QUALITY-ASSURANCE DATA FOR ROUTINE WATER ANALYSIS IN THE LABORATORIES OF THE U.S. GEOLOGICAL SURVEY FOR WATER YEAR 1990

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ABBREVIATIONS

	Units of measure
C	Celsius
mg/L	milligrams per liter
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25 degrees Celsius
	Analytical Methods
AA	atomic absorption spectrometry
COL	colorimetric
DCP	direct-current plasma emission spectrometry
ELEC	electrometric
GRAV	gravimetric
IC	ion chromatography
ICP	inductively coupled plasma emission spectrometry
ISE	ion-selective electrode
TITR	electrometric titration
TOT	total recoverable
TURB	turbidimetric
	Others
LOP	statistically significant lack of precision
MPD	most probable deviation
MPV	most probable value
N	negative bias
NWQL	National Water-Quality Laboratory
P	positive bias
QL	quantitation limit bias
QWSU	Quality of Water Service Unit
SD	standard deviation
SRWS	standard reference water samples
WATSTORE	Water Data Storage and Retrieval System

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

$$°C = 5/9\ (°F-32).$$

Quality-Assurance Data for Routine Water Analysis in the Laboratories of the U.S. Geological Survey for Water Year 1990

By Thomas J. Maloney, Amy S. Ludtke, *and* Teresa L. Krizman

Abstract

The U.S. Geological Survey maintains a quality-assurance program based on the analyses of reference samples for the National Water-Quality Laboratory in Arvada, Colorado, and the Quality of Water Services Unit in Ocala, Florida. Reference samples containing selected inorganic, nutrient, and low ionic strength constituents are prepared and disguised as routine samples. The program goal is to submit blind reference samples at a rate of approximately 5 percent of the annual environmental sample load for each constituent. The samples are distributed to the laboratories throughout the year. The results are stored permanently in the National Water Data Storage and Retrieval System (WATSTORE), the Survey's data base for all water data. These data are analyzed statistically for precision and bias and the results are described for data collected during water year 1990.

An overall evaluation of the inorganic (major ion and trace metal) constituent data for water year 1990 indicated a lack of precision in the National Water-Quality Laboratory for 5 of 65 analytical procedures: boron (direct-current plasma emission spectrometry), chloride (colorimetric and ion chromatography), fluoride (ion-selective electrode and ion chromatography), iron, total recoverable (atomic absorption spectrometry), and manganese, total recoverable (atomic absorption spectrometry). The results for 13 of 65 analytical procedures had positive or negative bias during water year 1990.

Lack of precision was indicated in the determination of one of the five National Water-Quality Laboratory nutrient constituents: phosphorus. Lack of precision for this constituent could be attributed to application of correction factors for samples requiring dilutions. A negative bias condition was indicated in the determination of nitrate plus nitrite as nitrogen.

Lack of precision was indicated in 1 of the 12 low-ionic strength analytical procedures tested in the National Water-Quality Laboratory program: cadmium (atomic absorption spectrometry; graphite furnace). Results for cobalt indicated a negative bias condition.

Quality-assurance sample submission to the Ocala Quality of Water Service Unit began in water year 1990. An overall evaluation indicated lack of precision for 4 of 35 analytical procedures: aluminum, total recoverable (atomic absorption spectrometry; chelation-extraction), copper, total recoverable (atomic absorption spectrometry; graphite-furnace), fluoride (colorimetric/ion-selective electrode), and iron, total recoverable (atomic absorption spectrometry; chelation-extraction). A positive bias condition was indicated for iron, total recoverable (atomic absorption spectrometry; chelation-extraction). There was acceptable precision and no indication of bias for all five nutrient procedures.

INTRODUCTION

The Water Resources Division of the U.S. Geological Survey (USGS) performs numerous hydrologic investigations that require analyses of water for inorganic constituents, nutrients, some physical properties, and priority pollutants as defined by the U.S. Environmental Protection Agency (Keith and Telliard, 1979). The National Water-Quality Laboratory (NWQL), in Arvada, Colorado, and the Quality of Water Service Unit (QWSU) laboratory, in Ocala, Florida, are the primary sources of analytical services for these hydrologic investigations.

This report describes the results of the quality-assurance programs used to monitor the quality of analytical work for inorganic constituents, nutrients, and some physical properties at the NWQL and the QWSU. Previous reports (Peart and Thomas, 1983a, 1983b, 1984; Peart and Sutphin, 1987; Lucey and Peart, 1988, 1989a, 1989b; Lucey, 1989; and Maloney and others, 1992) document results from February 1981 through September 1989. Some of the previous reports contained quality-assurance information for organic determinations.

During water year 1990, a total of 82 analytical procedures were evaluated at the NWQL. Seven procedures were added to the NWQL Blind Sample Program and four were removed during the year. Analytical procedures added to the program were beryllium (AA); molybdenum, total recoverable (AA); vanadium (COL); and low ionic strength determinations for cadmium, cobalt, copper, and lead, each measured by graphite-furnace atomic-absorption spectrometry. The analytical procedures removed from the program were low ionic strength nutrient determinations for ammonia, nitrate plus nitrite as nitrogen, orthophosphate as phosphorus, and phosphorus, each measured by colorimetry. These procedures were removed because the reference samples that were available were not preserved in the manner required for nutrient determinations.

Evaluation of the QWSU laboratory by this quality-assurance program began in water year 1990. The QWSU Blind Sample Program evaluated 40 analytical procedures. The analytes included in the 1990 NWQL and QWSU Blind Sample Programs are listed below by categories. Analytes determined by methods adapted to detect low concentrations are included in the low ionic strength category.

Inorganic constituents: (NWQL and QWSU Blind Sample Programs) alkalinity, aluminum, arsenic, beryllium, boron, cadmium, calcium, chloride, chromium, copper, dissolved solids (residue on evaporation at 180°C), fluoride, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silica, sodium, strontium, sulfate, vanadium, and zinc. (NWQL Blind Sample Program only) antimony, barium, cobalt, lithium, molybdenum, and silver.

Nutrient constituents: (NWQL and QWSU Blind Sample Programs) ammonia as nitrogen, ammonia plus organic nitrogen, nitrate plus nitrite as nitrogen, orthophosphate as phosphorus, and phosphorus.

Low ionic strength constituents and physical properties: (NWQL Blind Sample Program only) cadmium, calcium, chloride, cobalt, copper, fluoride, lead, magnesium, potassium, sodium, specific conductance, and sulfate.

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. No effort was made to correct non-analytical errors, even when it was obvious which corrective measures were appropriate, so the data are presented as originally produced by the laboratories. These include any sample login errors, transcription errors by the analyst, data-transmission errors by laboratory instruments, and manual data-entry errors. Therefore, if the data reviewer in the office that collected the sample detects non-analytical errors, the errors can be corrected to improve the quality of the data. For example, two samples from different sites are submitted to a laboratory on the same day and are misidentified in a way that the analytical data reported for one would actually belong to the other. A data reviewer familiar with one of the sites or its historical data usually could detect the problem and make the necessary corrections.

2. Requests for analysis reruns commonly are made for determinations that exceed control limits set at ± 2 standard deviations of the reference-sample concentration. The purpose of rerun requests is to identify reference samples that may be deteriorating or that may have been incorrectly bottled. If the analysis rerun confirms that one of these non-analytical problems has occurred, the quality-assurance data base is updated. The majority of analysis reruns confirm laboratory problems, such as analytical errors, internal bottle mix-ups, or data-transmission errors. If a laboratory problem is confirmed by the analysis rerun, the originally released data remains in the quality-assurance data base. However, if the quality-control section of the laboratory identifies problems with an analytical line and requires that updated analyses be released, then the quality-assurance data base is updated with the new values. Data reviewers in the offices that collect environmental samples are expected to scrutinize analytical data for discrepancies and make requests for analysis reruns. Analysis rerun requests made by the office reviewer may result in the detection of analytical and non-analytical errors. If these errors are detected

and data base corrections are made, the overall data quality would be better than the data quality presented in this report. Therefore, the quality-assurance evaluation of analytical data released from the NWQL and QWSU, as presented in this report, is considered conservative compared to the results of a quality assurance evaluation of data stored in an office's environmental data bases.

3. Control charts included in this report may be used to determine analytical conditions at any given time for water year 1990. A chart may show an analytical process to be out of statistical control for a short period of time, but in general, in statistical control for most of the year. The data for the short period may affect the statistical tests for the entire year such that they would indicate lack of precision or significant bias. The data for the period when the analytical process was in statistical control can be considered separately to evaluate precision and bias. An interactive quality-assurance data base is available that allows laboratory users to select specific analytes and time periods of interest. Lucey (1990) described the use of the program to retrieve information from the data base.

4. Dilution factors that were applied incorrectly account for some analytical errors. Sample dilutions are routinely made in the laboratory to bring sample concentrations into analytical range. If the dilution factor is not applied or is applied incorrectly, the reported value will be in error. For example, if a nutrient sample has a phosphorus concentration of 1.2 mg/L and an analysis is reported at 0.12 mg/L, a 10X dilution may have been used and not applied to the final result. These kinds of errors are difficult to confirm. Their detection, confirmation through rerun requests, and correction in the field offices will improve the data quality in the local QW data base compared to that indicated in this report.

5. Non-analytical errors for nutrient analyses can result when samples are not maintained at the ideal temperature of 4°C during shipping and receiving.

PROGRAM DESCRIPTION

Standard reference water samples (SRWS) (Skougstad and Fishman, 1975; Schroder and others, 1980; Janzer, 1985; Long and Farrar, 1992) are used to prepare samples for the Blind Sample Program. The SRWS are used undiluted, diluted with deionized water, or mixed in varying proportions with other SRWS. This sample mixing procedure produces a large number of unique samples available for quality-assurance purposes. The probability that the Blind Sample Program's quality-assurance samples will be recognized in the laboratories is low because of the diversity and number of samples.

Reference samples for the Blind Sample Program are made to appear as much like environmental samples as possible. Analytical request forms are completed to ensure that appropriate analyses have been requested for the samples. The samples and the forms are shipped to selected U.S. Geological Survey offices across the country. These offices send the quality-assurance samples for the Blind Sample Programs to the laboratories with their regular environmental samples.

The number of quality-assurance determinations requested for each analytical procedure is proportional to the number of requests for the procedure from all environmental samples submitted. The program goal is to have quality-assurance samples submitted for each analytical procedure at a rate of approximately five percent of the environmental sample load.

SRWS are filtered during preparation; therefore, all constituents in the Blind Reference Samples are in the dissolved phase. Constituents that are designated as "total recoverable" in this report are from reference samples that have undergone a digestion process (Fishman and Friedman, 1985, p. 87-88) during analysis, rather than from unfiltered or whole-water samples. Differences that appear in this report between the dissolved analyses and the total recoverable analyses will be due to the digestion process rather than from any difference in the sampling techniques or sample source.

Quality-assurance samples pass through each laboratory as routine samples, undergoing the normal laboratory quality-control and quality-assurance procedures; thus data from these quality-assurance samples reflect the quality of the analytical data that the laboratories produce for environmental samples. The data released by the laboratory are stored in the National Water Data Storage and Retrieval System (WATSTORE).

STATISTICAL EVALUATION

Control Chart Development and Evaluation

The SRWS samples are analyzed through a round-robin evaluation program by about 150 laboratories throughout the United States. The results are compiled and a statistical summary is prepared. Until 1988, the SRWS program used parametric statistics, mean and standard deviation, for statistical summaries. Since then, the program has used nonparametric statistics, median and f-pseudosigma (nonparametric statistic equivalent to the standard deviation), for the statistical summaries. Resultant mean or median values are used to estimate the most probably correct values or the most probable values (MPV's). These MPV's are used in this quality-assurance program to compare with analytical results. For reference samples composed of a mixture of two SRWS's or an SRWS and deionized water, the volume-weighted average of the SRWS is used to determine the constituent MPV's for the mixture.

A deviation-regression equation was determined by using linear-least-squares regression of the MPV for each constituent obtained from all the SRWS's analyzed during the last 7 years against the corresponding standard deviation or f-pseudosigma value for those constituents. The 7-year period was selected to account for general improvements in analytical methods over time and to provide enough data to prepare the regressions. The regression equations enable an estimation of a most probable deviation (MPD) for each constituent at various concentrations. The difference between the analysis concentration and the MPV was compared against the MPD to determine whether an analysis was statistically in or out of control. An individual reported value was considered in statistical control if it was within two MPDs of the MPV. In this report, the term "standard deviations" will be used when comparing individual determinations against the MPV.

Some MPV data for the SRWS program are reported with more significant figures than reported by the laboratories for environmental sample analyses. Because the MPD regression equations are based on SRWS data that are reported to a more accurate level, the MPD values, especially at lower concentrations, may have tolerances too small to be met by the laboratories. An administrative decision was made to establish a minimum most probable deviation at three-quarters of the reporting level. This allows at least one reportable value less than or greater than the MPV. For example, barium (AA), has a minimum reporting level of 100 μg/L (micrograms per liter). Many SRWS reference mixes have an MPV well below this minimum reporting level such that a reference with an MPV for barium of 20 μg/L would be reported as less than 100 μg/L. Therefore, data for the reference sample would be 3.81 standard deviations high. The minimum MPD for barium, by atomic absorption spectrometry, has been set to 75 μg/L. The equations for determining the MPD for each constituent and the established minimum MPDs are listed in table 1.

The number of standard deviations (NSD) that an analysis differs from the MPV was calculated by dividing the difference between the reported value and the MPV by the MPD. For each constituent, the NSD values were plotted against the date that samples were logged into the laboratory. The results for each constituent are shown on control charts in figures 1 through 83 for the NWQL and in figures 167 through 206 for the QWSU in the "Supplemental Data" section of this report.

Control charts for inorganic reference samples are shown in figures 1 through 66 for the NWQL and figures 167 through 201 for the QWSU. Three symbols are used in these figures to indicate results from the lower (✻), middle (Δ), and upper (❑) thirds of the analytical range tested. This range does not necessarily correspond with the analytical capabilities of laboratory instrumentation or methods, but rather corresponds with the concentration range of reference samples. The concentration range for samples submitted for some of the analytical procedures was narrow. In these cases, all data were plotted using the symbol for the middle (Δ) one-third of the data.

Control charts for nutrient constituents are shown in figures 67 through 71 for the NWQL and figures 202 through 206 for the QWSU. Control charts for NWQL low ionic strength constituents are shown in figures 72 through 83. Because of the low concentrations of constituents in these samples, the low concentration symbol (✻) is used for all data on the control charts.

On figures 1 through 83 for the NWQL and figures 167 through 206 for the QWSU, points that are greater than 6 standard deviations or less than -6 standard deviations are plotted at the top or bottom edge of the figure, with the actual number of standard deviations indicated adjacent to the point (see figure 1, for example).

Several of the control charts for both the NWQL and QWSU laboratories have vertical lines indicating a date when an analytical method was changed. The NWQL had three method changes within water year 1990, all on March 6, 1990; chloride (fig. 18) method changed from colorimetric to ion chromatography, fluoride (fig. 29) method changed from colorimetric to ion

Table 1. Linear least-squared equations for determining the most probable deviation

[MPD, most probable deviation; TITR, electrometric titration; mg/L, milligrams per liter; MPV, most probable value; *, not applicable; DCP, direct-current plasma emission spectrometry; µg/L, micrograms per liter; TOT, total recoverable; AA, atomic absorption spectrometry; ICP, inductively coupled plasma emission spectrometry; COL, colorimetric; IC, ion chromatography; GRAV, gravimetric; ISE, ion-selective electrode; TURB, turbidimetric; ELEC, electrometric; µS/cm, microsiemens per centimeter at 25°C]

Constituent (dissolved except as indicated) or physical property	Units	Equation to determine MPD	Minimum MPD
	Inorganic constituents		
Alkalinity (TITR)	mg/L	(0.025 × MPV) + 0.86	*
Aluminum (DCP)	µg/L	(0.022 × MPV) + 6.73	7.5
Aluminum (TOT, DCP)	µg/L	(0.022 × MPV) + 6.73	7.5
Aluminum (TOT, AA)	µg/L	(0.12 × MPV) + 23.5	*
Antimony (AA)	µg/L	(0.065 × MPV) + 1.29	*
Arsenic (AA)	µg/L	(0.13 × MPV) + 0.84	*
Barium (ICP)	µg/L	(0.34 × MPV) + 2.50	*
Barium (AA)	µg/L	(0.19 × MPV) + 14.0	75
Barium (TOT, AA)	µg/L	(0.19 × MPV) + 14.0	75
Beryllium (ICP)	µg/L	(0.022 × MPV) + 1.17	*
Beryllium (AA)	µg/L	(0.022 × MPV) + 1.17	7.5
Beryllium (TOT, AA)	µg/L	(0.022 × MPV) + 1.17	7.5
Boron (DCP)	µg/L	(0.016 × MPV) + 5.0	7.5
Boron (COL)	µg/L	(0.0478 × MPV) + 29.89	*
Cadmium (ICP)	µg/L	(0.11 × MPV) + 0.55	0.75
Cadmium (AA)	µg/L	(0.11 × MPV) + 0.55	0.75
Cadmium (TOT,AA)	µg/L	(0.11 × MPV) + 0.55	0.75
Calcium (ICP)	mg/L	(0.045 × MPV) + 0.08	*
Calcium (AA)	mg/L	(0.045 × MPV) + 0.08	*
Chloride (COL/IC)	mg/L	(0.039 × MPV) + 0.30	*
Chromium (ICP)	µg/L	(0.12 × MPV) + 1.42	3.75
Chromium (DCP)	µg/L	(0.12 × MPV) + 1.42	*
Chromium (TOT,DCP)	µg/L	(0.12 × MPV) + 1.42	*
Cobalt (ICP)	µg/L	(0.23 × MPV) + 0.46	*
Cobalt (AA)	µg/L	(0.23 × MPV) + 0.46	*
Cobalt (TOT,AA)	µg/L	(0.23 × MPV) + 0.46	*
Copper (ICP)	µg/L	(0.029 × MPV) + 3.25	7.5
Copper (AA)	µg/L	(0.029 × MPV) + 3.25	*
Copper (TOT,AA)	µg/L	(0.029 × MPV) + 3.25	*
Dissolved solids (GRAV)	mg/L	(0.020 × MPV) + 8.7	*
Fluoride (ISE/IC)	mg/L	(0.081 × MPV) + 0.01	0.075
Fluoride (IC/ISE)	mg/L	(0.081 × MPV) + 0.01	0.075
Iron (ICP)	µg/L	(0.079 × MPV) + 5.57	*
Iron (AA)	µg/L	(0.079 × MPV) + 5.57	7.5
Iron (TOT,AA)	µg/L	(0.079 × MPV) + 5.57	7.5
Lead (ICP)	µg/L	(0.150 × MPV) + 2.60	7.5
Lead (AA)	µg/L	(0.150 × MPV) + 2.60	*
Lead (TOT,AA)	µg/L	(0.150 × MPV) + 2.60	*
Lithium (ICP)	µg/L	(0.077 × MPV) + 2.98	3.0

Table 1. Linear least-squared equations for determining the most probable deviation --Continued

Constituent (dissolved except as indicated) or physical property	Units	Equation to determine MPD	Minimum MPD
Inorganic constituents --Continued			
Lithium (TOT,AA)	µg/L	(0.077 × MPV) + 2.98	7.5
Magnesium (ICP)	mg/L	(0.041 × MPV) + 0.11	*
Magnesium (AA)	mg/L	(0.041 × MPV) + 0.11	*
Manganese (ICP)	µg/L	(0.031 × MPV) + 3.68	*
Manganese (AA)	µg/L	(0.031 × MPV) + 3.68	7.5
Manganese (TOT,AA)	µg/L	(0.031 × MPV) + 3.68	7.5
Mercury (AA)	µg/L	(0.11 × MPV) + 0.13	*
Mercury (TOT,AA)	µg/L	(0.11 × MPV) + 0.13	*
Molybdenum (ICP)	µg/L	(0.052 × MPV) + 3.00	7.5
Molybdenum (AA)	µg/L	(0.052 × MPV) + 3.00	*
Molybdenum (TOT,AA)	µg/L	(0.052 × MPV) + 3.00	*
Nickel (ICP)	µg/L	(0.10 × MPV) + 3.30	7.5
Nickel (AA)	µg/L	(0.10 × MPV) + 3.30	*
Nickel (TOT,AA)	µg/L	(0.10 × MPV) + 3.30	*
Potassium (AA)	mg/L	(0.073 × MPV) + 0.12	*
Selenium (AA)	µg/L	(0.22 × MPV) + 0.56	0.75
Silica (ICP)	mg/L	(0.059 × MPV) + 0.21	*
Silica (COL)	mg/L	(0.059 × MPV) + 0.21	*
Silver (ICP)	µg/L	(0.11 × MPV) + 0.99	*
Silver (AA)	µg/L	(0.11 × MPV) + 0.99	*
Silver (TOT,AA)	µg/L	(0.11 × MPV) + 0.99	*
Sodium (ICP)	mg/L	(0.039 × MPV) + 0.14	*
Sodium (AA)	mg/L	(0.039 × MPV) + 0.14	*
Strontium (ICP)	µg/L	(0.049 × MPV) + 2.7	*
Sulfate (TURB/IC)	mg/L	(0.045 × MPV) + 1.1	*
Vanadium (ICP)	µg/L	(0.079 × MPV) + 2.4	*
Vanadium (COL)	µg/L	(0.079 × MPV) + 2.4	*
Zinc (ICP)	µg/L	(0.046 × MPV) + 4.43	*
Zinc (AA)	µg/L	(0.046 × MPV) + 4.43	7.5
Zinc (TOT,AA)	µg/L	(0.046 × MPV) + 4.43	7.5
Nutrient constituents			
Ammonia as nitrogen (COL)	mg/L	(0.11 × MPV) + 0.020	*
Ammonia plus organic (COL) nitrogen	mg/L	(0.52 × MPV) - 0.01	*
Nitrate plus nitrite as nitrogen (COL)	mg/L	(0.038 × MPV) + 0.040	*
Orthophosphate as phosphorus (COL)	mg/L	(0.055 × MPV) + 0.006	*
Phosphorus (COL)	mg/L	(0.061 × MPV) + 0.004	*
Low ionic strength constituents and properties			
Cadmium (AA)	µg/L	(0.11 × MPV) + 0.55	*
Calcium (AA)	mg/L	(0.066 × MPV) + 0.05	*
Chloride (IC)	mg/L	(0.077 × MPV) + 0.17	*

Table 1. Linear least-squared equations for determining the most probable deviation --Continued

Constituent (dissolved except as indicated) or physical property	Units	Equation to determine MPD	Minimum MPD
Low ionic strength constituents and properties --Continued			
Cobalt (AA)	µg/L	(0.23 × MPV) + 0.46	*
Copper (AA)	µg/L	(0.29 × MPV) + 3.25	*
Fluoride (IC)	mg/L	(0.16 × MPV) + 0.19	*
Lead (AA)	µg/L	(0.15 × MPV) + 2.60	*
Magnesium (AA)	mg/L	(0.051 × MPV) + 0.01	*
Potassium (AA)	mg/L	(0.12 × MPV) + 0.01	*
Sodium (AA)	mg/L	(0.046 × MPV) + 0.04	*
Specific conductance (ELEC)	µS/cm	(0.089 × MPV) + 0.27	*
Sulfate (IC)	mg/L	(0.038 × MPV) + 0.01	*

chromatography, and sulfate (fig. 61) method changed from turbidimetric to ion chromatography.

The QWSU had 11 method changes within water year 1990, which are indicated on the control charts with a vertical line. Chloride (fig. 176) changed from colorimetry to ion chromatography, and sulfate (fig.198) changed from turbidimetric to ion chromatography on April 1, 1990. Fluoride (fig. 181) changed from colorimetric to ion-selective electrode on June 1, 1990. Cadmium (AA) (fig. 173), cadmium (TOT,AA) (fig. 174), copper (AA) (fig. 178), copper (TOT, AA) (fig. 179), lead (AA) (fig. 184), lead (TOT,AA) (fig. 185), nickel (AA) (fig. 191), and nickel (TOT,AA) (fig. 192), all changed from atomic absorption spectrometry, chelation-extraction to atomic absorption spectrometry, graphite furnace on December 1, 1989.

The NWQL control charts for beryllium (AA) (fig. 10), chromium (ICP) (fig. 19), manganese (ICP) (fig. 40), manganese (TOT,AA) (fig. 42), nickel (ICP) (fig. 48), silver (ICP) (fig. 55), and the low ionic strength cobalt (AA) (fig. 75) and copper (AA) (fig. 76) have an uneven distribution of data points, because reference samples were not submitted for these constituents for several months

On March 6, 1990, a storm dropped in excess of 2 feet of wet snow on the NWQL facility. The excessive weight of the snow caused serious damage to the roof of the laboratory; many structural beams needed repair or replacement. The facility was closed for several days due to safety concerns. Repairs required months of construction that disrupted operations and caused serious concerns regarding contamination of the laboratory environment. Construction crews had to disassemble and move much of the analytical apparatus in order to complete repairs. Most of the wiring that connected the laboratory computer systems was cut during renovation. The NWQL took steps to address the data-quality concerns resulting from this incident. For several weeks, samples with short holding times were transferred to other government laboratories. The internal quality-control program at the NWQL increased submission of blank reference samples to provide assurance that construction operations had a minimal effect on analytical data quality.

The roof damage and resultant repairs caused the premature dismantling of apparatus used for chloride, fluoride, and sulfate determinations. Replacement of the existing analytical methods for these analytes with an ion chromatography method had been planned before the roof damage occurred and method development testing had been started. Because the NWQL believed that the amount of testing needed to put the ion chromatography method on line would be equivalent to the effort needed to retest the old methods after repairs were made to the disassembled apparatus, the NWQL decided to go forward with the method change. The control charts for chloride, fluoride, and sulfate (figures 18, 29, 61) indicate that the ion chromatography method was less precise than the methods replaced. Efforts to improve data precision throughout the remainder of the water year had minimal effect.

Precision Chart Development and Evaluation

Replicate determinations of reference samples were used to provide a measure of precision. For each sample mixture having at least three determinations, the mean, standard deviation, and relative standard deviation was calculated for each constituent. The relative standard deviation provides an estimate of error at concentrations of the reference samples. Replicate sample results as measured by this procedure provides an estimation of long-term laboratory precision.

Precision data charts (figs. 84 through 166 for the NWQL and figures 207 through 246 for the QWSU in the "Supplemental data" section of this report) were prepared by plotting the relative standard deviations for inorganic, nutrient, and low ionic strength constituents as a percent against their mean concentrations. These charts allow a data reviewer to estimate precision at any concentration shown for a constituent. For example, figure 84 shows a typical distribution of relative standard deviation data for total alkalinity determinations to be ±15 percent for the analyzed range of concentrations. In order to use the precision charts to estimate an expected error from the analytical results, outliers were deleted from the data set. An outlier was defined as a value that is greater than 6 or less than -6 standard deviations from the MPV. The total number of analyses for each constituent processed during the water year, the number of analyses with standard deviations greater than 2 or less than -2 from the MPV, and the number of analyses with standard deviations greater than 6 or less than -6 from the MPV are listed in table 2 for the NWQL and in table 3 for the QWSU. If the relative standard deviation for a given sample mix has a value of zero, the data point will plot on the horizontal axis of the precision data chart, as in figures 90 and 91. A relative standard deviation of zero occurs when all values reported by the laboratory for a constituent in a unique sample mix are the same. Although this suggests that the results are from a reproducible analytical method, repetitive results can be an artifact of small sample size or reporting level. For example, the minimum reporting level for barium (AA) is 100 micrograms per liter and, because the mixes used during the water year 1990 have MPV's less than this value (fig. 7), the precision chart (fig. 90) shows a relative standard deviation of 0 at a mean concentration of 100 micrograms per liter.

Binomial-Probability-Distribution Technique to Assess Precision and Bias

Measures of precision and bias were determined from control chart data by applying binomial-probability-distribution procedures described by Friedman, Bradford, and Peart (1983) and by Peart and Thomas (1983a).

The precision analysis is based on whether or not the analytical method could produce results within ± 2 standard deviations of the theoretical values. The binomial equation identifies the maximum number of determinations that could exceed the control limit at a confidence level of 99 percent. A comparison is then made between the number of analytical determinations exceeding control limits and the results of the binomial-probability-distribution equation for the total number of analytical determinations. Analytes exhibit lack of precision if they have more determinations outside the control limits than the result of the binomial equation. The binomial-probability-distribution procedure to measure precision allows tracking of short-term variations in analytical measurements. However, this statistical test can fail to identify periods of serious imprecision of laboratory methods because it is based on MPV's from inter-laboratory testing using multiple-methods rather than means of determinations from the individual laboratories.

The bias analysis is made by tabulating the total number of analyses and the number of determinations above, below, and at the MPV concentration. A binomial equation is used to determine the maximum number of determinations above or below the MPV at a confidence level of 99 percent. Analyses exhibit a positive bias if the number of determinations above the MPV exceeded the result of the binomial equation. Likewise, analyses exhibit a negative bias if the number of determinations below the MPV exceeded the result of the binomial equation.

For the bias analysis in previous reports, an analytical determination would have to exactly match the MPV to be considered "at" the MPV concentration. This unrealistically stringent criteria resulted in positive or negative bias classifications for many analytical determinations. Beginning in the water year 1990, a correction has been applied to the bias analysis to allow determinations in a window from -0.25 to +0.25 standard deviations of the MPV to be considered "at" the MPV concentration.

Table 2. Total number of analyses from quality-assurance samples during water year 1990 with number greater than two and six standard deviations from the most probable value for the National Water-Quality Laboratory

[>2SD, number of analyses greater than 2 or less than -2 standard deviations from the most probable value; >6SD, number of analyses greater than 6 or less than -6 standard deviations from the most probable value; TITR, electrometric titration; DCP, direct-current plasma emission spectrometry; TOT, total recoverable; AA, atomic absorption spectrometry; ICP, inductively coupled plasma emission spectrometry; COL, colorimetric; IC, ion chromatography; GRAV, gravimetric; ISE, ion-selective electrode; TURB, turbidimetric; ELEC, electrometric]

Constituent (dissolved except as indicated) or physical property	Number of analyses			Constituent (dissolved except as indicated) or physical property	Number of analyses		
	Total	>2SD	>6SD		Total	>2SD	>6SD
Inorganic constituents							
Alkalinity (TITR)	372	11	5	Barium (TOT,AA)	79	2	0
Aluminum (DCP)	164	16	5	Beryllium (ICP)	171	0	0
Aluminum (TOT,AA)	16	4	0	Beryllium (AA)	63	0	0
Antimony (AA)	75	2	0	Beryllium (TOT,AA)	17	0	0
Arsenic (AA)	332	8	1	Boron (DCP)	285	23	4
Barium (ICP)	173	1	1	Cadmium (ICP)	172	9	1
Barium (AA)	130	7	0	Cadmium (AA)	231	8	1
Cadmium (TOT,AA)	81	2	0	Iron (AA)	224	12	1
Calcium (ICP)	440	5	3	Iron (TOT,AA)	82	44	17
Calcium (AA)	173	6	1	Lead (ICP)	171	16	0
Chloride (COL/IC)	382	34	7	Lead (AA)	226	5	0
Chromium (ICP)	98	0	0	Lead (TOT,AA)	77	1	0
Chromium (DCP)	300	3	1	Lithium (ICP)	172	0	0
Chromium (TOT,DCP)	79	5	0	Lithium (TOT,AA)	17	0	0
Cobalt (ICP)	173	0	0	Magnesium (ICP)	437	3	0
Cobalt (AA)	134	2	0	Magnesium (AA)	173	1	1
Cobalt (TOT,AA)	81	2	0	Manganese (ICP)	96	0	0
Copper (ICP)	171	0	0	Manganese (AA)	149	2	0
Copper (AA)	226	8	1	Manganese (TOT,AA)	47	19	4
Copper (TOT,AA)	77	6	1	Mercury (AA)	160	3	2
Dissolved solids (GRAV)	376	14	2	Mercury (TOT,AA)	92	6	3
Fluoride (ISE/IC)	369	68	9	Molybdenum (ICP)	171	1	0
Iron (ICP)	172	0	0	Molybdenum (AA)	143	2	0
Molybdenum (TOT,AA)	17	1	1	Silver (TOT,AA)	81	5	0
Nickel (ICP)	97	1	0	Sodium (ICP)	426	10	0
Nickel (AA)	299	14	0	Sodium (AA)	171	0	0
Nickel (TOT,AA)	77	2	0	Strontium (ICP)	237	5	0
Potassium (AA)	366	8	3	Sulfate (TURB/IC)	378	26	6
Selenium (AA)	233	2	0	Vanadium (ICP)	170	4	0
Silica (ICP)	429	3	0	Vanadium (COL)		78	0
Silica (COL)	114	4	3	Zinc (ICP)		172	50
Silver (ICP)	97	5	0	Zinc (AA)		226	30
Silver (AA)	209	15	0	Zinc (TOT,AA)		77	61
Nutrient constituents							
Ammonia as nitrogen (COL)	404	8	2	Orthophosphate as phosphorus (COL)	279	20	9
Ammonia plus organic nitrogen (COL)	319	4	1	Phosphorus (COL)	320	53	11
Nitrate plus nitrite as nitrogen (COL)	397	18	4				

Table 2. Total number of analyses from quality-assurance samples during water year 1990 with number greater than two and six standard deviations from the most probable value for the National Water-Quality Laboratory --Continued

Constituent (dissolved except as indicated) or physical property	Number of analyses			Constituent (dissolved except as indicated) or physical property	Number of analyses		
	Total	>2SD	>6SD		Total	>2SD	>6SD
Low ionic strength constituents							
Cadmium (AA)	19	6	0	Lead (AA)	19	1	0
Calcium (AA)	72	2	0	Magnesium (AA)	70	2	0
Chloride (IC)	72	2	1	Potassium (AA)	74	5	1
Cobalt (AA)	15	0	0	Sodium (AA)	72	5	1
Copper (AA)	15	1	1	Specific conductance (ELEC)	74	1	1
Fluoride (IC)	49	4	0	Sulfate (IC)	70	3	1

Table 3. Total number of analyses from quality-assurance samples during water year 1990 with number greater than two and six standard deviations from the most probable value for the Quality of Water Service Unit

[>2SD, number of analyses greater than 2 or less than -2 standard deviations from the most probable value; >6SD, number of analyses greater than 6 or less than -6 standard deviations from the most probable value; TITR, electrometric titration; TOT, total recoverable; AA, atomic absorption spectrometry; COL, colorimetric; IC, ion chromatography; GRAV, gravimetric; ISE, ion-selective electrode; TURB, turbidimetric]

Co .stituent (dissolved except as indicated)	Number of analyses			Constituent (dissolved except as indicated)	Number of analyses		
	Total	>2SD	>6SD		Total	>2SD	>6SD
Inorganic constituents							
Alkalinity (TITR)	55	3	1	Chloride (COL/IC)	66	0	0
Aluminum (TOT,AA)	11	6	0	Chromium (TOT)	20	0	0
Arsenic (AA)	39	0	0	Copper (AA)	22	1	0
Beryllium (AA)	9	0	0	Copper (TOT,AA)	20	6	0
Beryllium (TOT,AA)	17	0	0	Dissolved solids (GRAV)	58	0	0
Boron (COL)	6	0	0	Fluoride (COL/ISE)	58	6	2
Cadmium (AA)	10	0	0	Iron (AA)	22	3	0
Cadmium (TOT,AA)	28	1	0	Iron (TOT)	11	7	1
Calcium (AA)	61	0	0	Lead (AA)	22	0	0
Lead (TOT,AA)	31	0	0	Selenium (AA)	24	0	0
Magnesium (AA)	61	0	0	Silica (COL)	58	0	0
Manganese (AA)	11	0	0	Sodium (AA)	58	0	0
Manganese (TOT,AA)	8	0	0	Strontium (AA)	39	1	0
Mercury (AA)	9	0	0	Sulfate (TURB/IC)	65	0	0
Mercury (TOT,AA)	30	0	0	Vanadium (COL)	9	0	0
Nickel (AA)	10	0	0	Zinc (AA)	23	0	0
Nickel (TOT,AA)	31	0	0	Zinc (TOT,AA)	20	3	0
Potassium (AA)	58	0	0				
Nutrient constituents							
Ammonia as nitrogen (COL)	99	2	0	Orthophosphate as phosphorus (COL)	90	2	0
Ammonia plus organic nitrogen (COL)	79	0	0	Phosphorus (COL)	95	4	0
Nitrate plus nitrite as nitrogen (COL)	94	3	0				

QUALITY-ASSURANCE DATA FOR INORGANIC-CONSTITUENT SAMPLES

Precision

The results of statistical testing for precision for each inorganic constituent are listed in table 4 for the NWQL and in table 5 for the QWSU. These tables show either acceptable results (indicated by "+") or a significant lack of precision at the 99-percent confidence level (indicated by "LOP") for each constituent.

NWQL data for water year 1990 for boron (DCP), chloride (COL and IC), fluoride (ISE and IC), iron (TOT, AA), and manganese (TOT, AA) indicated lack of precision. Boron (DCP) failed the precision criterion for both water years 1989 (Maloney and others, 1992) and 1990. Iron (TOT, AA) has failed the precision criterion for 6 consecutive years (Lucey and Peart, 1988, 1989a, 1989b; Lucey, 1989; and Maloney and others, 1992). NWQL determinations of aluminum (TOT, AA), copper (TOT, AA), sodium (ICP), zinc (ICP), zinc (AA), and zinc (TOT, AA) had acceptable results during water year 1990 after failing the precision tests during water year 1989 (Maloney and others,1992).

QWSU data for water year 1990 for aluminum (TOT, AA), copper (TOT, AA), fluoride (COL and ISE), and iron (TOT, AA) indicated lack of precision. The lack of precision for fluoride occurred during the first half of the water year, as shown on figure 181, when a colorimetric method of analysis was being used. After June 1, 1990, the QWSU used an ion-selective electrode method for fluoride determinations and no out-of-control points were reported for analyses determined by that method. No comparisons to historical quality-assurance data can be made because this is the first year that the QWSU participated in the blind sample project.

Bias

Analytical bias for NWQL determinations is indicated for 13 inorganic constituents for water year 1990 compared to 37 for water year 1989 (Maloney, and others,1992). The results of the binomial-probability-distribution statistical test for bias for each inorganic constituent are listed in table 6. As explained earlier, the method for assessment of analytical bias was changed for this report. The decrease in the number of analytes indicating statistical bias is largely due to the change in the bias-assessment methodology. The degree of bias for each constituent is evident through review of control charts.

Molybdenum (AA) was the only NWQL constituent that showed negative bias for both water years 1989 (Maloney and others, 1992) and 1990. In addition, cobalt (AA), cobalt (TOT,AA), magnesium (AA), silver (TOT,AA), and vanadium (COL) had negative bias for water year 1990. Positively biased constituents for water years 1989 (Maloney and others, 1992) and 1990 were: iron (AA), iron (TOT,AA), lead (ICP), manganese (TOT,AA), silica (ICP), and zinc (TOT,AA). In addition, mercury (AA) had a positive bias for water year1990 but not during water year 1989.

In addition to the 13 constituents with statistical bias, the control charts for arsenic (AA), barium (AA), barium (TOT,AA), manganese (AA), and selenium (AA) display results that appear to indicate an analytical technique with positive bias. This apparent positive bias occurs because the minimum reporting levels (arsenic (AA), 1ug/L; barium (AA), 100 mg/L; barium (TOT,AA), 100 mg/L; manganese (AA), 10 ug/L; and selenium (AA), 1 ug/L) were greater than the MPV's of many of the reference samples that were submitted. table 6 designates the results of the bias evaluation for these constituents as a quantitation limit bias (QL).

Statistical tests of water year 1990 QWSU inorganic procedures indicated that only the results for iron (TOT,AA) showed analytical bias (table 7). Iron (TOT,AA) results indicated positive bias. No QWSU inorganic analytical procedure indicated negative bias. In addition, the control charts for beryllium (AA), manganese (AA), manganese (TOT,AA), and strontium (AA) displayed results that appear to indicate analytical techniques with positive bias. The apparent positive bias occurs because the minimum reporting levels (beryllium (AA), 10 ug/L; manganese (AA), 10 ug/L; manganese (TOT,AA), 10 ug/L; and strontium (AA), 0.5 ug/L) were greater than the MPV's of many of the reference samples submitted. Table 7 designates the results of the bias evaluation for these constituents as a quantitation limit bias (QL). The degree of bias is evident through review of control charts.

Several factors might have affected the results for other constituents that indicate occasional bias; the factors include 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, reporting levels being higher or lower than the MPV's or undetected contamination of the SRWS.

Table 4. Results of statistical testing for lack of precision in inorganic constituent data for the National Water-Quality Laboratory

[TITR, titration; +, acceptable results; DCP, direct-current plasma emission spectrometry; TOT, total recoverable; AA, atomic absorption spectrometry; ICP, inductively coupled plasma emission spectrometry; LOP, statistically significant lack of precision; COL, colorimetric; IC, ion chromatography; GRAV, gravimetric; ISE, ion-selective electrode; TURB, turbidimetric]

Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990
Alkalinity (TITR)	+	Cadmium (TOT,AA)	+
Aluminum (DCP)	+	Calcium (ICP)	+
Aluminum (TOT,DCP)	+	Calcium (AA)	+
Antimony (AA)	+	Chloride (COL/IC)	LOP
Arsenic (AA)	+	Chromium (ICP)	+
Barium (ICP)	+	Chromium (DCP)	+
Barium (AA)	+	Chromium (TOT,DCP)	+
Barium (TOT,AA)	+	Cobalt (ICP)	+
Beryllium (ICP)	+	Cobalt (AA)	+
Beryllium (TOT,AA)	+	Cobalt (TOT,AA)	+
Boron (DCP)	LOP	Copper (ICP)	+
Cadmium (ICP)	+	Copper (AA)	+
Cadmium (AA)	+	Copper (TOT,AA)	+
Dissolved solids (GRAV)	+	Nickel (ICP)	+
Fluoride (ISE/IC)	LOP	Nickel (AA)	+
Iron (ICP)	+	Nickel (TOT,AA)	+
Iron (AA)	+	Potassium (AA)	+
Iron (TOT,AA)	LOP	Selenium (AA)	+
Lead (ICP)	+	Silica (ICP)	+
Lead (AA)	+	Silica (COL)	+
Lead (TOT,AA)	+	Silver (ICP)	+
Lithium (ICP)	+	Silver (AA)	+
Lithium (TOT,AA)	+	Silver (TOT,AA)	+
Magnesium (ICP)	+	Sodium (ICP)	+
Magnesium (AA)	+	Sodium (AA)	+
Manganese (ICP)	+	Strontium (ICP)	+
Manganese (AA)	+	Sulfate (TURB/IC)	+
Manganese (TOT,AA)	LOP	Vanadium (ICP)	+
Mercury (AA)	+	Vanadium (COL)	+
Mercury (TOT,AA)	+	Zinc (ICP)	+
Molybdenum (ICP)	+	Zinc (AA)	+
Molybdenum (AA)	+	Zinc (TOT,AA)	+
Molybdenum (TOT,AA)	+		

Table 5. Results of statistical testing for lack of precision in inorganic constituent data for the Quality of Water Service Unit Laboratory

[TITR, titration; +, acceptable results; TOT, total recoverable; AA, atomic absorption spectrometry; LOP, statistically significant lack of precision; COL, colorimetric; IC, ion chromatography; GRAV, gravimetric; ISE, ion selective electrode; TURB, turbidimetric]

Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990
Alkalinity (TITR)	+	Magnesium (AA)	+
Aluminum (TOT,AA)	LOP	Manganese (AA)	+
Arsenic (AA)	+	Manganese (TOT,AA)	+
Beryllium (AA)	+	Mercury (AA)	+
Beryllium (TOT,AA)	+	Mercury (TOT,AA)	+
Boron (COL)	+	Nickel (AA)	+
Cadmium (AA)	+	Nickel (TOT,AA)	+
Cadmium (TOT,AA)	+	Potassium (AA)	+
Calcium (AA)	+	Selenium (AA)	+
Chloride (COL/IC)	+	Silica (AA)	+
Chromium (TOT,AA)	+	Sodium (AA)	+
Copper (AA)	+	Strontium (AA)	+
Copper (TOT,AA)	LOP	Sulfate (TURB/IC)	+
Dissolved solids (GRAV)	+	Vanadium (COL)	+
Fluoride (COL/ISE)	LOP	Zinc (AA)	+
Iron (AA)	+	Zinc (TOT,AA)	+
Iron (TOT,AA)	LOP		+
Lead (AA)	+		+
Iron (TOT,AA)	+		+

Table 6. Results of statistical testing for bias in inorganic constituent data for the National Water-Quality Laboratory

[TITR, titration; +, acceptable results; DCP, direct-current plasma emission spectrometry; TOT, total recoverable; AA, atomic absorption spectrometry; QL, quantitation limit; ICP, inductively coupled plasma emission spectrometry; COL, colorimetric; IC, ion chromatography; N, negative bias; GRAV, gravimetric; ISE, ion-selective electrode; P, positive bias; TURB, turbidimetric]

Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990
Alkalinity (TITR)	+	Cadmium (TOT,AA)	+
Aluminum (DCP)	+	Calcium (ICP)	+
Aluminum (TOT,DCP)	+	Calcium (AA)	+
Antimony (AA)	+	Chloride (COL/IC)	+
Arsenic (AA)	QL[1]	Chromium (ICP)	+
Barium (ICP)	+	Chromium (DCP)	+
Barium (AA)	QL[1]	Chromium (TOT,DCP)	+
Barium (TOT,AA)	QL[1]	Cobalt (ICP)	+
Beryllium (ICP)	+	Cobalt (AA)	N
Beryllium (TOT,AA)	+	Cobalt (TOT,AA)	N
Boron (DCP)	+	Copper (ICP)	+
Cadmium (ICP)	+	Copper (AA)	+
Cadmium (AA)	+	Copper (TOT,AA)	+
Dissolved solids (GRAV)	+	Nickel (ICP)	+
Fluoride (ISE/IC)	+	Nickel (AA)	+
Iron (ICP)	+	Nickel (TOT,AA)	+
Iron (AA)	P	Potassium (AA)	+
Iron (TOT,AA)	P	Selenium (AA)	QL[1]
Lead (ICP)	P	Silica (ICP)	P
Lead (AA)	+	Silica (COL)	+
Lead (TOT,AA)	+	Silver (ICP)	+
Lithium (ICP)	+	Silver (AA)	+
Lithium (TOT,AA)	+	Silver (TOT,AA)	N
Magnesium (ICP)	+	Sodium (ICP)	+
Magnesium (AA)	N	Sodium (AA)	+
Manganese (ICP)	+	Strontium (ICP)	+
Manganese (AA)	QL[1]	Sulfate (TURB/IC)	+
Manganese (TOT,AA)	P	Vanadium (ICP)	+
Mercury (AA)	P	Vanadium (COL)	N
Mercury (TOT,AA)	+	Zinc (ICP)	+
Molybdenum (ICP)	+	Zinc (AA)	+
Molybdenum (AA)	N	Zinc (TOT,AA)	P
Molybdenum (TOT,AA)	+		

[1] Positive bias is indicated because the most probable values of most or all reference samples were below the quantitation limit of the method.

Table 7. Results of statistical testing for bias in inorganic constituent data for the Quality of Water Service Unit Laboratory

[TITR, titration; +, acceptable results; TOT, total recoverable; AA, atomic absorption spectrometry; QL, quantitation limit; COL, colorimetric; IC, ion chromatography; GRAV, gravimetric; ISE, ion-selective electrode; P, positive bias; TURB, turbidimetric]

Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved, except as indicated)	Results from Oct. 1989 - Sept. 1990
Alkalinity (TITR)	+	Magnesium (AA)	+
Aluminum (TOT,AA)	+	Manganese (AA)	QL
Arsenic (AA)	+	Manganese (TOT,AA)	QL1
Beryllium (AA)	QL1	Mercury (AA)	+
Beryllium (TOT,AA)	+	Mercury (TOT,AA)	+
Boron (COL)	+	Nickel (AA)	+
Cadmium (AA)	+	Nickel (TOT,AA)	+
Cadmium (TOT,AA)	+	Potassium (AA)	+
Calcium (AA)	+	Selenium (AA)	+
Chloride (COL/IC)	+	Silica (AA)	+
Chromium (TOT,AA)	+	Sodium (AA)	+
Copper (AA)	+	Strontium (AA)	QL
Copper (TOT,AA)	+	Sulfate (TURB/IC)	+
Dissolved Solids (GRAV	+	Vanadium (COL)	+
Fluoride (COL/ISE)	+	Zinc (AA)	+
Iron (AA)	+	Zinc (TOT,AA)	+
Iron (TOT,AA)	P		
Lead (AA)	+		
Lead (TOT,AA)	+		

[1] Positive bias is indicated because the most probable values of most or all reference samples were below the quantitation limit of the method.

QUALITY-ASSURANCE DATA FOR NUTRIENT-CONSTITUENT SAMPLES

Precision

The results of statistical testing for lack of precision for each nutrient constituent are listed in table 8 for the NWQL and table 9 for the QWSU. The only nutrient constituent for either laboratory to fail the precision test for the water year 1990 was the NWQL determination for phosphorus (COL). The control chart for NWQL phosphorus determinations (fig. 71) shows numerous points that plot outside of the control limits throughout the year, whereas the control chart for QWSU phosphorus determinations (fig. 206) does not show an inordinate number of points outside the control limits. Because the same four SRWS nutrient samples were used in the blind sample programs for each laboratory, comparisons were made of the data from both laboratories. The concentration of phosphorus in the four reference samples ranged from 0.36 to 1.39 mg/L. The SRWS sample with the 1.39 mg/L concentration of phosphorus accounted for approximately 60 percent of the out-of-control determinations at the NWQL. However, the QWSU never reported an out-of-control result for this reference sample. The techniques used by both laboratories were very similar, except that the top end of the analytical range used by the NWQL was set at 1.00 mg/L, and analyses above this concentration required dilutions, including the SRWS with a concentration of 1.39 mg/L. However, the top end of the analytical range for the QWSU laboratory phosphorus determinations was set at 2.00 mg/L, which meant that no dilutions were required for blind sample program determinations. The lack of precision for NWQL phosphorus determinations can possibly be attributed to dilution errors.

Table 8. Results of statistical testing for lack of precision in nutrient constituent data for the National Water-Quality Laboratory

[COL, colorimetric; +, acceptable results; LOP, statistically significant lack of precision]

Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990
Ammonia as nitrogen (COL)	+	Orthophosphate as phosphorus (COL)	+
Ammonia plus organic nitrogen (COL)	+	Phosphorus (COL)	LOP
Nitrate plus nitrite as nitrogen (COL)	+		

Table 9. Results of statistical testing for lack of precision in nutrient constituent data for the Quality of Water Service Unit Laboratory

[COL, colorimetric; +, acceptable results]

Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990
Ammonia as nitrogen (COL)	+	Orthophosphate as phosphorus (COL)	+
Ammonia plus organic nitrogen (COL)	+	Phosphorus (COL)	+
Nitrate plus nitrite as nitrogen (COL)	+		

As noted in the 1989 annual report (Maloney and others, 1992), the NWQL made an analytical method change during water year 1990 for the nitrate plus nitrite as nitrogen (COL) determinations to allow analysis of water in a wider pH range. The control chart for NWQL nitrate plus nitrite as nitrogen (fig. 69) determinations shows that the vast majority of water year 1990 data are within the control limits. This is the first time in four years that the NWQL's nitrate plus nitrite as nitrogen method did not fail the precision test. The significant increase in precision is attributed to the method change.

Bias

Results of the statistical tests for bias are listed in table 10 for the NWQL and table 11 for the QWSU. The only nutrient constituent for either laboratory to fail the binomial-probability-distribution bias test for water year 1990 was the NWQL determination for nitrate plus nitrite as nitrogen (COL). The control chart for NWQL nitrate plus nitrite as nitrogen (fig. 69) shows a definite negative bias, however, the vast majority of the data plot within one standard deviation of the MPV.

QUALITY-ASSURANCE DATA FOR LOW IONIC STRENGTH SAMPLES

Precision

Low ionic strength determinations are offered by the NWQL but not by the QWSU. The results of the statistical tests of precision for each low ionic strength analytical procedure are listed in table 12. Beginning in water year 1990, the Blind Sample Project included evaluations for four metals: cadmium, cobalt, copper, and lead. The NWQL low ionic strength section determines each of these metals by atomic absorption spectrometry, graphite furnace. The results for cadmium failed the precision test. This is the first low ionic strength determination to fail the precision test since the blind sample program began low ionic evaluations in water year 1986 (Lucey, K.J. and Peart, D.B., 1989a and 1989b, Lucey, 1989, and Maloney, and others, 1992).

Bias

The results of the binomial-probability-distribution statistical test of bias for each constituent in the low ionic strength samples are listed in table 13. Cobalt (AA), which has a negative bias, was the only low ionic

Table 10. Results of statistical testing for bias in nutrient constituent data for the National Water-Quality Laboratory

[COL, colorimetric; +, acceptable results; N, negative bias]

Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990
Ammonia as nitrogen (COL)	+	Orthophosphate as phosphorus (COL)	+
Ammonia plus organic nitrogen (COL)	+	Phosphorus (COL)	+
Nitrate plus nitrite as nitrogen (COL)	N		

Table 11. Results of statistical testing for bias in nutrient constituent data for the Quality of Water Service Unit Laboratory

[COL, colorimetric; +, acceptable results]

Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved)	Results from Oct. 1989 - Sept. 1990
Ammonia as nitrogen (COL)	+	Orthophosphate as phosphorus (COL)	+
Ammonia plus organic nitrogen (COL)	+	Phosphorus (COL)	+
Nitrate plus nitrite as nitrogen (COL)	+		

Table 12. Results of statistical testing for lack of precision in low ionic strength data for the National Water-Quality Laboratory

[AA, atomic absorption spectrometry; LOP, statistically significant lack of precision; +, acceptable results; IC, ion chromatography; ELEC, electrometric]

Constituent (dissolved) or physical property	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved) or physical property	Results from Oct. 1989 - Sept. 1990
Cadmium (AA)	LOP	Lead (AA)	+
Calcium (AA)	+	Magnesium (AA)	+
Chloride (IC)	+	Potassium (AA)	+
Cobalt (AA)	+	Sodium (AA)	+
Copper (AA)	+	Specific conductance (ELEC)	+
Fluoride (IC)	+	Sulfate (IC)	+

Table 13. Results of statistical testing for bias in low ionic strength data for the National Water-Quality Laboratory

[AA, atomic absorption spectrometry; +, acceptable results; IC, ion chromatography; N, negative bias; ELEC, electrometric]

Constituent (dissolved) or physical property	Results from Oct. 1989 - Sept. 1990	Constituent (dissolved) or physical property	Results from Oct. 1989 - Sept. 1990
Cadmium (AA)	+	Lead (AA)	+
Calcium (AA)	+	Magnesium (AA)	+
Chloride (IC)	+	Potassium (AA)	+
Cobalt (AA)	N	Sodium (AA)	+
Copper (AA)	+	Specific conductance (ELEC)	+
Fluoride (IC)	+	Sulfate (IC)	+

strength determination with a statistical bias for water year 1990.

SUMMARY

Reference water samples with established most probable value's were disguised as regular samples and submitted with environmental water samples by U.S. Geological Survey offices to the National Water-Quality Laboratory in Arvada, Colorado, and the Quality of Water Service Unit laboratory in Ocala, Florida. This was the first year that the Ocala laboratory was evaluated as part of this blind sample program. Resulting analytical data are stored in the WATSTORE data base.

For each constituent, control charts were prepared based on the difference between the analytical results and the most probable values of the reference samples. To allow the data for all reference mixes to be plotted on the same chart, the difference from the above calculations was divided by each sample's most probable deviation, which was determined from a linear regression technique. Replicate sample determinations allowed the preparation of precision charts for each constituent. Data for inorganic, nutrient, and low-ionic strength constituent samples then were evaluated statistically for precision and bias by using a binomial-probability-distribution equation.

An overall evaluation of the inorganic constituent data for water year 1990 indicates a lack of precision in results from the NWQL for boron (DCP), chloride (COL and IC), fluoride (COL and IC), iron total (AA), and manganese total (AA). Inorganic constituent data for the Ocala laboratory during 1990 indicated lack of precision for aluminum total (AA), copper total (AA), fluoride (COL and ISE), and iron total (AA).

The procedure to evaluate analytical bias for water year 1990 determinations from the two laboratories had been modified from the procedure used in previous years. The procedure groups determinations within 0.25 standard deviations of the MPV as matching the MPV. This change in the bias evaluation significantly decreased the number of biased analytical procedures. Determinations outside the 0.25 standard deviation limit are grouped as positive or negative bias determinations as appropriate.

The water year 1990 evaluation of analytical bias for inorganic determinations indicates statistically significant bias for 13 NWQL analytical procedures: cobalt dissolved and total by AA, iron dissolved and total by AA, lead dissolved by ICP, magnesium by AA, manganese total by AA, mercury dissolved by AA, molybdenum dissolved by AA, silica by ICP, silver total by AA, vanadium by colorimetry, and zinc total by AA. Iron total by AA was the only QWSU inorganic procedure to indicate statistically significant bias.

Statistical evaluations of nutrient procedures at the NWQL indicated that the results for phosphorus (COL) failed the precision test and the results for nitrate plus nitrite as nitrogen (COL) showed a negative bias. Evaluations of the QWSU nutrient methods did not indicate lack of precision or analytical bias.

For low ionic strength procedures at the NWQL, cadmium (AA) failed the precision test,.and cobalt (AA) indicated a negative bias.

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SUPPLEMENTAL DATA

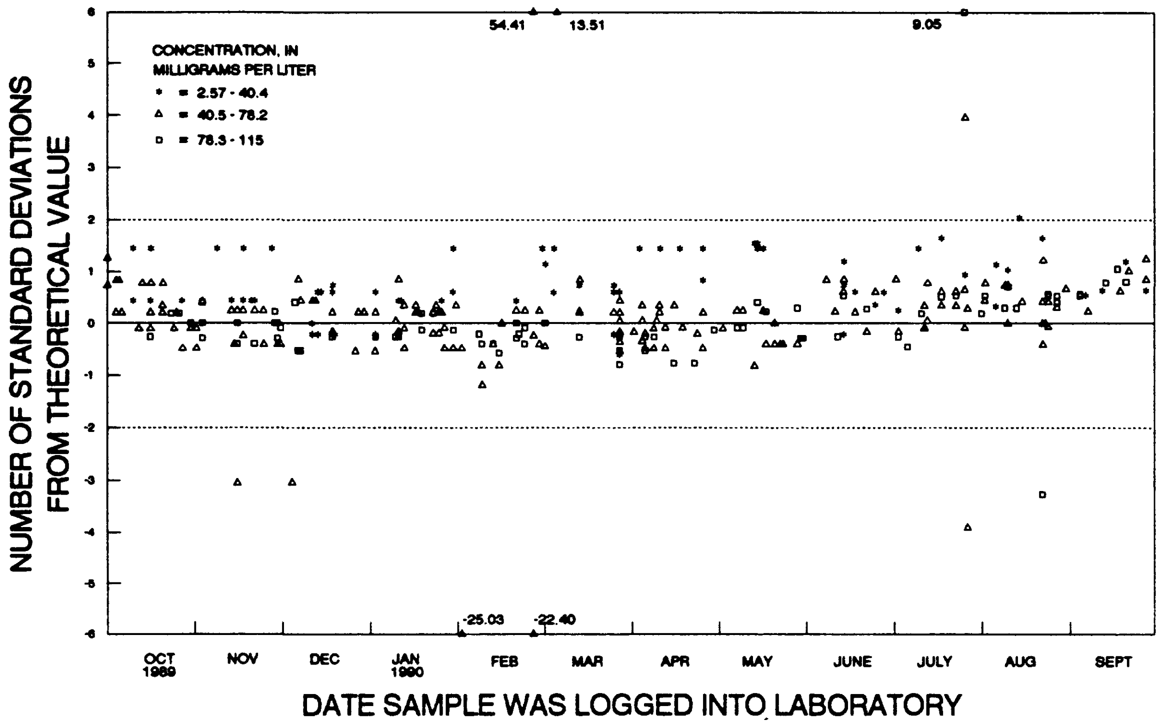

Figure 1. Alkalinity, total, (electrometric titration) data from the National Water-Quality Laboratory.

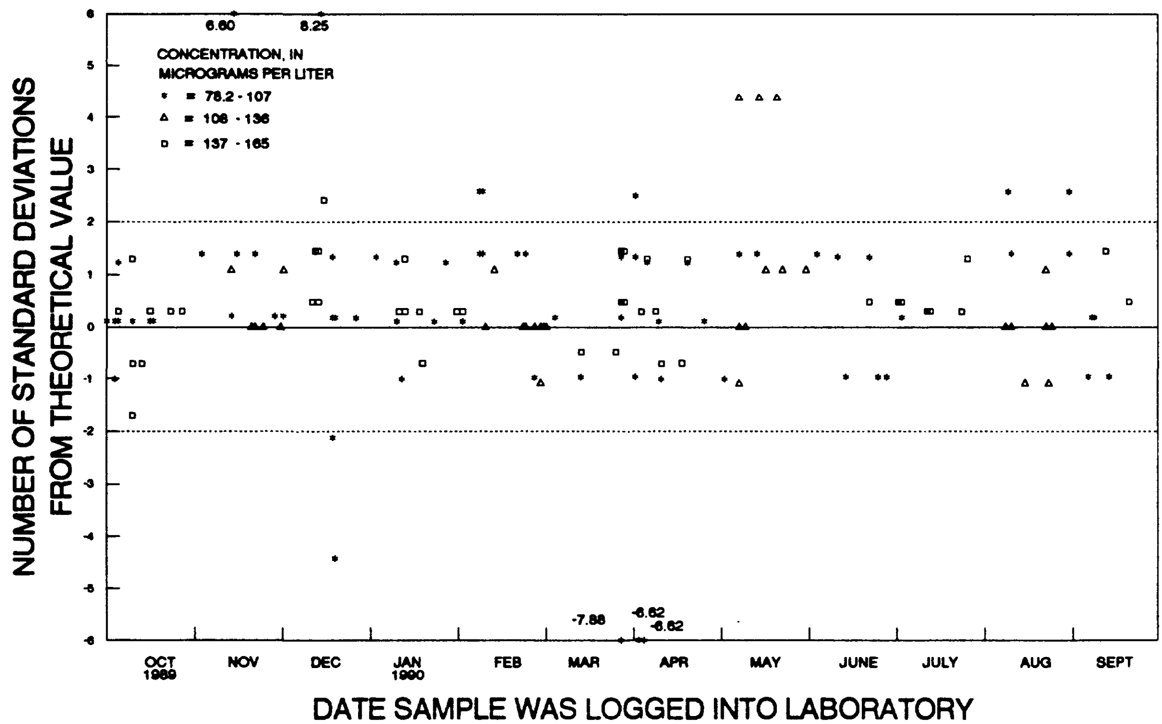

Figure 2. Aluminum, dissolved, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

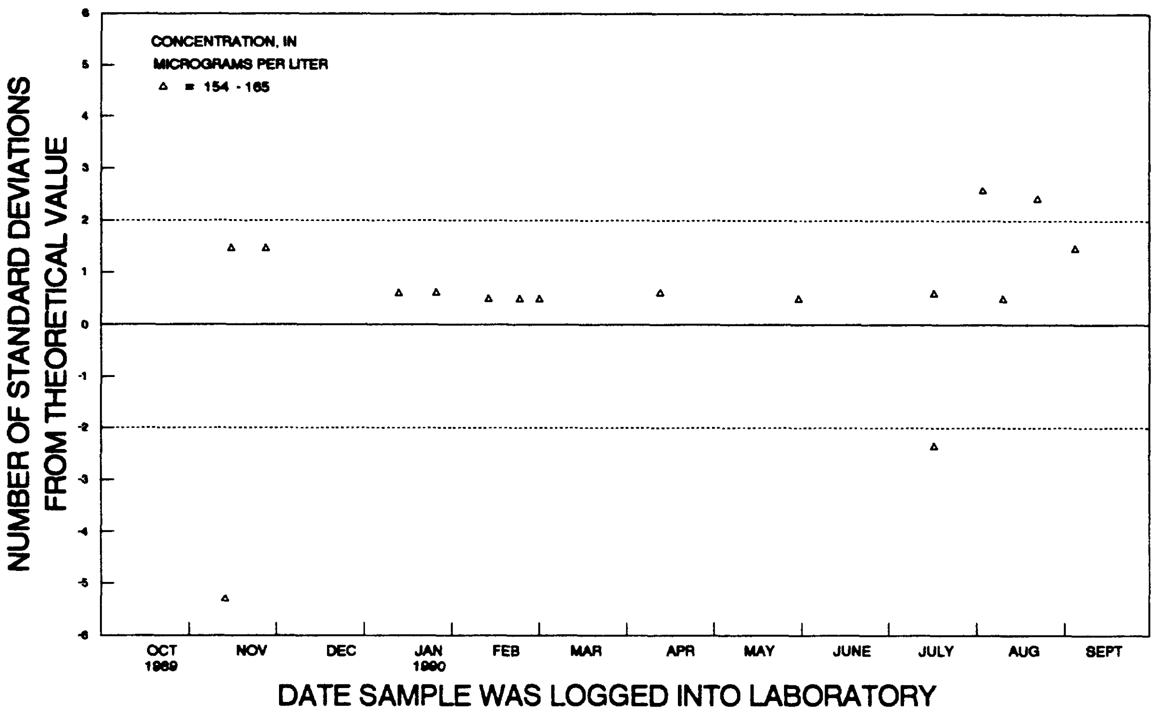

Figure 3. Aluminum, total recoverable, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

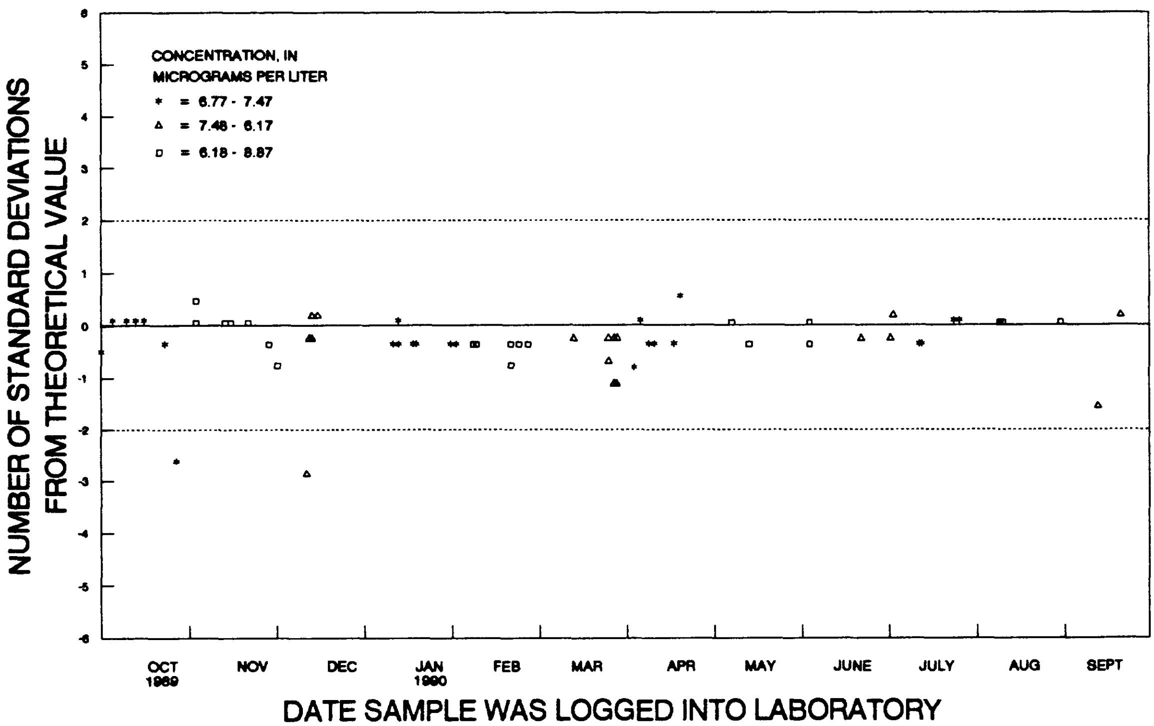

Figure 4. Antimony, dissolved, (atomic absorption spectrometry, hydride) data from the National Water-Quality Laboratory.

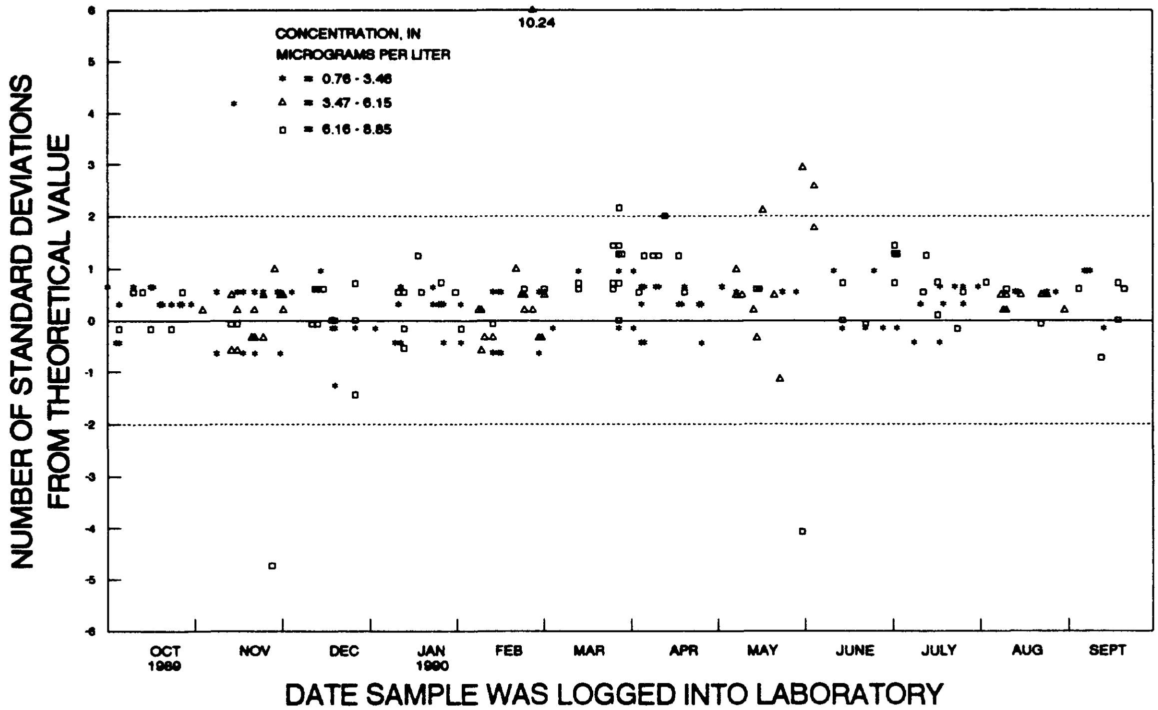

Figure 5. Arsenic, dissolved and total, (atomic absorption spectrometry, hydride) data from the National Water-Quality Laboratory.

