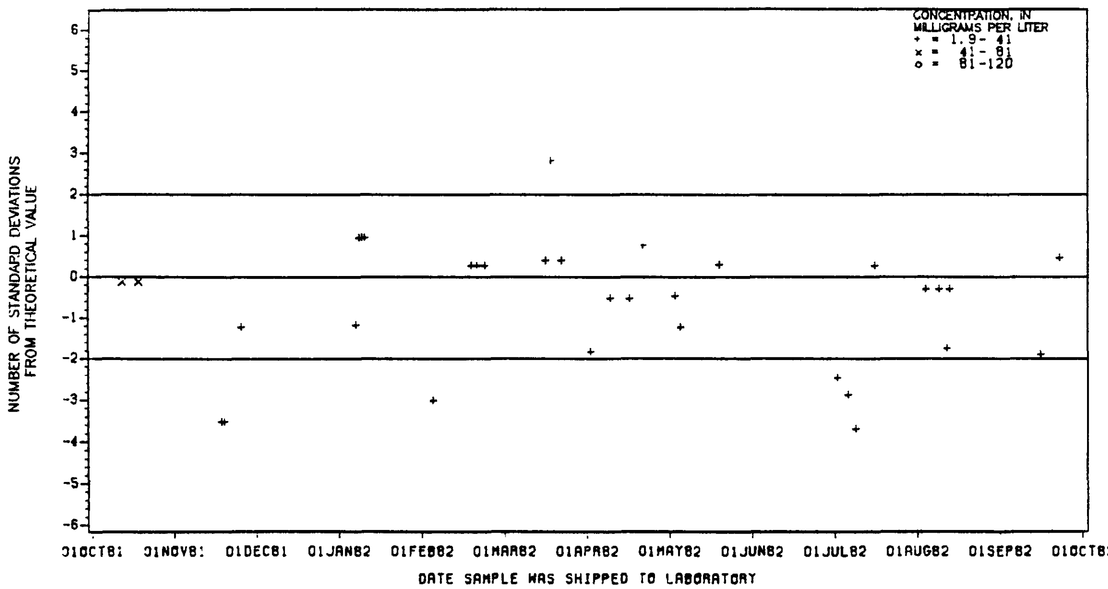

Figure 55.-- Magnesium, dissolved(atomic absorption spectrometry), data from the Atlanta laboratory.

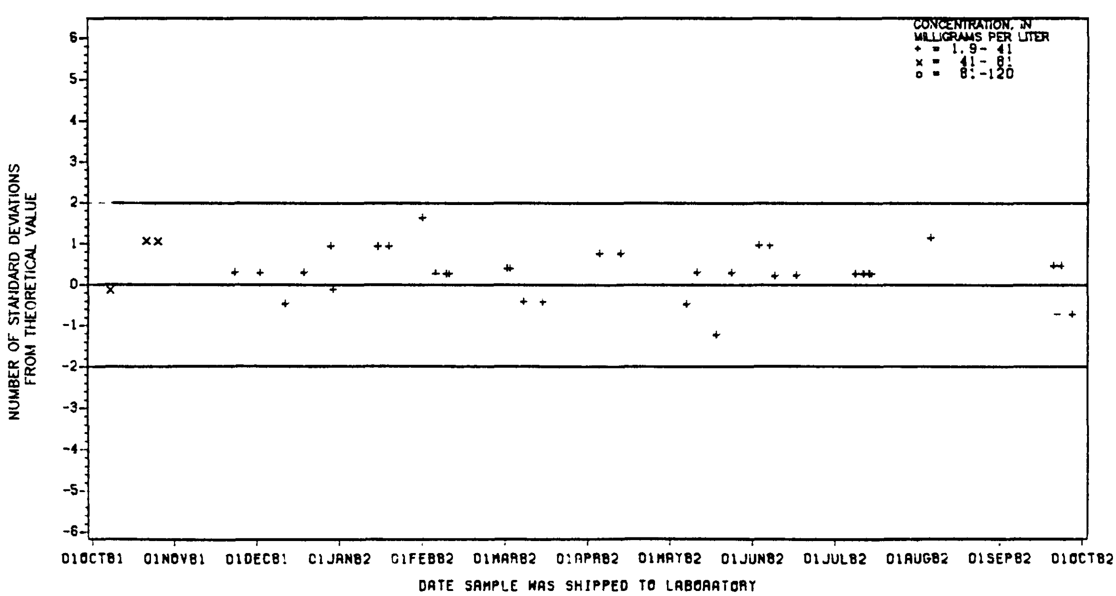

Figure 56.-- Magnesium, dissolved(atomic absorption spectrometry), data from the Denver laboratory.

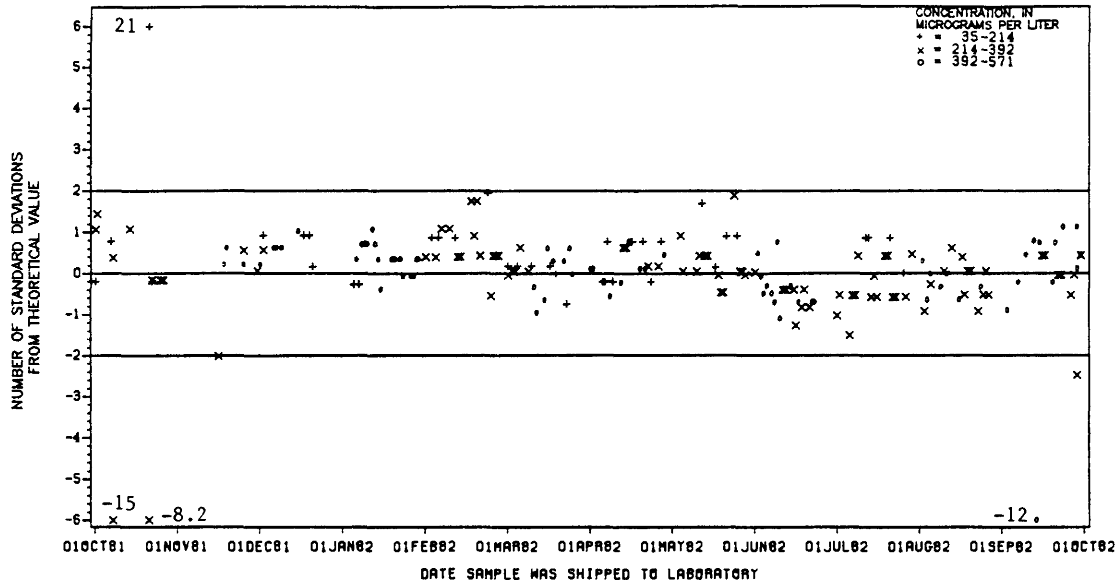

Figure 57.-- Manganese, dissolved, data from the Atlanta laboratory.

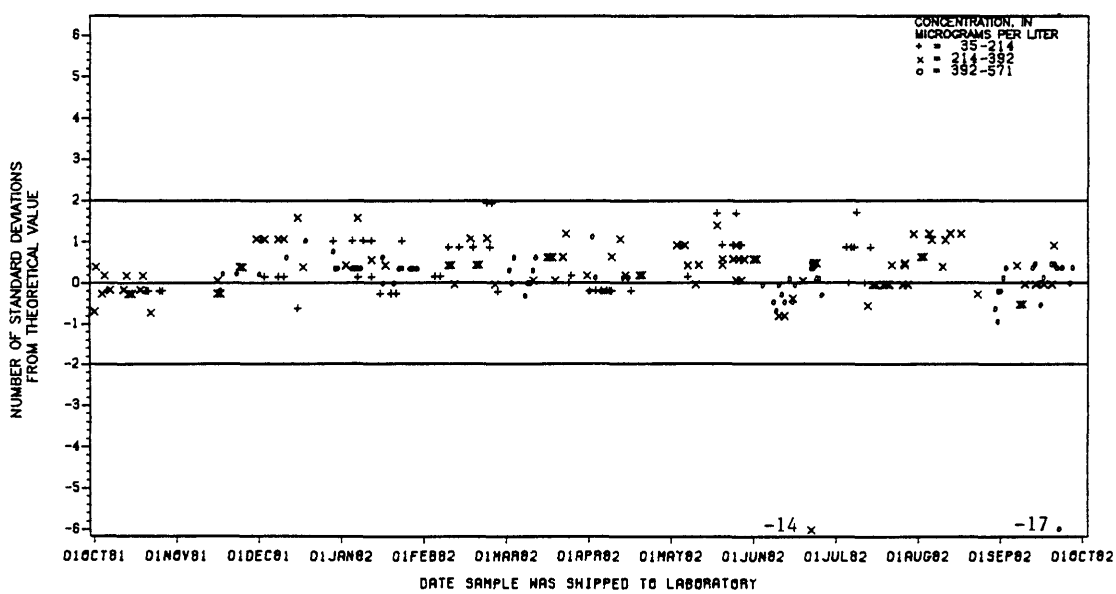

Figure 58.-- Manganese, dissolved, data from the Denver laboratory.

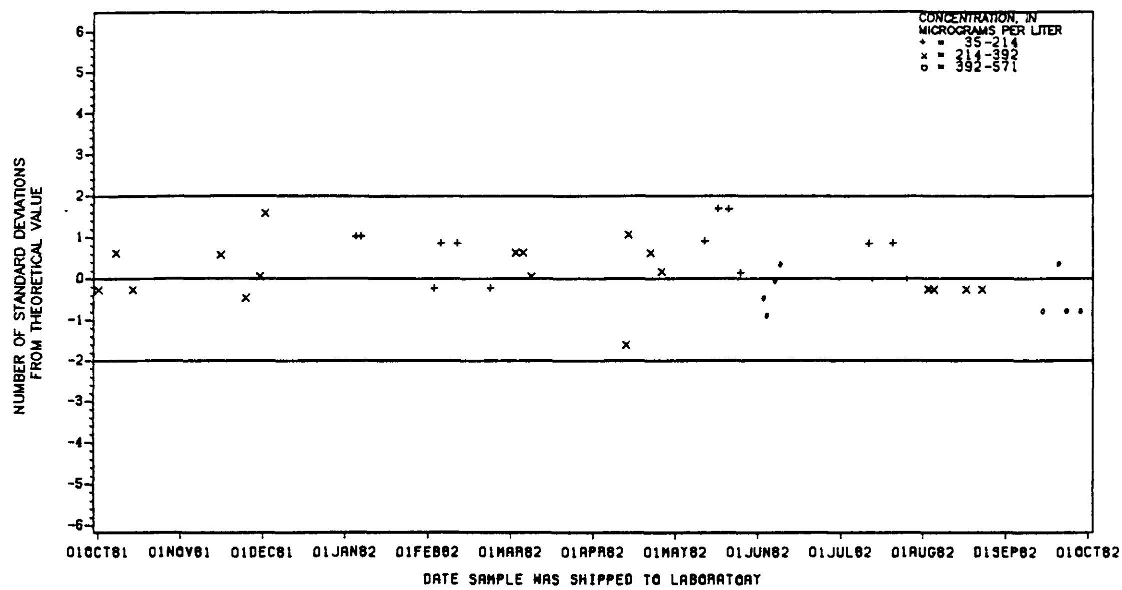

Figure 59.-- Manganese, total recoverable, data from the Atlanta laboratory.

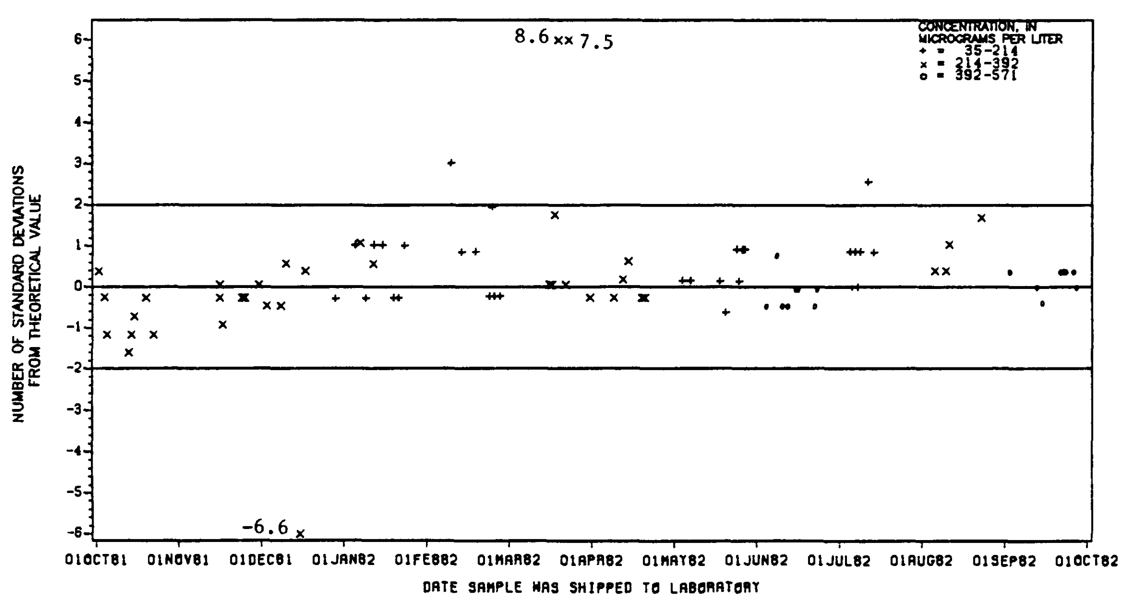

Figure 60.-- Manganese, total recoverable, data from the Denver laboratory.

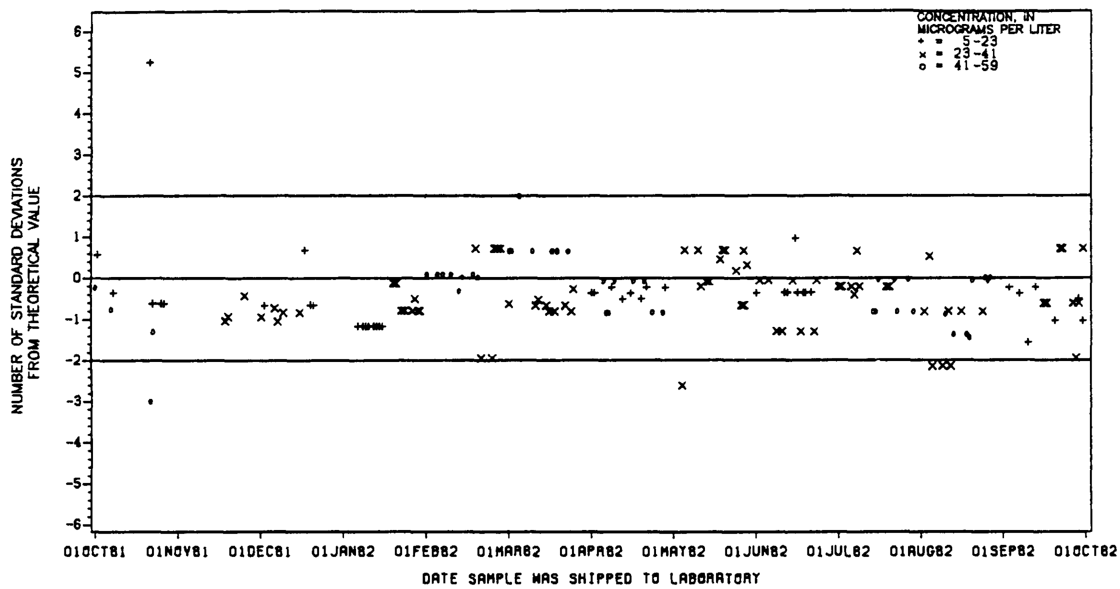

Figure 61.-- Molybdenum, dissolved, data from the Atlanta laboratory.

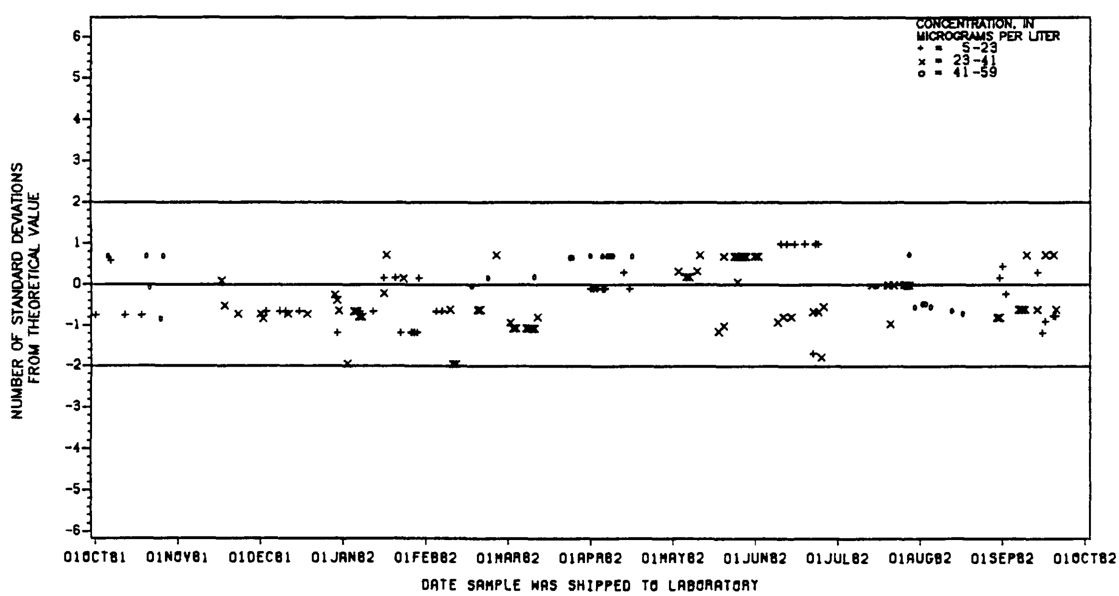

Figure 62.-- Molybdenum, dissolved, data from the Denver laboratory.

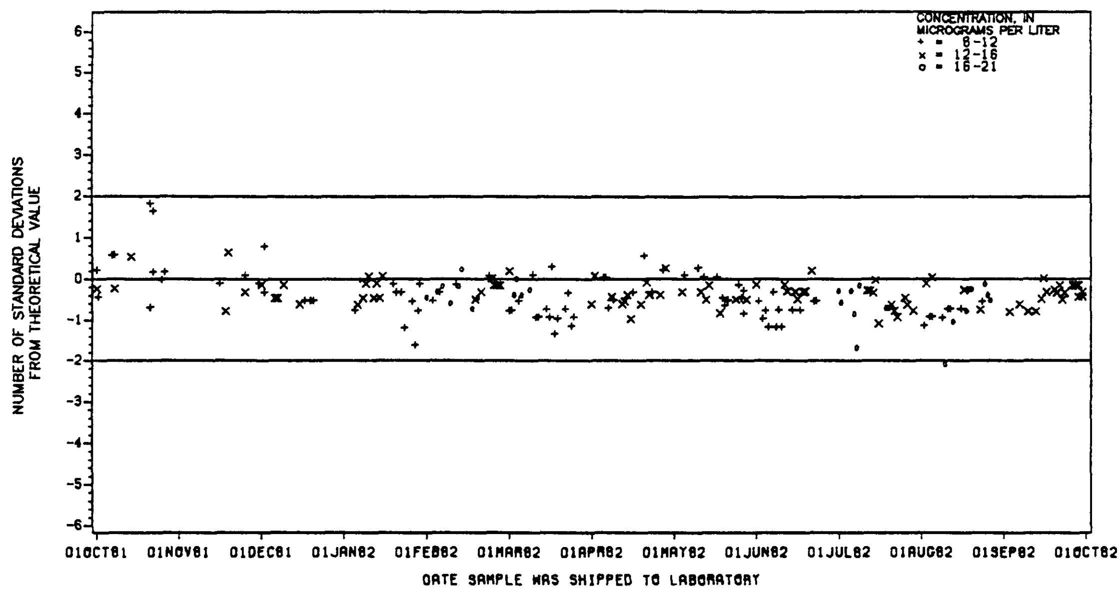

Figure 63.-- Nickel, dissolved, data from the Atlanta laboratory.

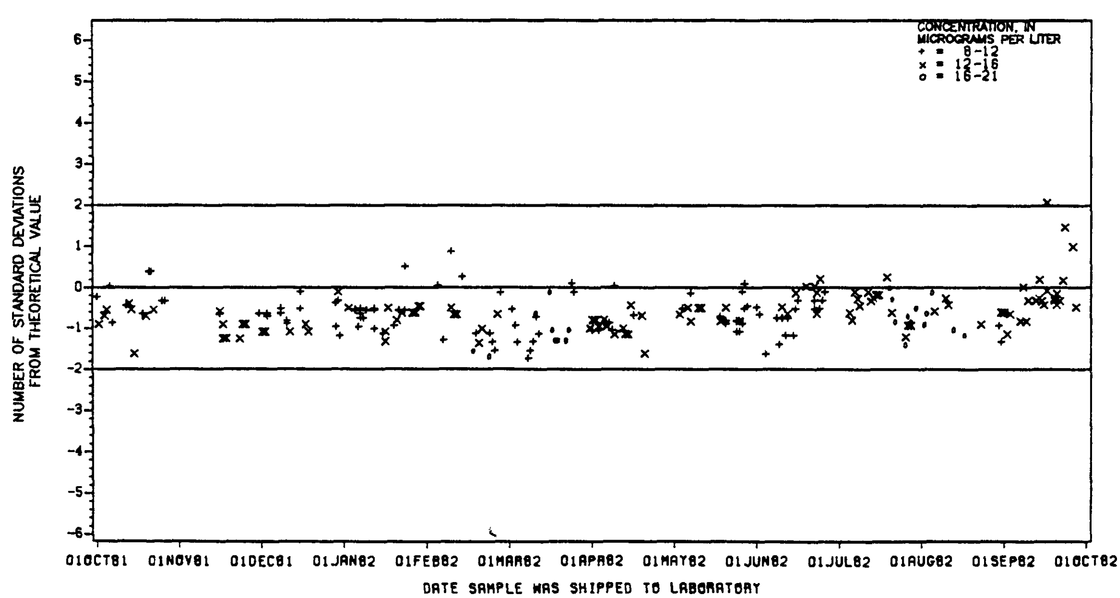

Figure 64.-- Nickel, dissolved, data from the Denver laboratory.

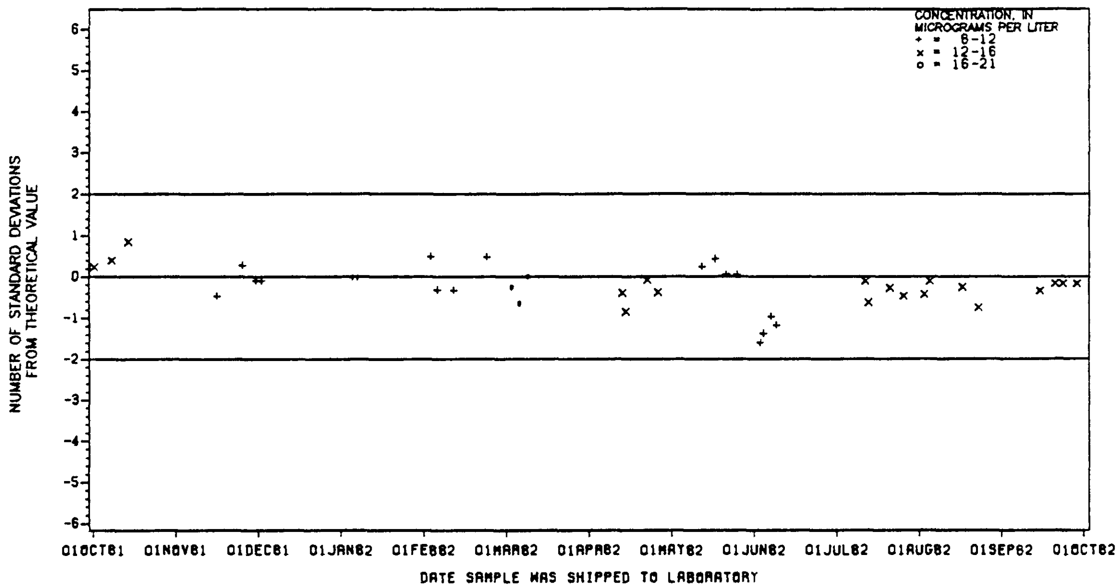

Figure 65.-- Nickel, total recoverable, data from the Atlanta laboratory.

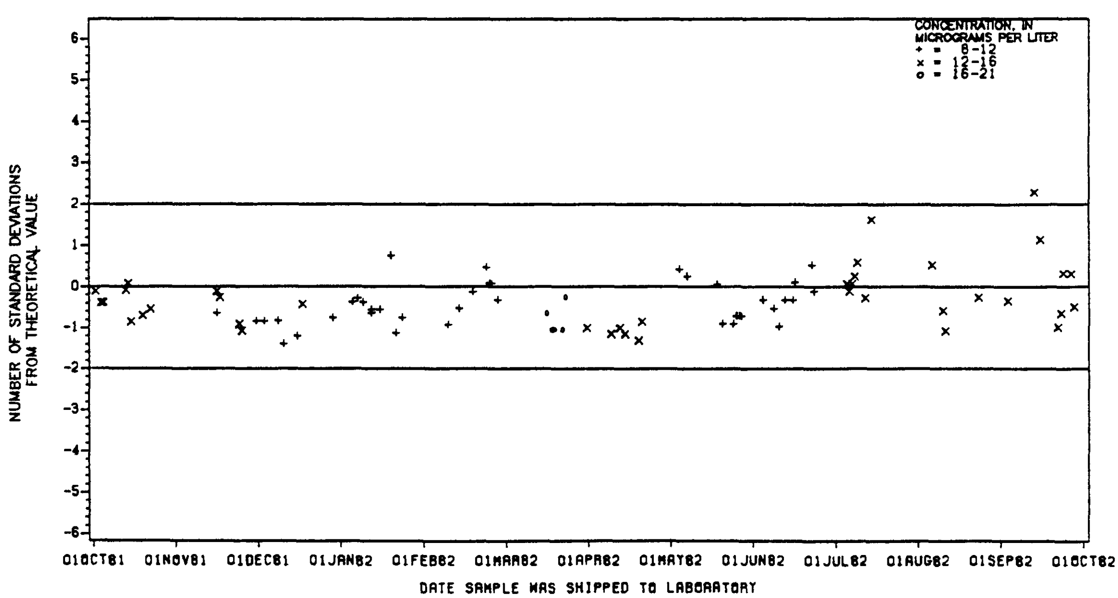

Figure 66.-- Nickel, total recoverable, data from the Denver laboratory.

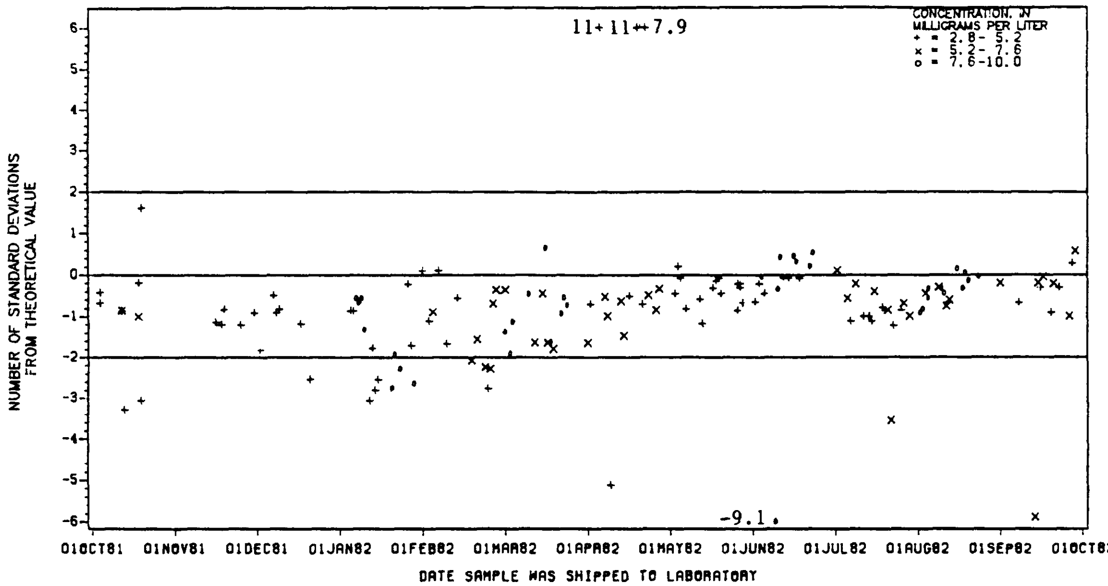

Figure 67.-- Potassium, dissolved, data from the Atlanta laboratory.

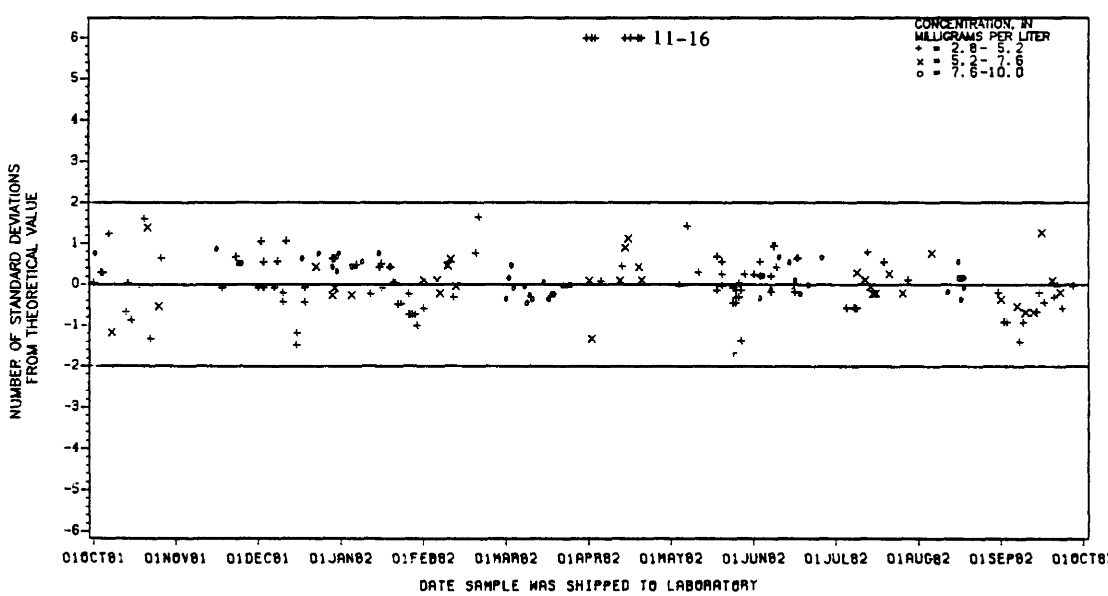

Figure 68.-- Potassium, dissolved, data from the Denver laboratory.

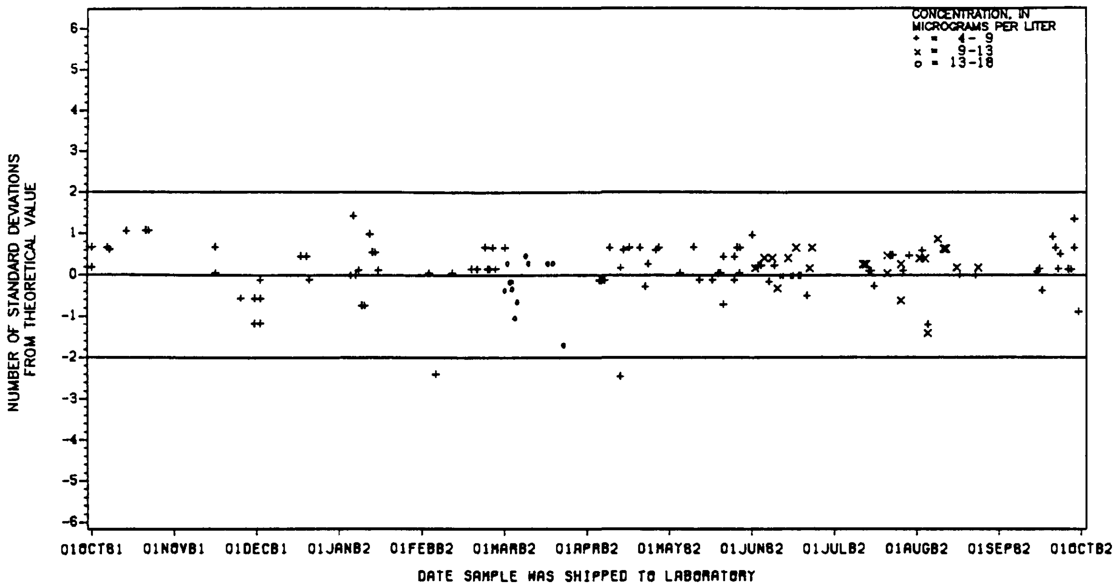

Figure 69.-- Selenium, dissolved, data from the Atlanta laboratory.

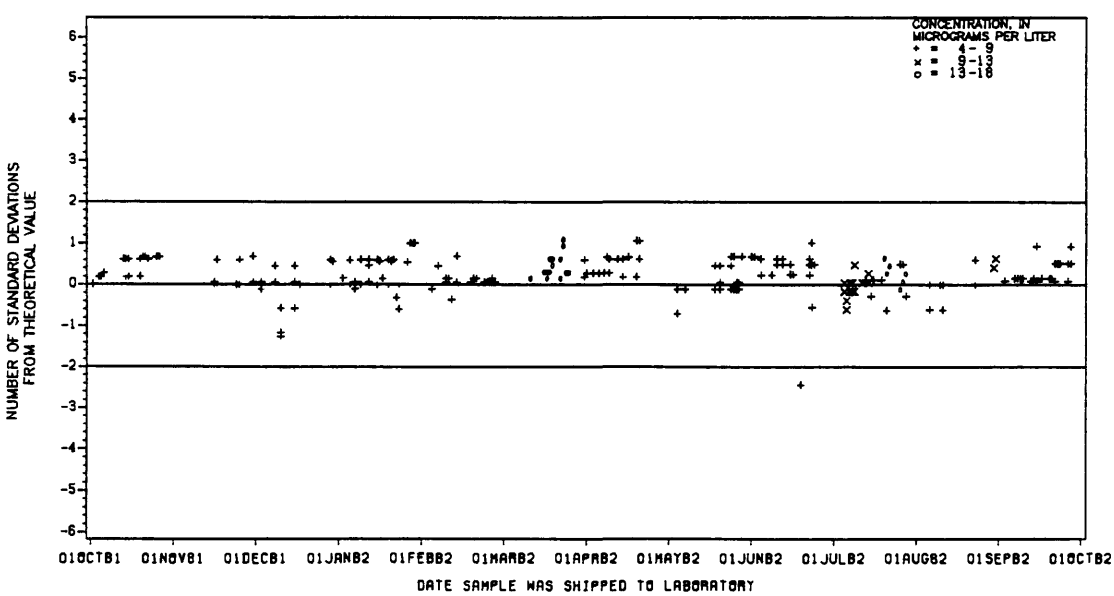

Figure 70.-- Selenium, dissolved, data from the Denver laboratory.

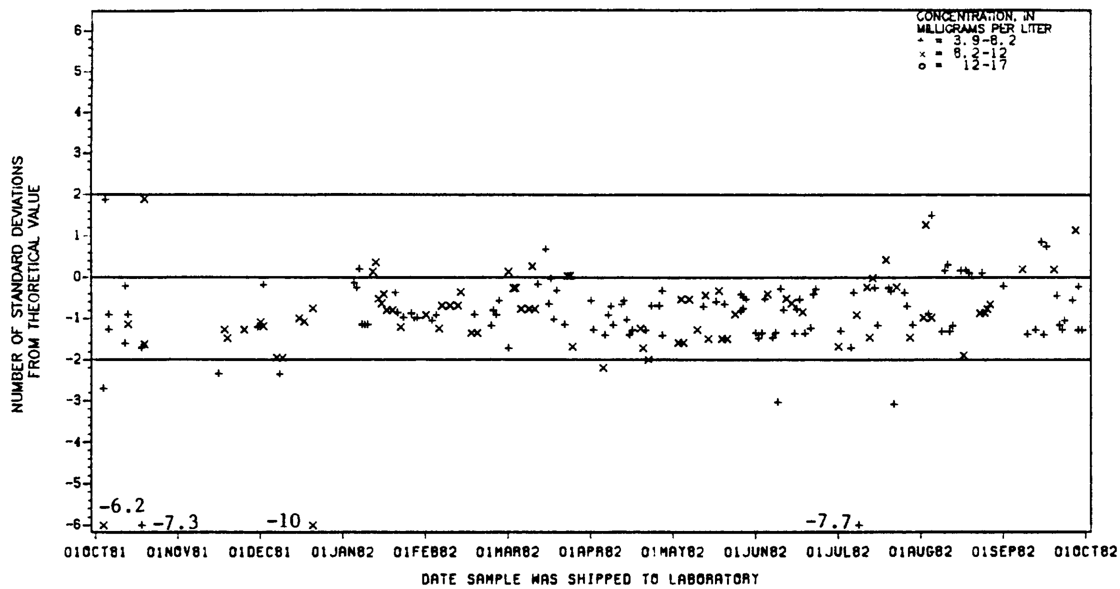

Figure 71.-- Silica, dissolved, data from the Atlanta laboratory.