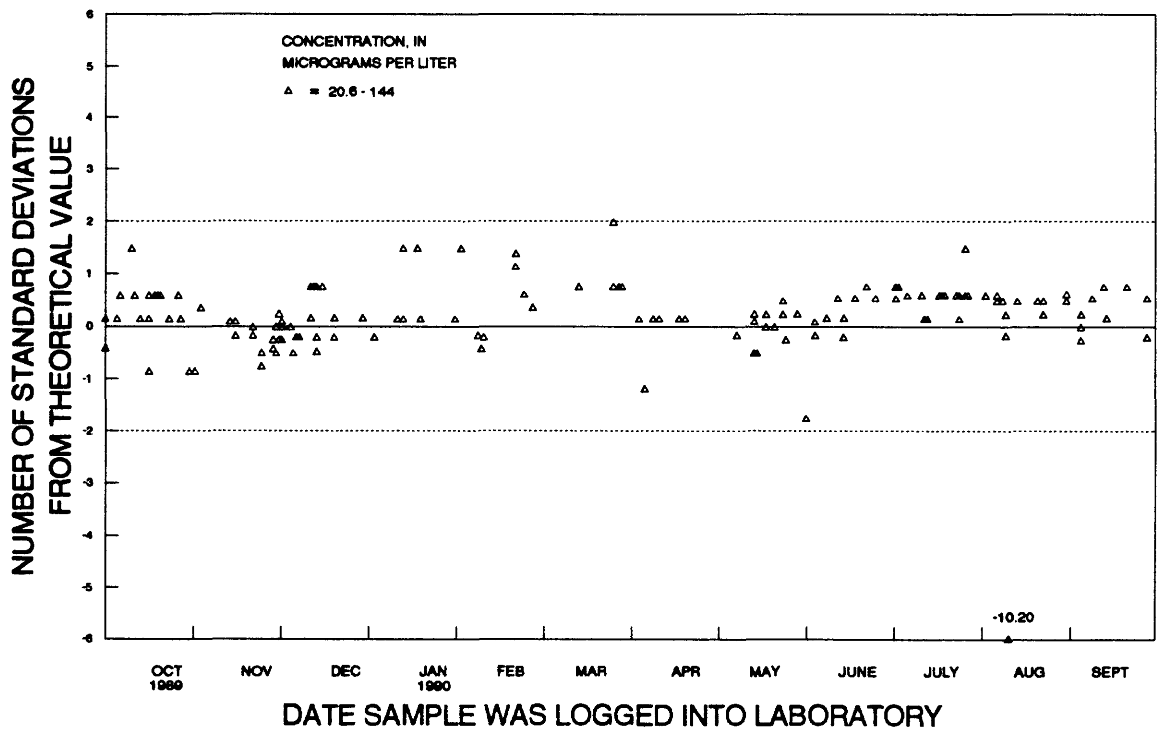

Figure 6. Barium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

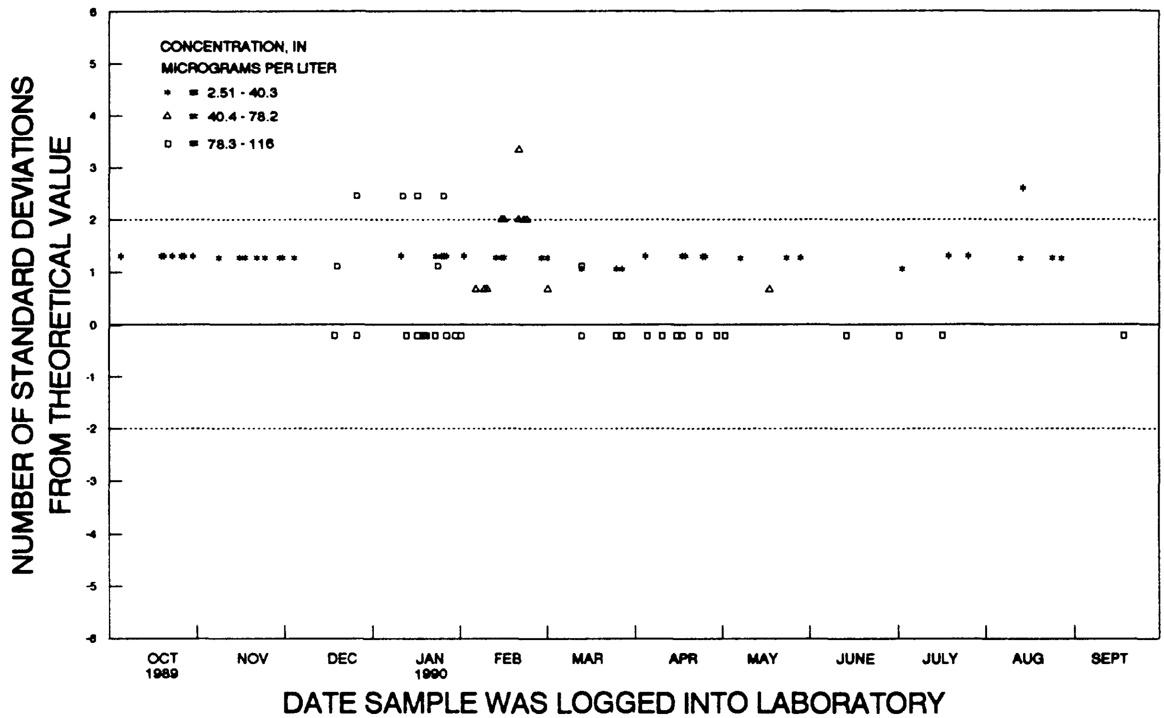

Figure 7. Barium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

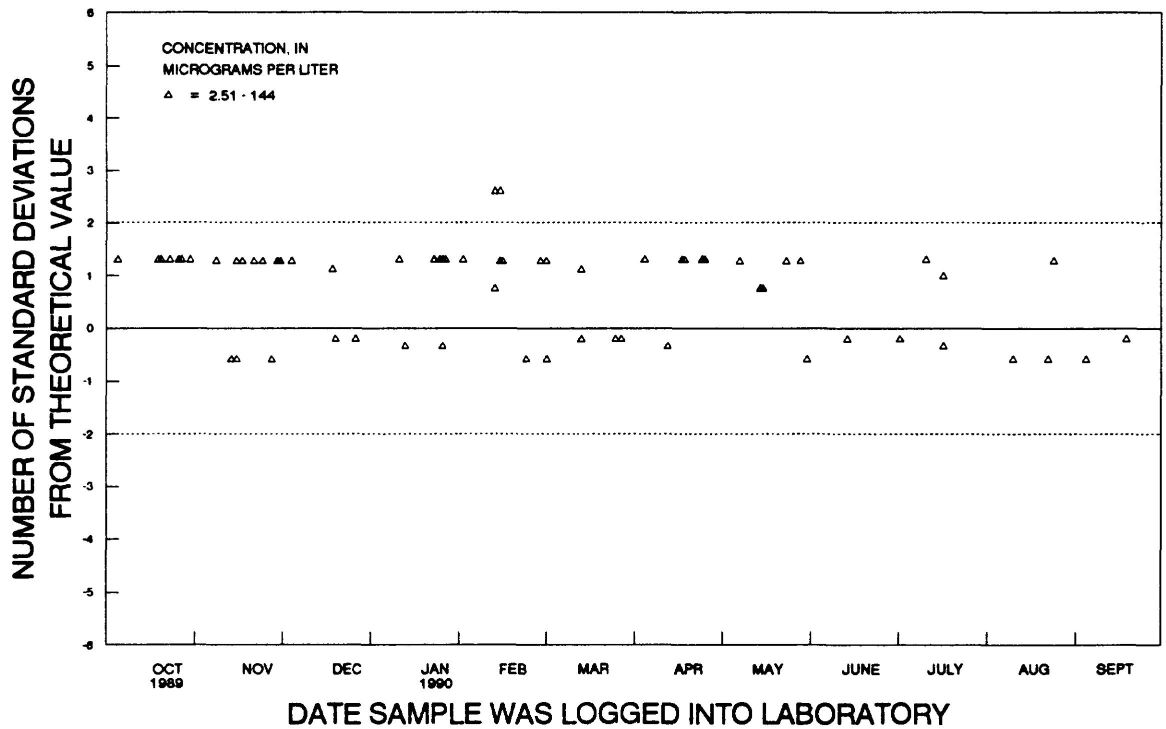

Figure 8. Barium, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

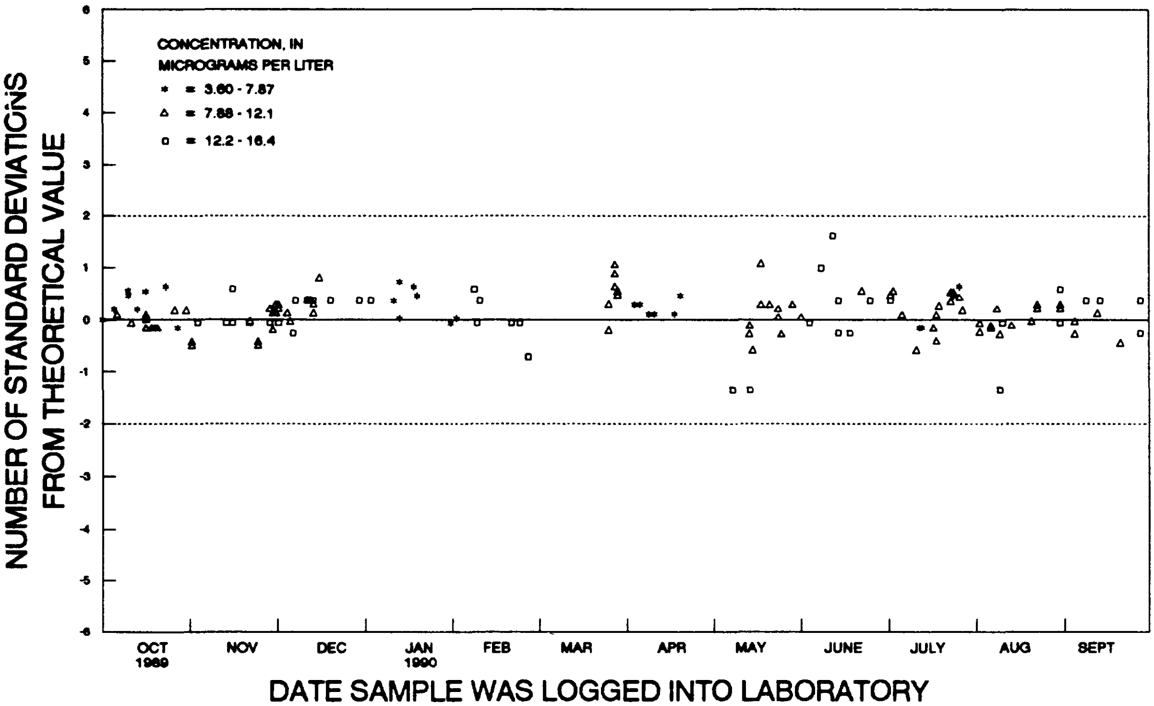

Figure 9. Beryllium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Wate^-Quality Laboratory.

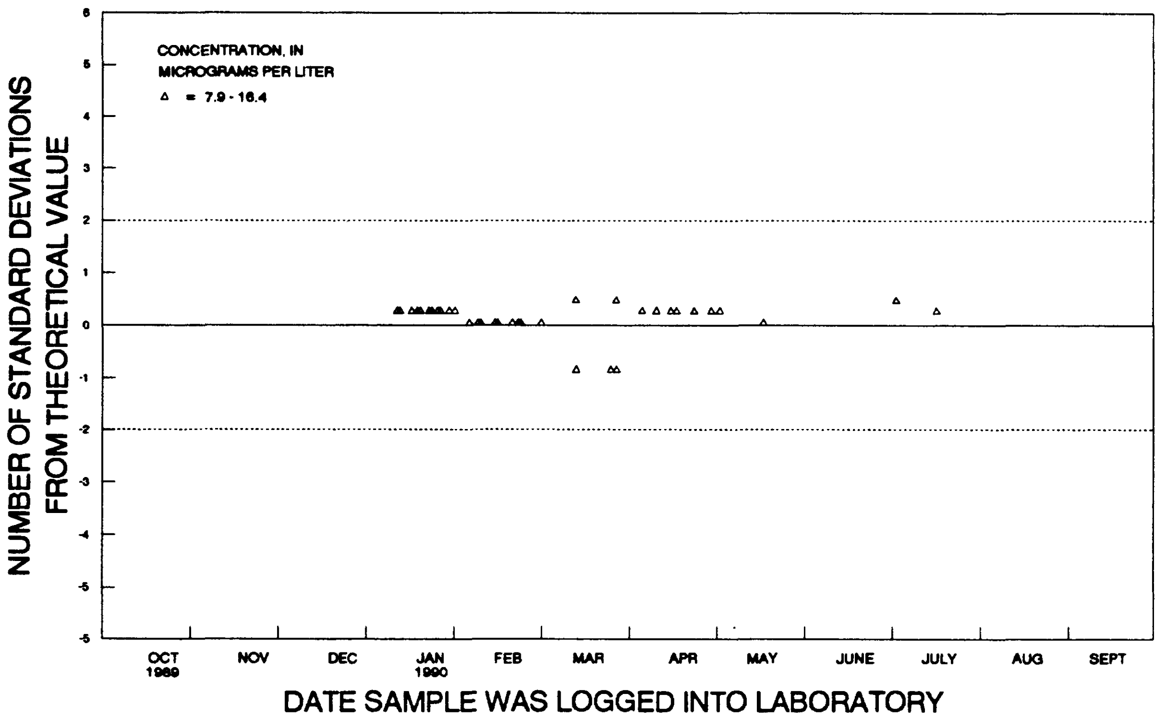

Figure 10. Beryllium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

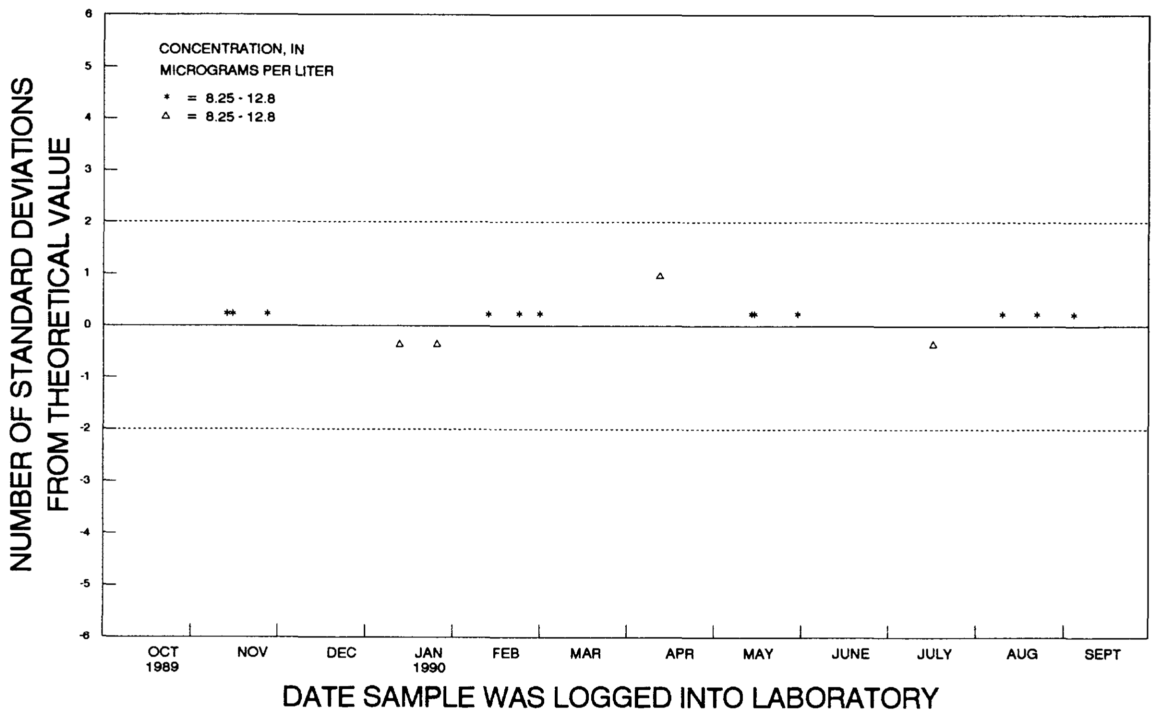

Figure 11. Beryllium, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

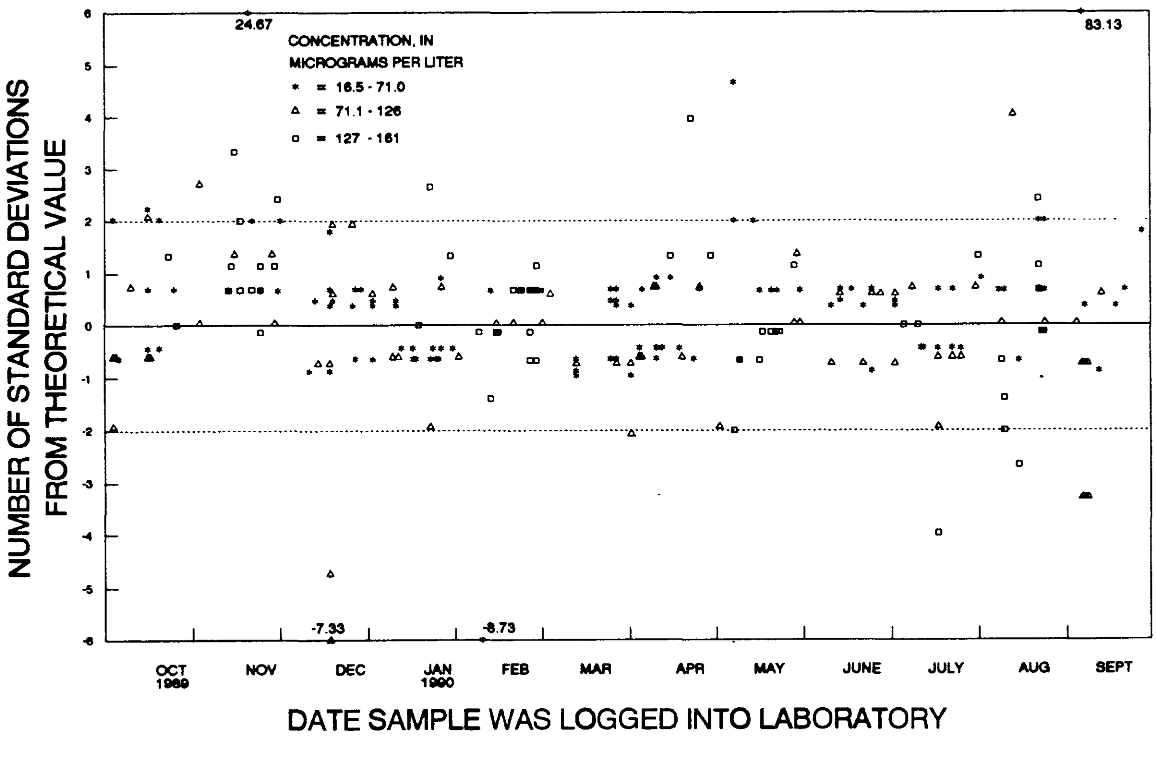

Figure 12. Boron, dissolved, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

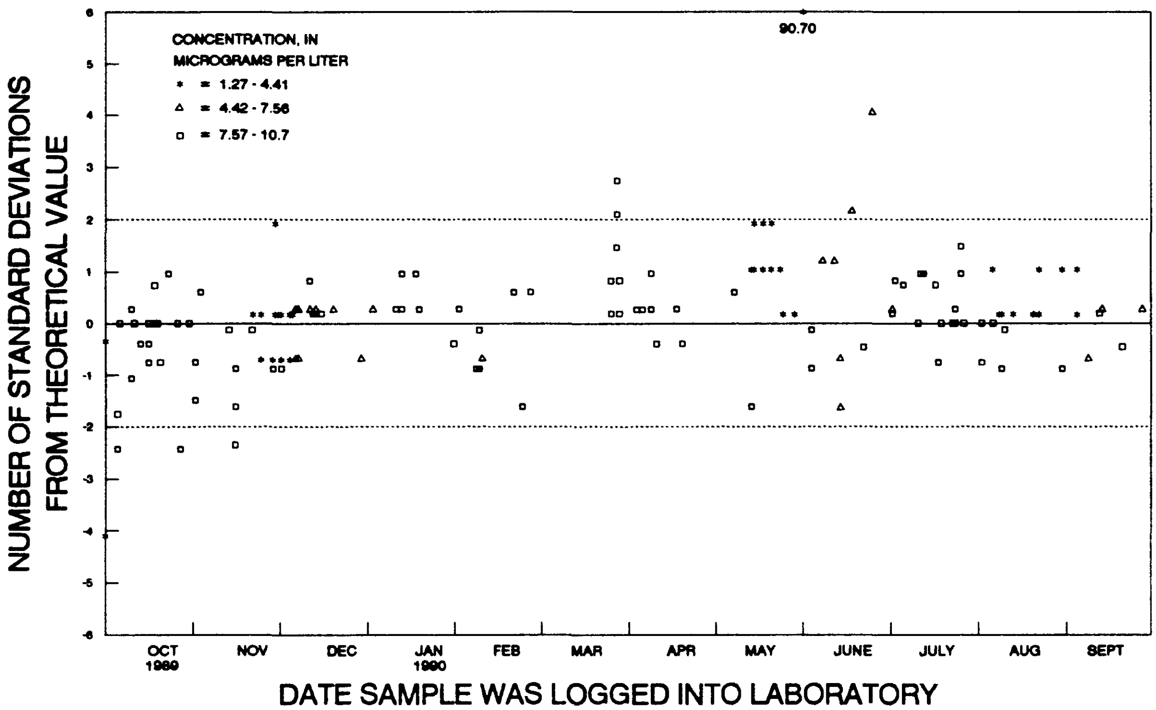

Figure 13. Cadmium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

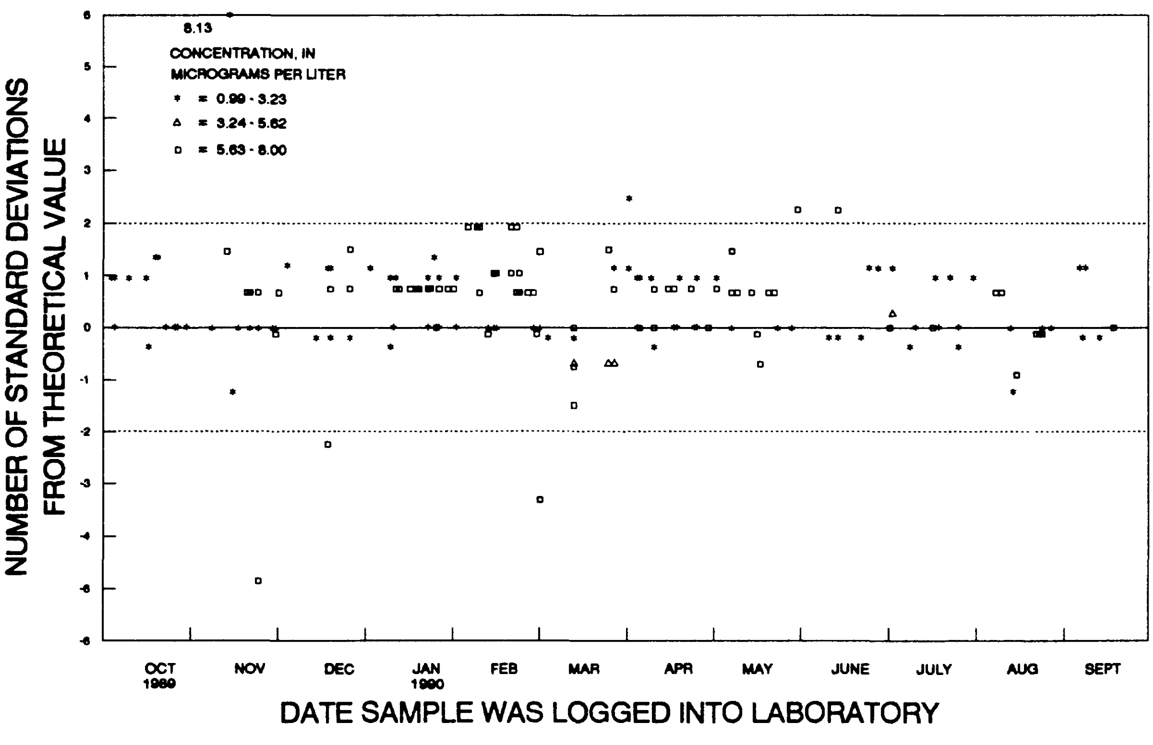

Figure 14. Cadmium, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

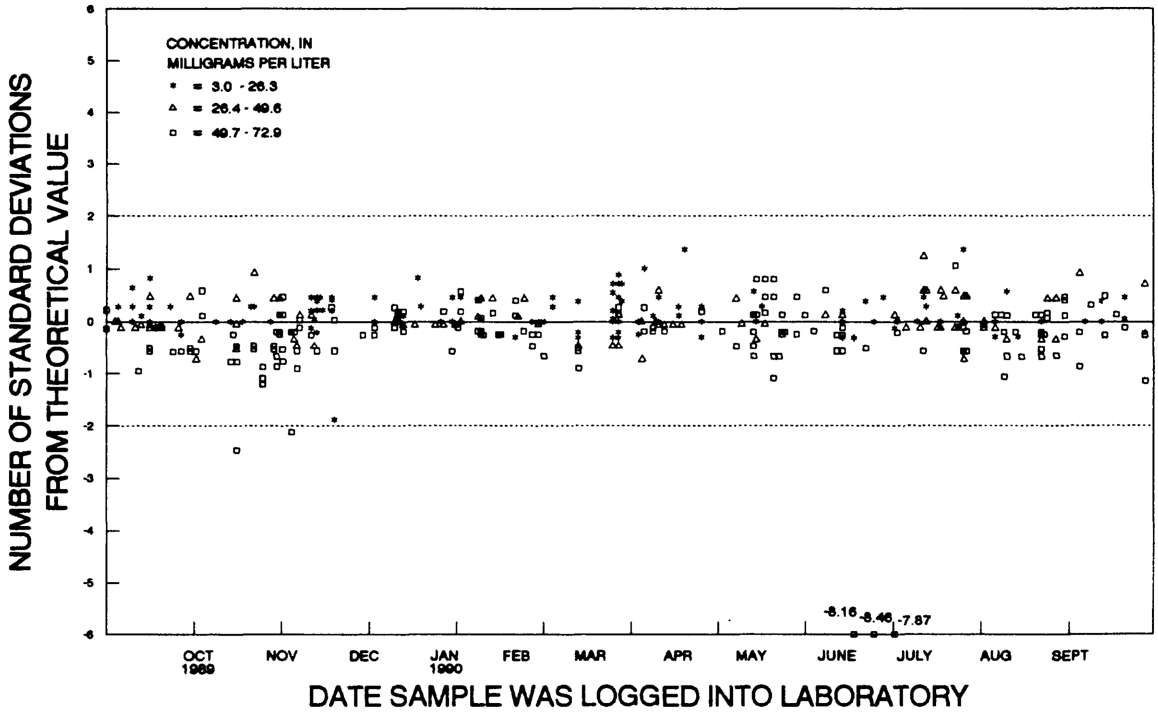

Figure 15. Cadmium, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

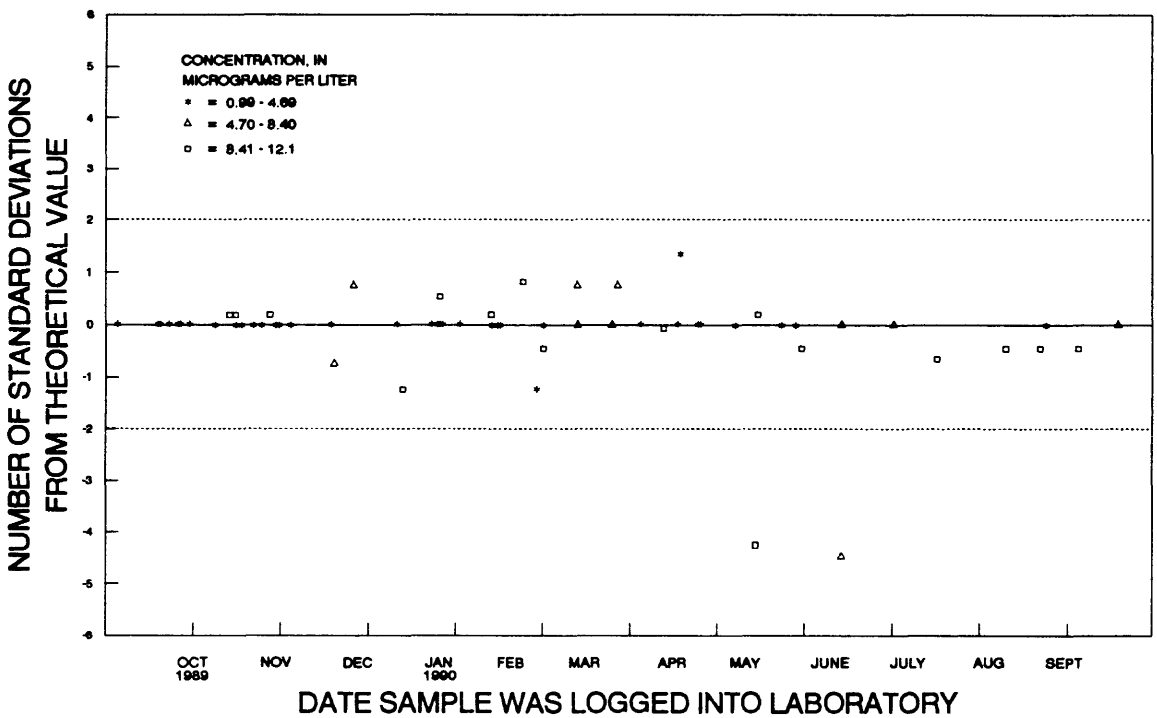

Figure 16. Calcium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

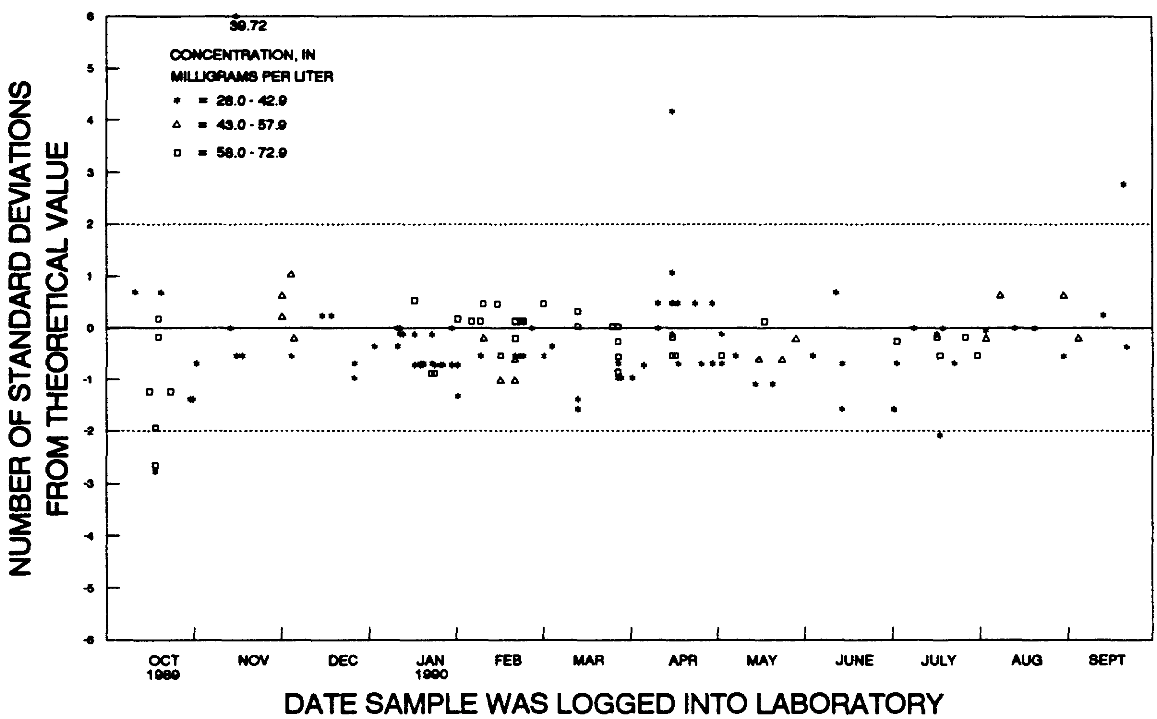

Figure 17. Calcium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

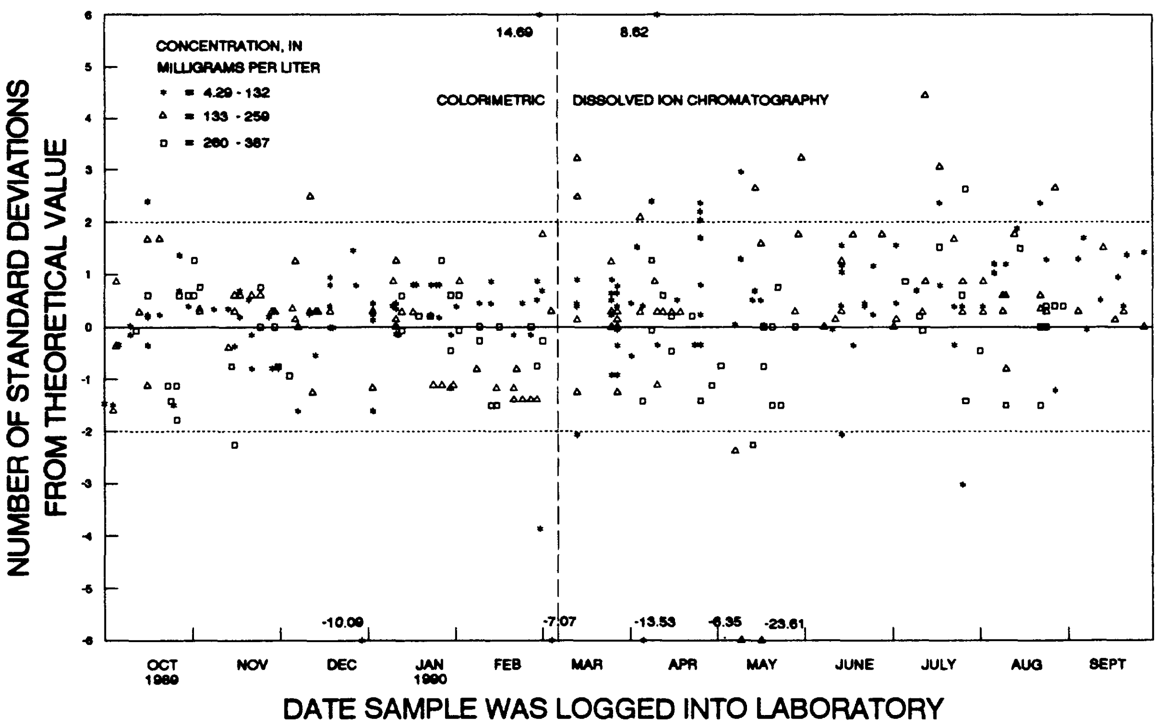

Figure 18. Chloride, dissolved, (colorimetric and ion chromatography) data from the National Water-Quality Laboratory.

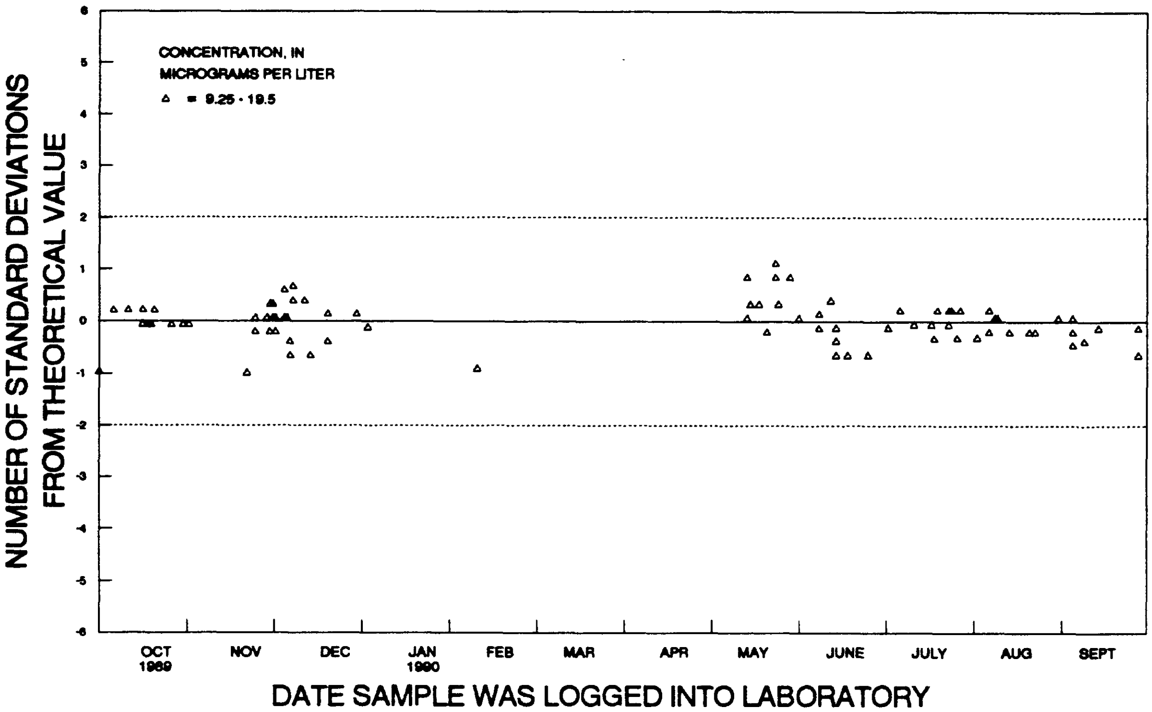

Figure 19. Chromium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

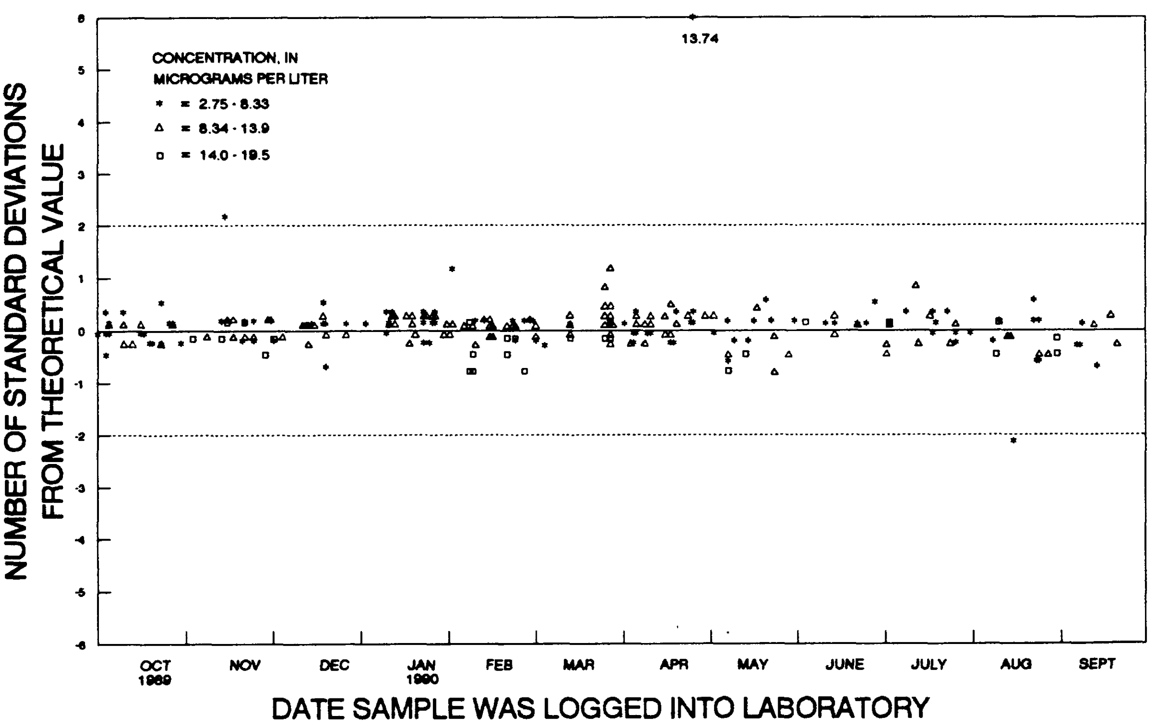

Figure 20. Chromium, dissolved, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

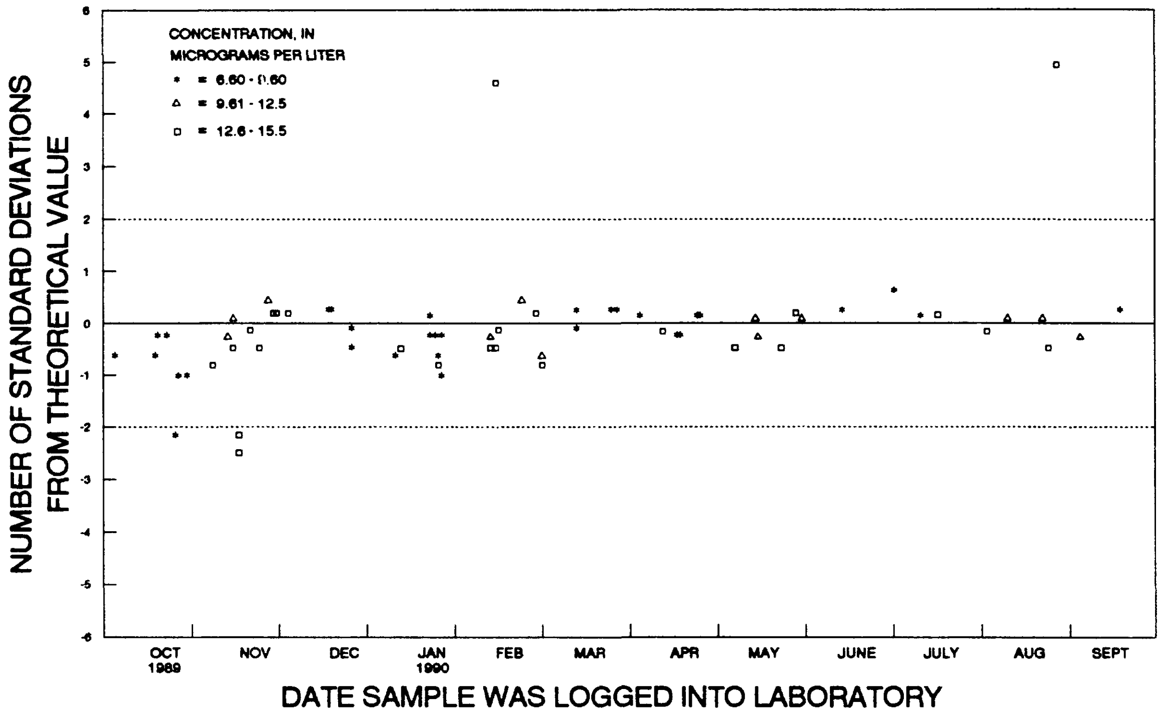

Figure 21. Chromium, total recoverable, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

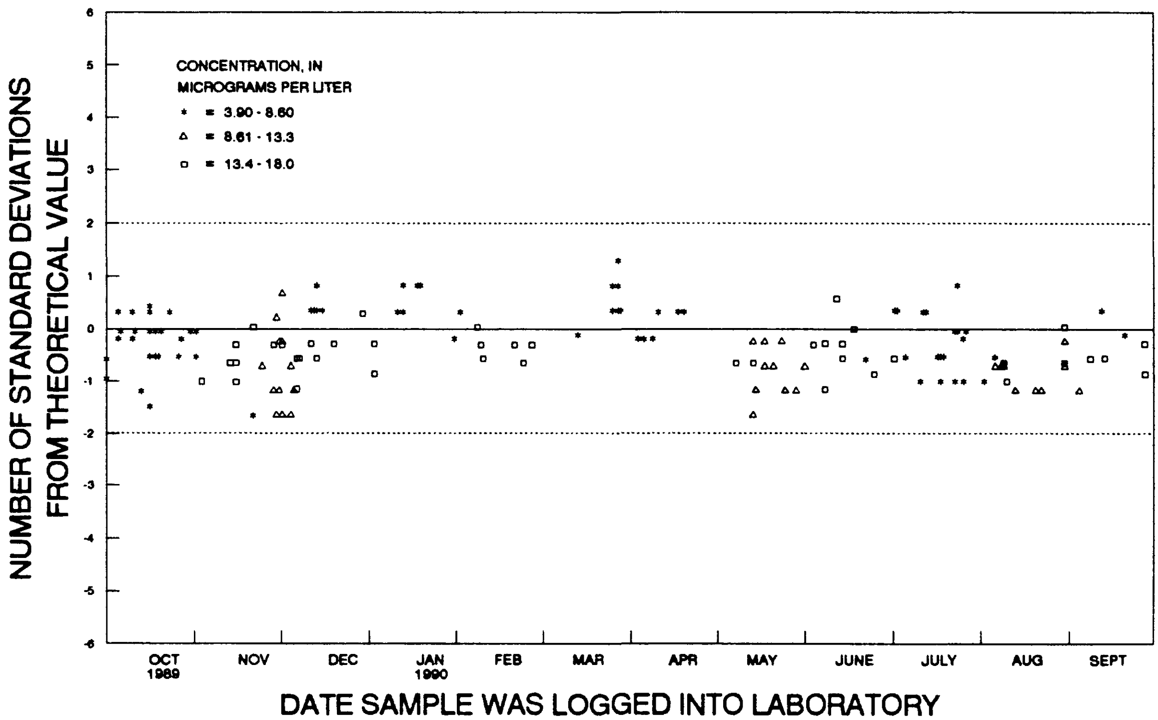

Figure 22. Cobalt, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

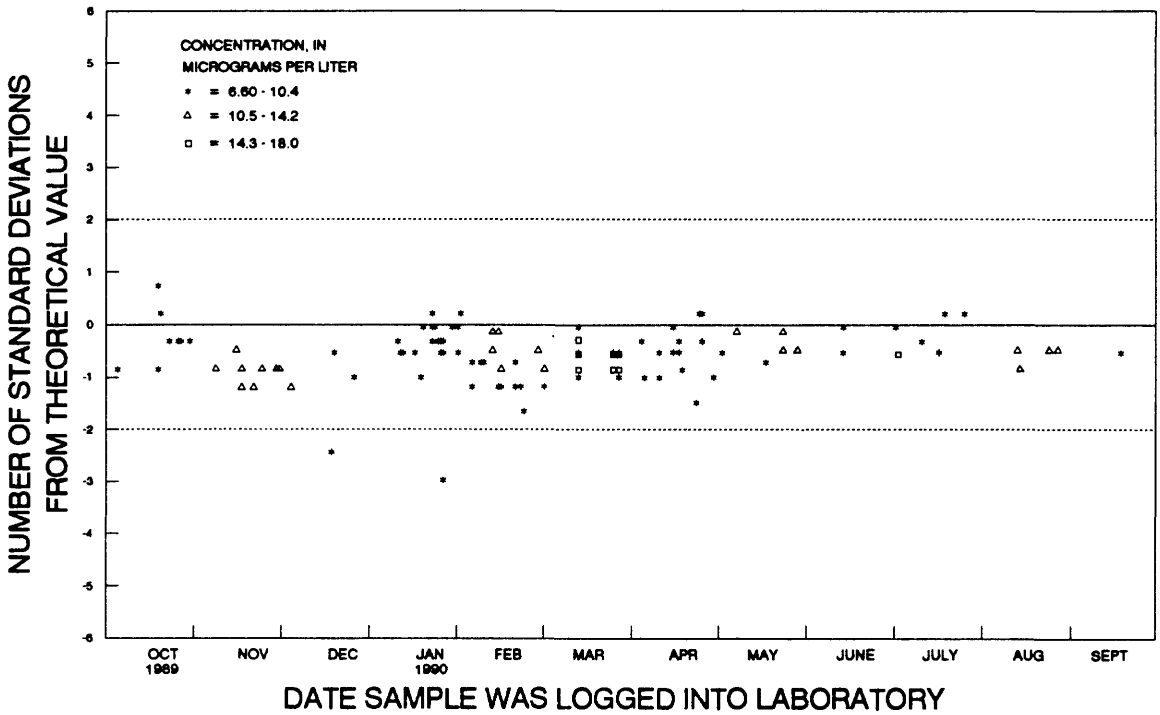

Figure 23. Cobalt, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

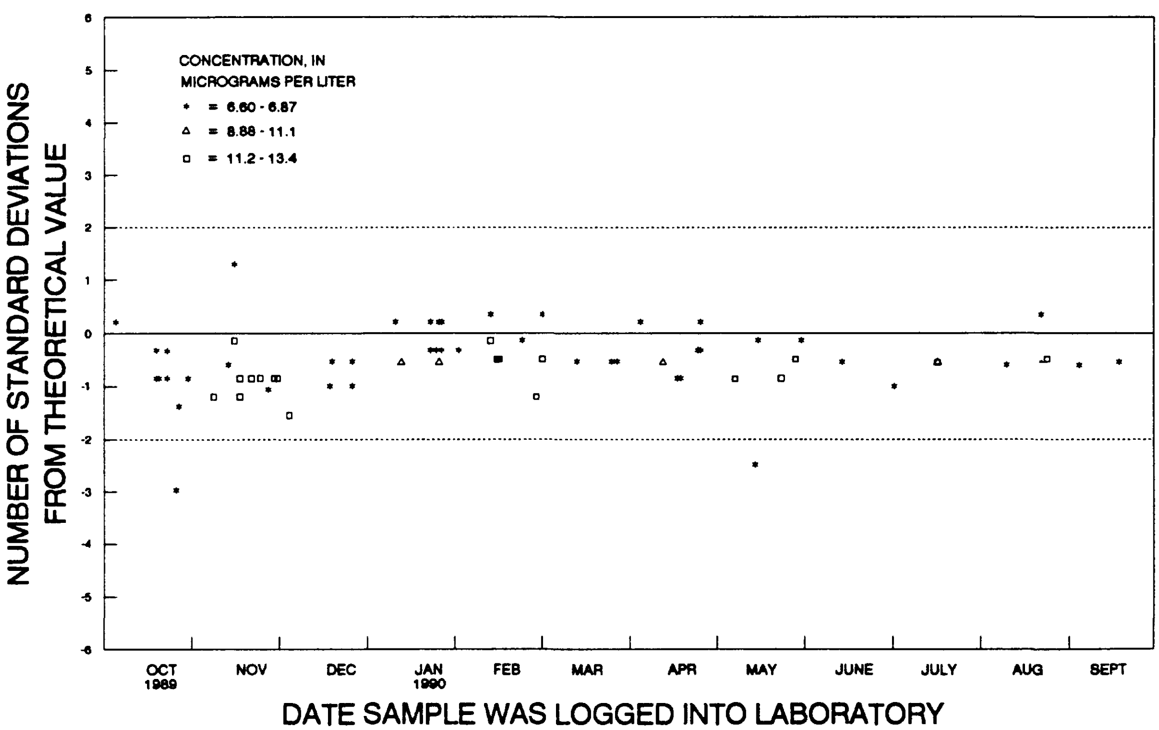

Figure 24. Cobalt, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

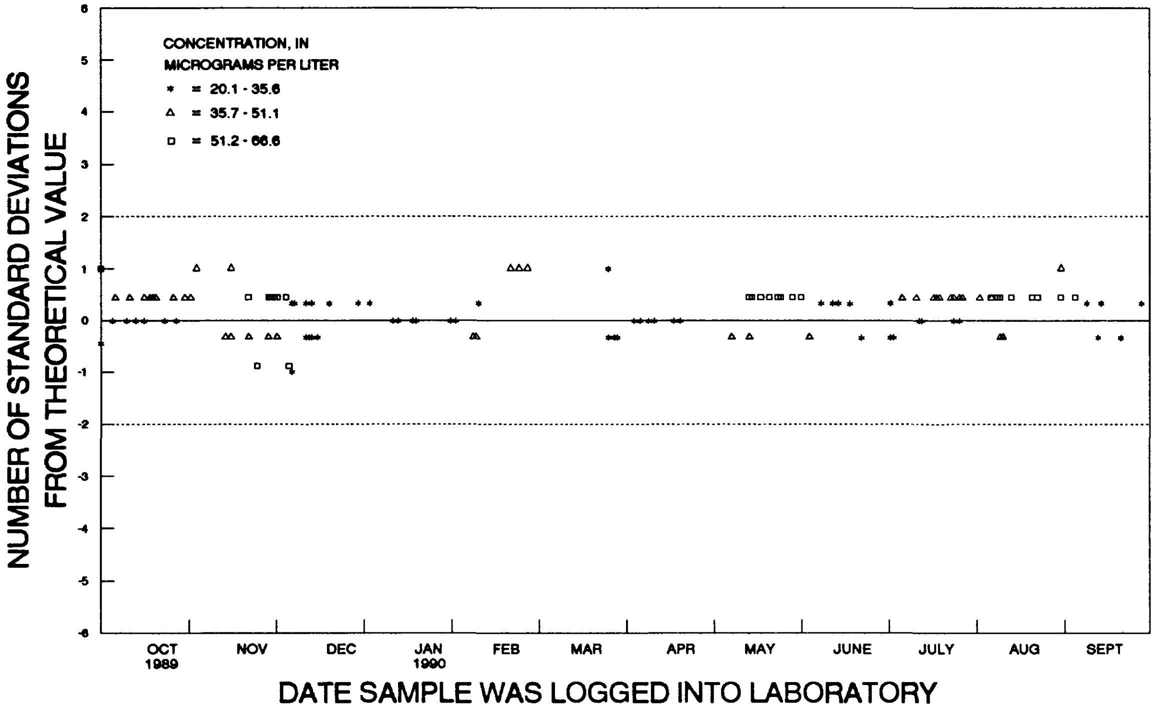

Figure 25. Copper, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

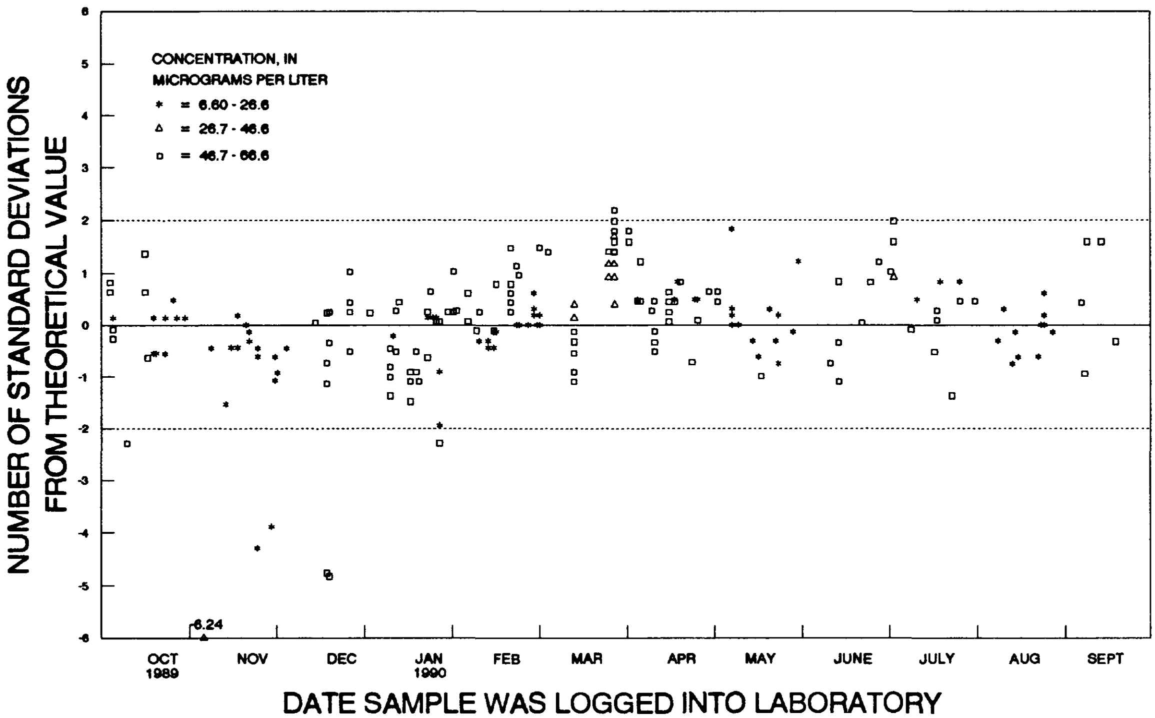

Figure 26. Copper, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

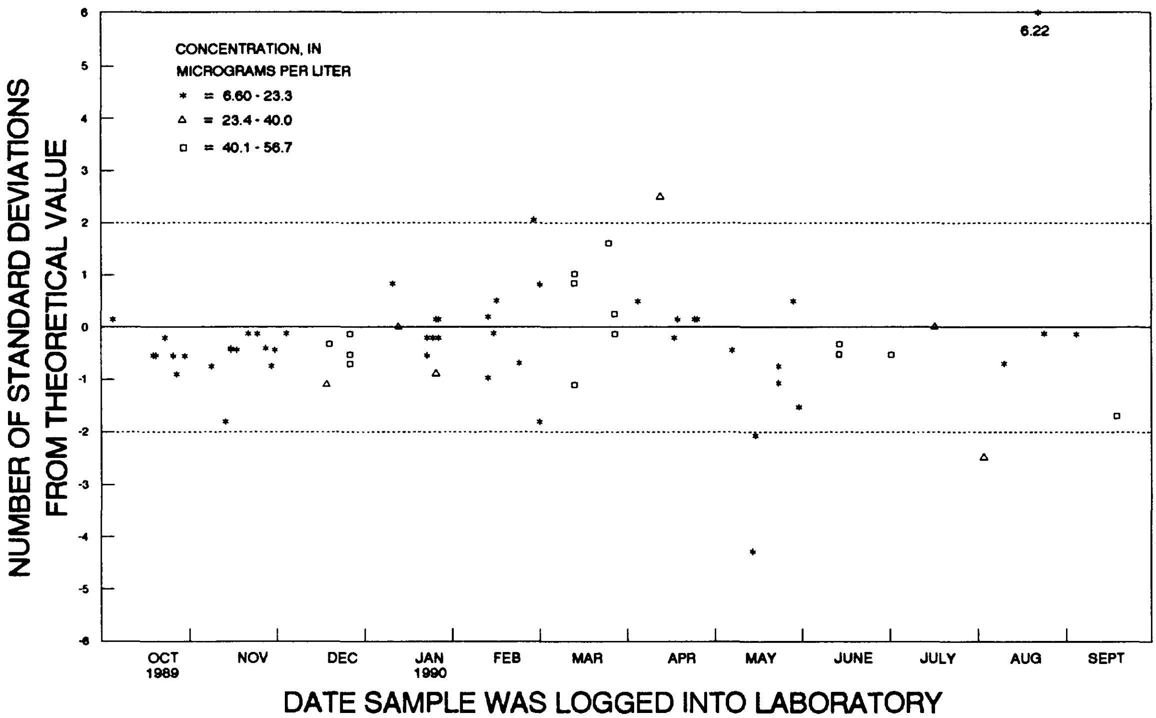

Figure 27. Copper, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

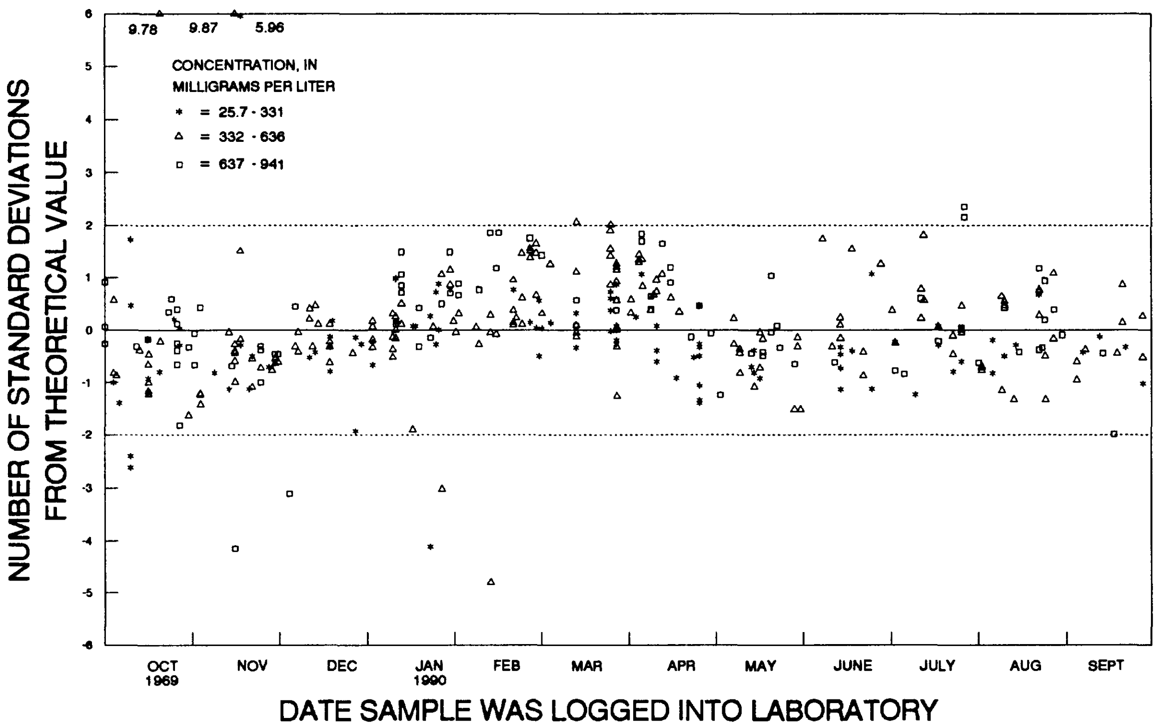

Figure 28. Dissolved solids, (gravimetric) data from the National Water-Quality Laboratory.

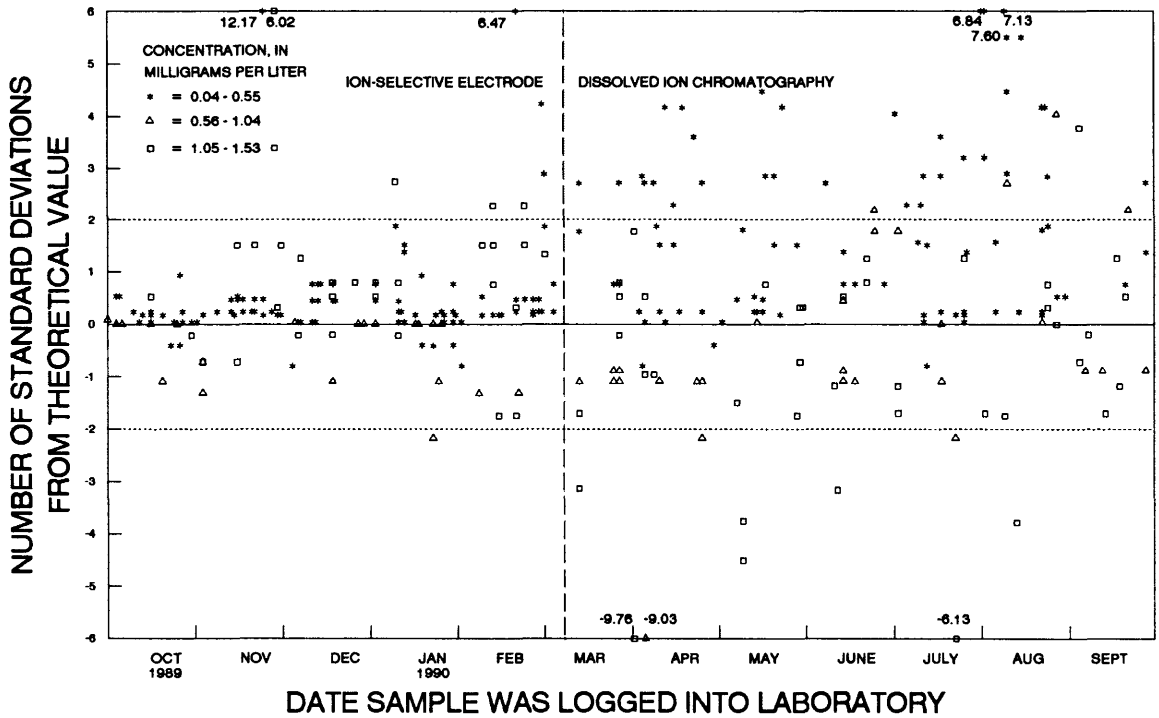

Figure 29. Fluoride, dissolved, (ion-selective electrode and ion chromatography) data from the National Water-Quality Laboratory.

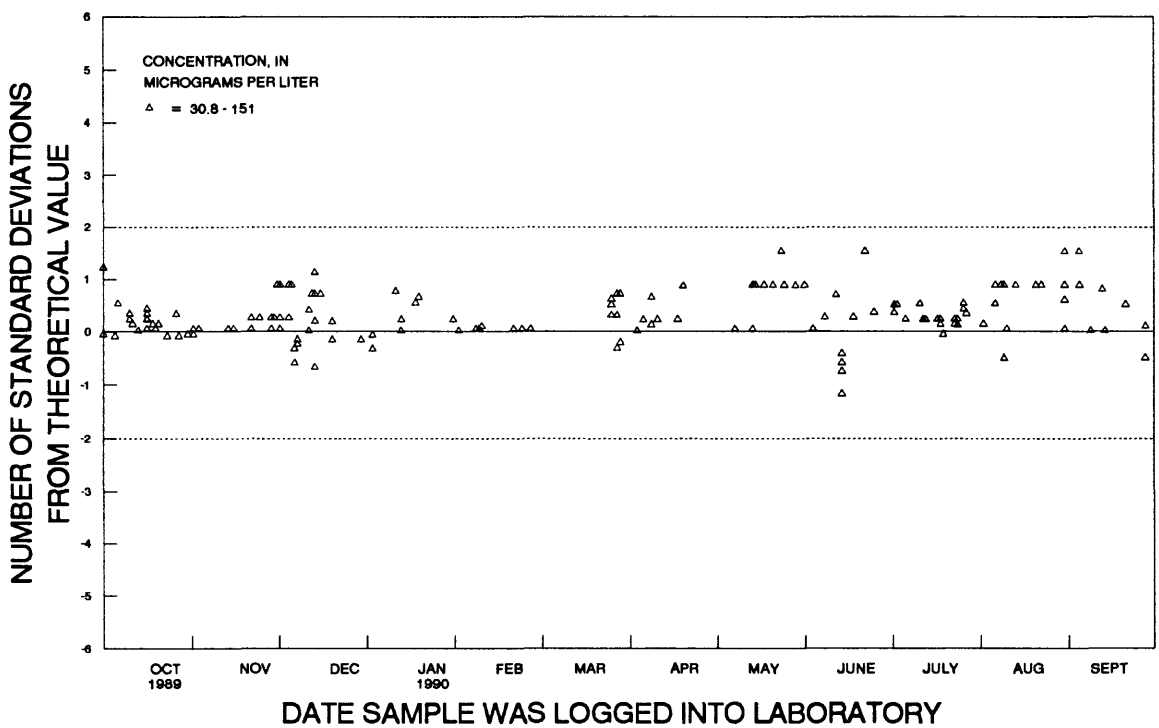

Figure 30. Iron, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

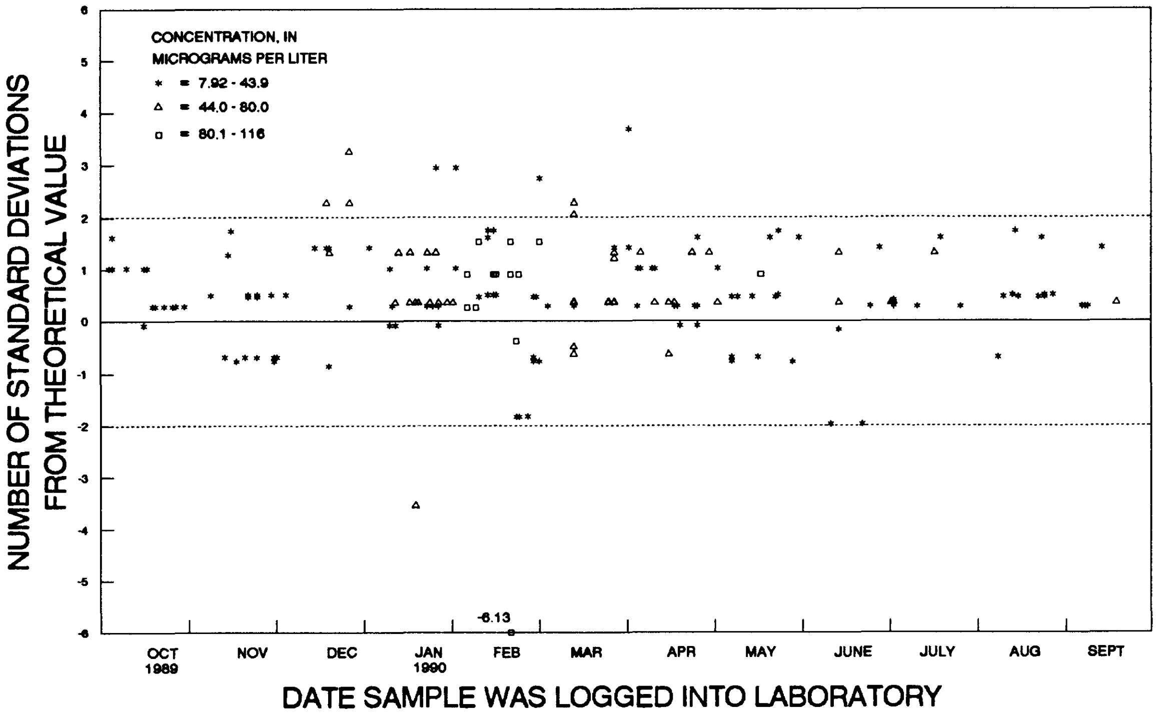

Figure 31. Iron, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

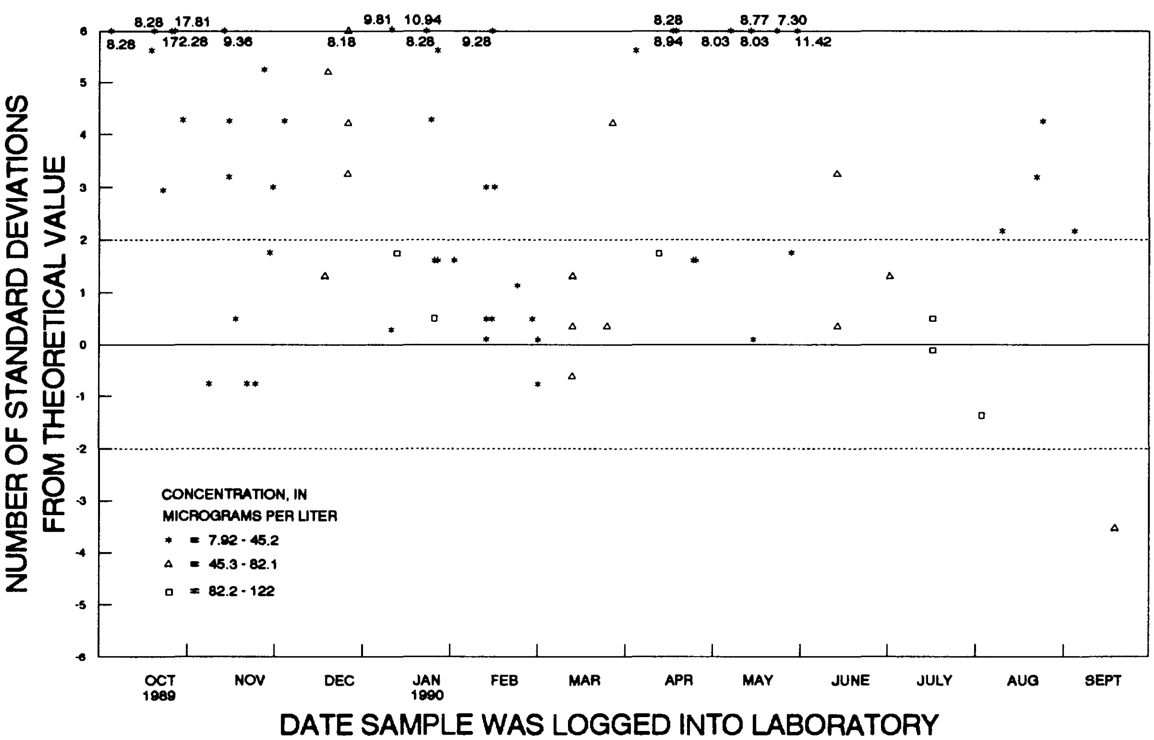

Figure 32. Iron, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

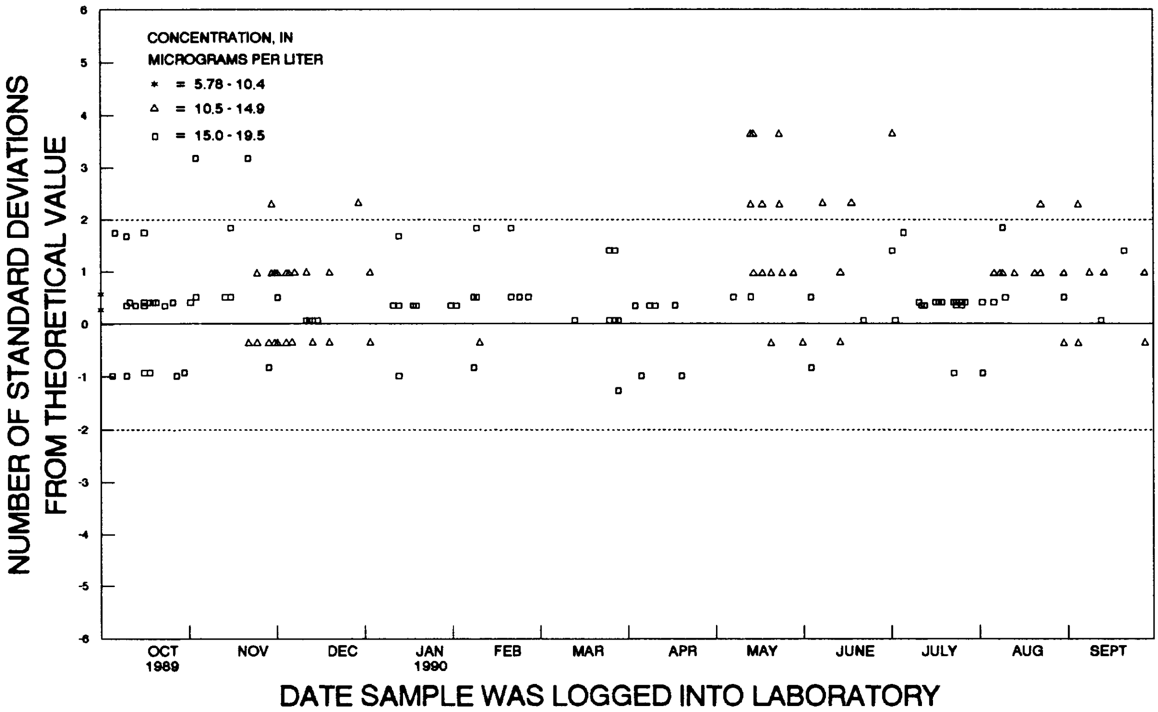

Figure 33. Lead, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

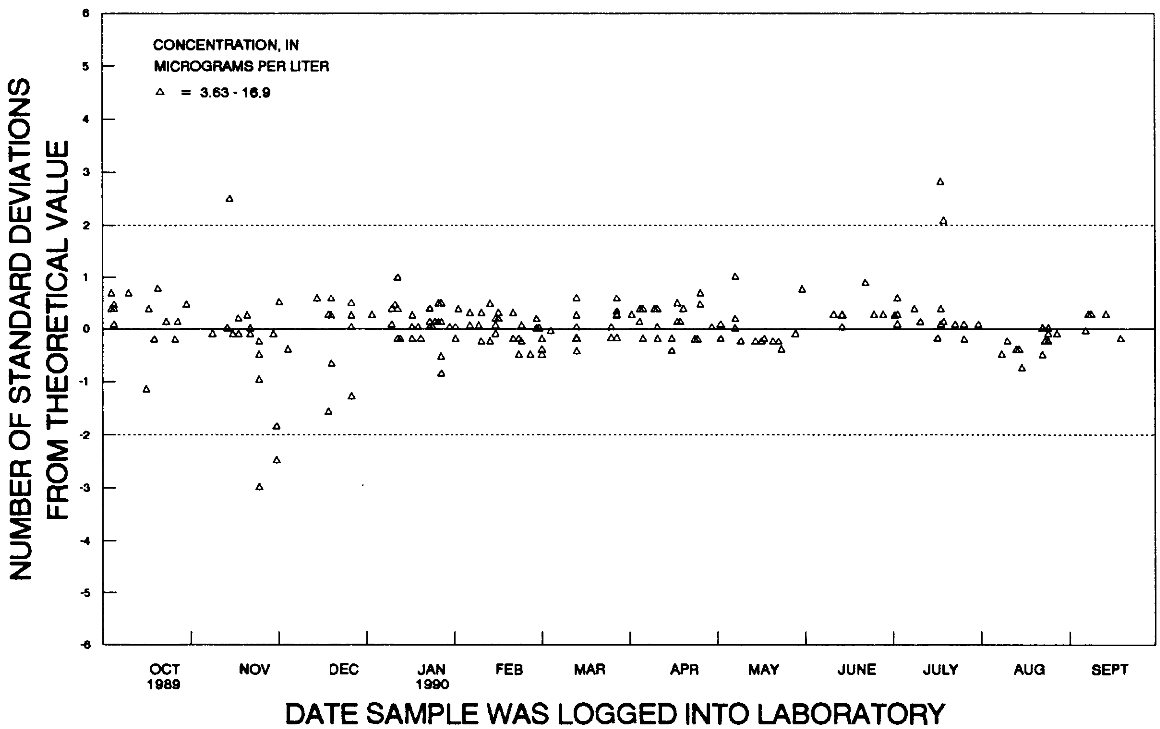

Figure 34. Lead, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

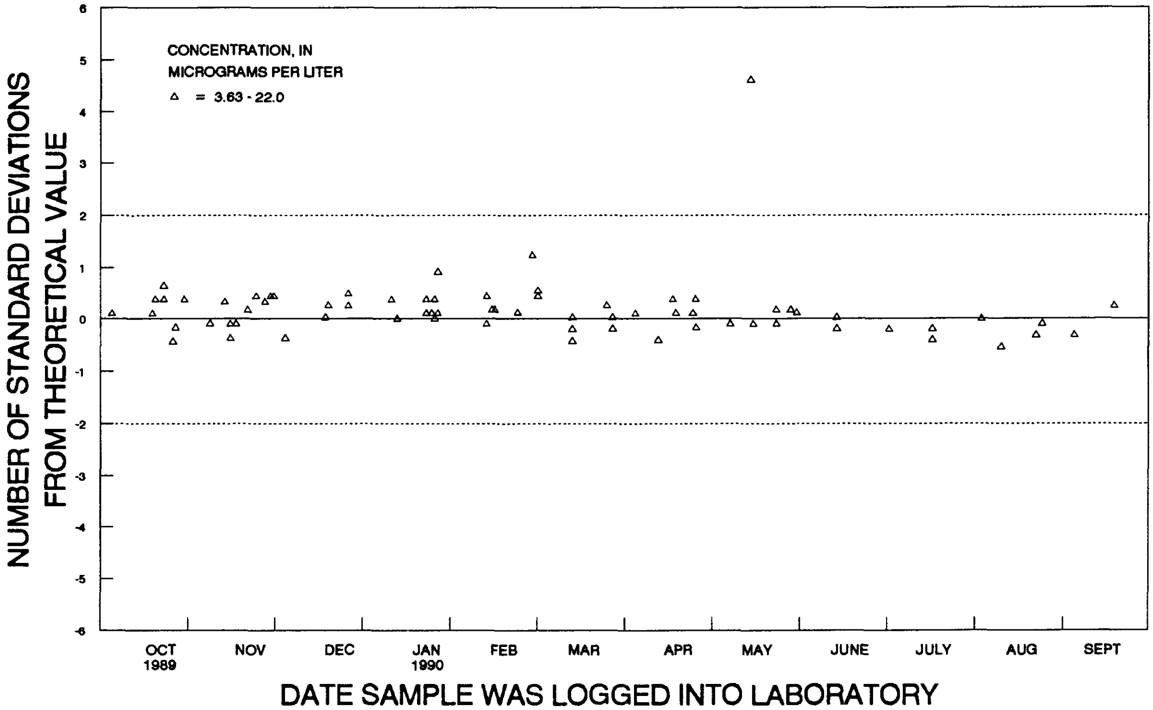

Figure 35. Lead, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

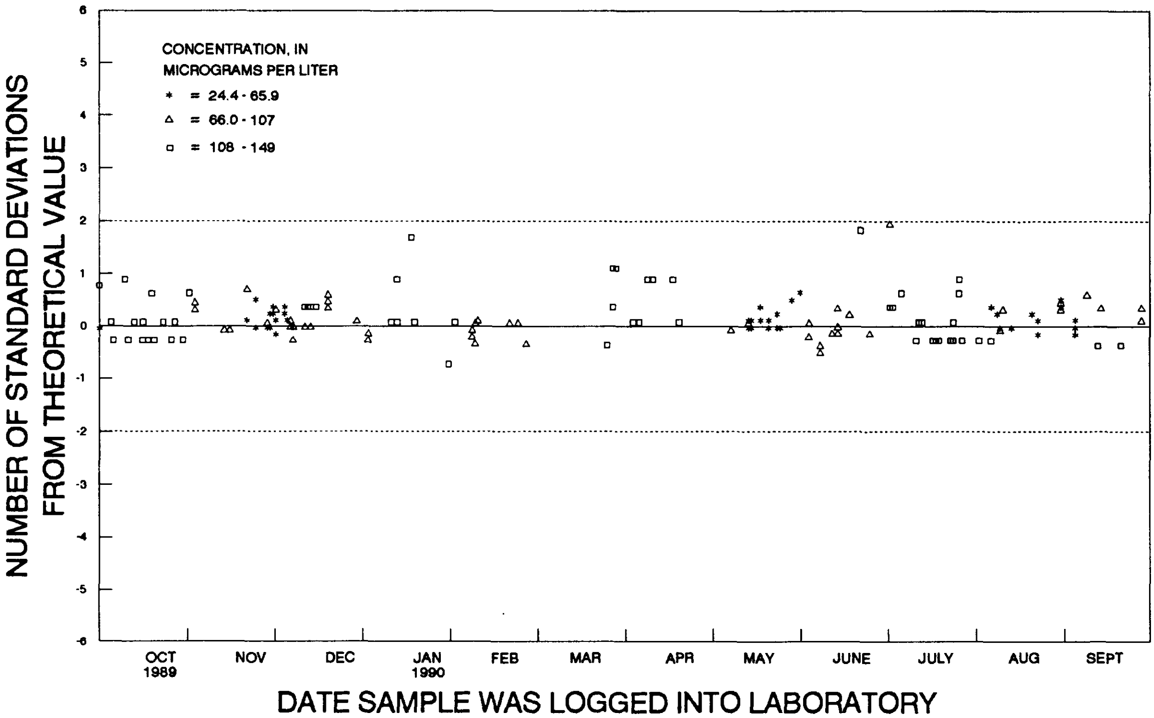

Figure 36. Lithium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

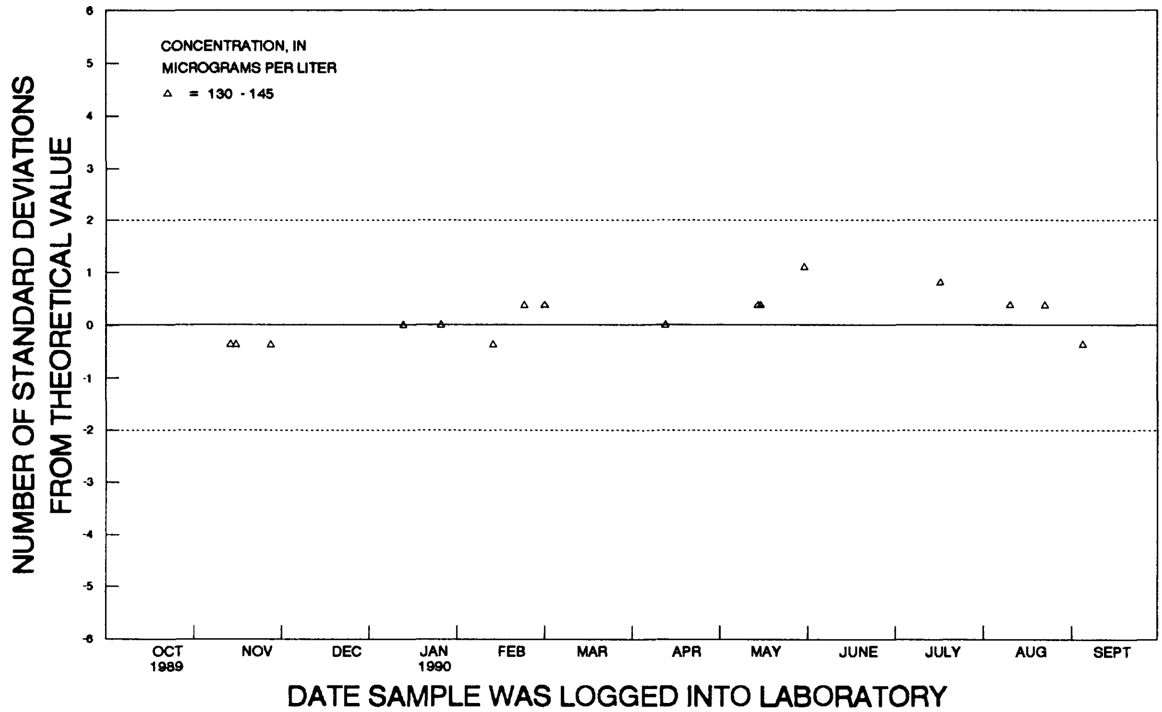

Figure 37. Lithium, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

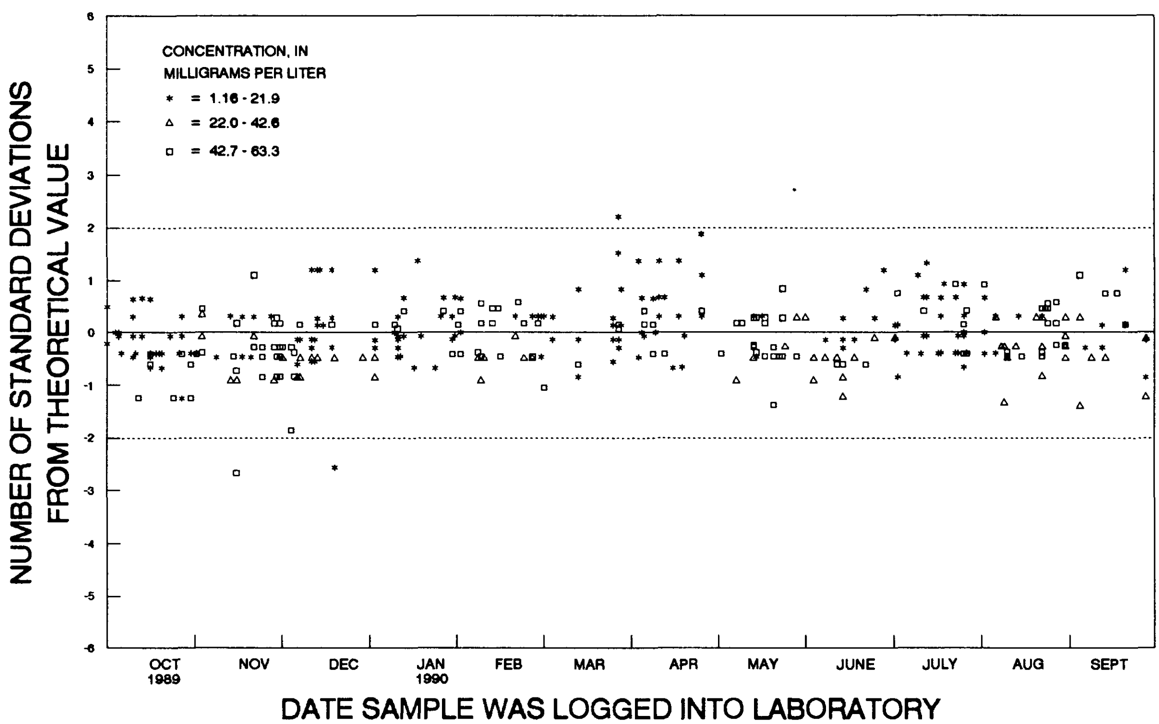

Figure 38. Magnesium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

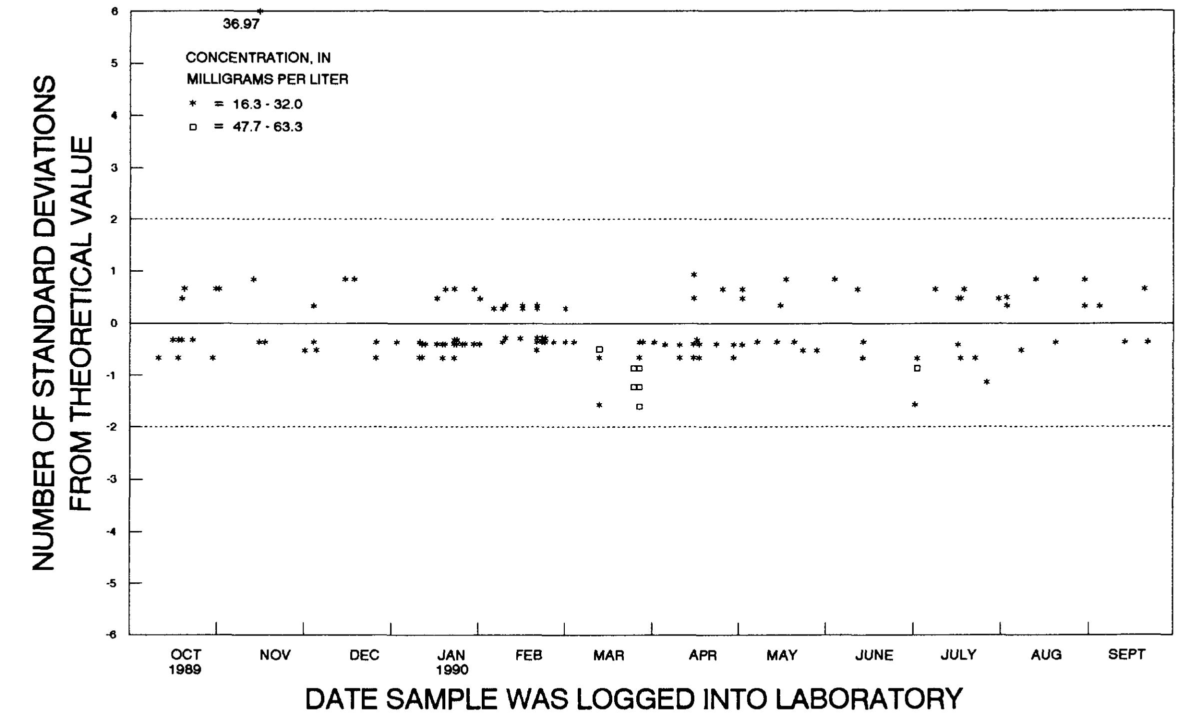

Figure 39. Magnesium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

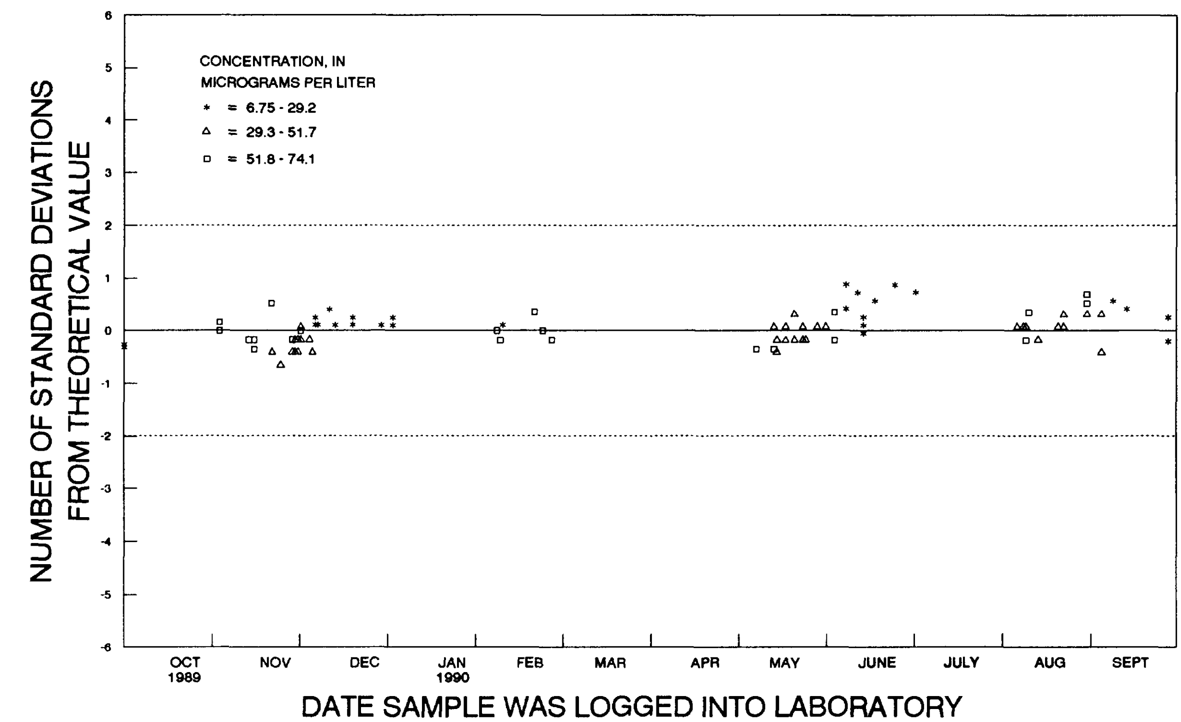

Figure 40. Manganese, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

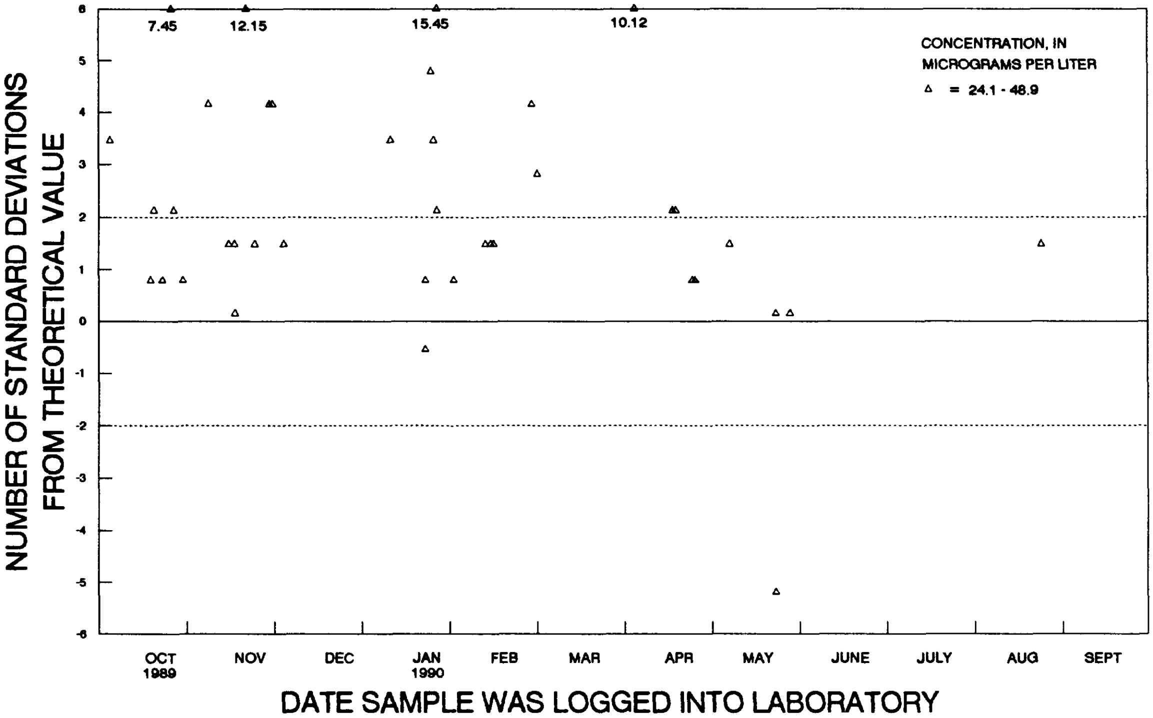

Figure 41. Manganese, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

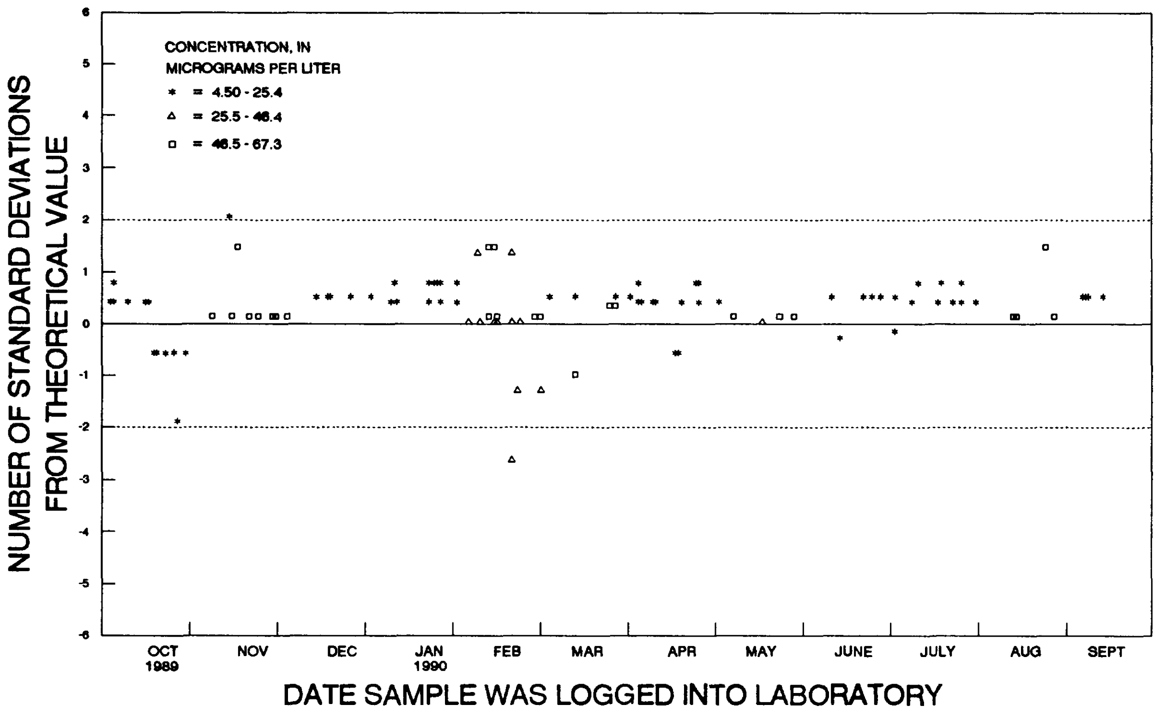

Figure 42. Manganese, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

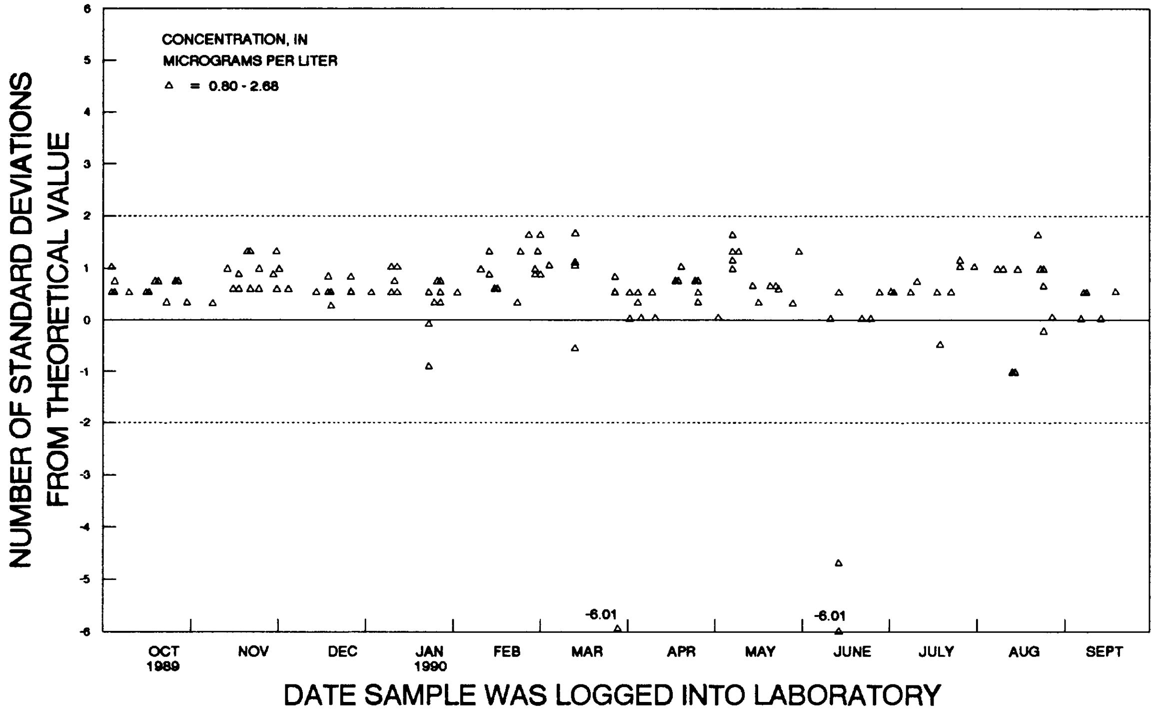

Figure 43. Mercury, dissolved, (atomic absorption spectrometry, flameless) data from the National Water-Quality Laboratory.

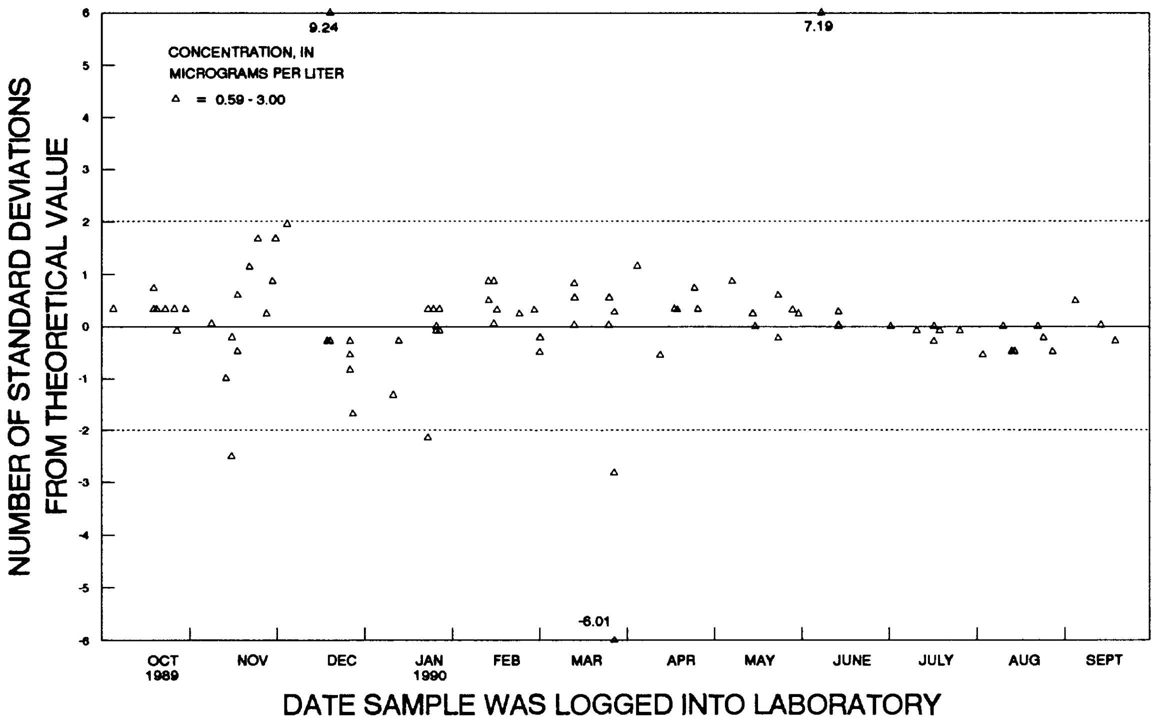

Figure 44. Mercury, total recoverable, (atomic absorption spectrometry, flameless) data from the National Water-Quality Laboratory.

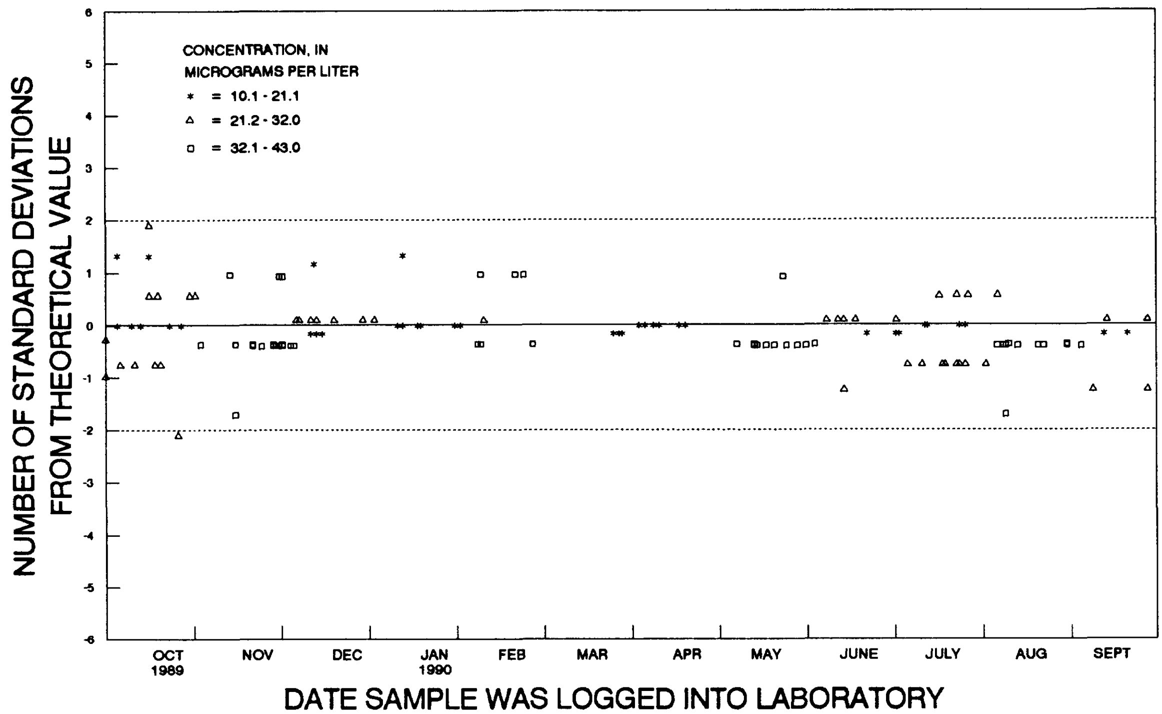

Figure 45. Molybdenum, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

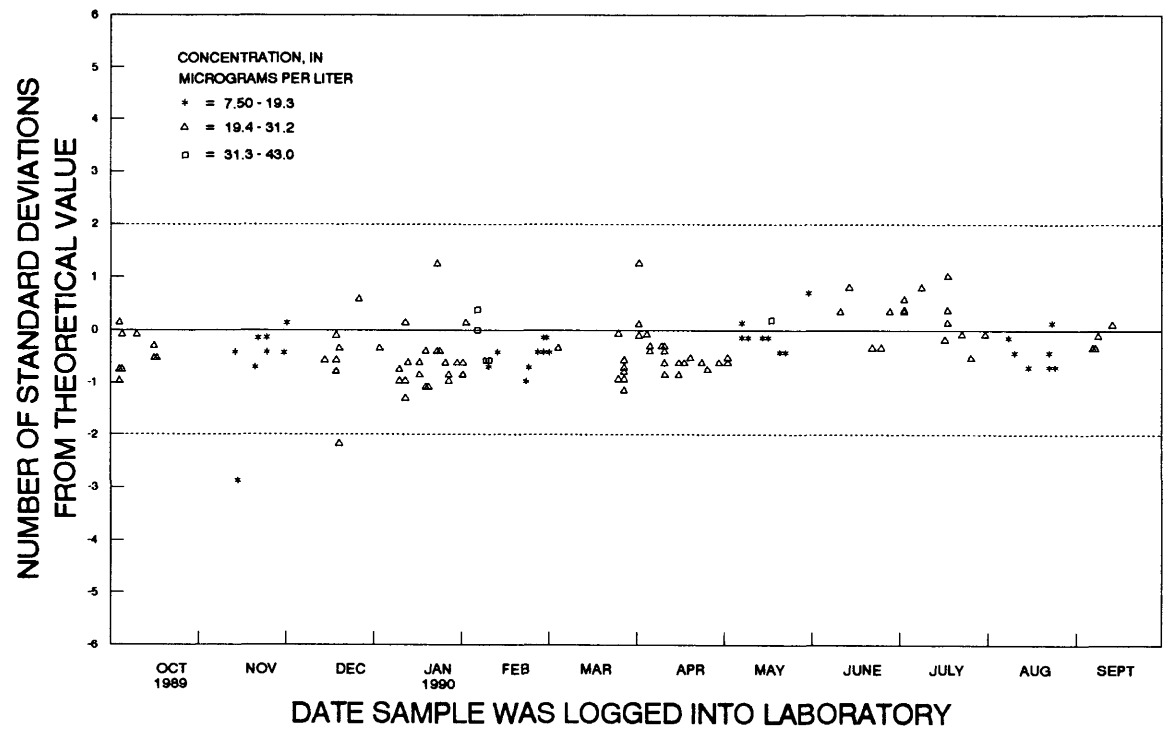

Figure 46. Molybdenum, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

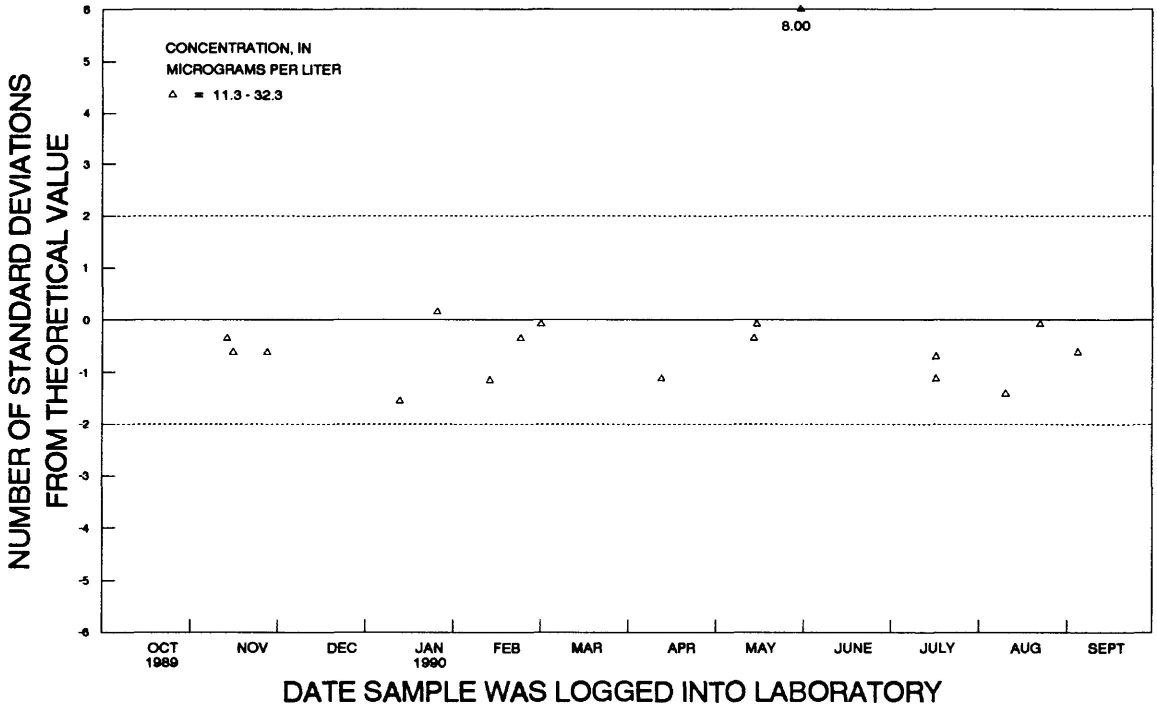

Figure 47. Molybdenum, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

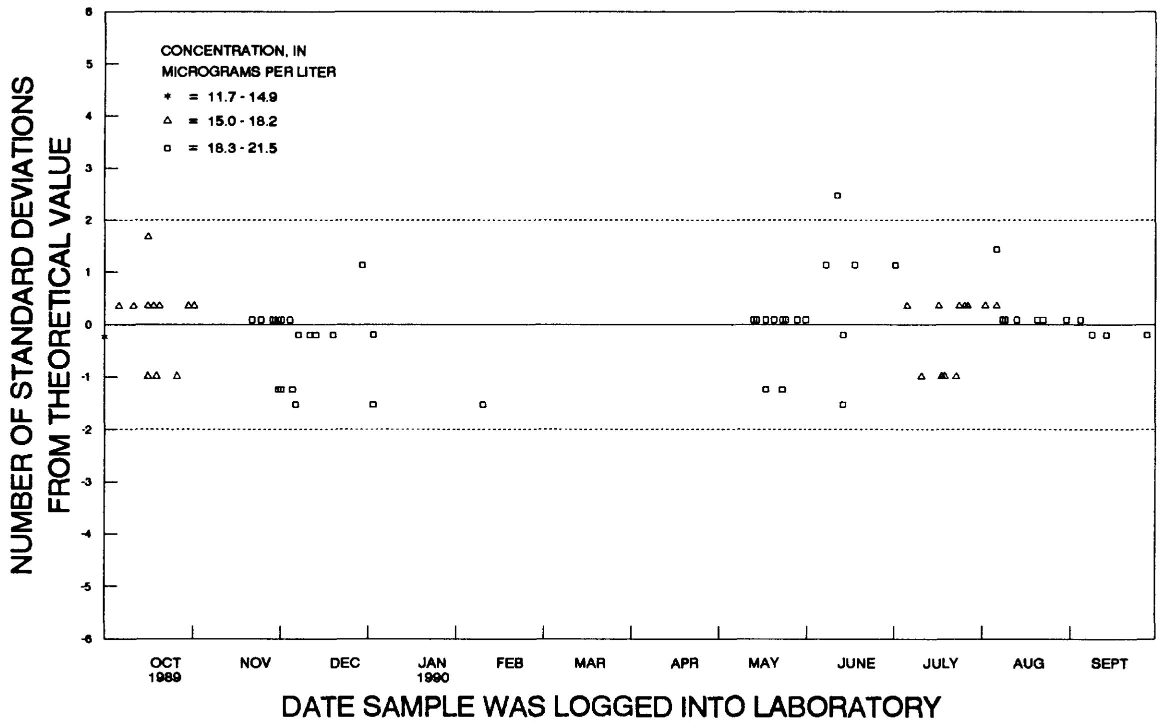

Figure 48. Nickel, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

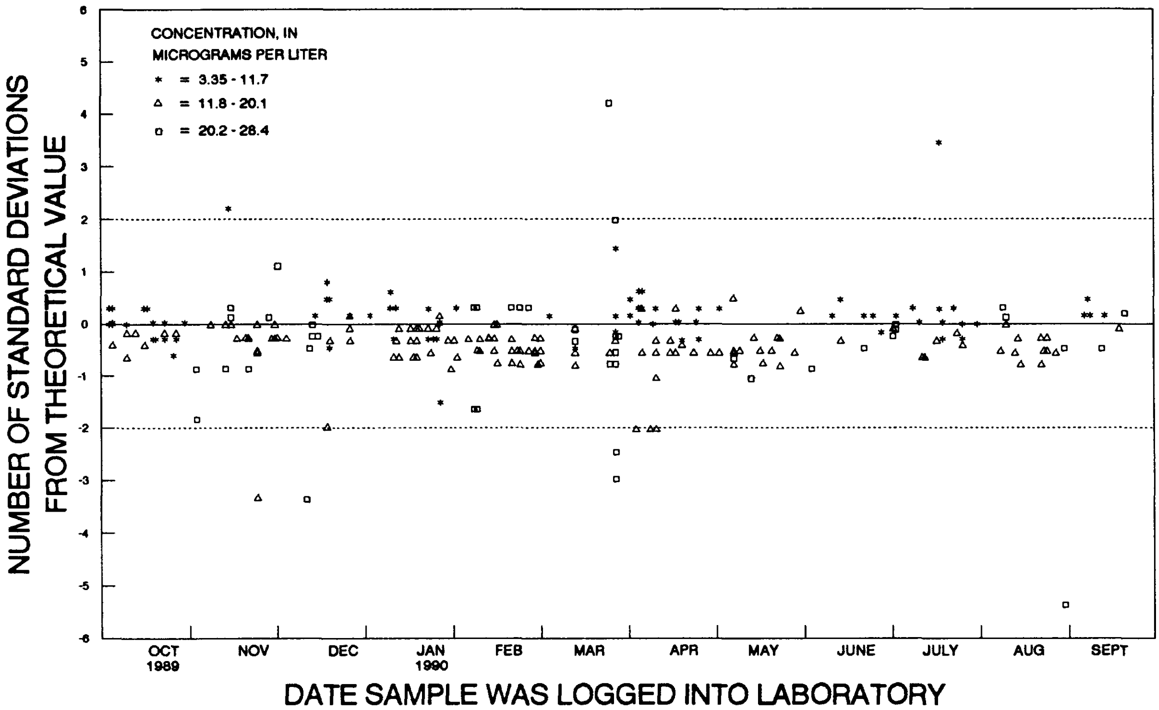

Figure 49. Nickel, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

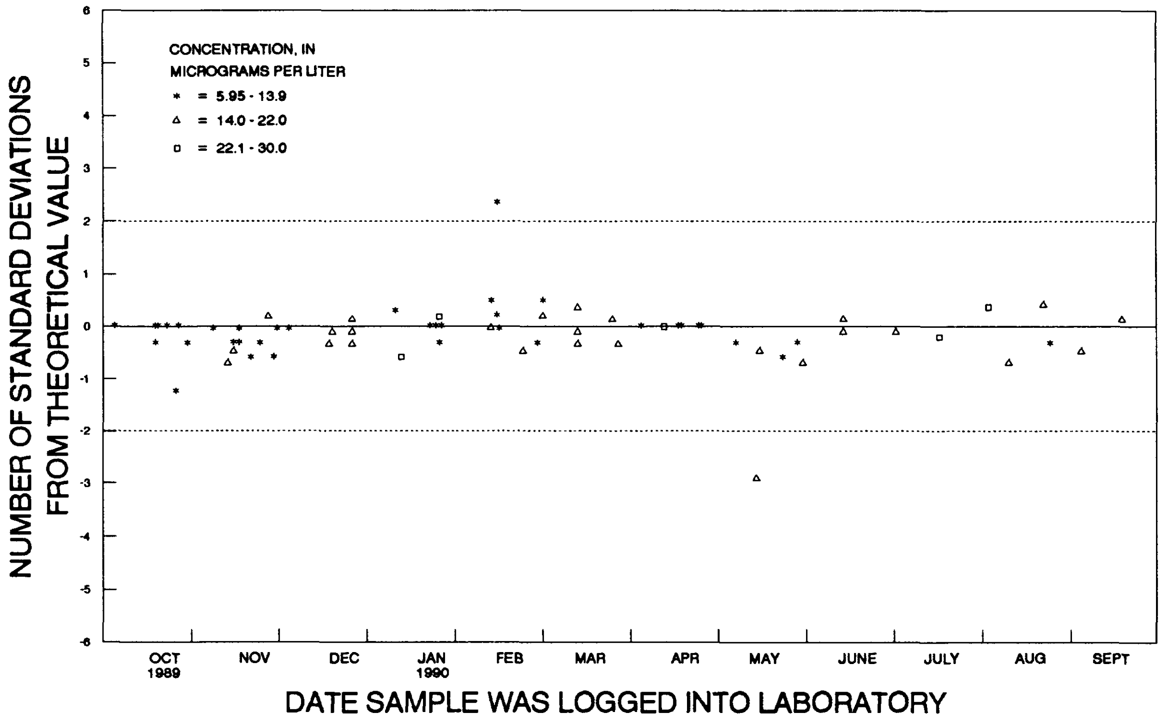

Figure 50. Nickel, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

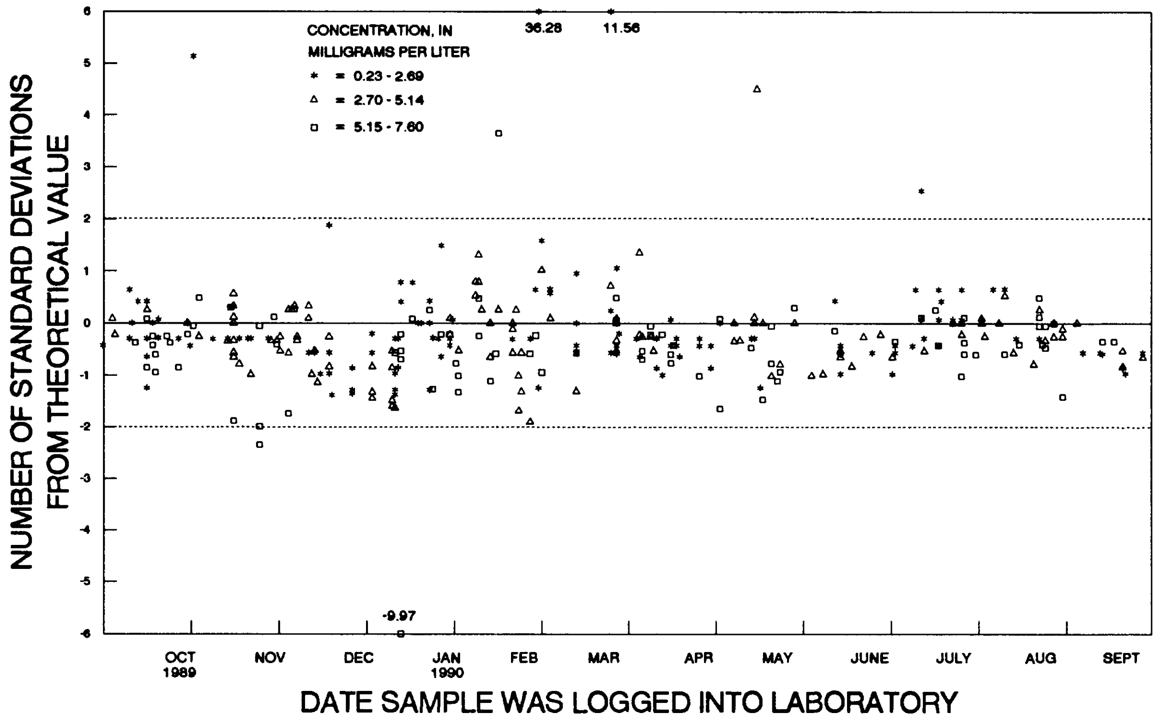

Figure 51. Potassium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

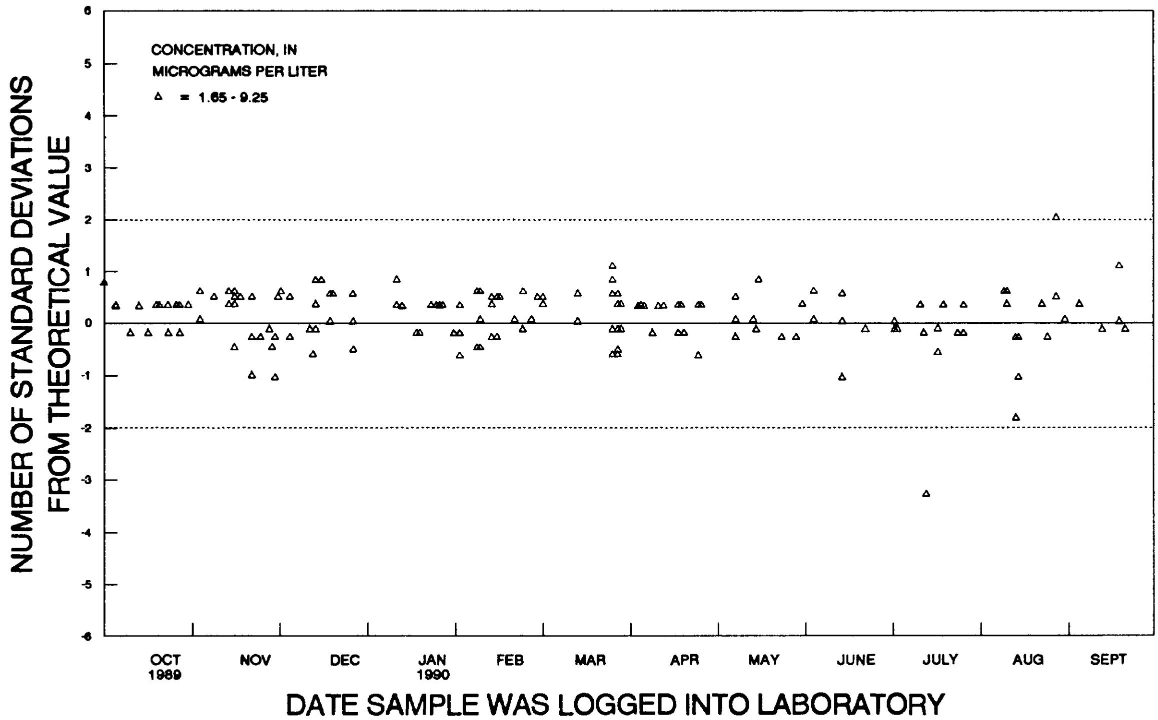

Figure 52. Selenium, dissolved and total, (atomic absorption spectrometry, hydride) data from the National Water-Quality Laboratory.

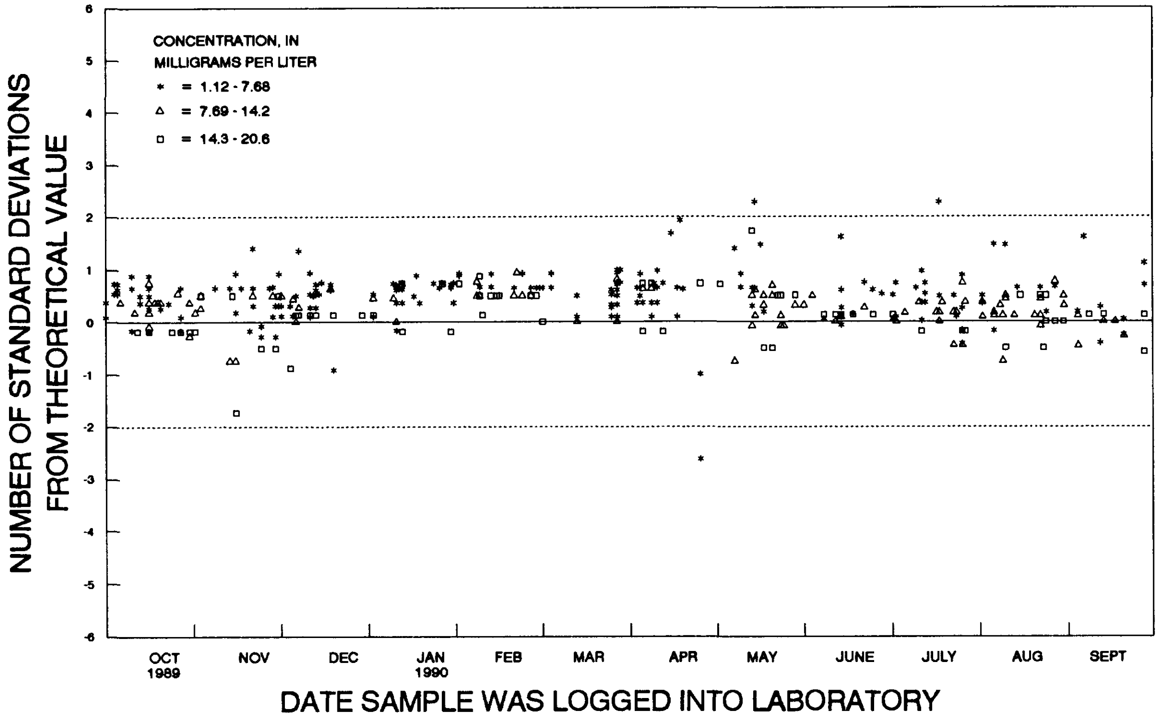

Figure 53. Silica, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

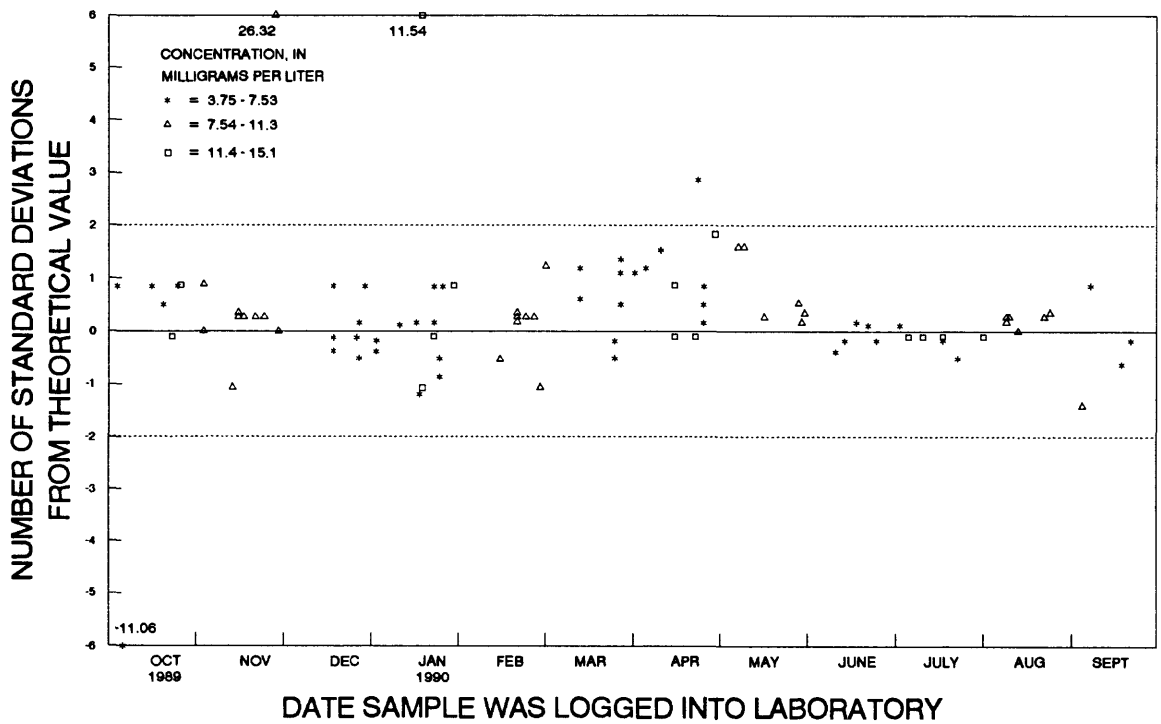

Figure 54. Silica, dissolved, (colorimetric) data from the National Water-Quality Laboratory.