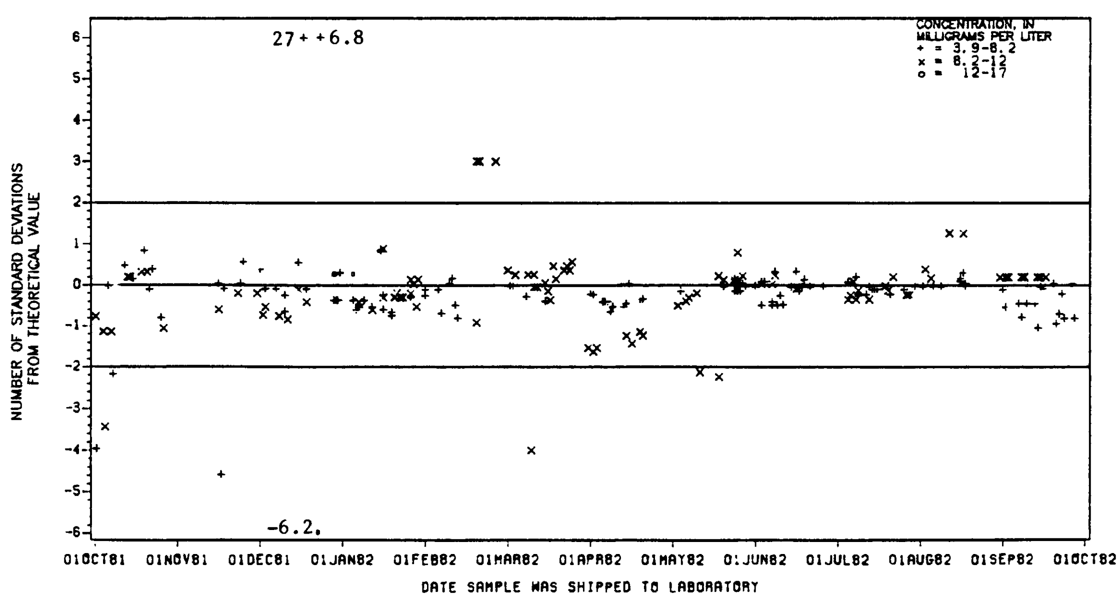

Figure 72.-- Silica, dissolved, data from the Denver laboratory.

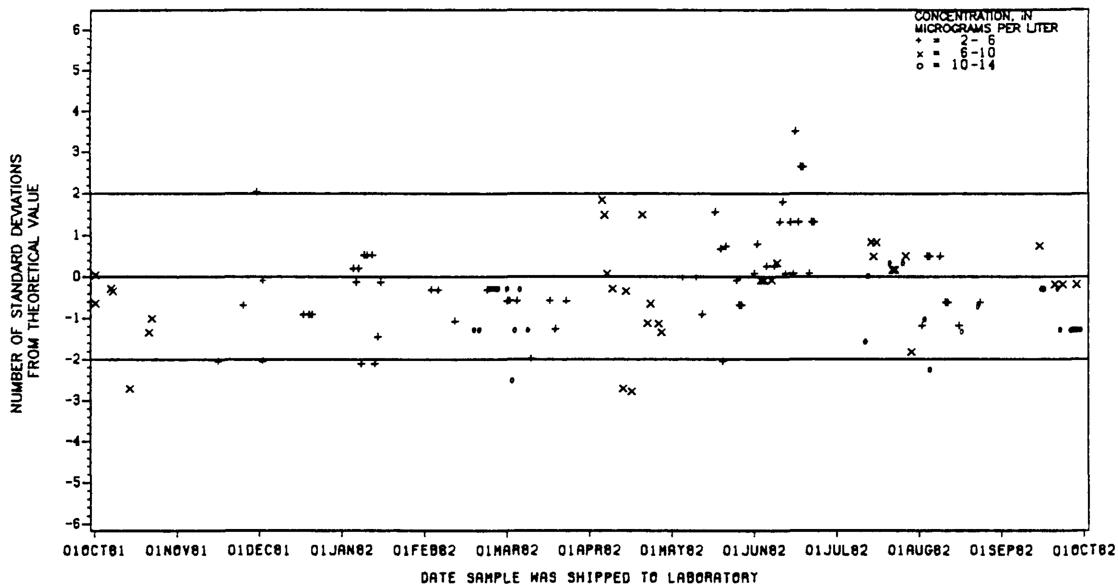

Figure 73.-- Silver, dissolved, data from the Atlanta laboratory.

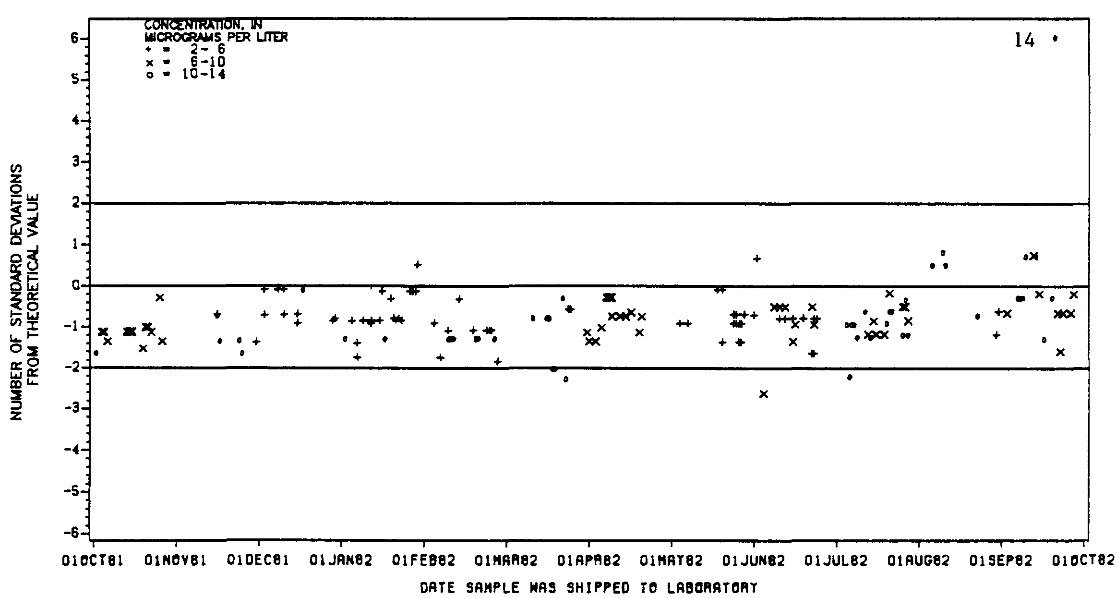

Figure 74.-- Silver, dissolved, data from the Denver laboratory.

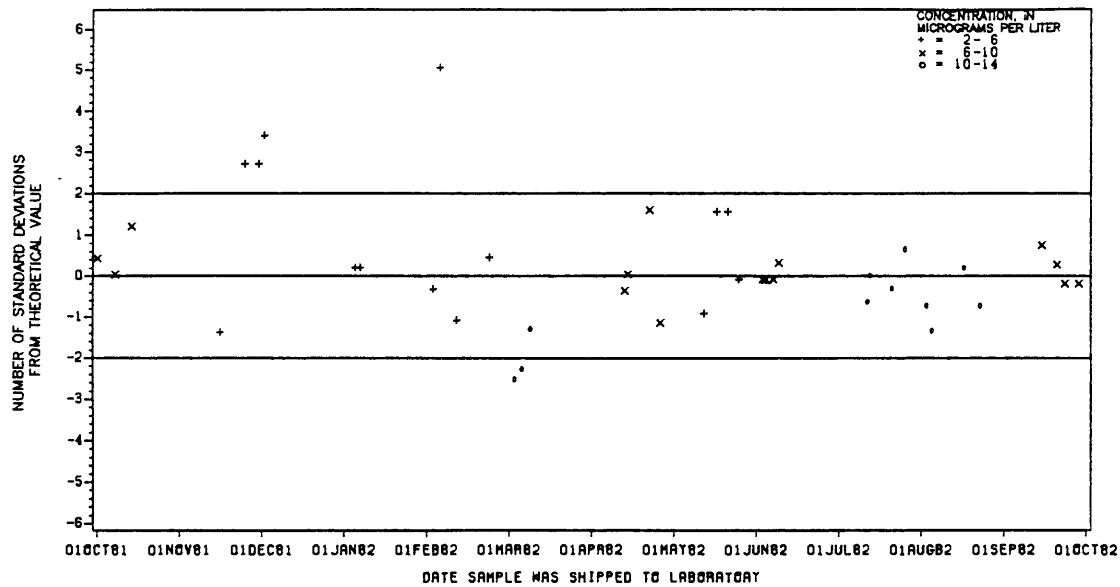

Figure 75.-- Silver, total recoverable, data from the Atlanta laboratory.

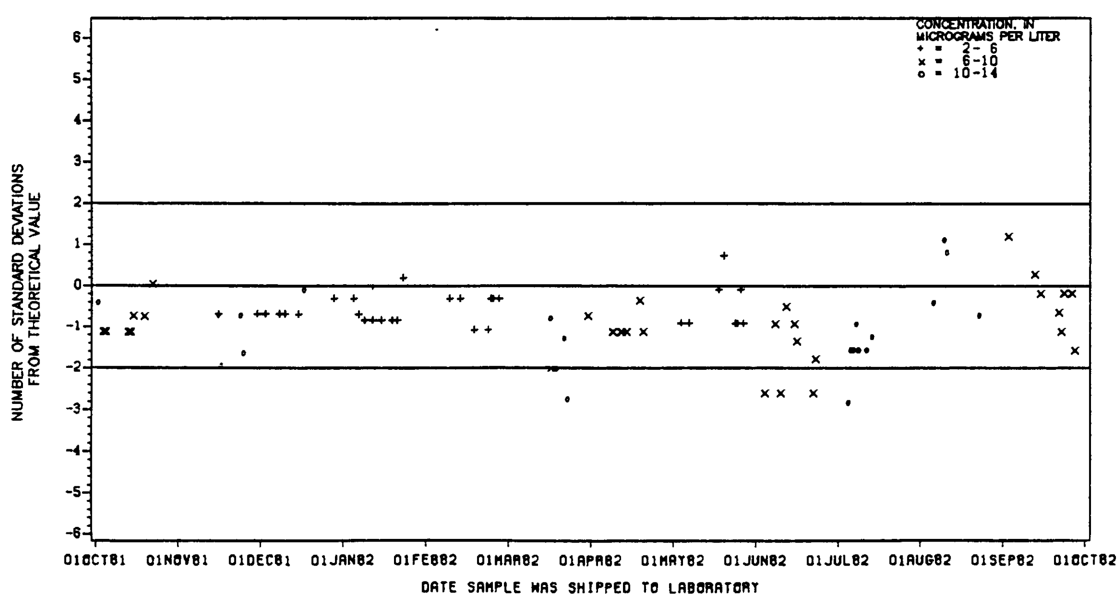

Figure 76.-- Silver, total recoverable, data from the Denver laboratory.

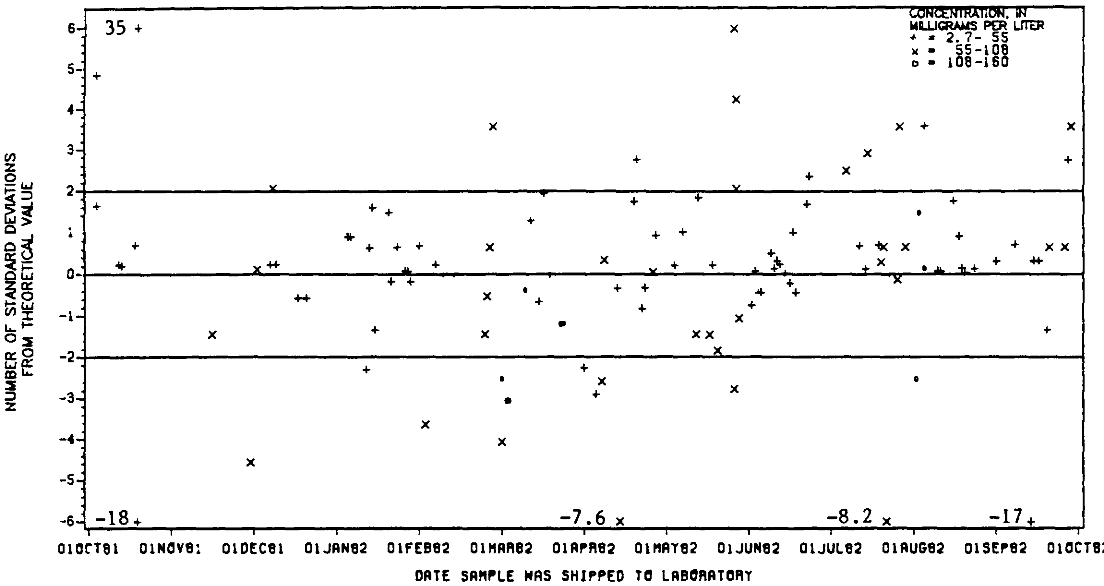

Figure 77.-- Sodium, dissolved(inductively coupled plasma emission spectrometry), data from the Atlanta laboratory.

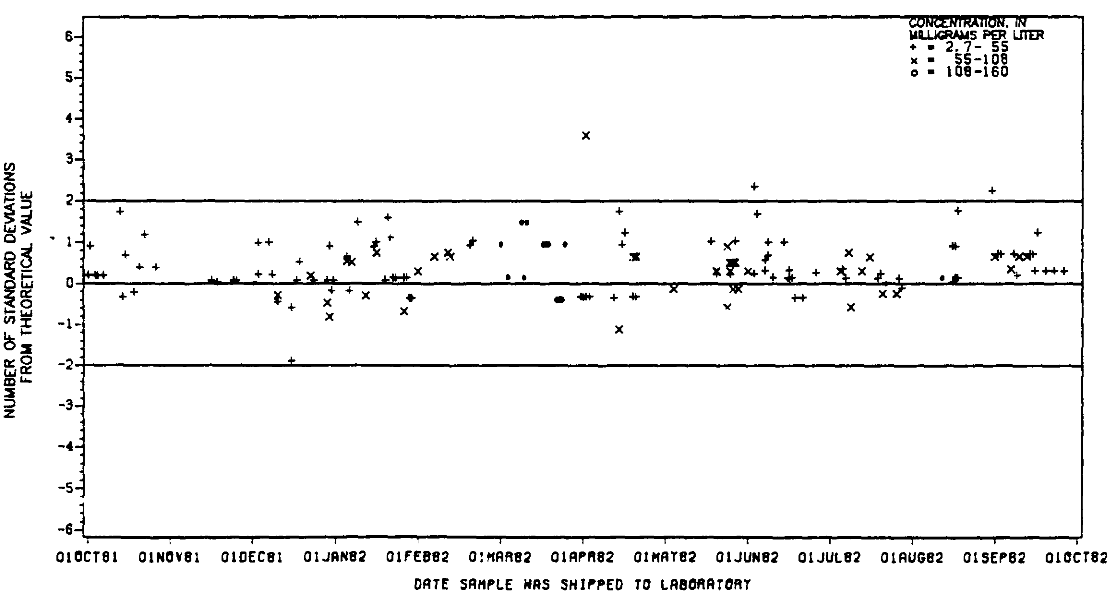

Figure 78.-- Sodium, dissolved(inductively coupled plasma emission spectrometry), data from the Denver laboratory.

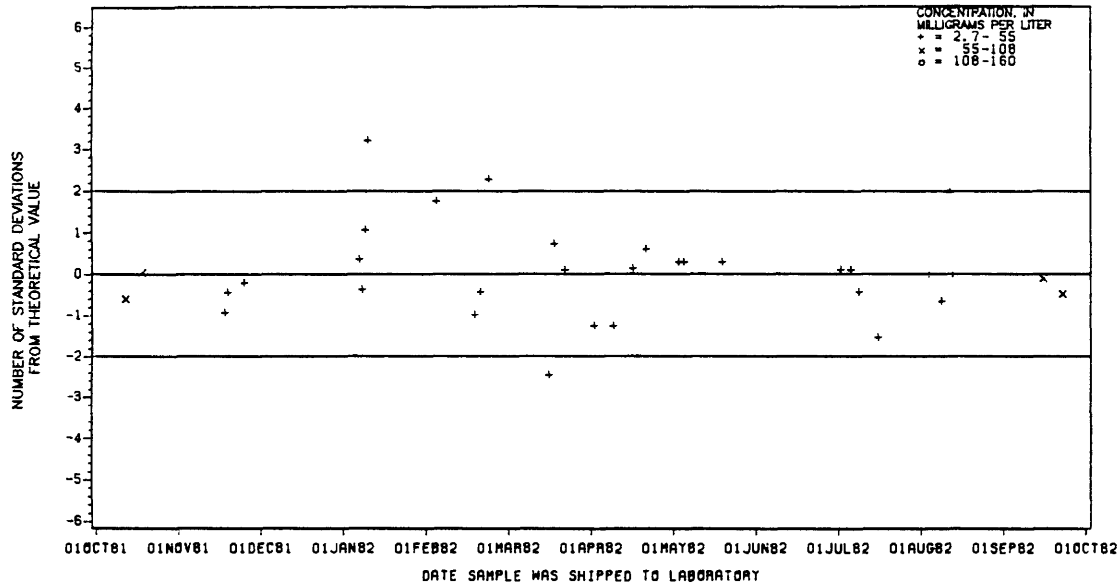

Figure 79.-- Sodium, dissolved(atomic absorption spectrometry), data from the Atlanta laboratory.

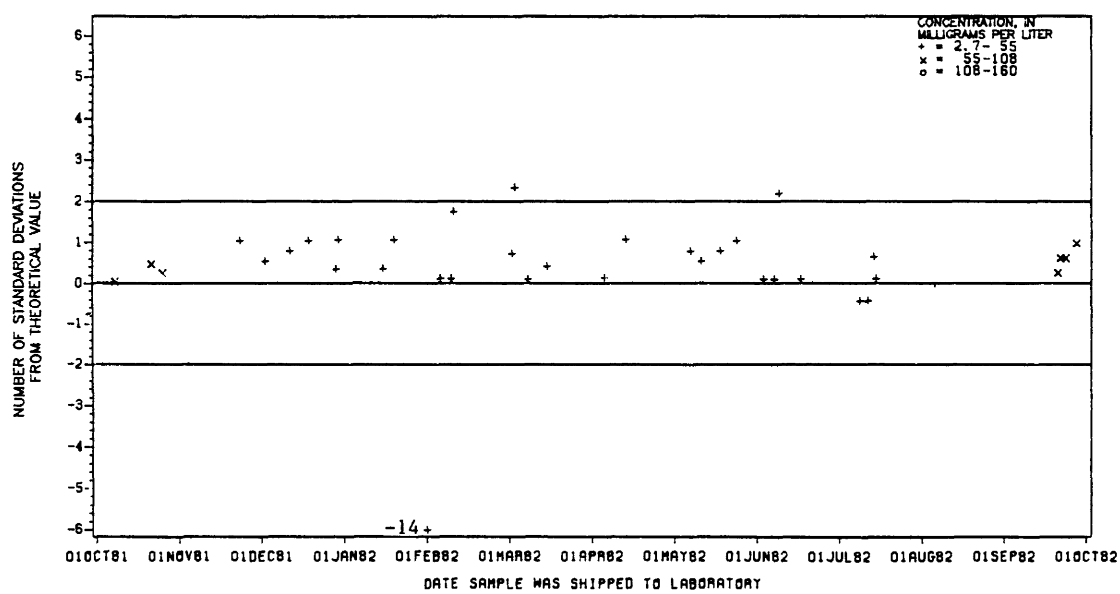

Figure 80.-- Sodium, dissolved(atomic absorption spectrometry), data from the Denver laboratory.

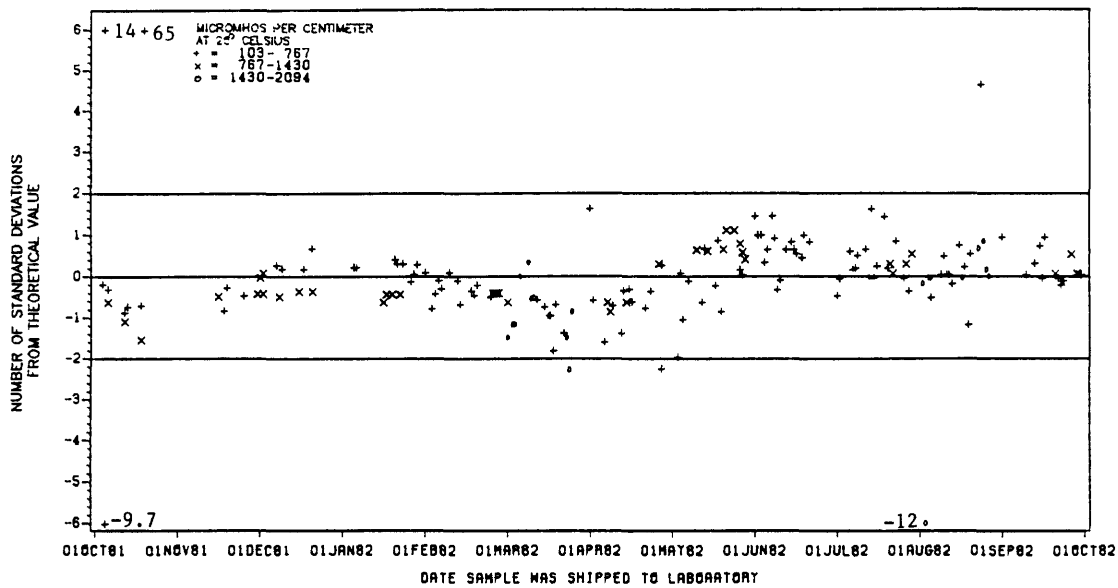

Figure 81.-- Specific conductance, data from the Atlanta laboratory.

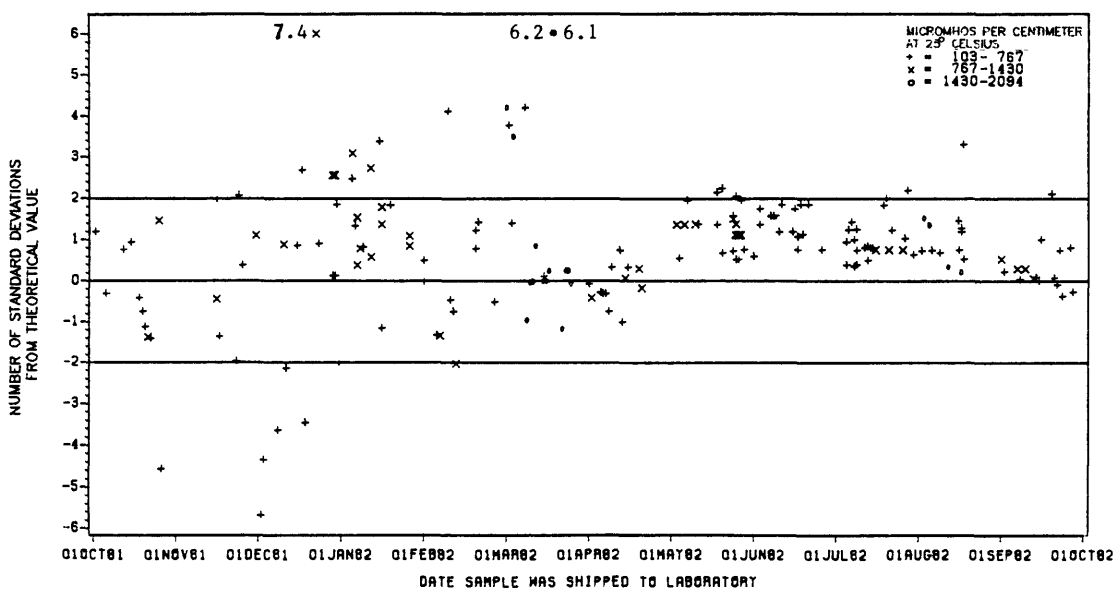

Figure 82.-- Specific conductance, data from the Denver laboratory.

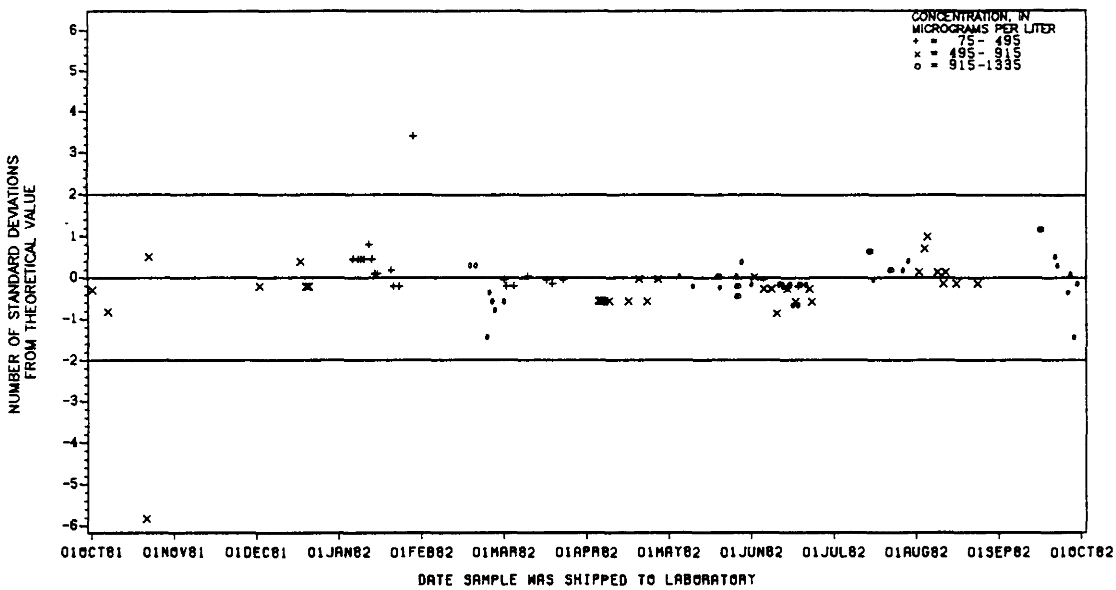

Figure 83.-- Strontium, dissolved, data from the Atlanta laboratory.

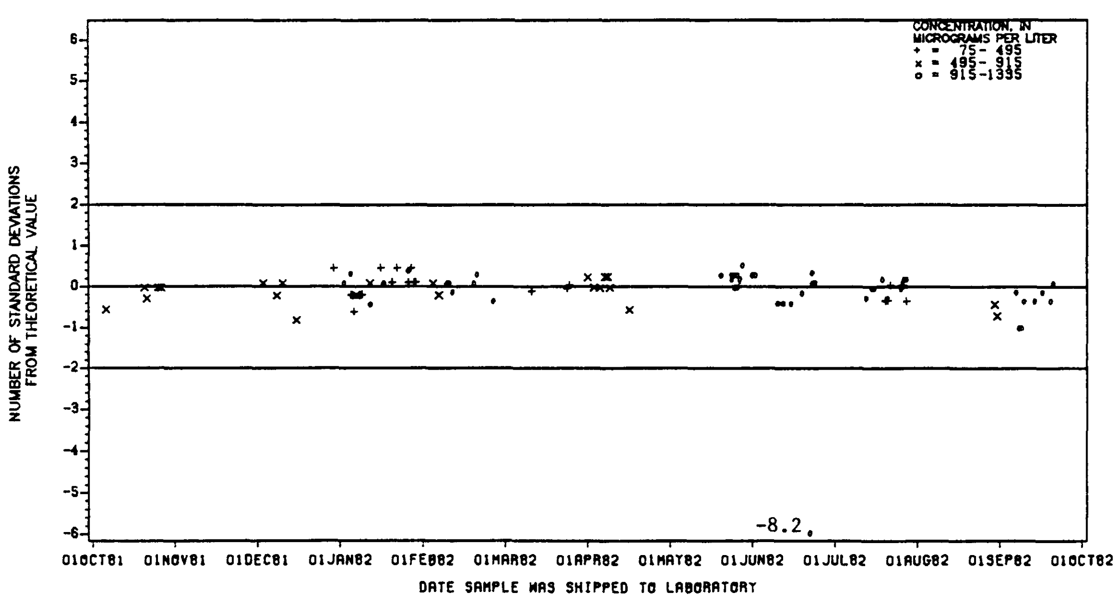

Figure 84.-- Strontium, dissolved, data from the Denver laboratory.

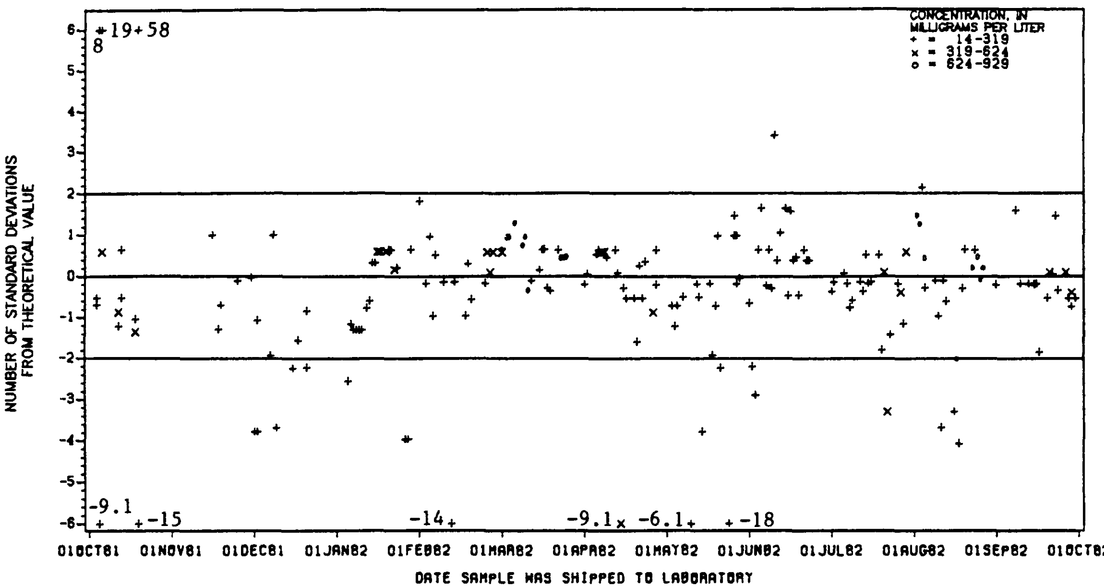

Figure 85.-- Sulfate, dissolved, data from the Atlanta laboratory.

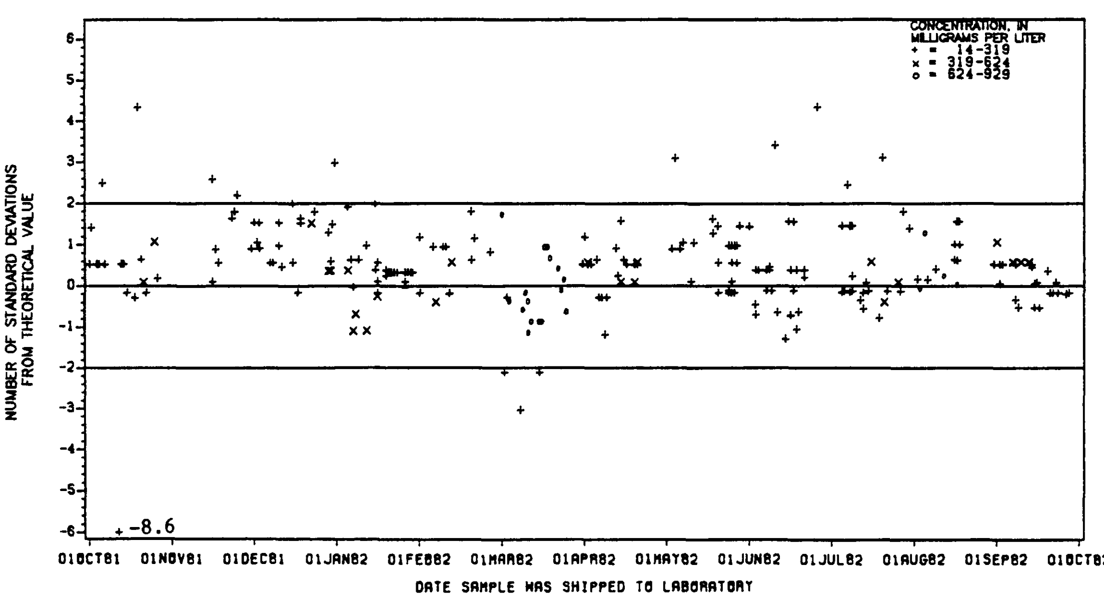

Figure 86.-- Sulfate, dissolved, data from the Denver laboratory.

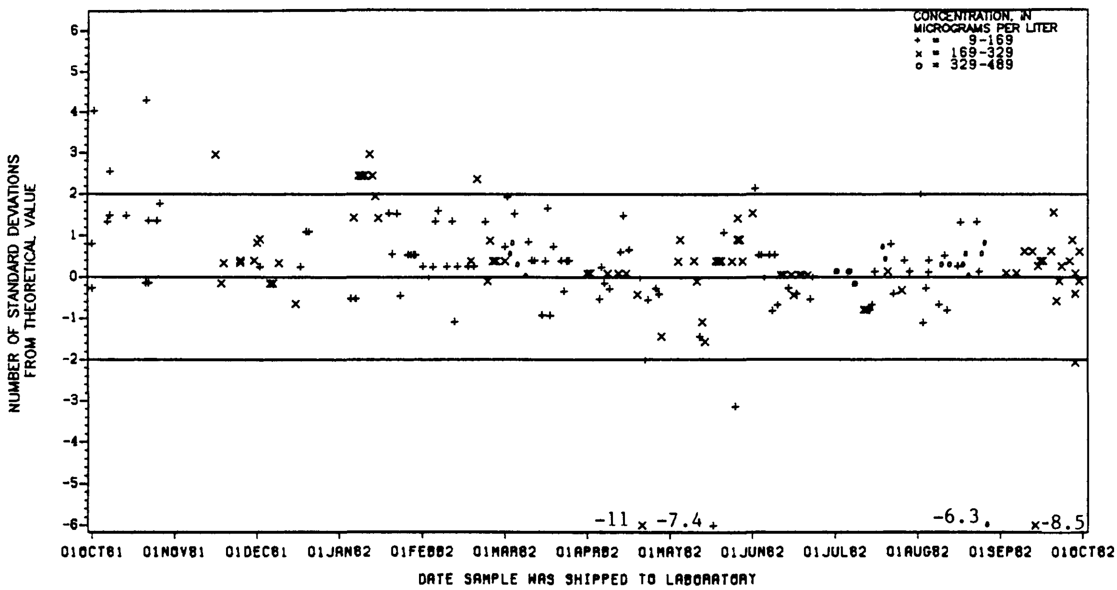

Figure 87.-- Zinc, dissolved, data from the Atlanta laboratory.

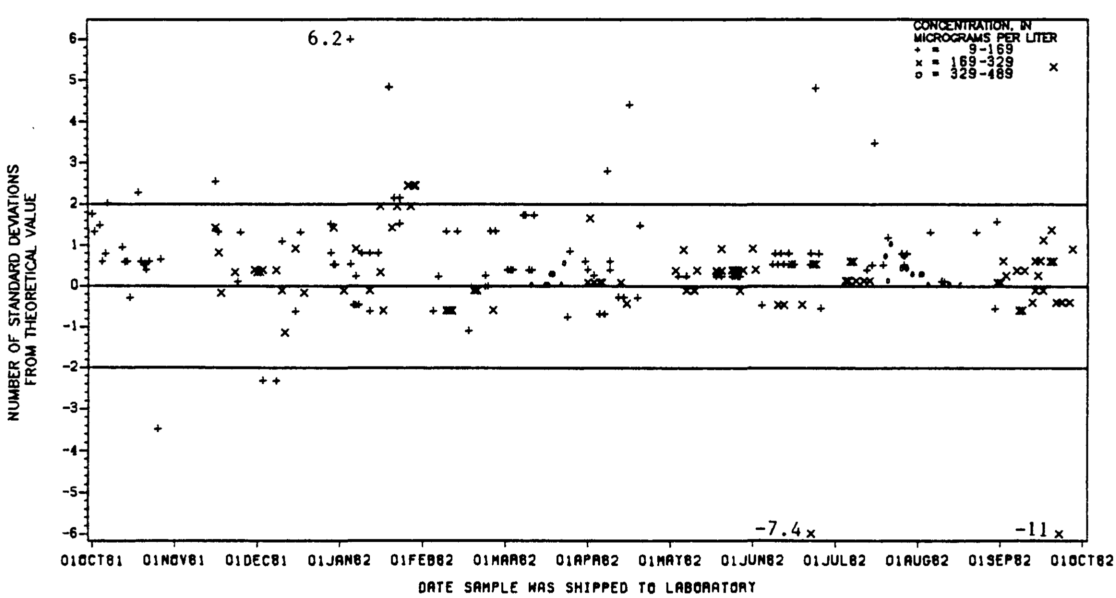

Figure 88.-- Zinc, dissolved, data from the Denver laboratory.

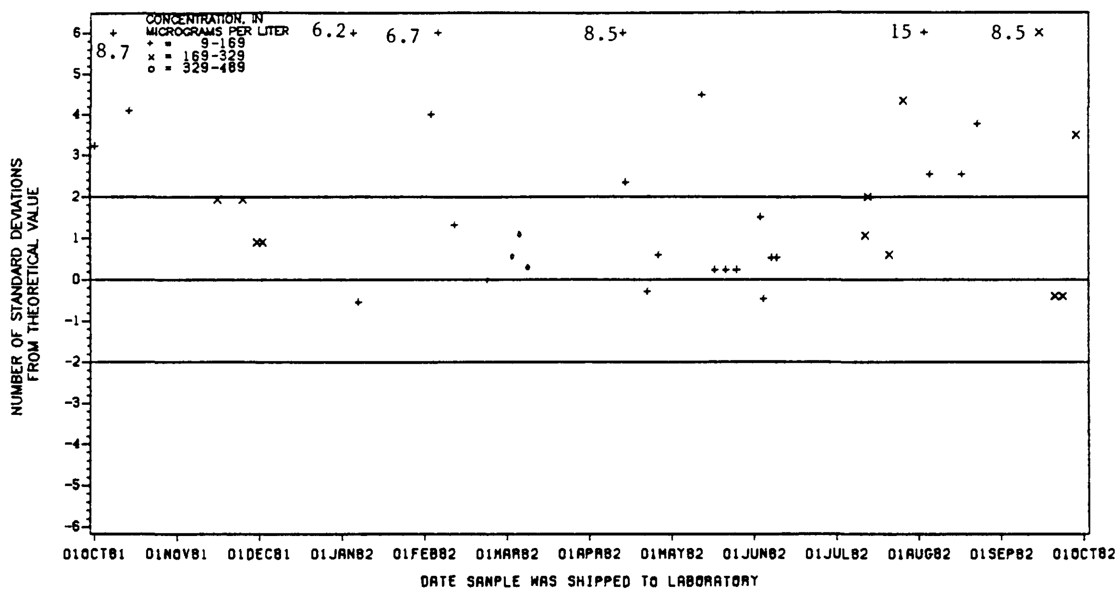

Figure 89.-- Zinc, total recoverable, data from the Atlanta laboratory.