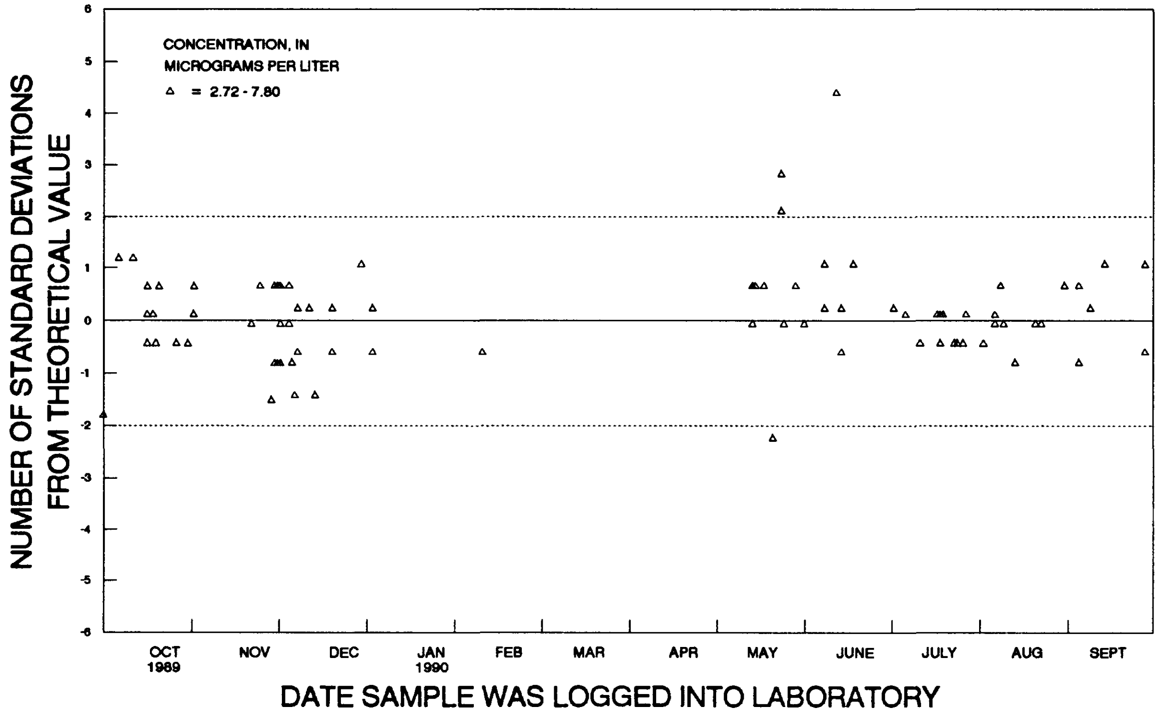

Figure 55. Silver, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

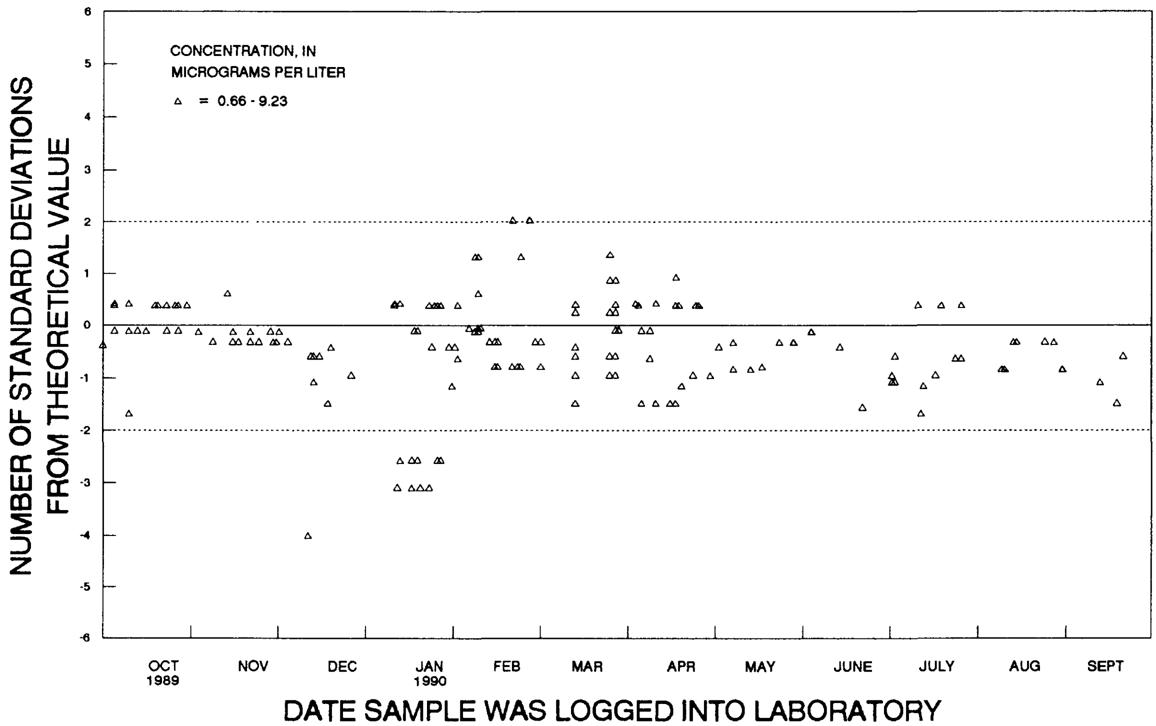

Figure 56. Silver, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

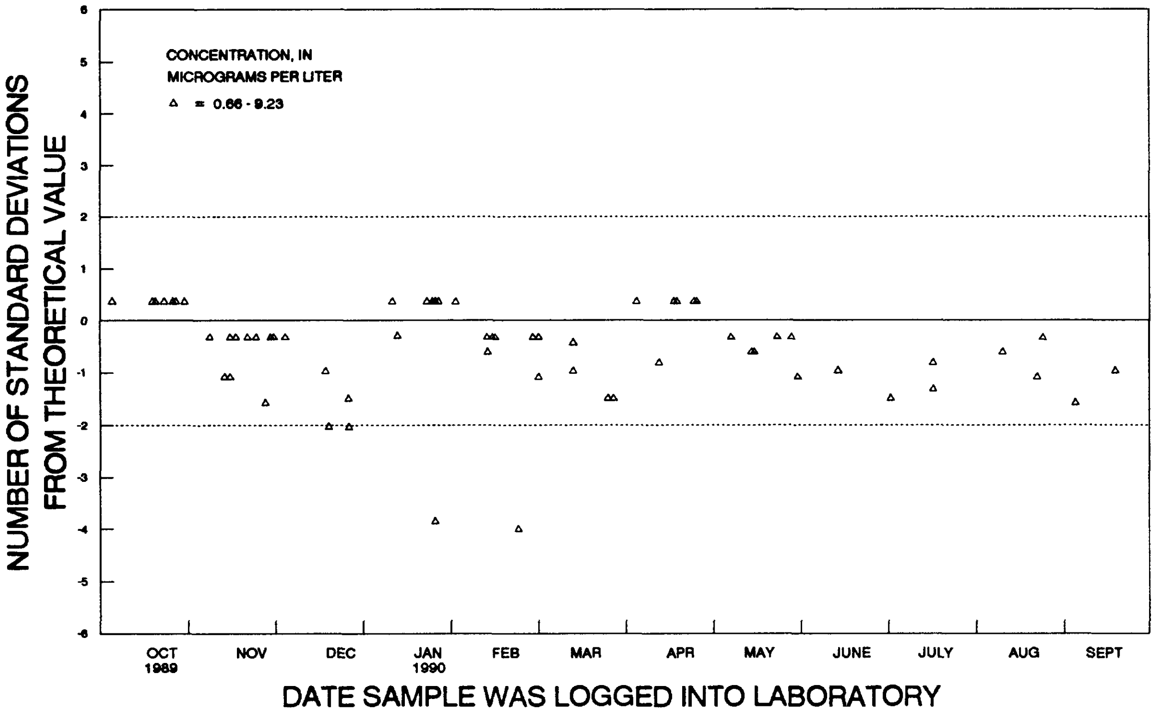

Figure 57. Silver, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

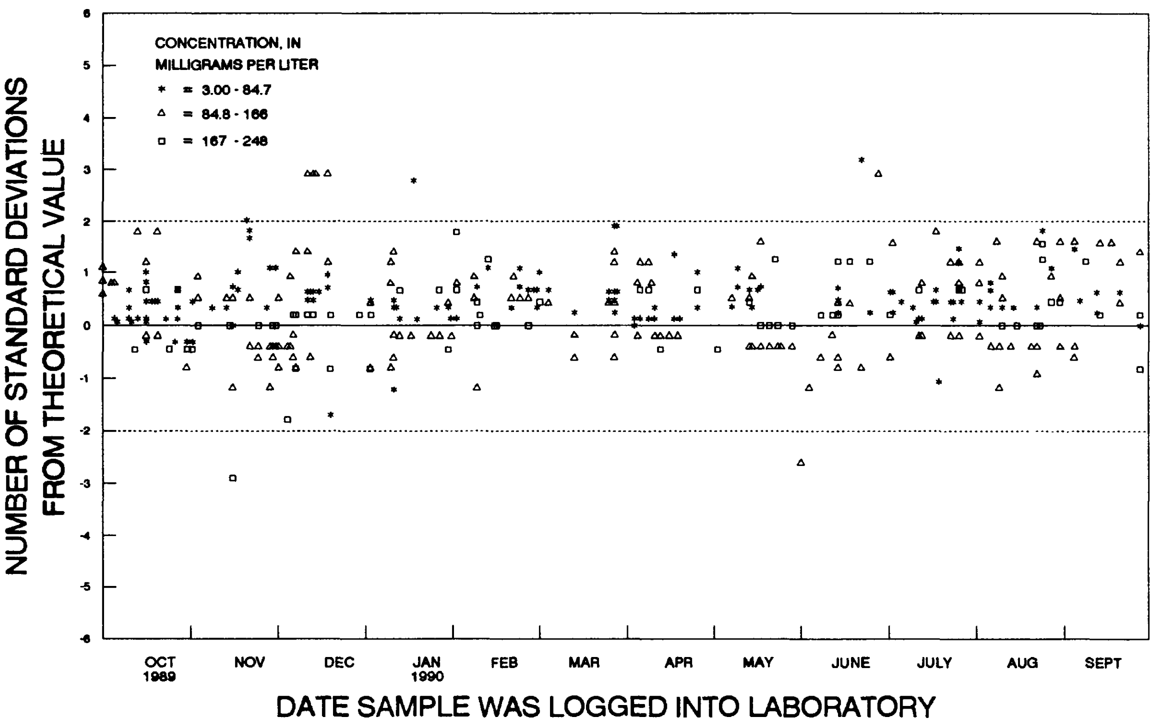

Figure 58. Sodium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

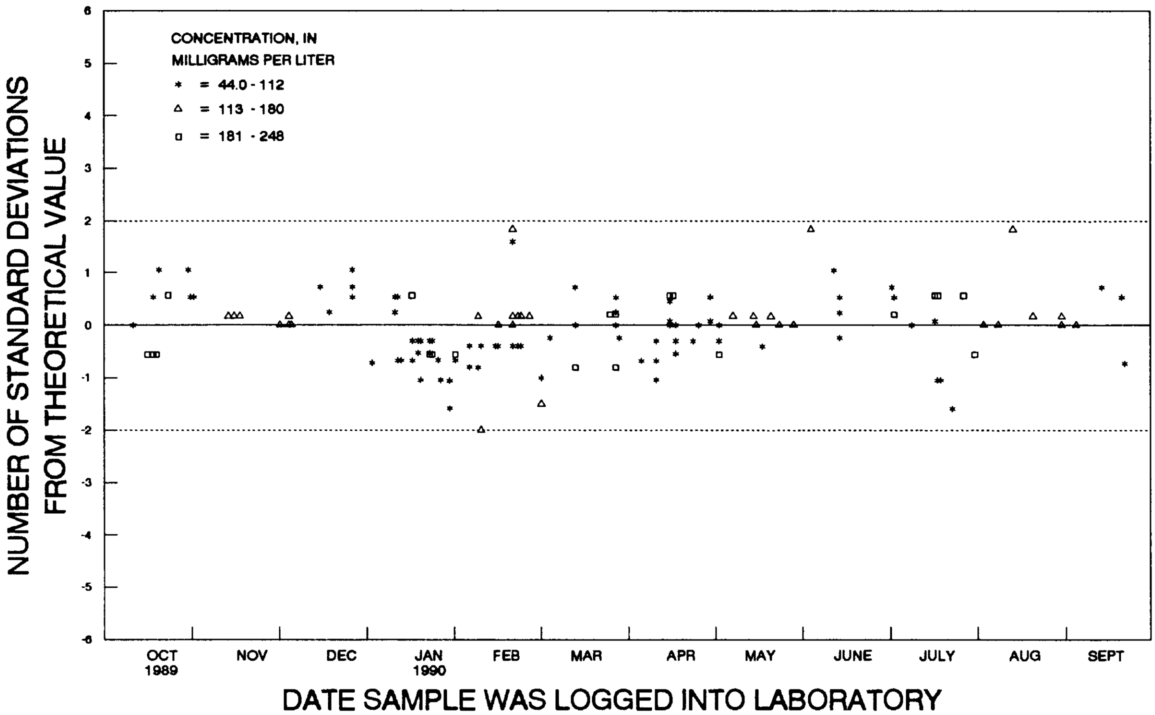

Figure 59. Sodium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

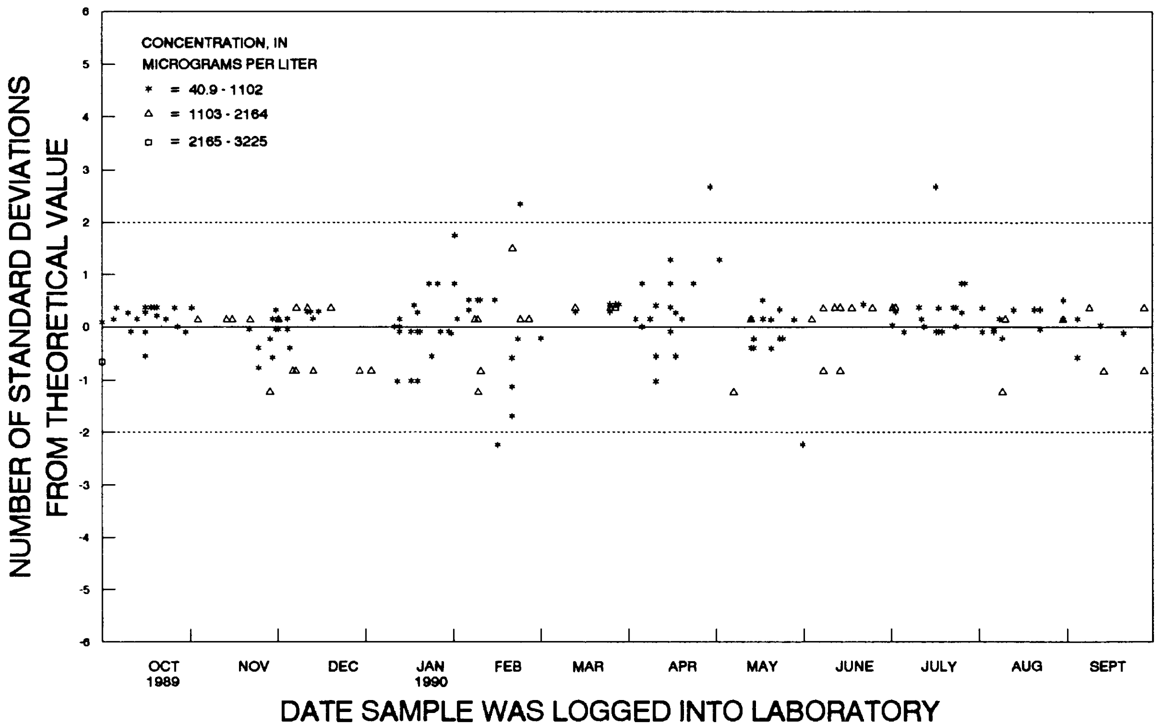

Figure 60. Strontium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

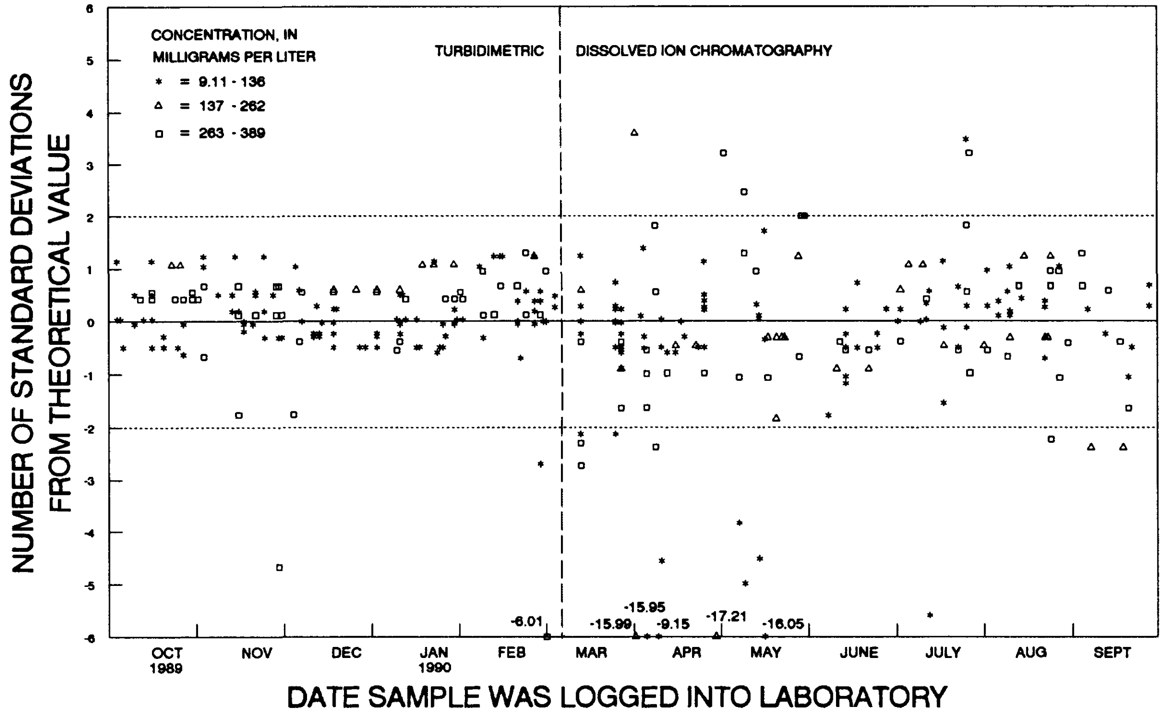

Figure 61. Sulfate, dissolved, (turbidimetric and ion chromatography) data from the National Water-Quality Laboratory.

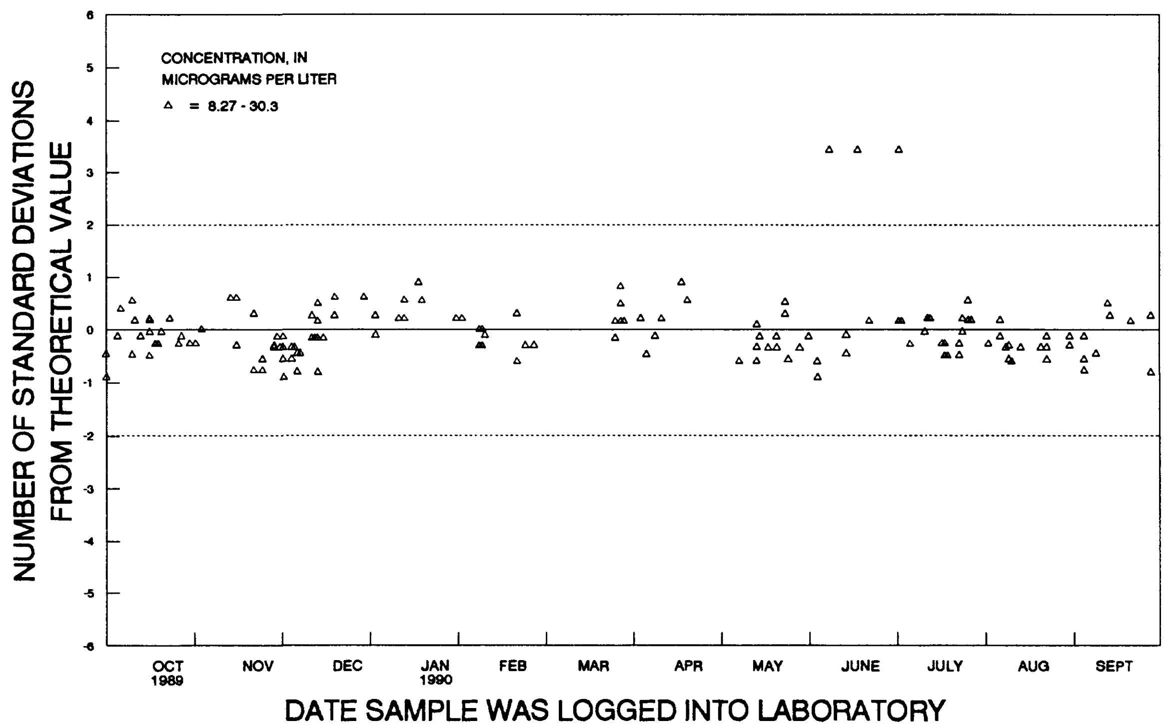

Figure 62. Vanadium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

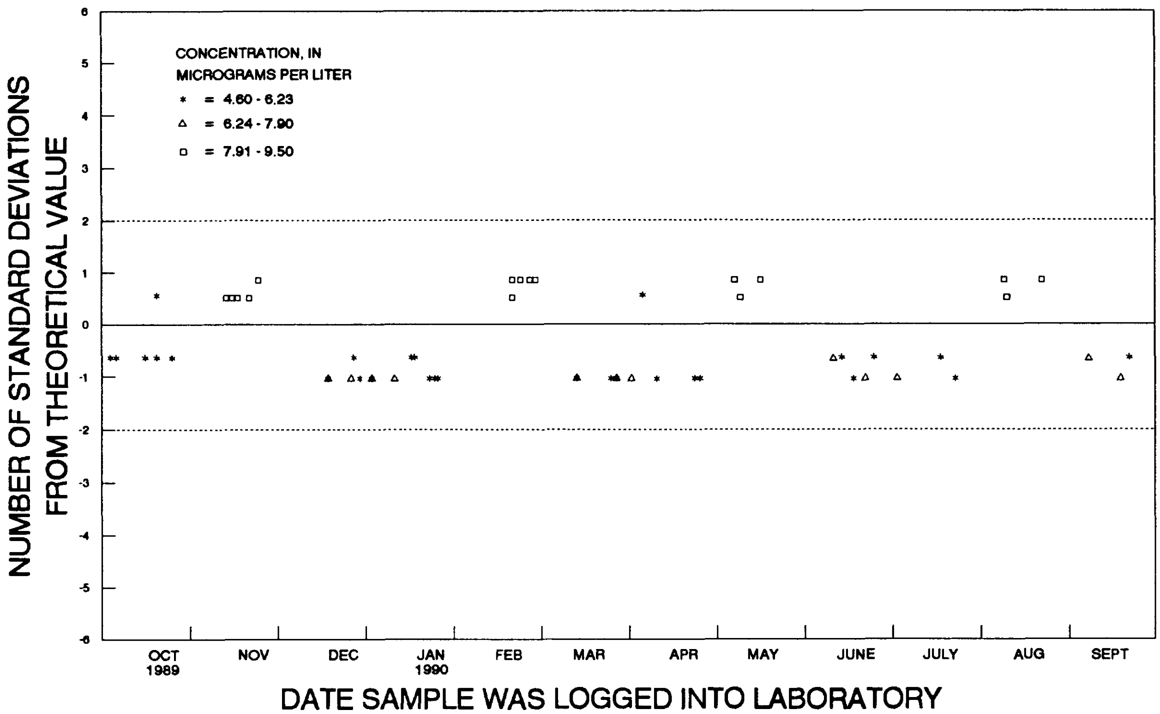

Figure 63. Vanadium, dissolved, (colorimetric) data from the National Water-Quality Laboratory.

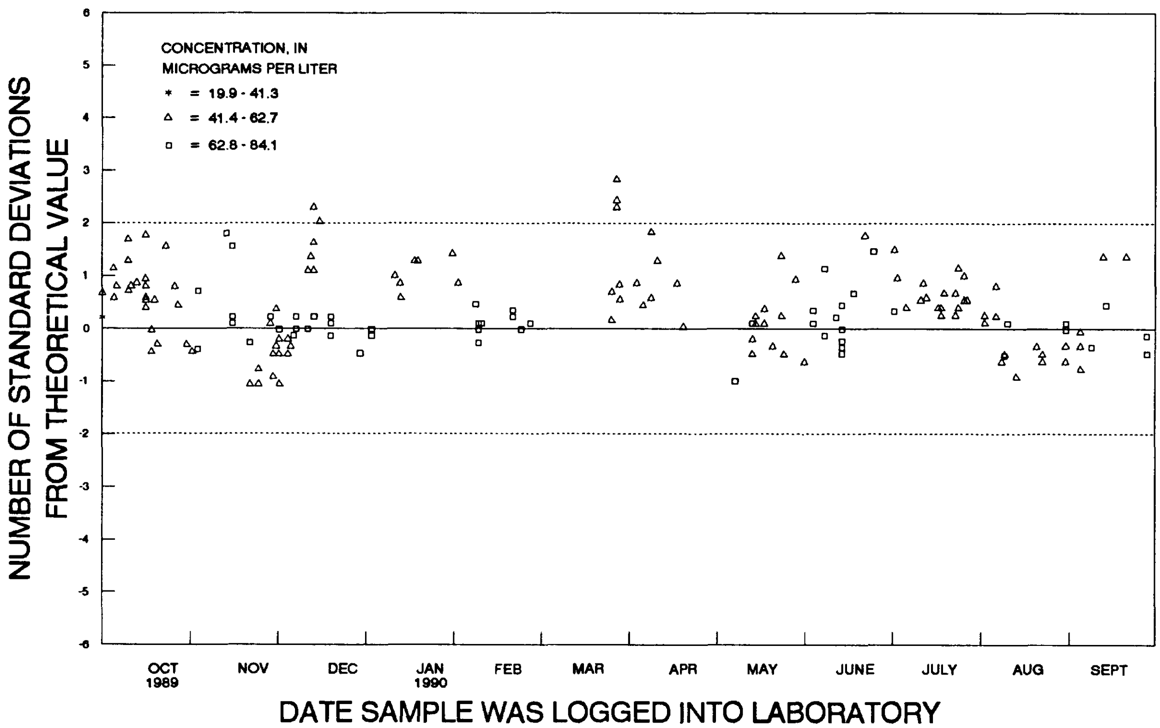

Figure 64. Zinc, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

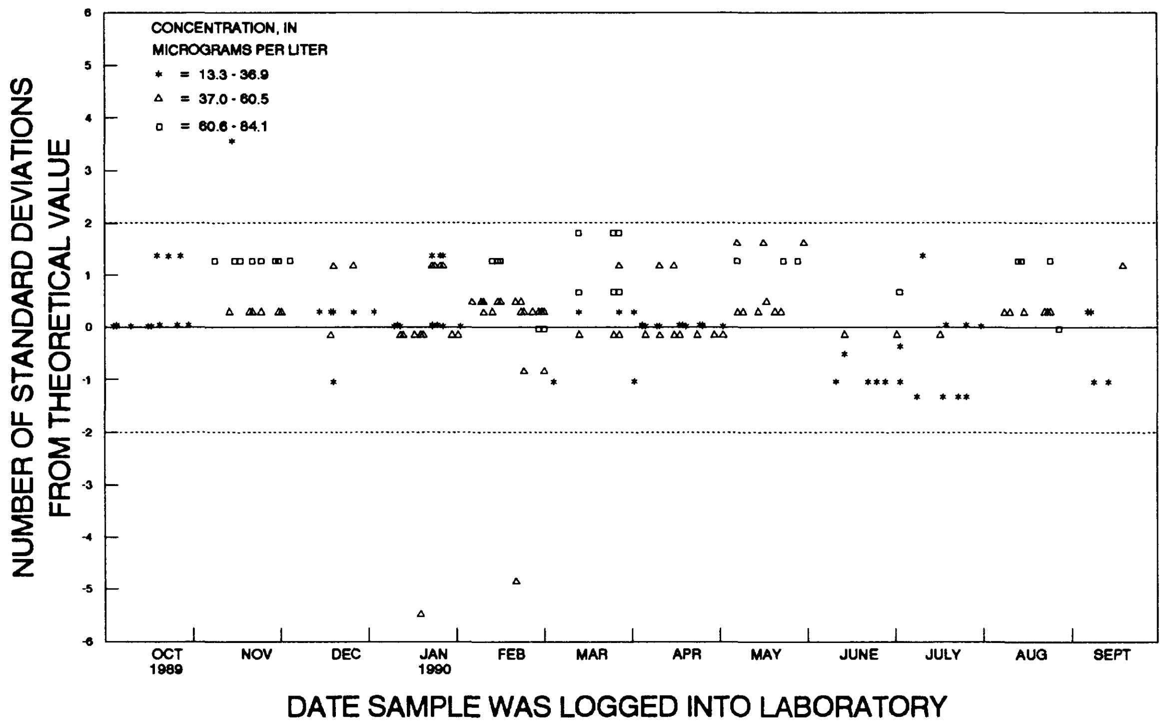

Figure 65. Zinc, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

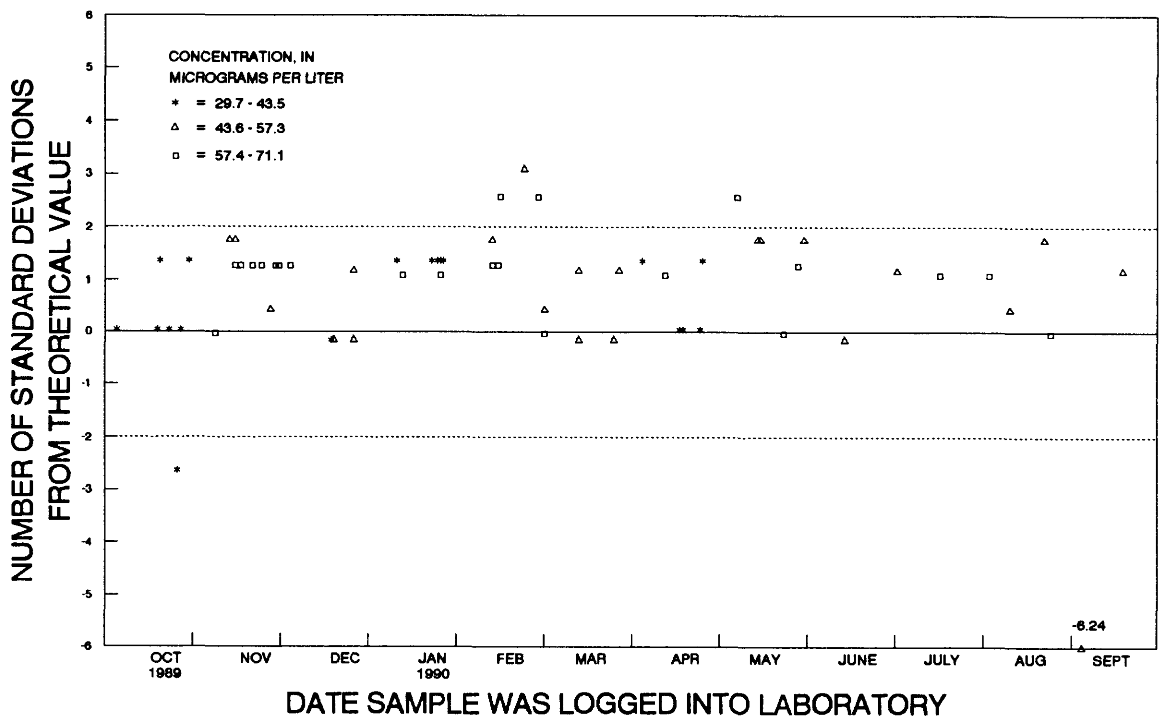

Figure 66. Zinc, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

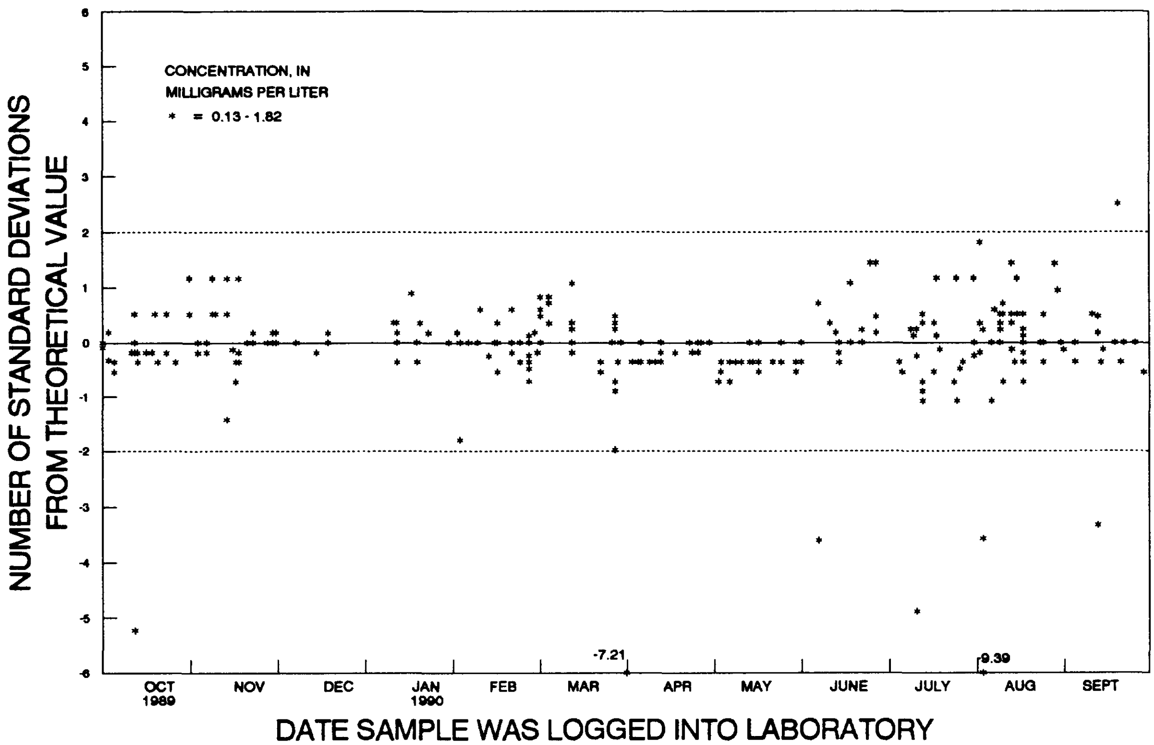

Figure 67. Ammonia as nitrogen, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

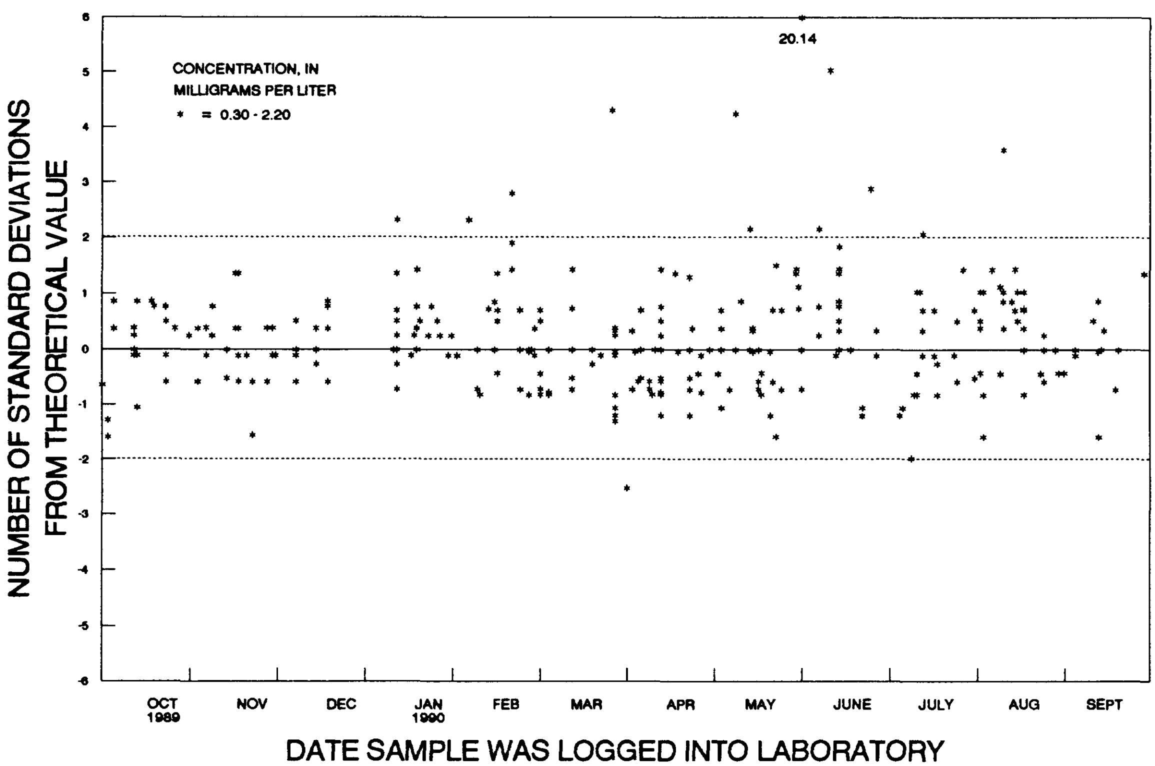

Figure 68. Ammonia plus organic nitrogen, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

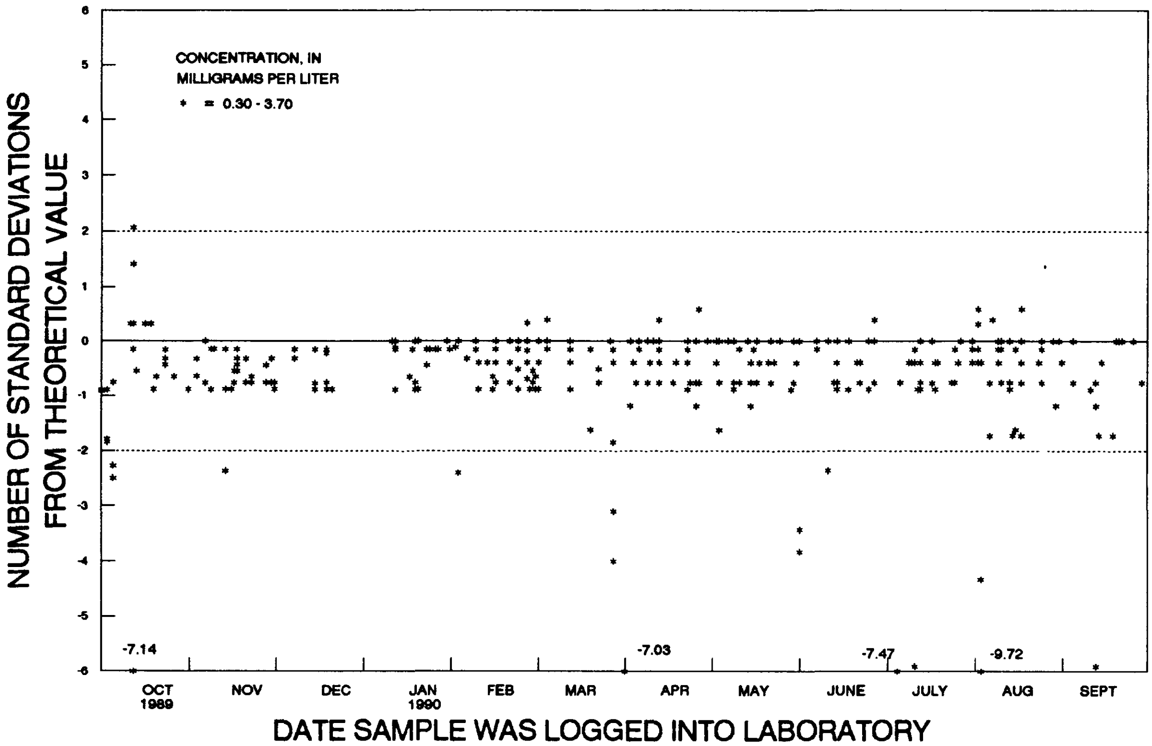

Figure 69. Nitrate plus nitrite as nitrogen, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

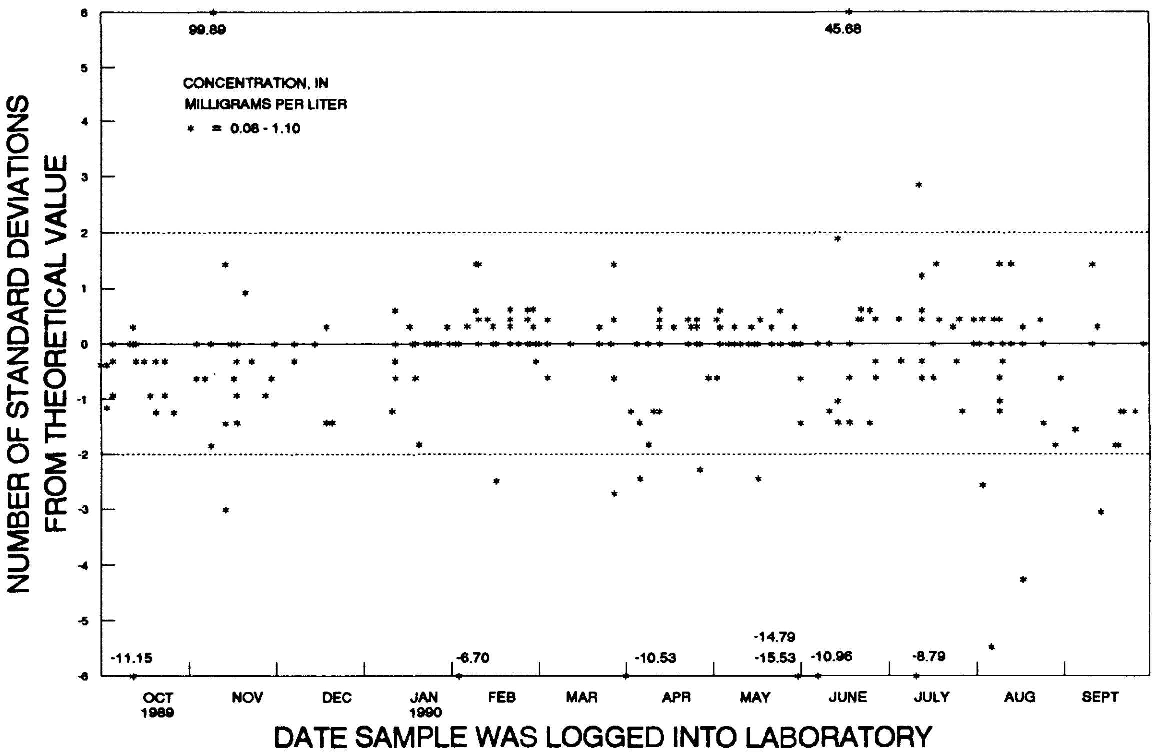

Figure 70. Orthophosphate as phosphorus, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

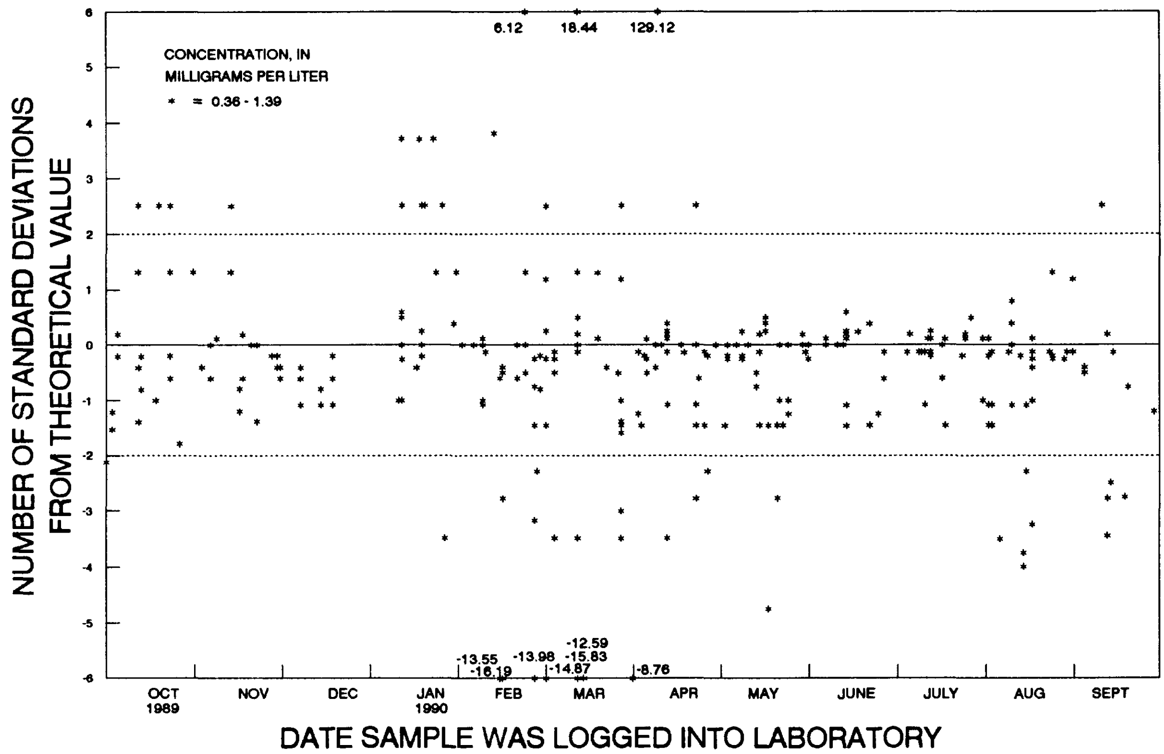

Figure 71. Phosphorus, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

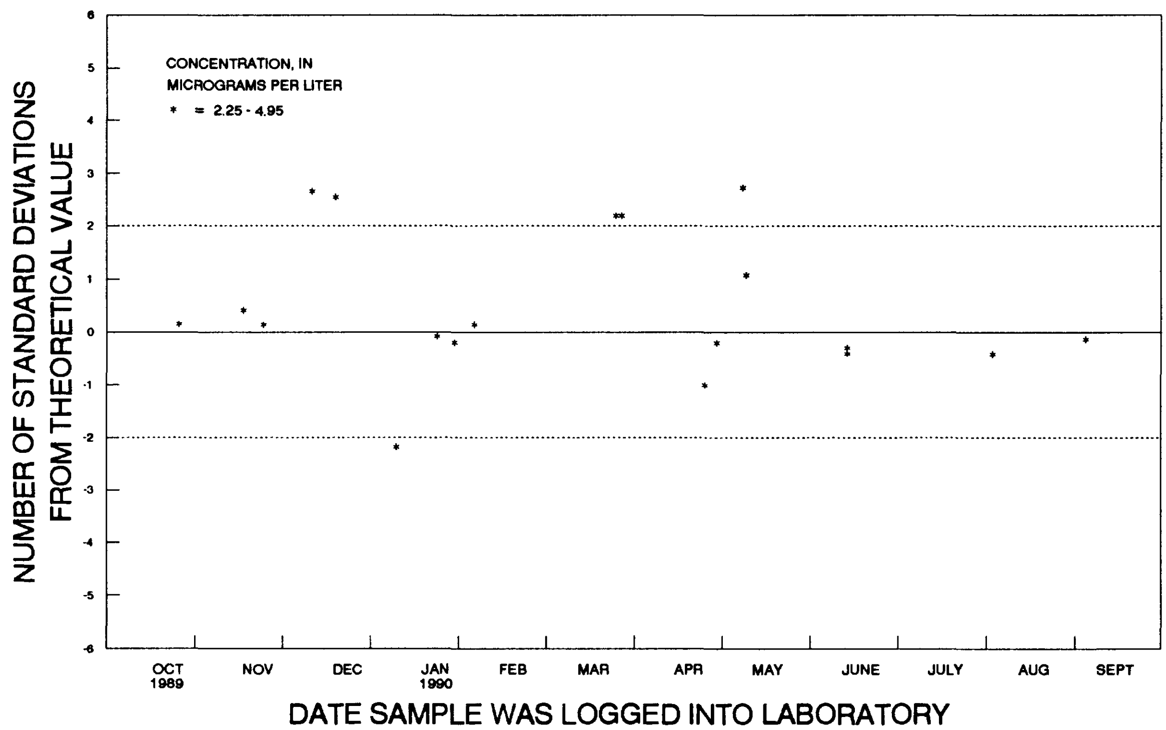

Figure 72. Cadmium, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

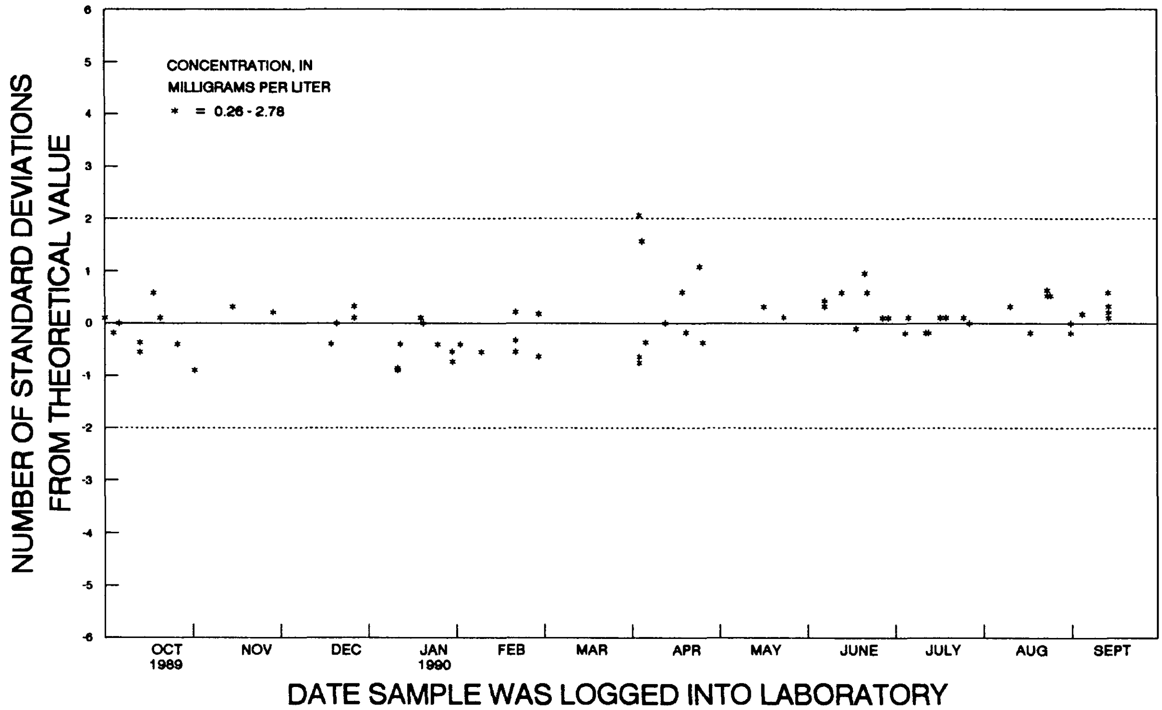

Figure 73. Calcium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

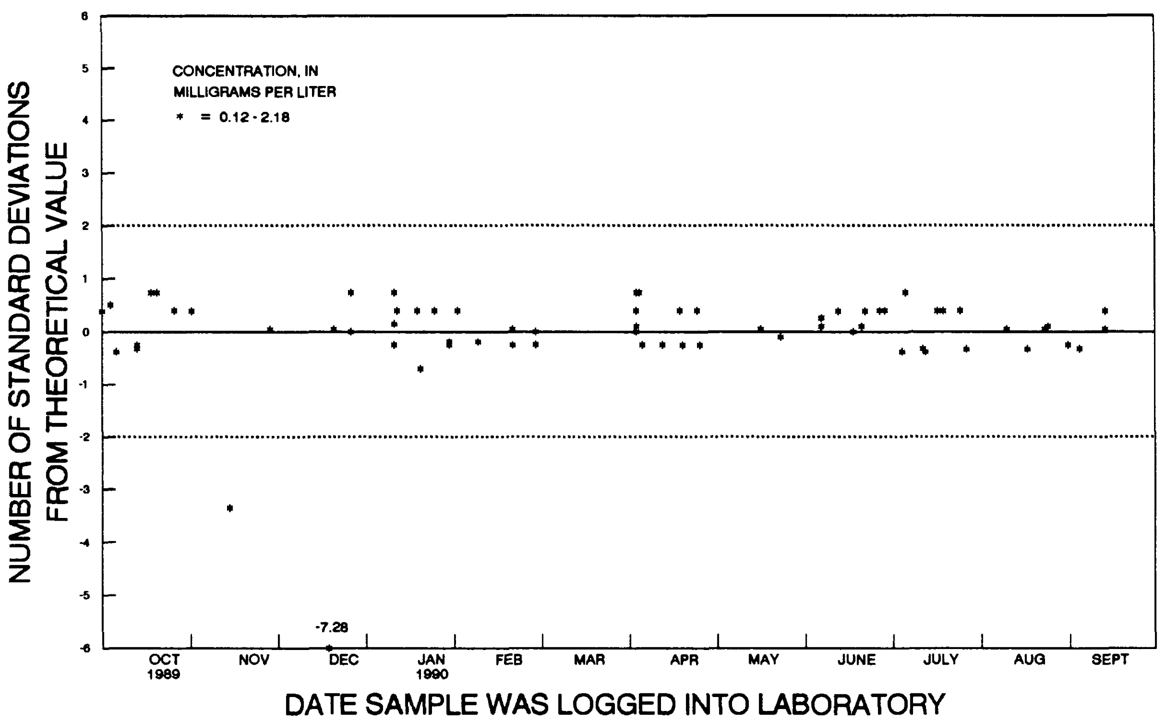

Figure 74. Chloride, dissolved, low ionic strength, (ion chromatography) data from the National Water-Quality Laboratory.

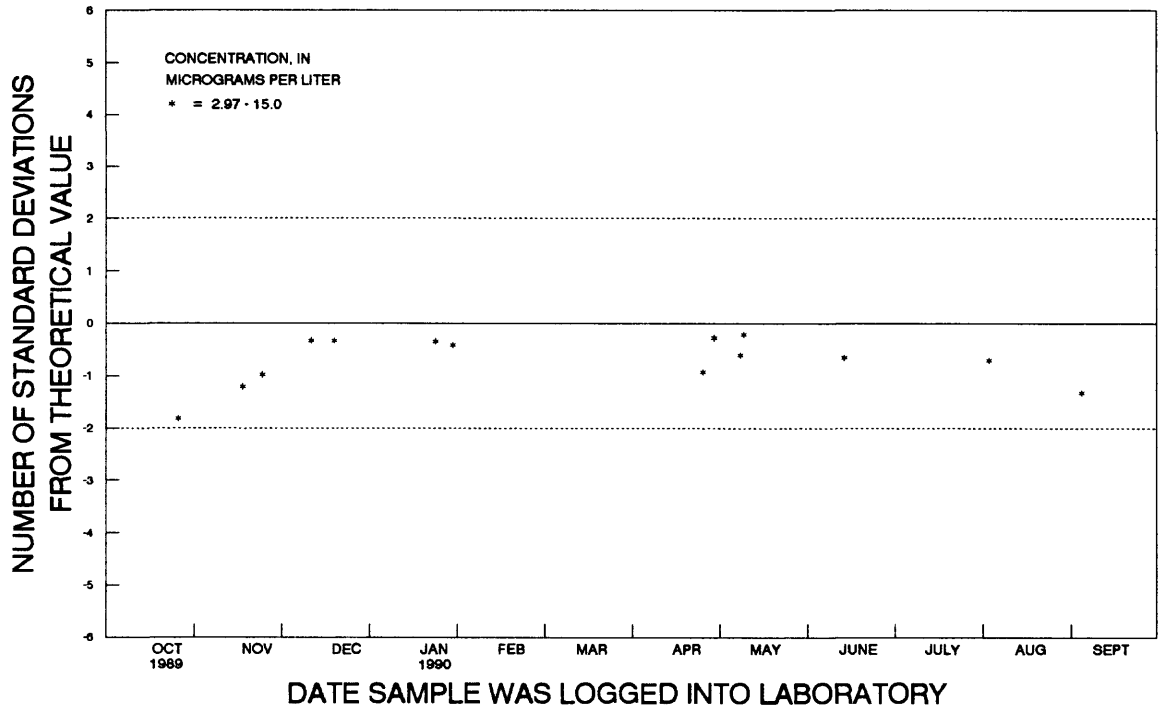

Figure 75. Cobalt, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

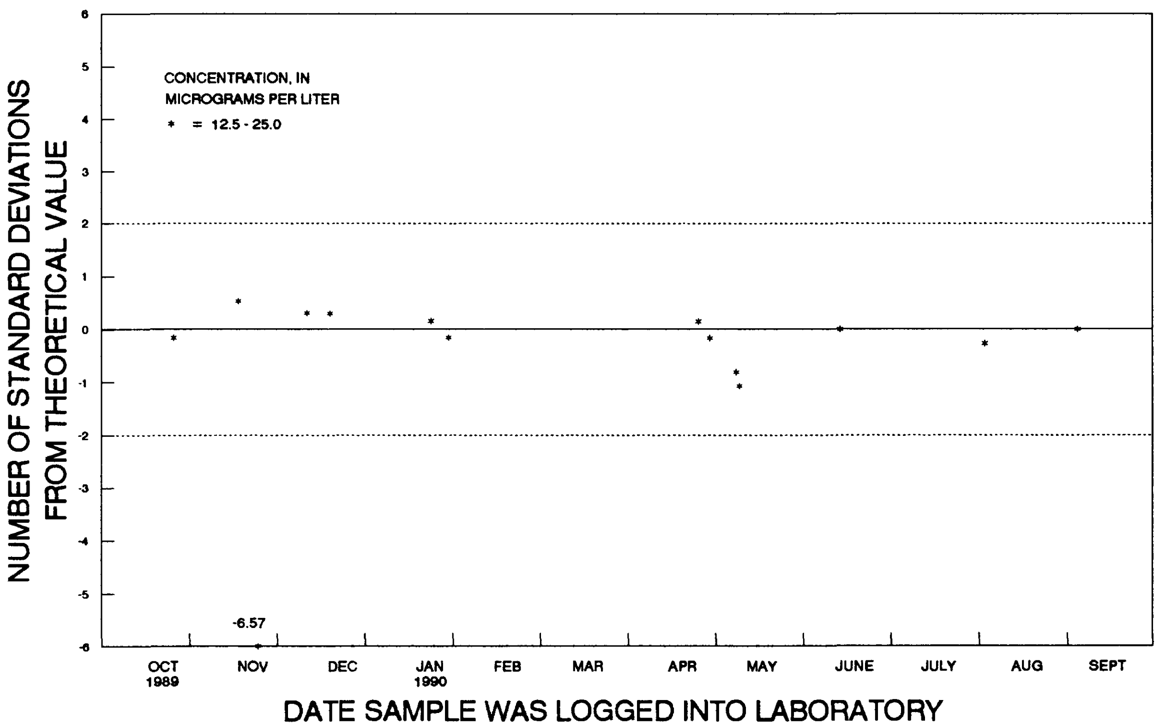

Figure 76. Copper, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

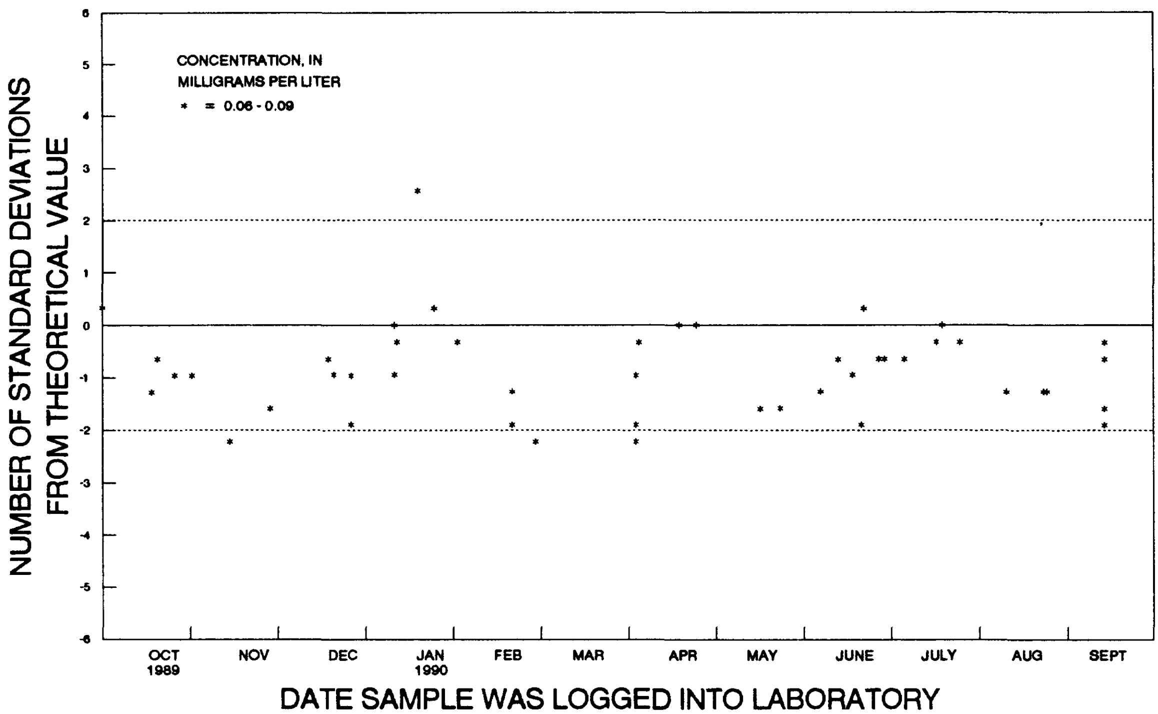

Figure 77. Fluoride, dissolved, low ionic strength, (ion chromatography) data from the National Water-Quality Laboratory.

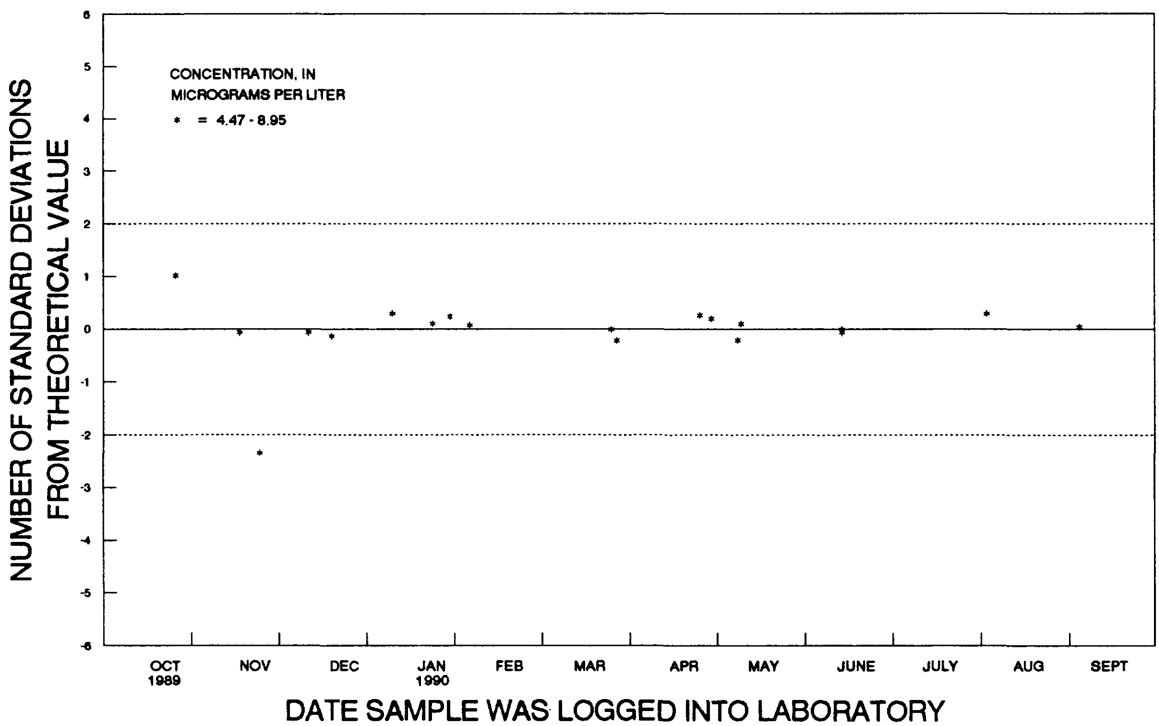

Figure 78. Lead, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

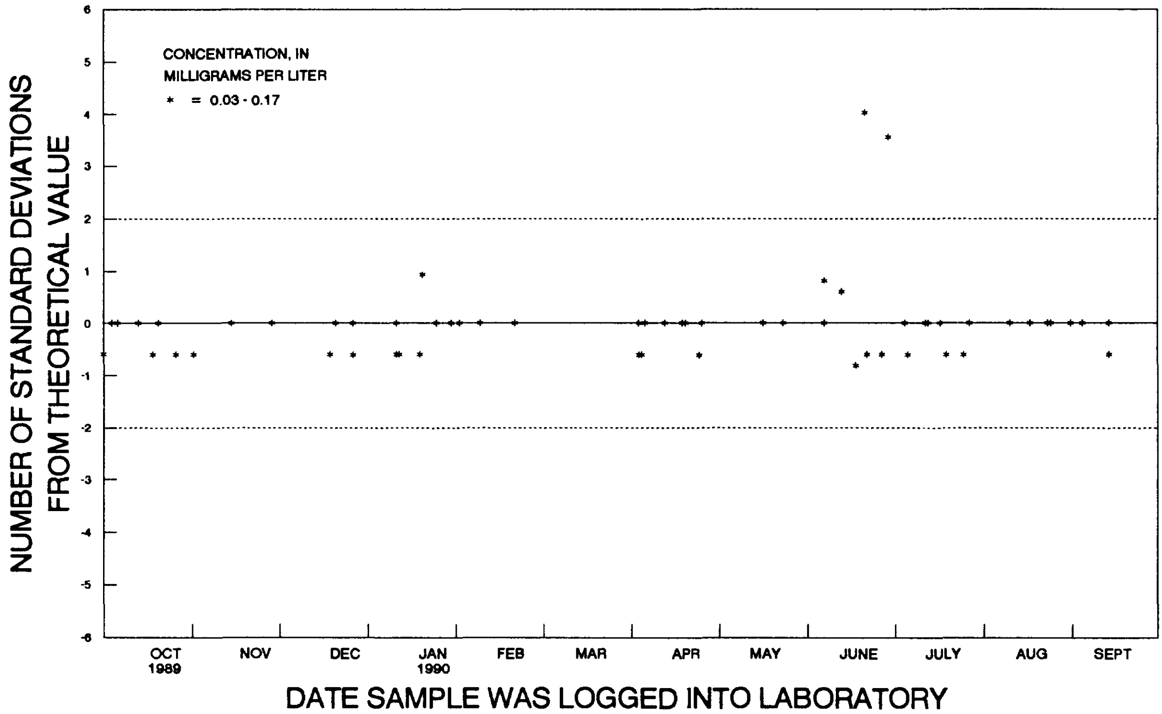

Figure 79. Magnesium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

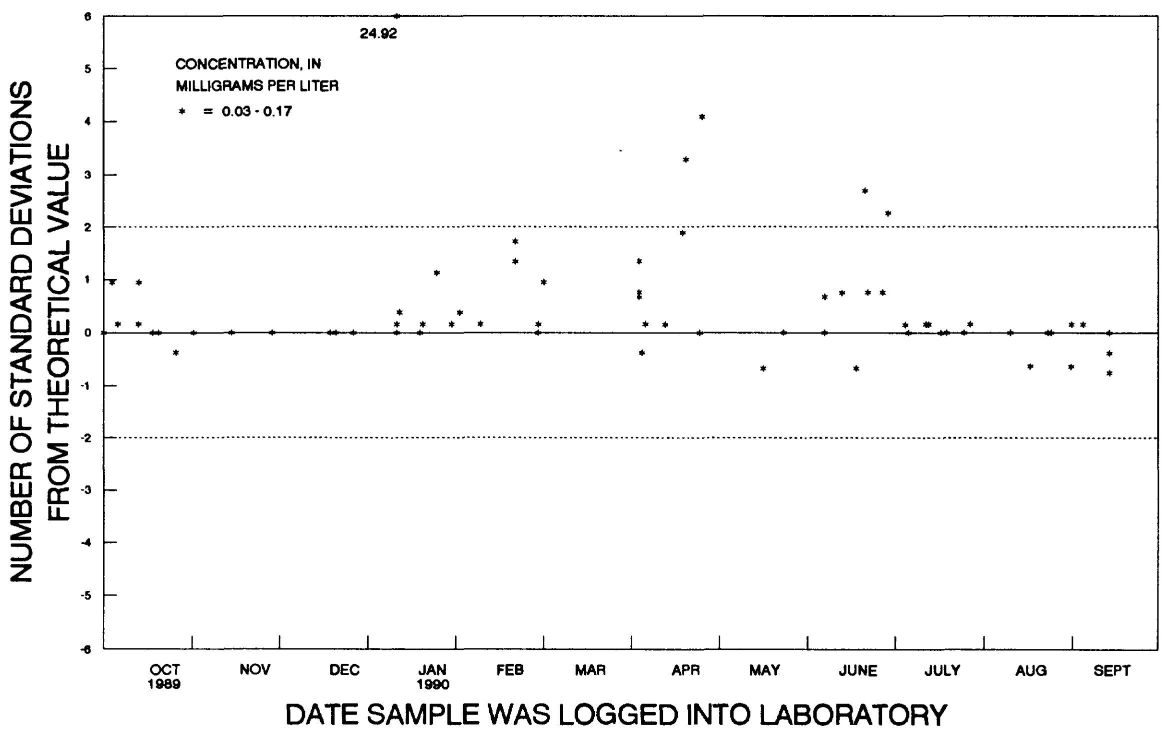

Figure 80. Potassium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

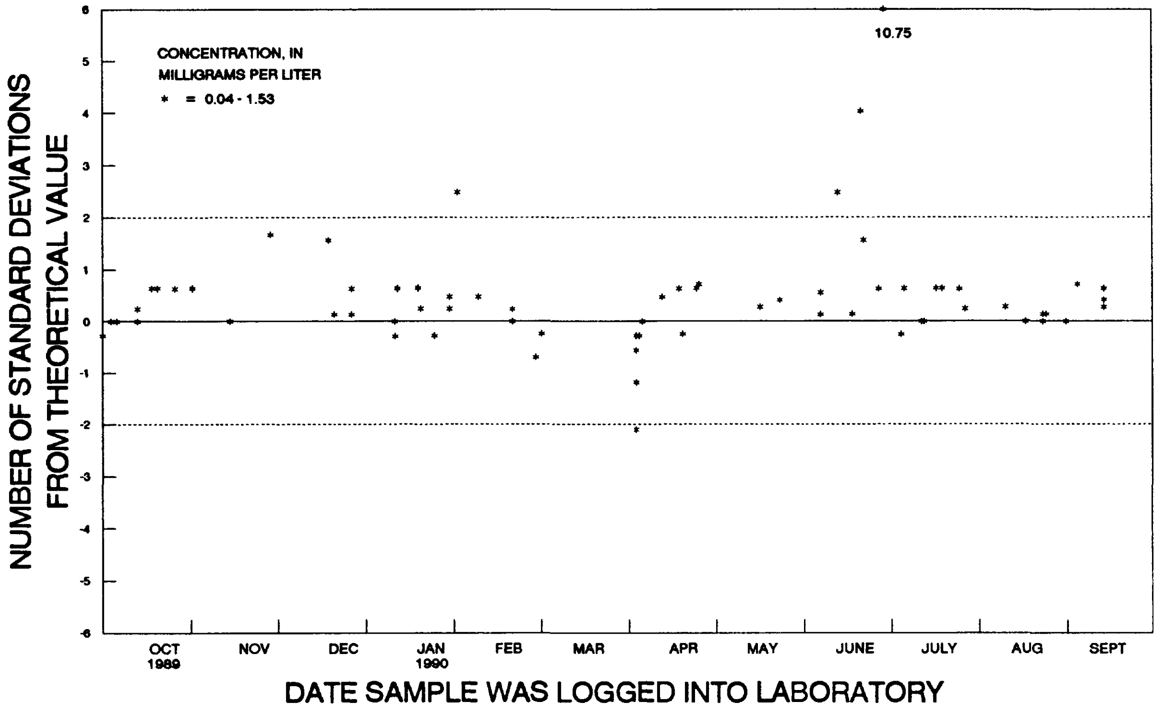

Figure 81. Sodium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

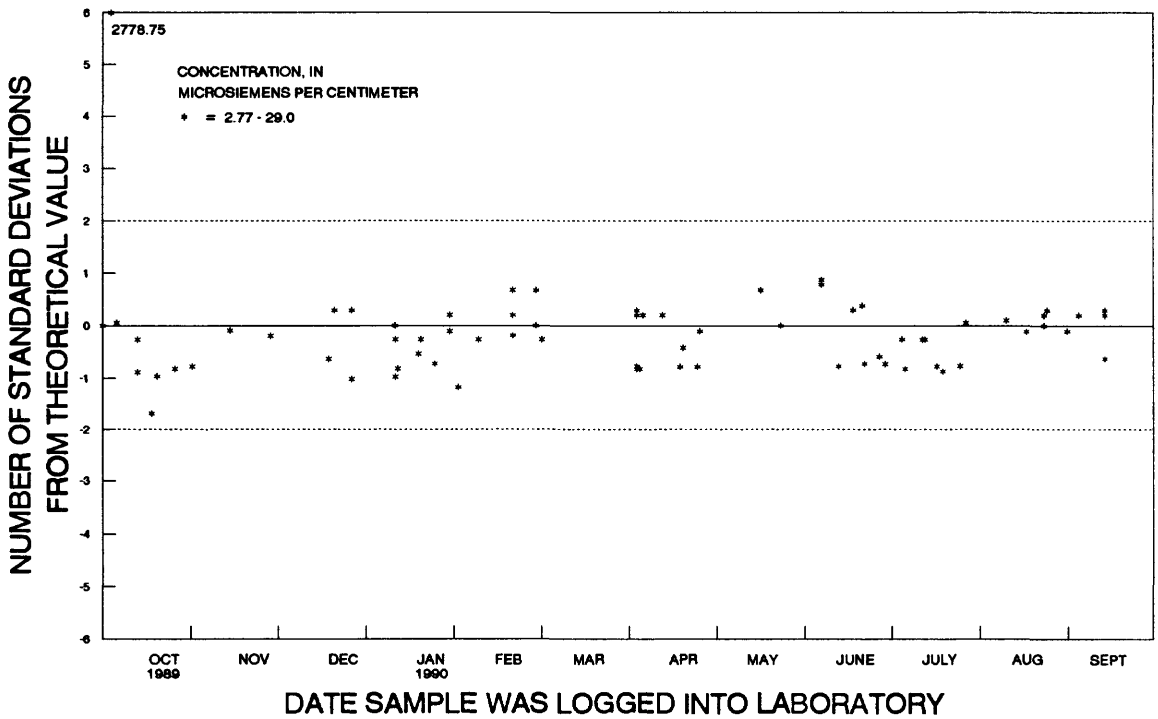

Figure 82. Specific conductance, dissolved, low ionic strength, (electrometric, Wheatstone bridge) data from the National Water-Quality Laboratory.

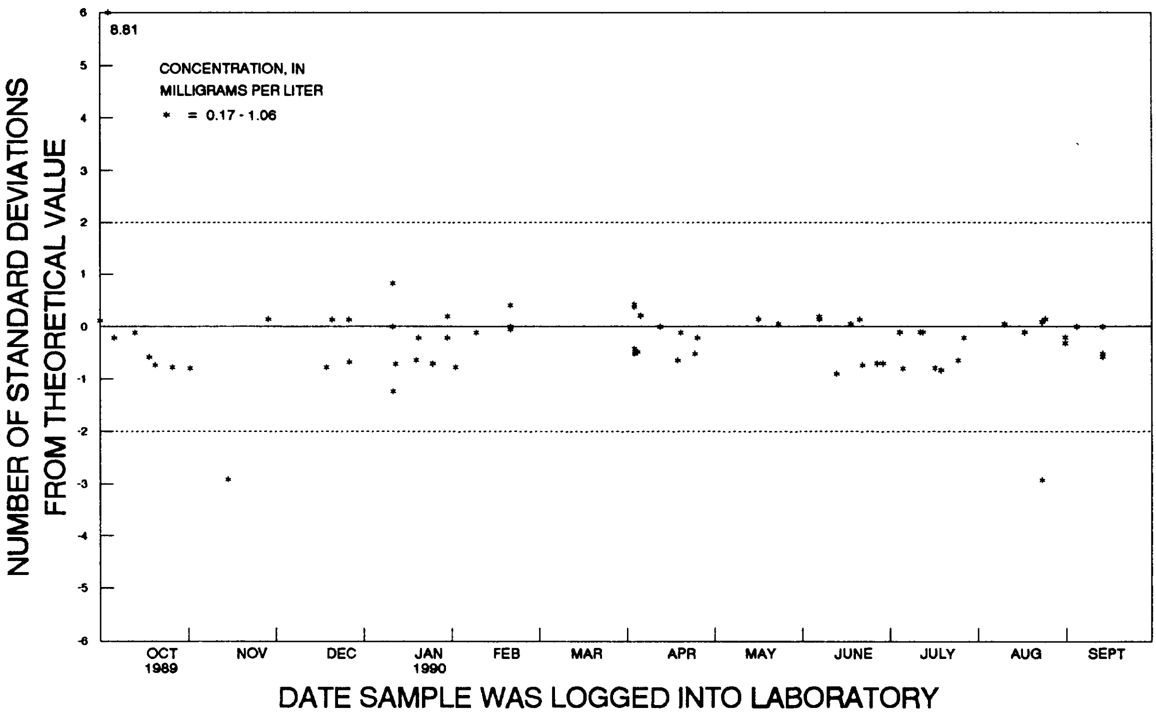

Figure 83. Sulfate, dissolved, low ionic strength, (ion chromatography) data from the National Water-Quality Laboratory.

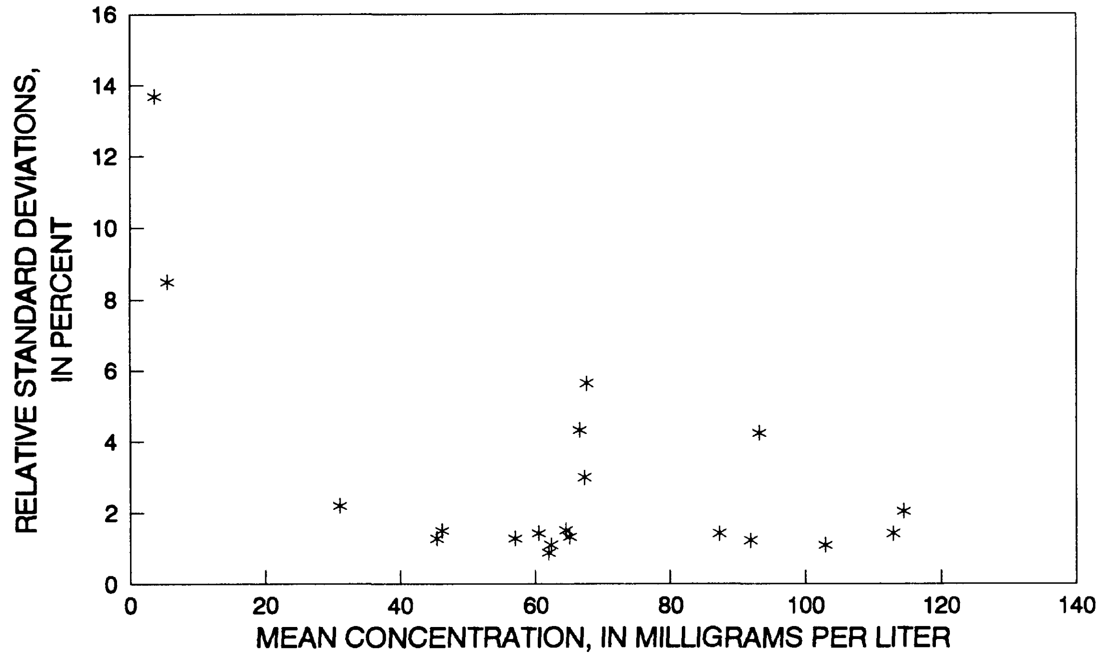

Figure 84. Precision data for alkalinity, total, (electrometric titration) data from the National Water-Quality Laboratory.

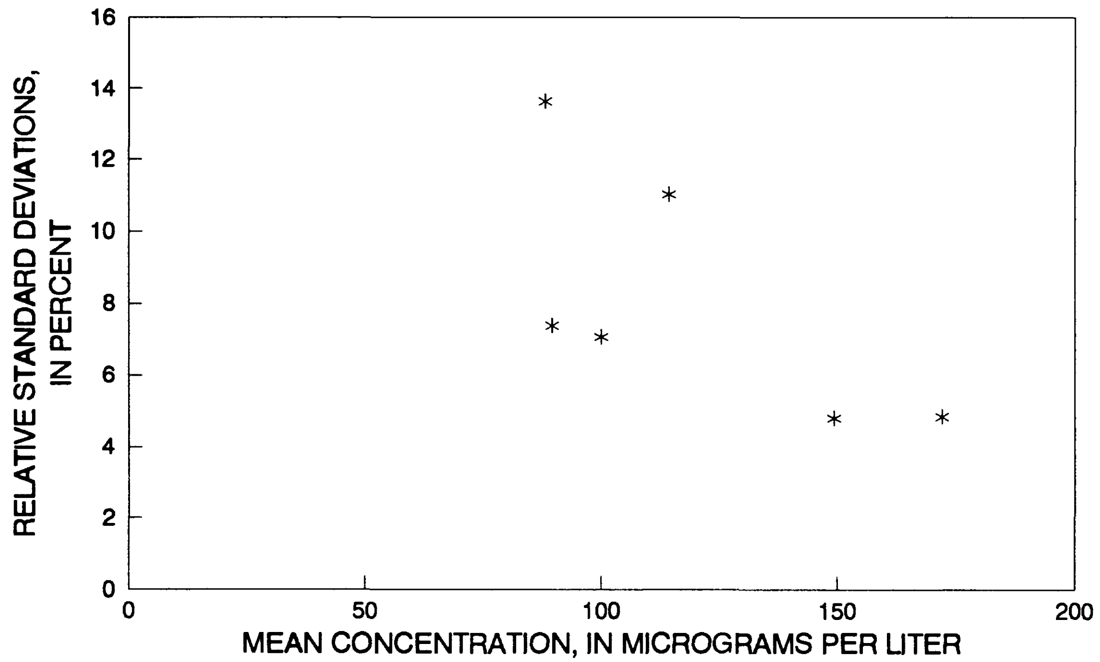

Figure 85. Precision data for aluminum, dissolved, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

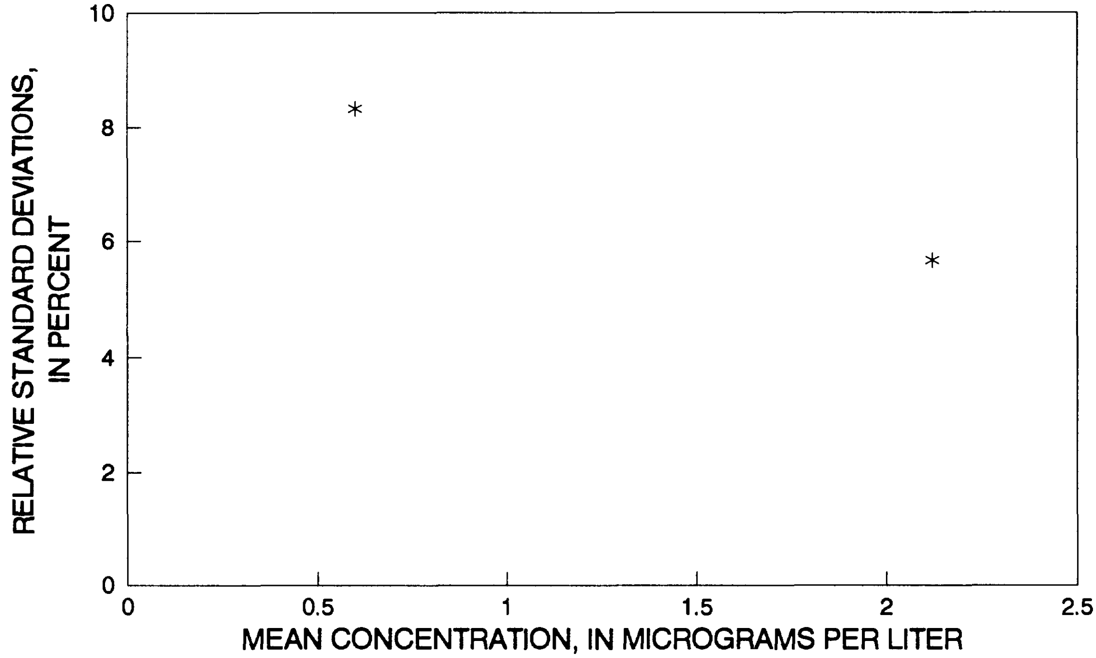

Figure 86. Precision data for aluminum, total recoverable, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

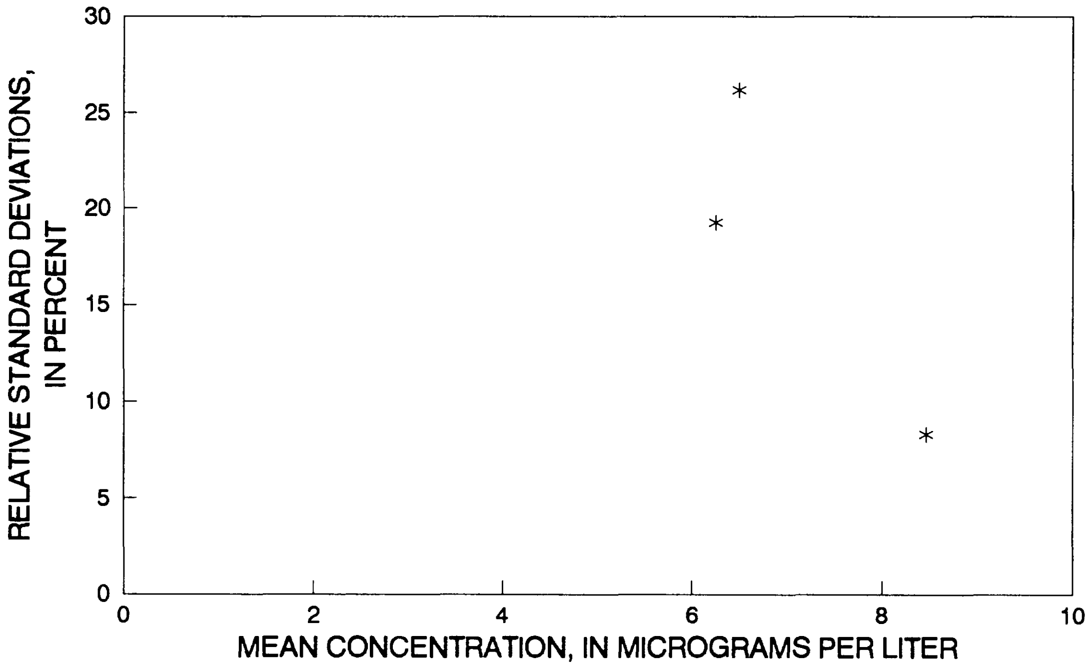

Figure 87. Precision data for antimony, dissolved, (atomic absorption spectrometry, hydride) data from the National Water-Quality Laboratory.

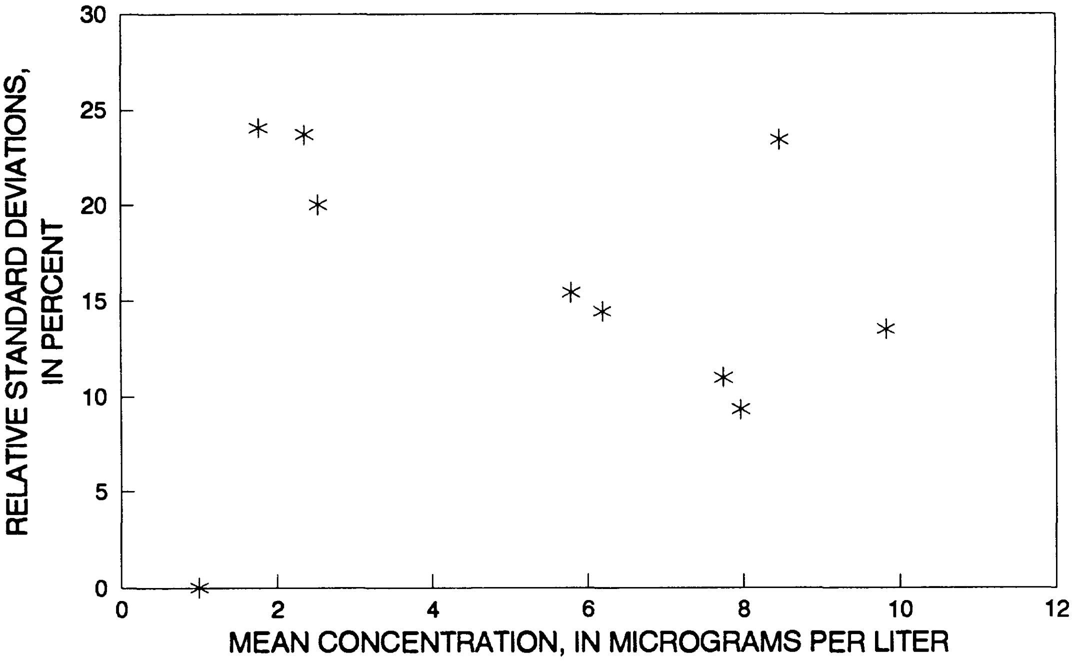

Figure 88. Precision data for arsenic, dissolved and total, (atomic absorption spectrometry, hydride) data from the National Water-Quality Laboratory.

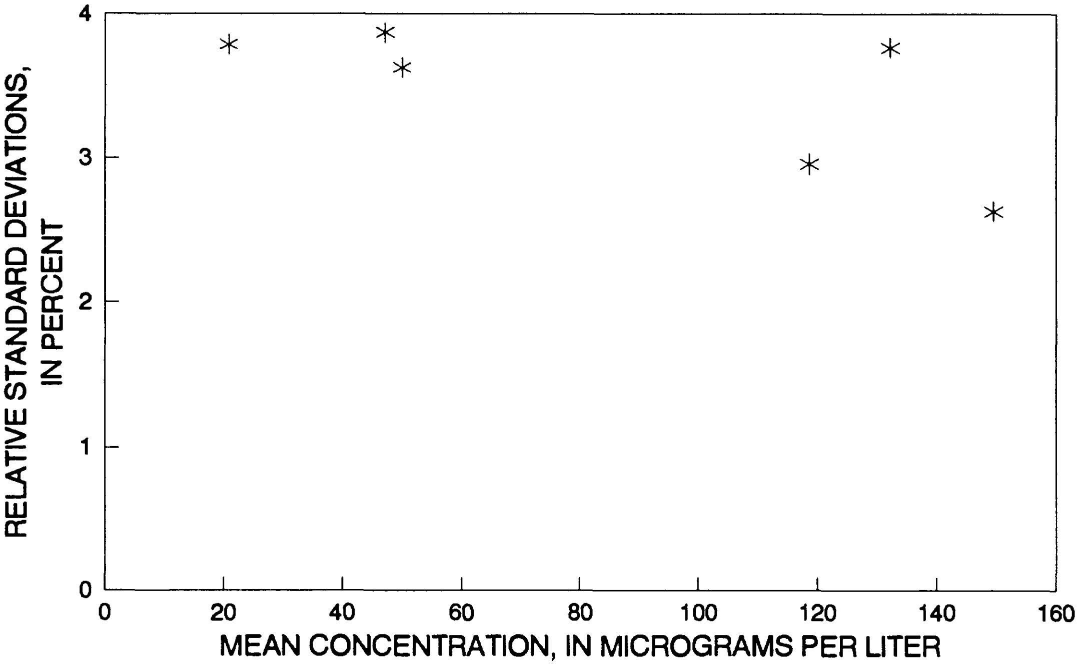

Figure 89. Precision data for barium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

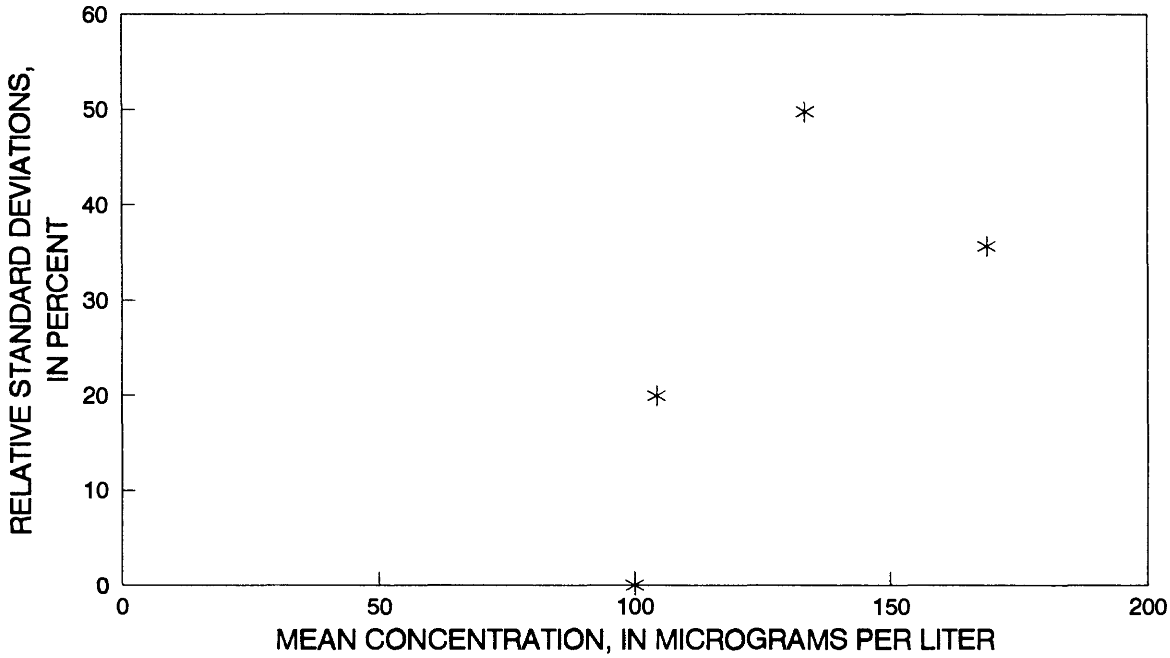

Figure 90. Precision data for barium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

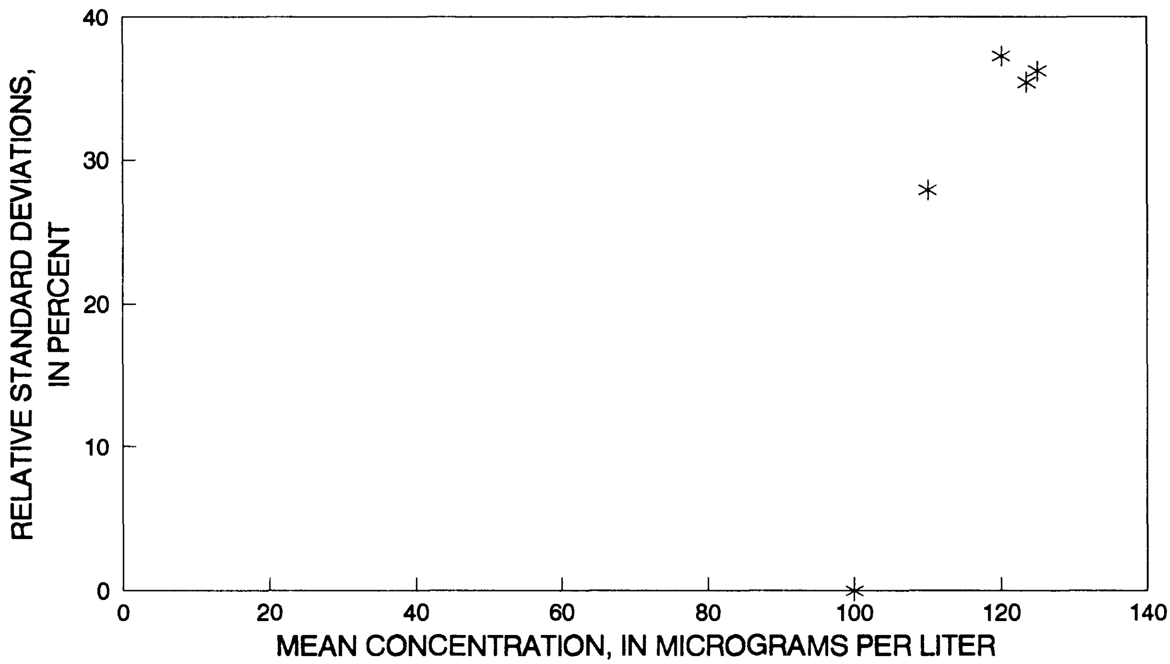

Figure 91. Precision data for barium, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

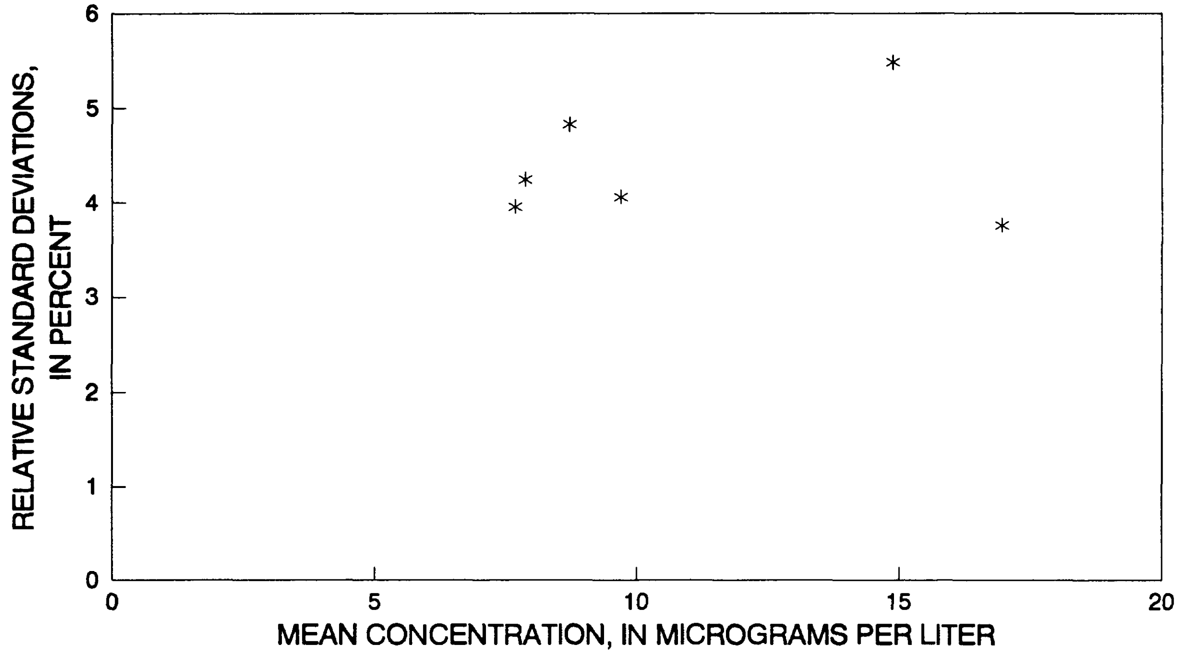

Figure 92. Precision data for beryllium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

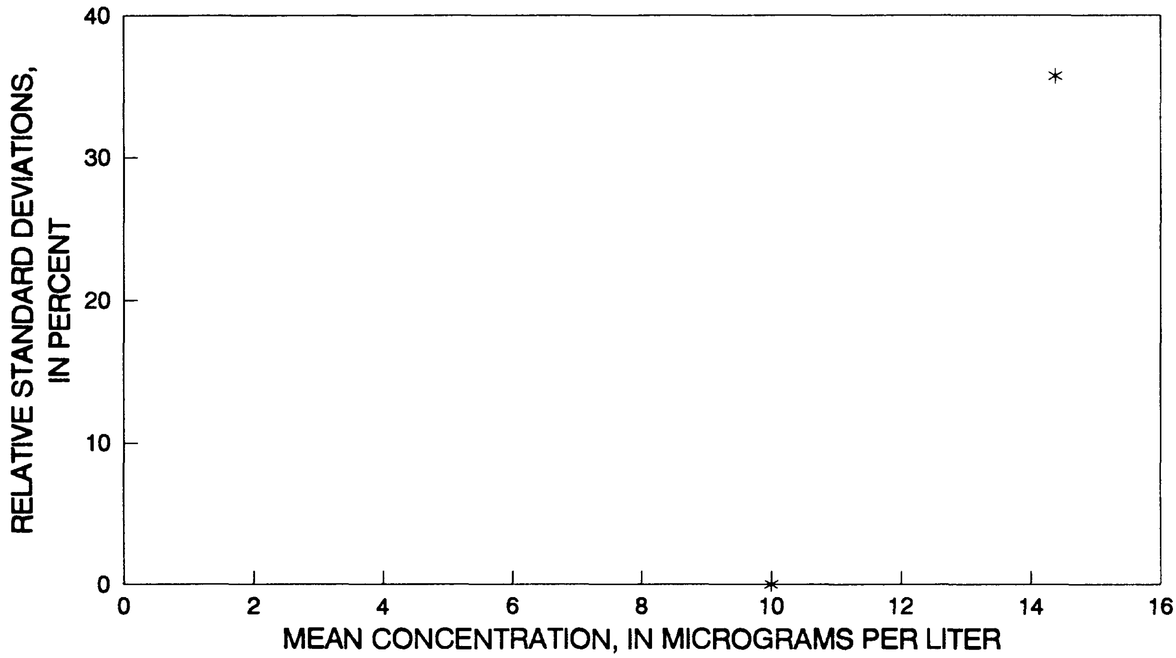

Figure 93. Precision data for beryllium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

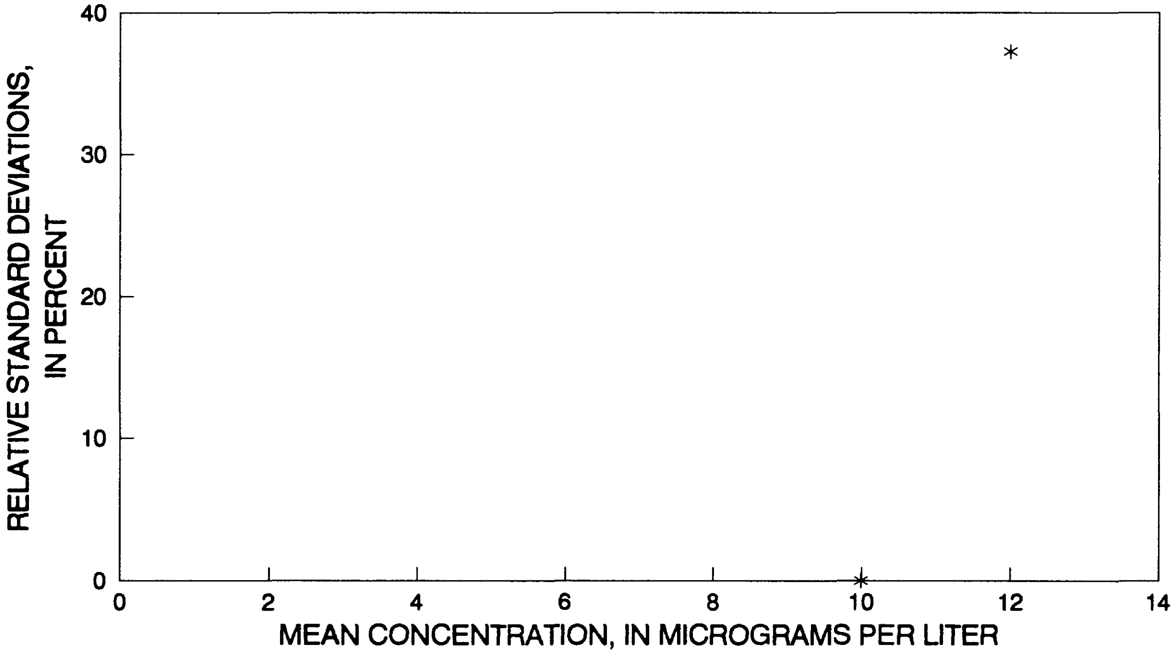

Figure 94. Precision data for beryllium, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

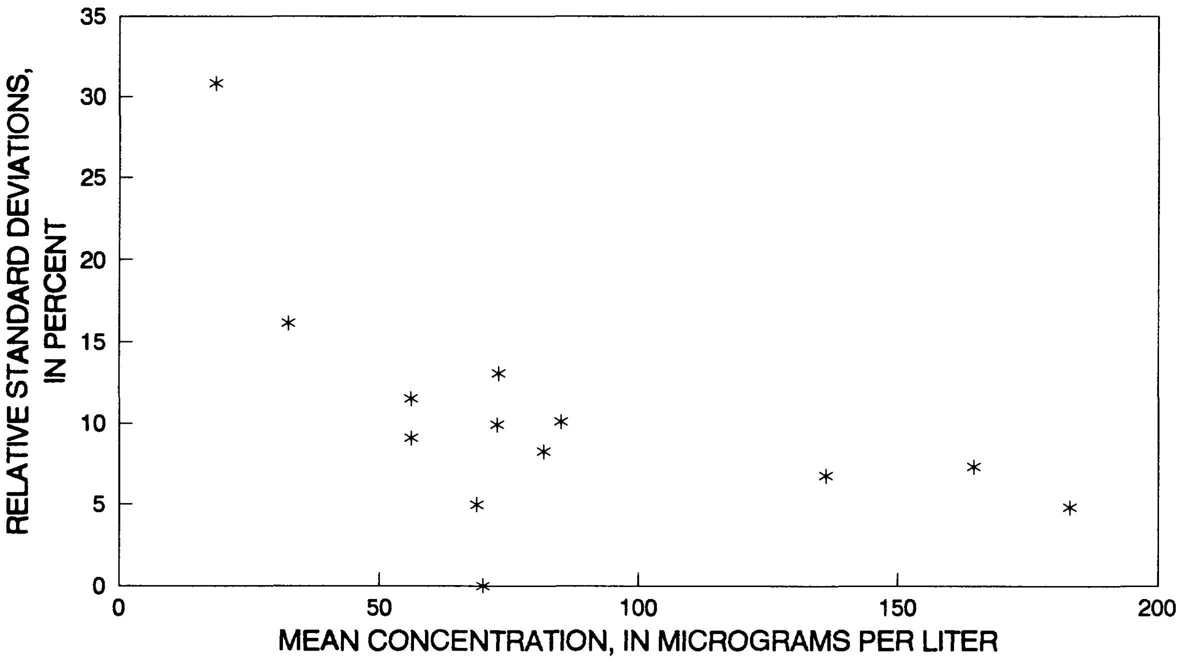

Figure 95. Precision data for boron, dissolved, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

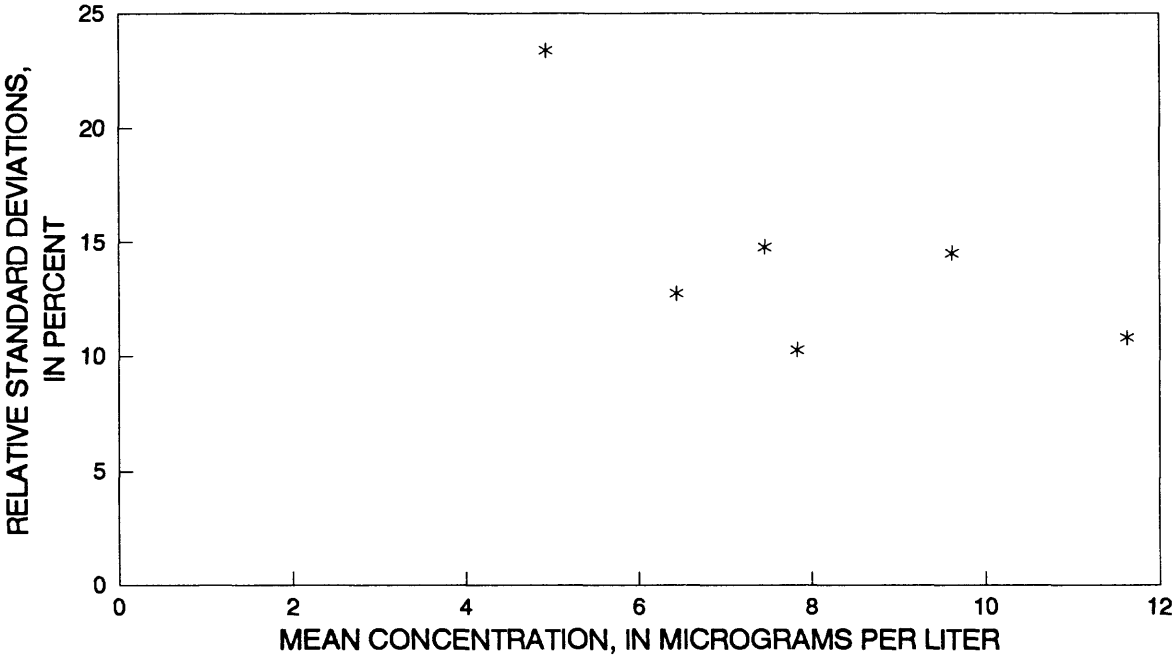

Figure 96. Precision data for cadmium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

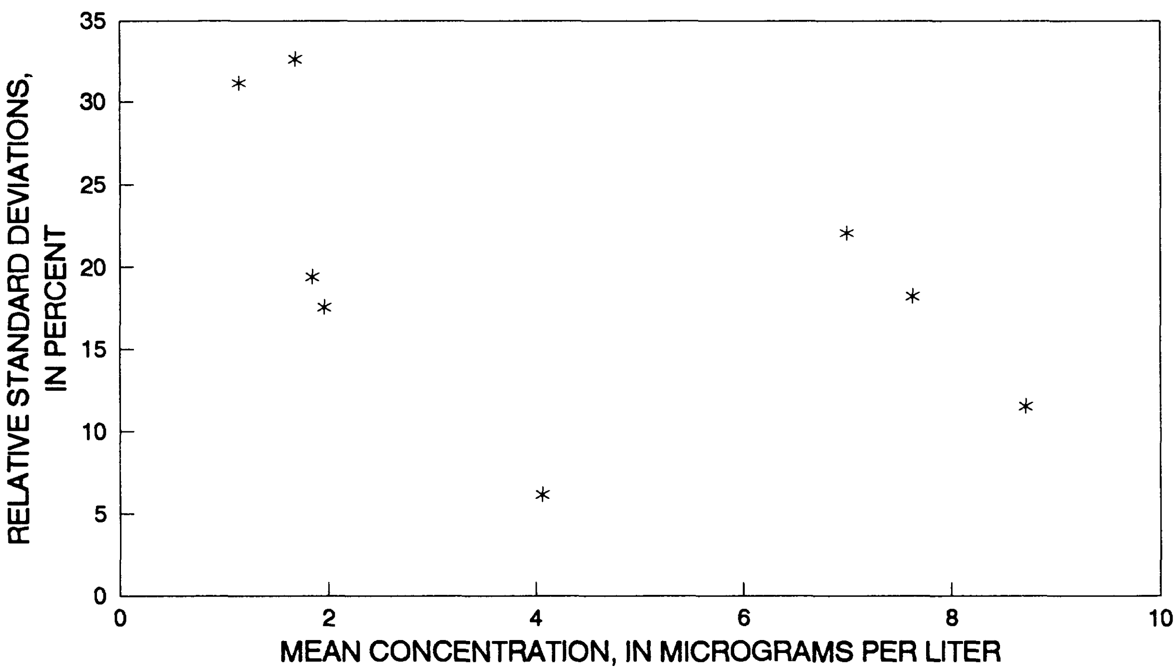

Figure 97. Precision data for cadmium, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

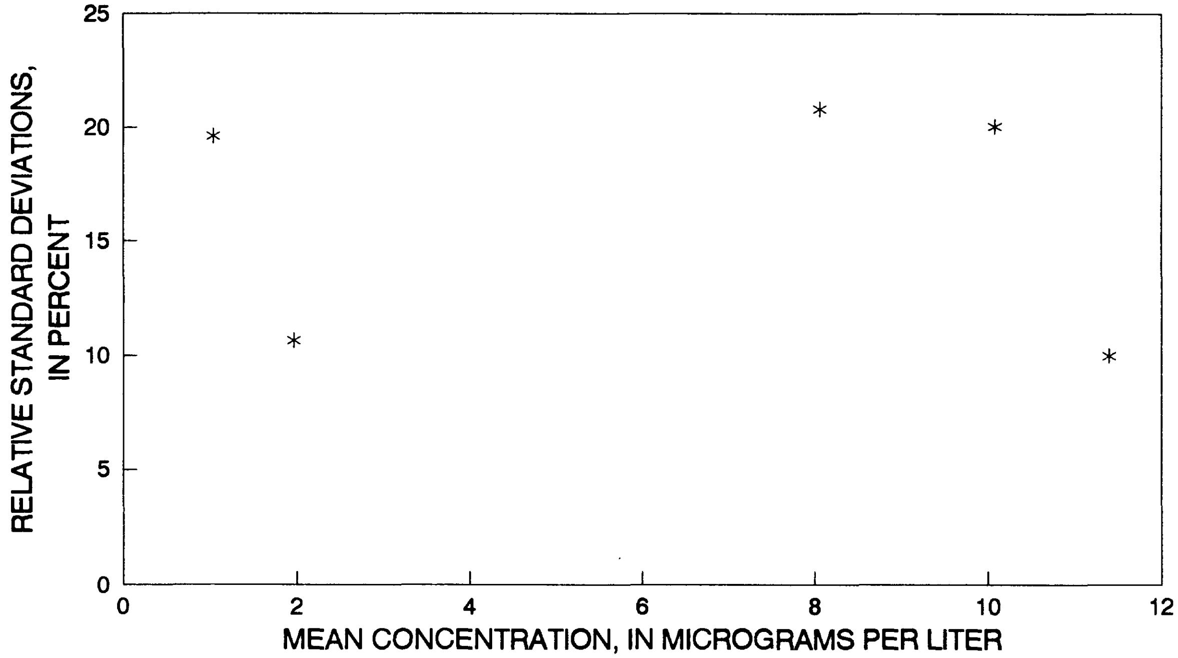

Figure 98. Precision data for cadmium, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

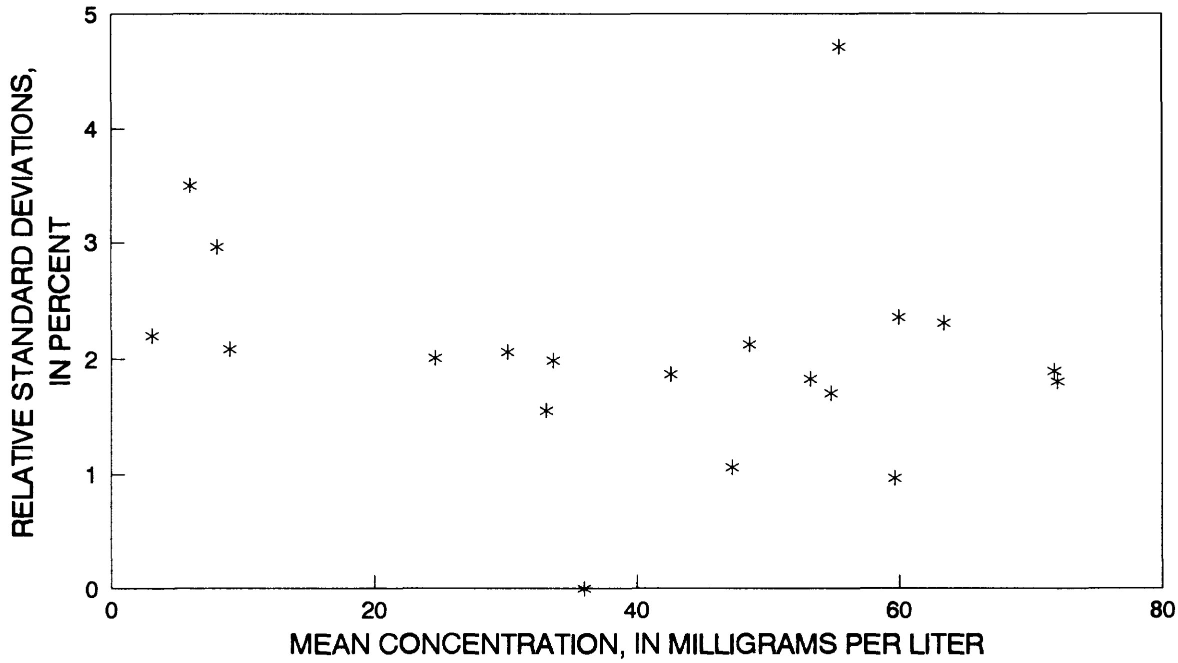

Figure 99. Precision data for calcium, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

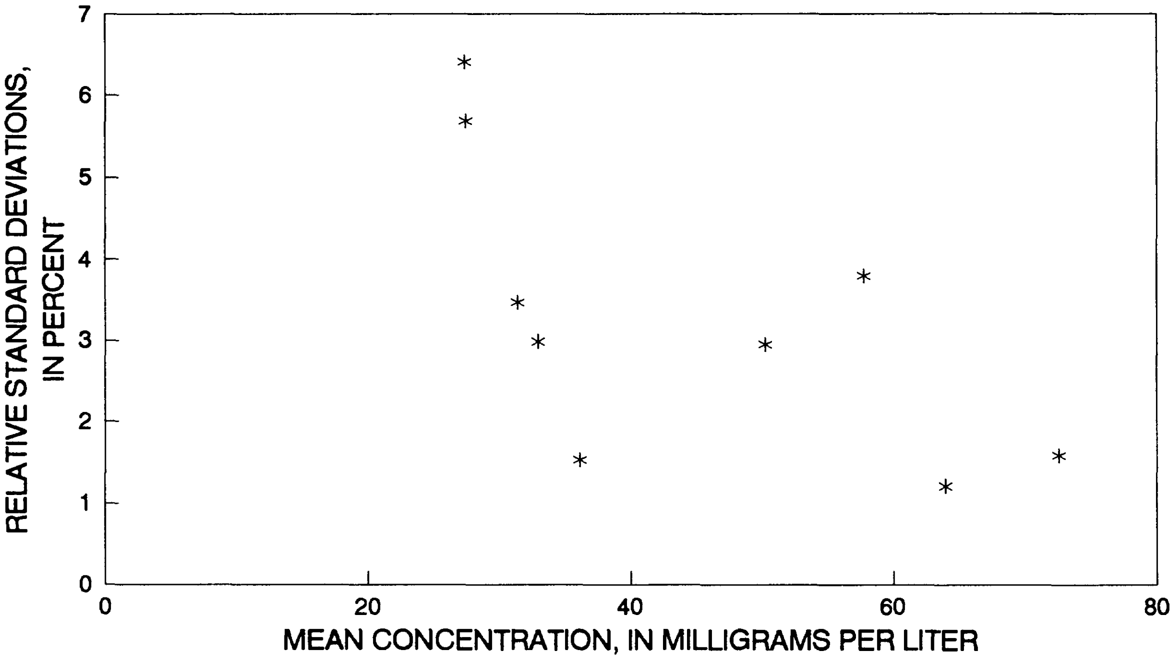

Figure 100. Precision data for calcium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

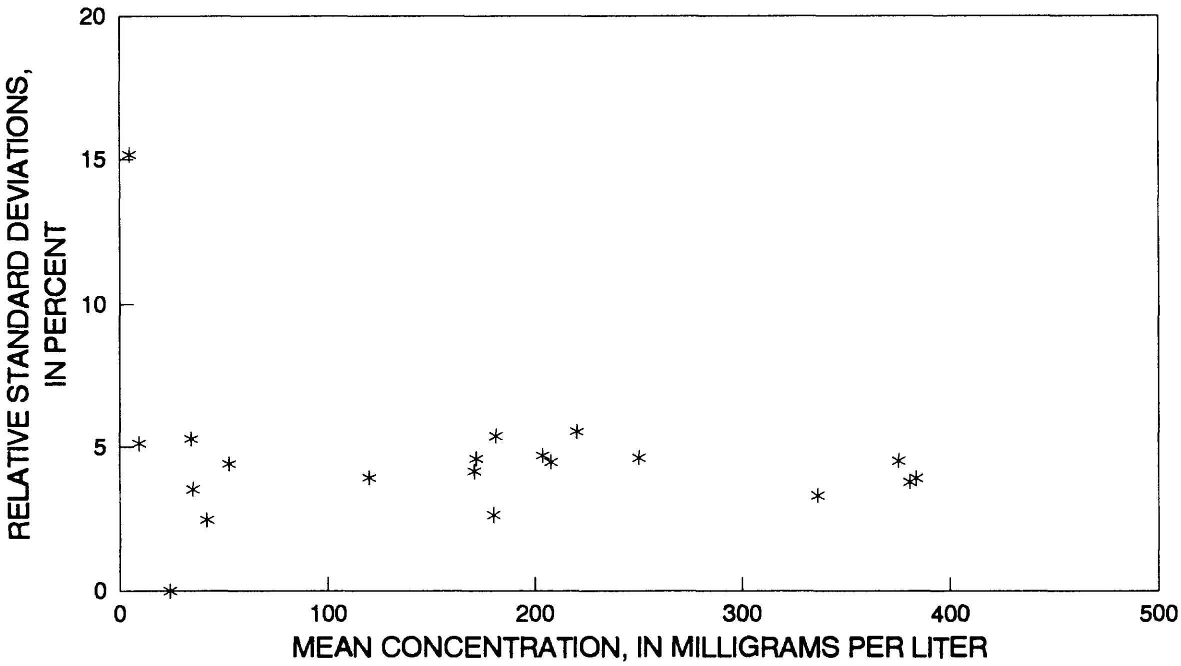

Figure 101. Precision data for chloride, dissolved, (colorimetric and ion chromatography) data from the National Water-Quality Laboratory.

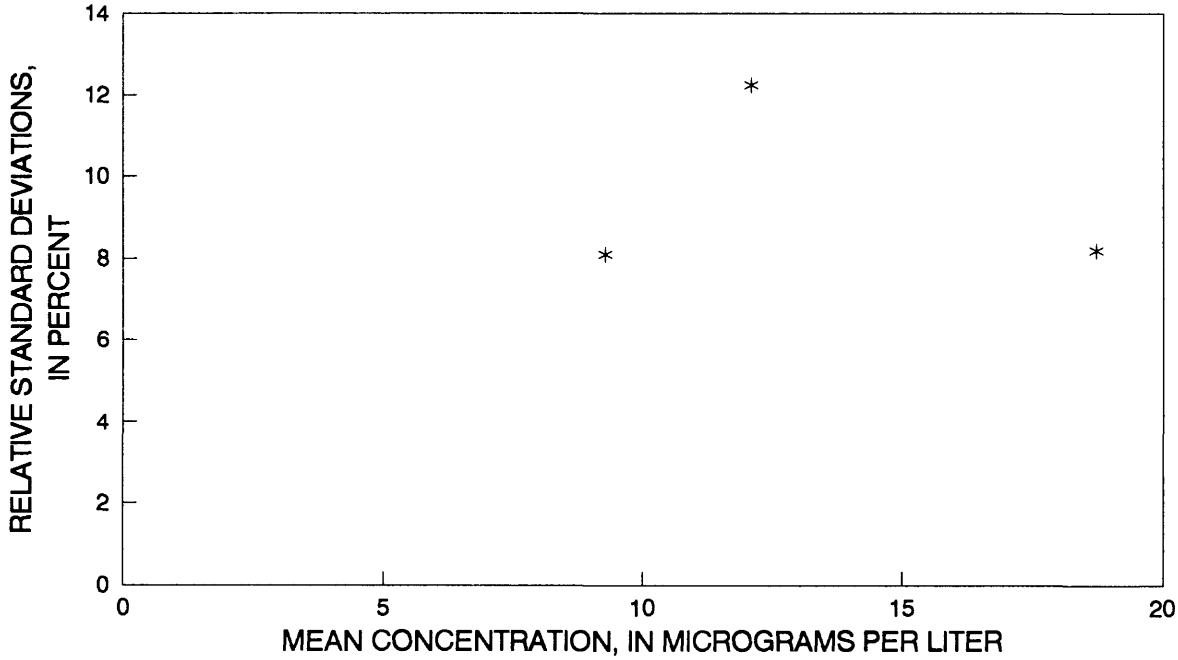

Figure 102. Precision data for chromium, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

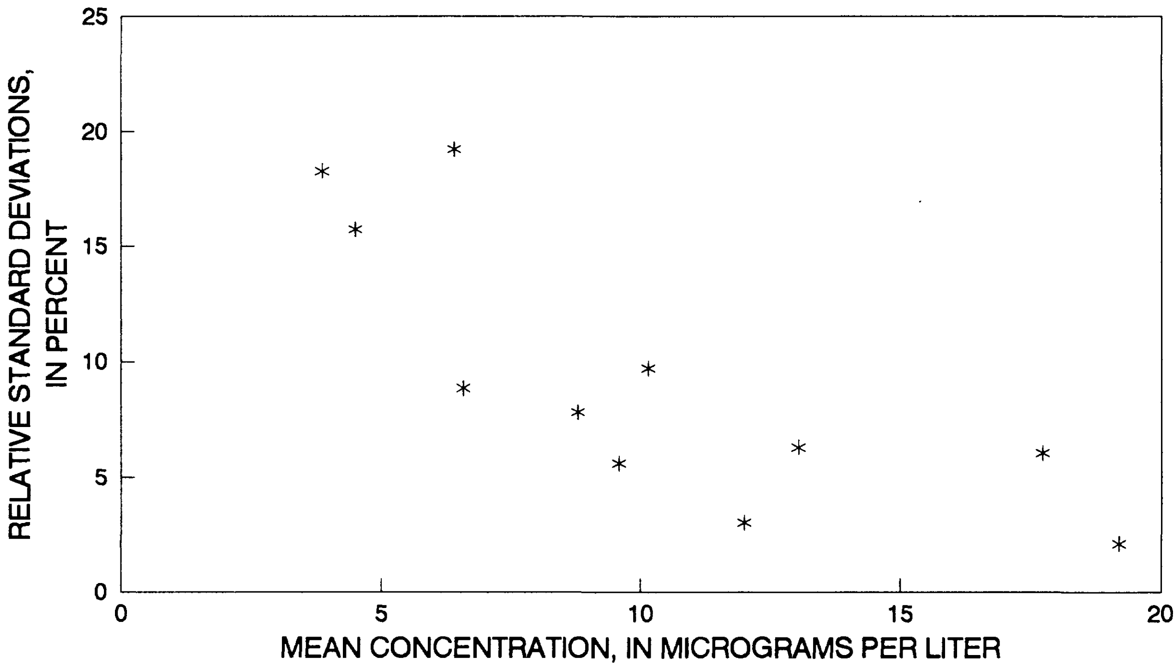

Figure 103. Precision data for chromium, dissolved, (direct-current plasma emission spectrometry) data from the National Water-Quality Laboratory.

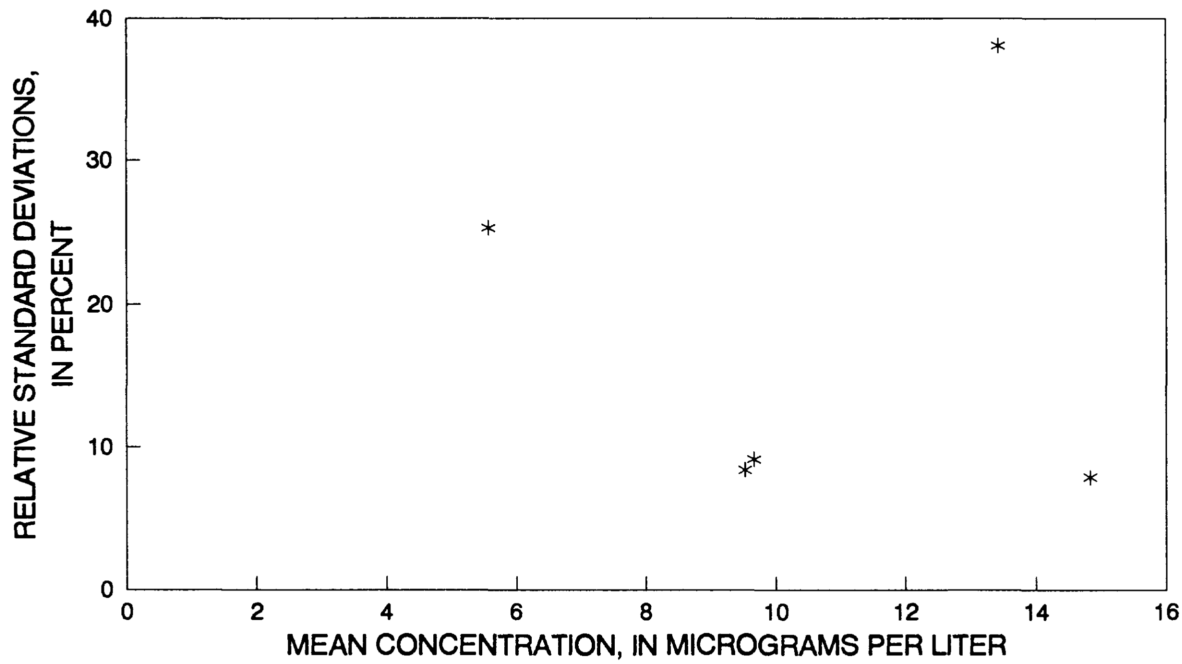

Figure 104. Precision data for chromium, total recoverable, (direct-current plasma emission spectrometry) data frᵔm the National Water-Quality Laboratory.

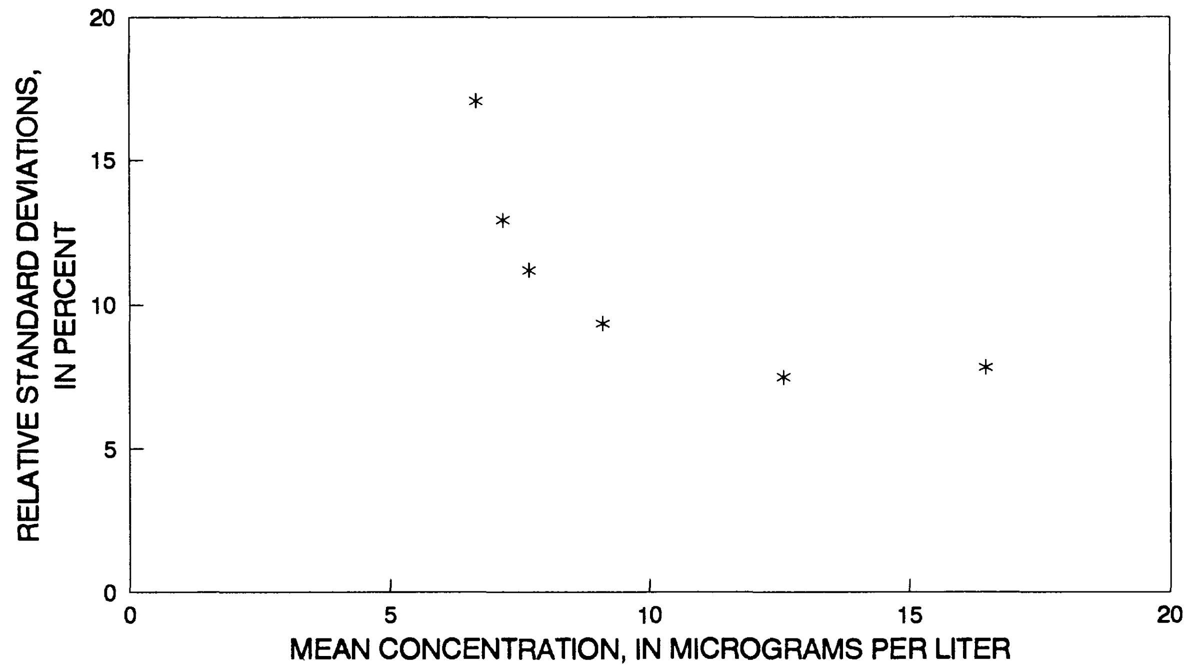

Figure 105. Precision data for cobalt, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

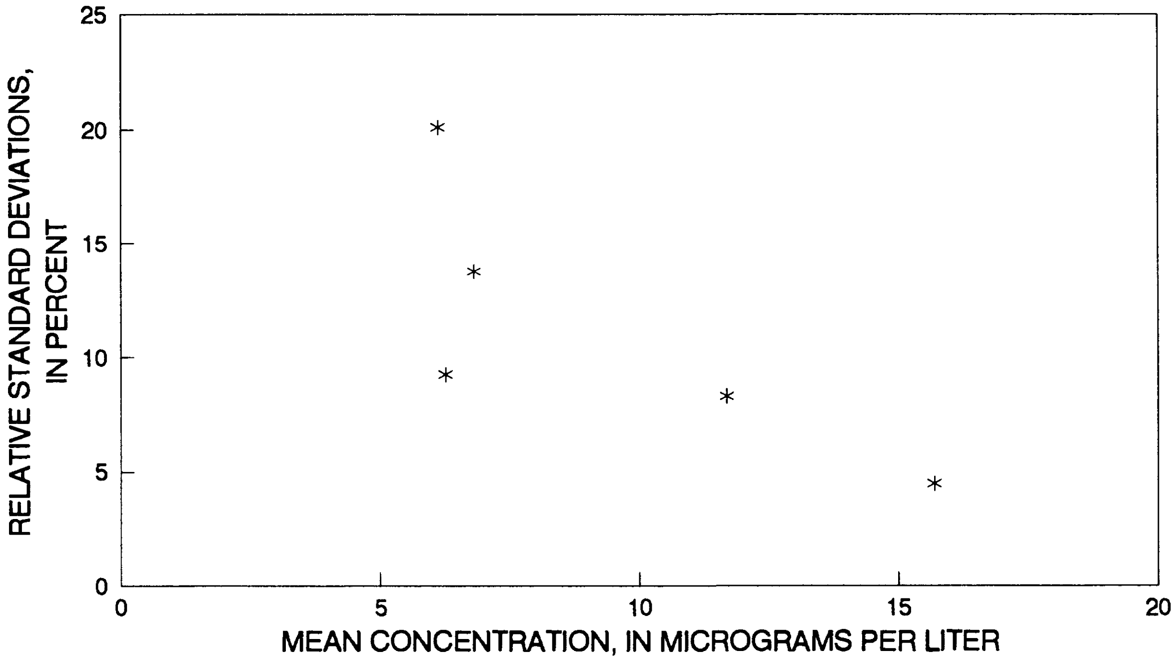

Figure 106. Precision data for cobalt, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

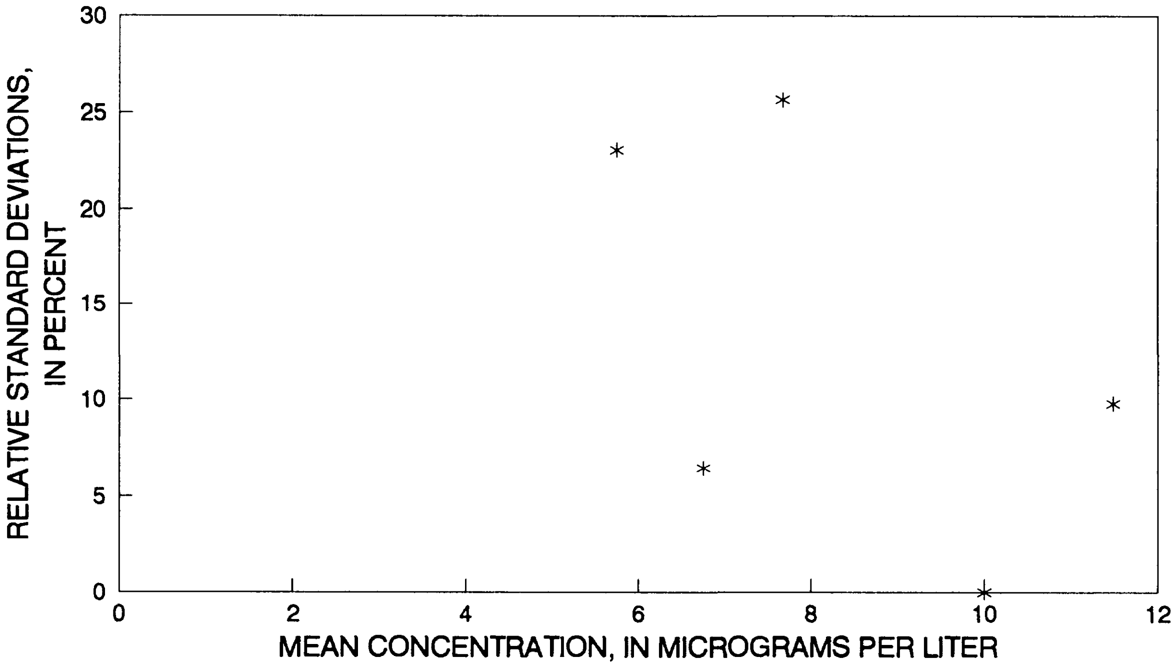

Figure 107. Precision data for cobalt, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

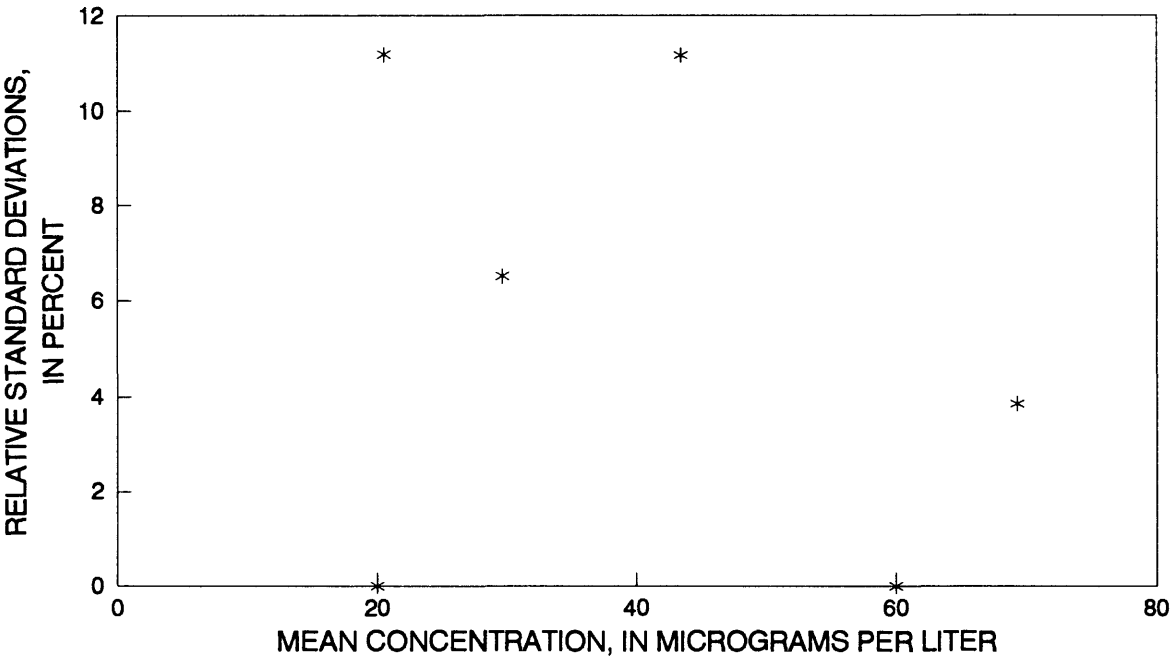

Figure 108. Precision data for copper, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

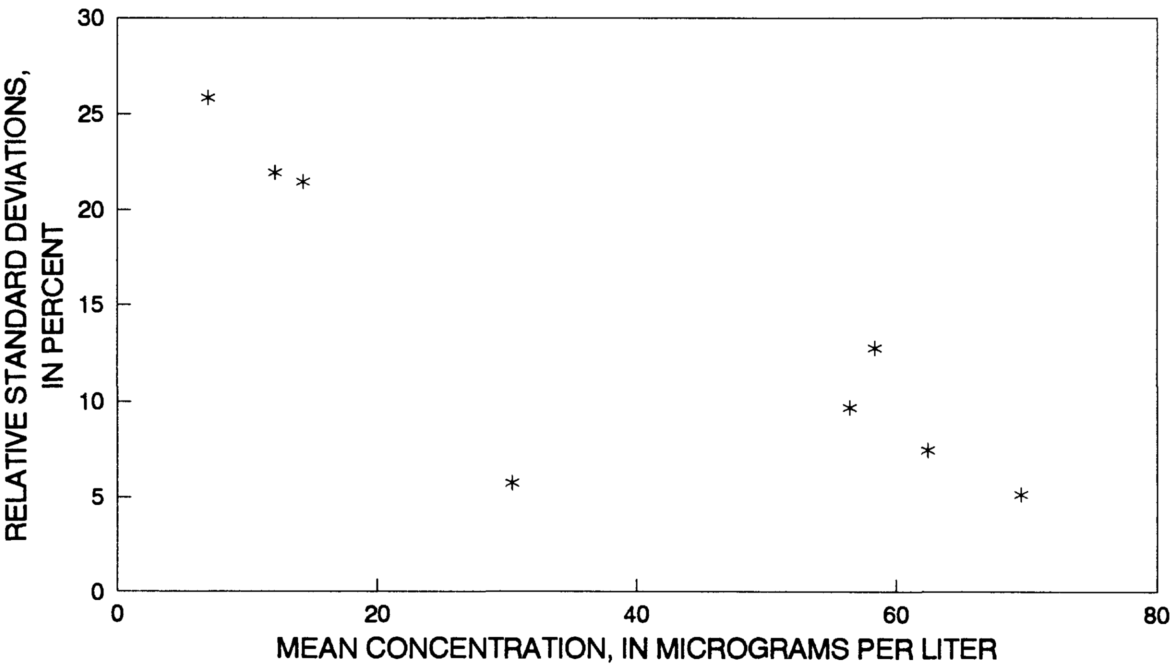

Figure 109. Precision data for copper, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

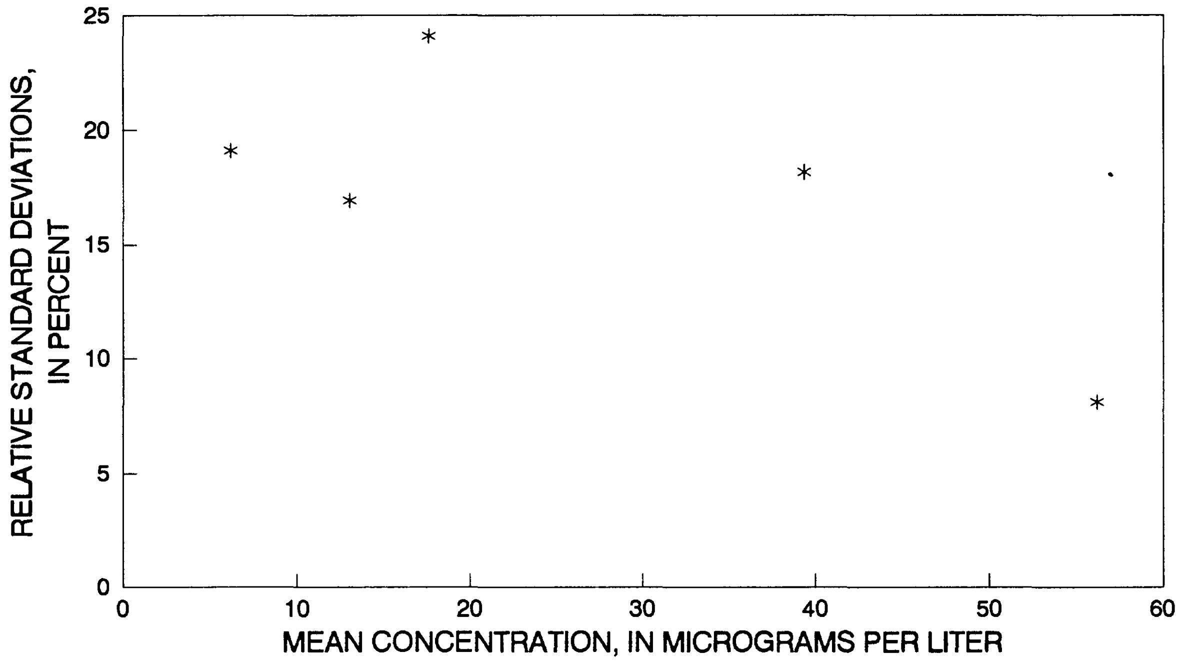

Figure 110. Precision data for copper, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

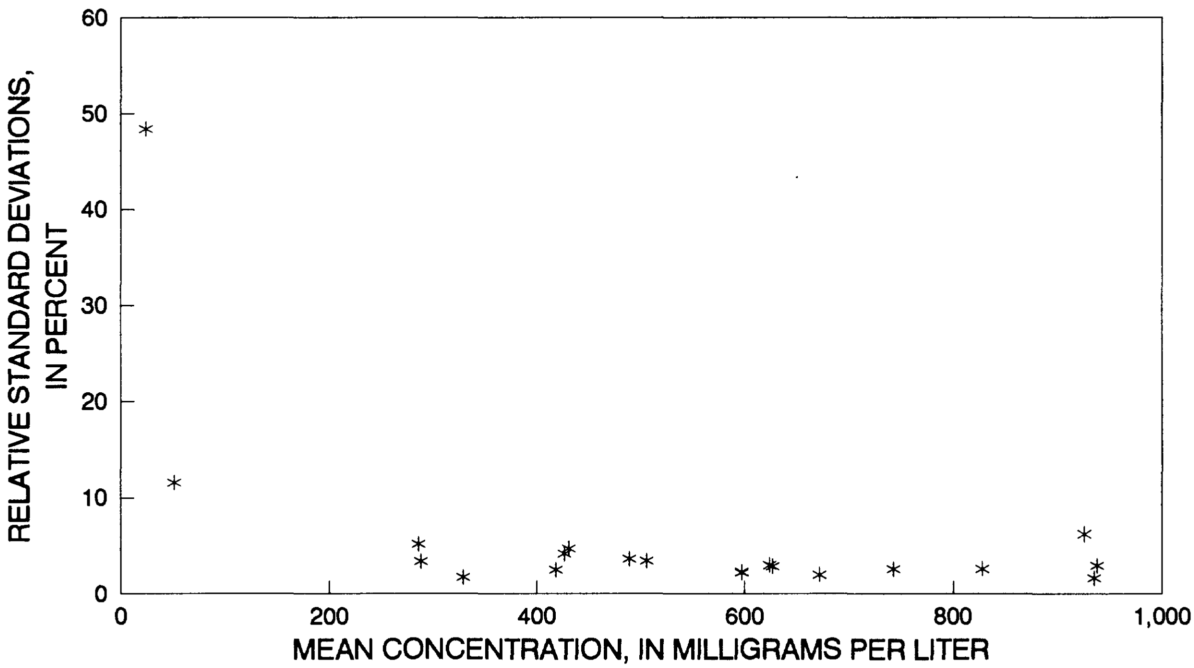

Figure 111. Precision data for dissolved solids, (gravimetric) data from the National Water-Quality Laboratory.

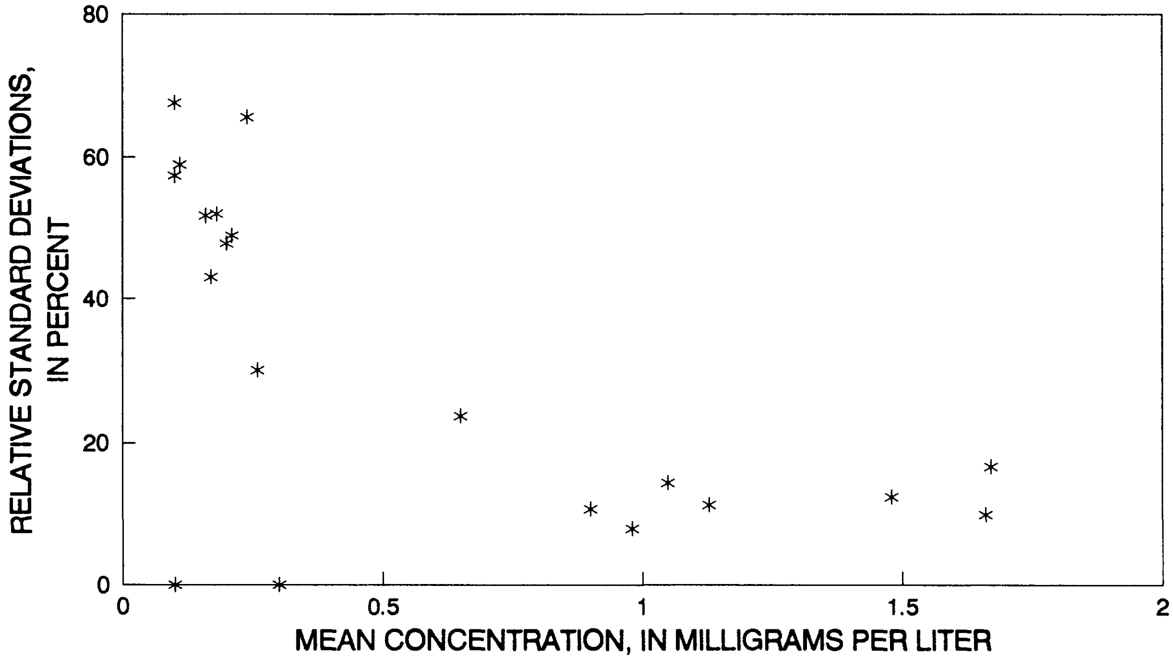

Figure 112. Precision data for fluoride, dissolved, (ion-selective electrode and ion chromatography) data from the National Water-Quality Laboratory.