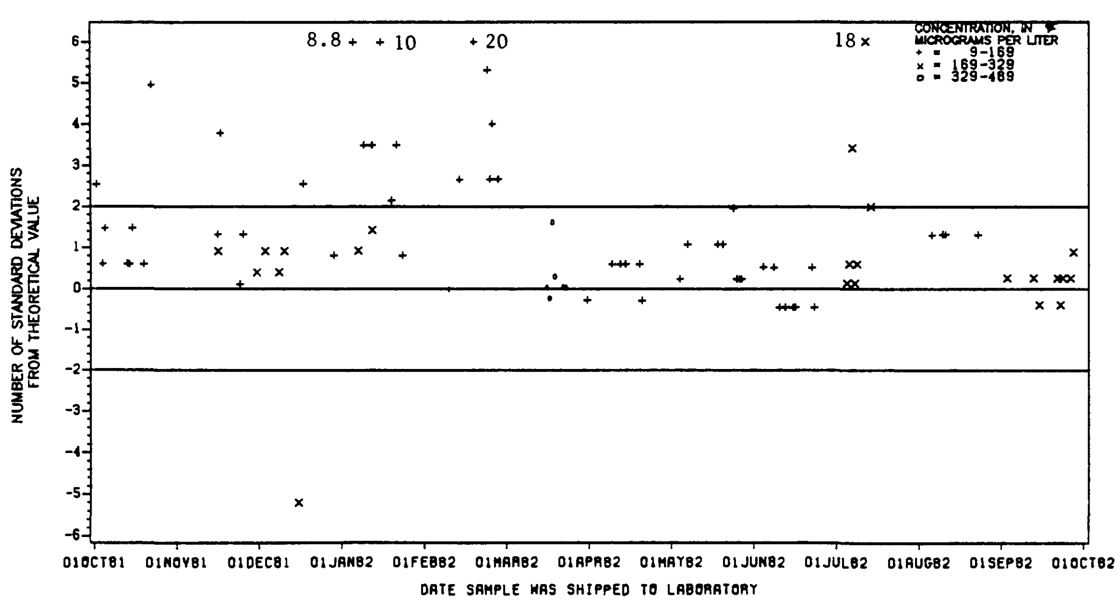

Figure 90.-- Zinc, total recoverable, data from the Denver laboratory.

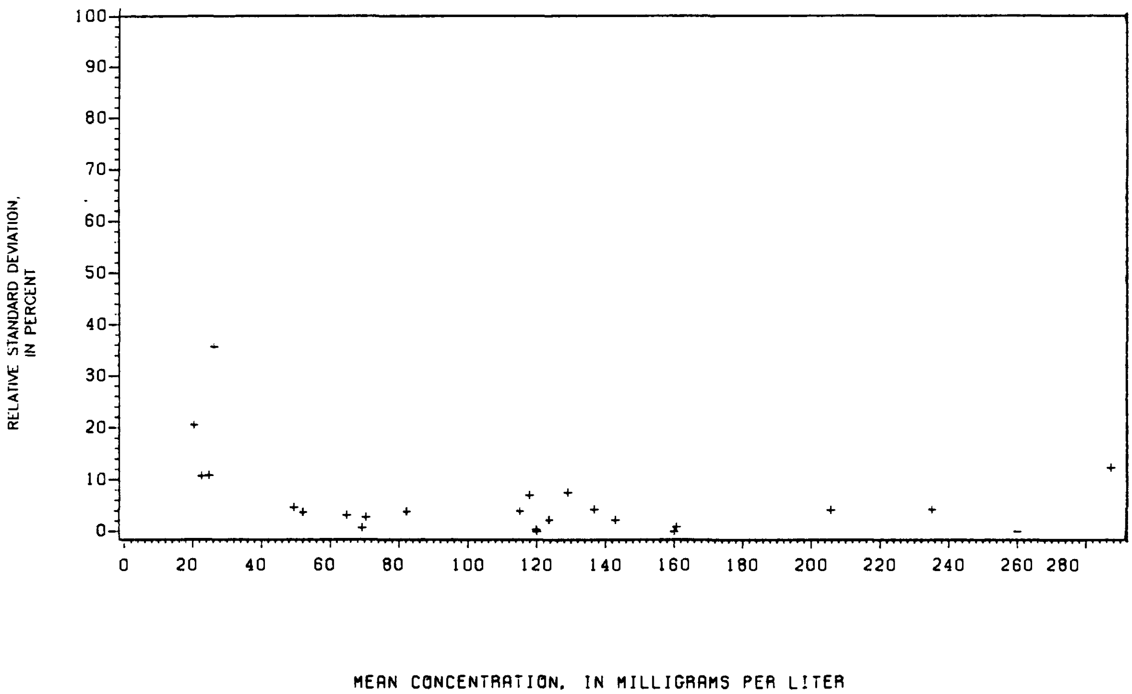

Figure 91.-- Precision data for alkalinity, dissolved, at the Atlanta laboratory.

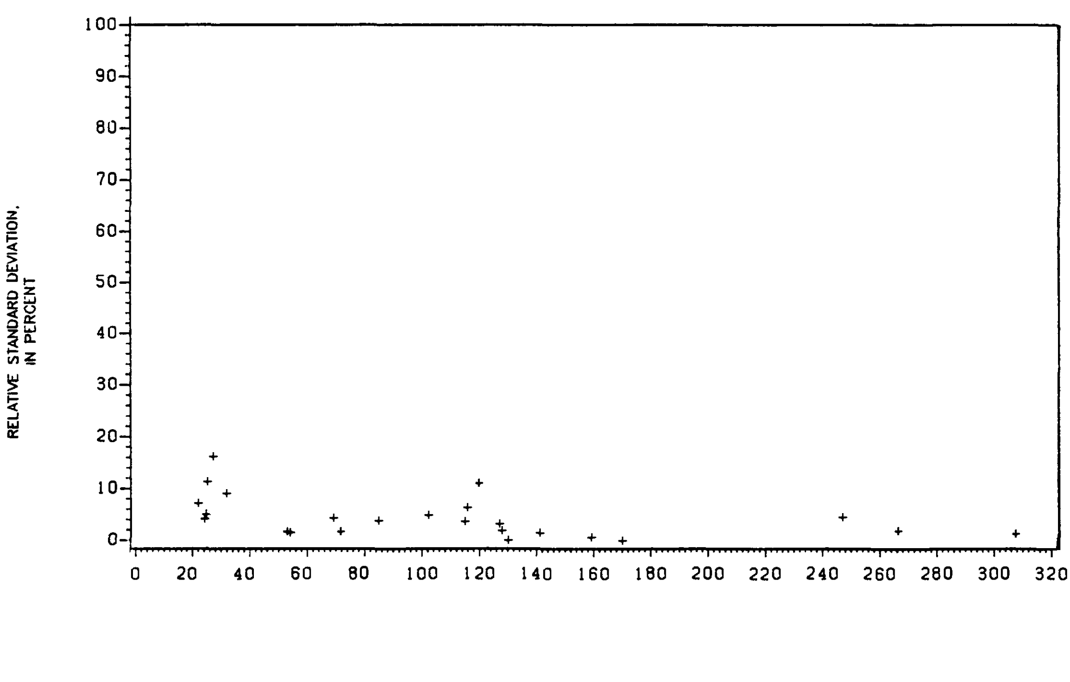

Figure 92.-- Precision data for alkalinity, dissolved, at the Denver laboratory.

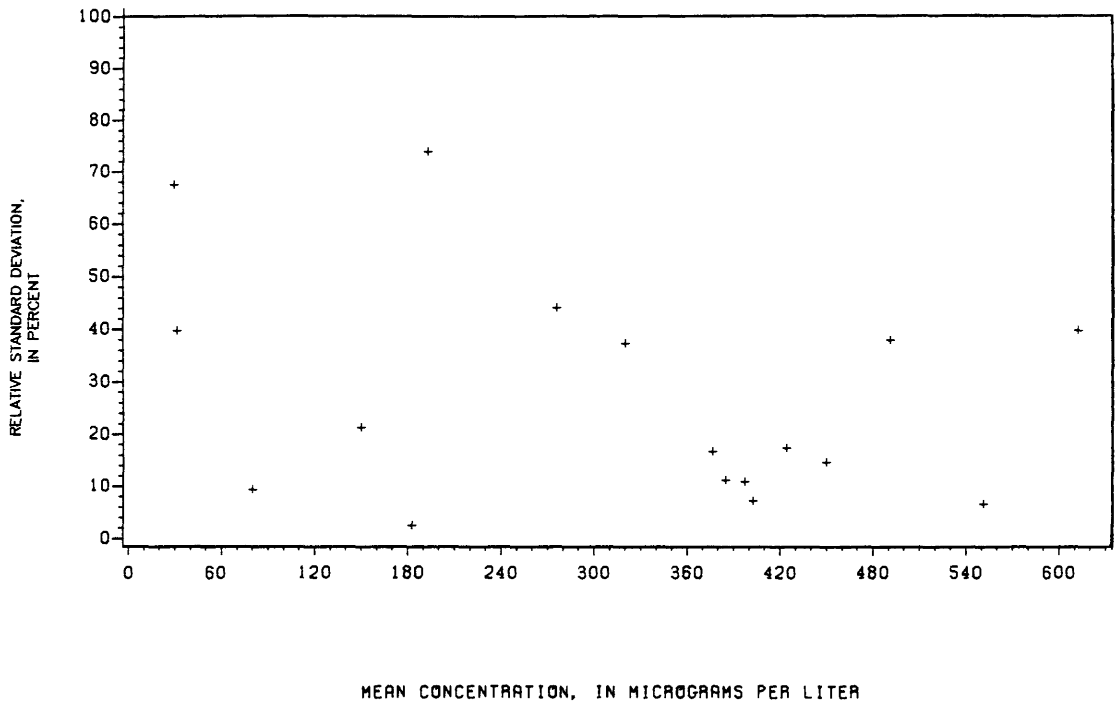

Figure 93.-- Precision data for aluminum, dissolved, at the Atlanta laboratory.

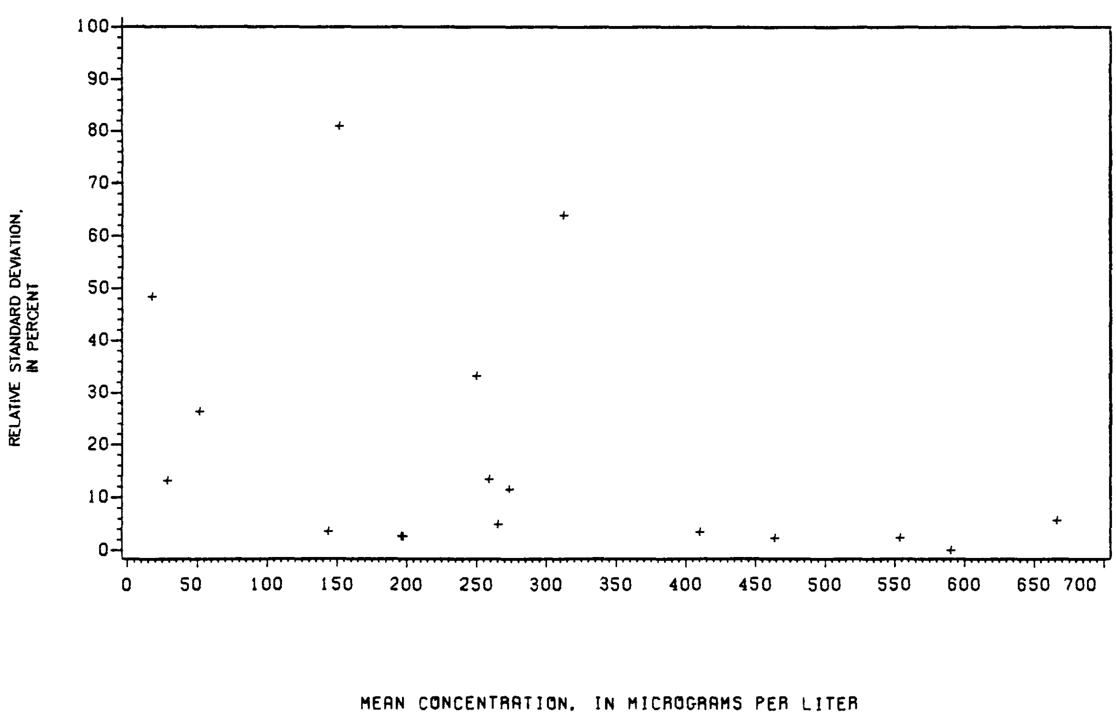

Figure 94.-- Precision data for aluminum, dissolved, at the Denver laboratory.

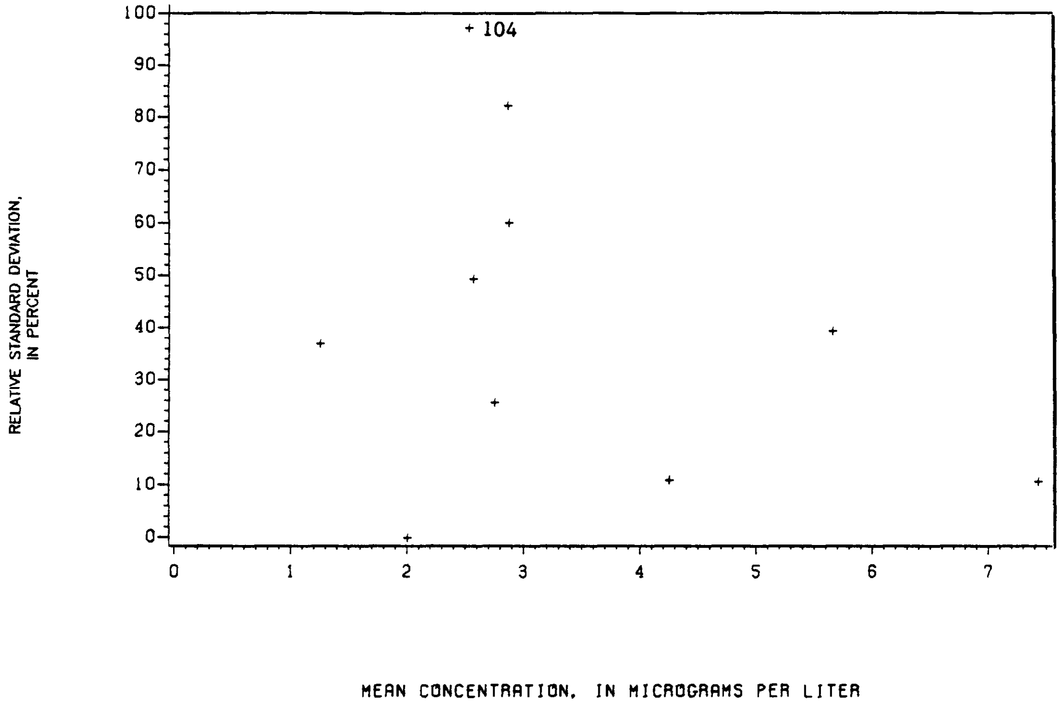

Figure 95.-- Precision data for antimony, dissolved, at the Atlanta laboratory.

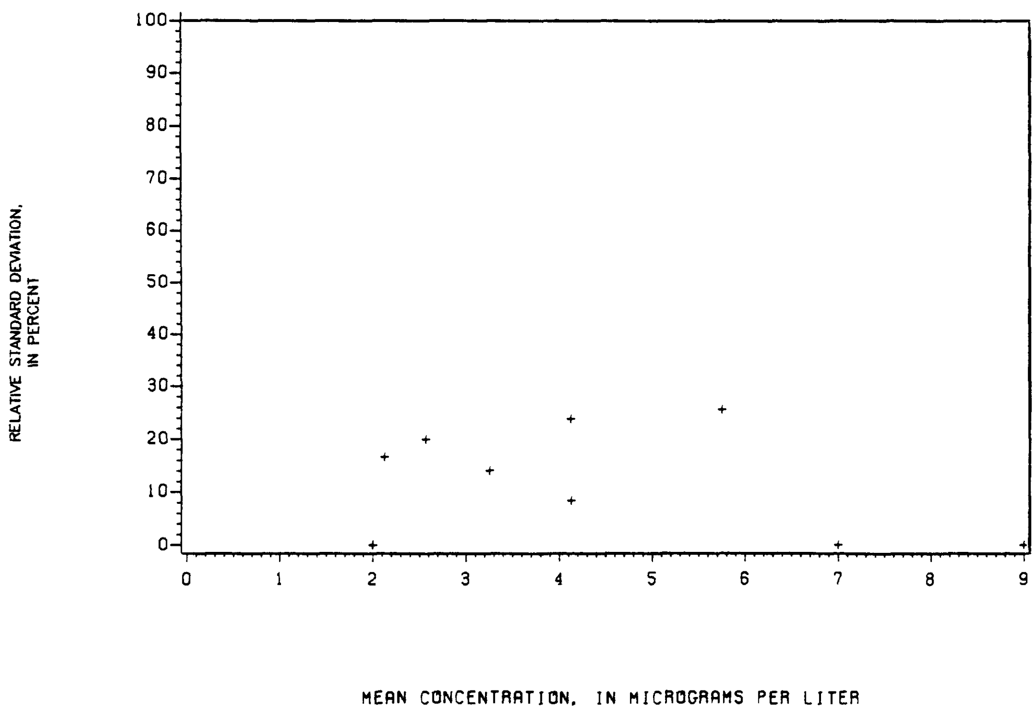

Figure 96.-- Precision data for antimony, dissolved, at the Denver laboratory.

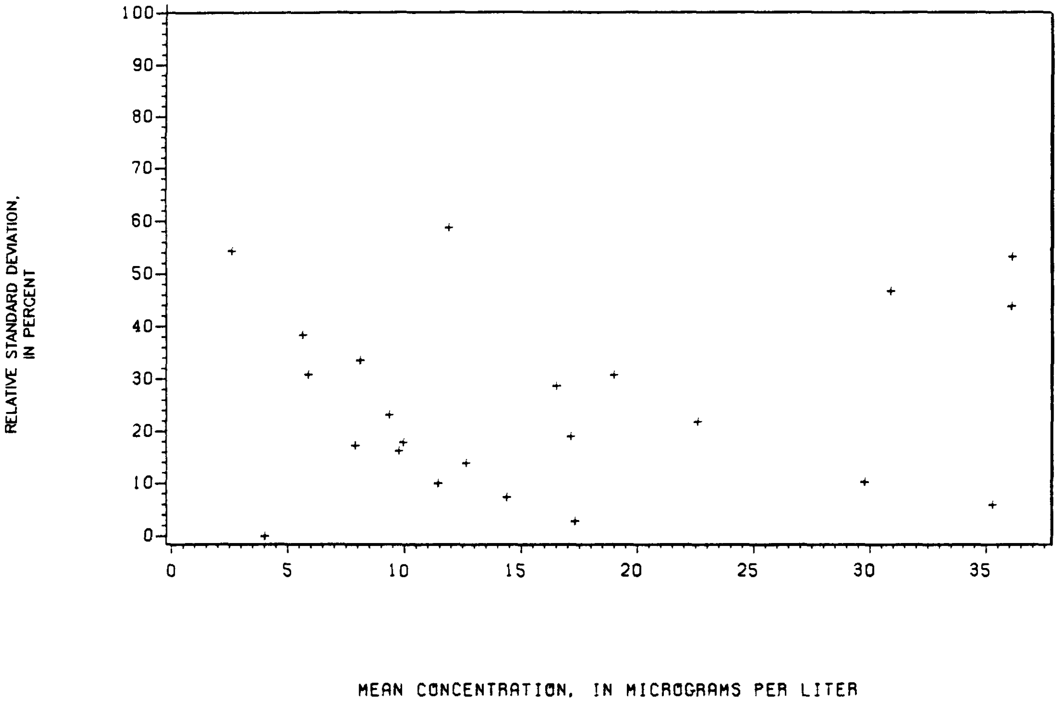

Figure 97.-- Precision data for arsenic, dissolved, at the Atlanta laboratory.

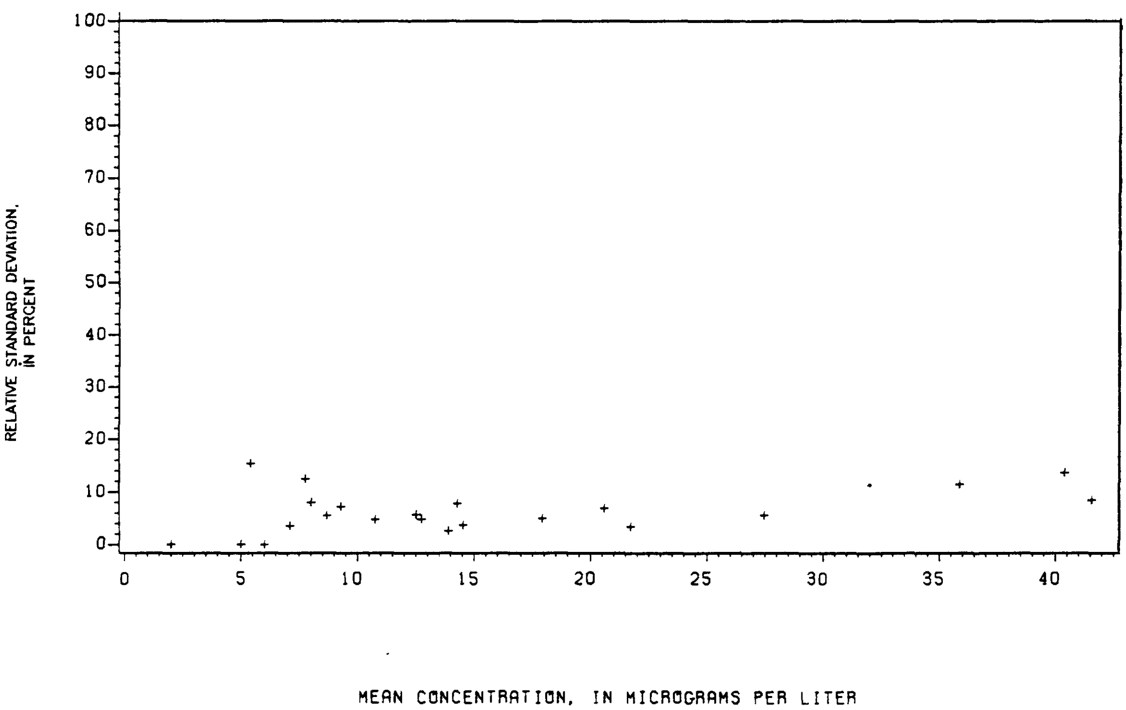

Figure 98.-- Precision data for arsenic, dissolved, at the Denver laboratory.

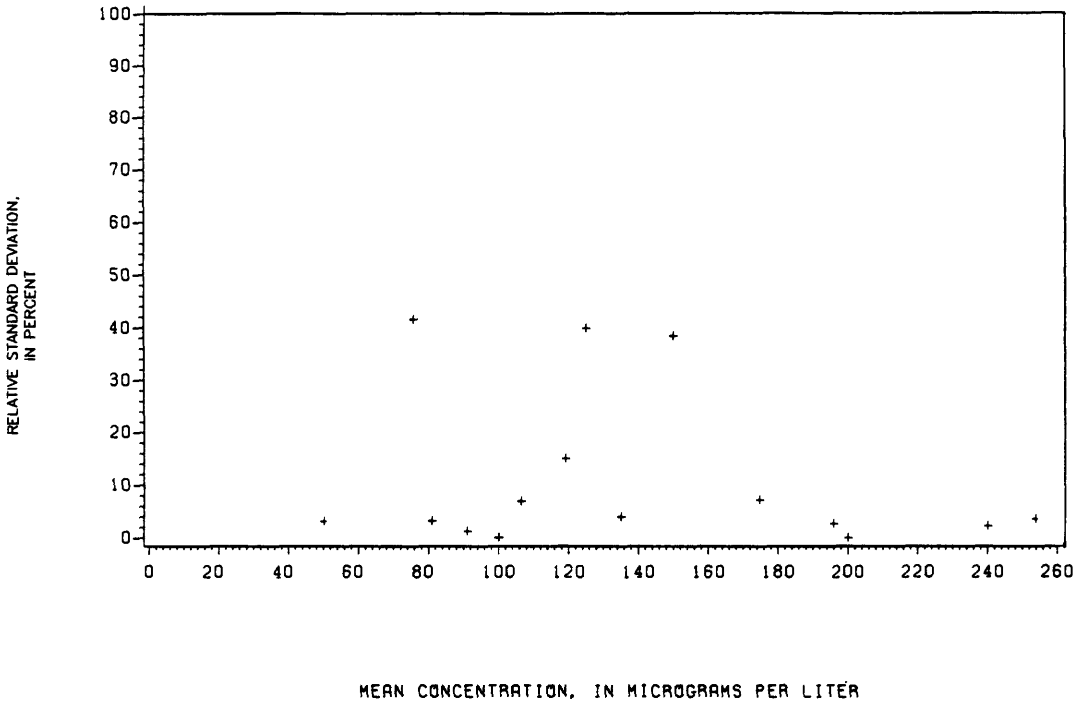

Figure 99.-- Precision data for barium, dissolved, at the Atlanta laboratory.

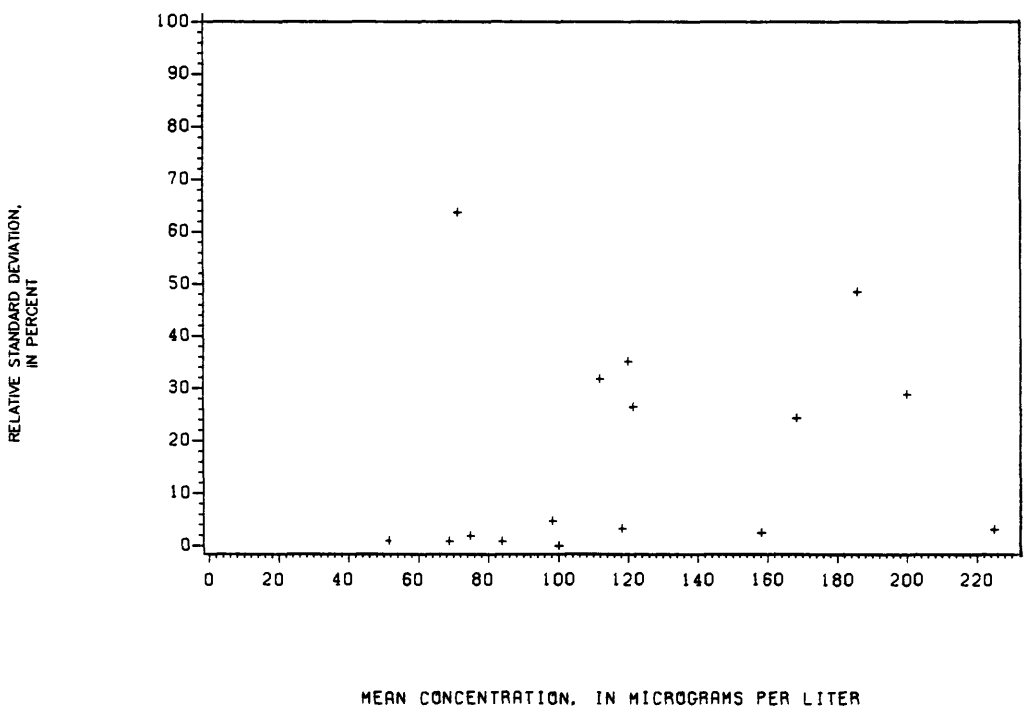

Figure 100.-- Precision data for barium, dissolved, at the Denver laboratory.

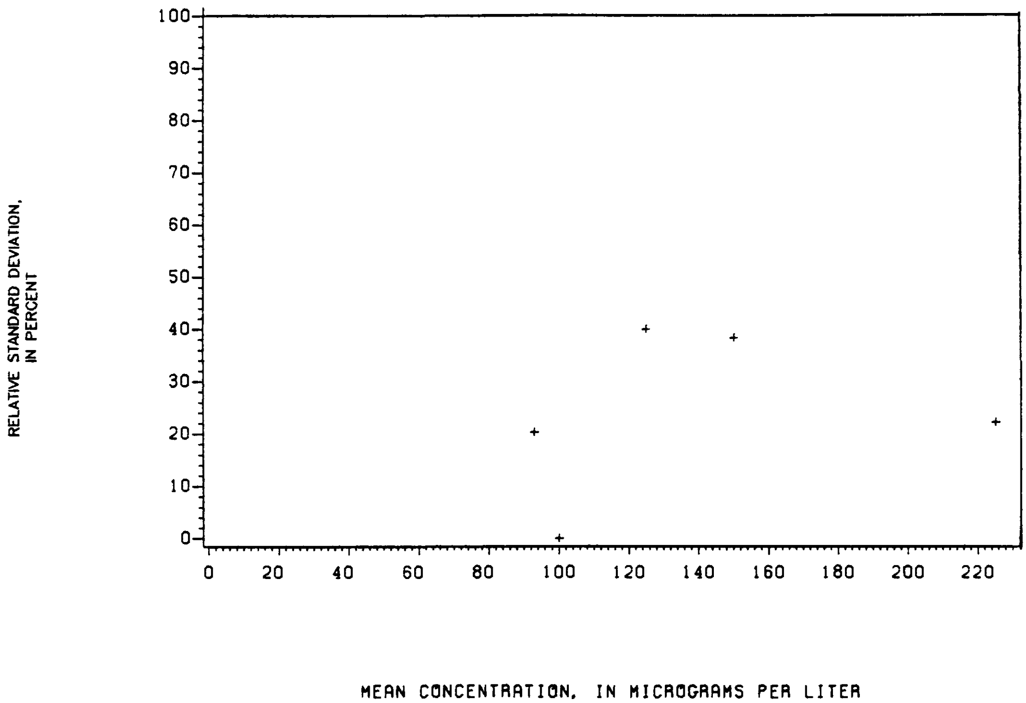

Figure 101.-- Precision data for barium, total recoverable, at the Atlanta laboratory.

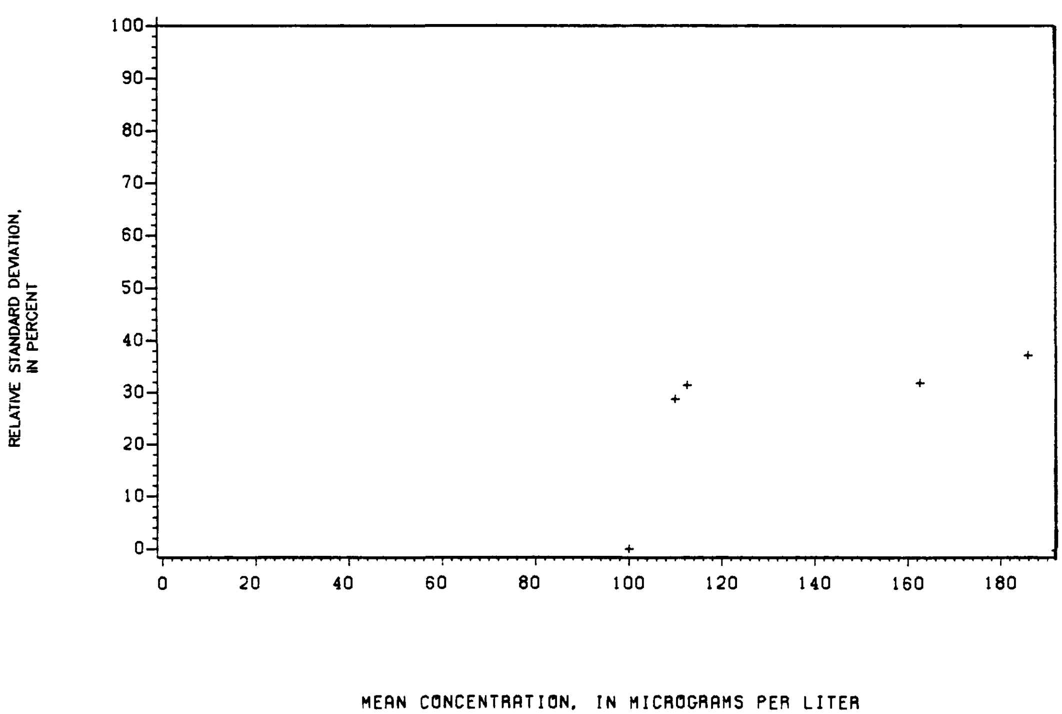

Figure 102.-- Precision data for barium, total recoverable, at the Denver laboratory.

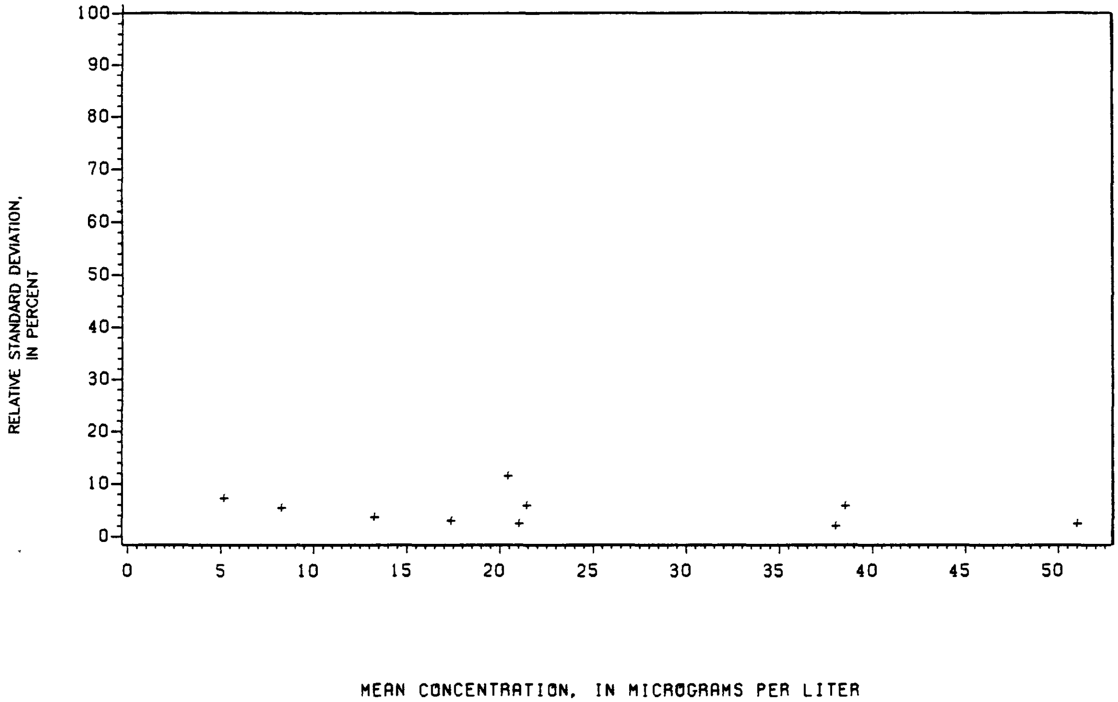

Figure 103.-- Precision data for beryllium, dissolved, at the Atlanta laboratory.

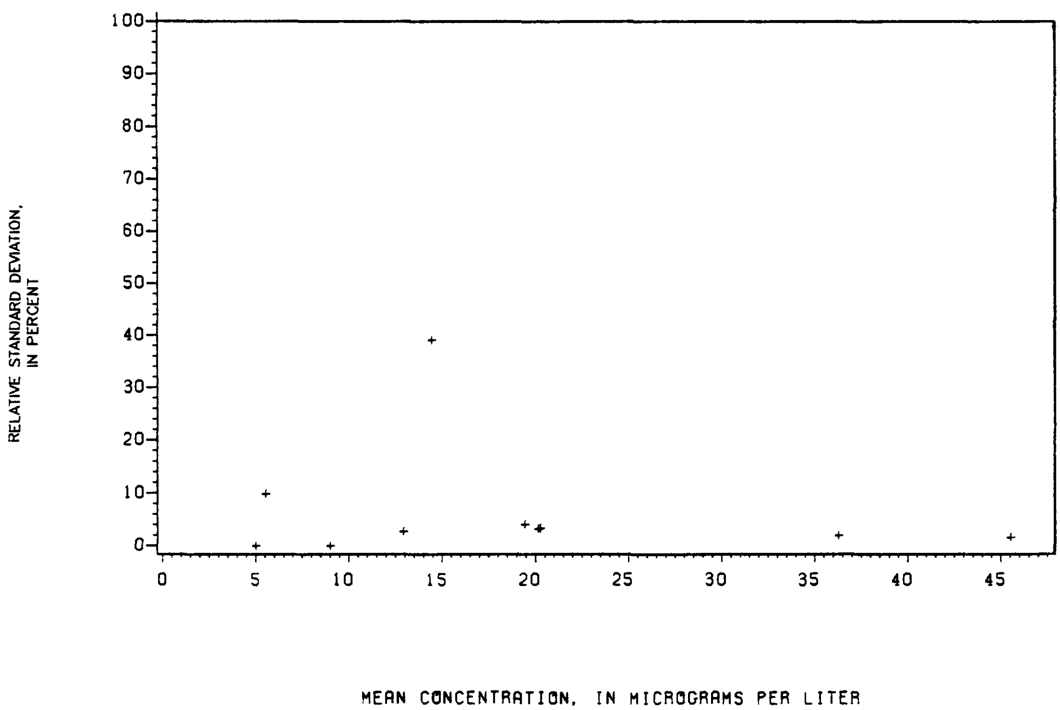

Figure 104.-- Precision data for beryllium, dissolved, at the Denver laboratory.