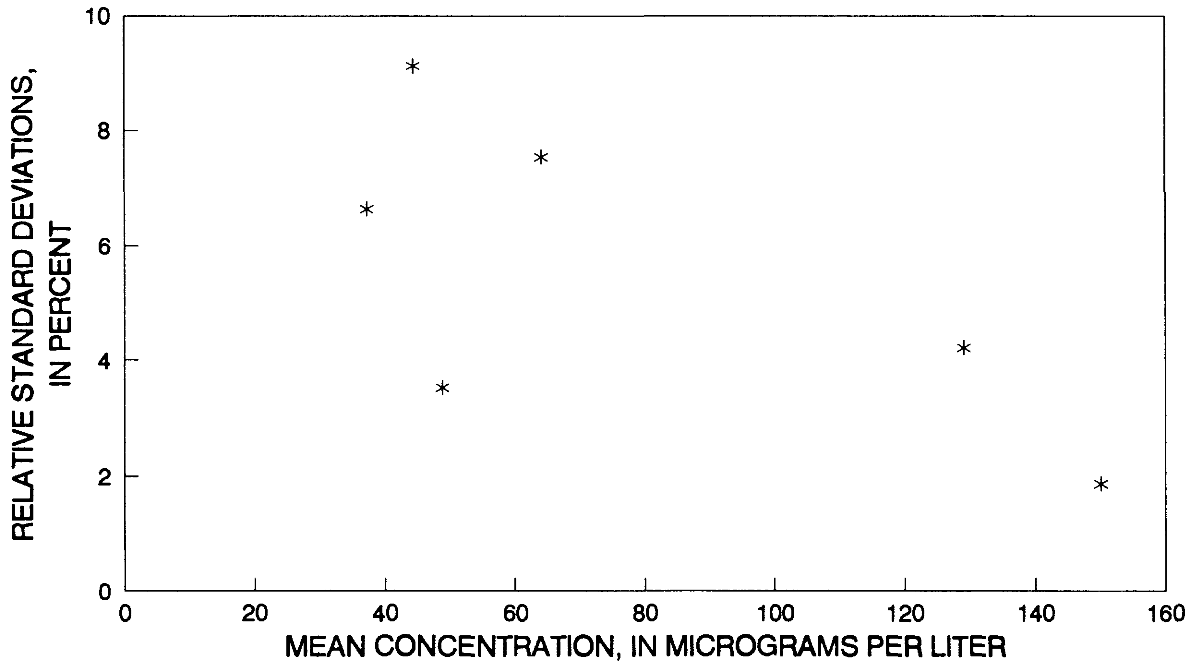

Figure 113. Precision data for iron, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

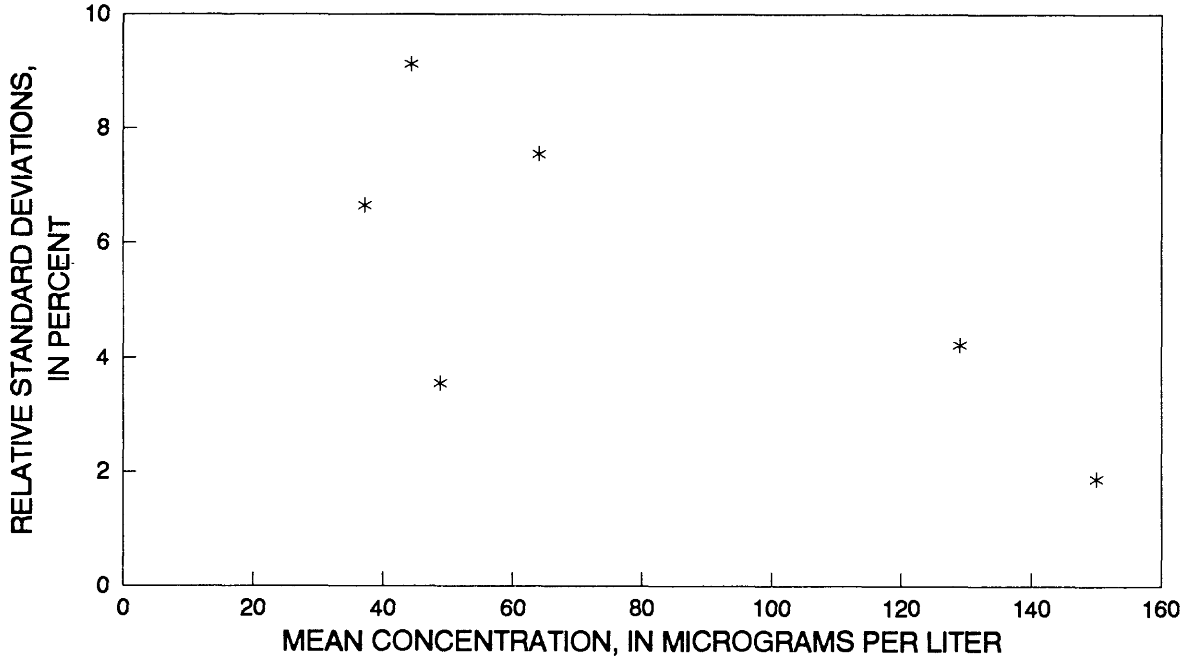

Figure 114. Precision data for iron, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

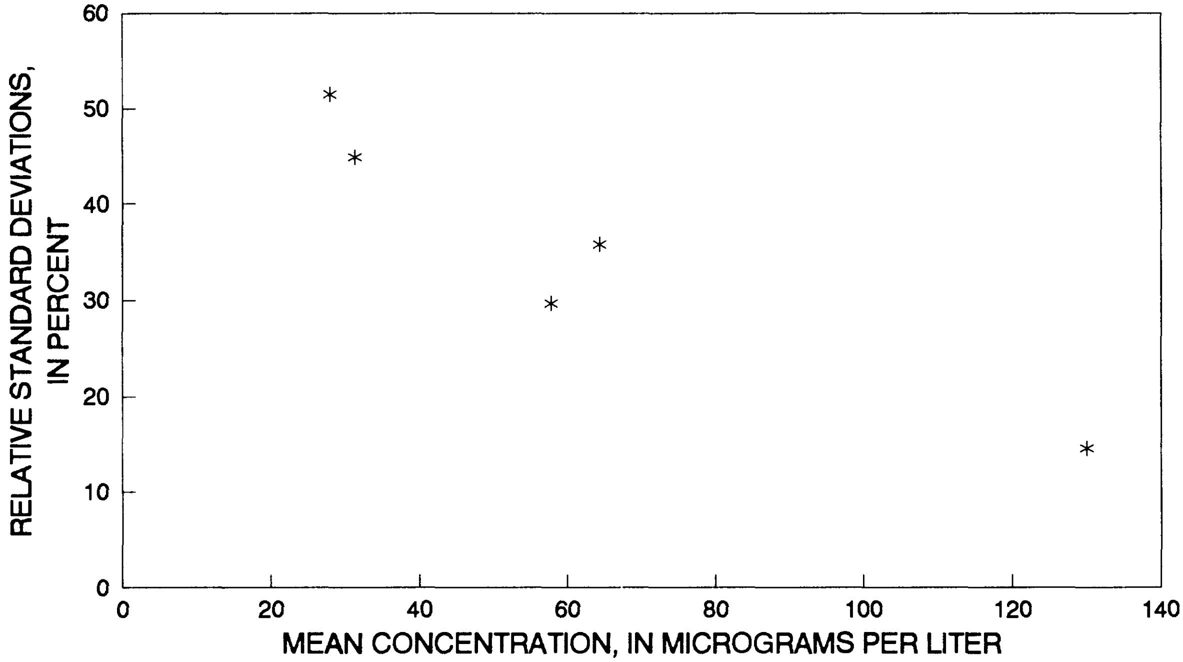

Figure 115. Precision data for iron, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

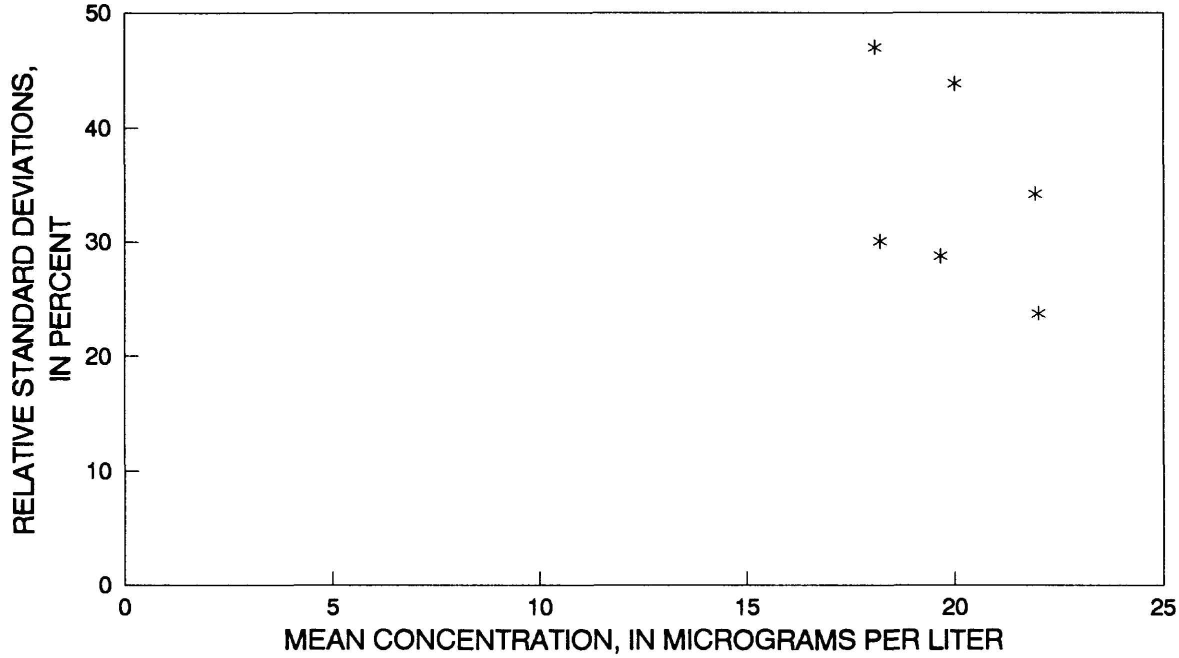

Figure 116. Precision data for lead, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

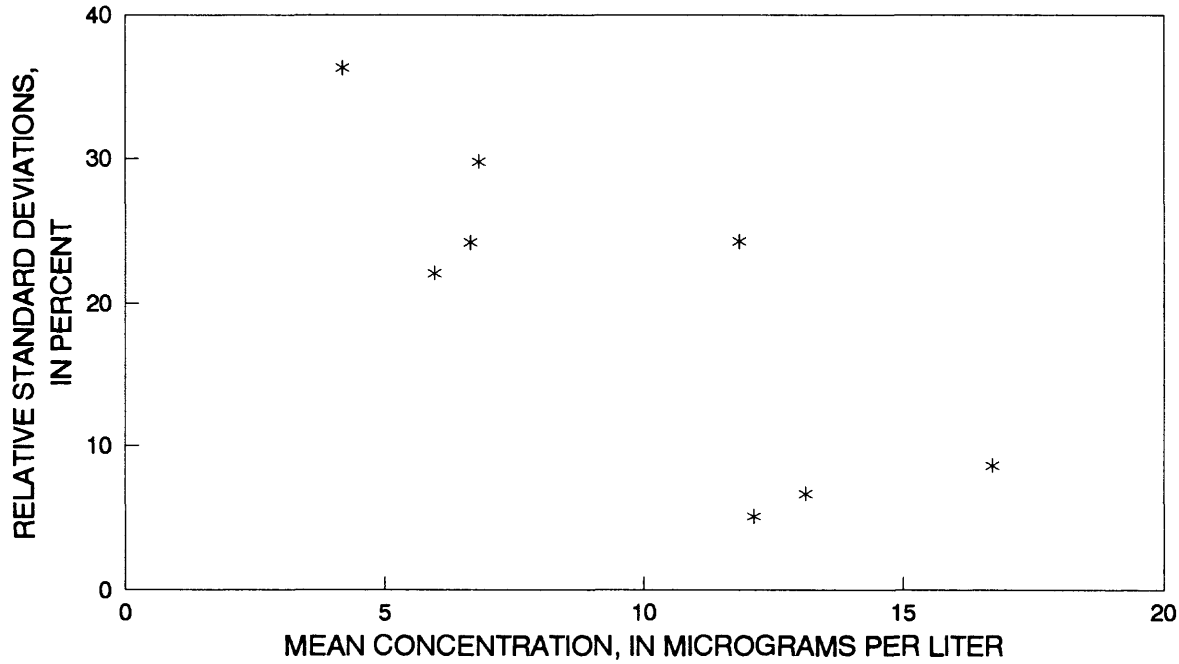

Figure 117. Precision data for lead, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

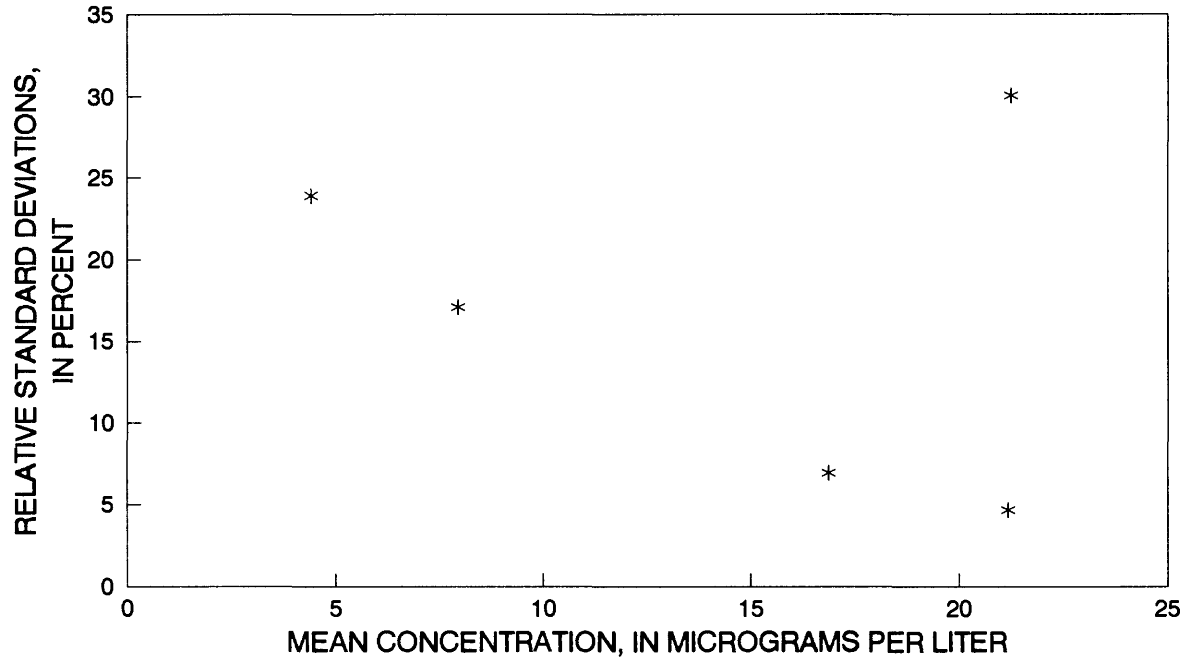

Figure 118. Precision data for lead, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

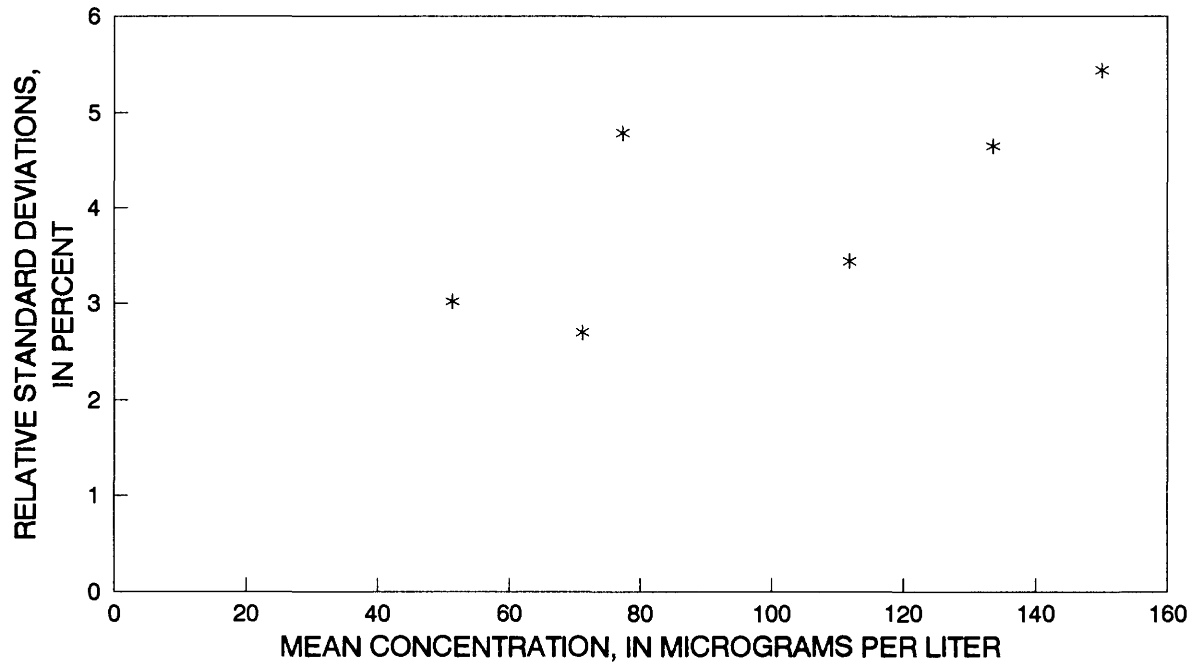

Figure 119. Precision data for lithium, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

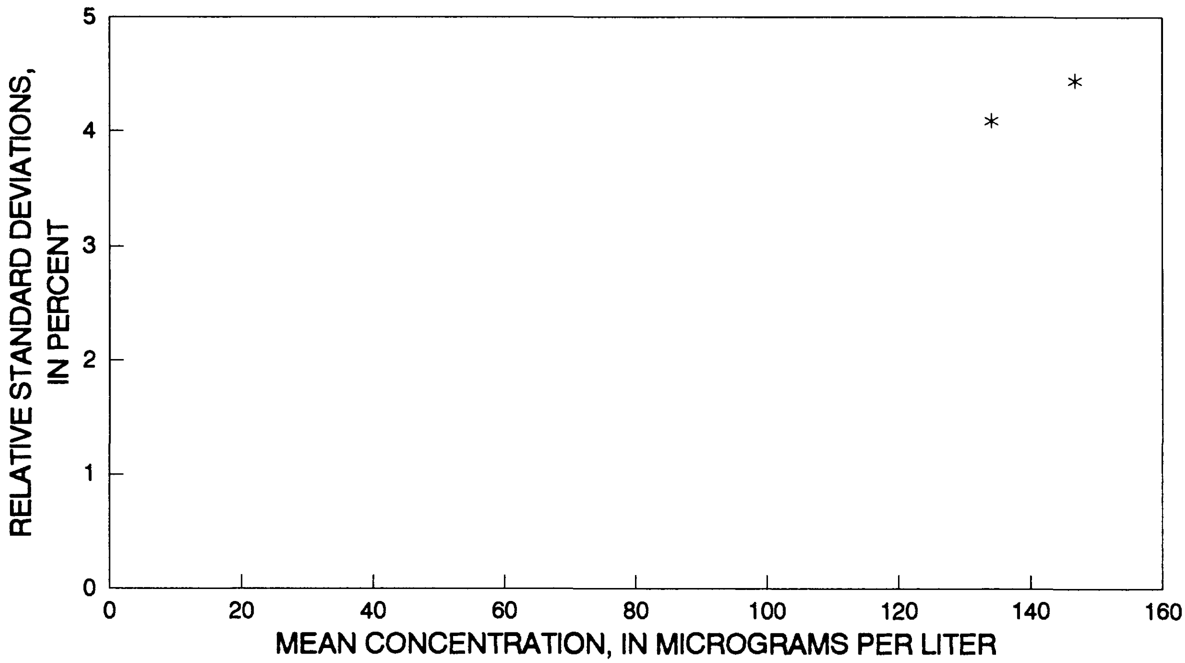

Figure 120. Precision data for lithium, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

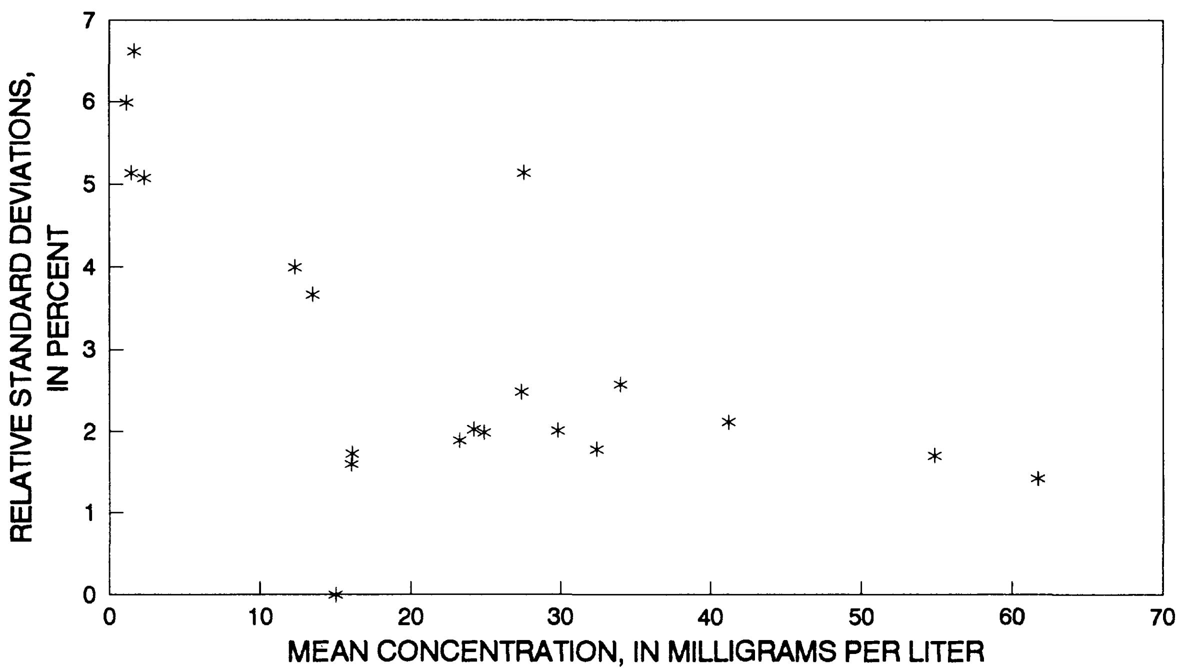

Figure 121. Precision data for magnesium, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

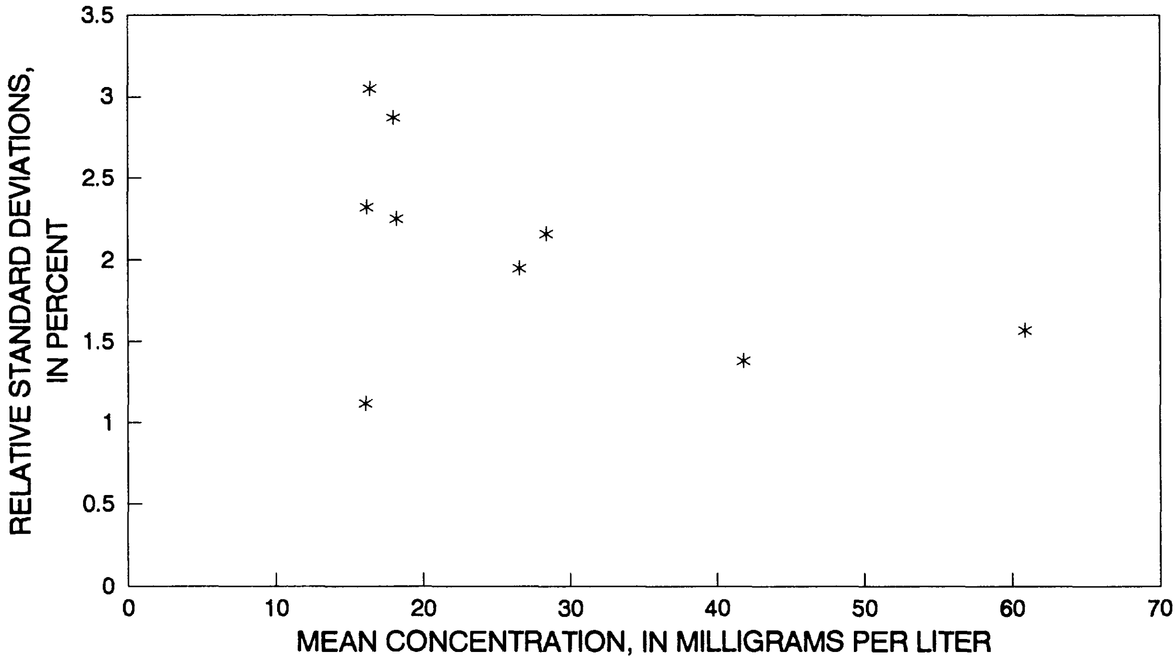

Figure 122. Precision data for magnesium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

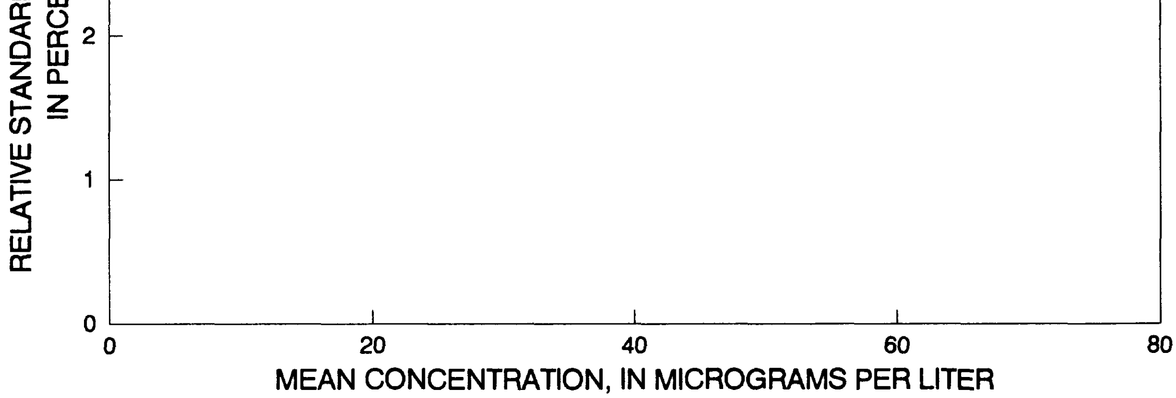

Figure 123. Precision data for manganese, dissolved, (inductively coupled plasma emission spectrometry) data from the National Water-Quality Laboratory.

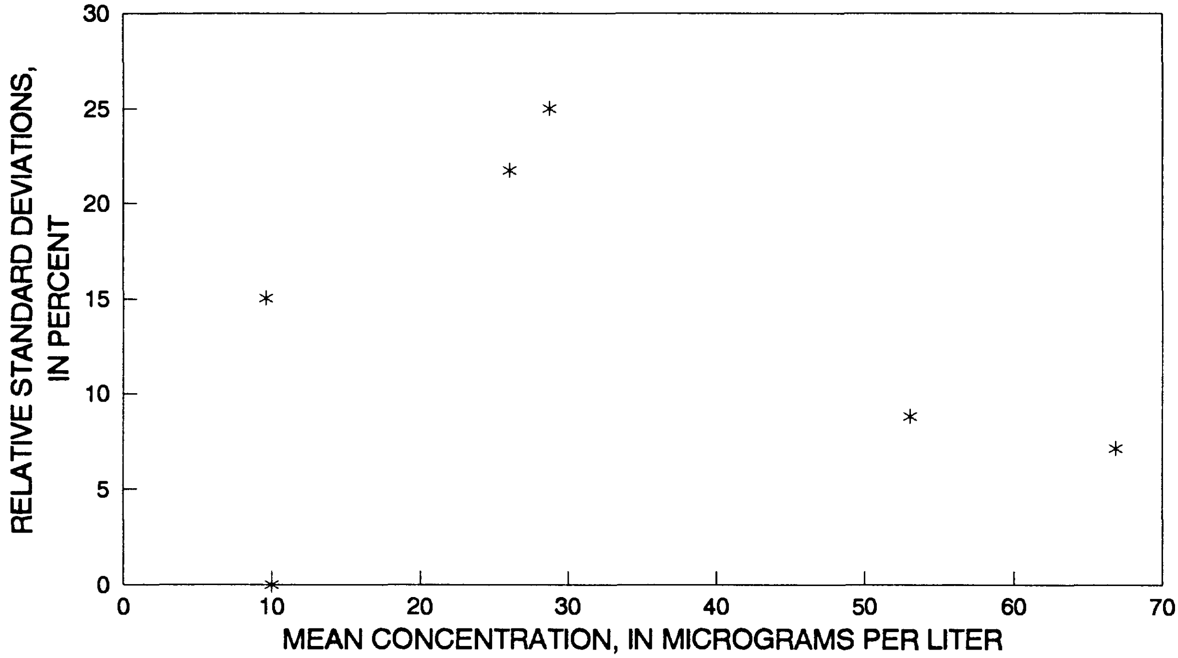

Figure 124. Precision data for manganese, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

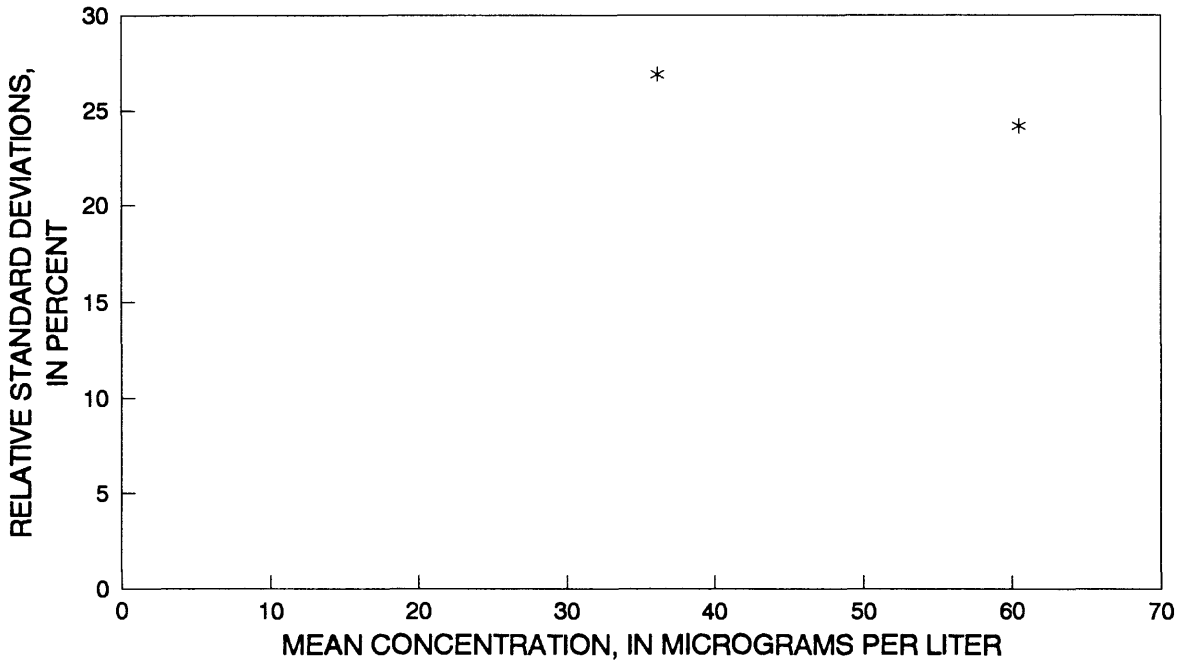

Figure 125. Precision data for manganese, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

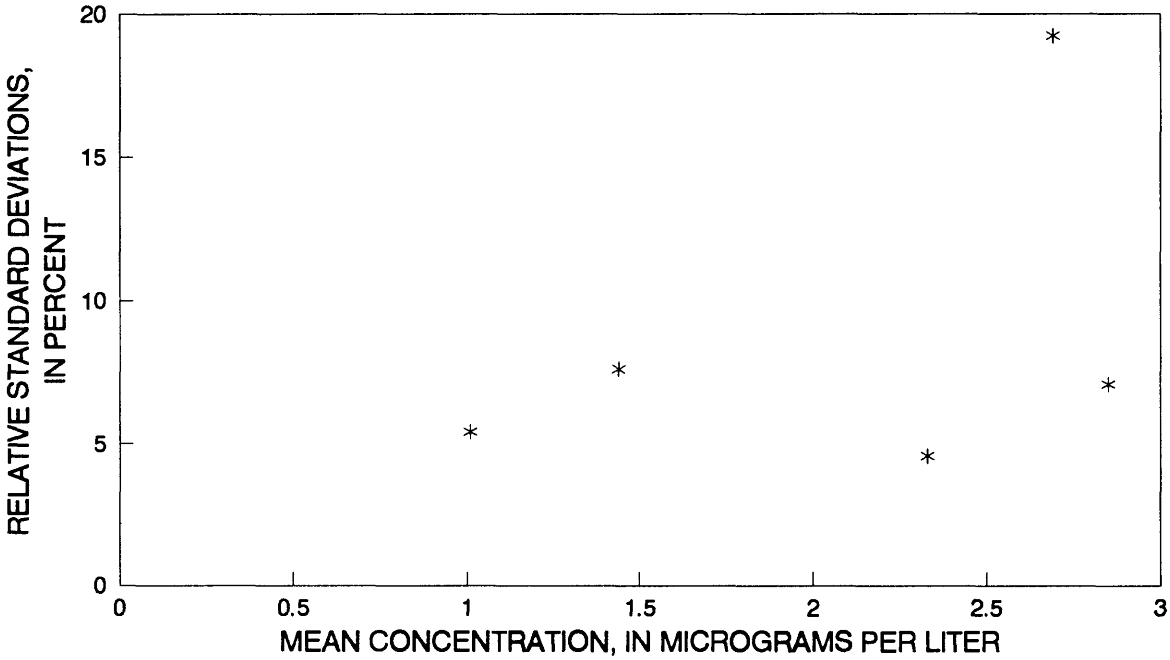

Figure 126. Precision data for mercury, dissolved, (atomic absorption spectrometry, flameless) data from the National Water-Quality Laboratory.

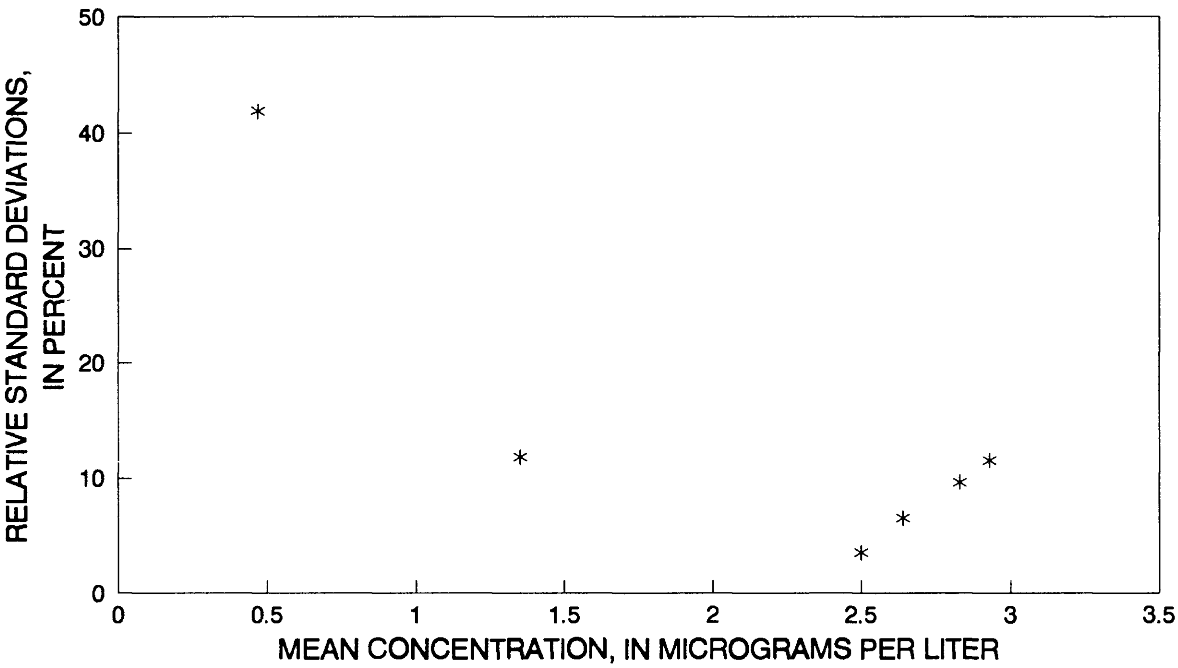

Figure 127. Precision data for mercury, total recoverable, (atomic absorption spectrometry, flameless) data from the National Water-Quality Laboratory.

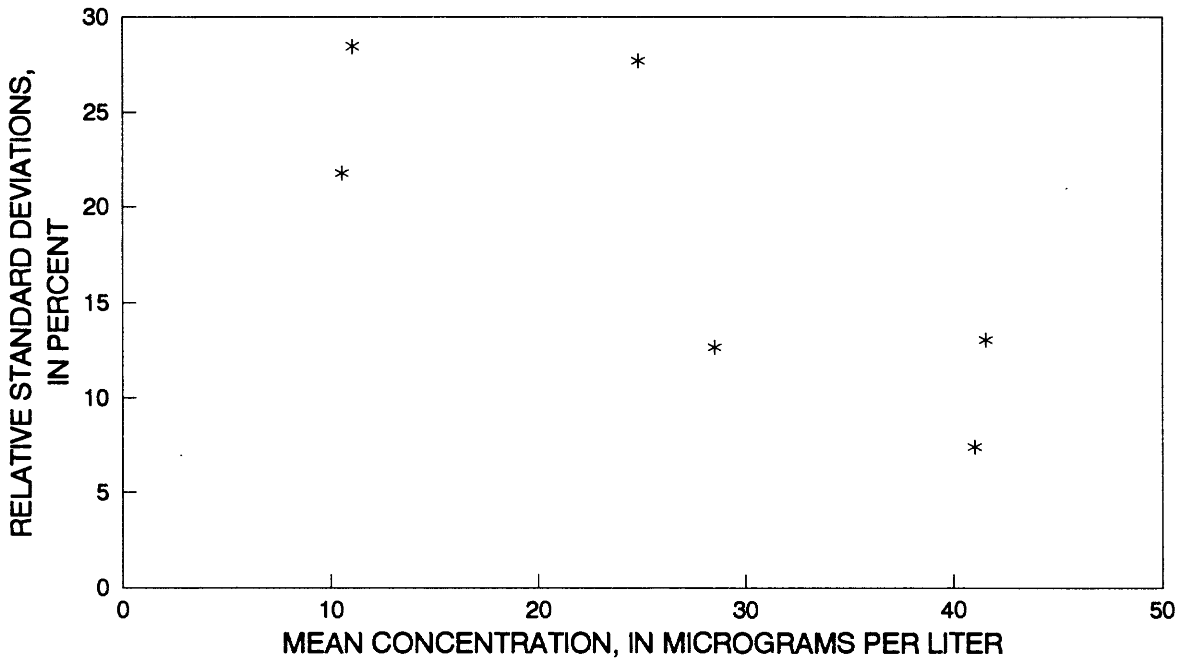

Figure 128. Precision data for molybdenum, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

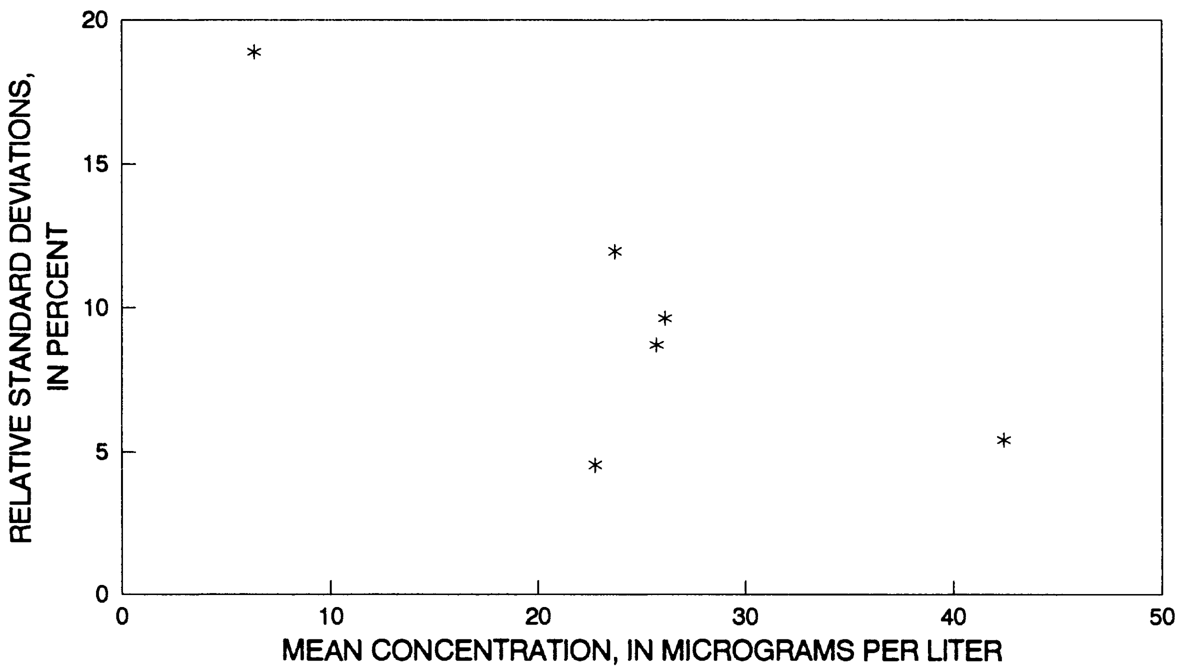

Figure 129. Precision data for molybdenum, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

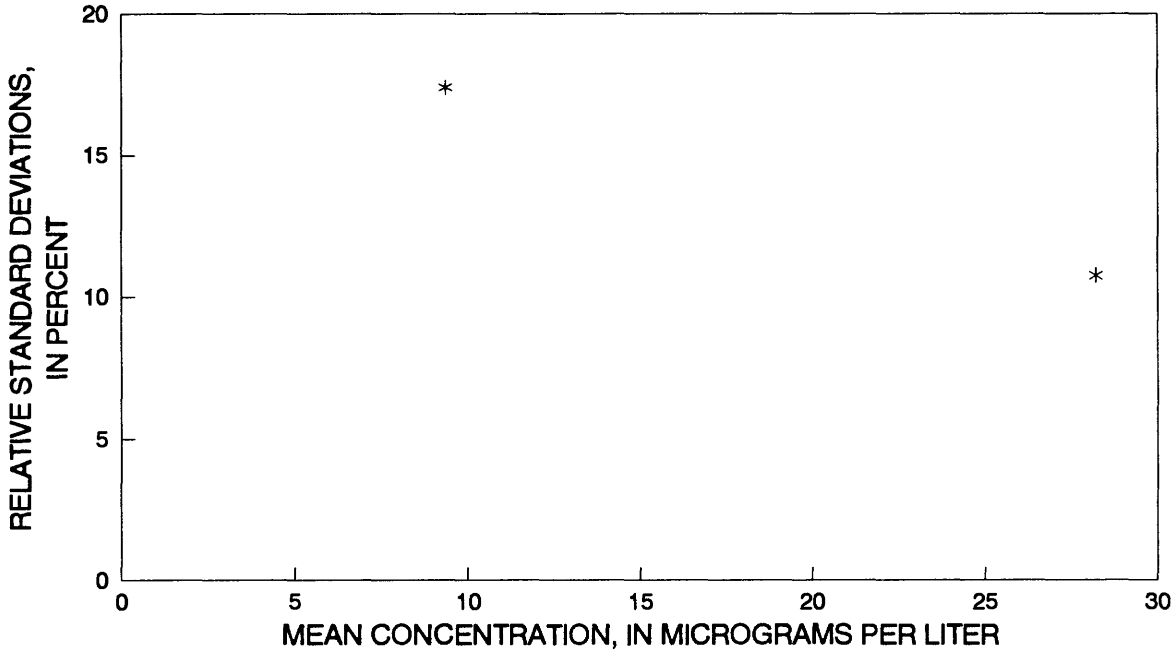

Figure 130. Precision data for molybdenum, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

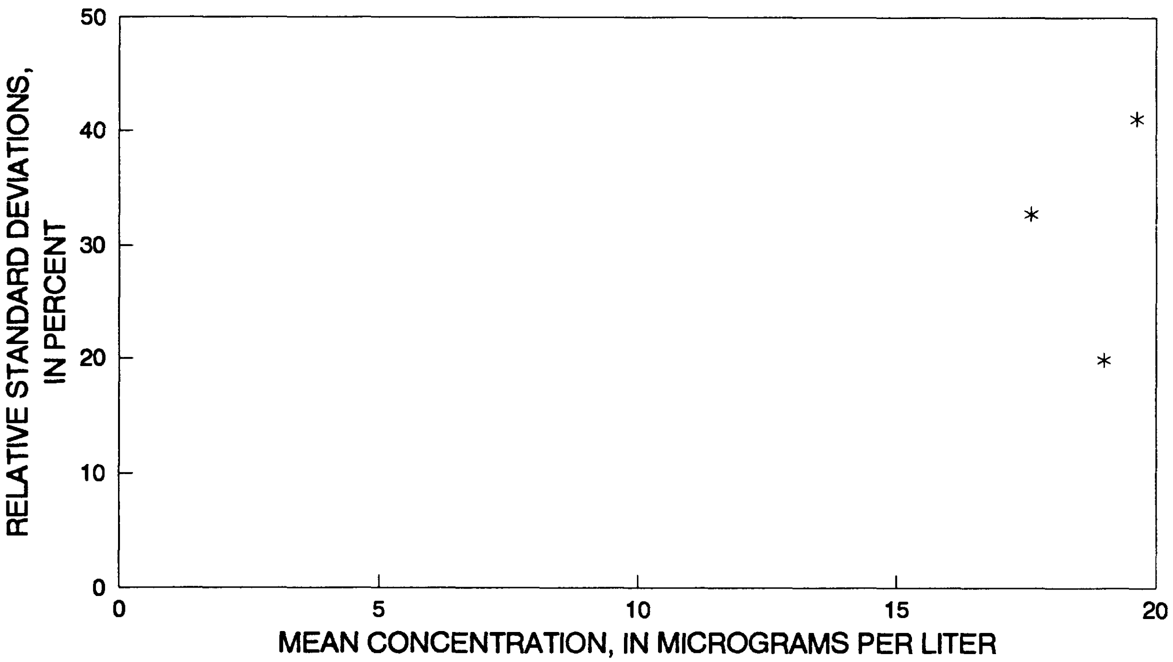

Figure 131. Precision data for nickel, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

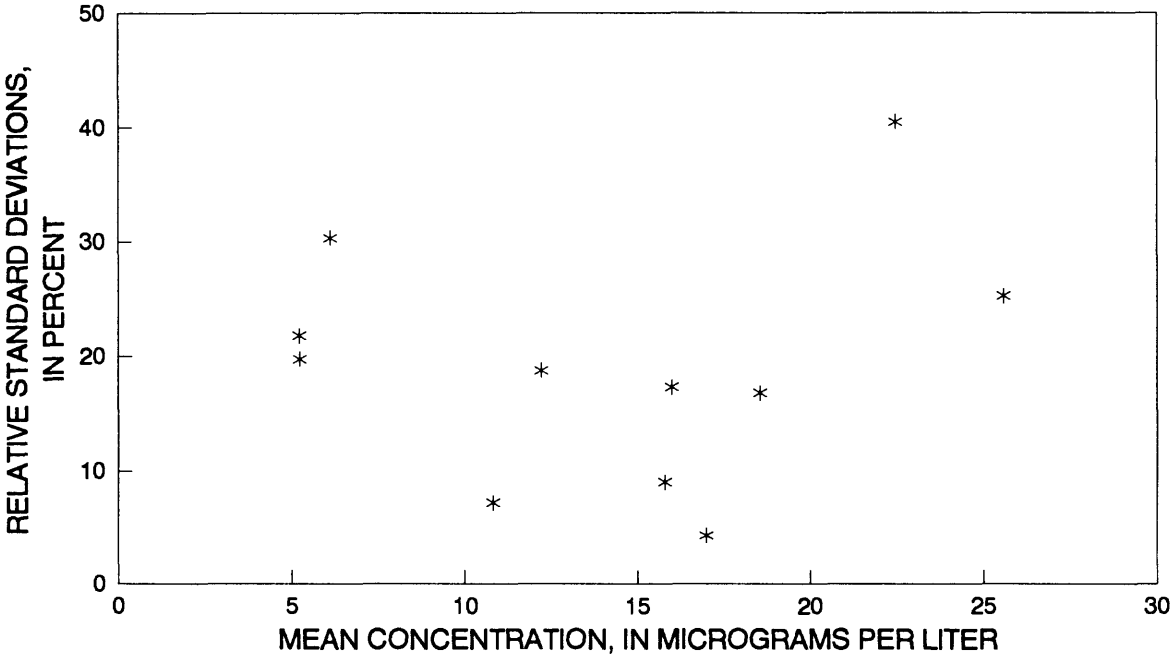

Figure 132. Precision data for nickel, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

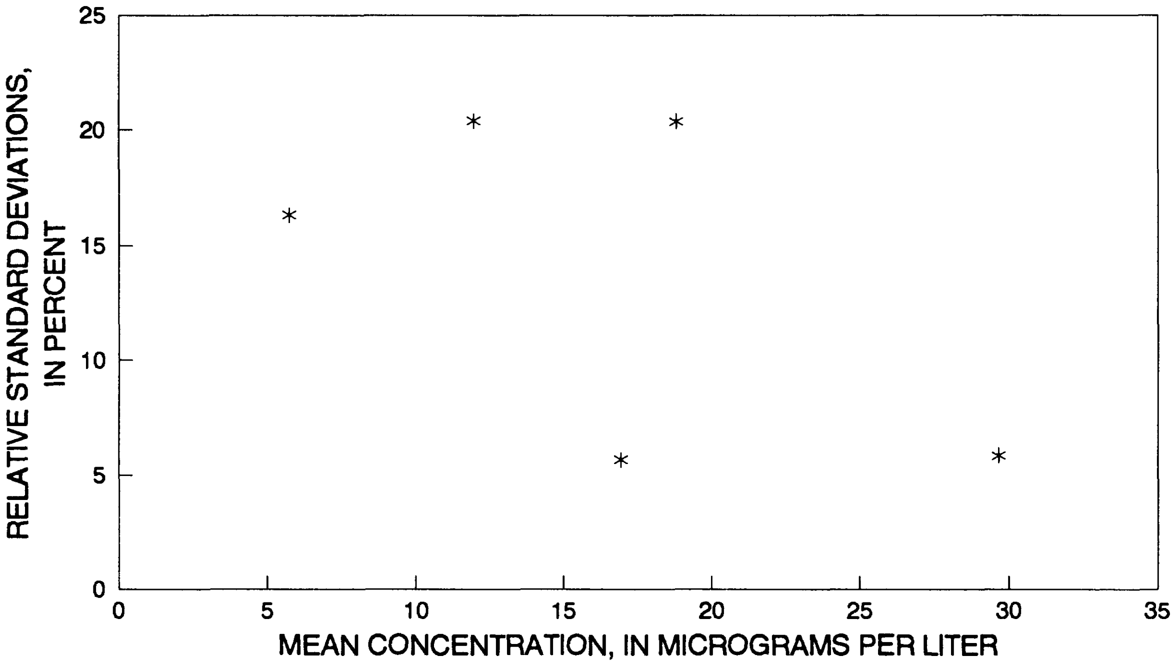

Figure 133. Precision data for nickel, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

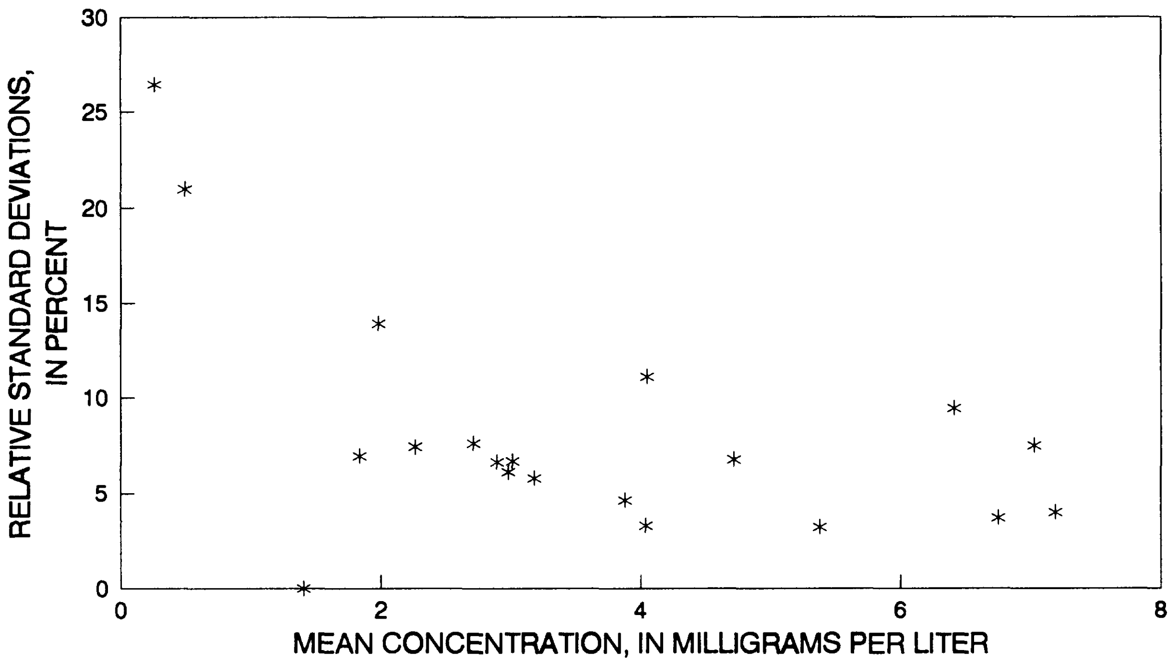

Figure 134. Precision data for potassium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

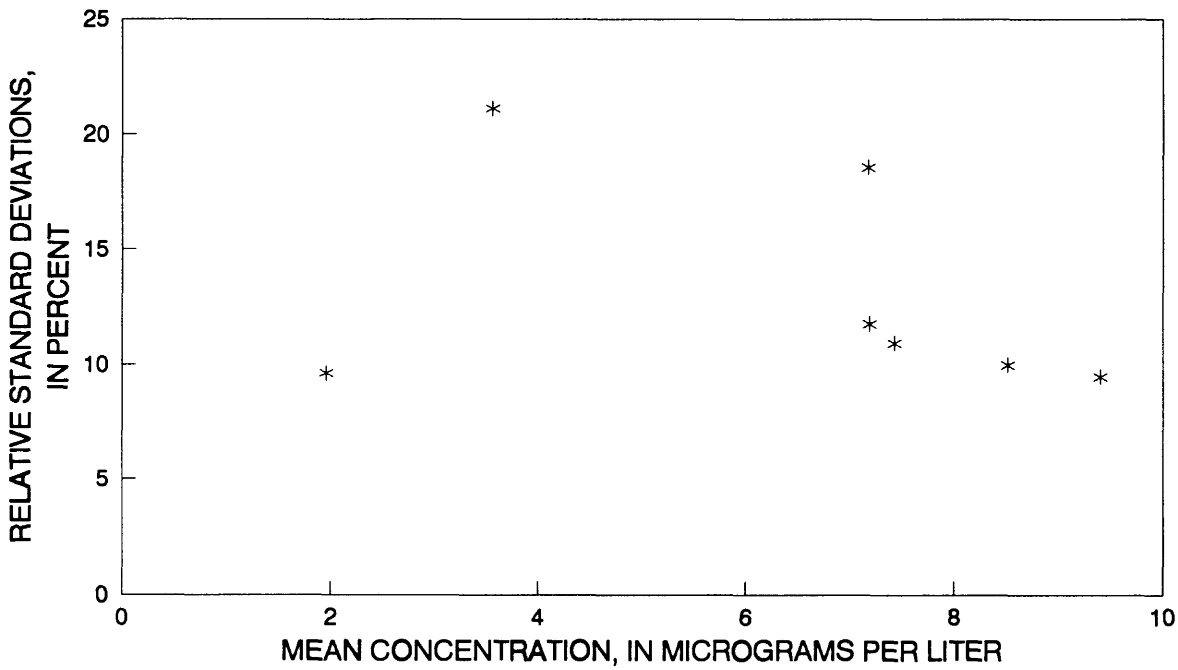

Figure 135. Precision data for selenium, dissolved and total, (atomic absorption spectrometry, hydride) data from the National Water-Quality Laboratory.

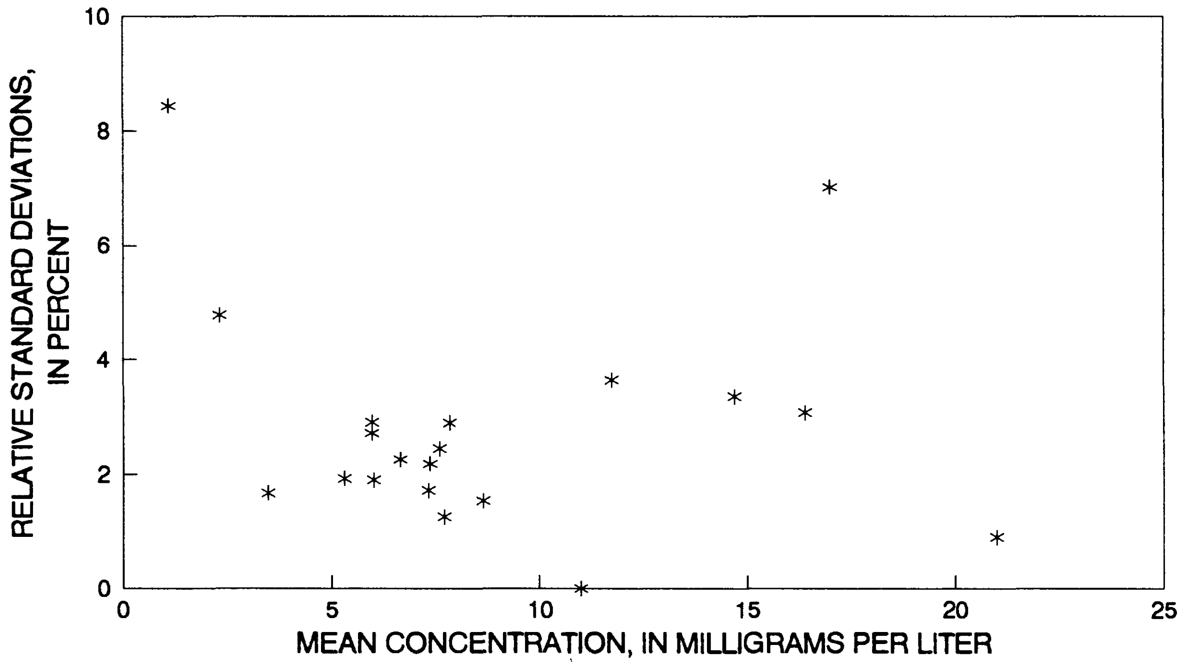

Figure 136. Precision data for silica, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

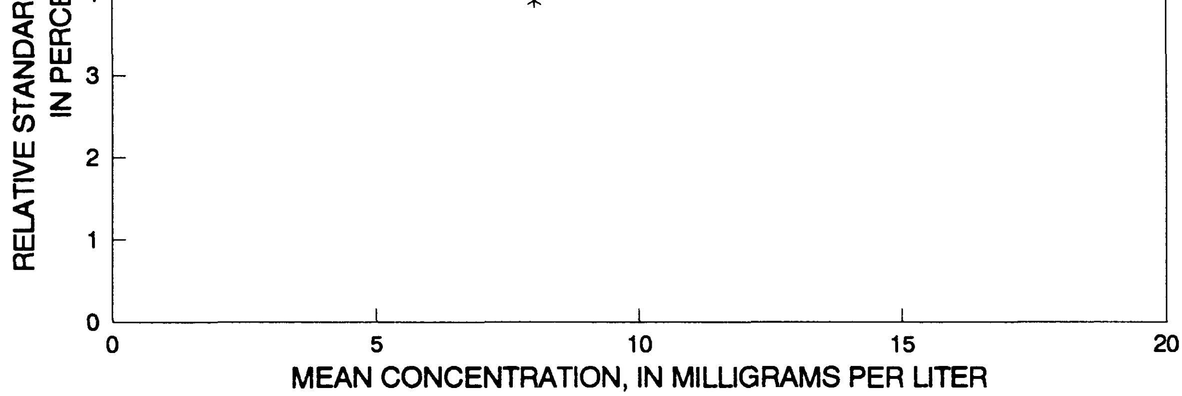

Figure 137. Precision data for silica, dissolved, (colorimetric) data from the National Water-Quality Laboratory.

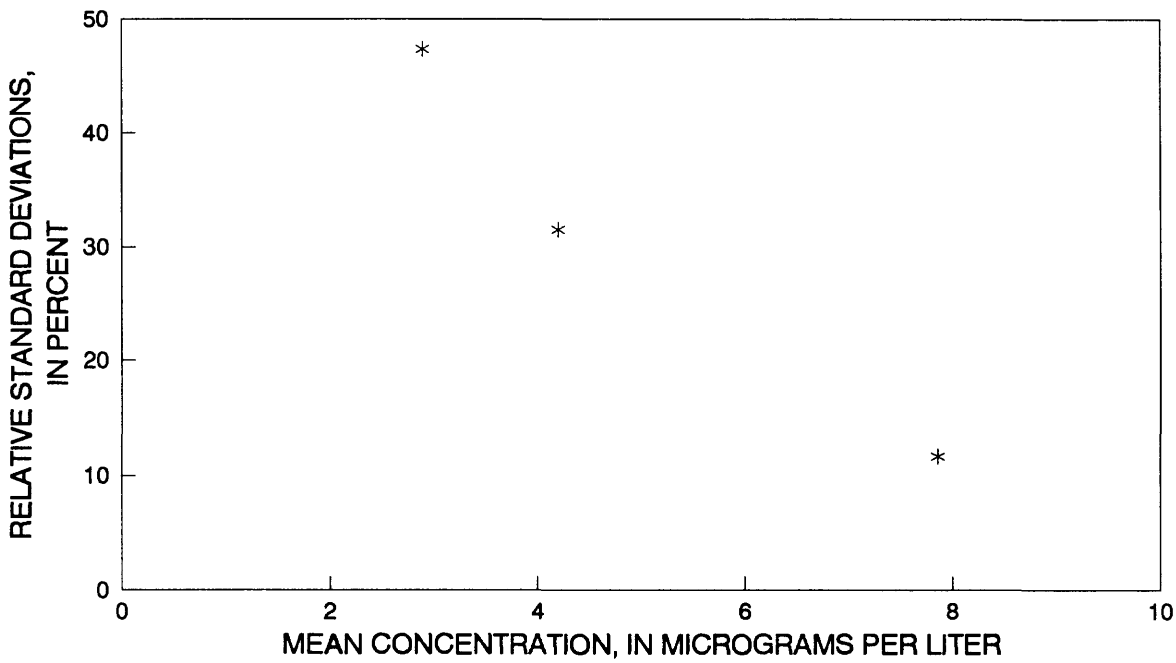

Figure 138. Precision data for silver, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

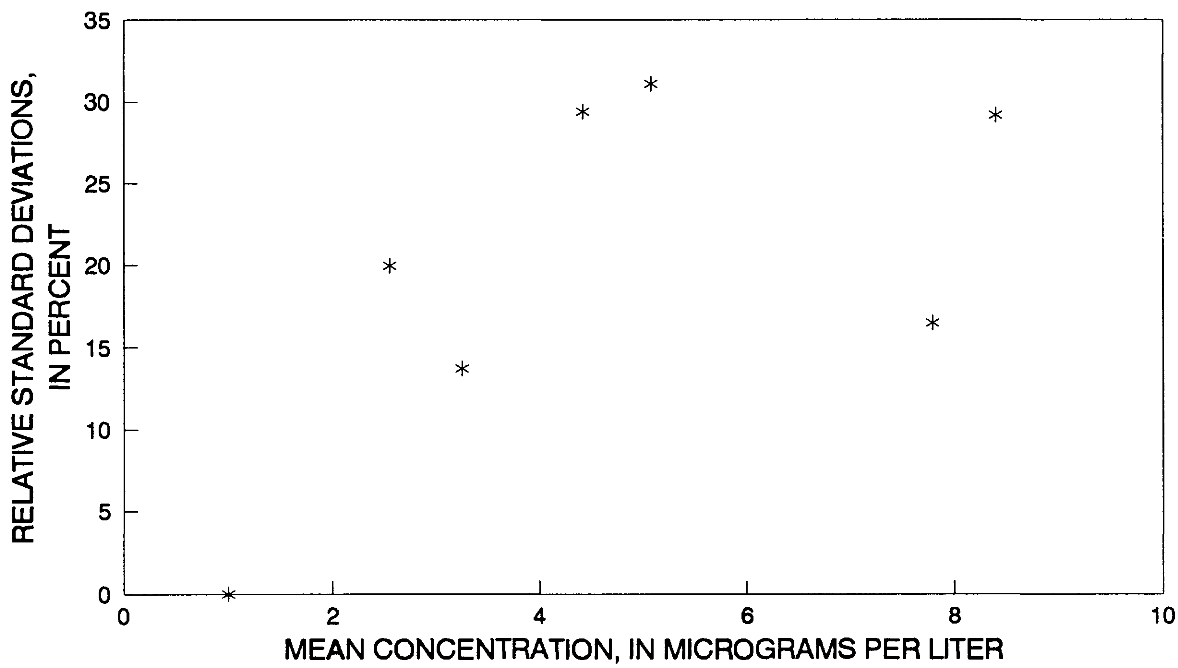

Figure 139. Precision data for silver, dissolved, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

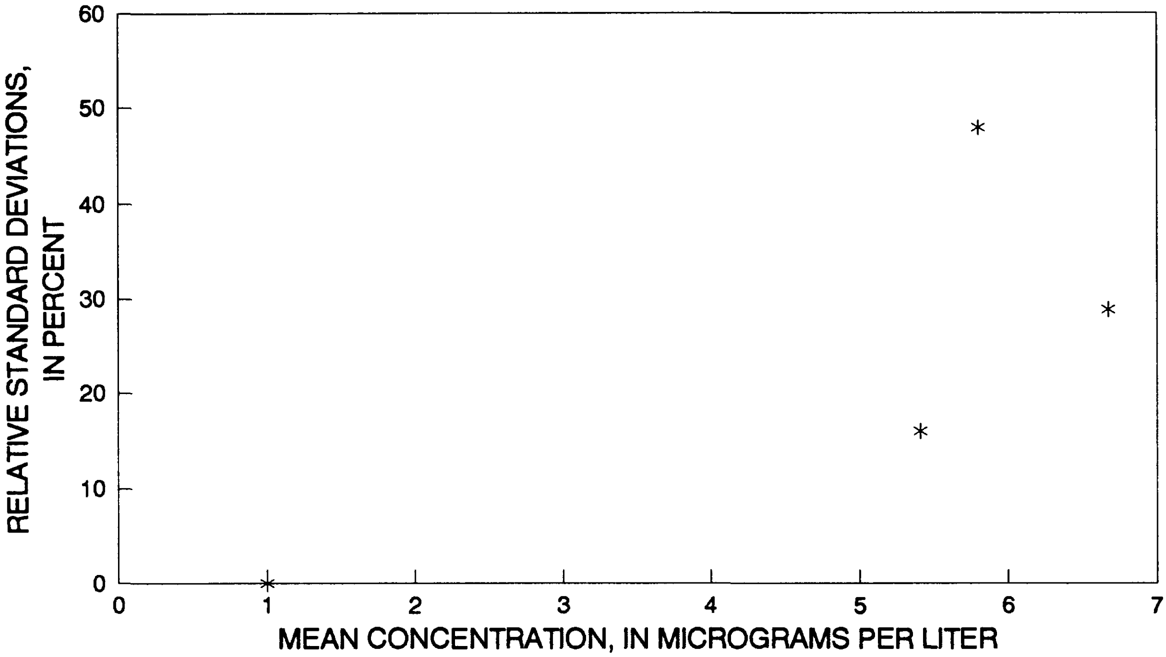

Figure 140. Precision data for silver, total recoverable, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

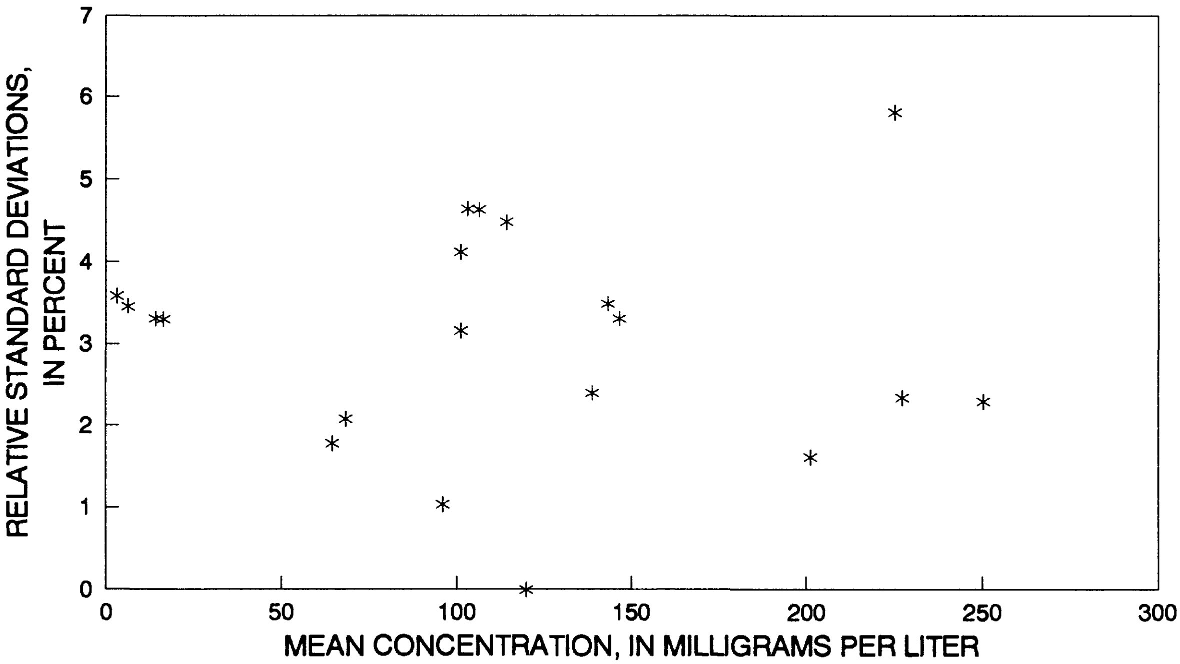

Figure 141. Precision data for sodium, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

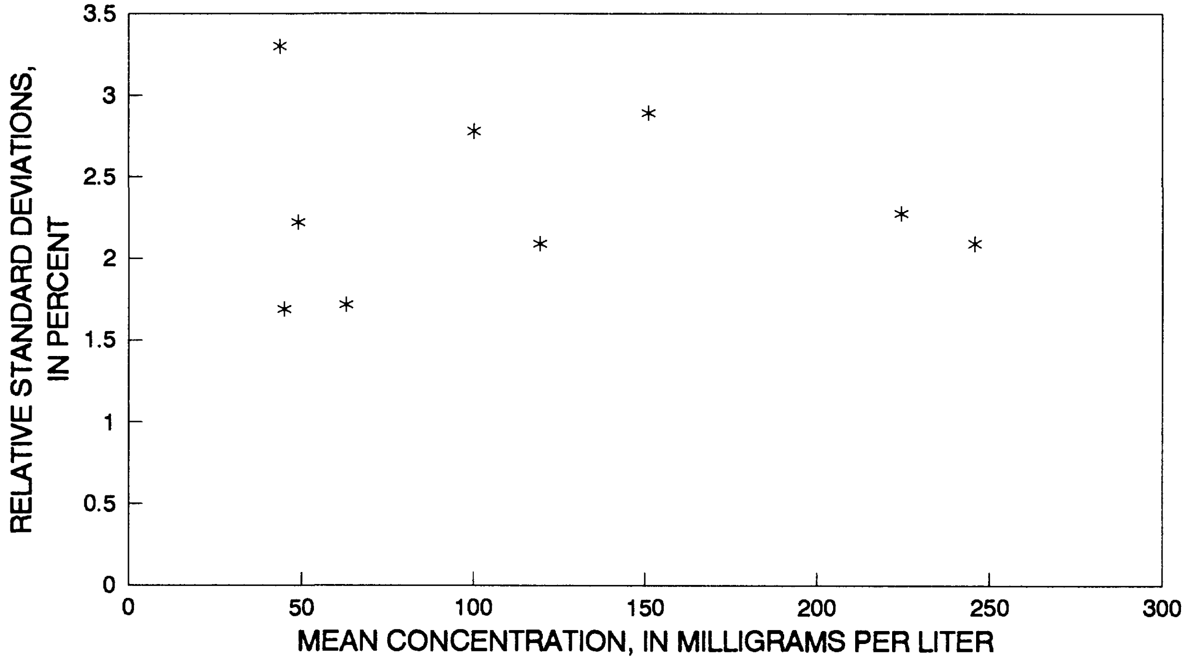

Figure 142. Precision data for sodium, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

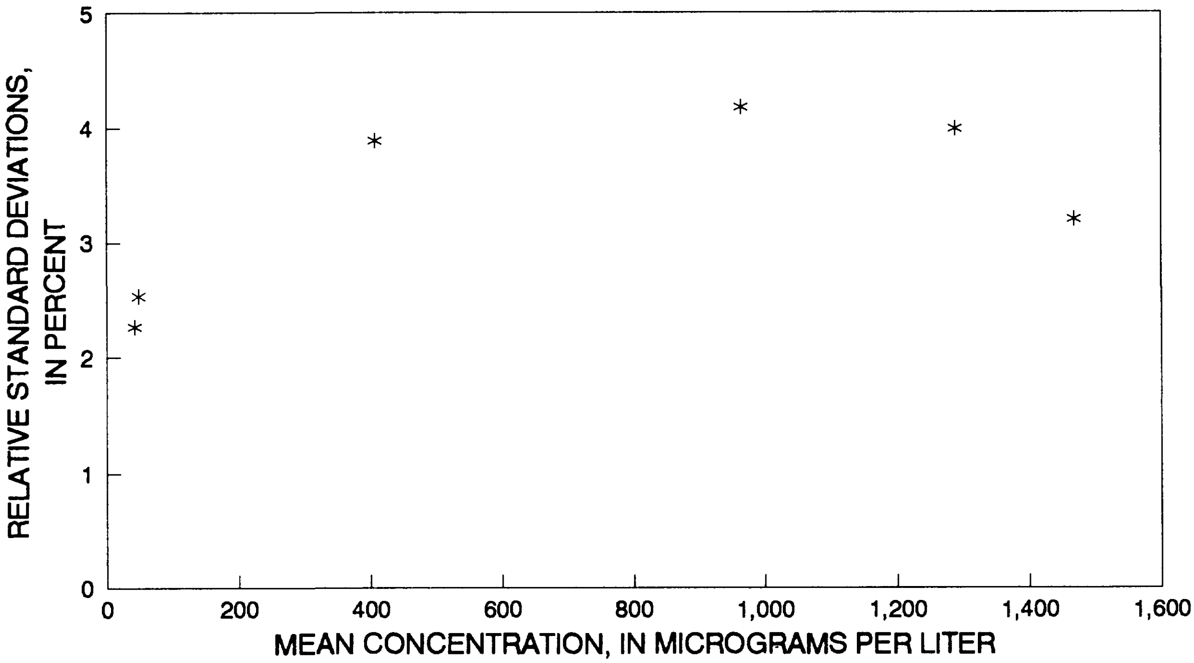

Figure 143. Precision data for strontium, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

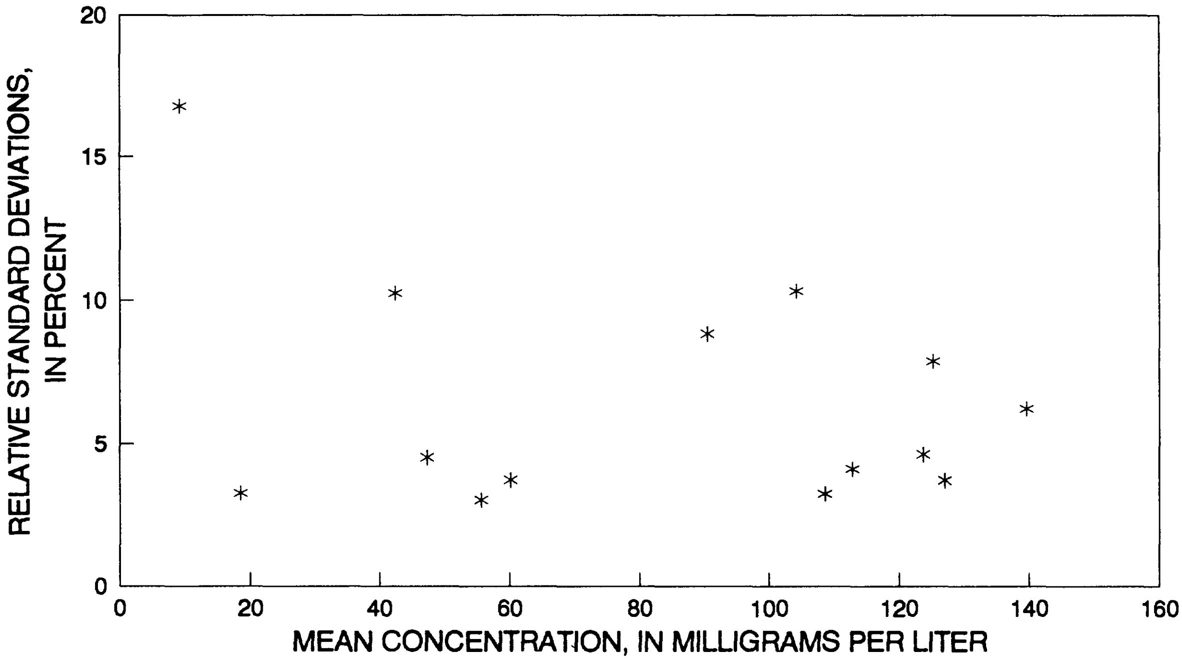

Figure 144. Precision data for sulfate, dissolved, (turbidimetric and ion chromatography) data from the National Water-Quality Laboratory.

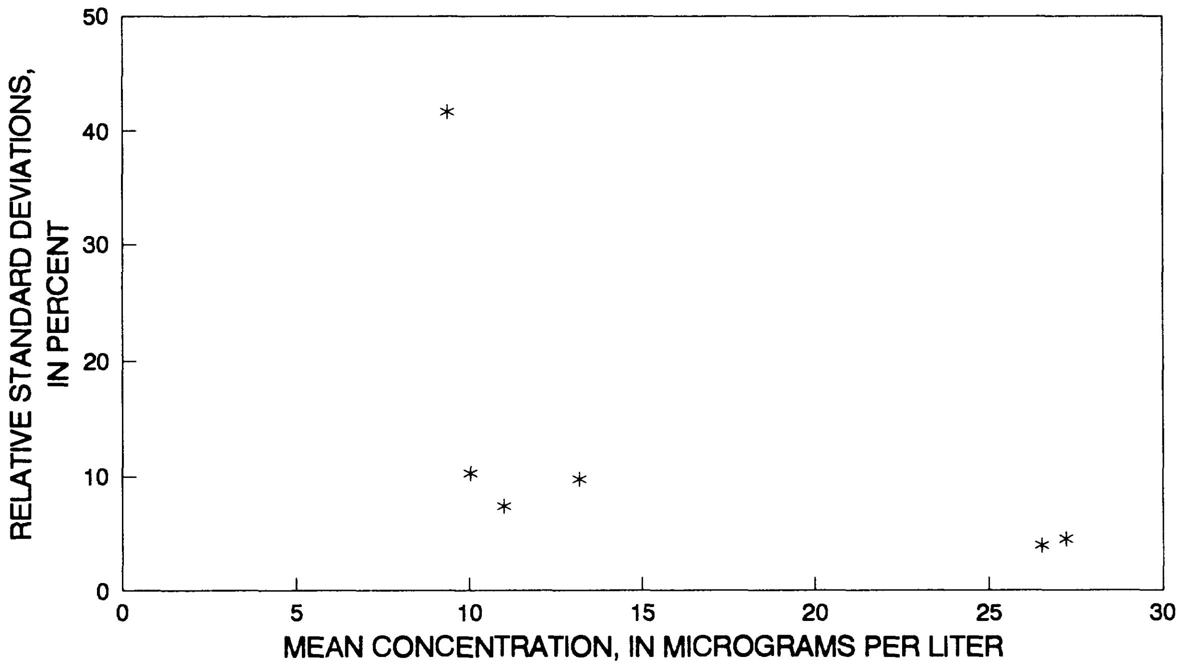

Figure 145. Precision data for vanadium, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

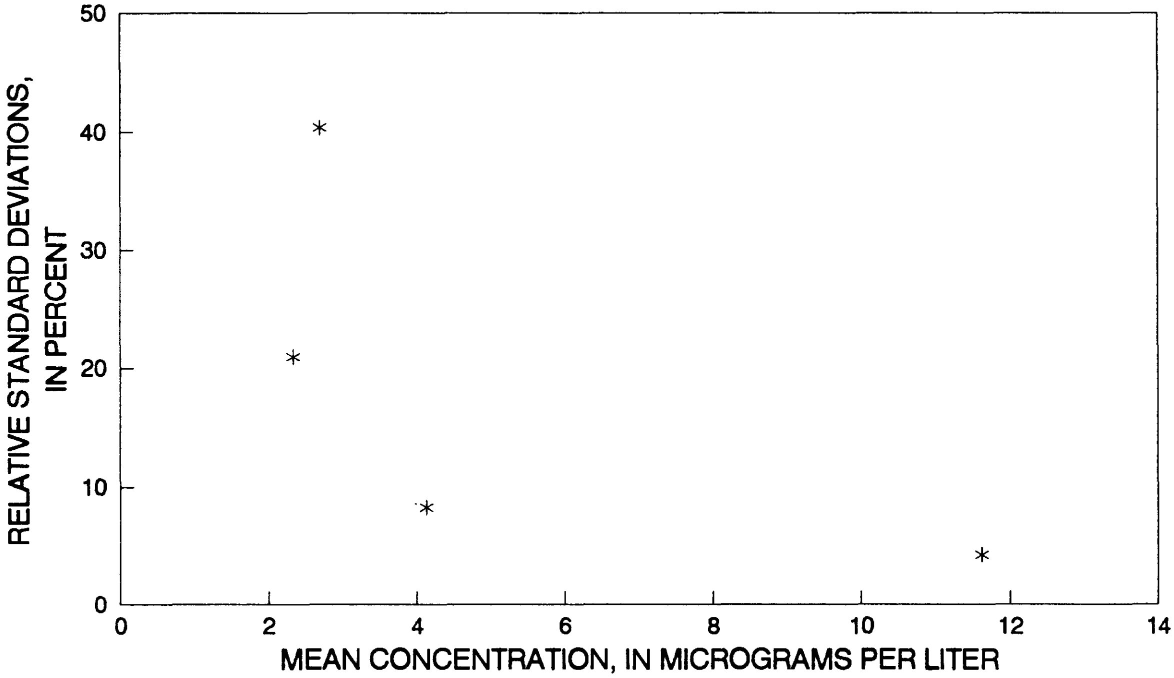

Figure 146. Precision data for vanadium, dissolved, (colorimetric) data from the National Water-Quality Laboratory.

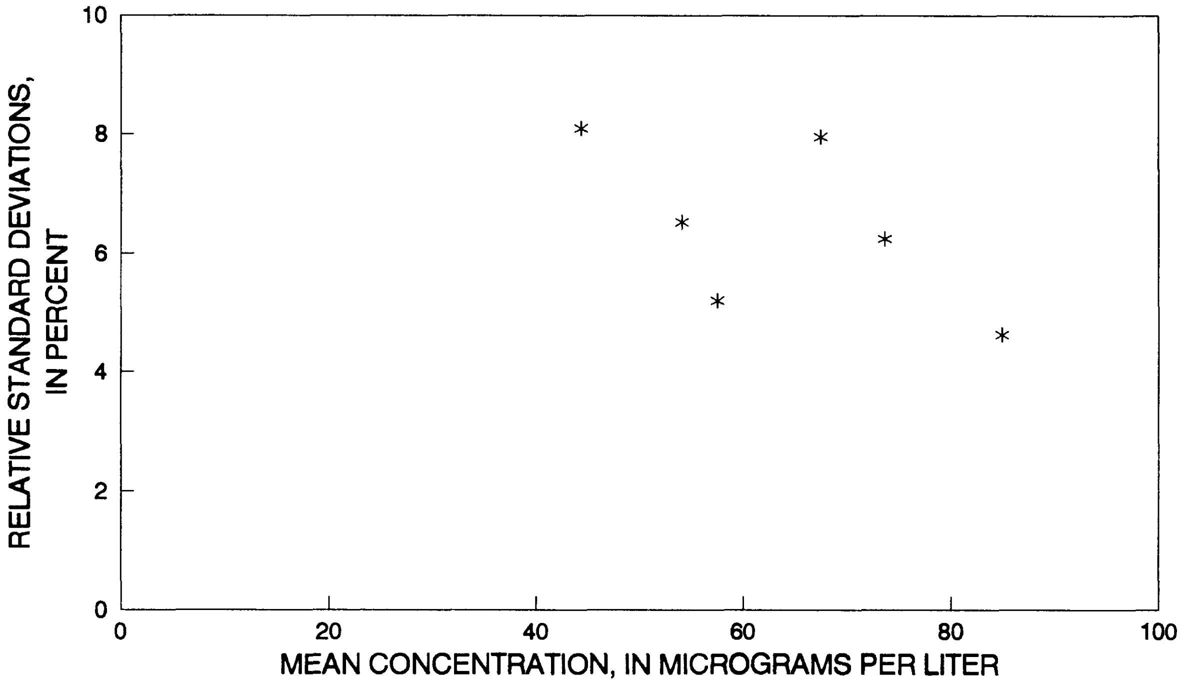

Figure 147. Precision data for zinc, dissolved, (inductively coupled plasma, emission spectrometry) data from the National Water-Quality Laboratory.

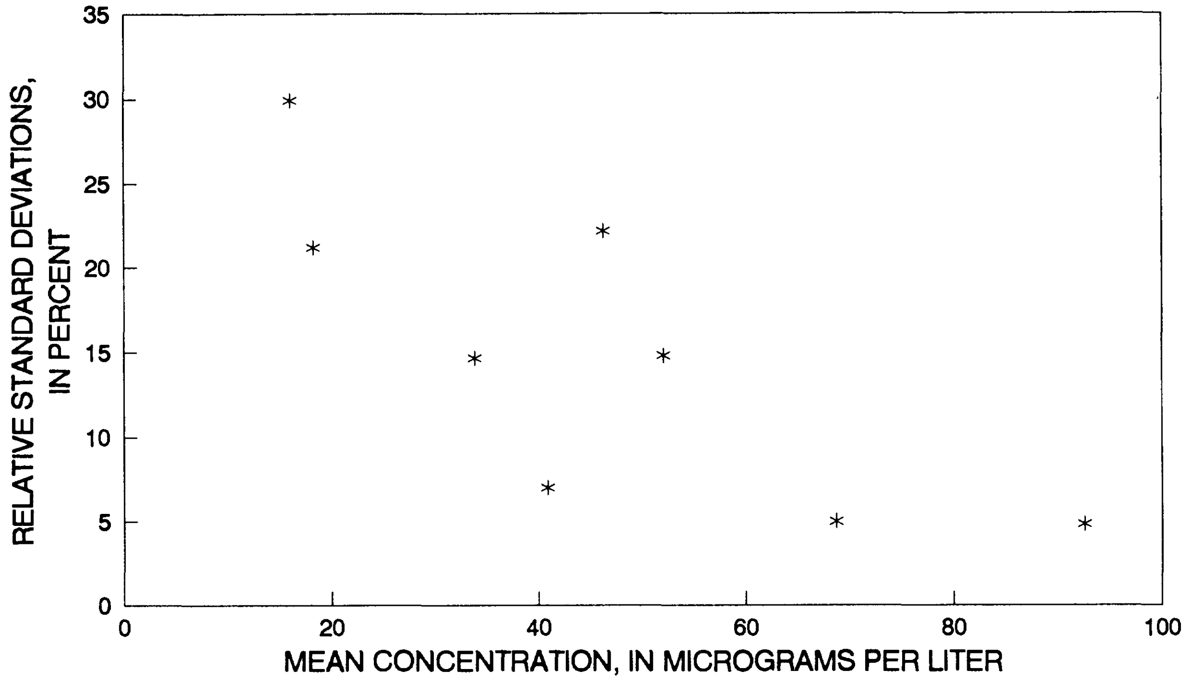

Figure 148. Precision data for zinc, dissolved, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

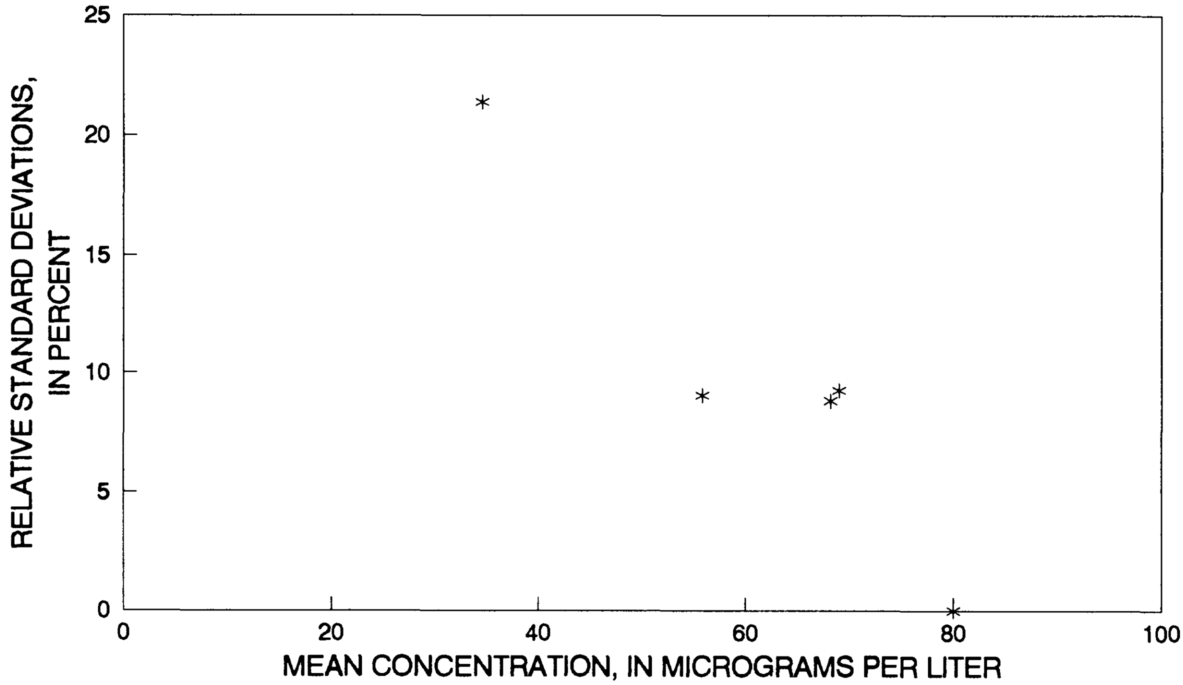

Figure 149. Precision data for zinc, total recoverable, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

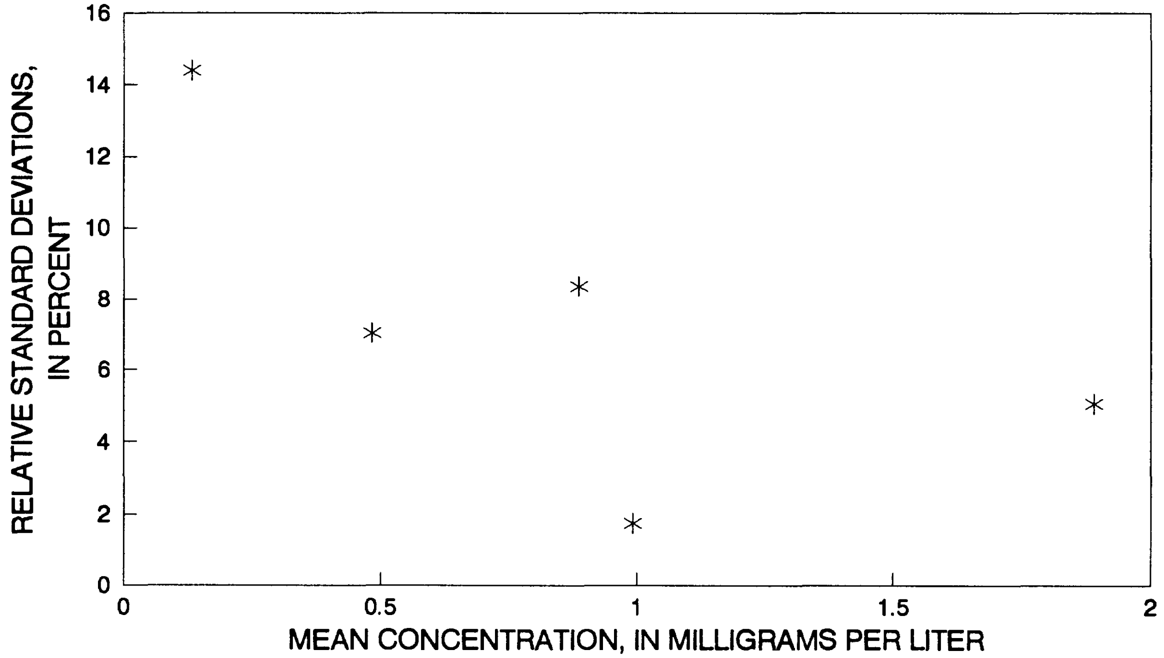

Figure 150. Precision data for ammonia as nitrogen, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

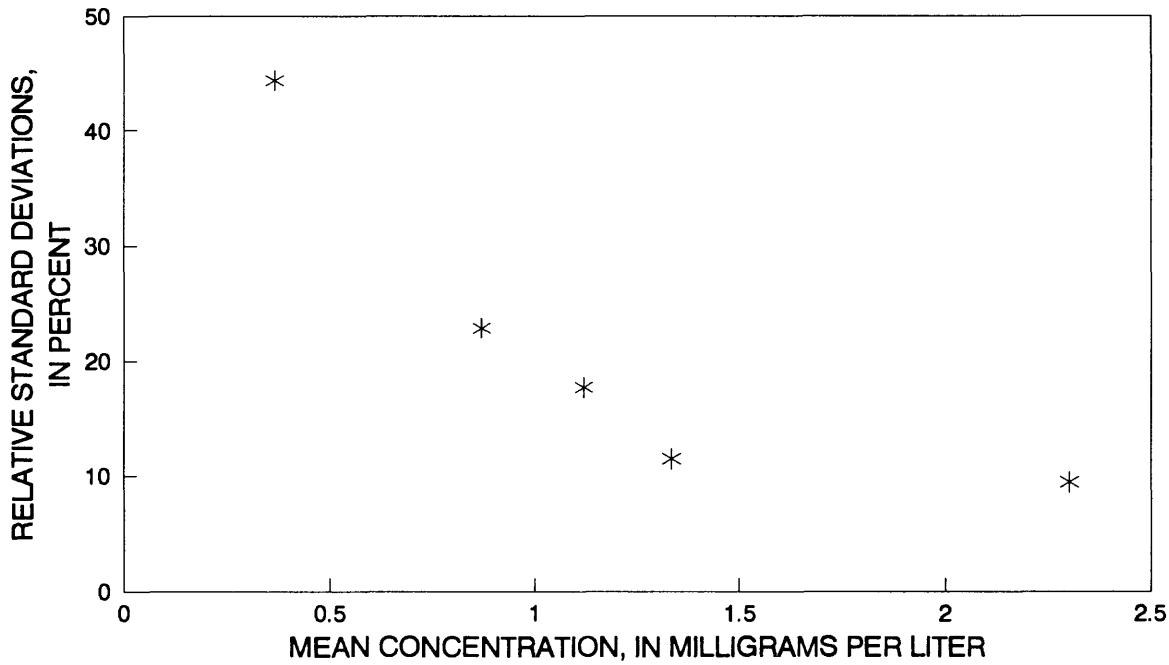

Figure 151. Precision data for ammonia plus organic nitrogen, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

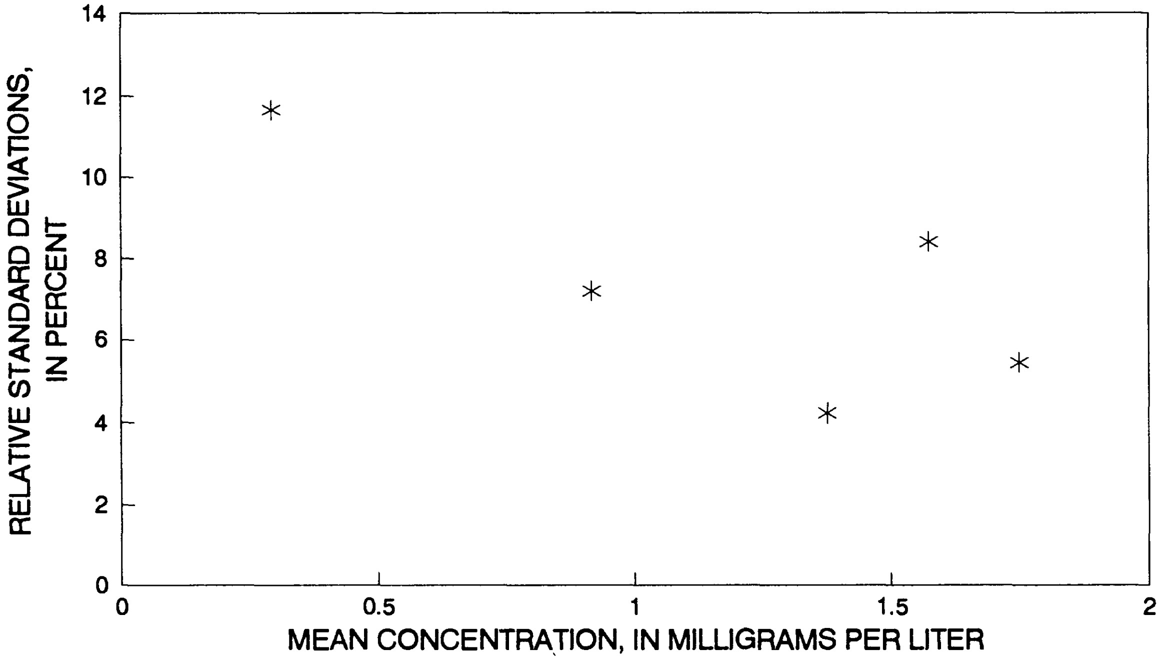

Figure 152. Precision data for nitrate plus nitrite as nitrogen, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

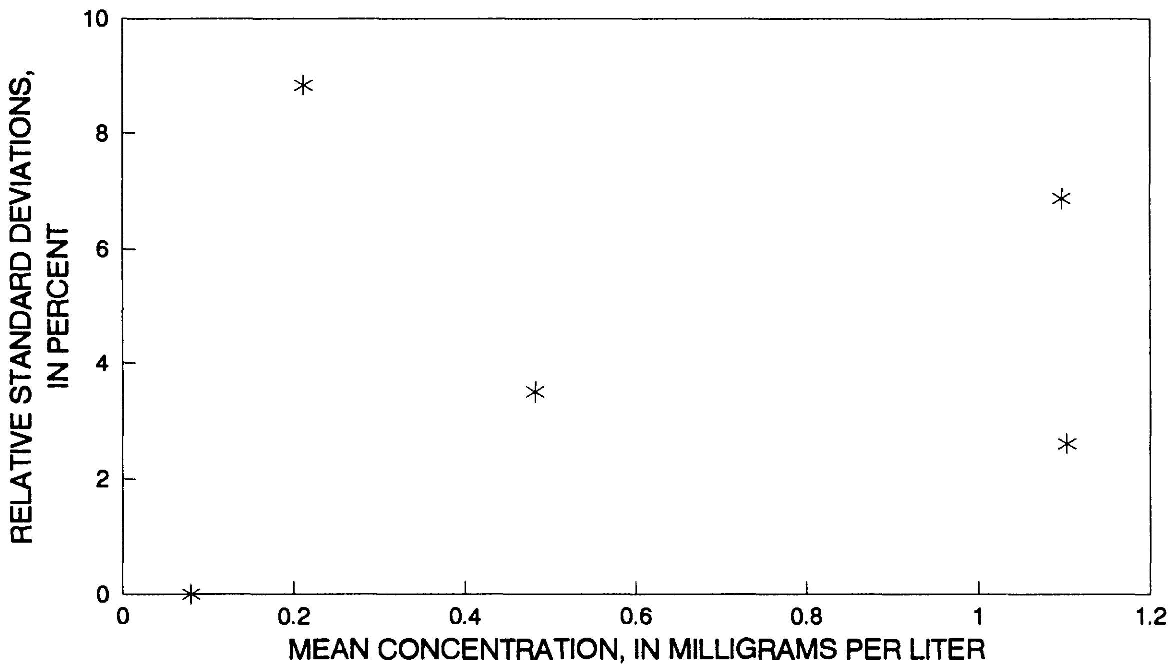

Figure 153. Precision data for orthophosphate as phosphorus, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

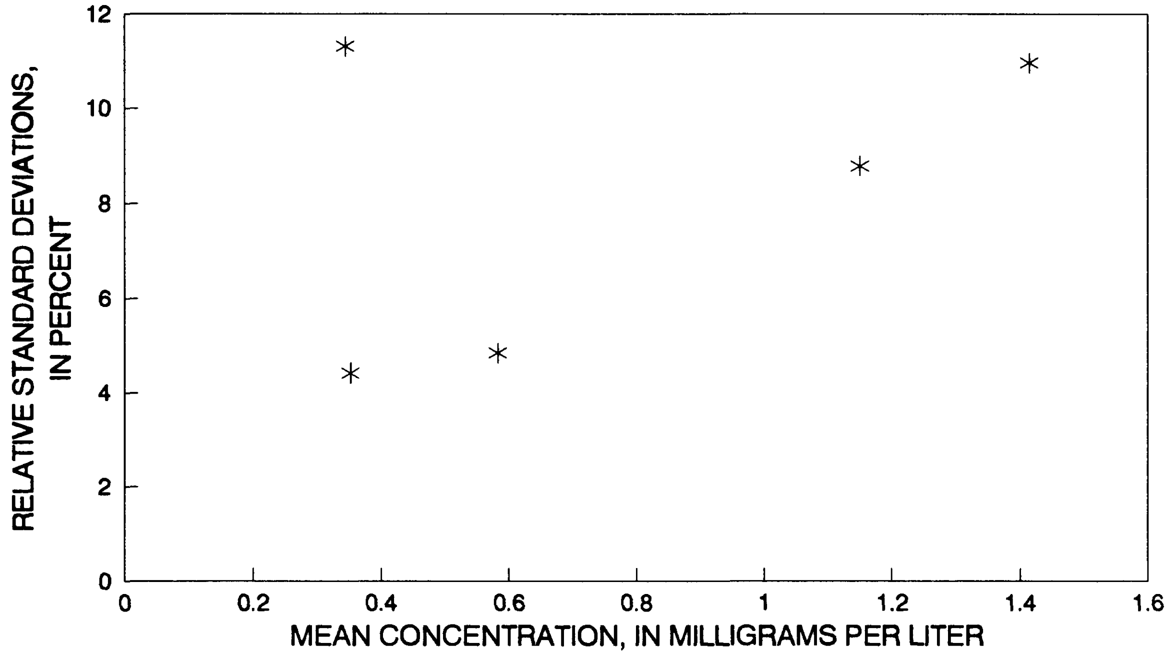

Figure 154. Precision data for phosphorus, dissolved and total, (colorimetric) data from the National Water-Quality Laboratory.

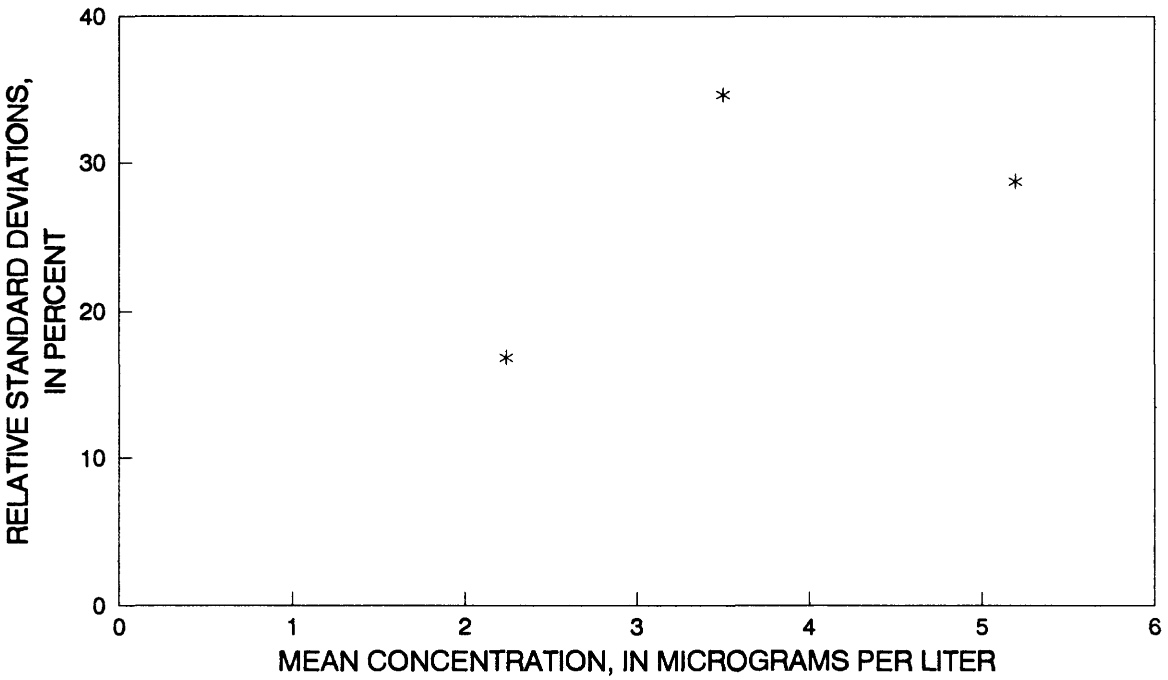

Figure 155. Precision data for cadmium, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

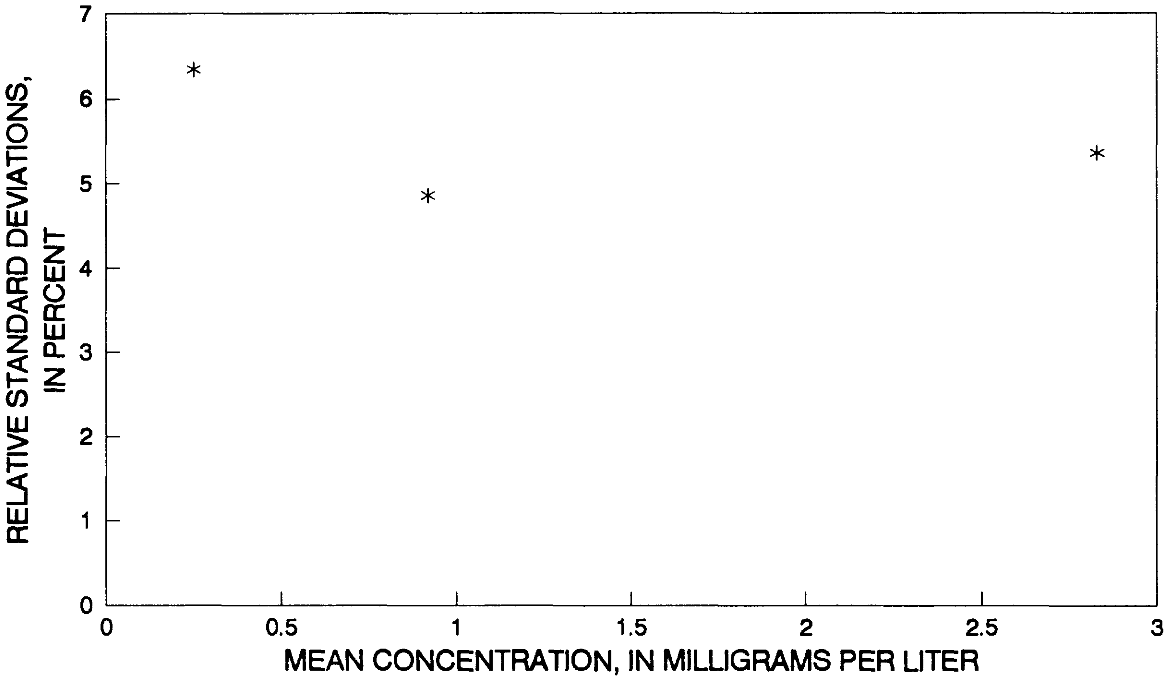

Figure 156. Precision data for calcium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

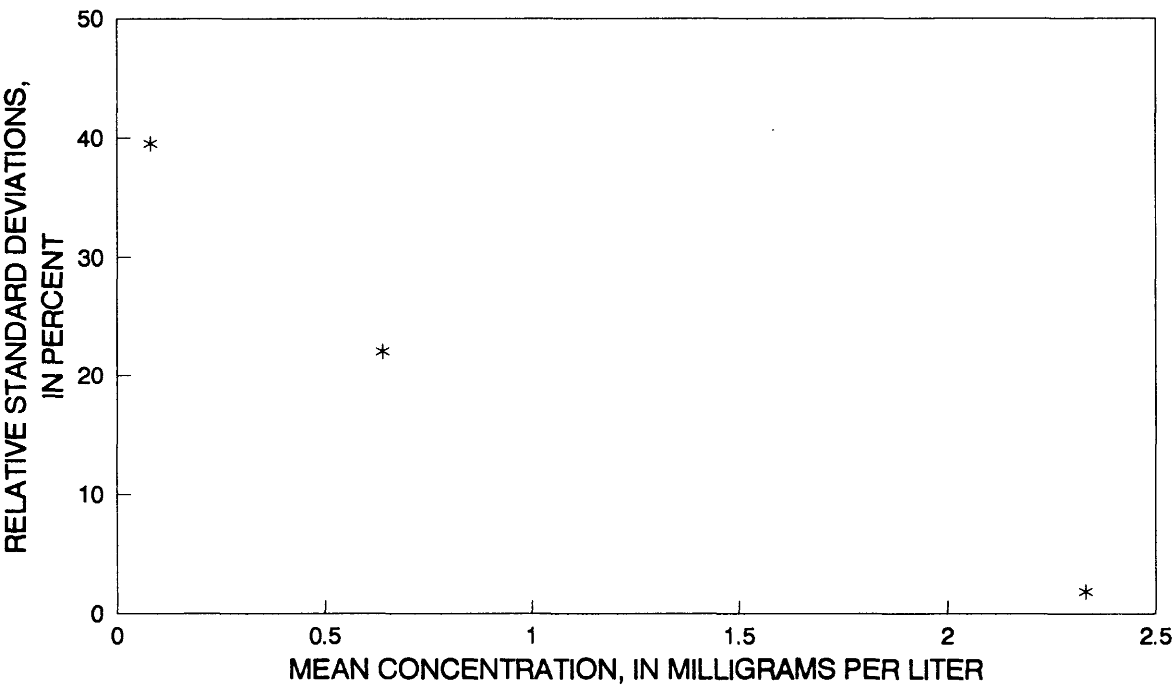

Figure 157. Precision data for chloride, dissolved, low ionic strength, (ion chromatography) data from the National Water-Quality Laboratory.

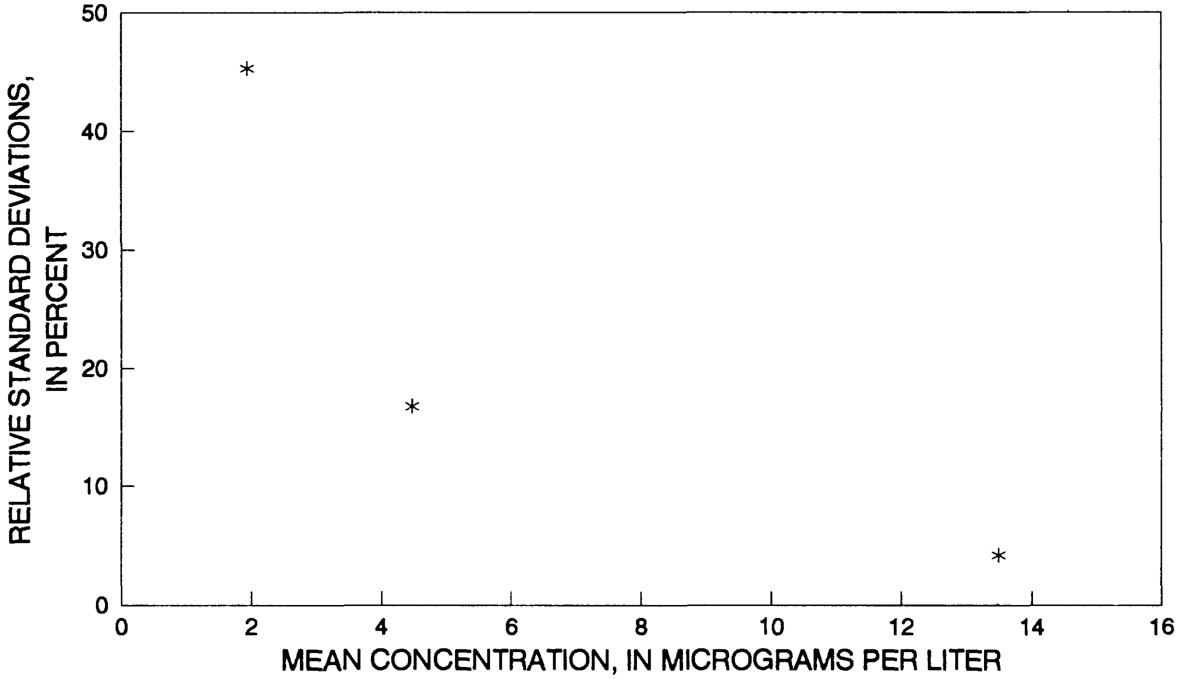

Figure 158. Precision data for cobalt, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

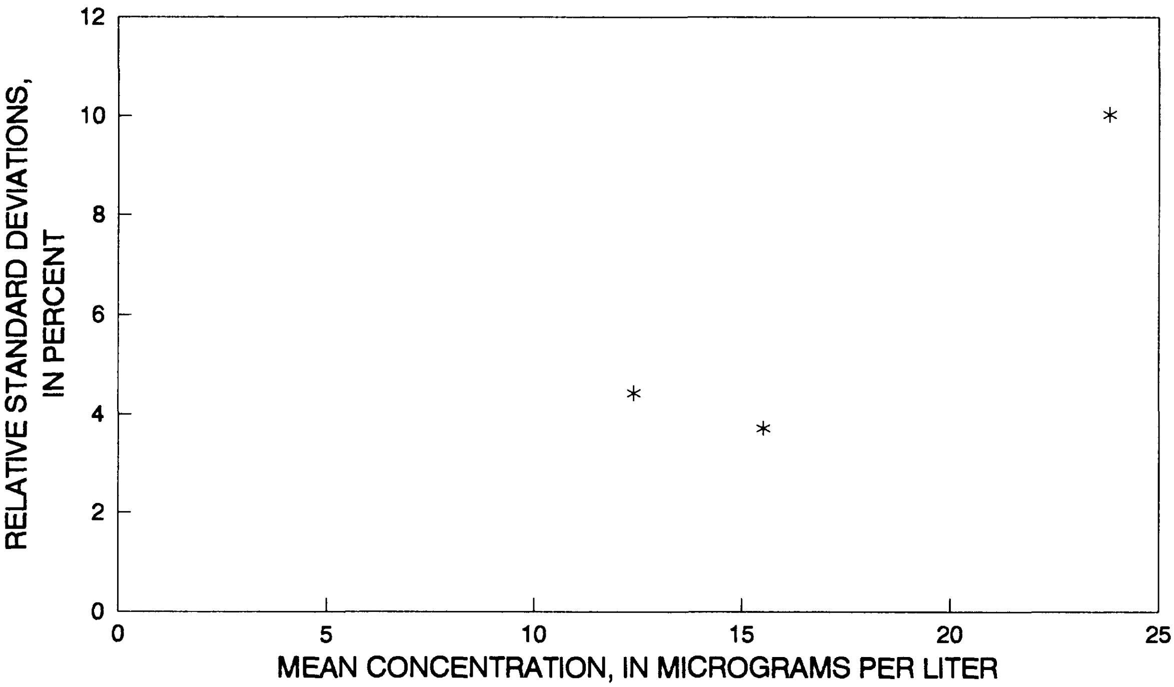

Figure 159. Precision data for copper, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

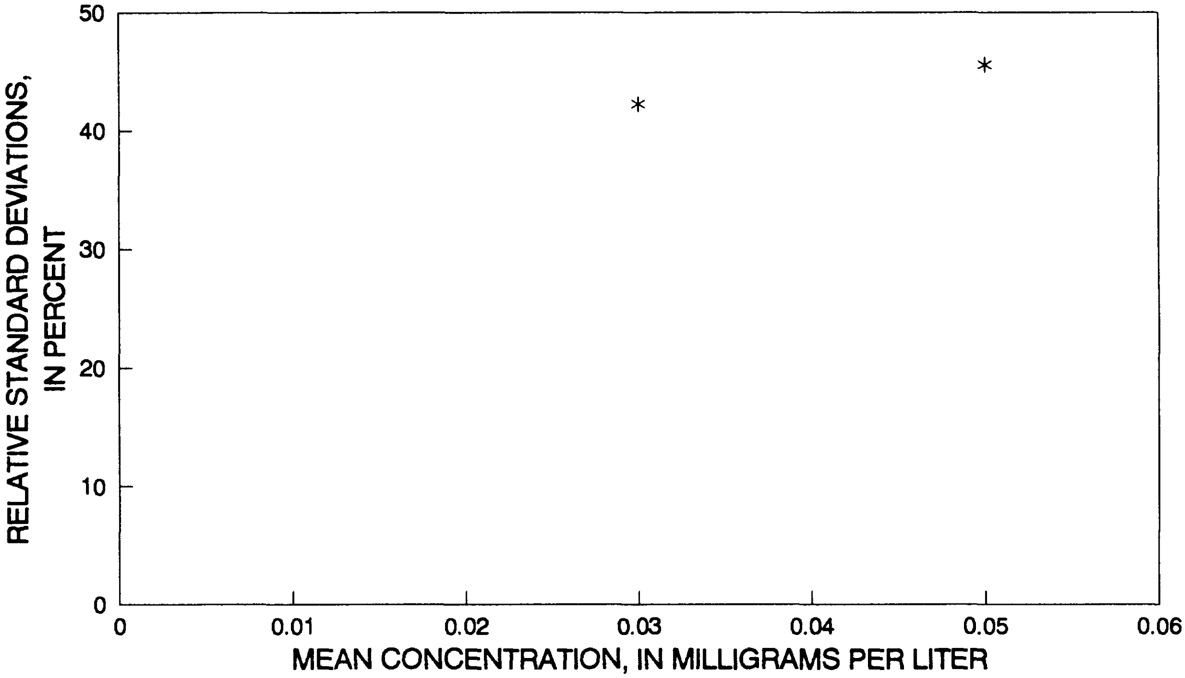

Figure 160. Precision data for fluoride, dissolved, low ionic strength, (ion chromatography) data from the National Water-Quality Laboratory.

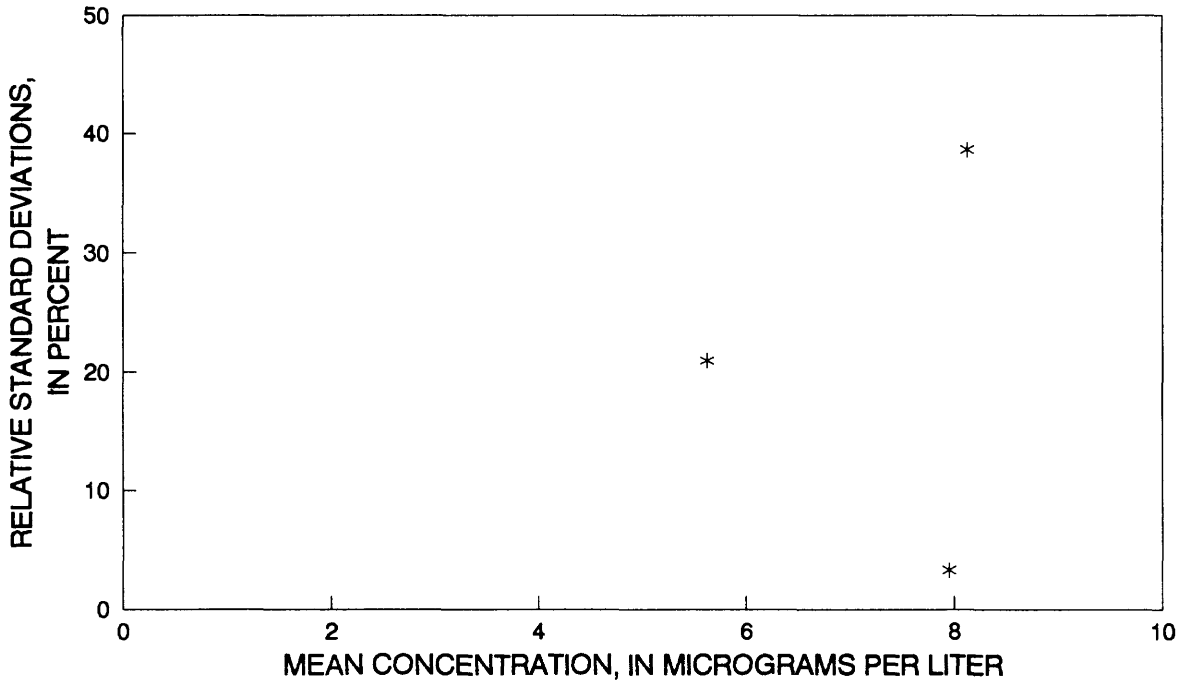

Figure 161. Precision data for lead, dissolved, low ionic strength, (atomic absorption spectrometry, graphite furnace) data from the National Water-Quality Laboratory.

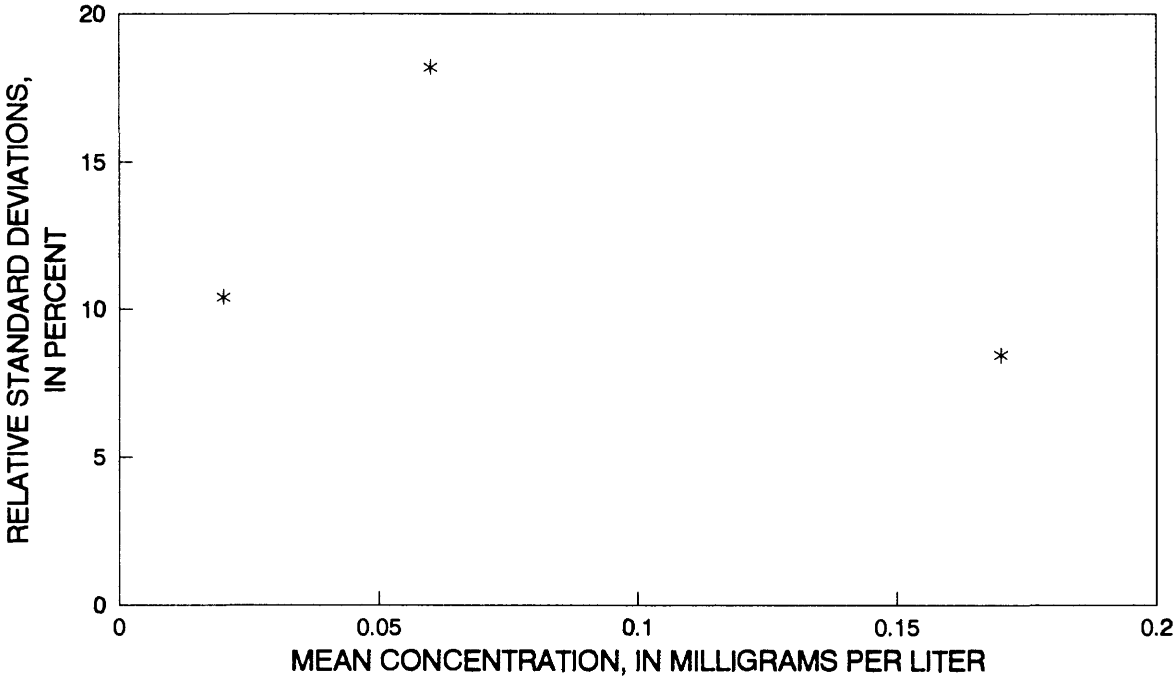

Figure 162. Precision data for magnesium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

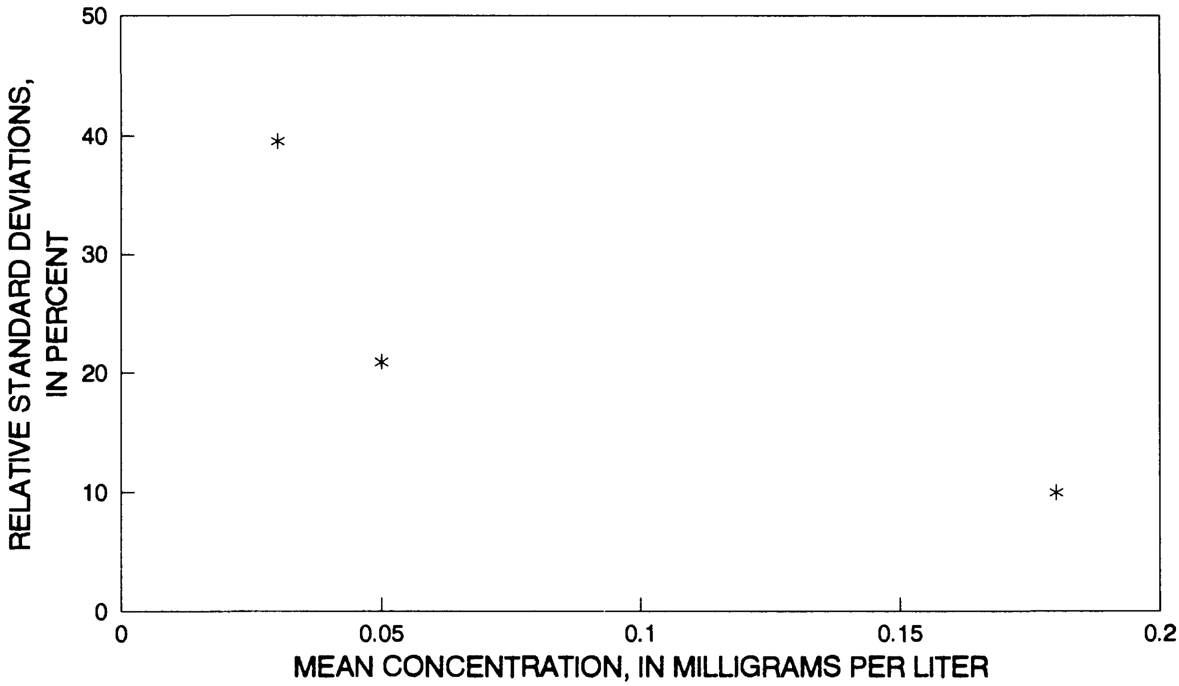

Figure 163. Precision data for potas%%[PrinterError: out of paper]%%%%[PrinterError: no paper tray]%% data from the National Water-Quality Laboratory.

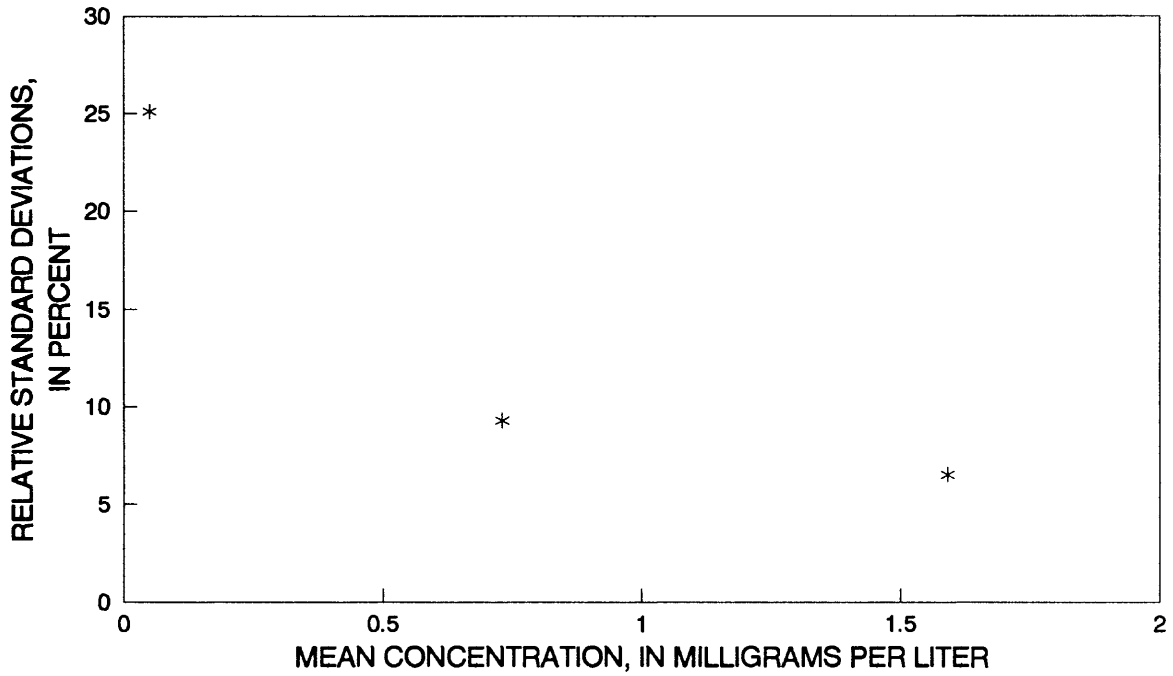

Figure 164. Precision data for sodium, dissolved, low ionic strength, (atomic absorption spectrometry) data from the National Water-Quality Laboratory.

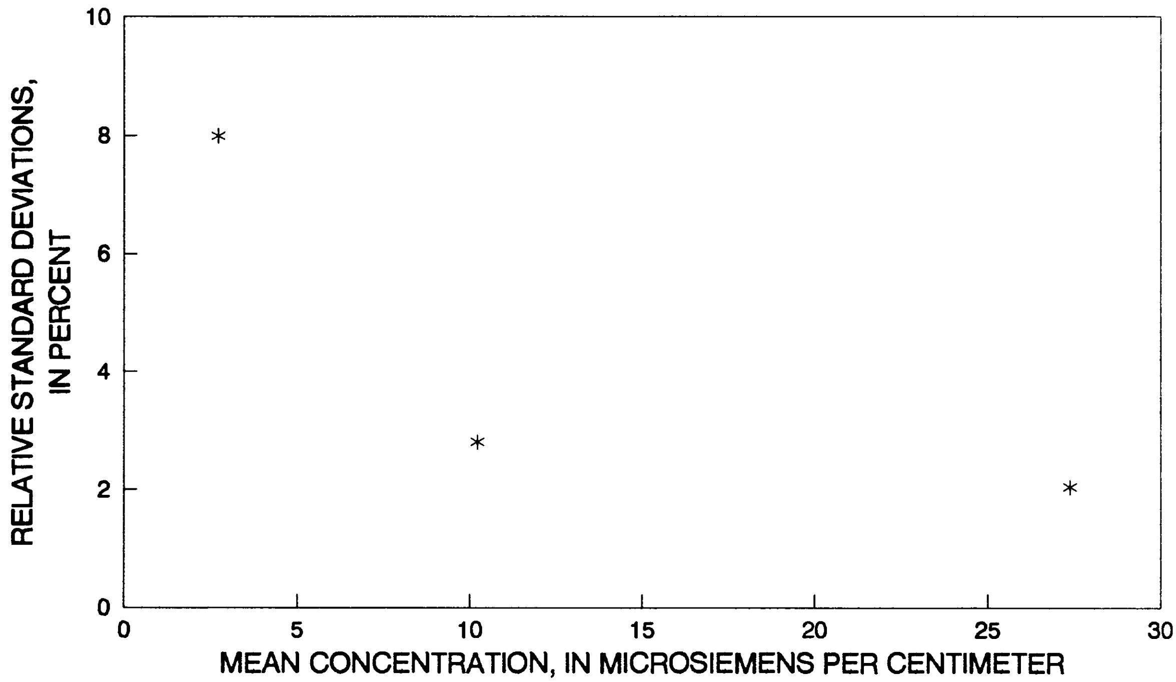

Figure 165. Precision data for specific conductance, low ionic strength, (electrometric, Wheatstone bridge) data from the National Water-Quality Laboratory.

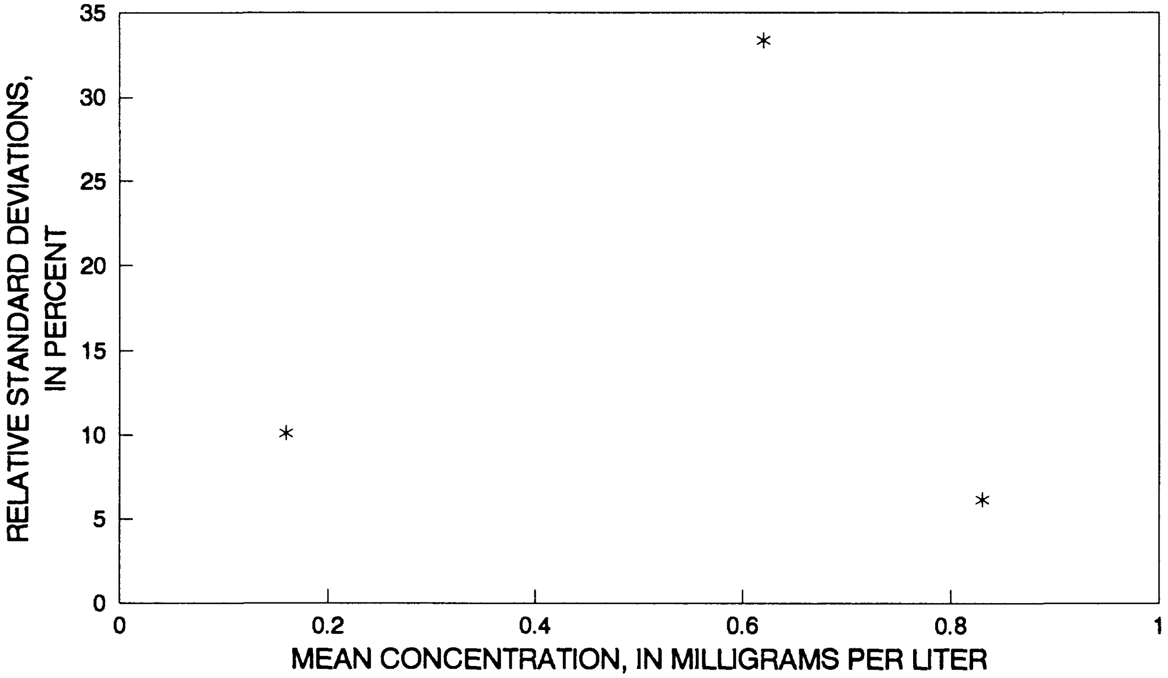

Figure 166. Precision data for sulfate, dissolved, low ionic strength, (ion chromatography) data from the National Water-Quality Laboratory.

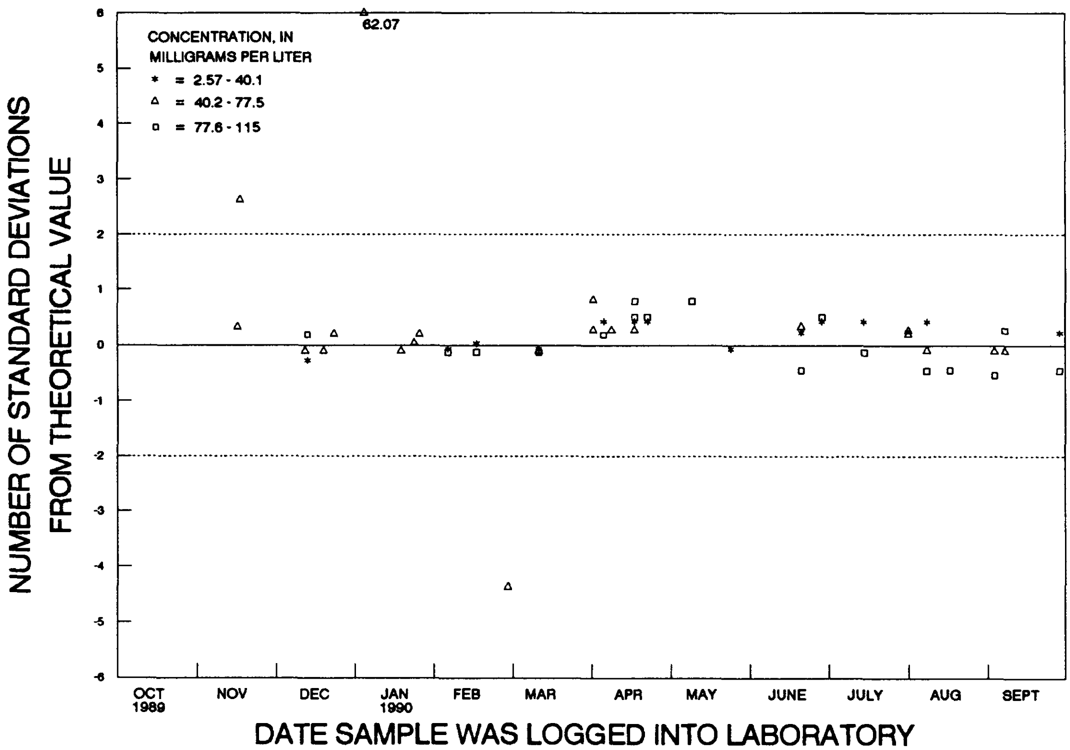

Figure 167. Alkalinity, dissolved, (electrometric titration) data from the Quality of Water Service Unit Laboratory.

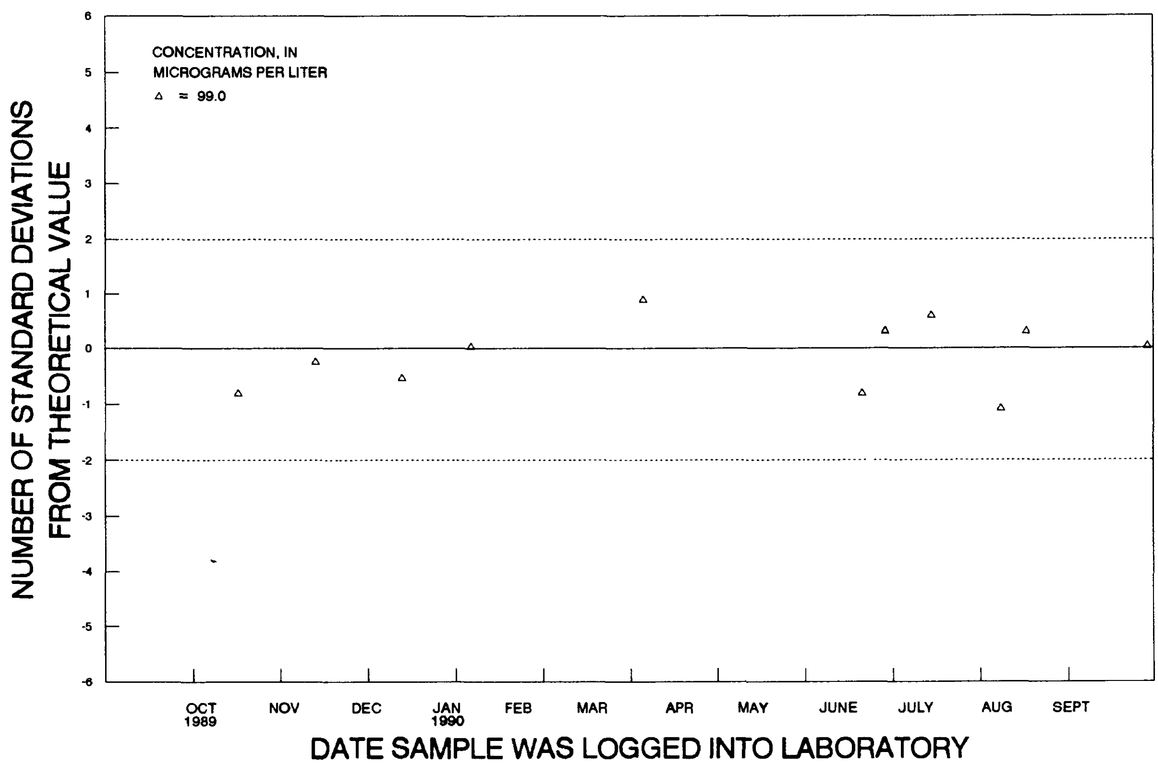

Figure 168. Aluminum, total recoverable, (atomic absorption spectrometry, chelation-extraction) data from the Quality of Water Service Unit Laboratory.