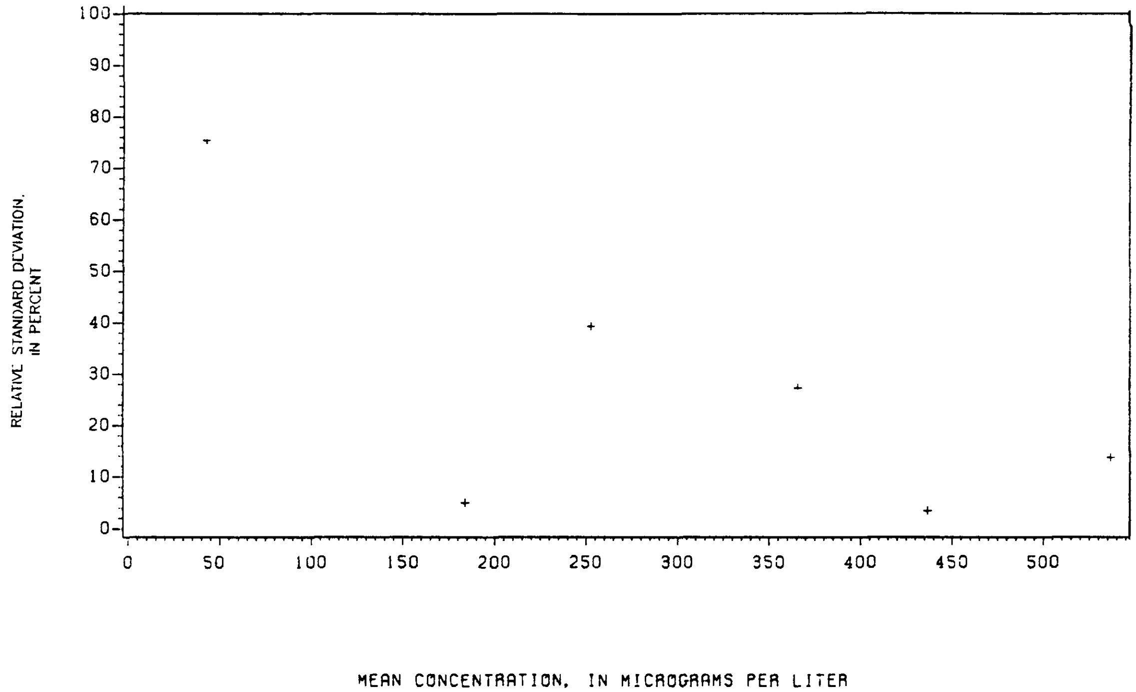

Figure 105.-- Precision data for boron, dissolved, at the Atlanta laboratory.

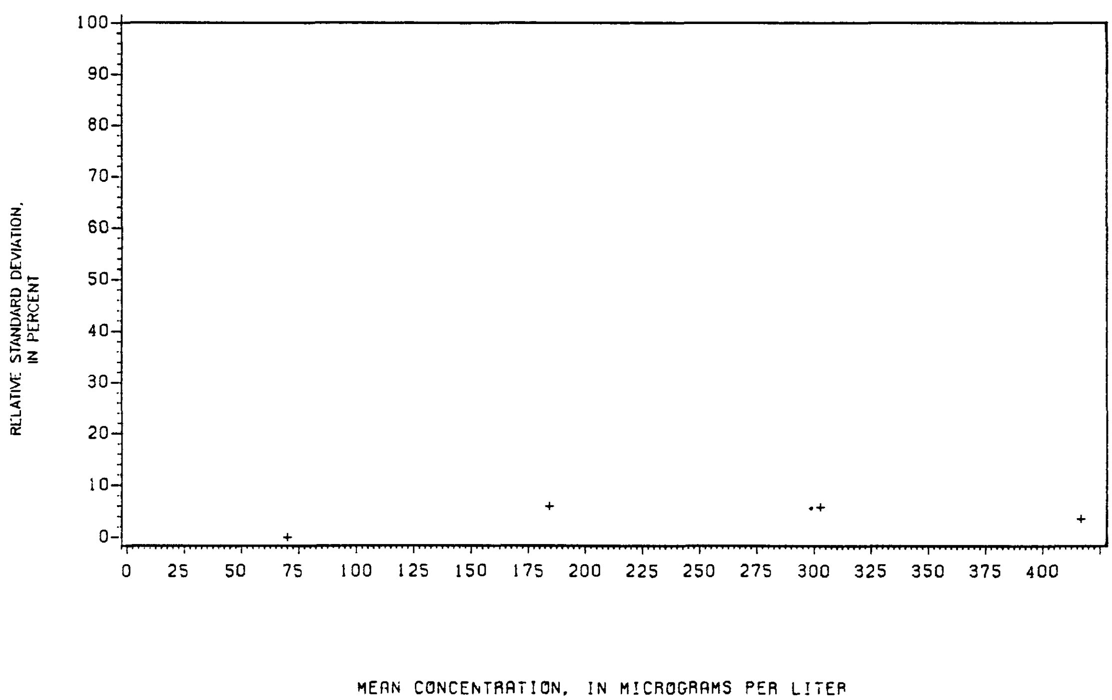

Figure 106.-- Precision data for boron, dissolved, at the Denver laboratory.

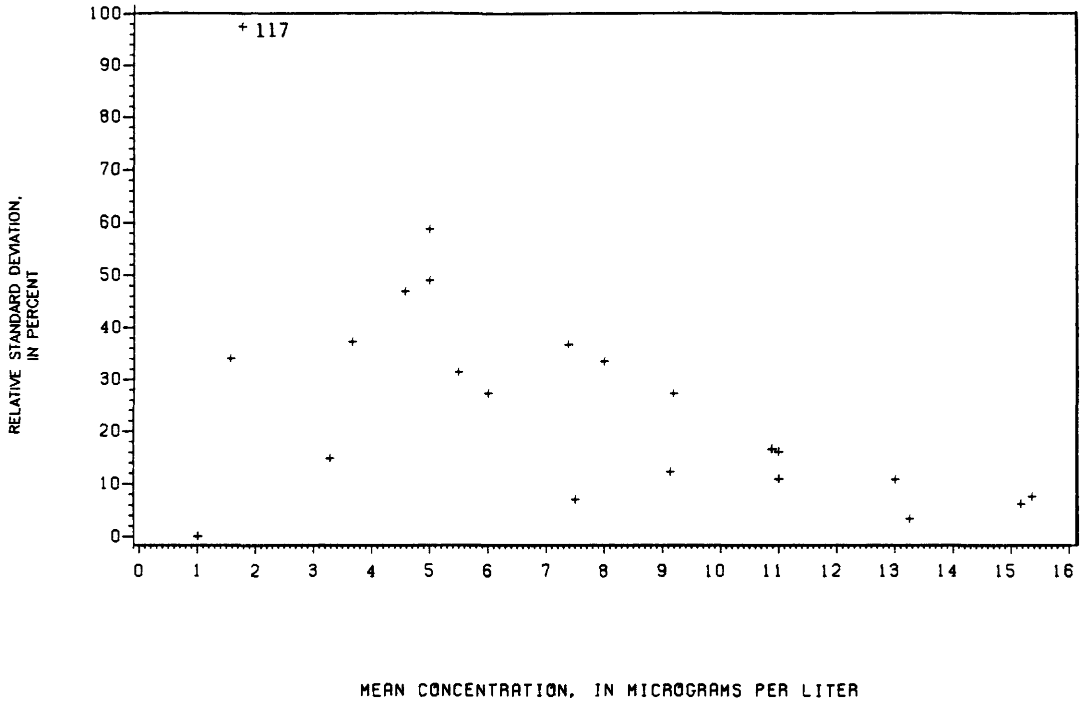

Figure 107.-- Precision data for cadmium, dissolved, at the Atlanta laboratory.

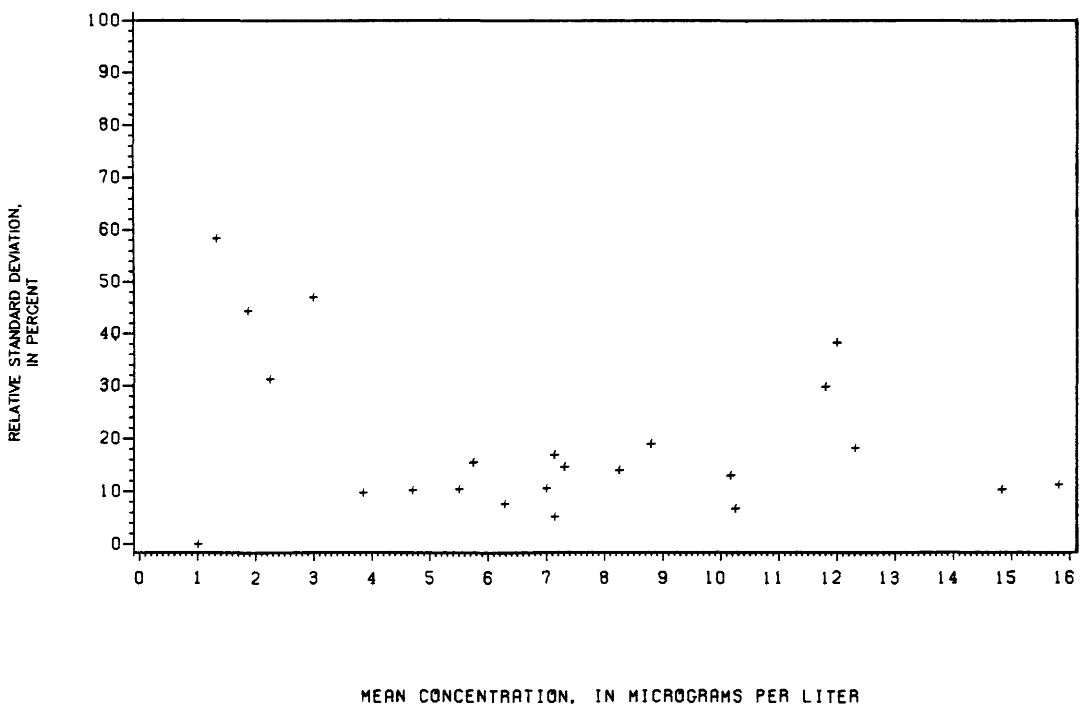

Figure 108.-- Precision data for cadmium, dissolved, at the Denver laboratory.

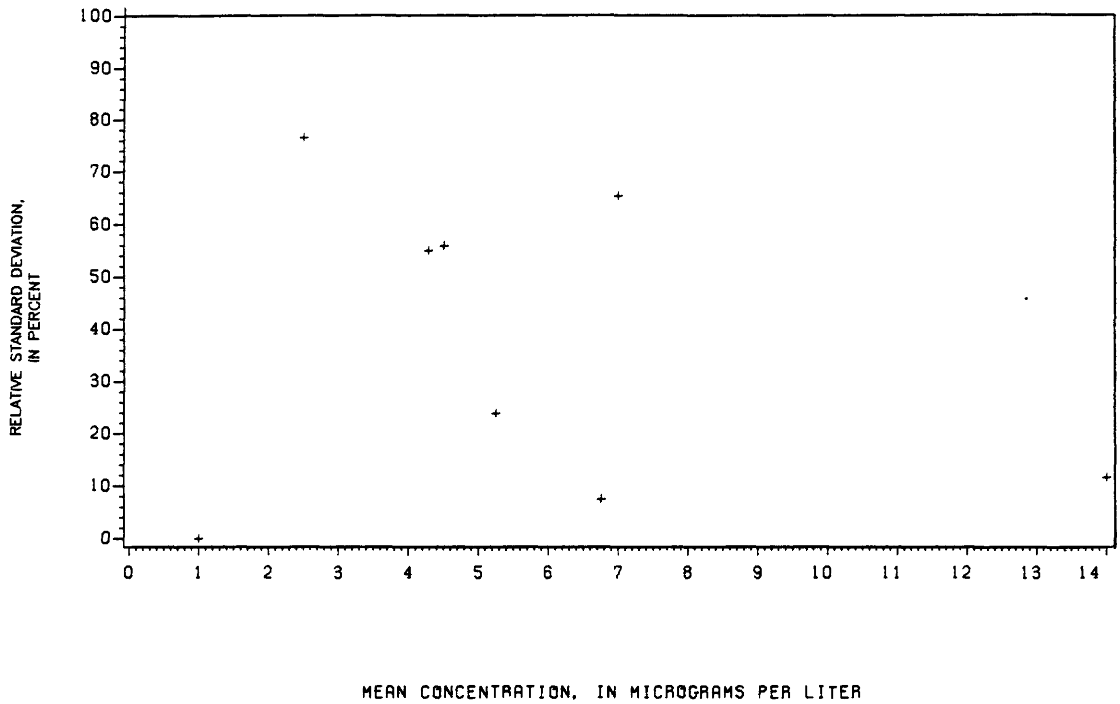

Figure 109.-- Precision data for cadmium, total recoverable, at the Atlanta laboratory.

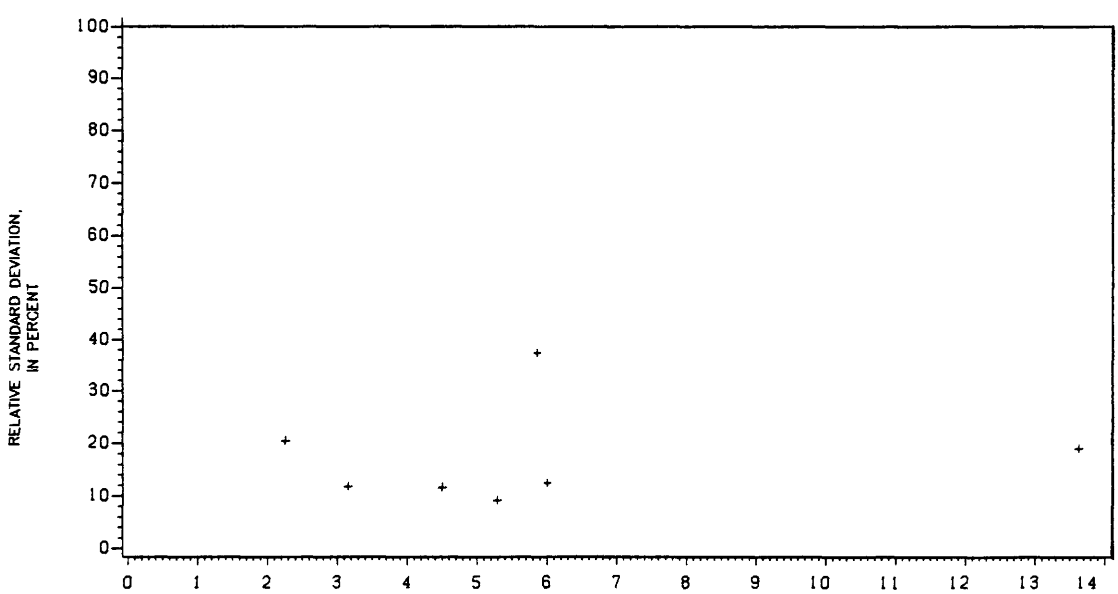

Figure 110.-- Precision data for cadmium, total recoverable, at the Denver laboratory.

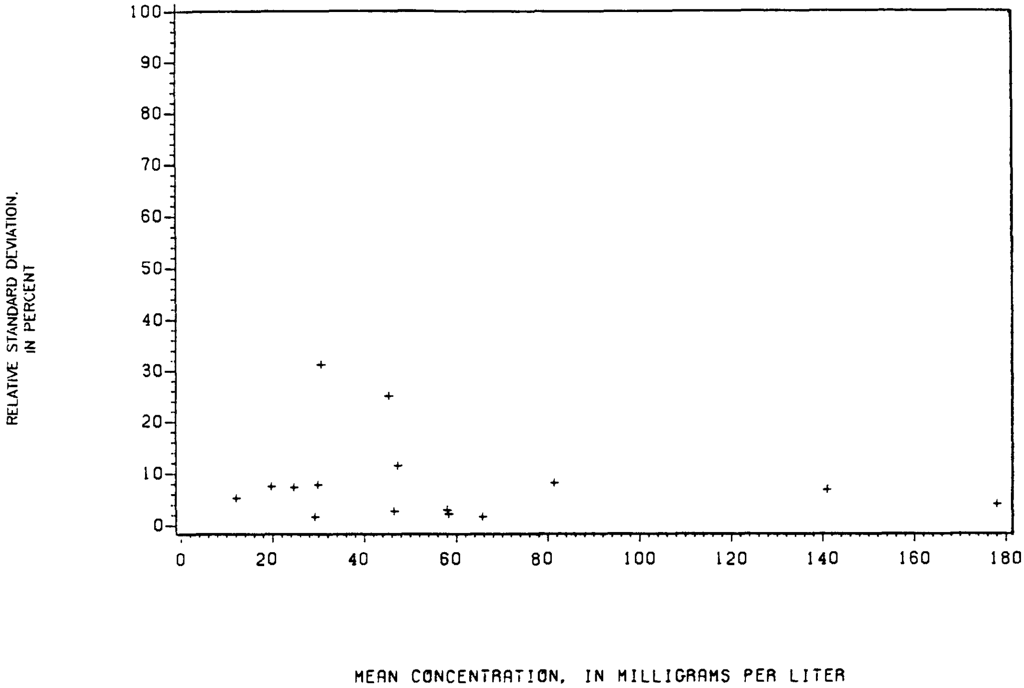

Figure 111.-- Precision data for calcium dissolved(inductively coupled plasma emmision spectrometry), at the Atlanta laboratory.

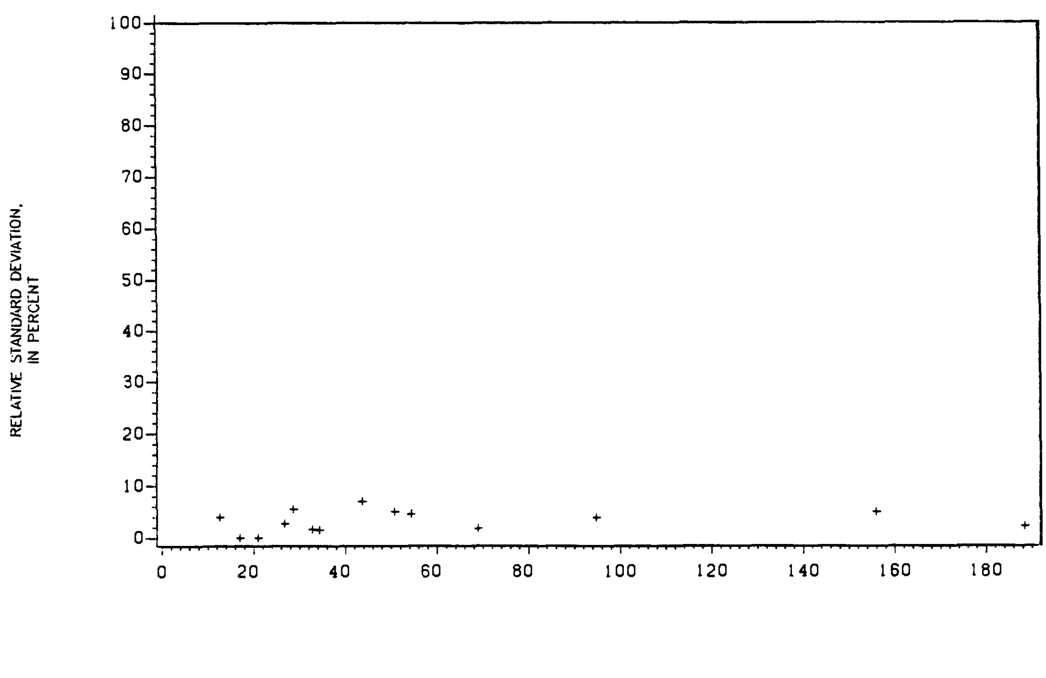

Figure 112.-- Precision data for calcium dissolved(inductively coupled plasma emmision spectrometry), at the Denver laboratory.

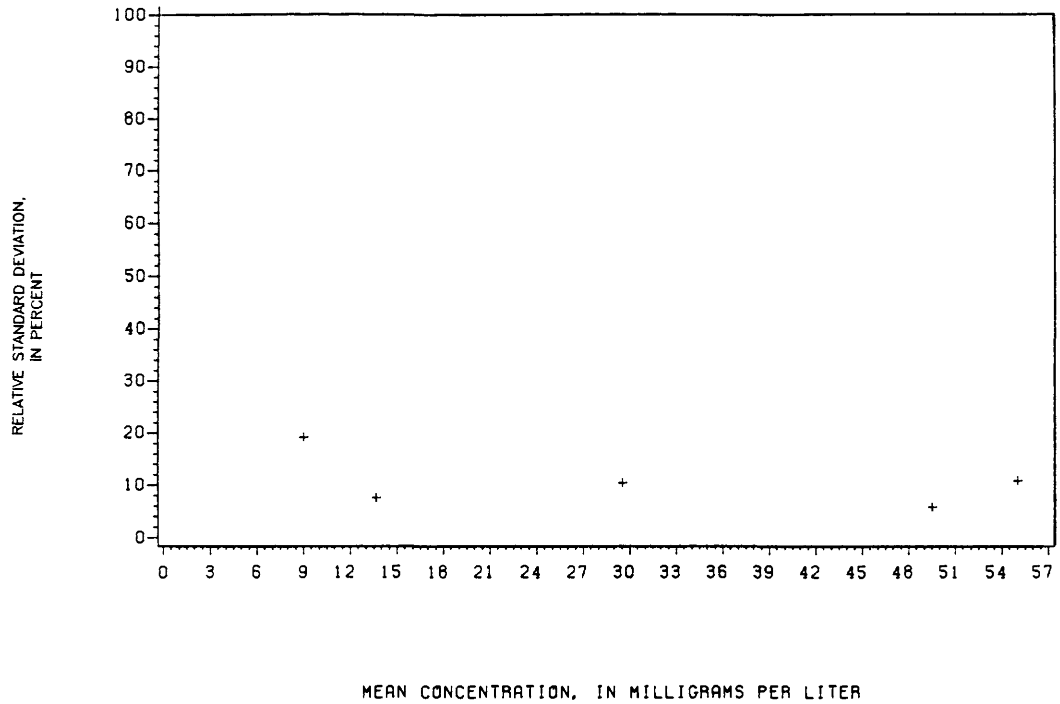

Figure 113.-- Precision data for calcium dissolved(atomic absorption spectrometry), at the Atlanta laboratory.

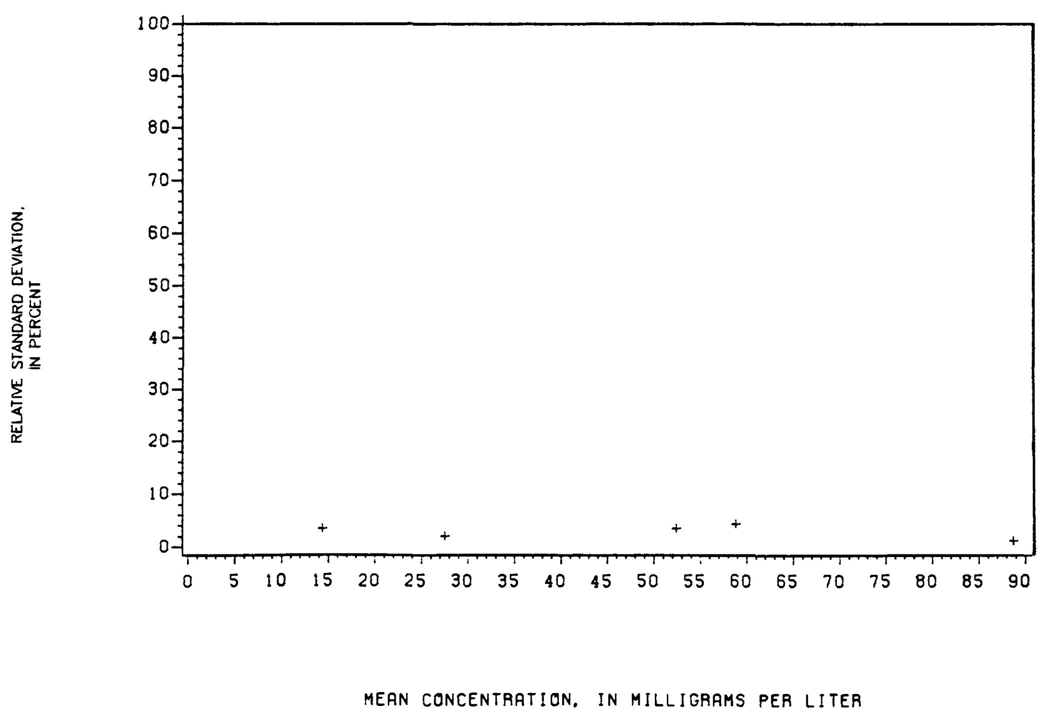

Figure 114.-- Precision data for calcium dissolved(atomic absorption spectrometry), at the Denver laboratory.

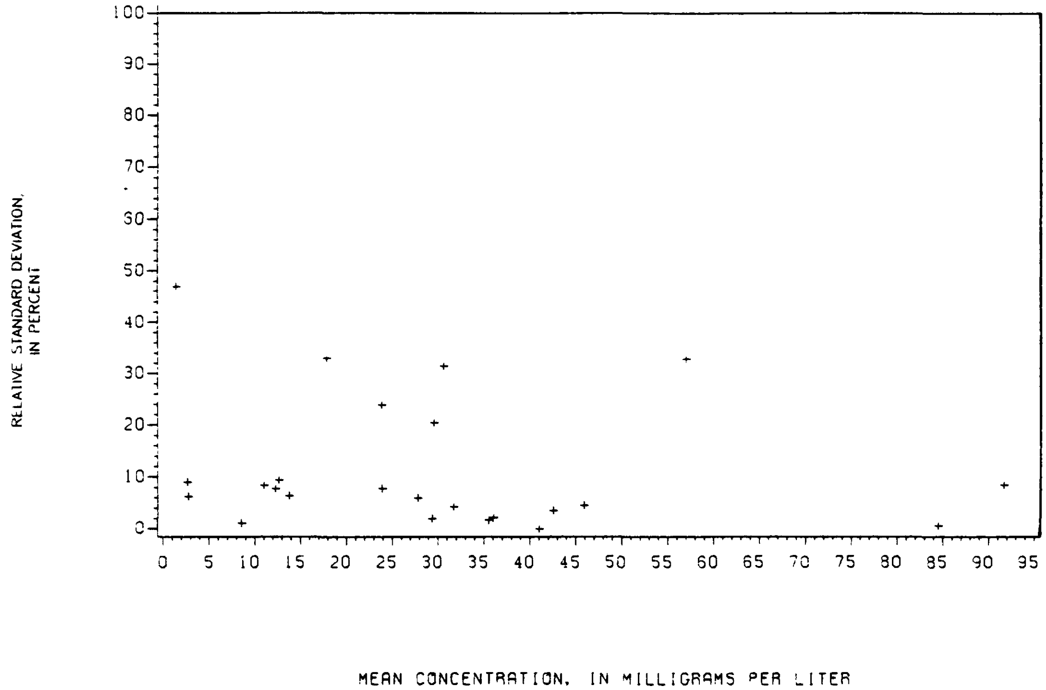

Figure 115.-- Precision data for chloride, dissolved, at the Atlanta laboratory.

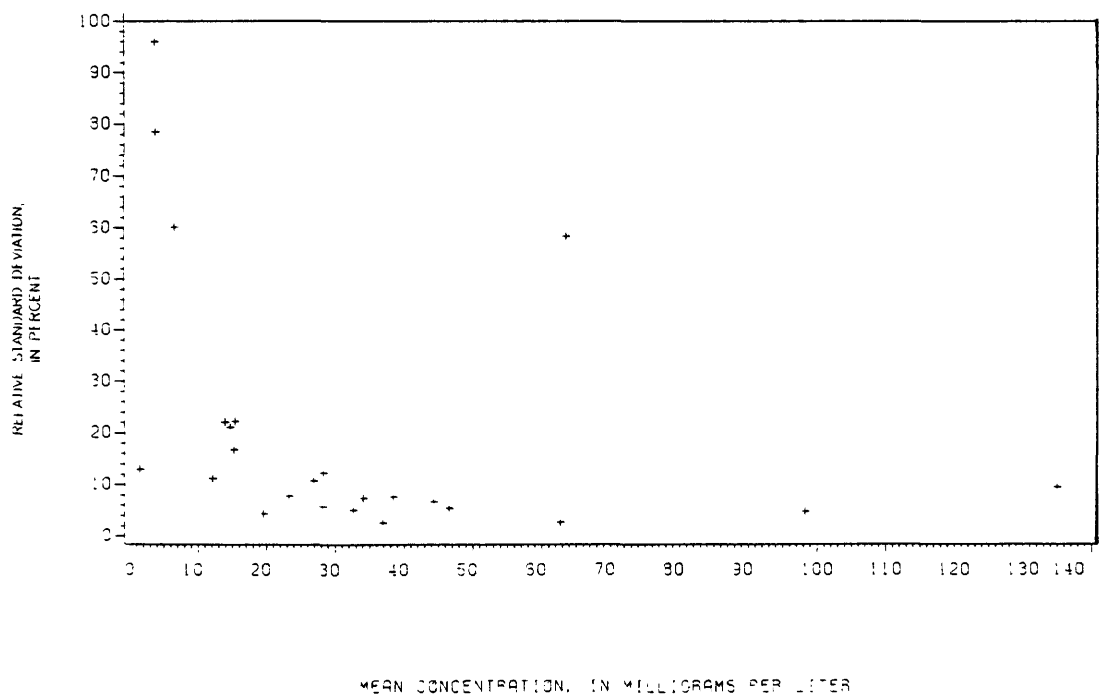

Figure 116.-- Precision data for chloride, dissolved, at the Denver laboratory.

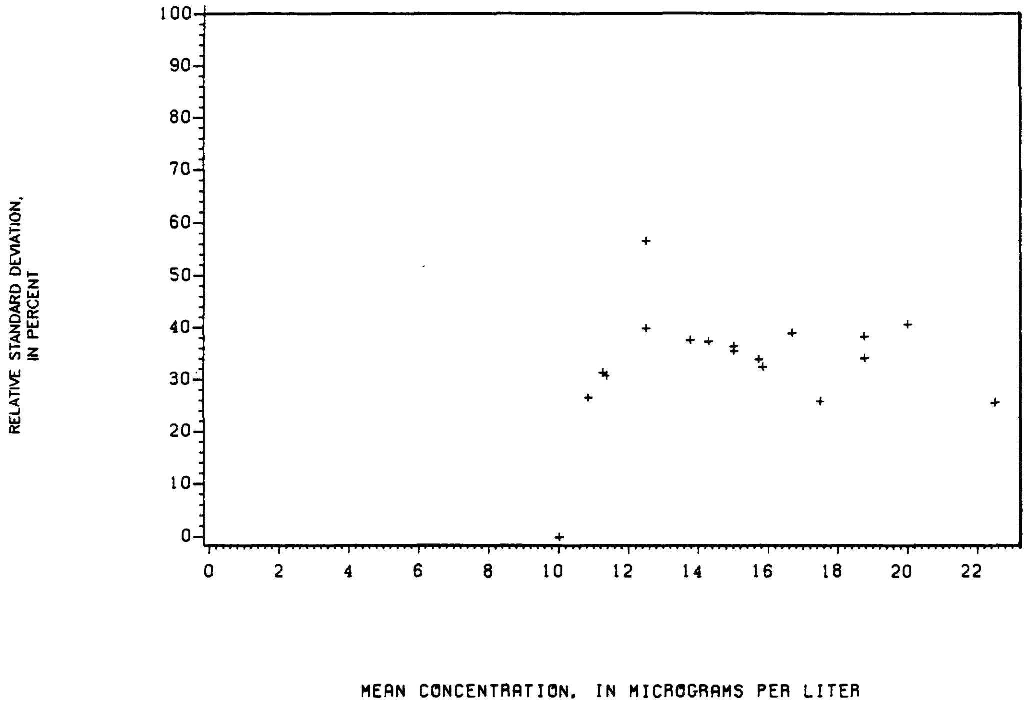

Figure 117.-- Precision data for chromium, dissolved, at the Atlanta laboratory.

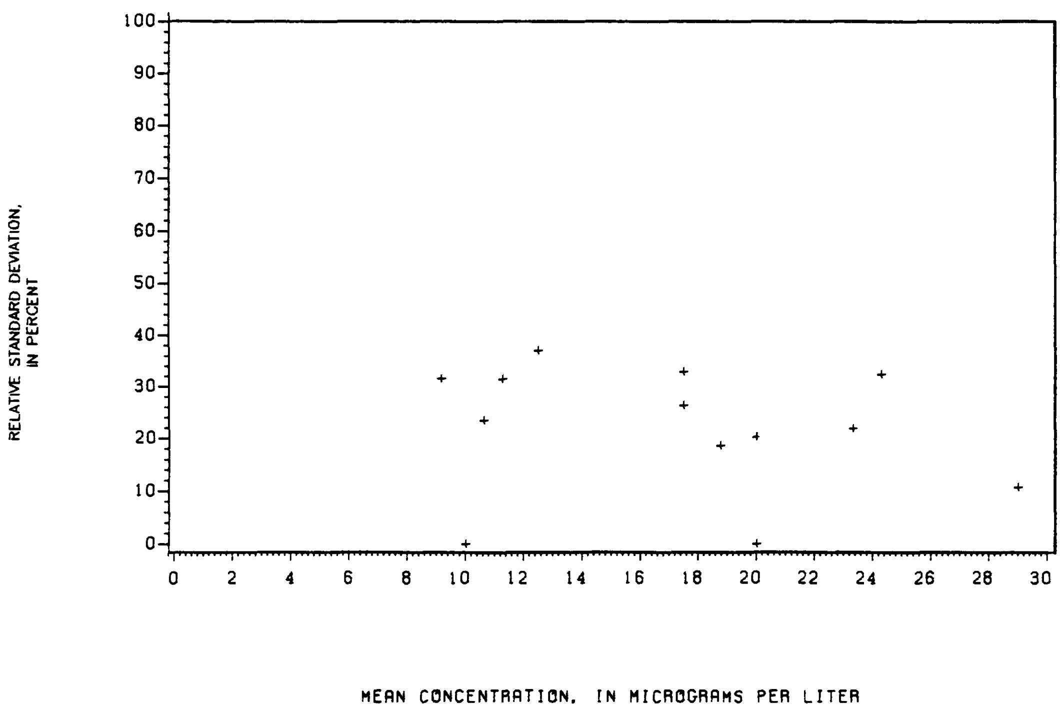

Figure 118.-- Precision data for chromium, dissolved, at the Denver laboratory.

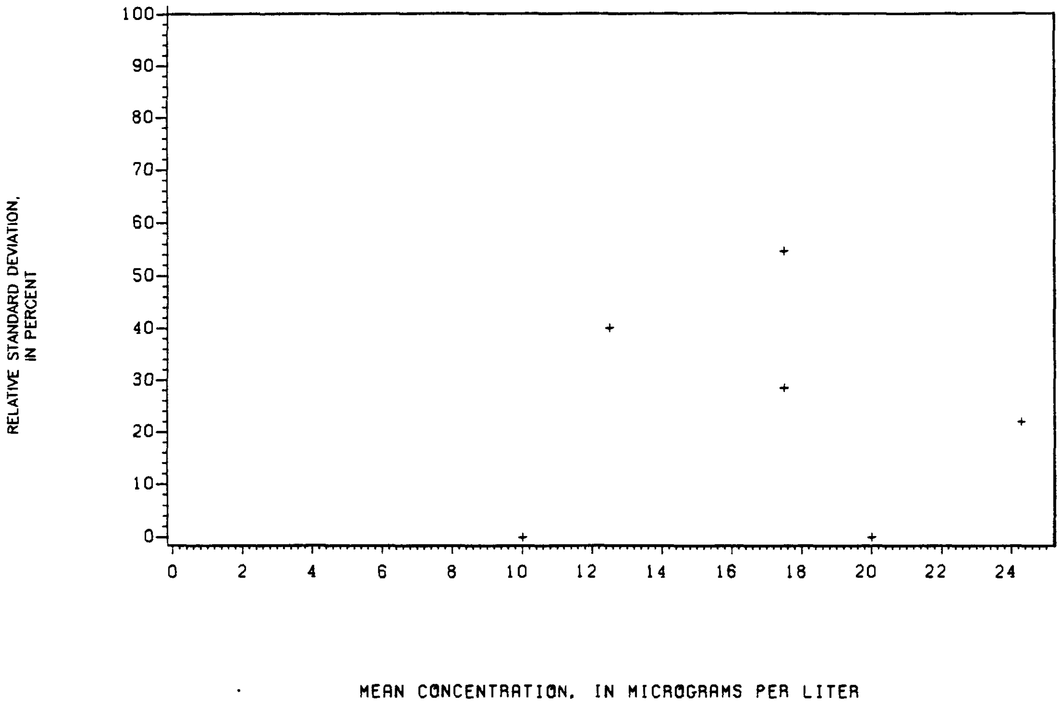

Figure 119.-- Precision data for chromium, total recoverable, at the Atlanta laboratory.

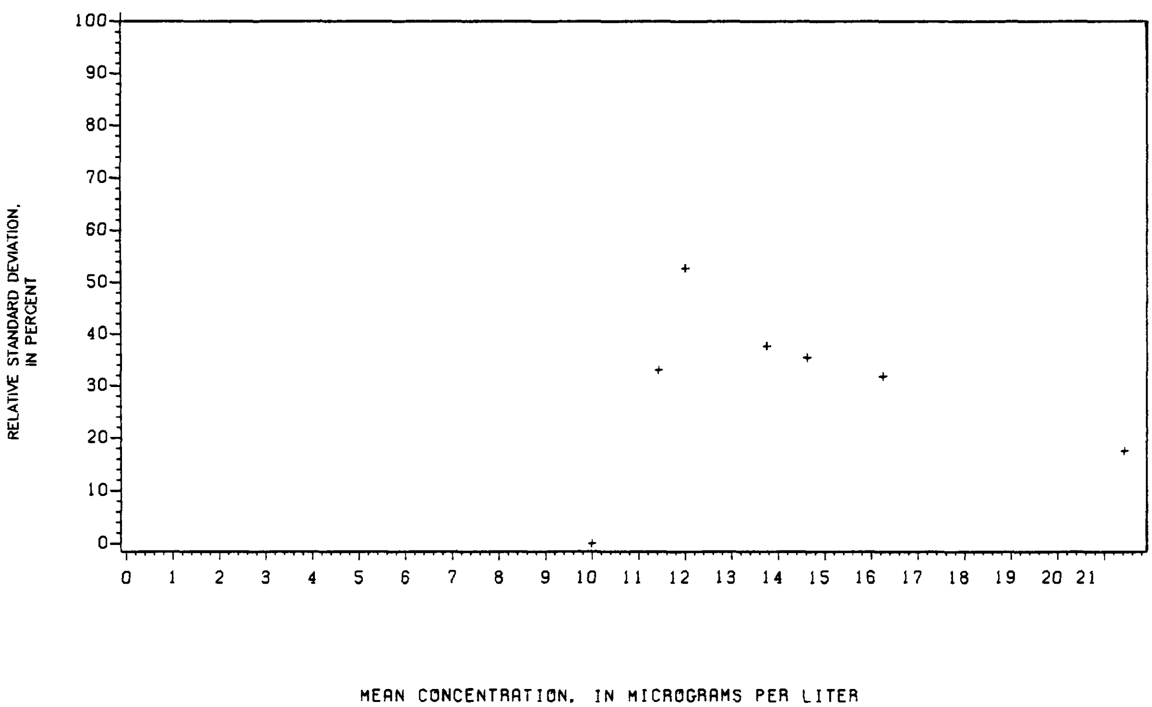

Figure 120.-- Precision data for chromium, total recoverable, at the Denver laboratory.

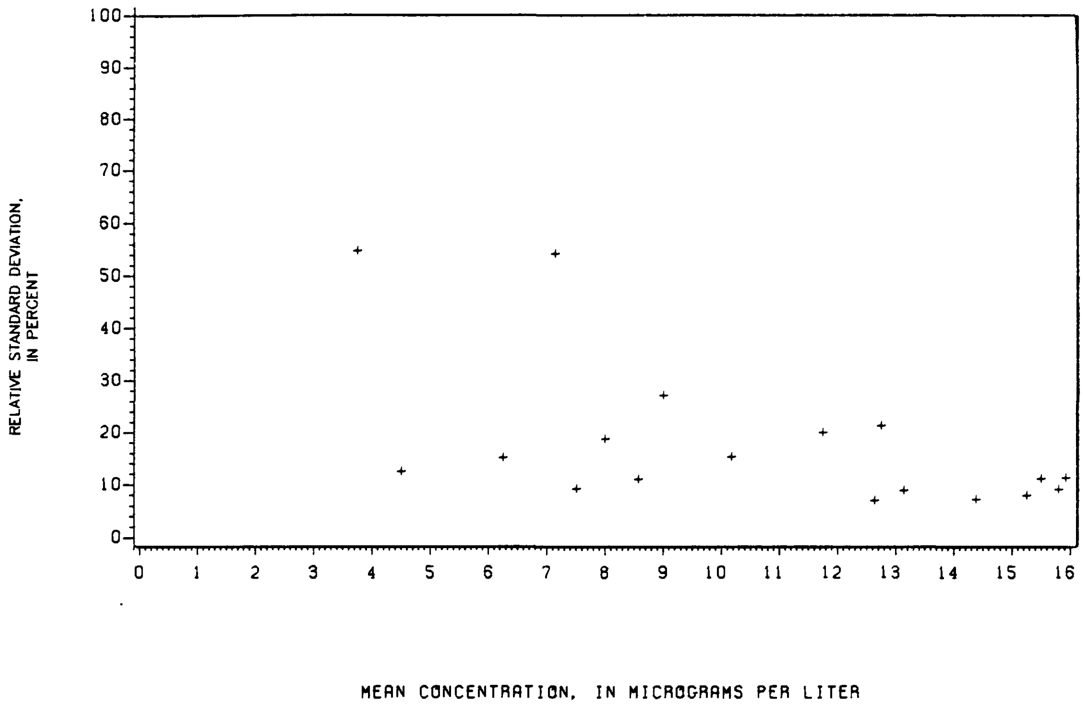

Figure 121.-- Precision data for cobalt, dissolved, at the Atlanta laboratory.

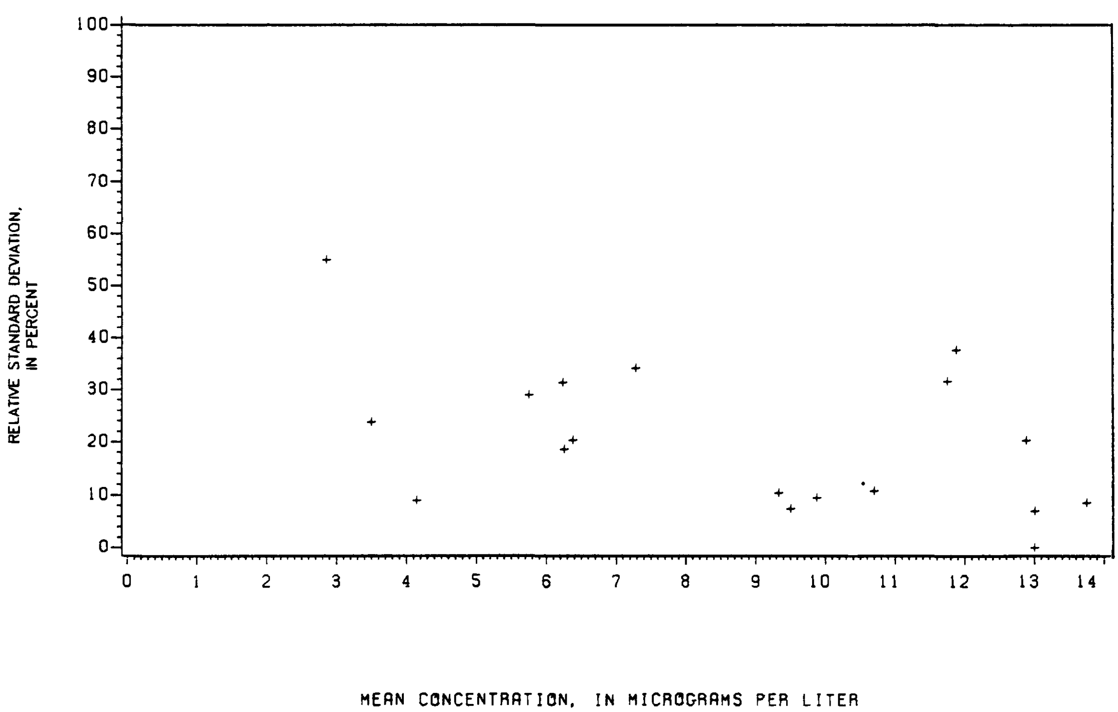

Figure 122.-- Precision data for cobalt, dissolved, at the Denver laboratory.

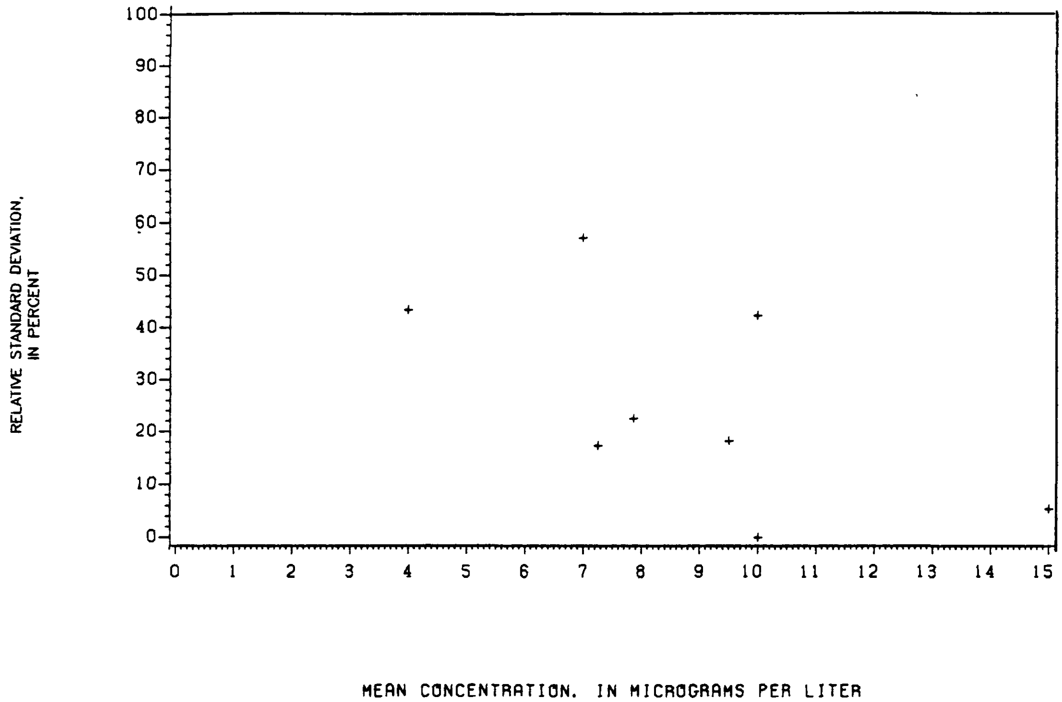

Figure 123.-- Precision data for cobalt, total recoverable, at the Atlanta laboratory.

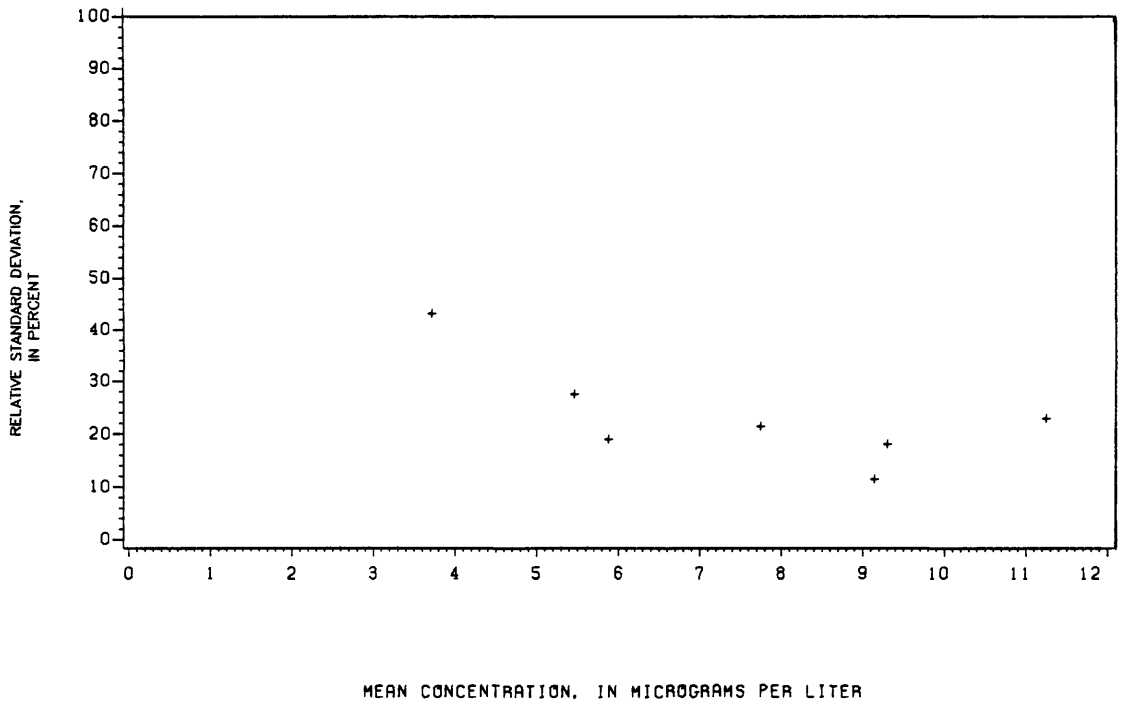

Figure 124.-- Precision data for cobalt, total recoverable, at the Denver laboratory.

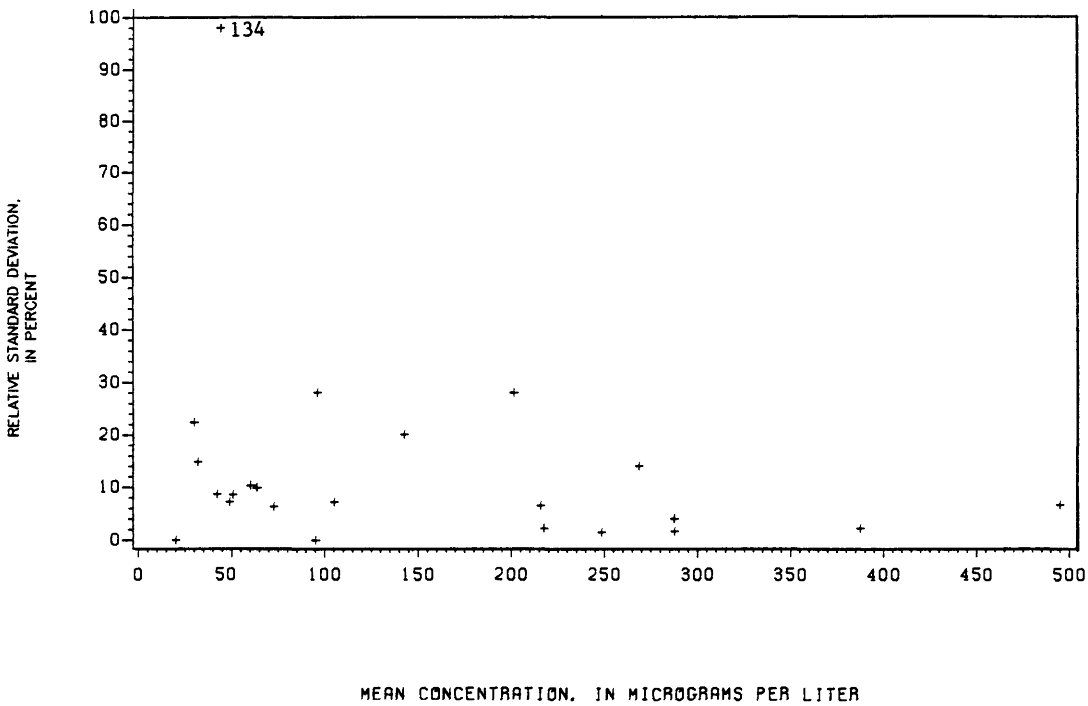

Figure 125.-- Precision data for copper, dissolved, at the Atlanta laboratory.

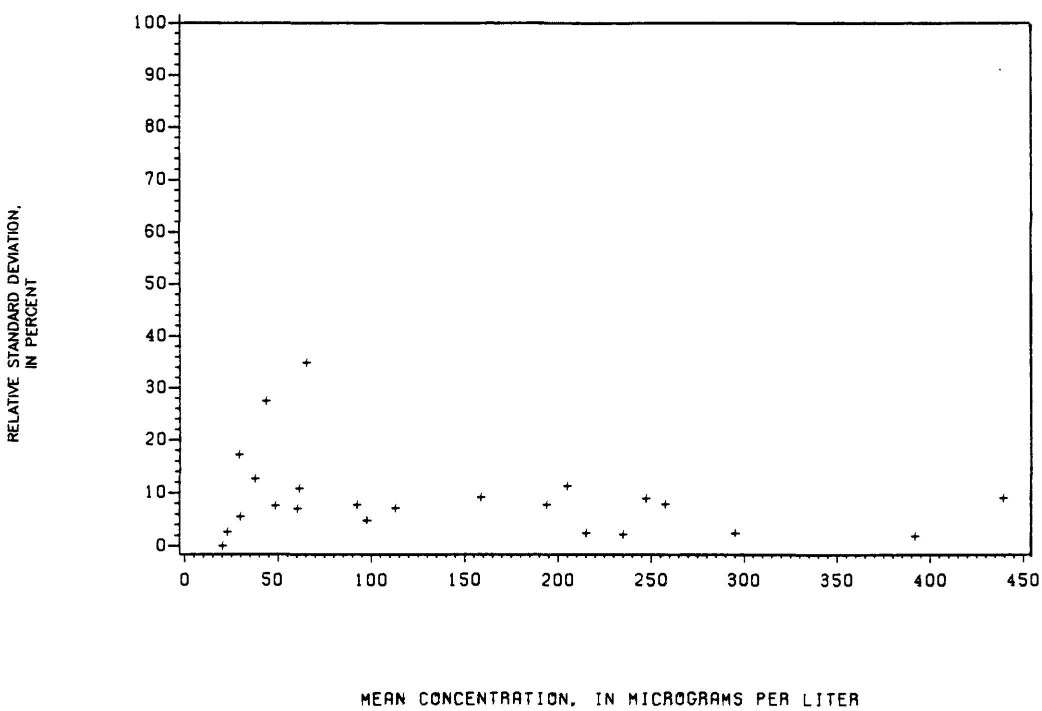

Figure 126.-- Precision data for copper, dissolved, at the Denver laboratory.

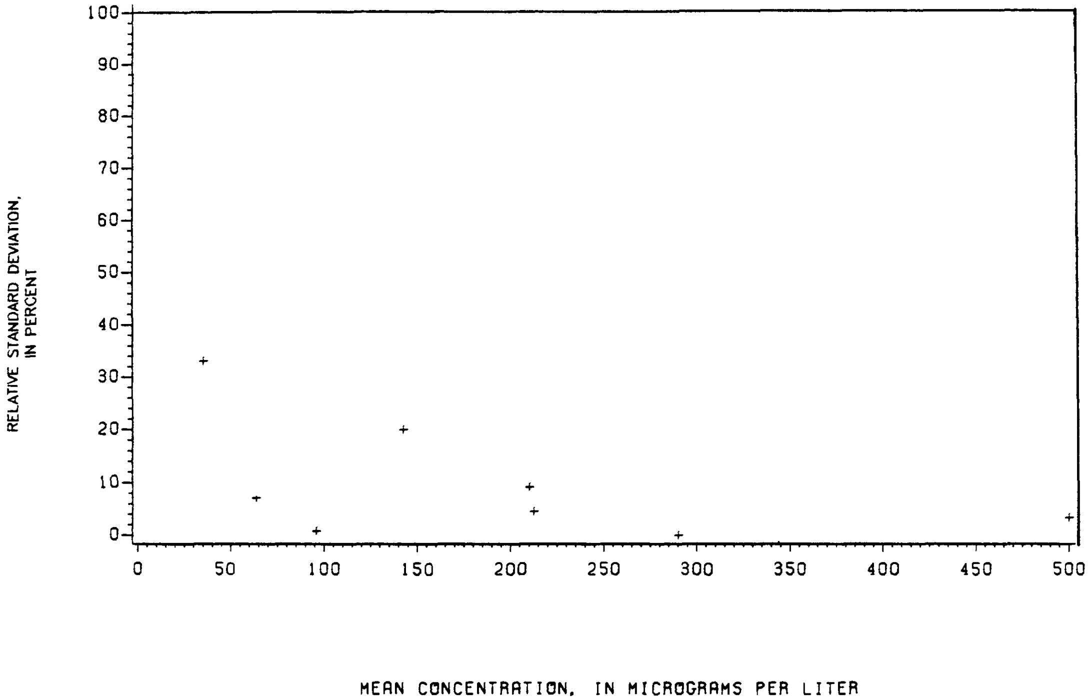

Figure 127.-- Precision data for copper, total recoverable, at the Atlanta laboratory.

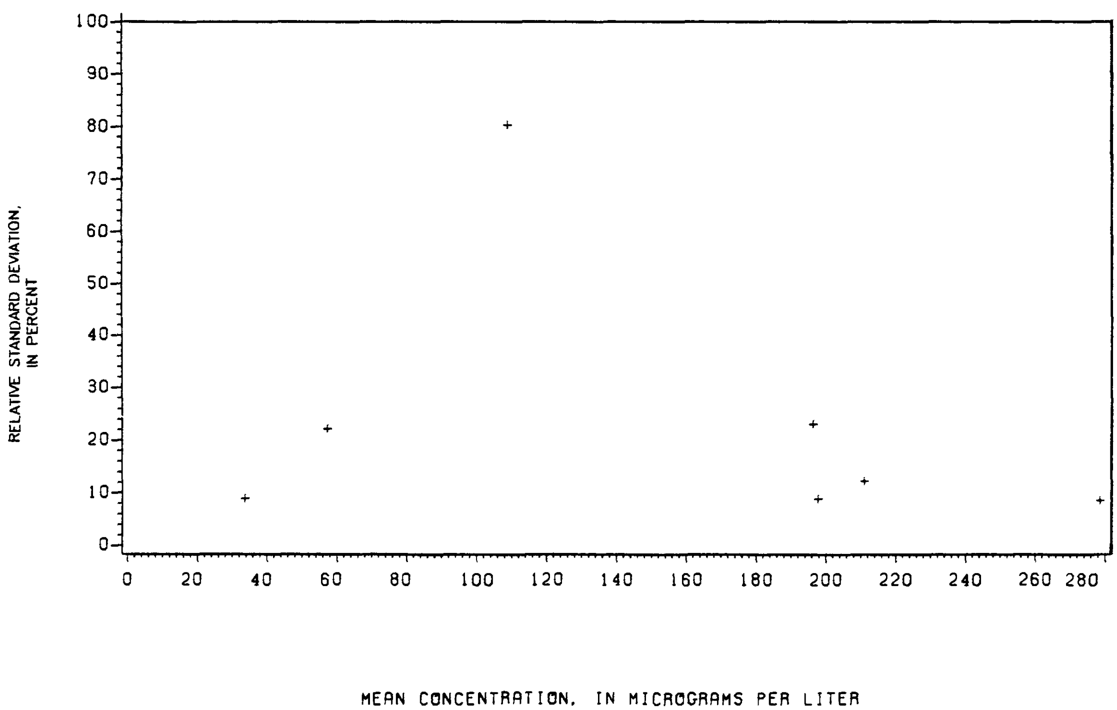

Figure 128.-- Precision data for copper, total recoverable, at the Denver laboratory.

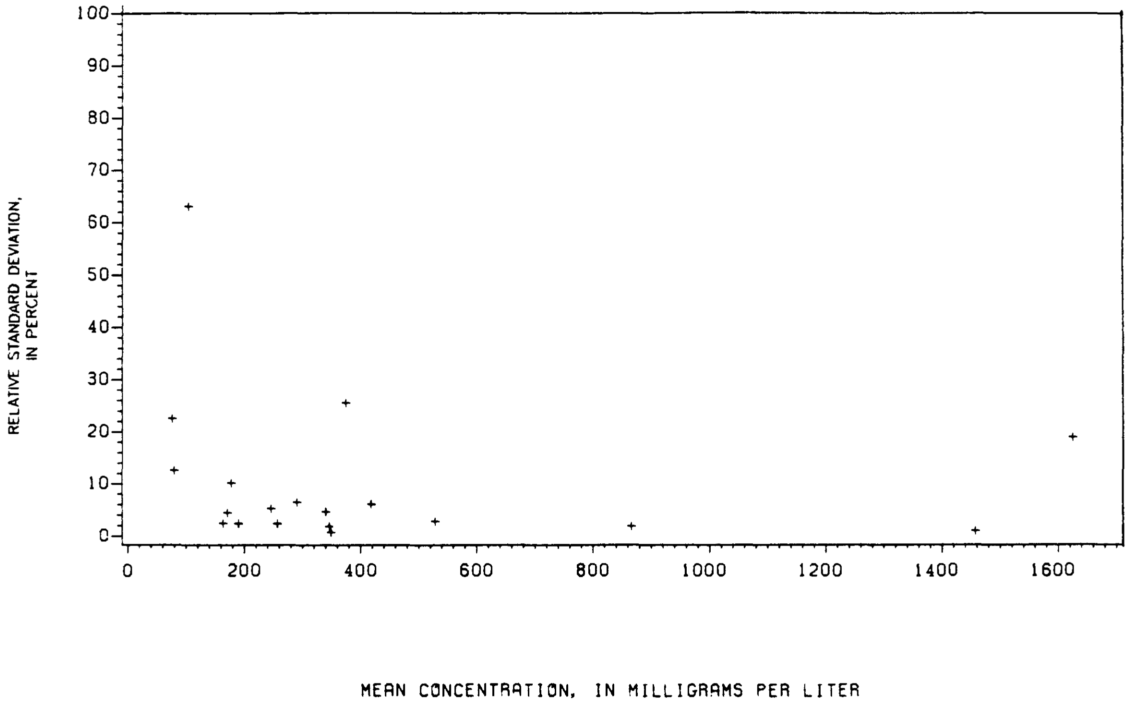

Figure 129.-- Precision data for dissolved solids at the Atlanta laboratory.

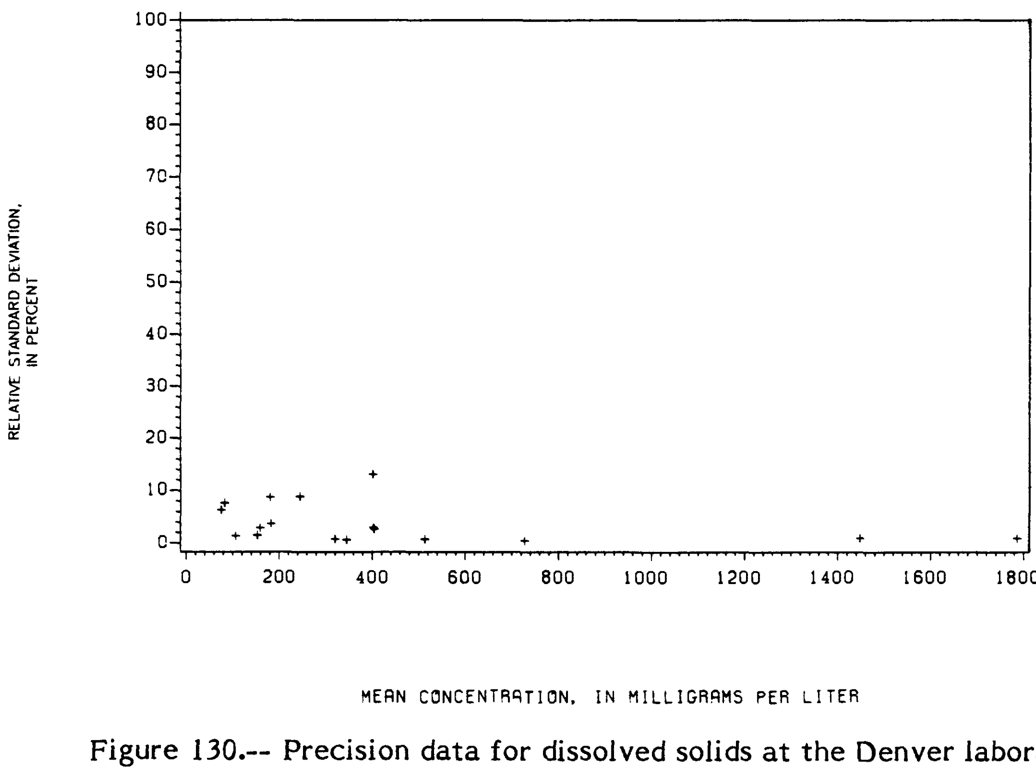

Figure 130.-- Precision data for dissolved solids at the Denver laboratory.

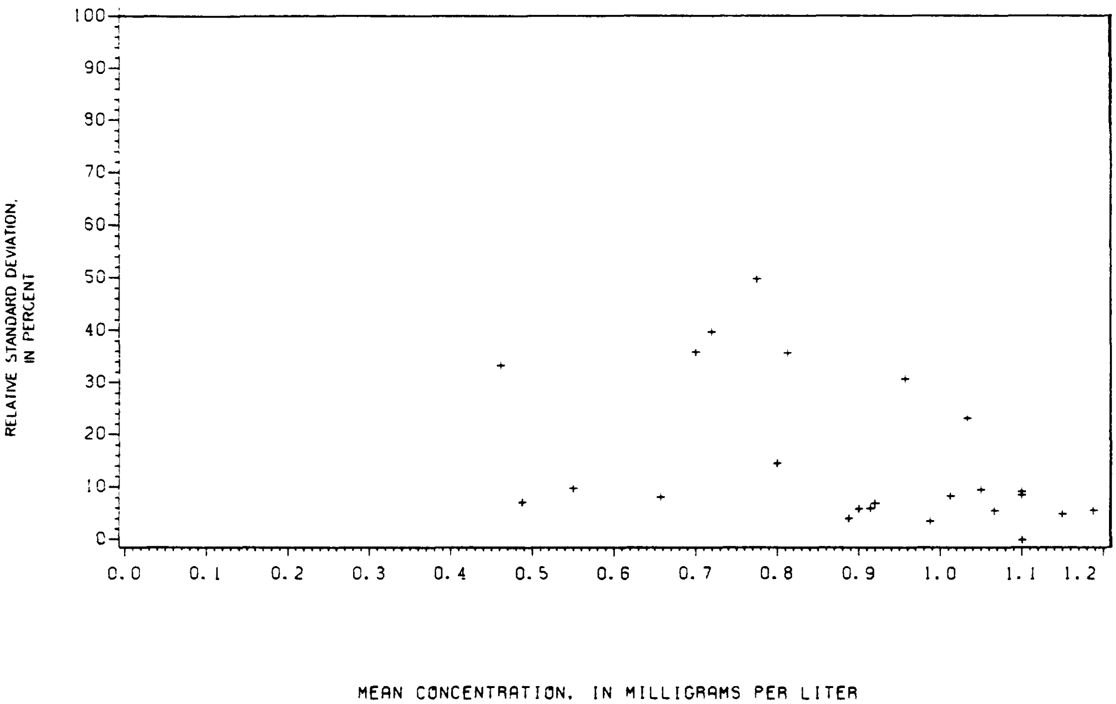

Figure 131.-- Precision data for fluoride, dissolved, at the Atlanta laboratory.

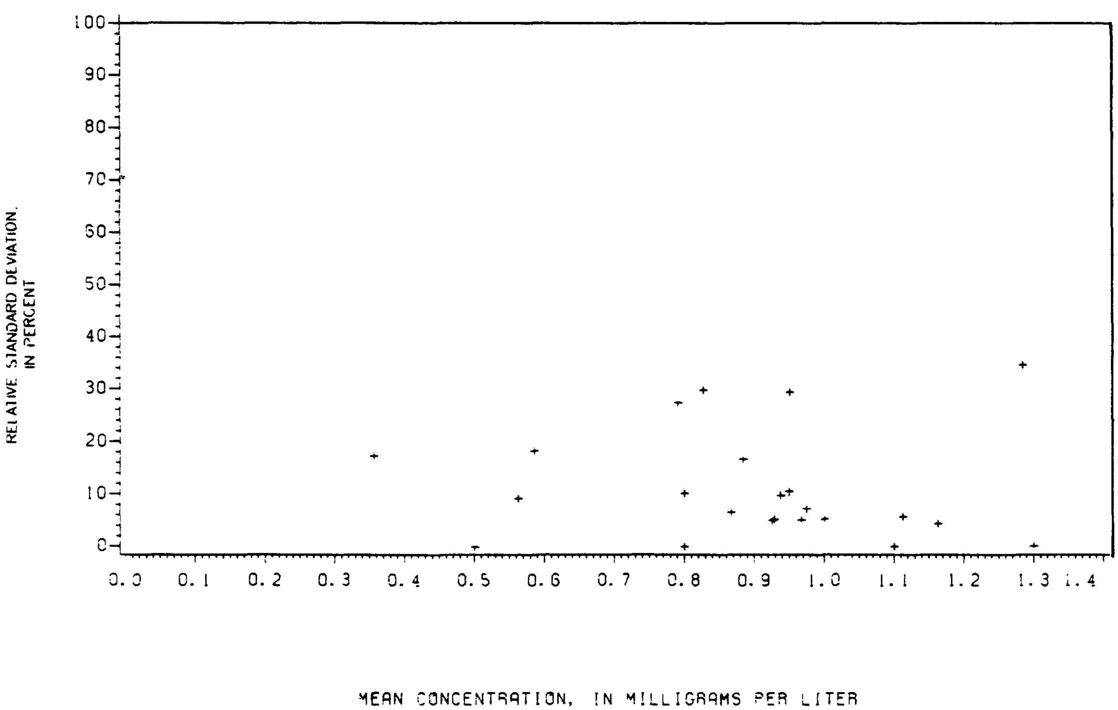

Figure 132.-- Precision data for fluoride, dissolved, at the Denver laboratory.

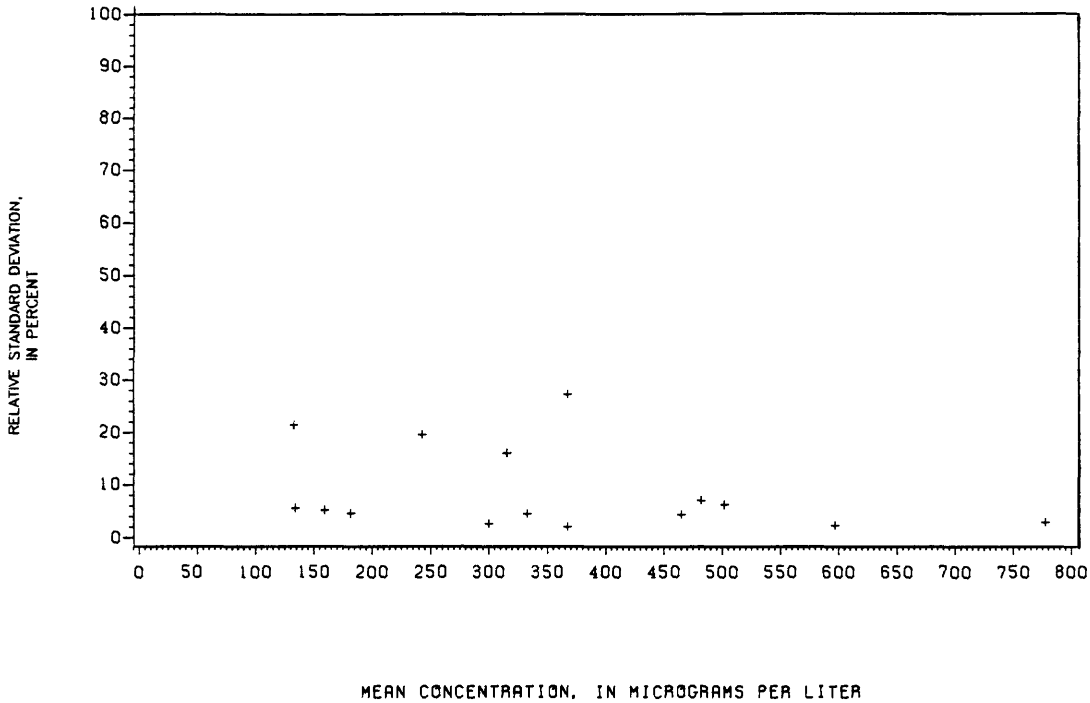

Figure 133.-- Precision data for iron, dissolved, at the Atlanta laboratory.

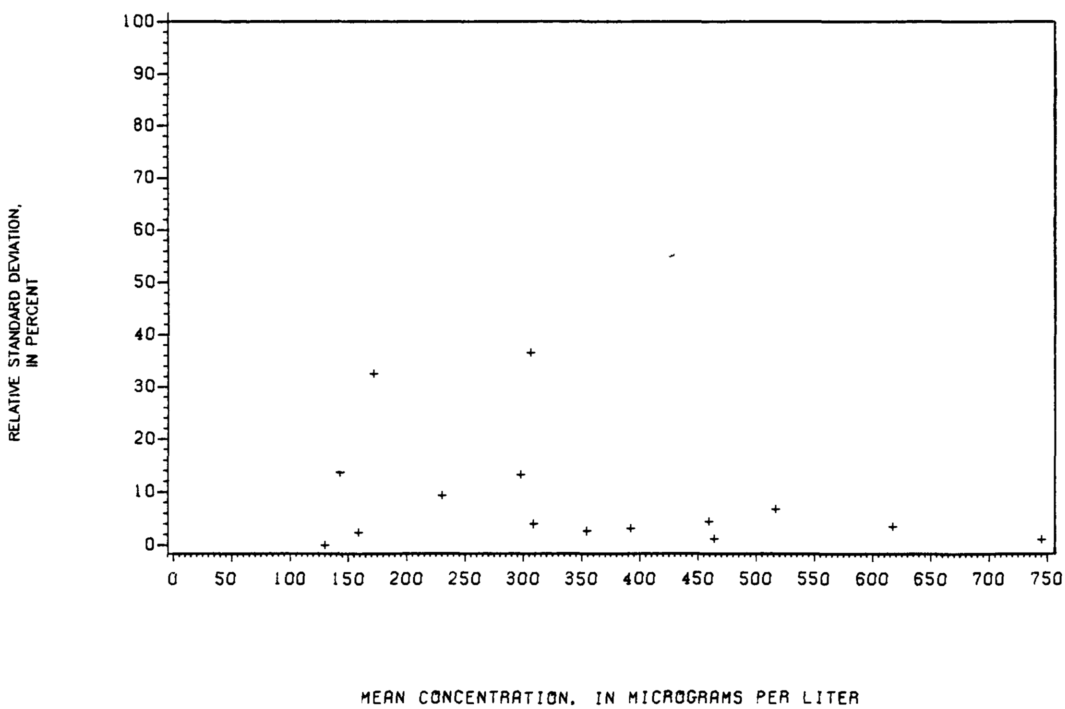

Figure 134.-- Precision data for iron, dissolved, at the Denver laboratory.

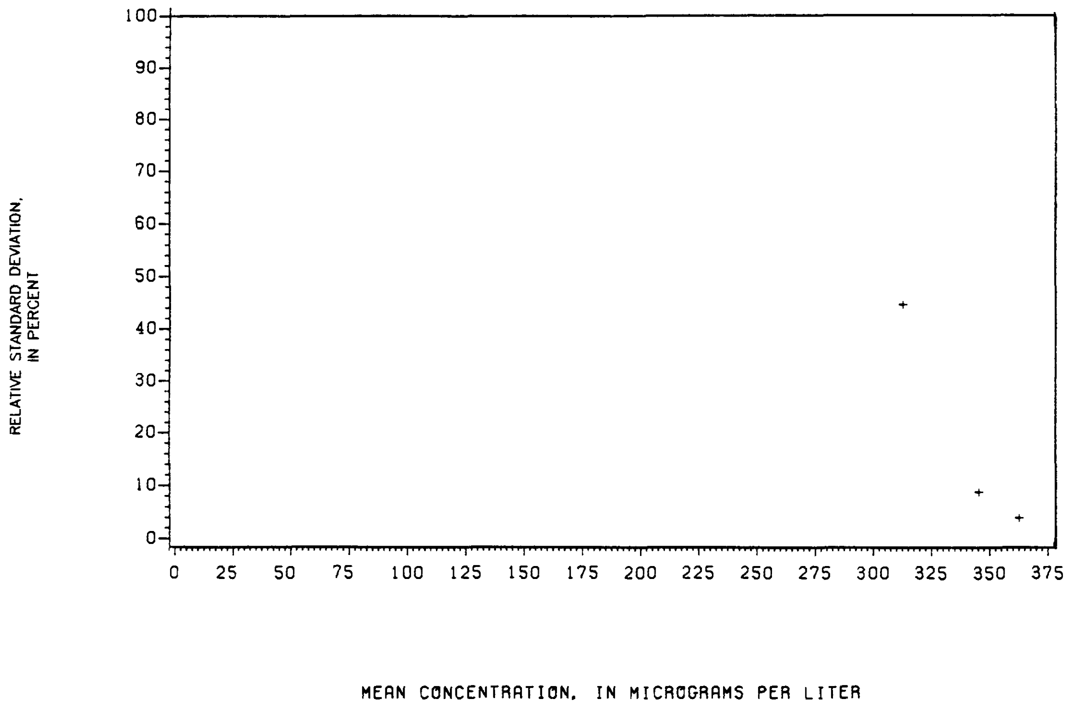

Figure 135.-- Precision data for iron, total recoverable, at the Atlanta laboratory.

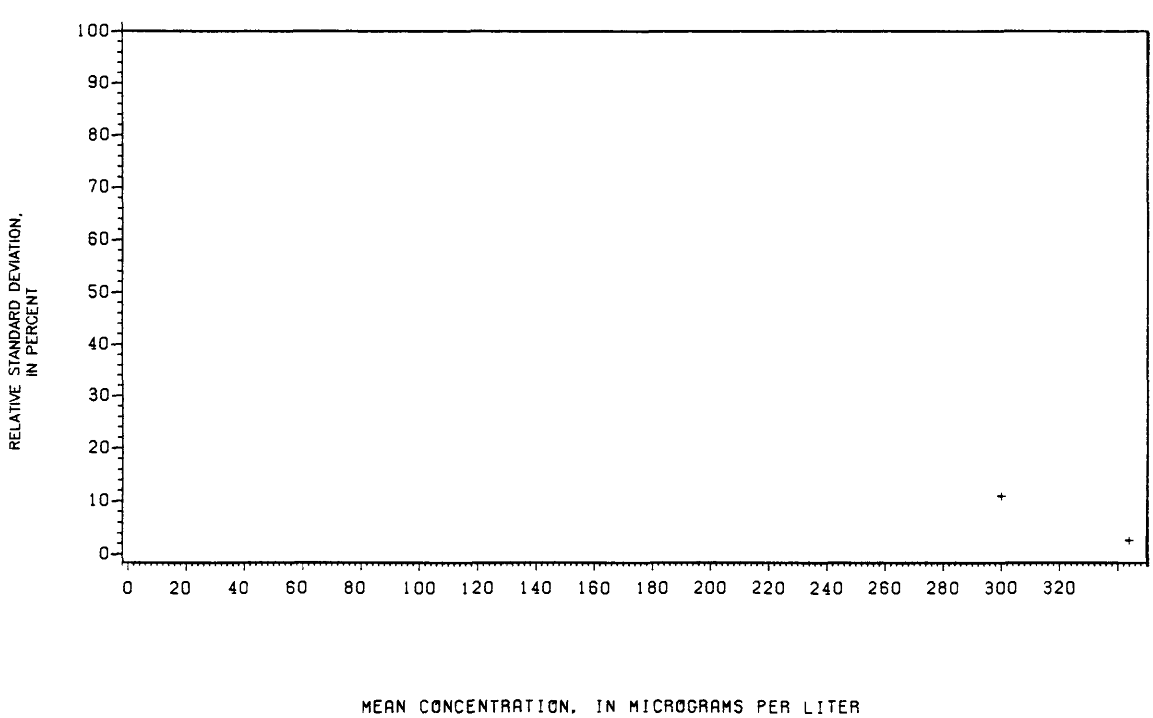

Figure 136.-- Precision data for iron, total recoverable, at the Denver laboratory.

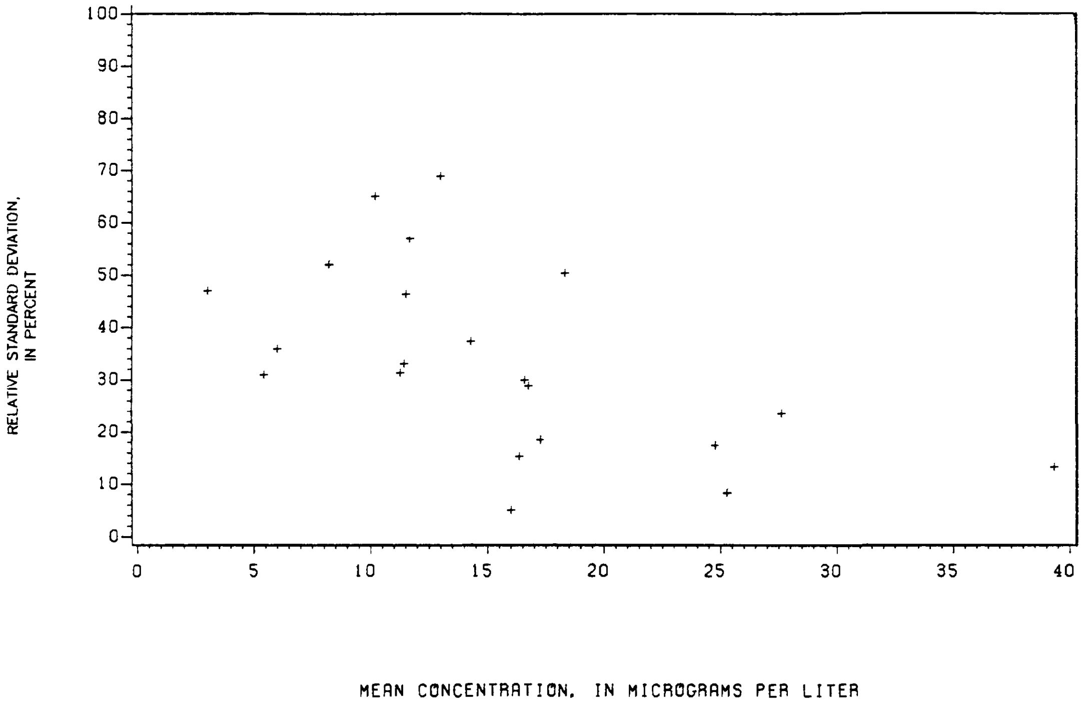

Figure 137.-- Precision data for lead, dissolved, at the Atlanta laboratory.

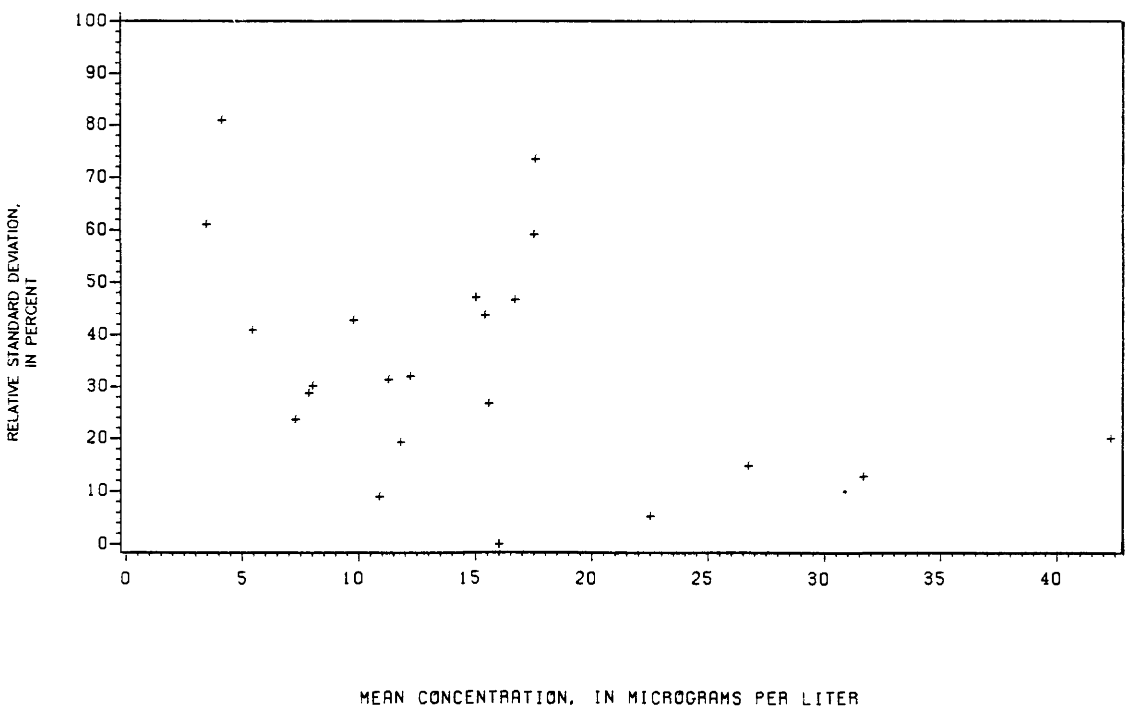

Figure 138.-- Precision data for lead, dissolved, at the Denver laboratory.

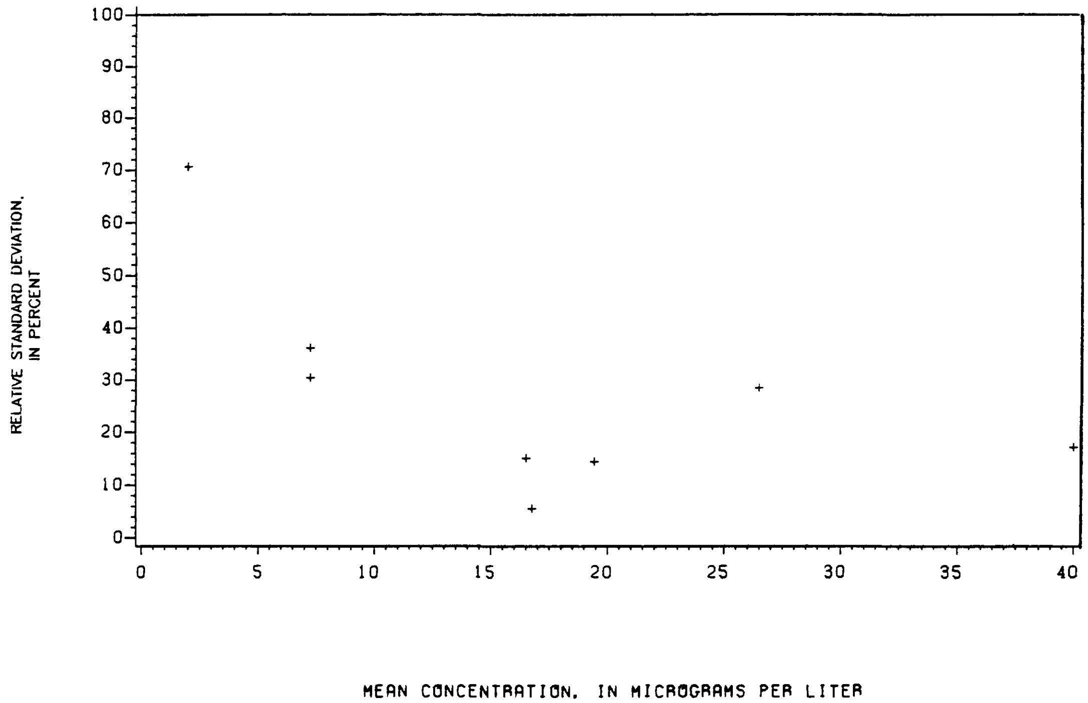

Figure 139.-- Precision data for lead, total recoverable, at the Atlanta laboratory.

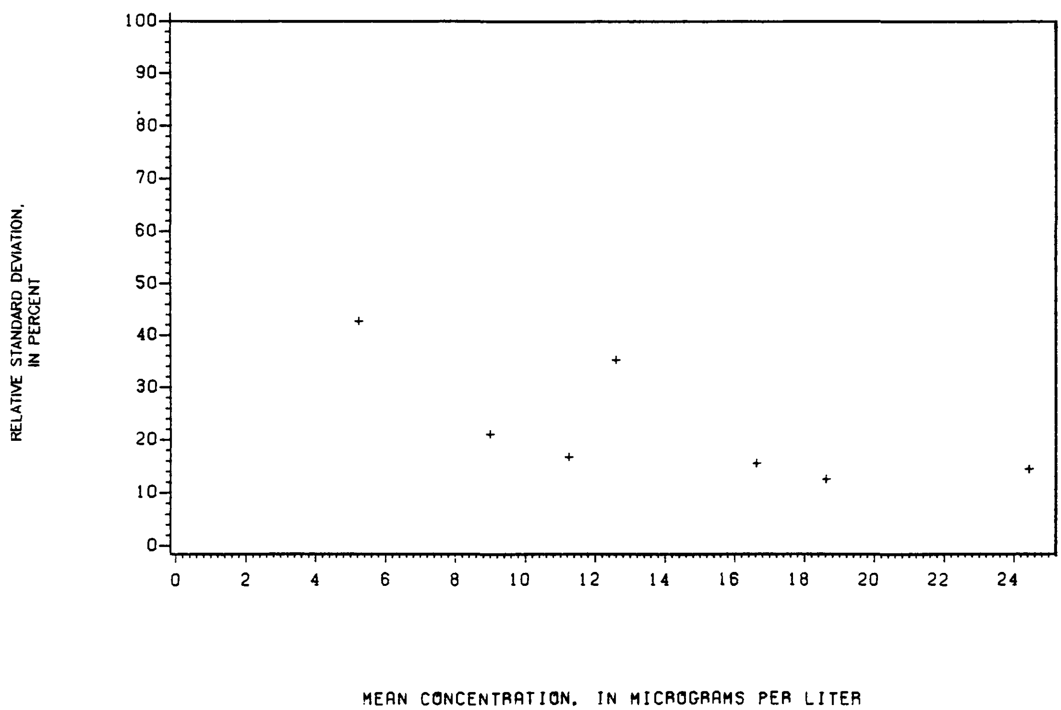

Figure 140.-- Precision data for lead, total recoverable, at the Denver laboratory.

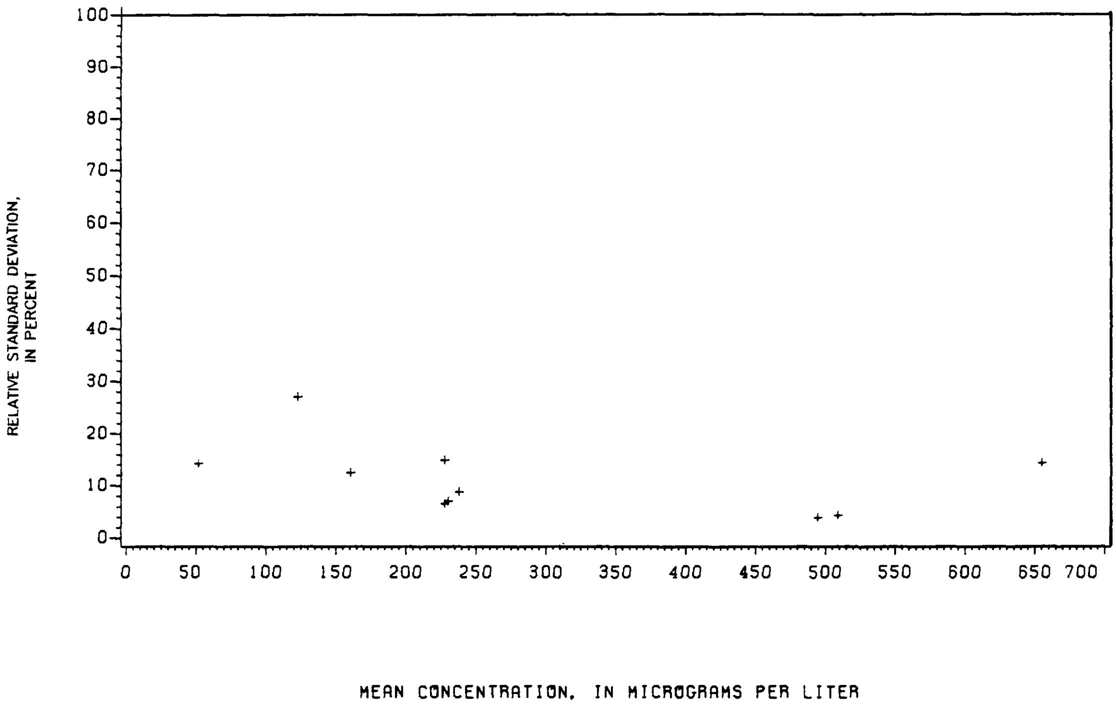

Figure 141.-- Precision data for lithium, dissolved, at the Atlanta laboratory.

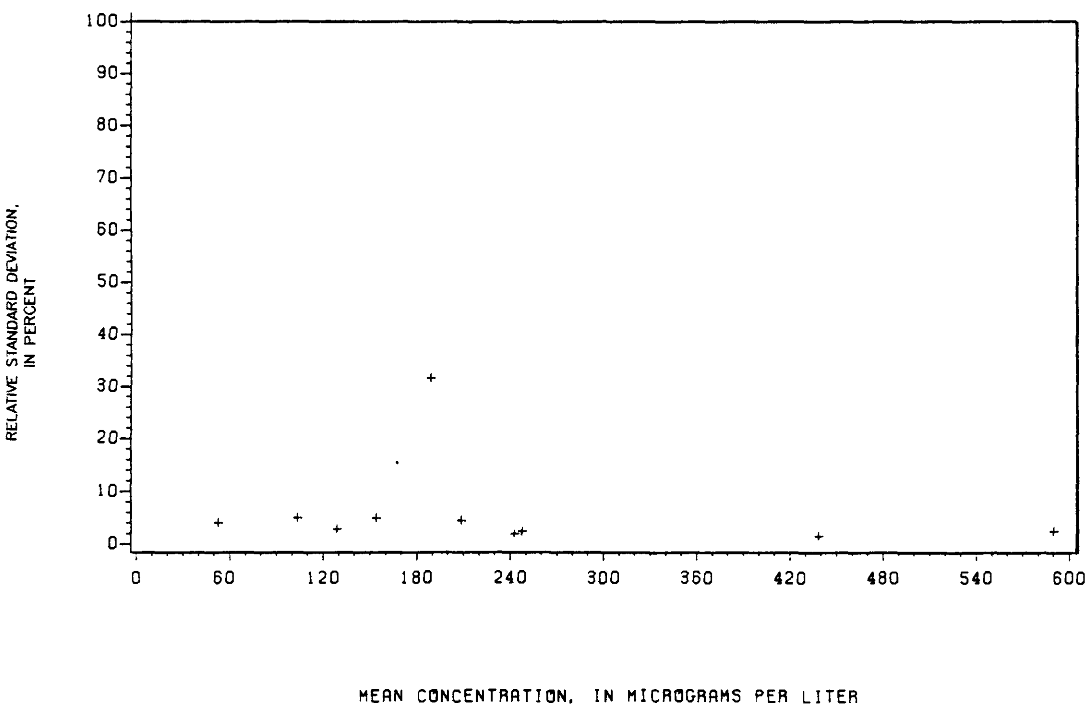

Figure 142.-- Precision data for lithium, dissolved, at the Denver laboratory.

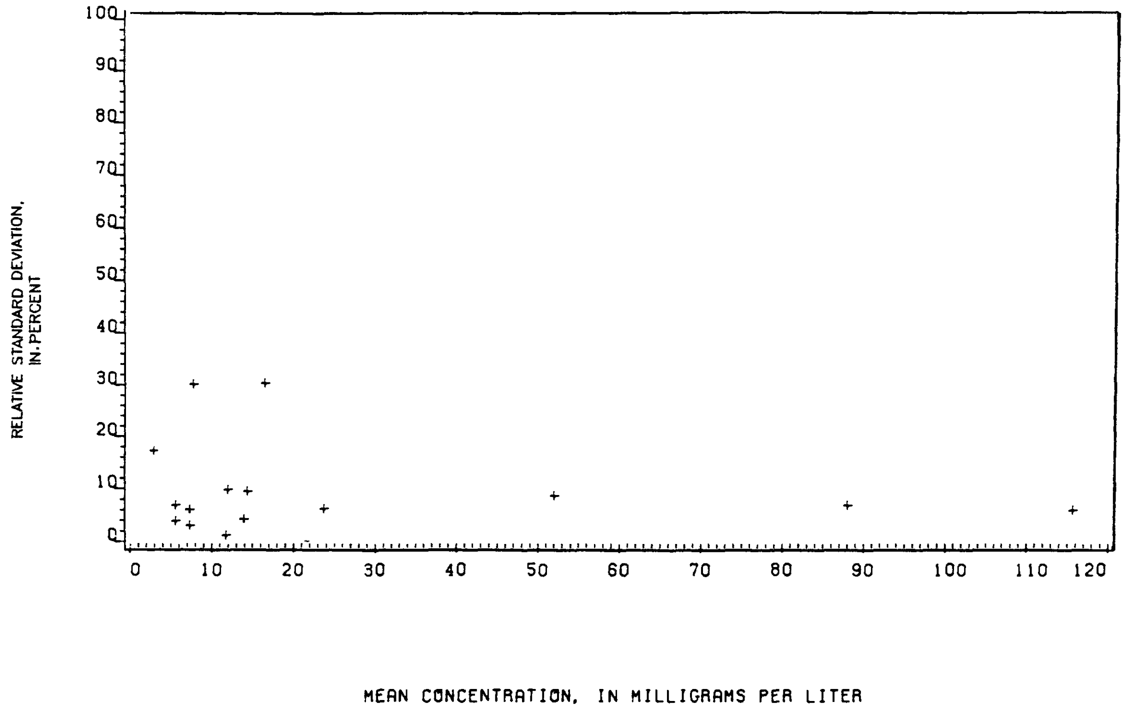

Figure 143.-- Precision data for magnesium dissolved(inductively coupled plasma emmision spectrometry), at the Atlanta laboratory.

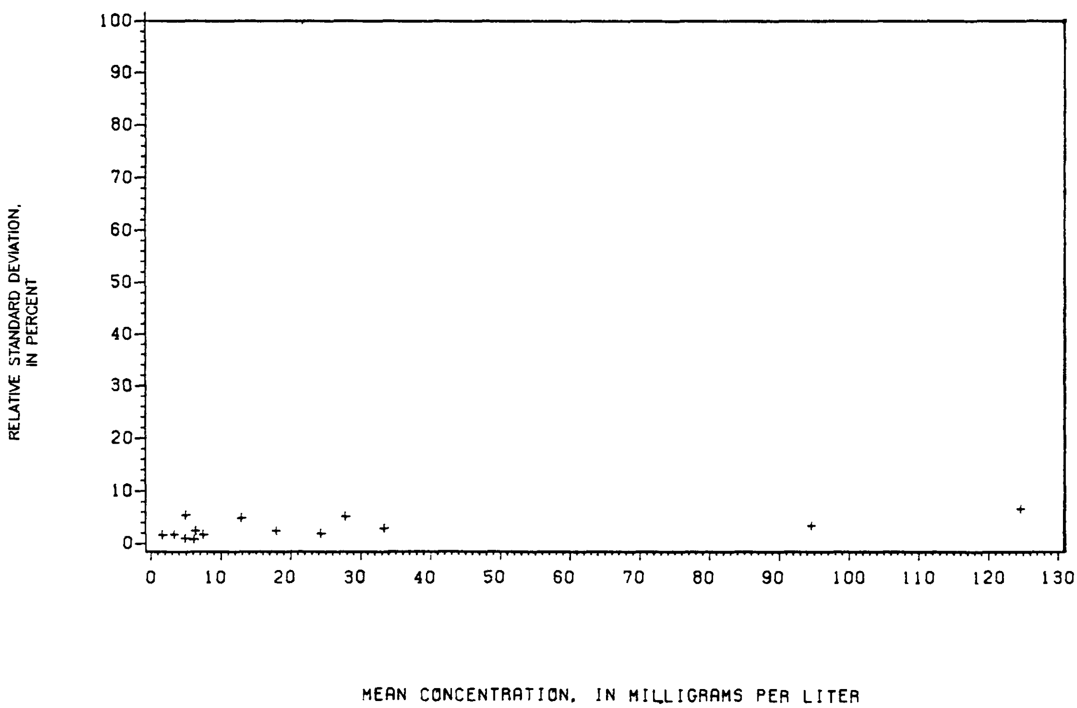

Figure 144.-- Precision data for magnesium dissolved(inductively coupled plasma emmision spectrometry), at the Denver laboratory.

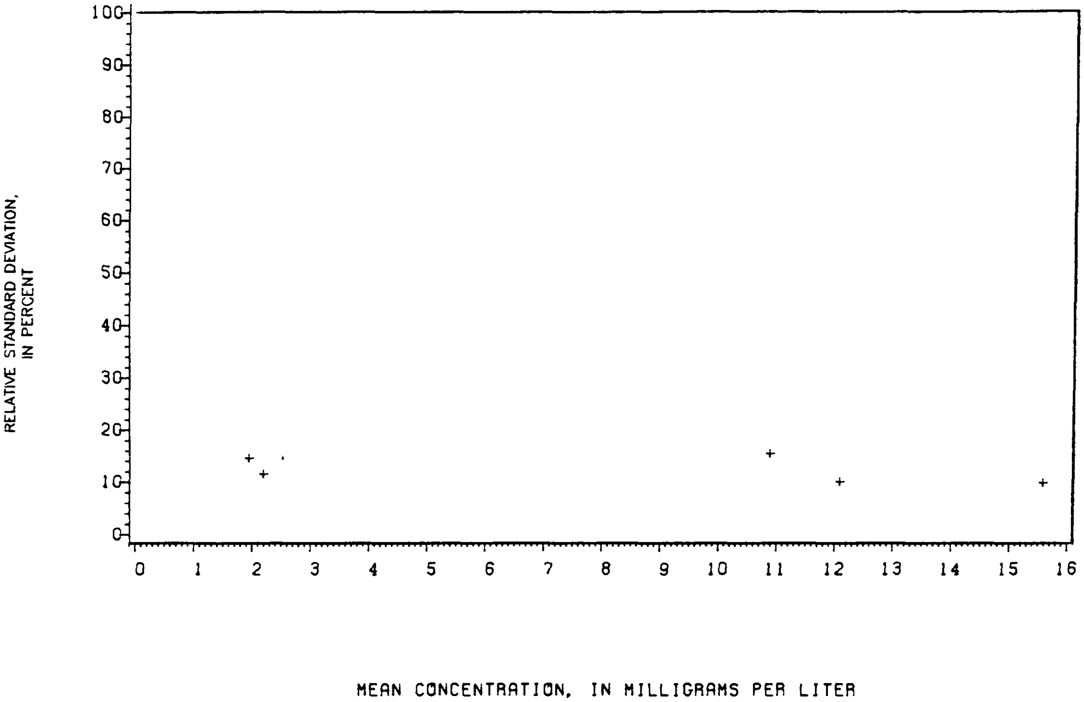

Figure 145.-- Precision data for magnesium dissolved(atomic absorption spectrometry), at the Atlanta laboratory.

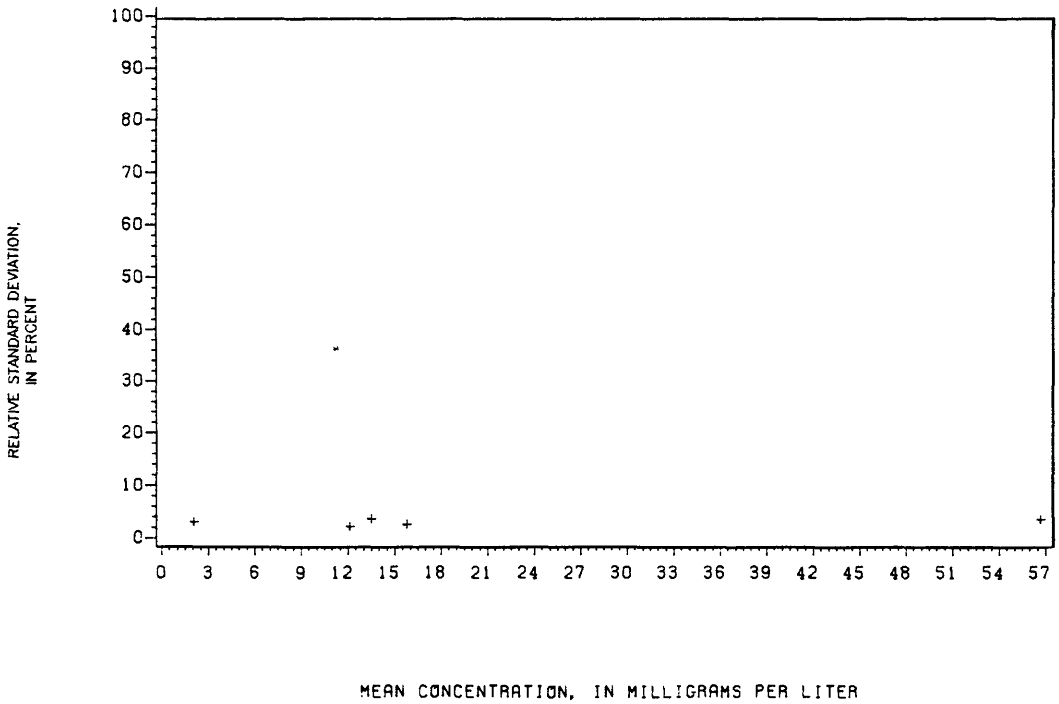

Figure 146.-- Precision data for magnesium dissolved(atomic absorption spectrometry), at the Denver laboratory.

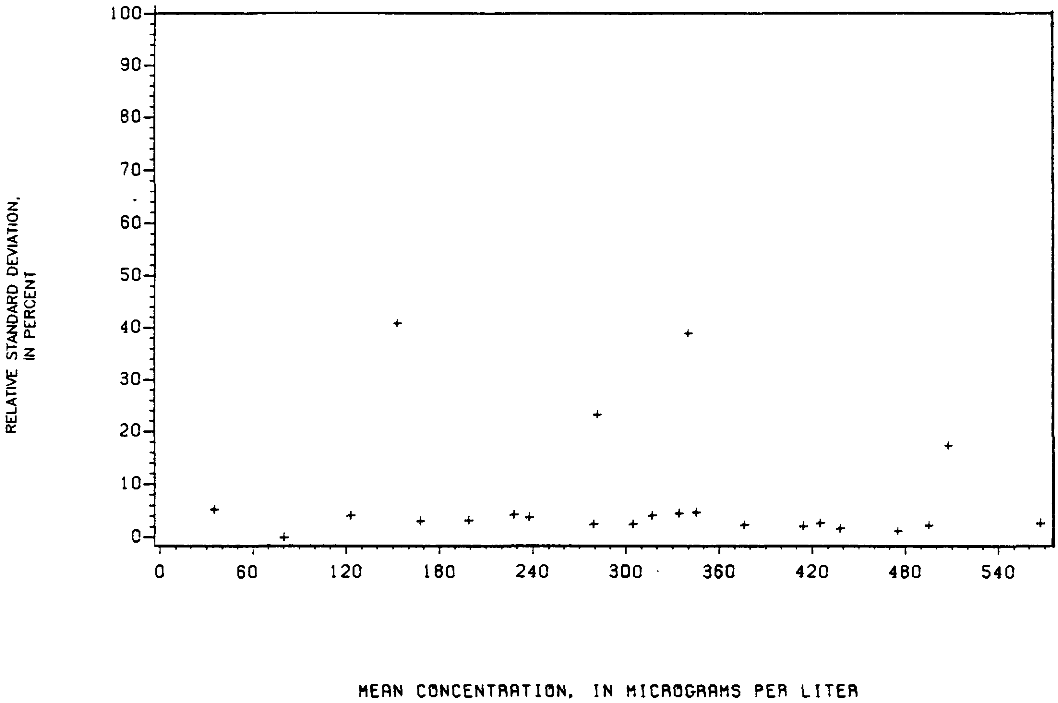

Figure 147.-- Precision data for manganese, dissolved, at the Atlanta laboratory.

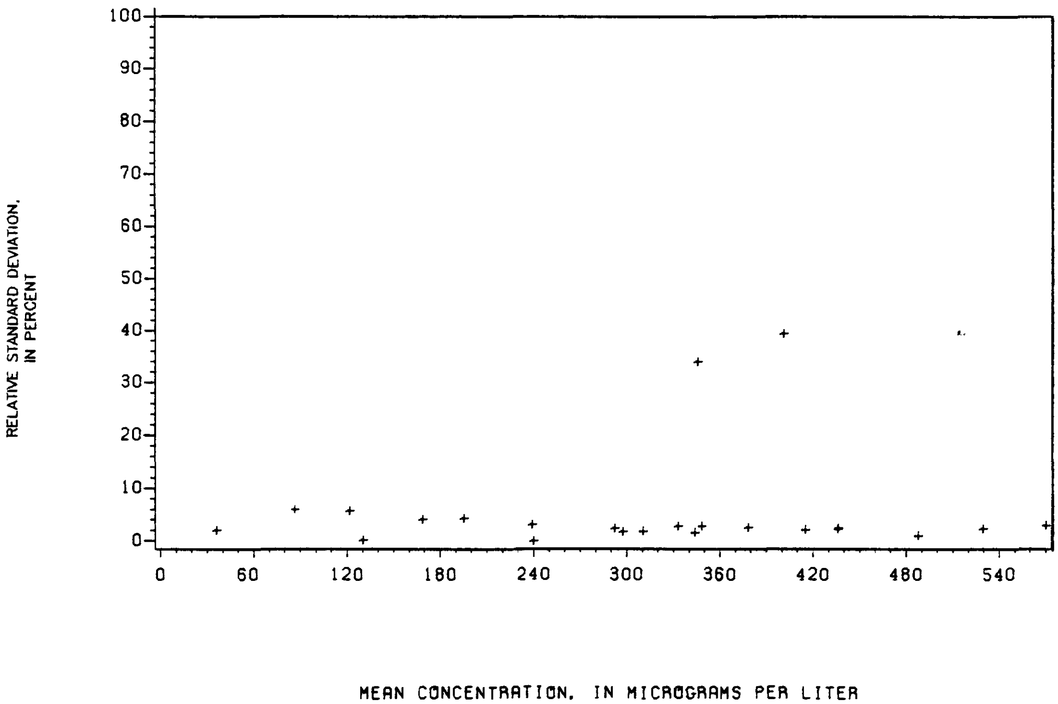

Figure 148.-- Precision data for manganese, dissolved, at the Denver laboratory.

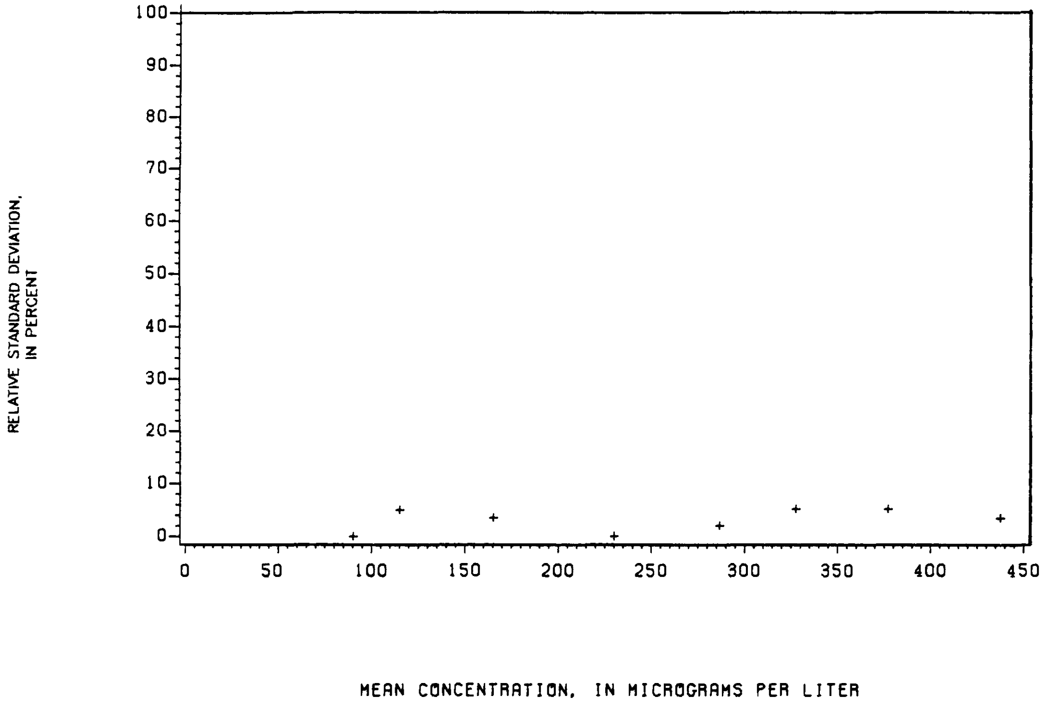

Figure 149.-- Precision data for manganese, total recoverable, at the Atlanta laboratory.

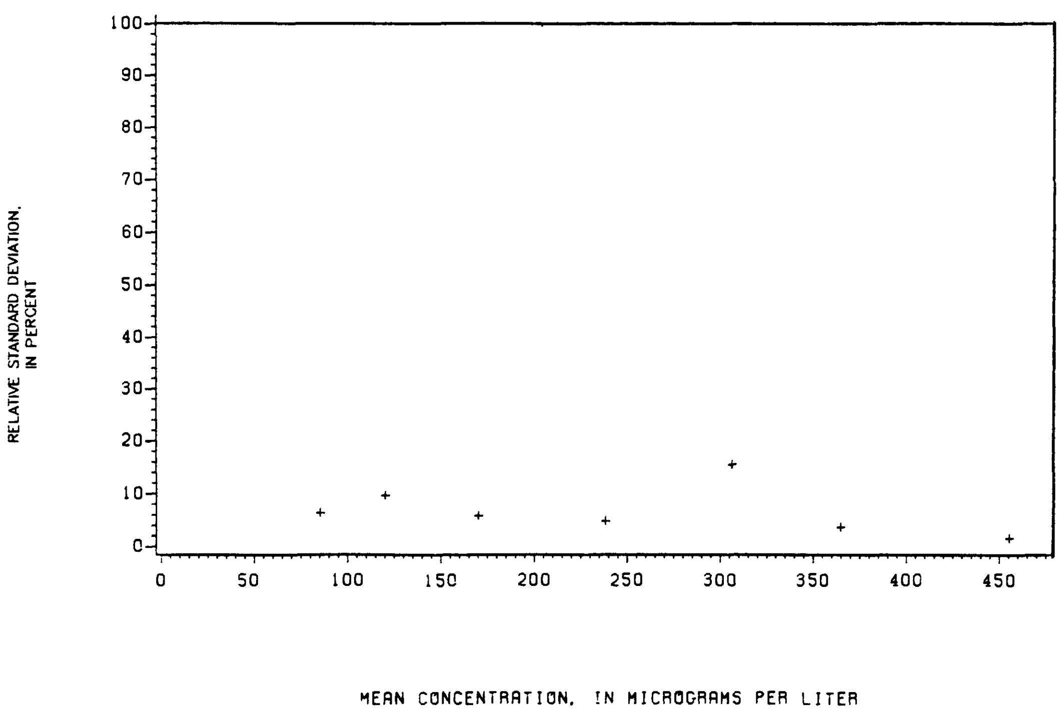

Figure 150.-- Precision data for manganese, total recoverable, at the Denver laboratory.

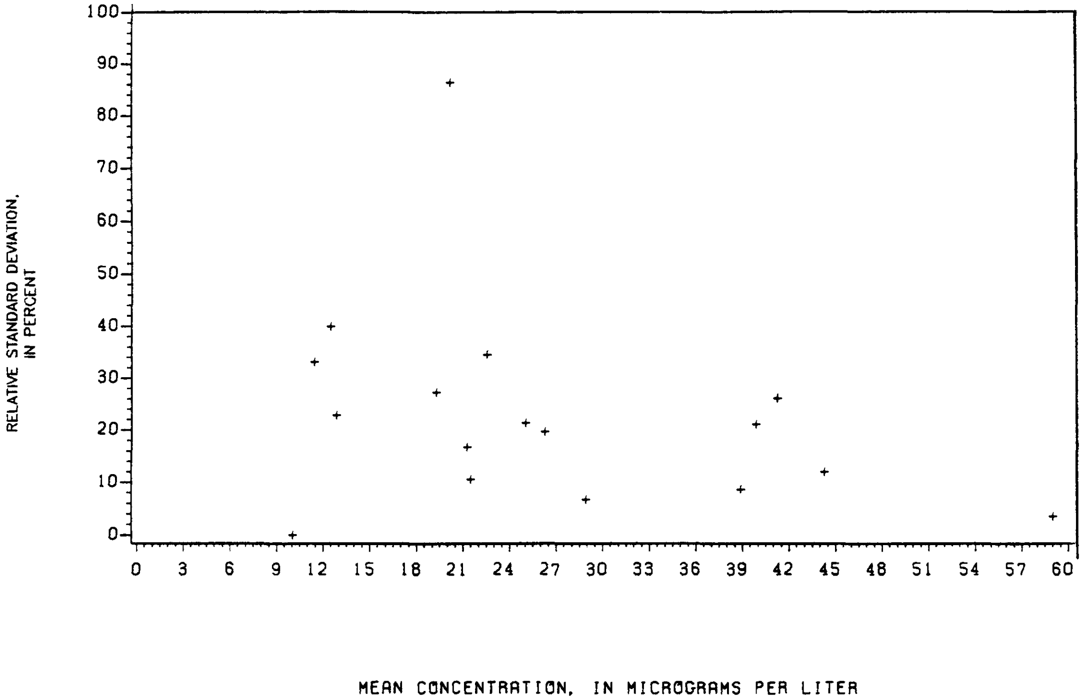

Figure 151.-- Precision data for molybdenum, dissolved, at the Atlanta laboratory.

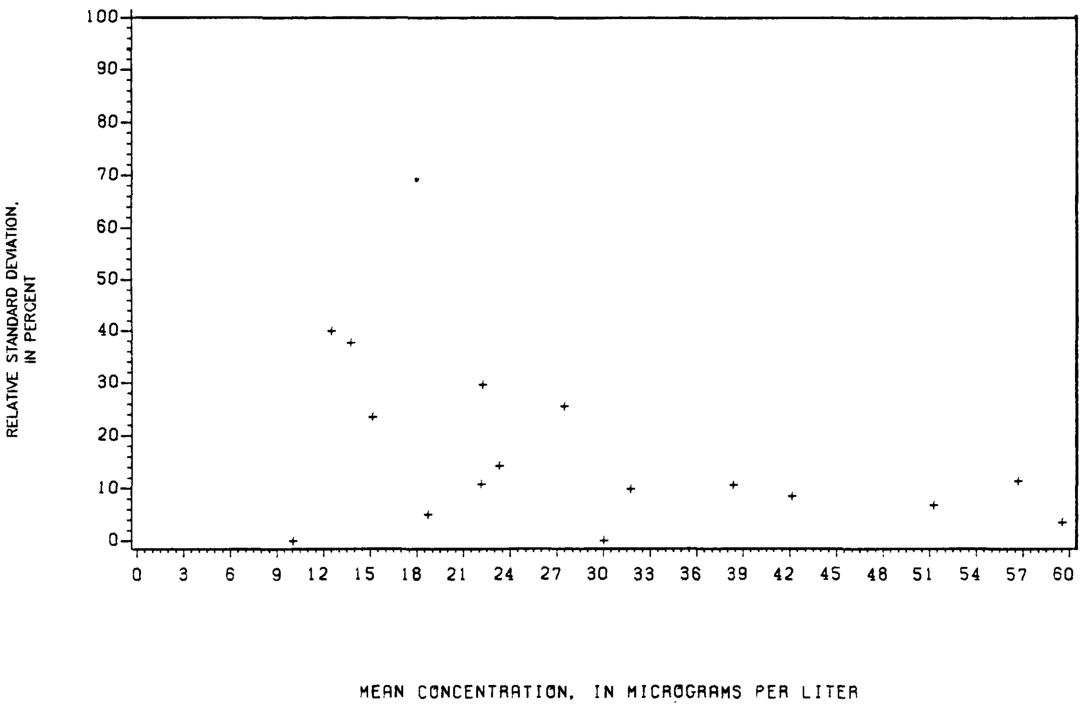

Figure 152.-- Precision data for molybdenum, dissolved, at the Denver laboratory.

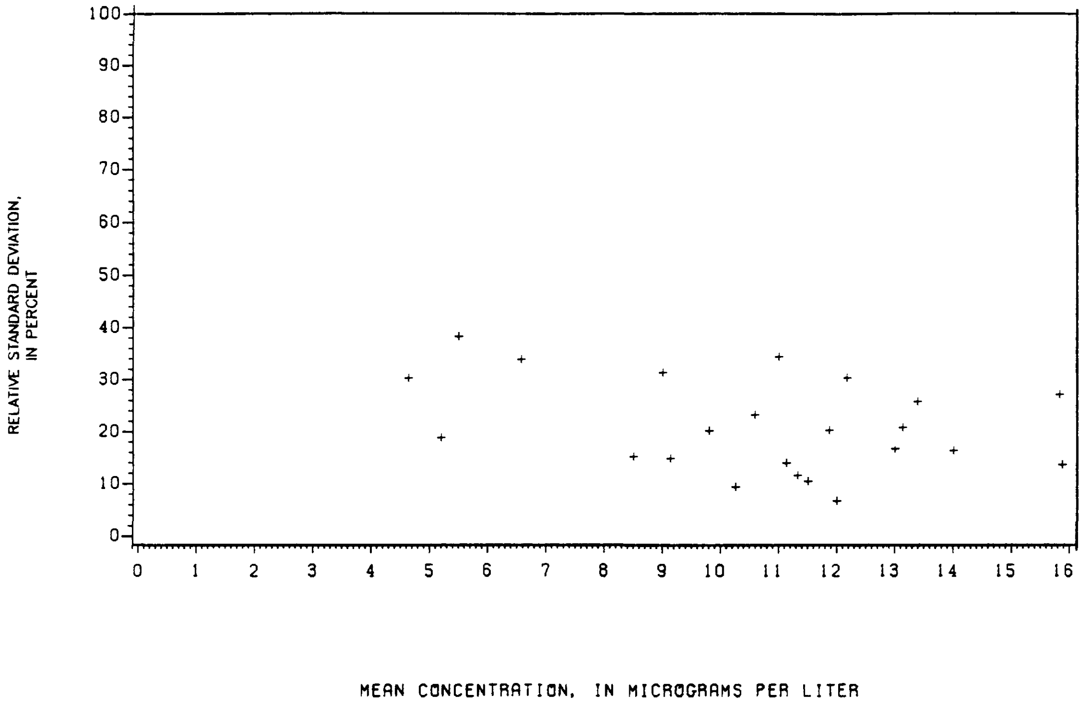

Figure 153.-- Precision data for nickel, dissolved, at the Atlanta laboratory.

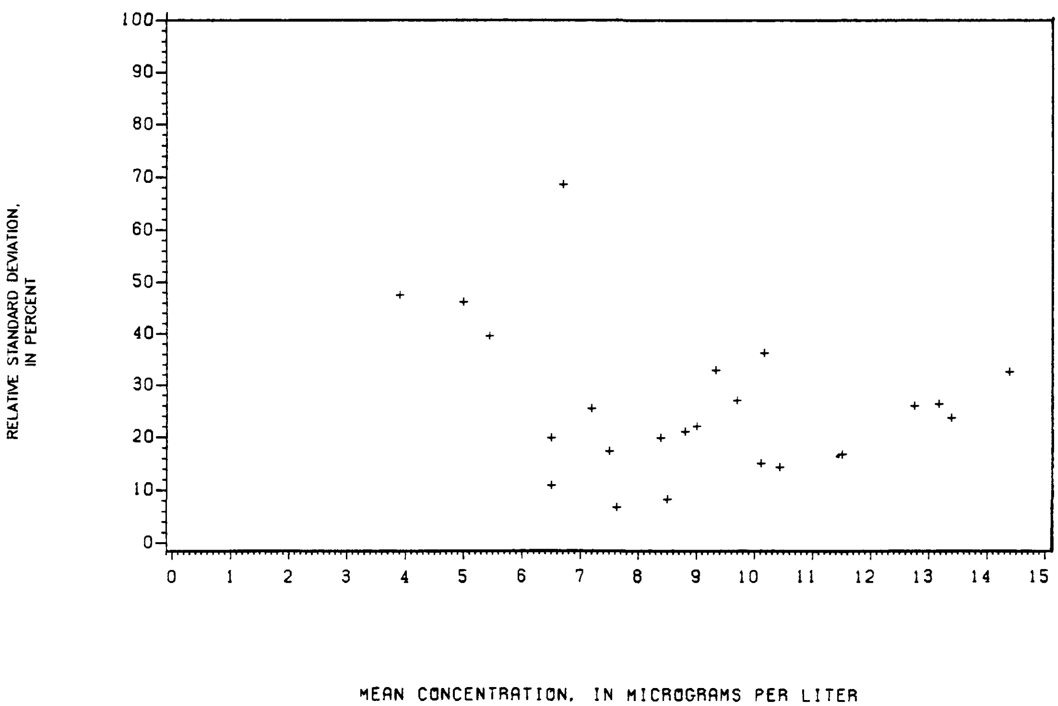

Figure 154.-- Precision data for nickel, dissolved, at the Denver laboratory.

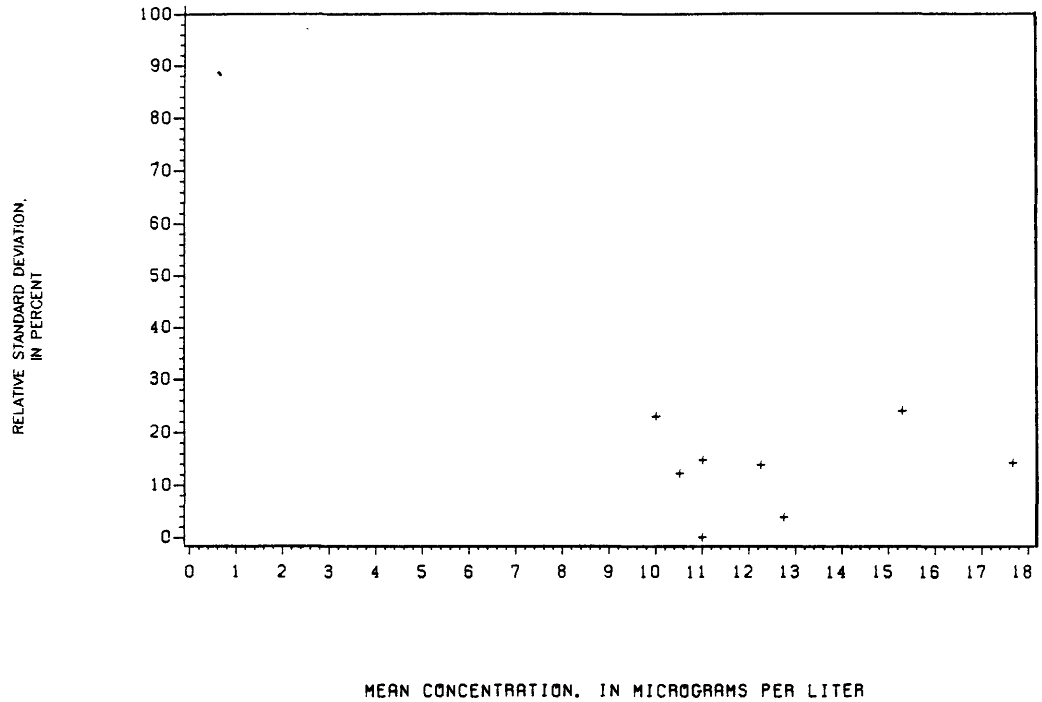

Figure 155.-- Precision data for nickel, total recoverable, at the Atlanta laboratory.

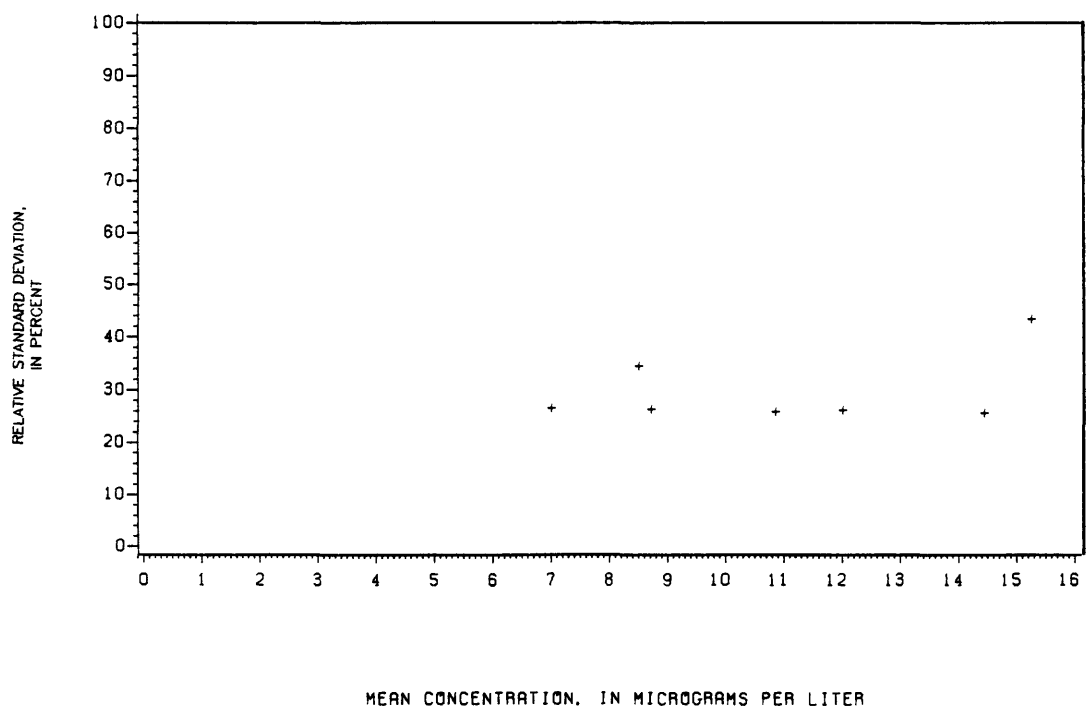

Figure 156.-- Precision data for nickel, total recoverable, at the Denver laboratory.

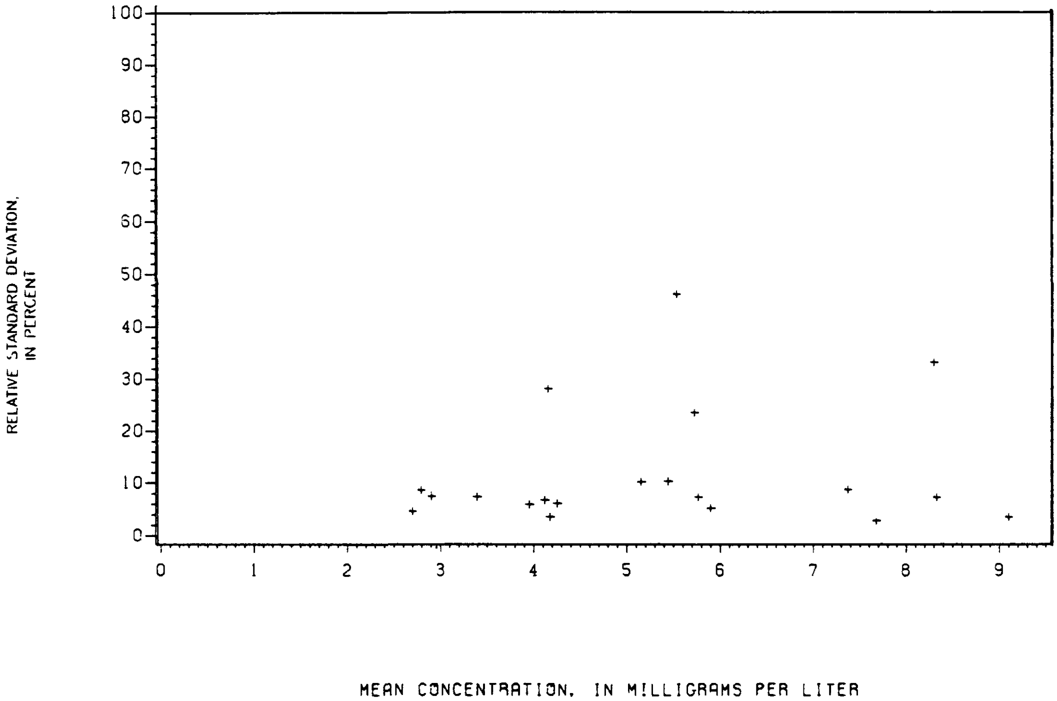

Figure 157.-- Precision data for potassium, dissolved, at the Atlanta laboratory.

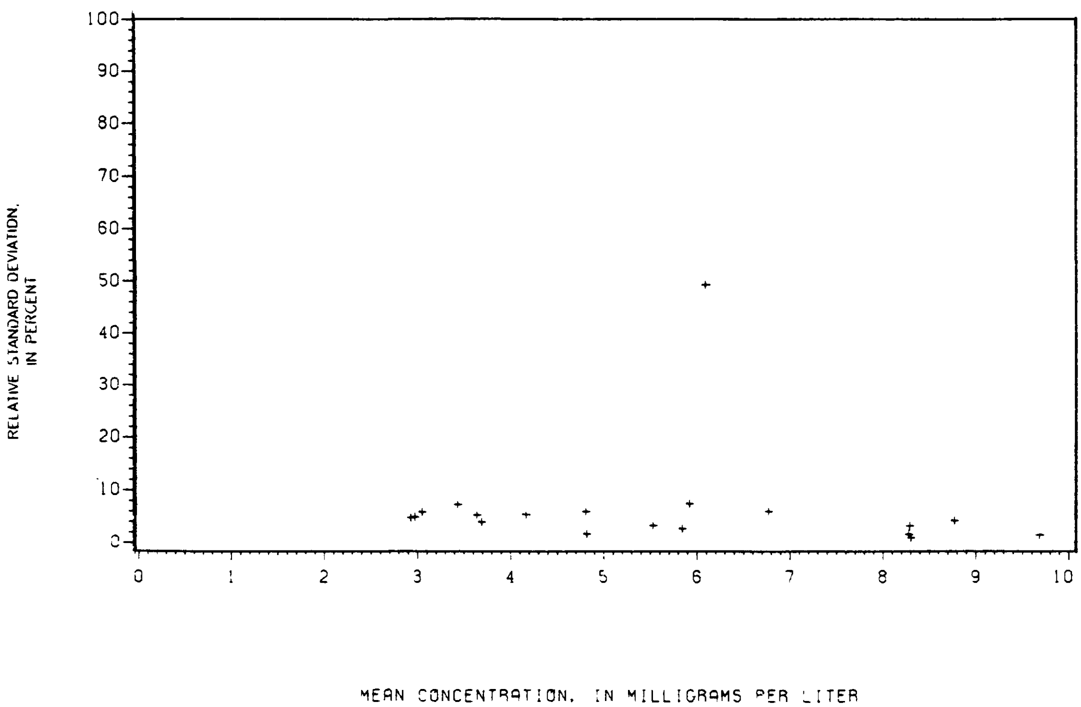

Figure 158.-- Precision data for potassium, dissolved, at the Denver laboratory.

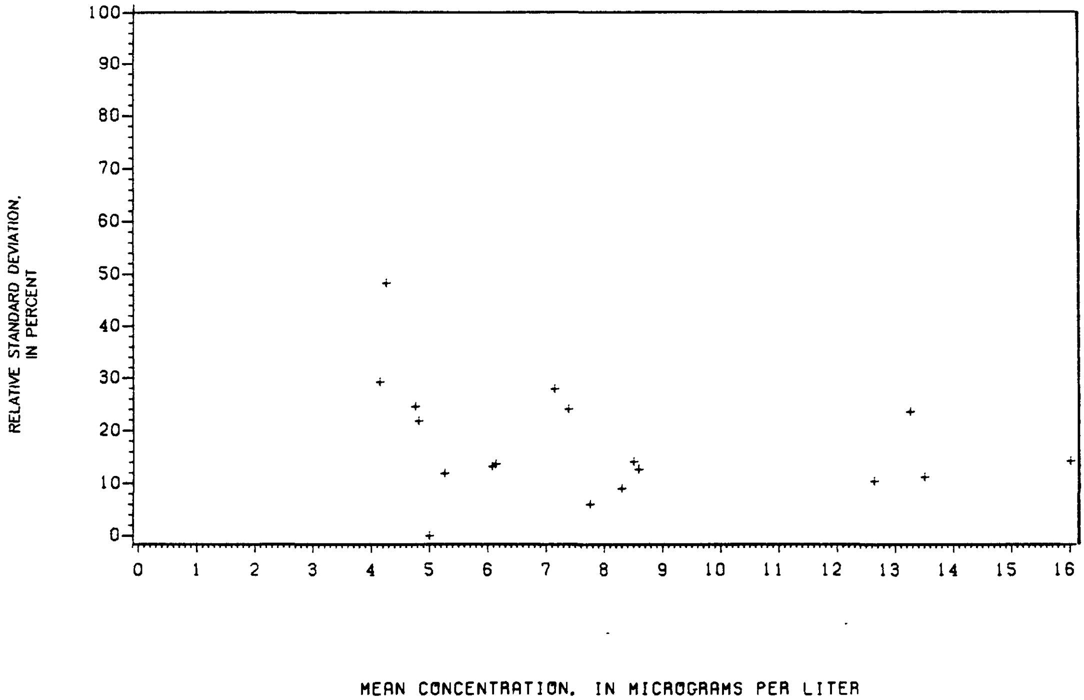

Figure 159.-- Precision data for selenium, dissolved, at the Atlanta laboratory.

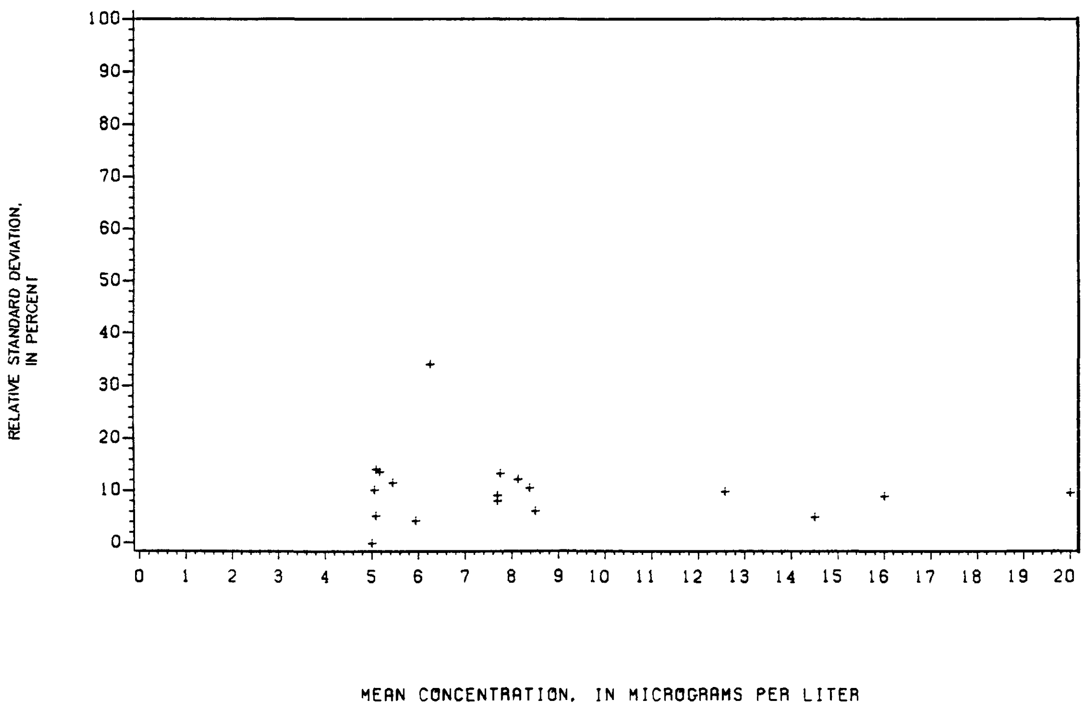

Figure 160.-- Precision data for selenium, dissolved, at the Denver laboratory.

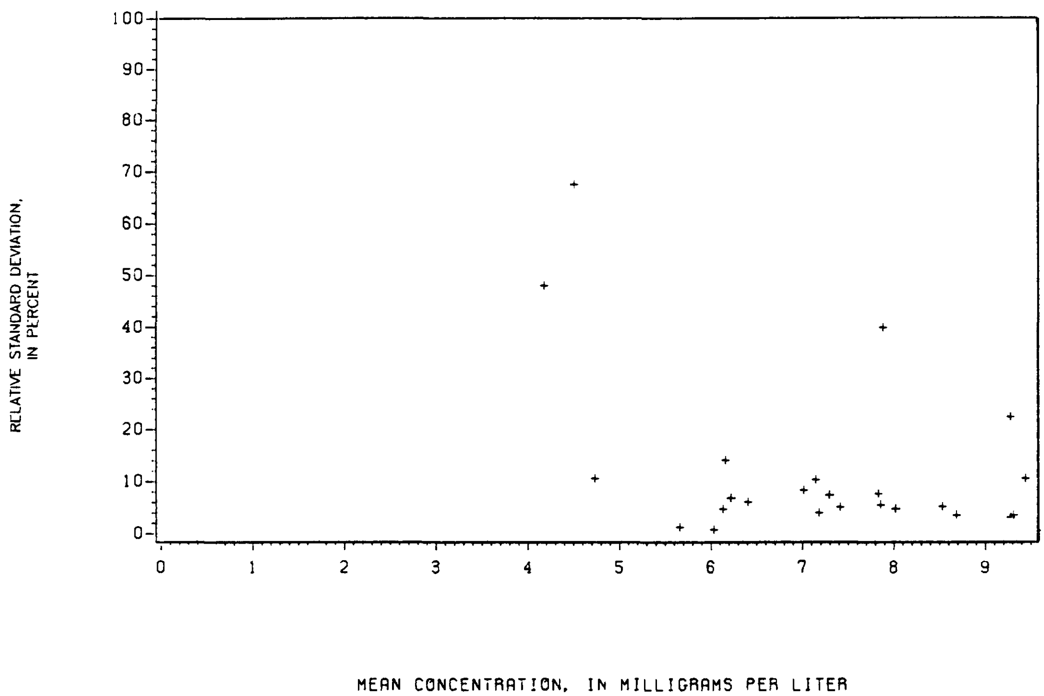

Figure 161.-- Precision data for silica, dissolved, at the Atlanta laboratory.

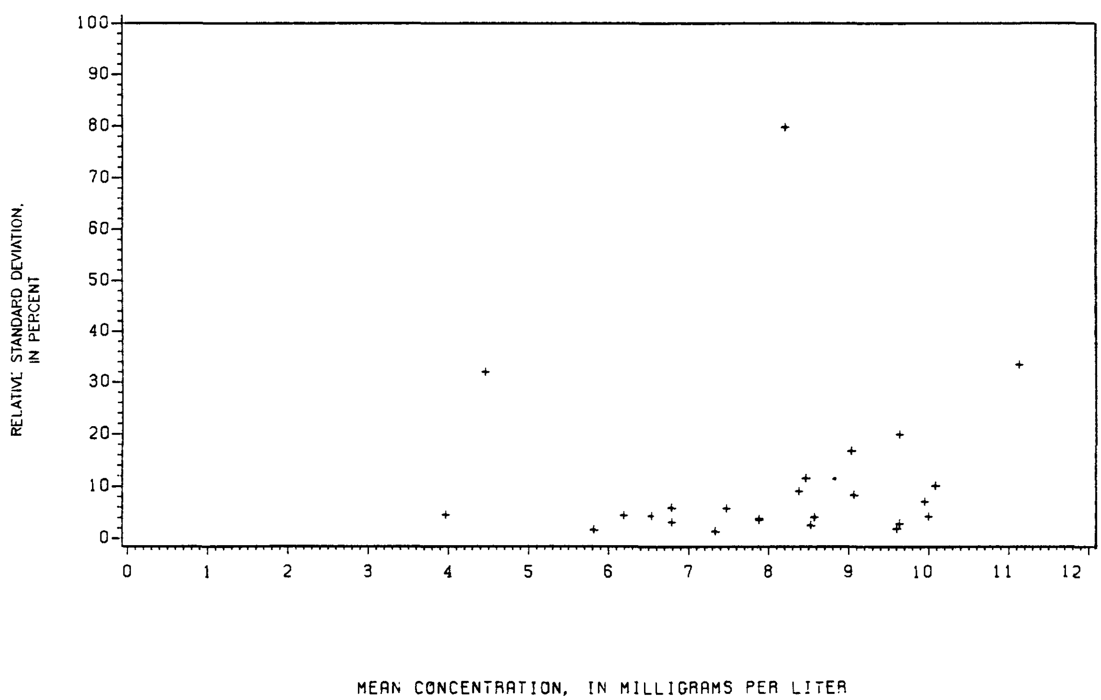

Figure 162.-- Precision data for silica, dissolved, at the Denver laboratory.

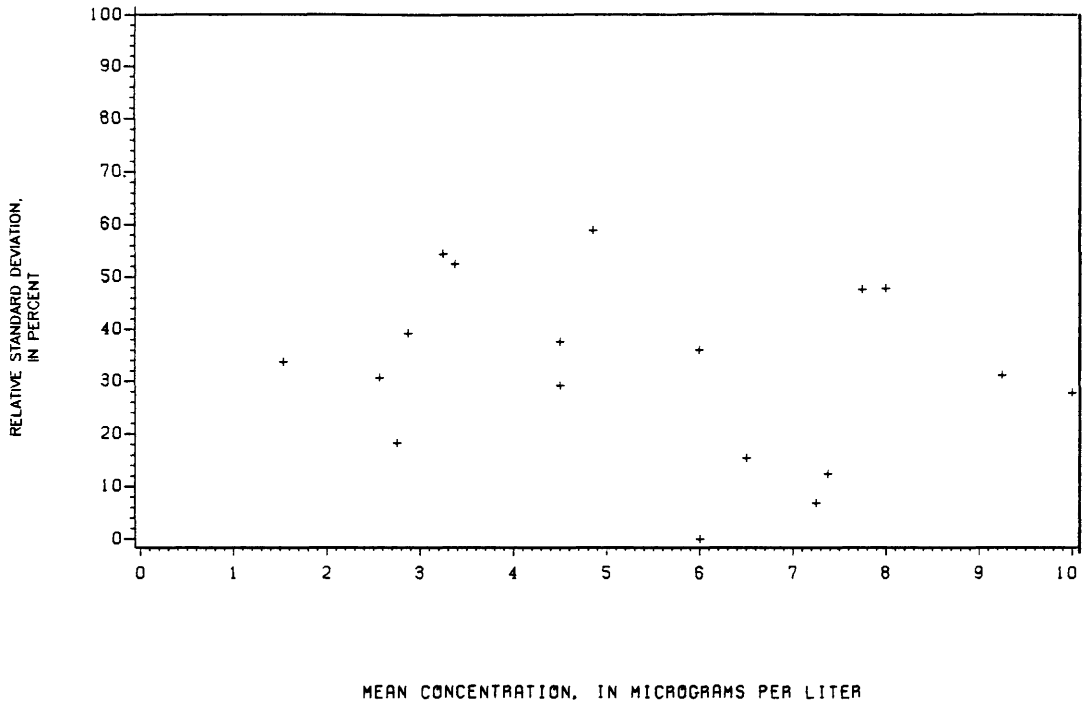

Figure 163.-- Precision data for silver, dissolved, at the Atlanta laboratory.

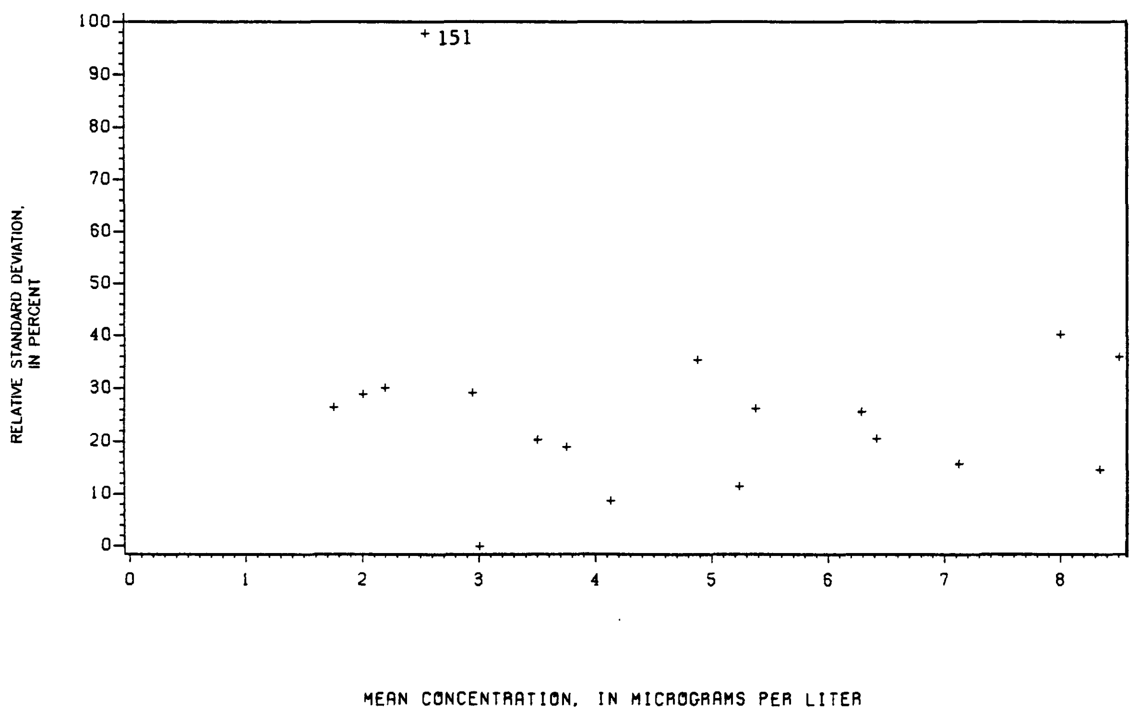

Figure 164.-- Precision data for silver, dissolved, at the Denver laboratory.

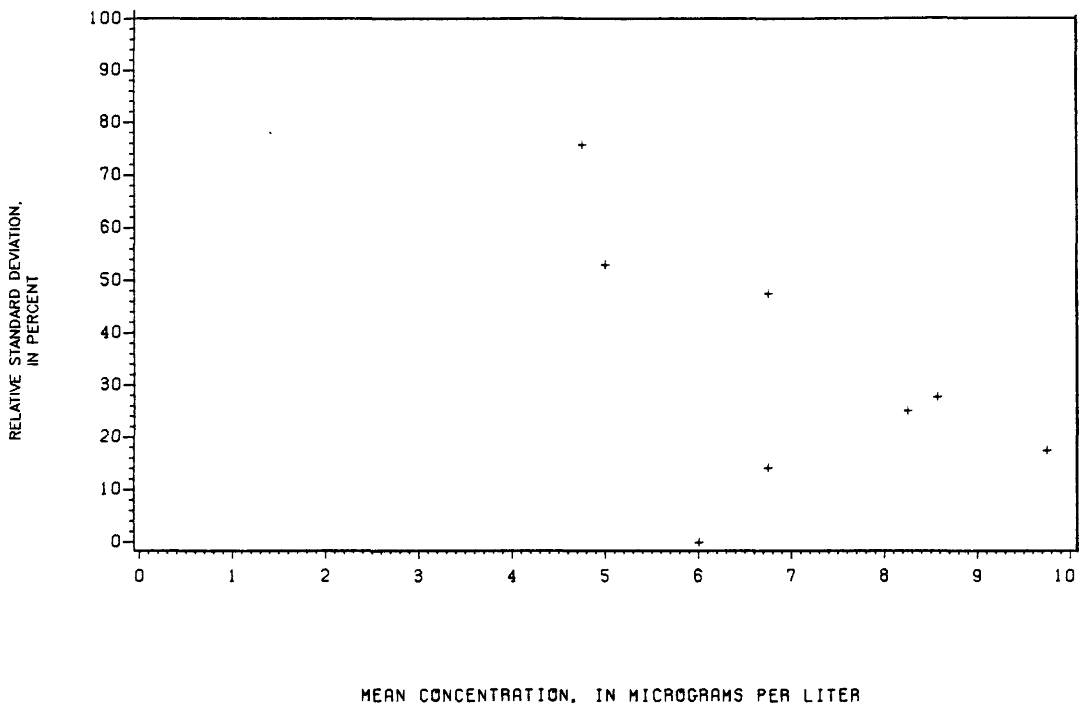

Figure 165.-- Precision data for silver, total recoverable, at the Atlanta laboratory.

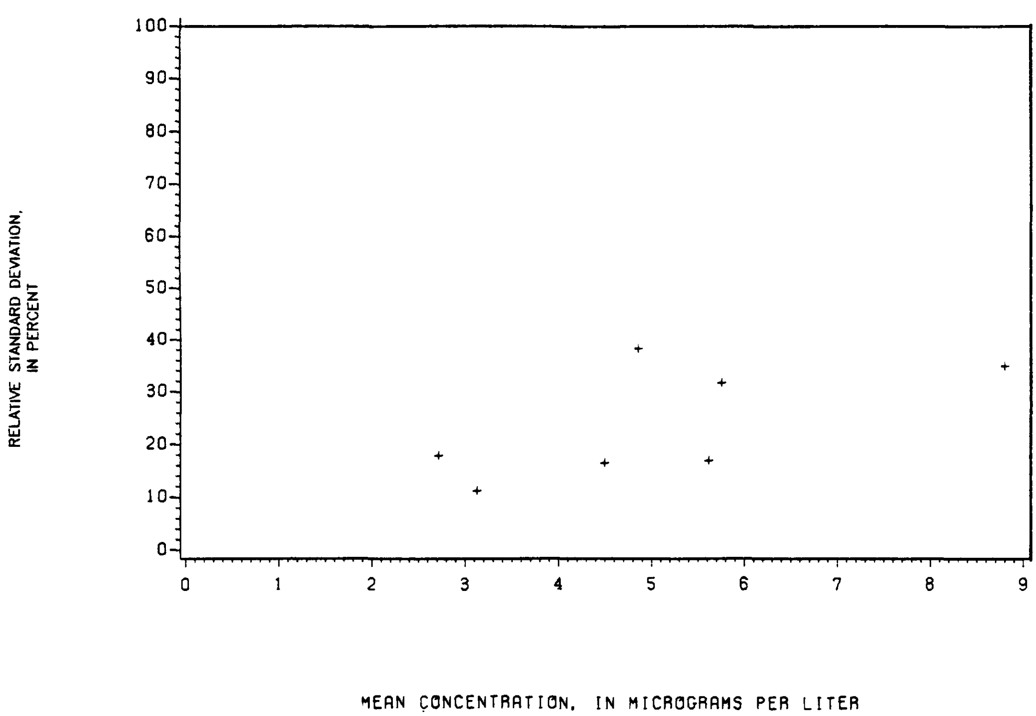

Figure 166.-- Precision data for silver, total recoverable, at the Denver laboratory.

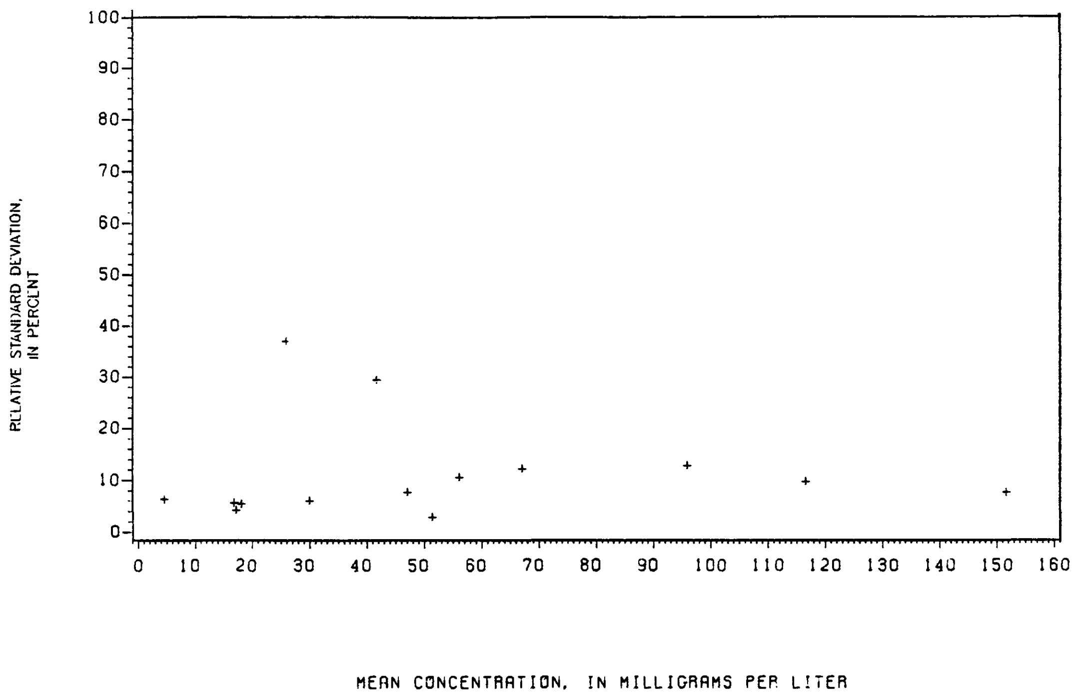

Figure 167.-- Precision data for sodium dissolved(inductively coupled plasma emmision spectrometry), at the Atlanta laboratory.

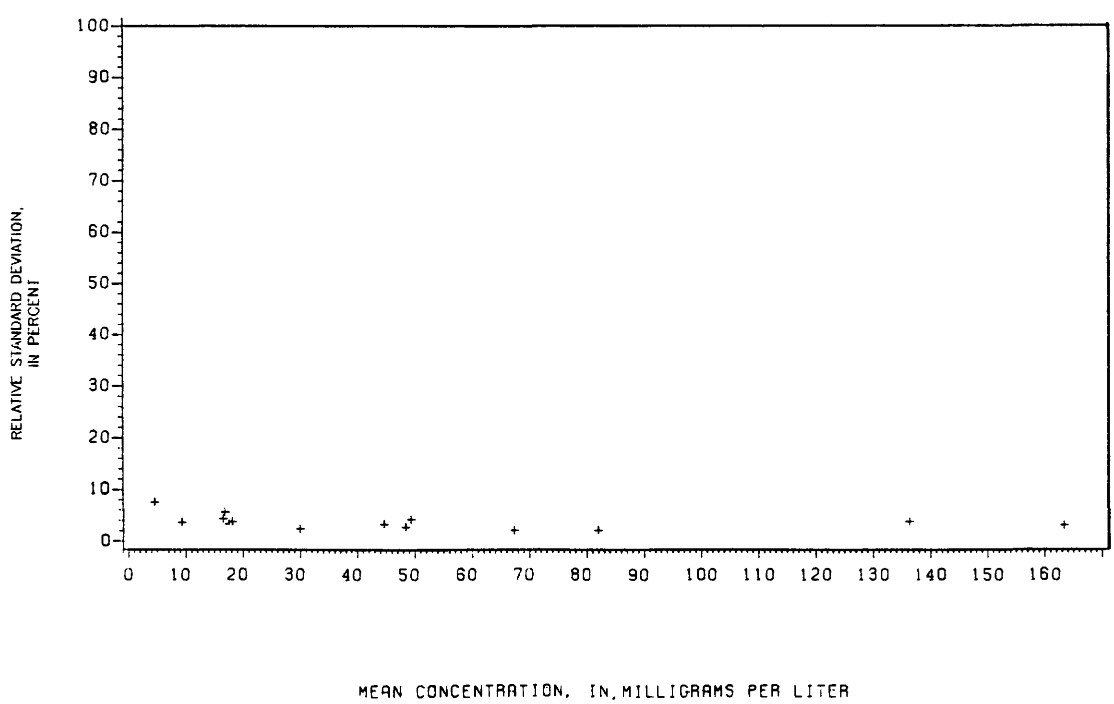

Figure 168.-- Precision data for sodium dissolved(inductively coupled plasma emmision spectrometry), at the Denver laboratory.

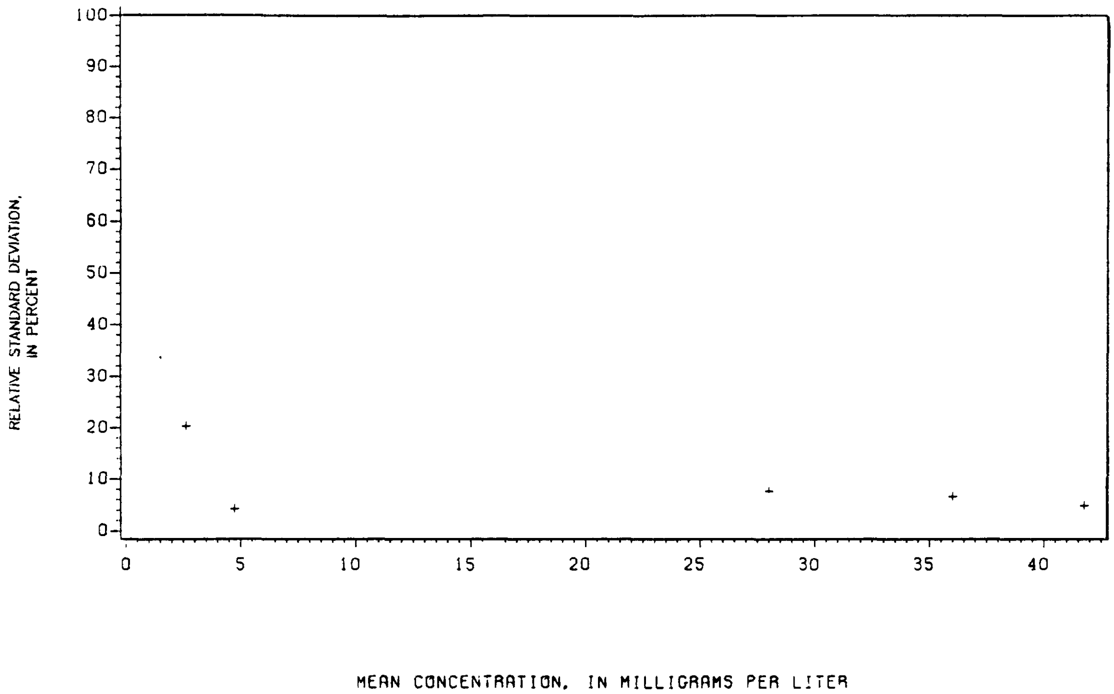

Figure 169.-- Precision data for sodium dissolved(atomic absorption spectrometry), at the Atlanta laboratory.

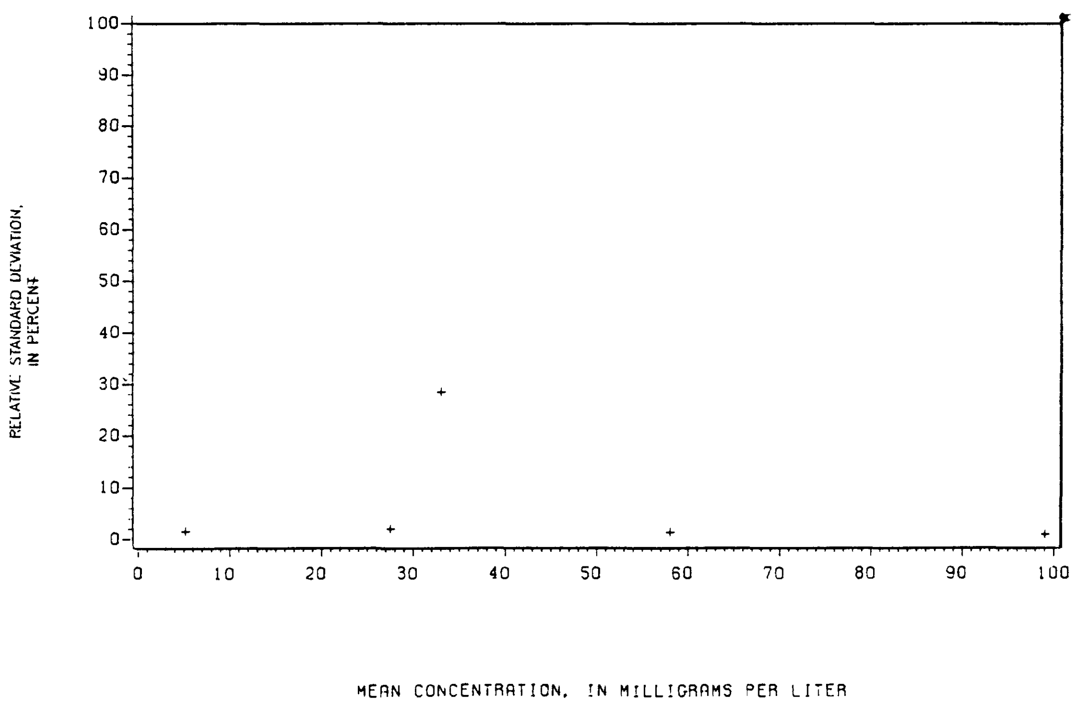

Figure 170.-- Precision data for sodium dissolved(atomic absorption spectrometry), at the Denver laboratory.

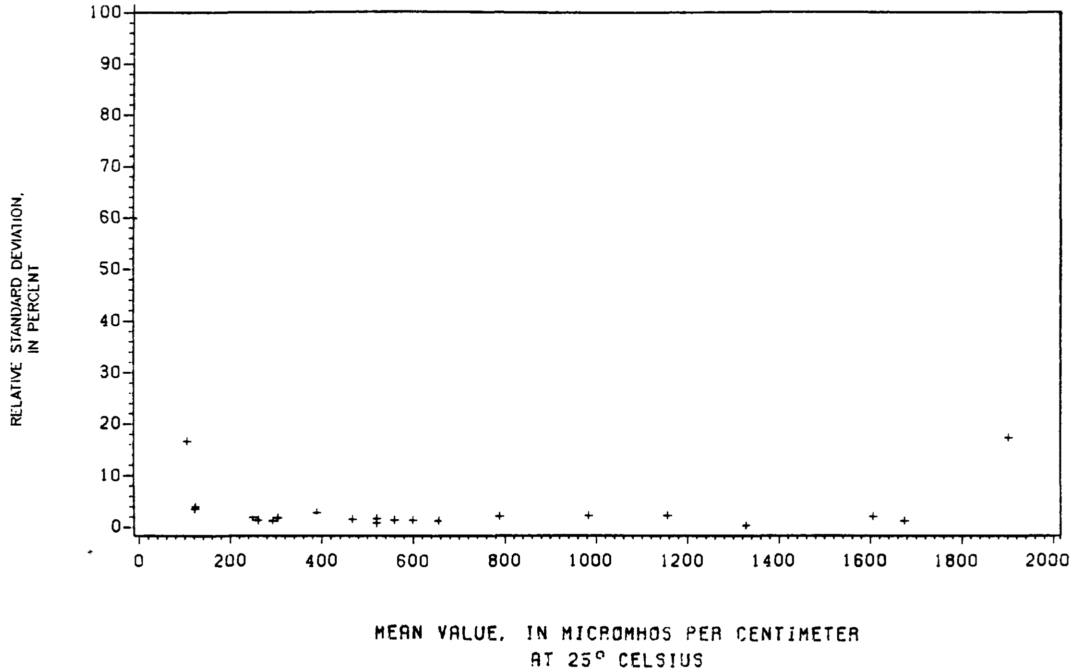

Figure 171.-- Precision data for specific conductance at the Atlanta laboratory.

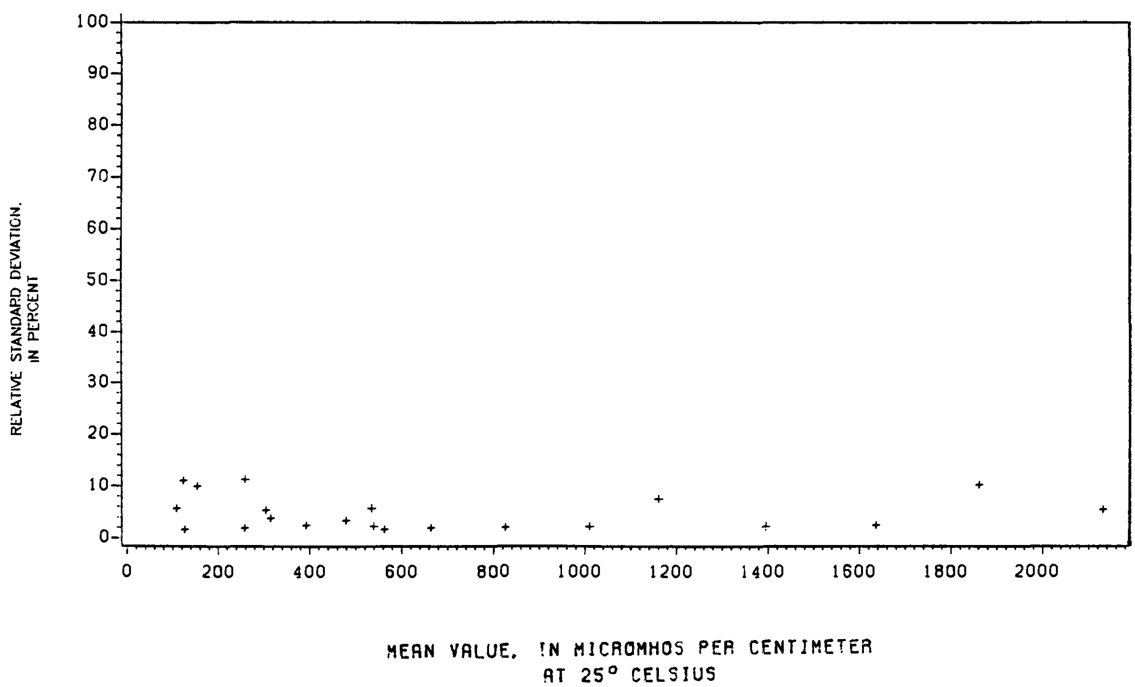

Figure 172.-- Precision data for specific conductance at the Denver laboratory.

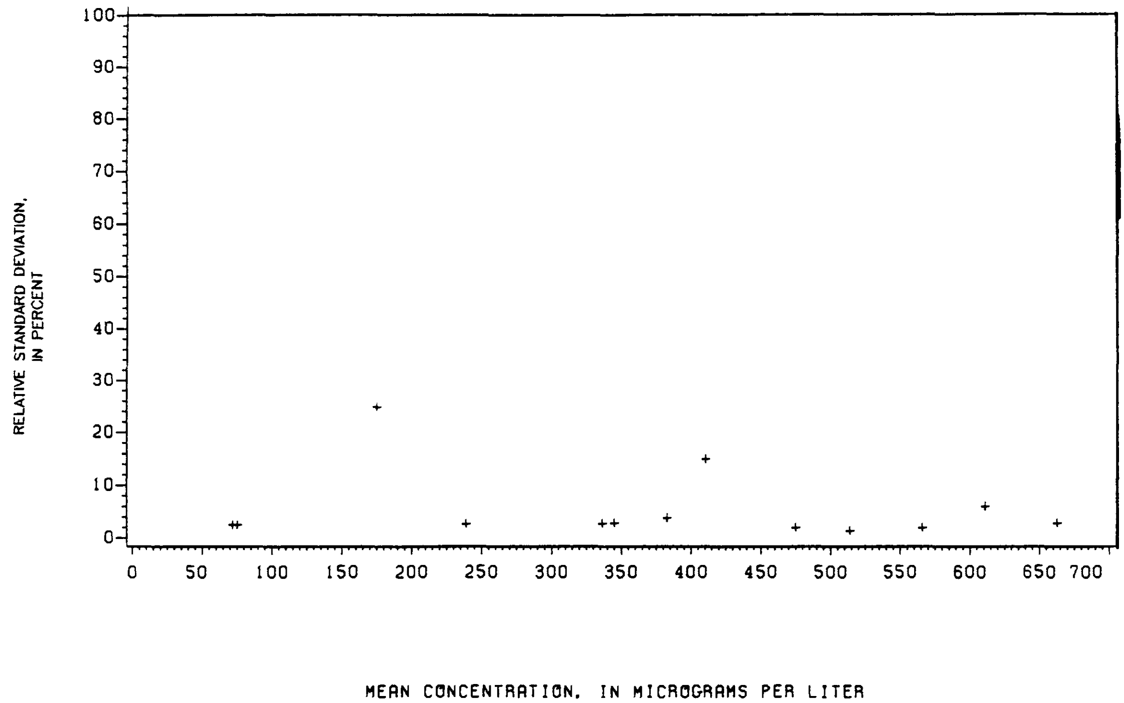

Figure 173.-- Precision data for strontium, dissolved, at the Atlanta laboratory.

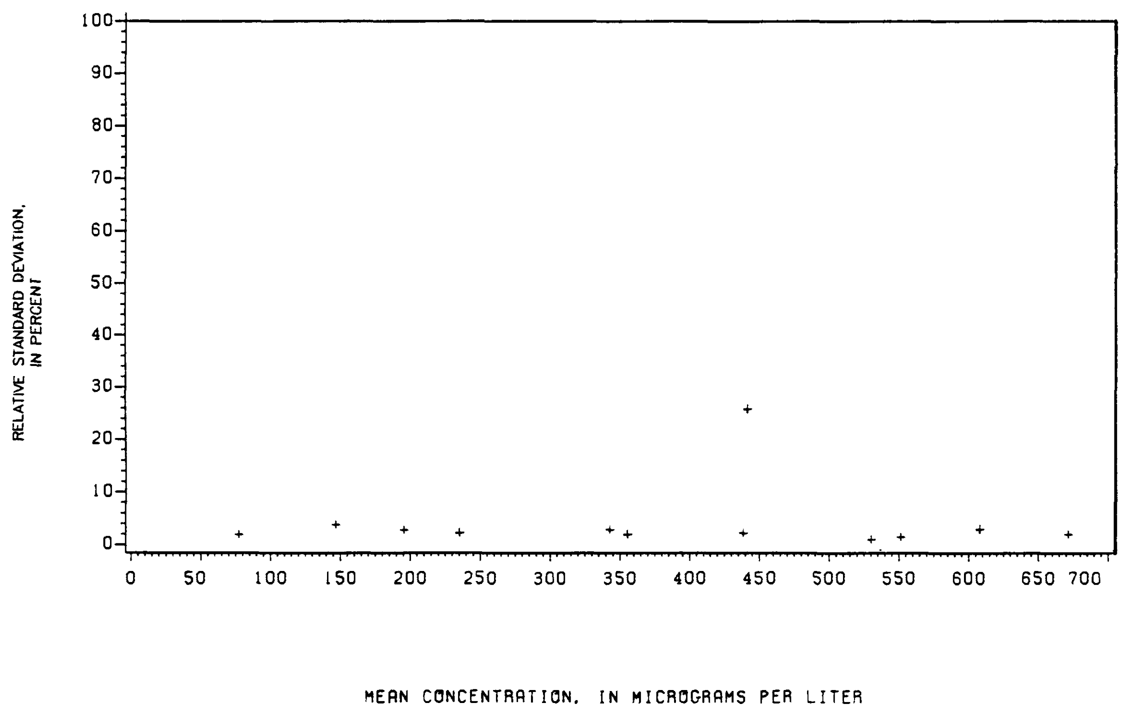

Figure 174.-- Precision data for strontium, dissolved, at the Denver laboratory.

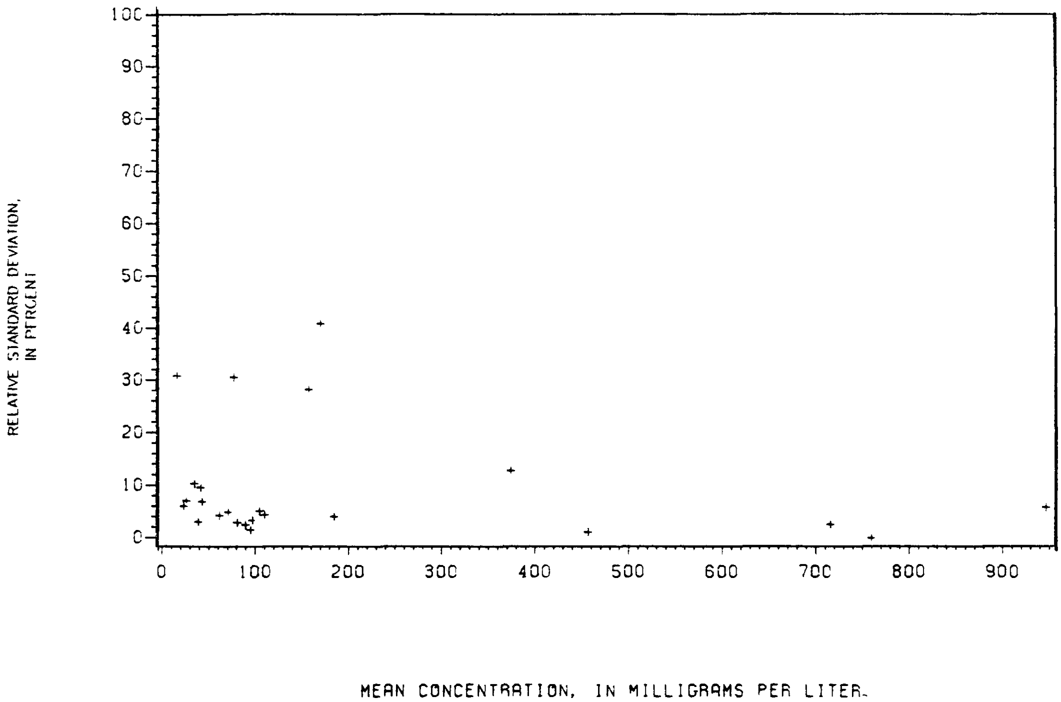

Figure 175.-- Precision data for sulfate, dissolved, at the Atlanta laboratory.

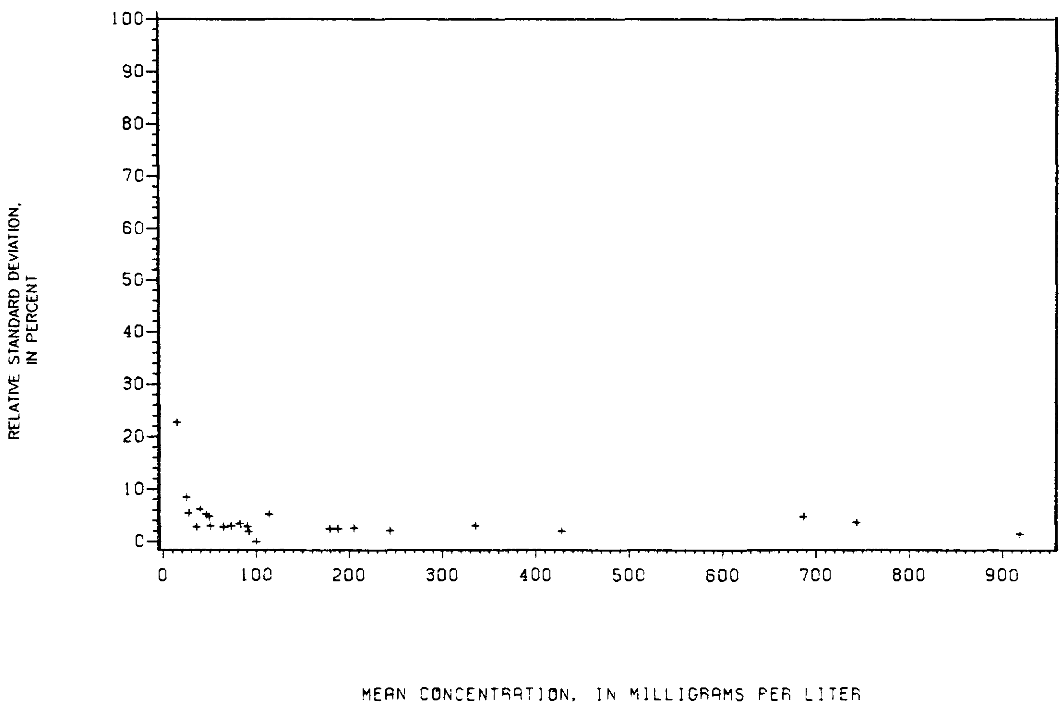

Figure 176.-- Precision data for sulfate, dissolved, at the Denver laboratory.

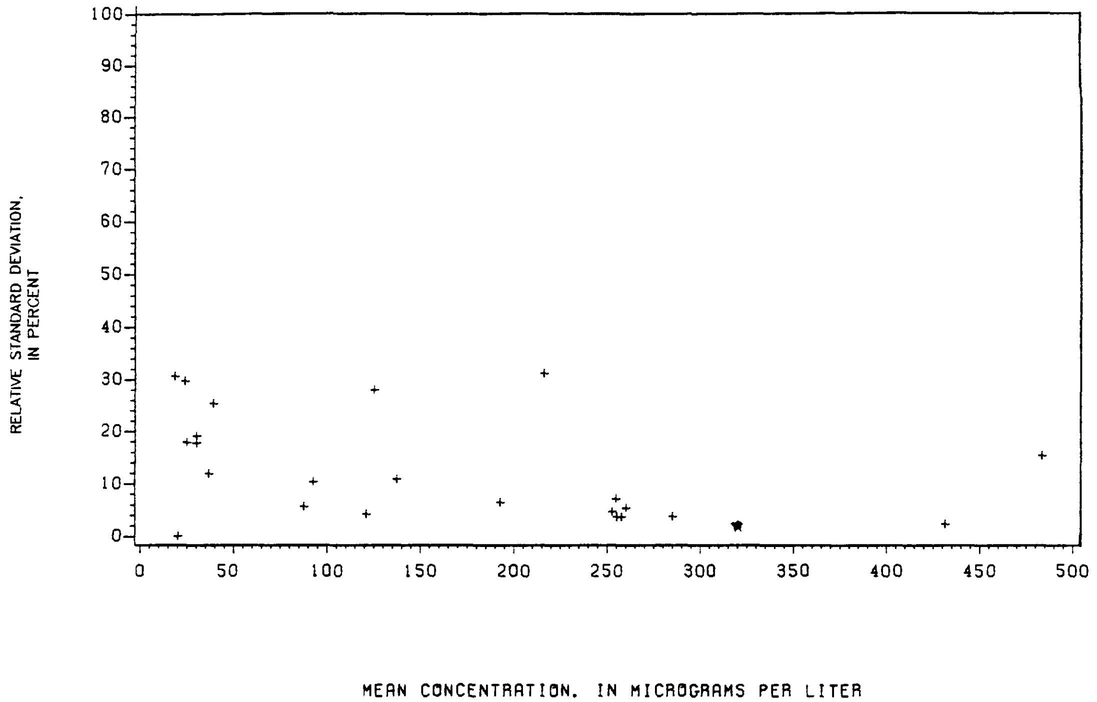

Figure 177.-- Precision data for zinc, dissolved, at the Atlanta laboratory.

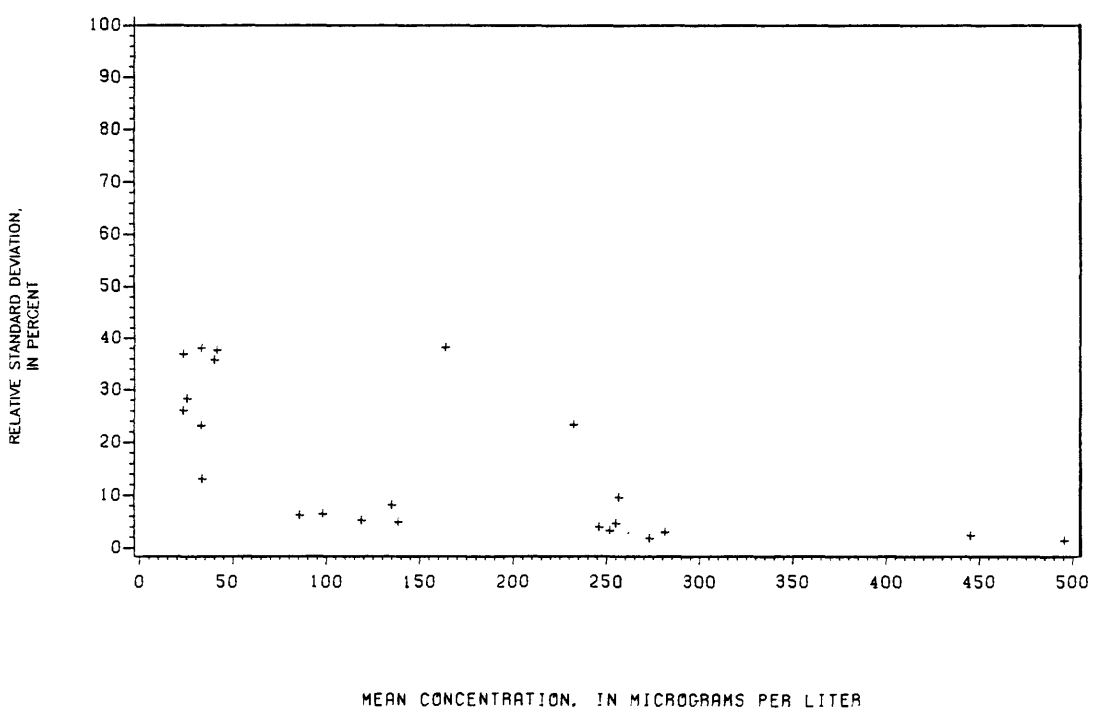

Figure 178.-- Precision data for zinc, dissolved, at the Denver laboratory.

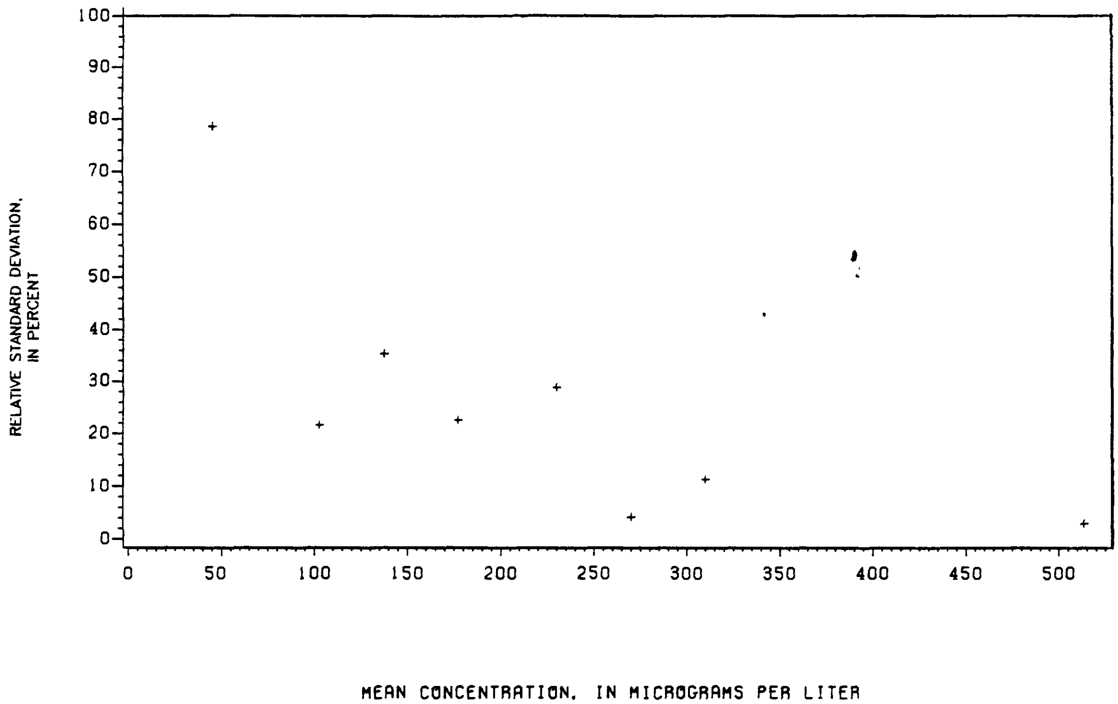

Figure 179.-- Precision data for zinc, total recoverable, at the Atlanta laboratory.

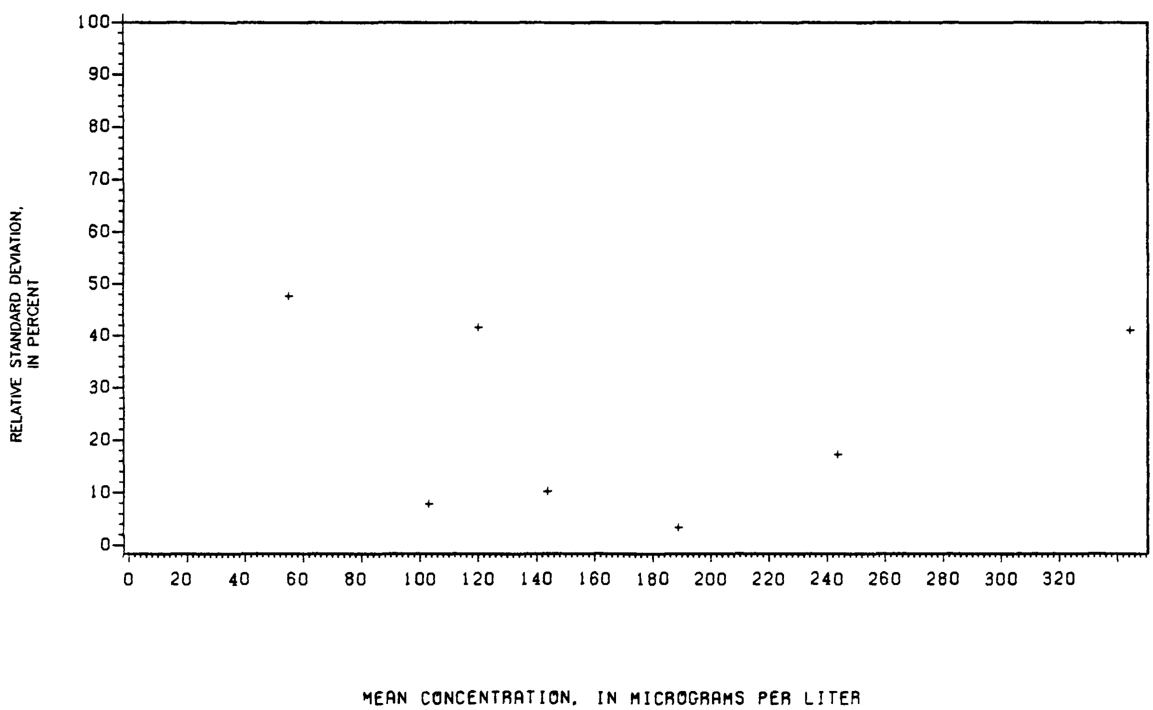

Figure 180.-- Precision data for zinc, total recoverable, at the Denver laboratory.