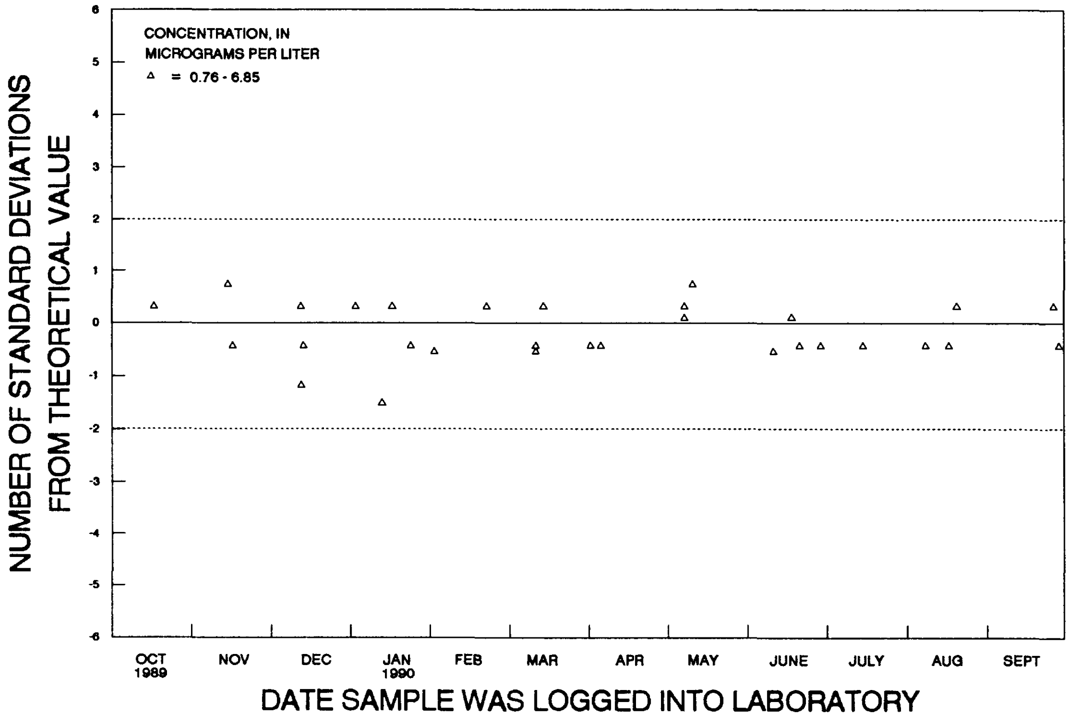

Figure 169. Arsenic, dissolved and total, (atomic absorption spectrometry, hydride) data from the Quality of Water Service Unit Laboratory.

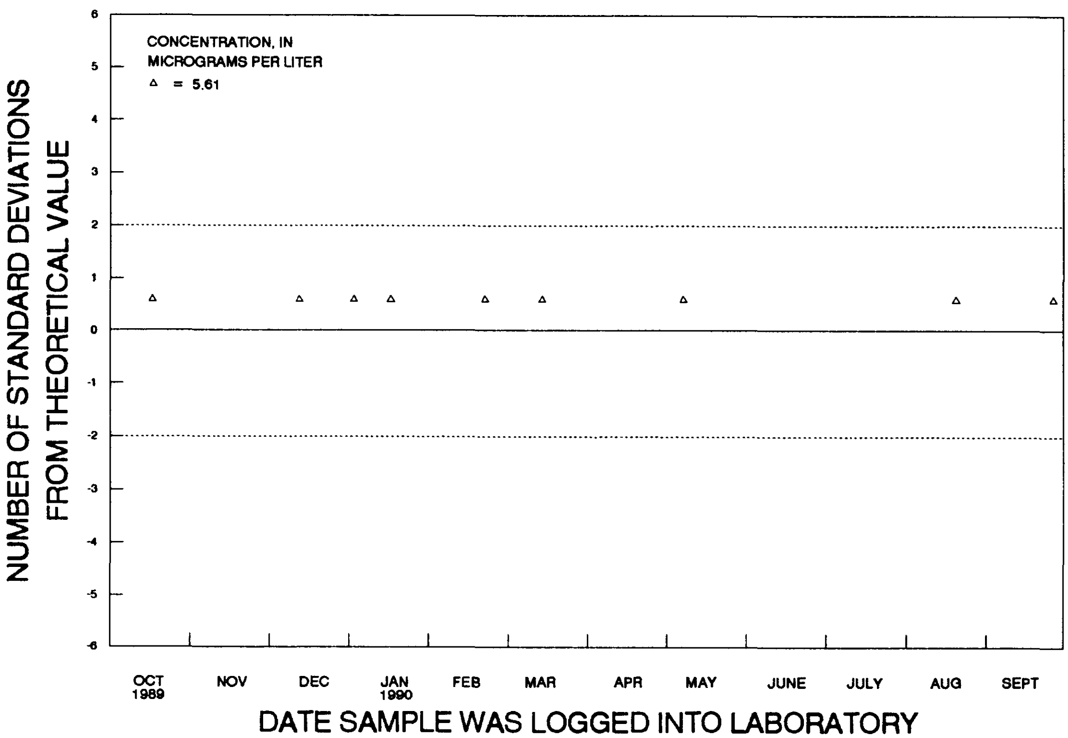

Figure 170. Beryllium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

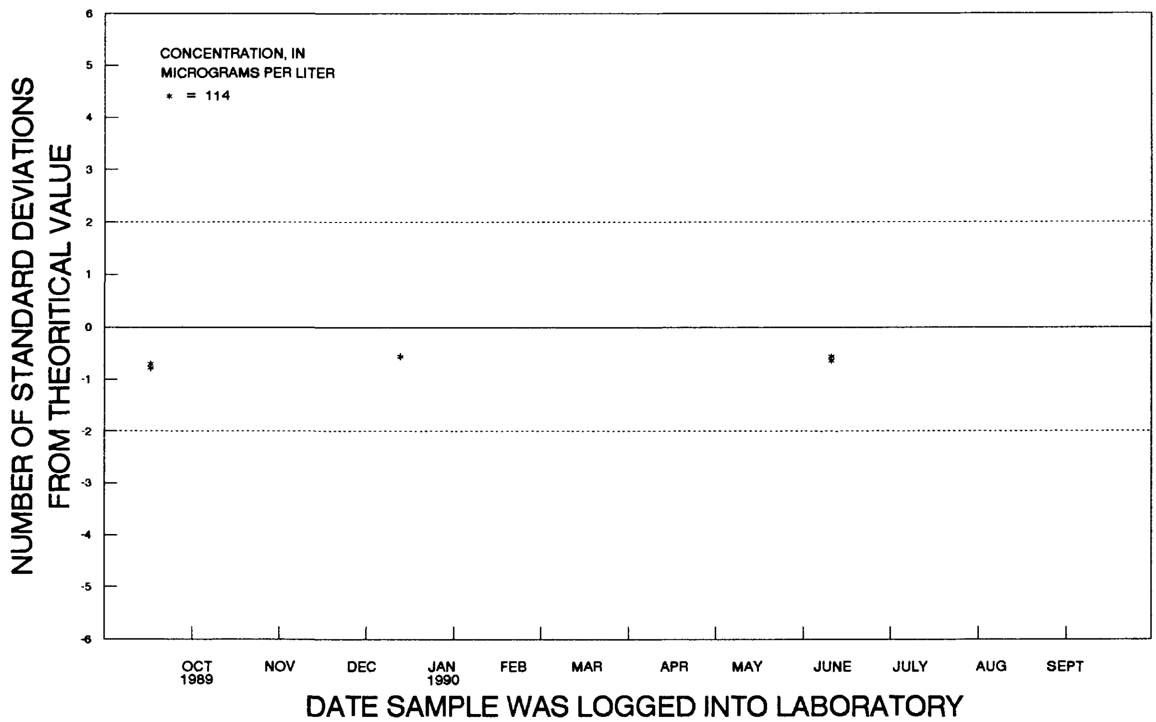

Figure 171. Beryllium, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

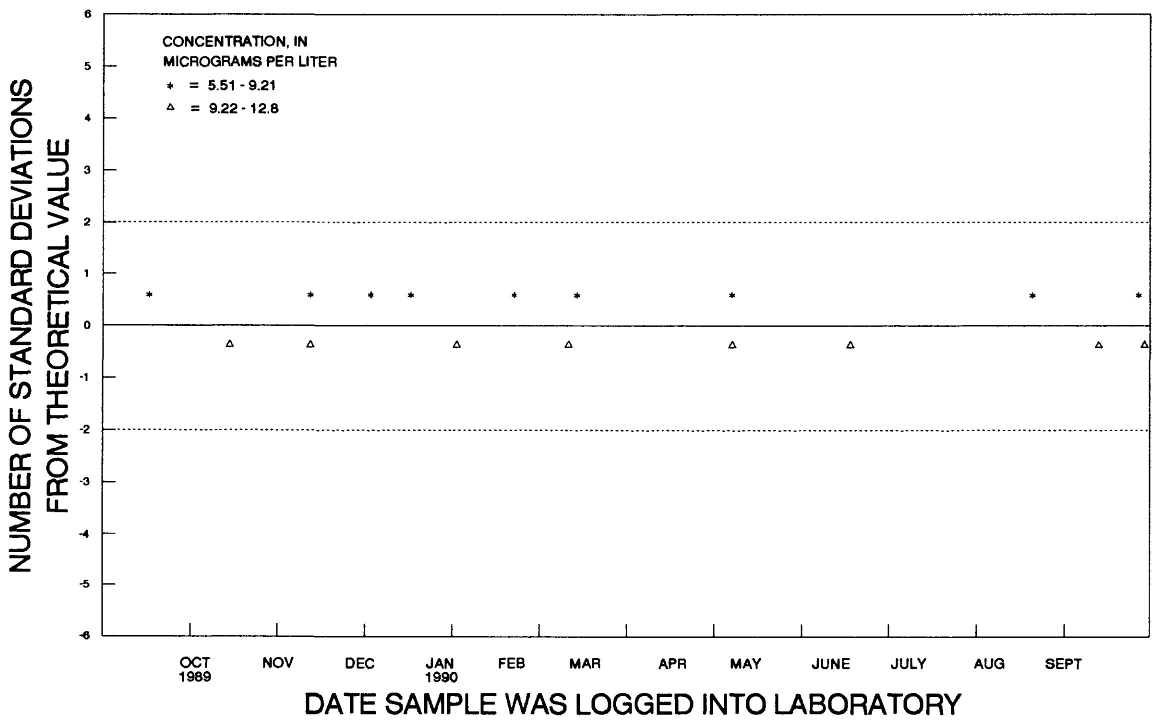

Figure 172. Boron, dissolved, (colorimetric) data from the Quality of Water Service Unit Laboratory.

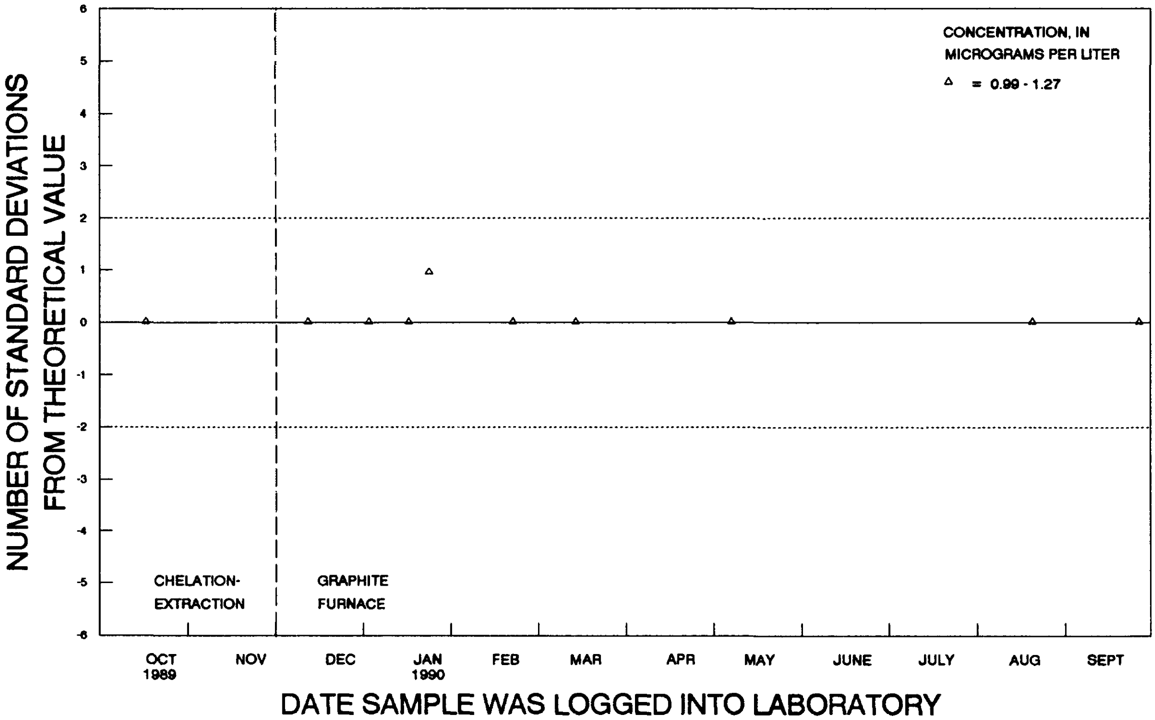

Figure 173. Cadmium, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

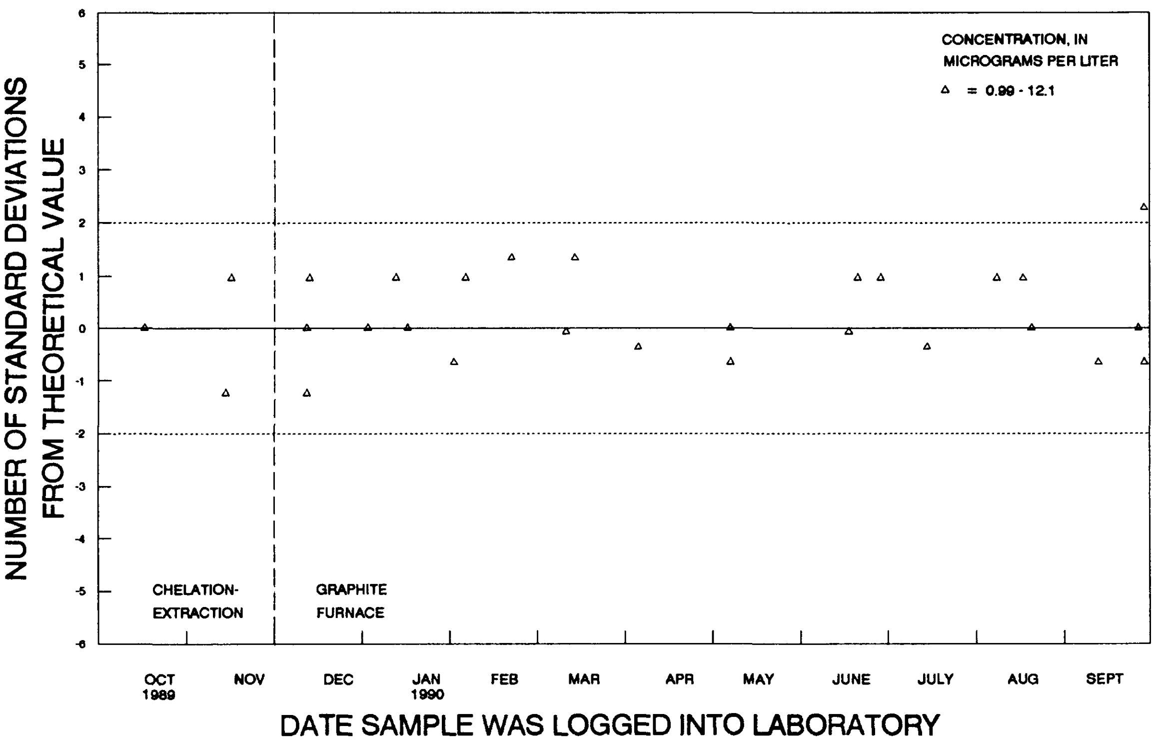

Figure 174. Cadmium, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

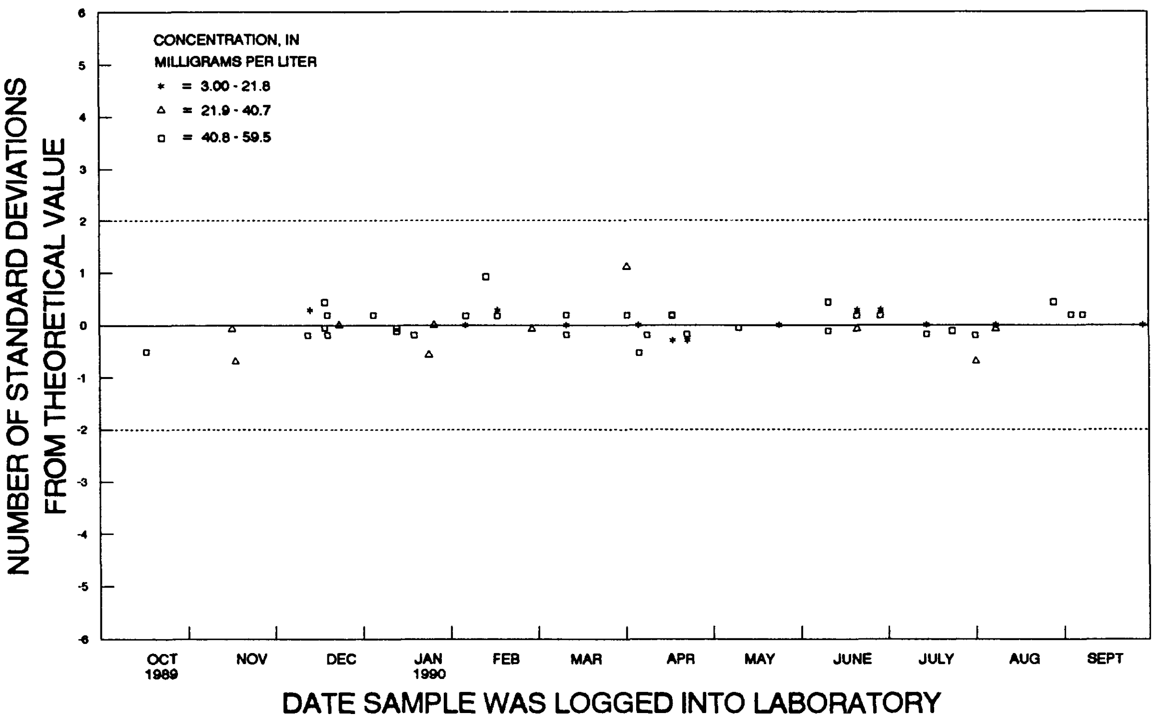

Figure 175. Calcium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

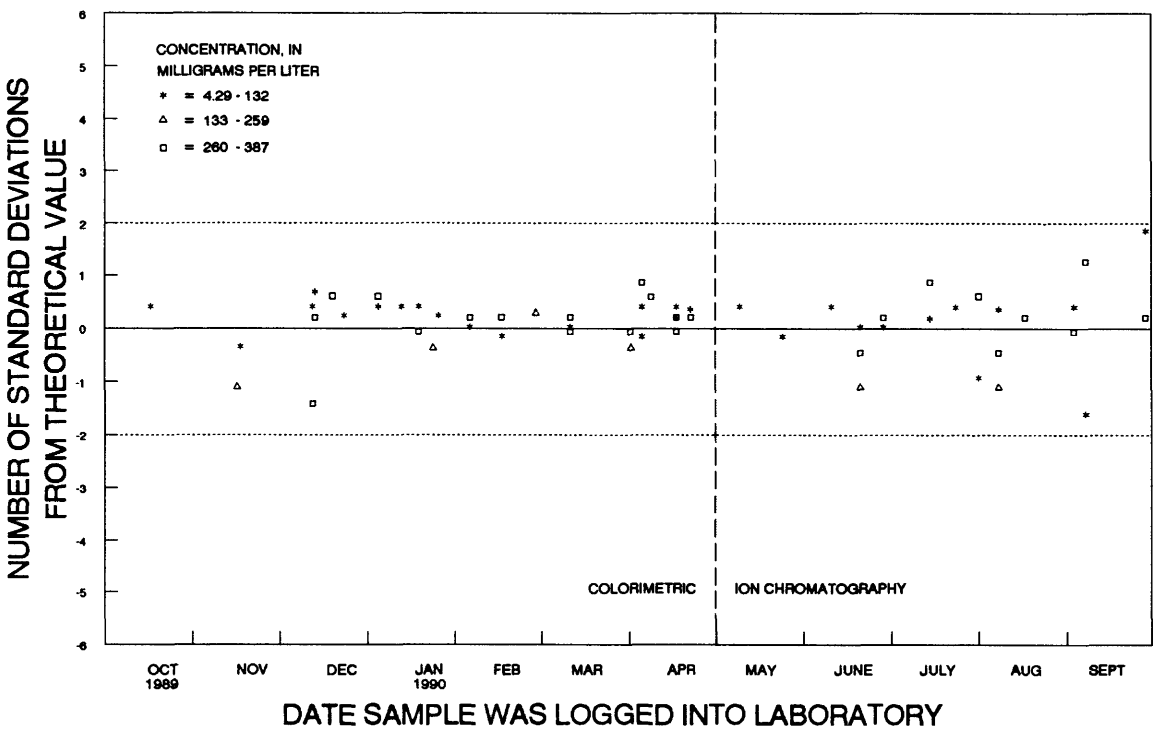

Figure 176. Chloride, dissolved, (colorimetric and ion chromatography) data from the Quality of Water Service Unit Laboratory.

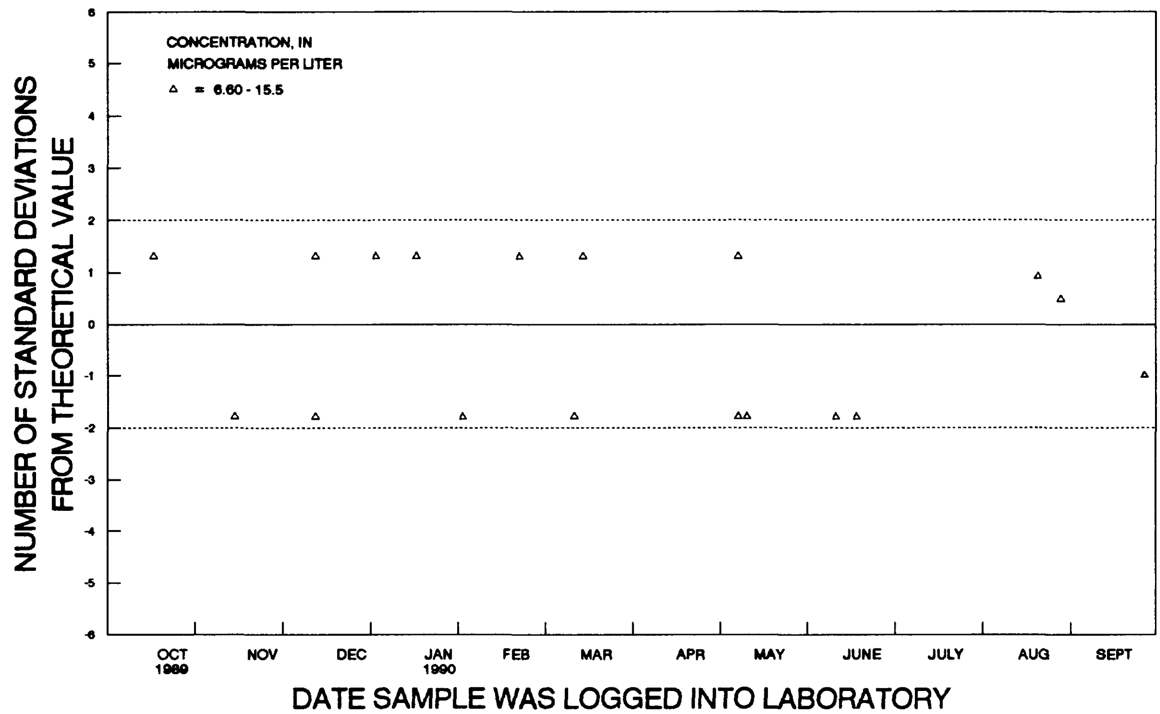

Figure 177. Chromium, total recoverable, (atomic absorption spectrometry, chelation-extraction) data from the Quality of Water Service Unit Laboratory.

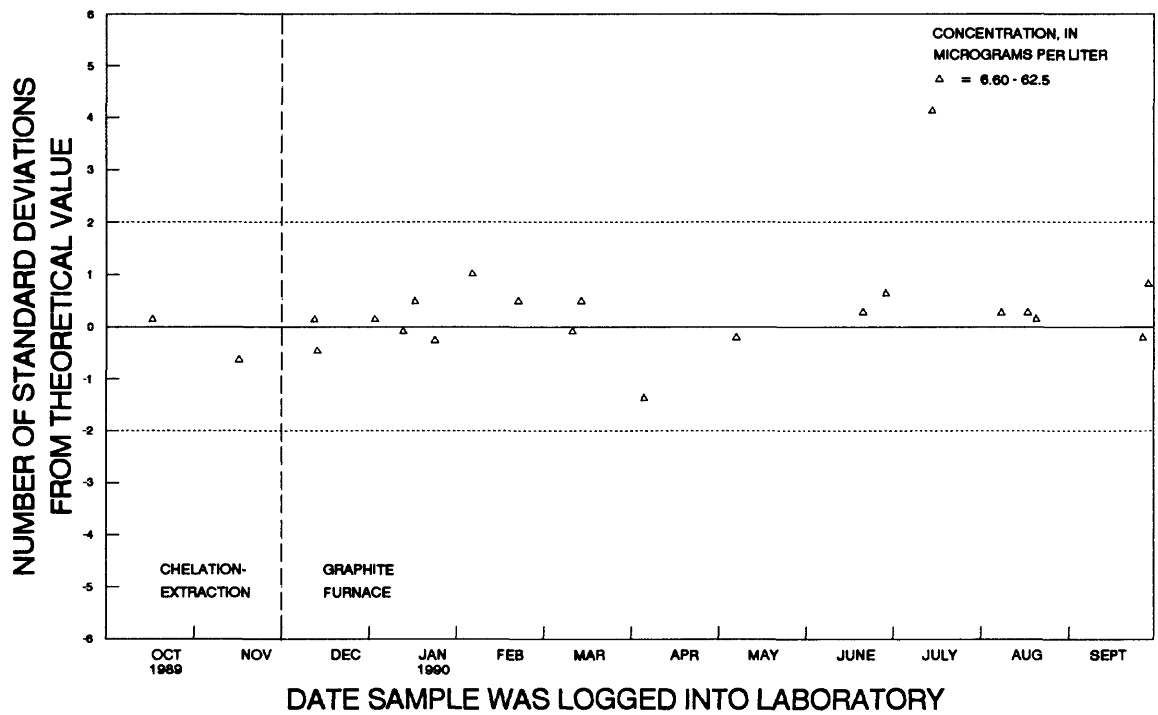

Figure 178. Copper, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

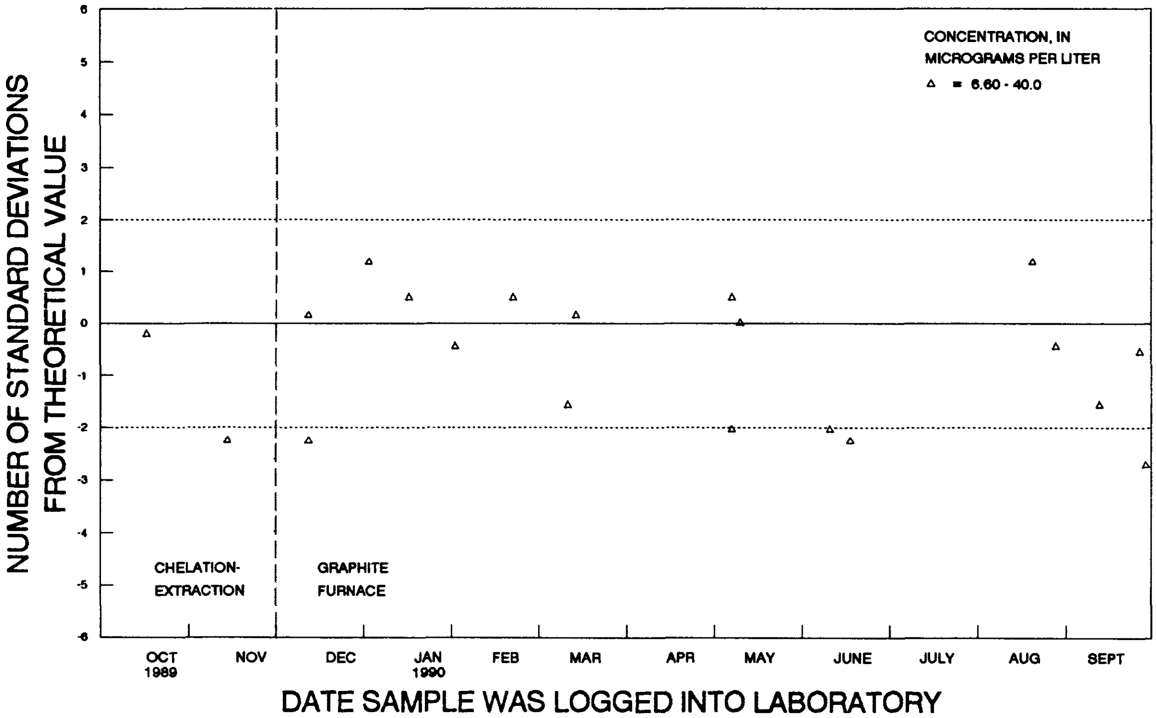

Figure 179. Copper, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

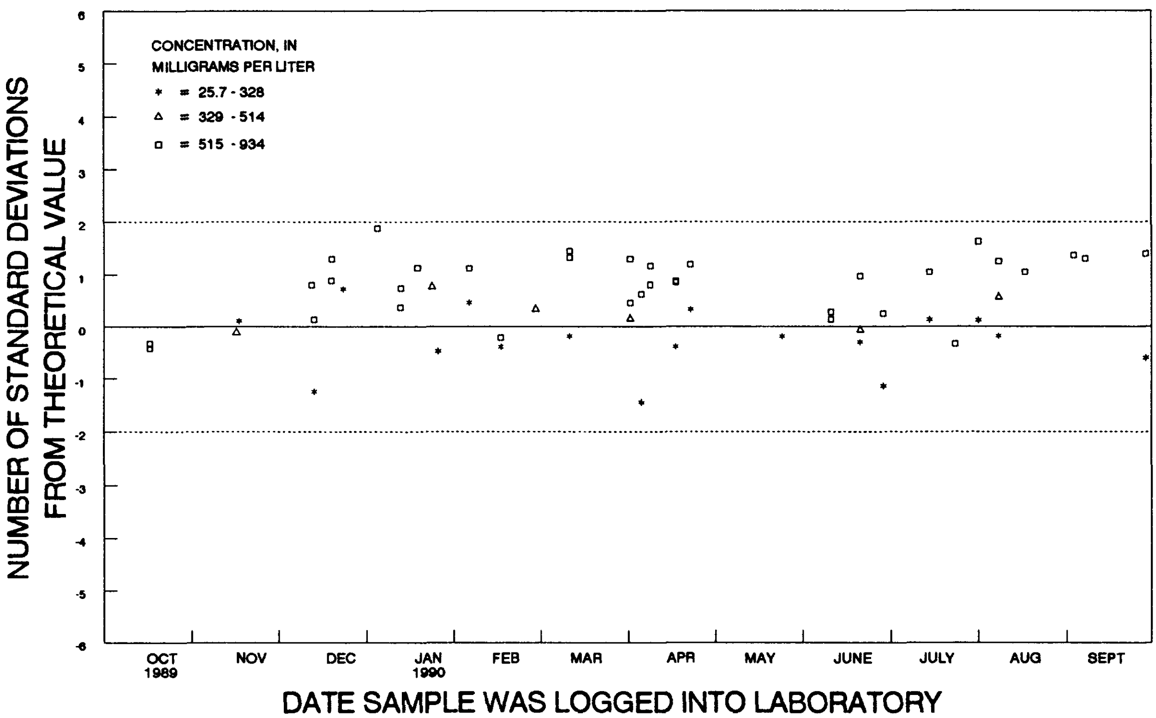

Figure 180. Dissolved solids, (gravimetric) data from the Quality of Water Service Unit Laboratory.

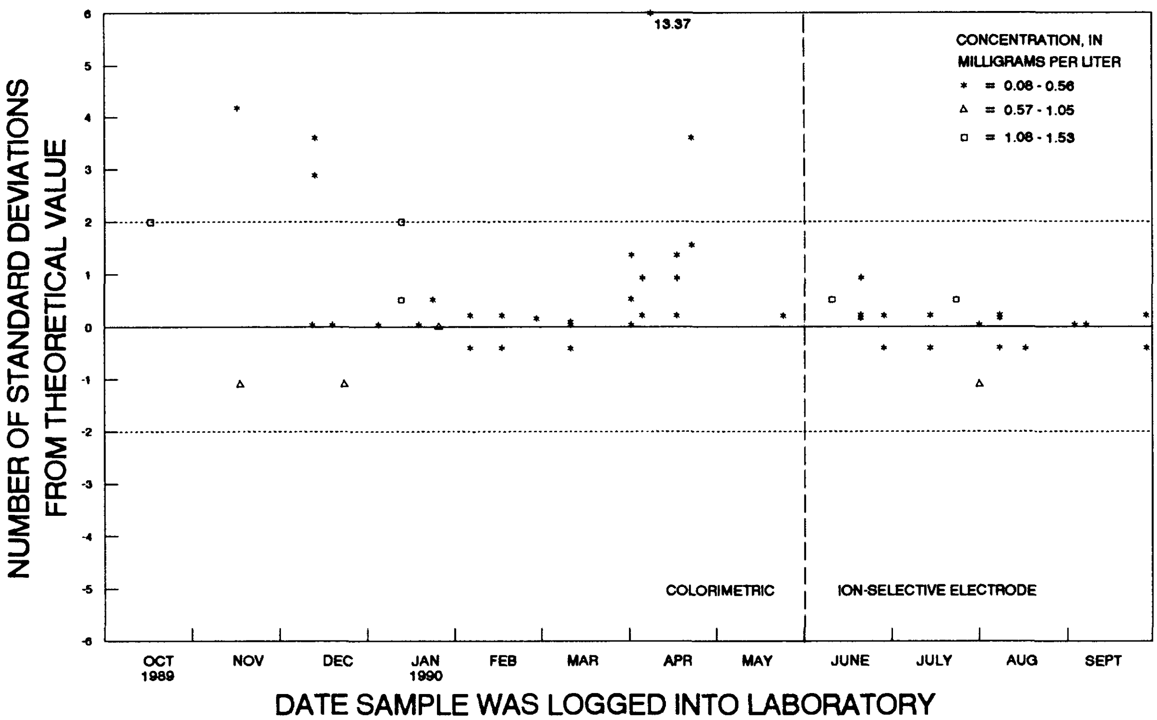

Figure 181. Fluoride, dissolved, (colorimetric and ion-selective electrode) data from the Quality of Water Service Unit Laboratory.

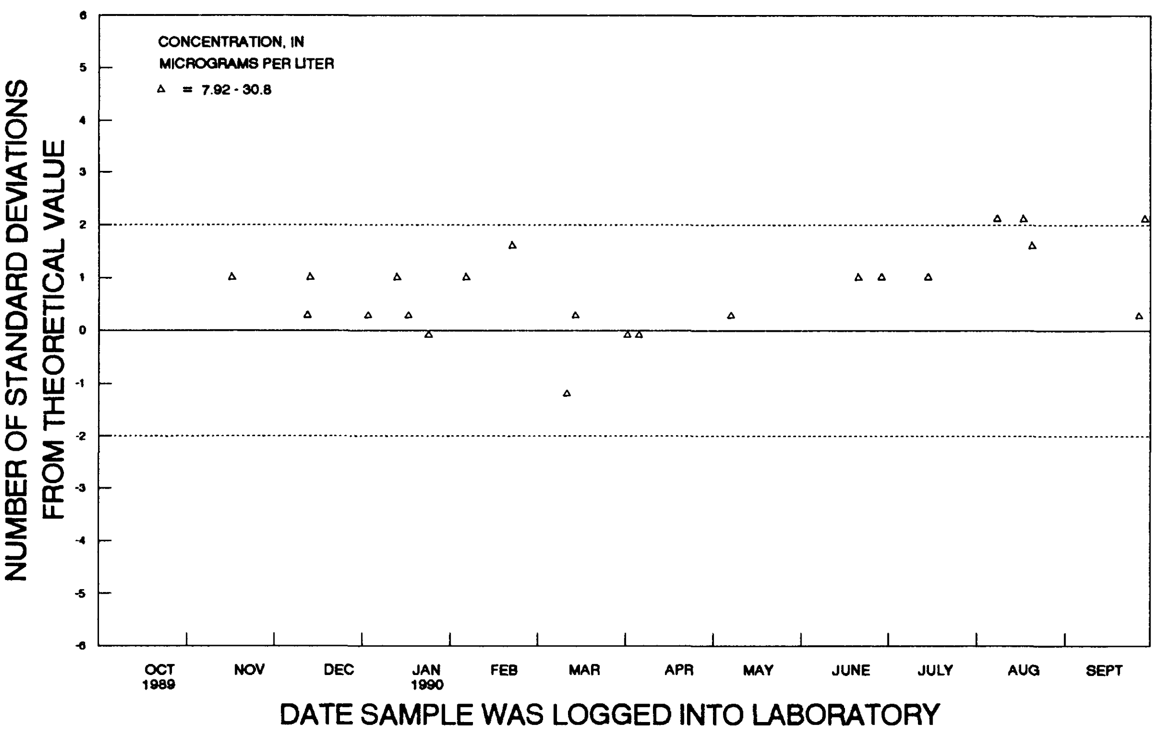

Figure 182. Iron, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

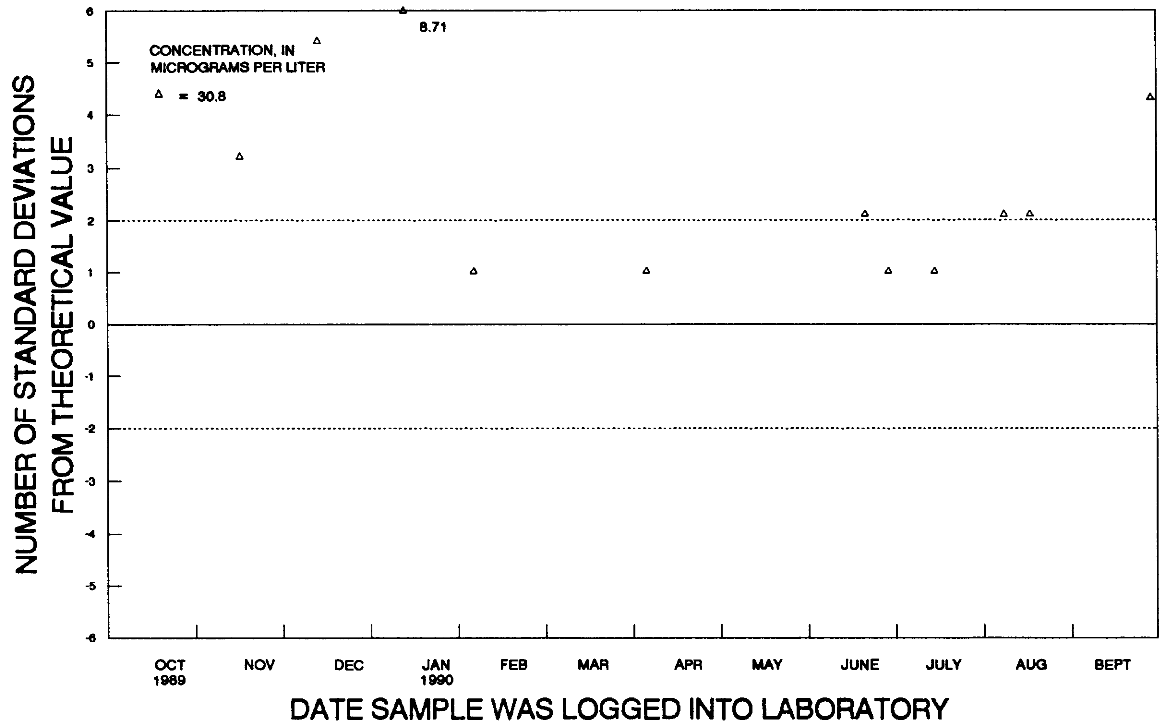

Figure 183. Iron, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

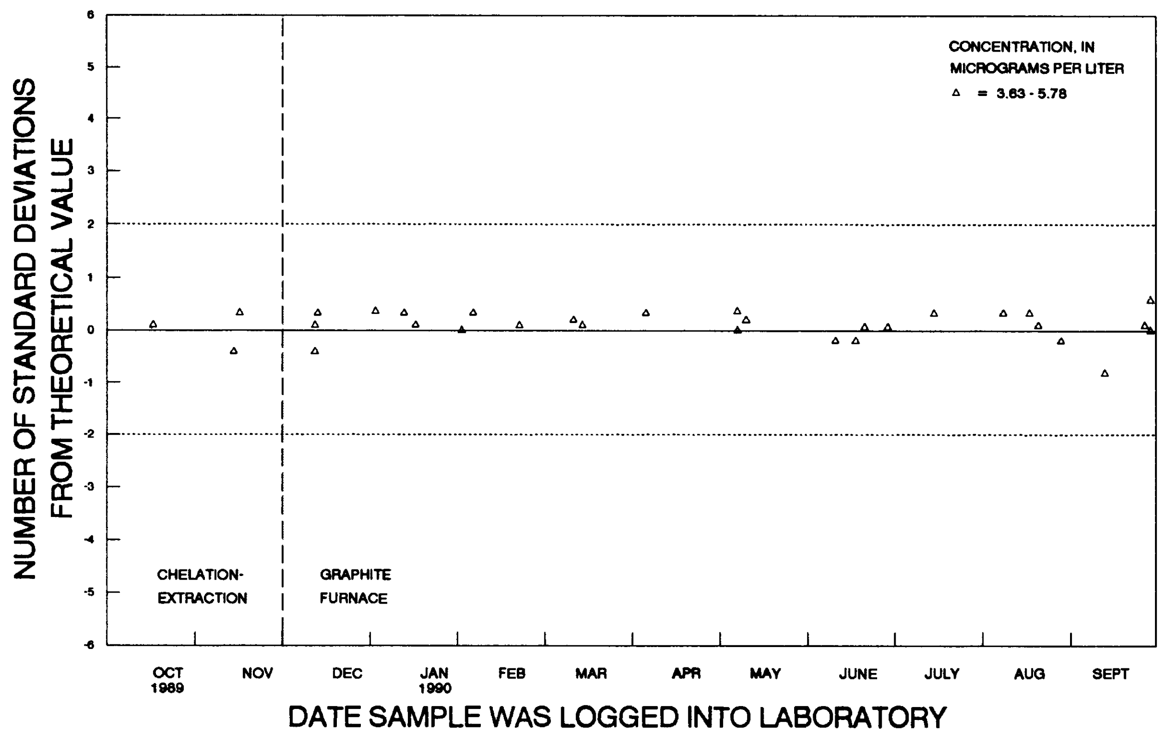

Figure 184. Lead, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

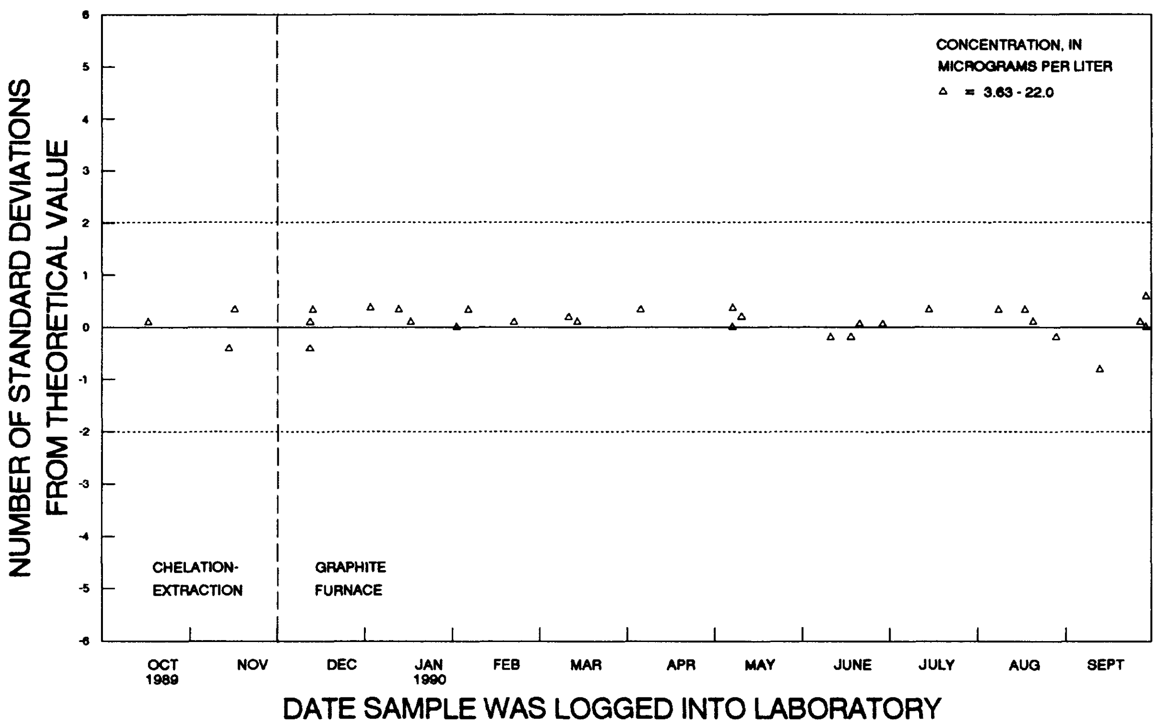

Figure 185. Lead, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

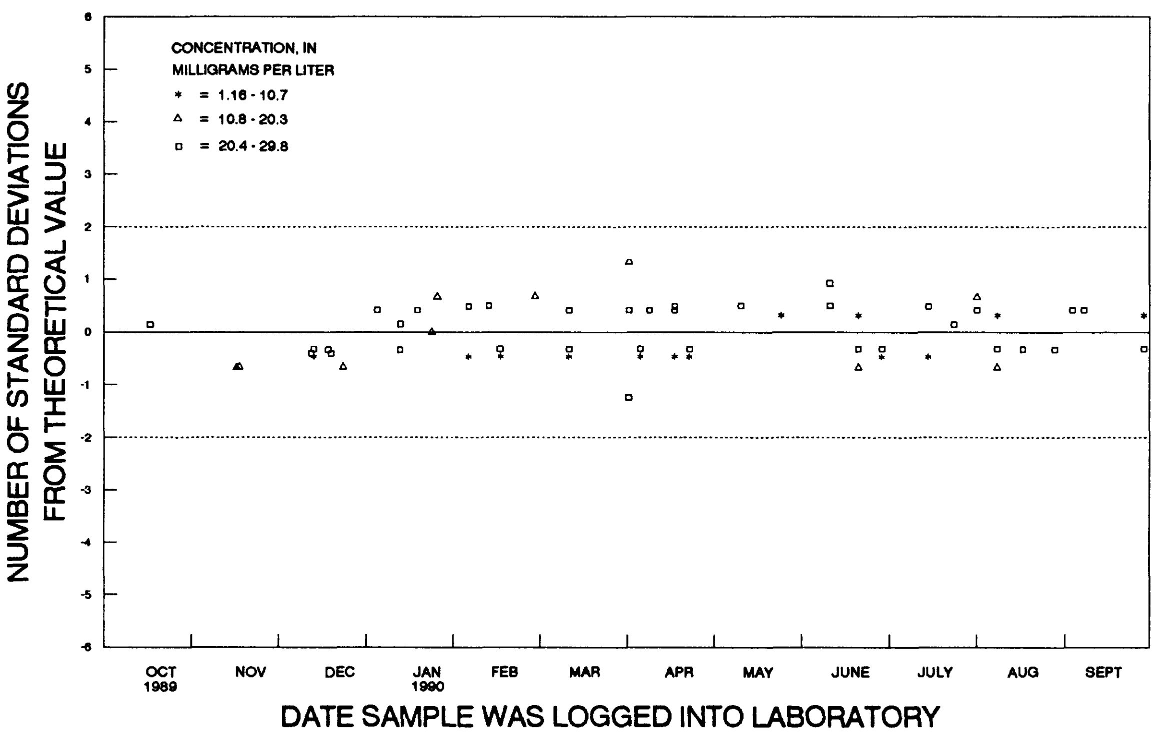

Figure 186. Magnesium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

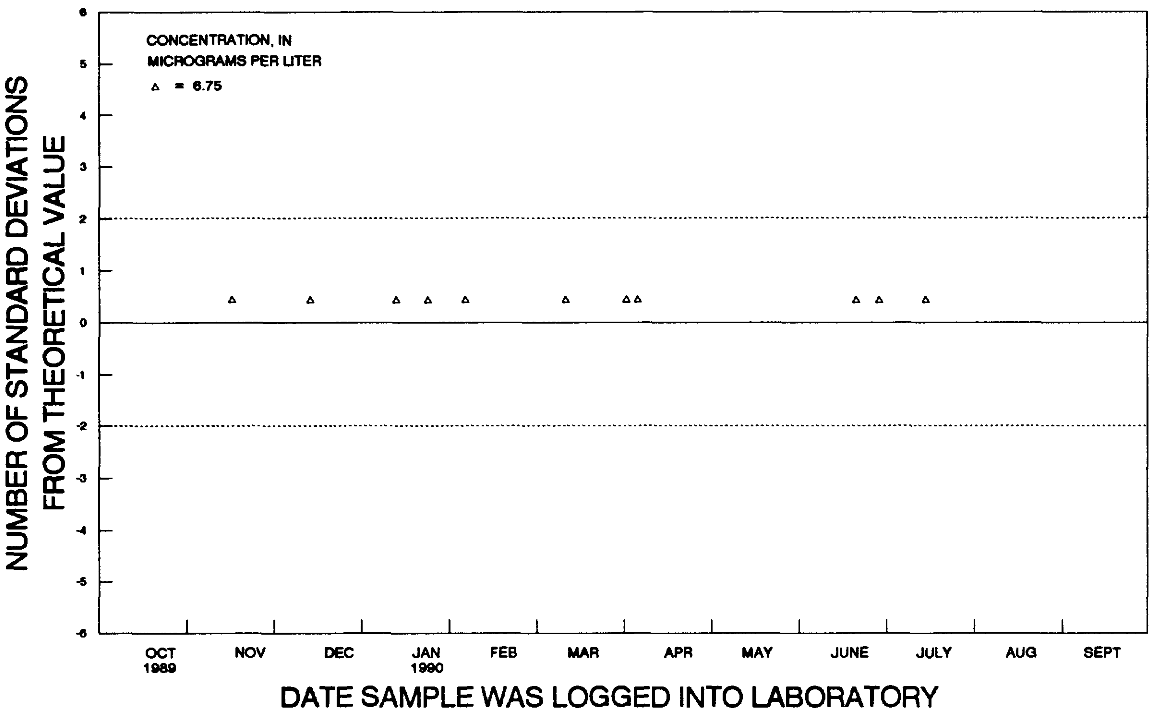

Figure 187. Manganese, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

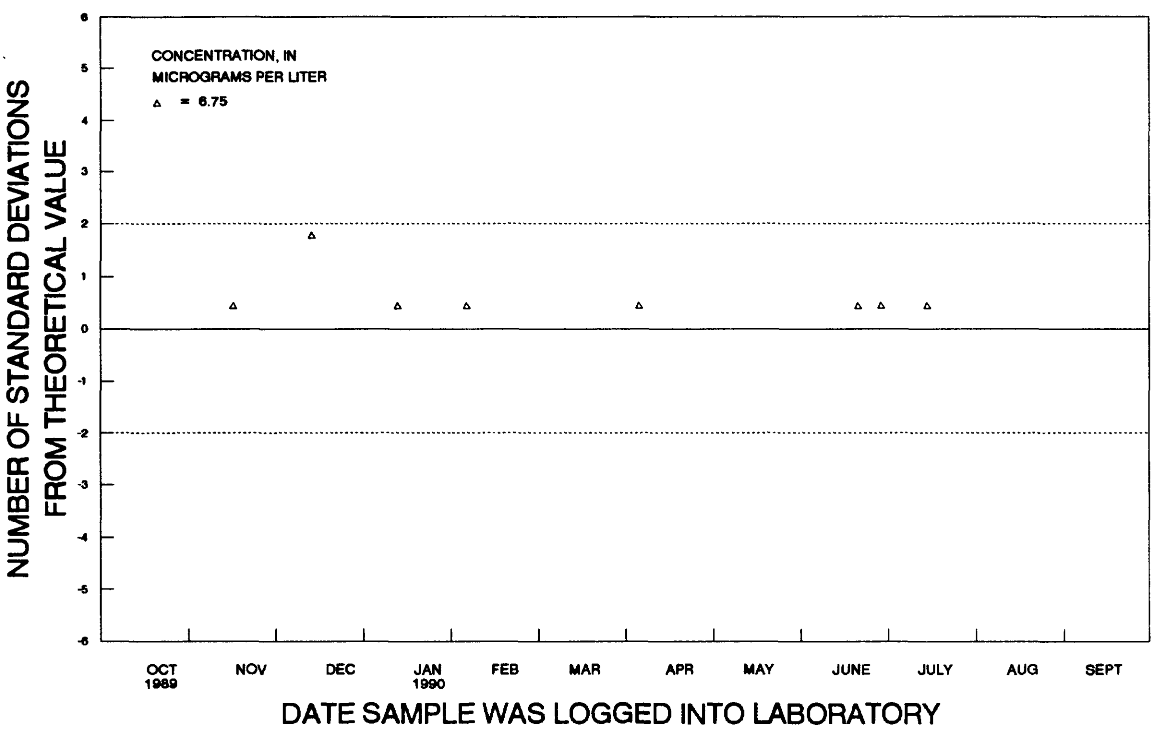

Figure 188. Manganese, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

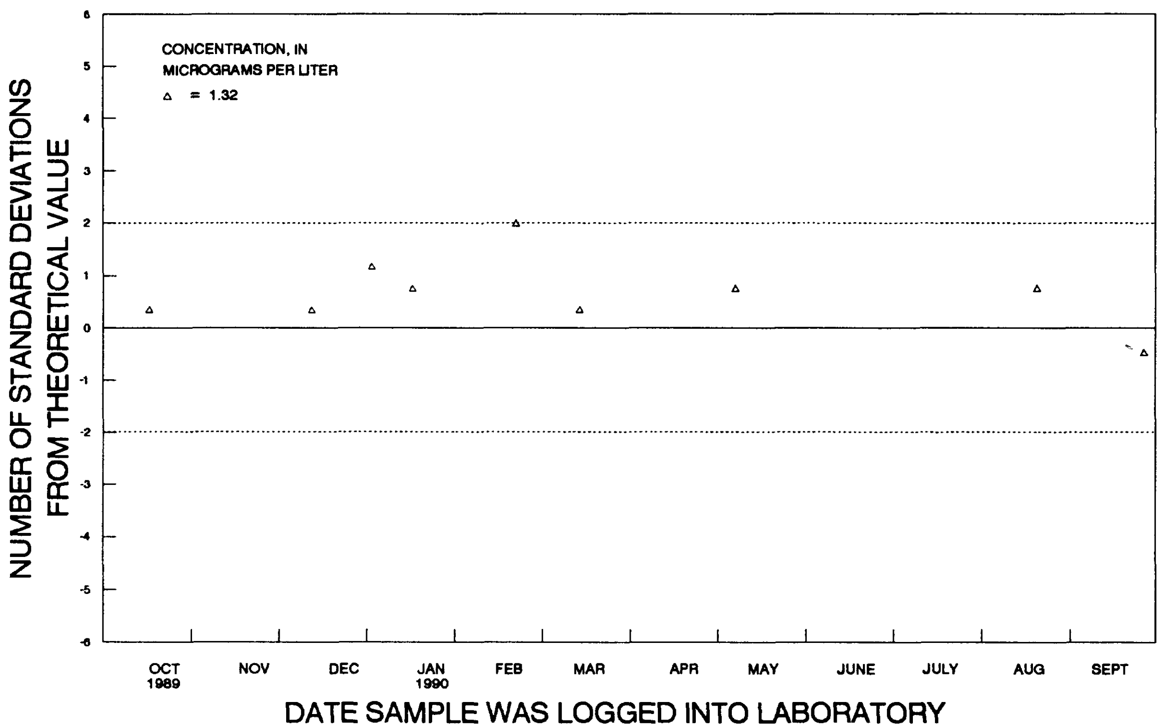

Figure 189. Mercury, dissolved, (atomic absorption spectrometry, flameless) data from the Quality of Water Service Unit Laboratory.

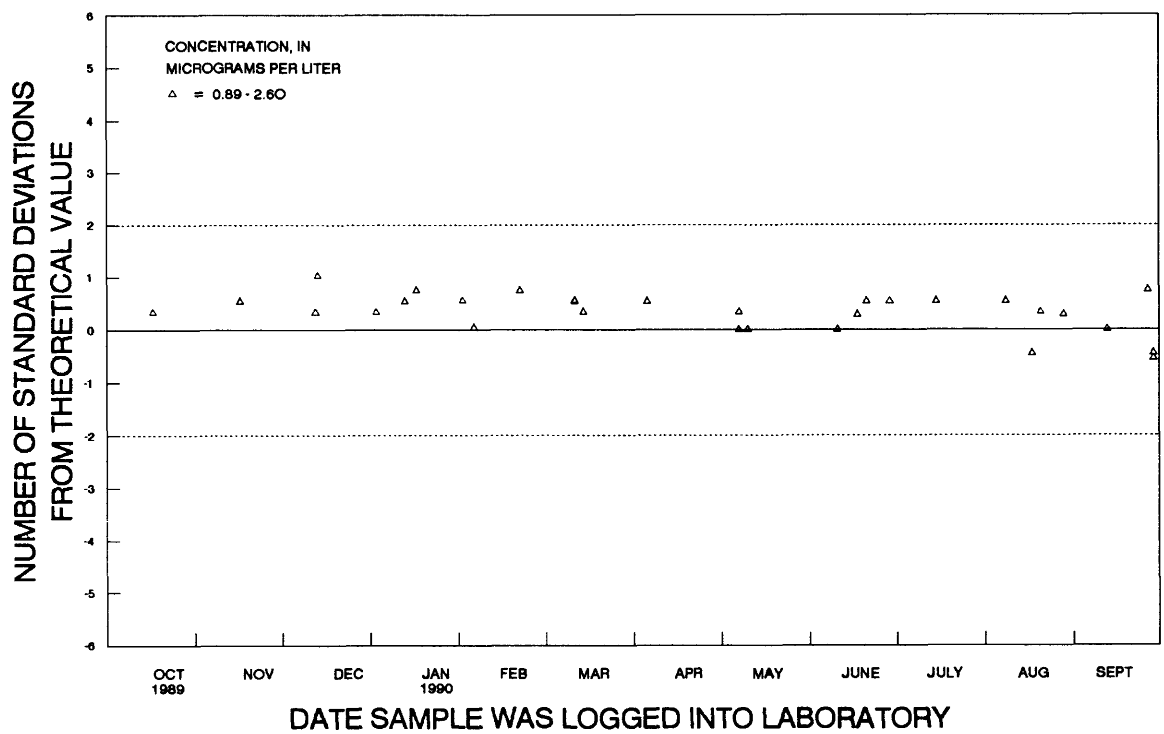

Figure 190. Mercury, total recoverable, (atomic absorption spectrometry, flameless) data from the Quality of Water Service Unit Laboratory.

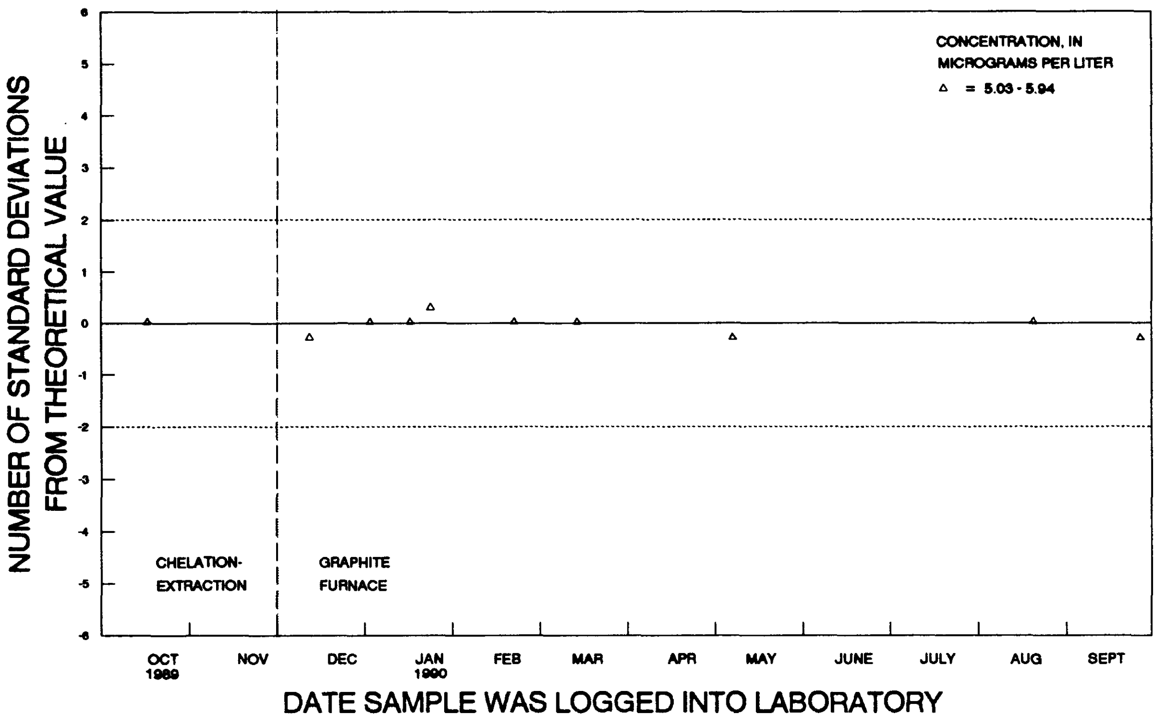

Figure 191. Nickel, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

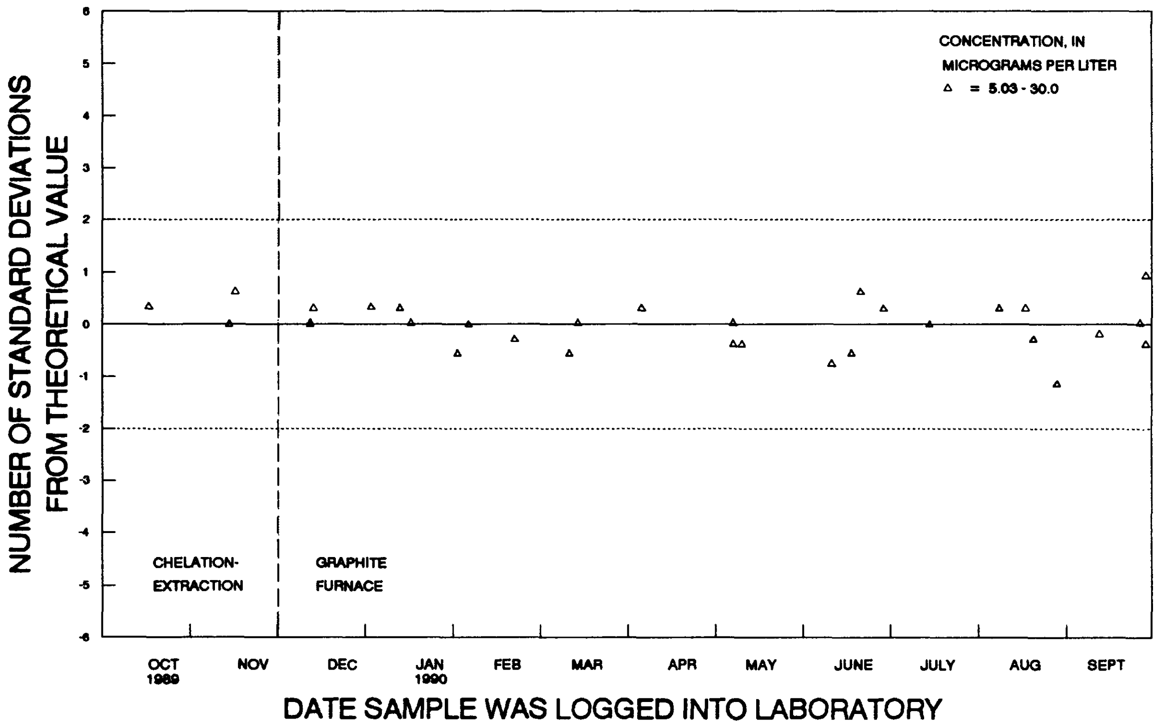

Figure 192. Nickel, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

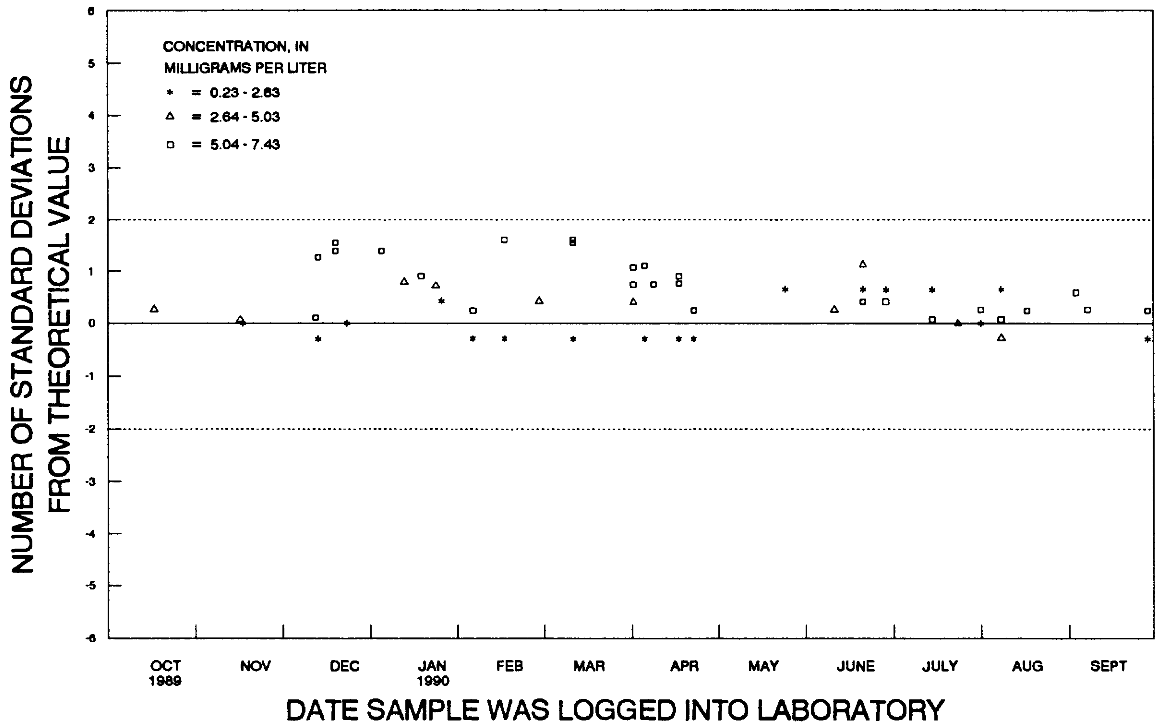

Figure 193. Potassium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

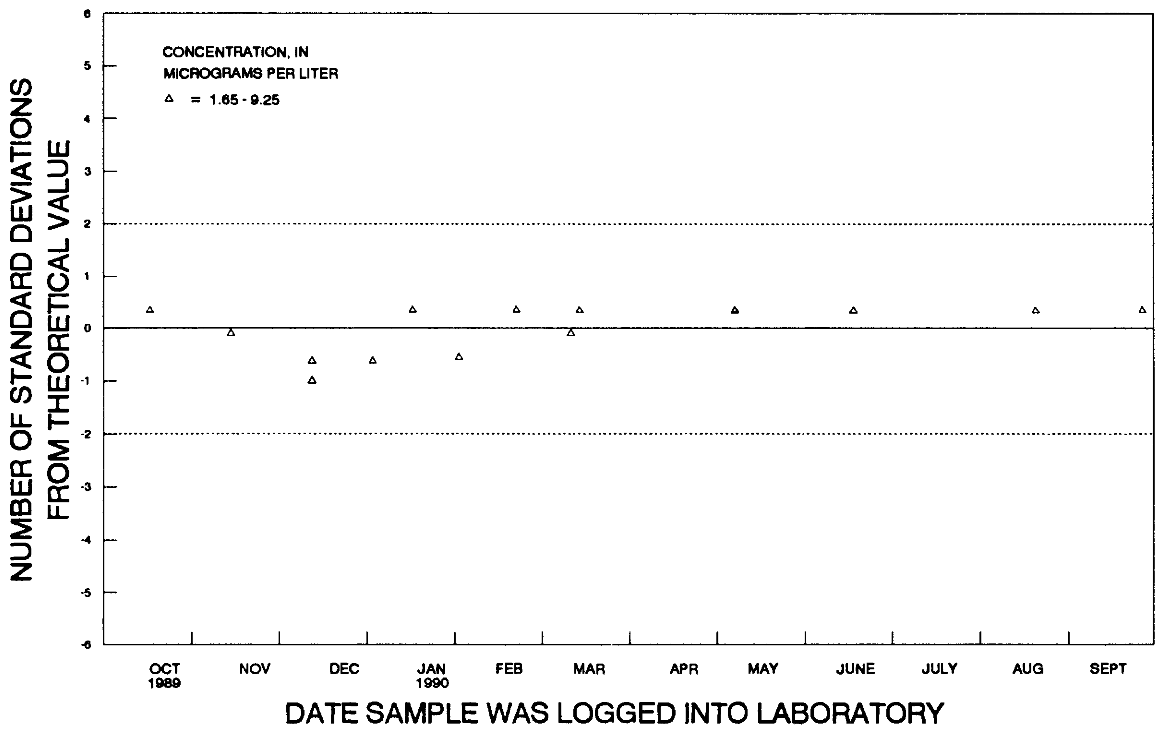

Figure 194. Selenium, dissolved and total, (atomic absorption spectrometry, hydride) data from the Quality of Water Service Unit Laboratory.

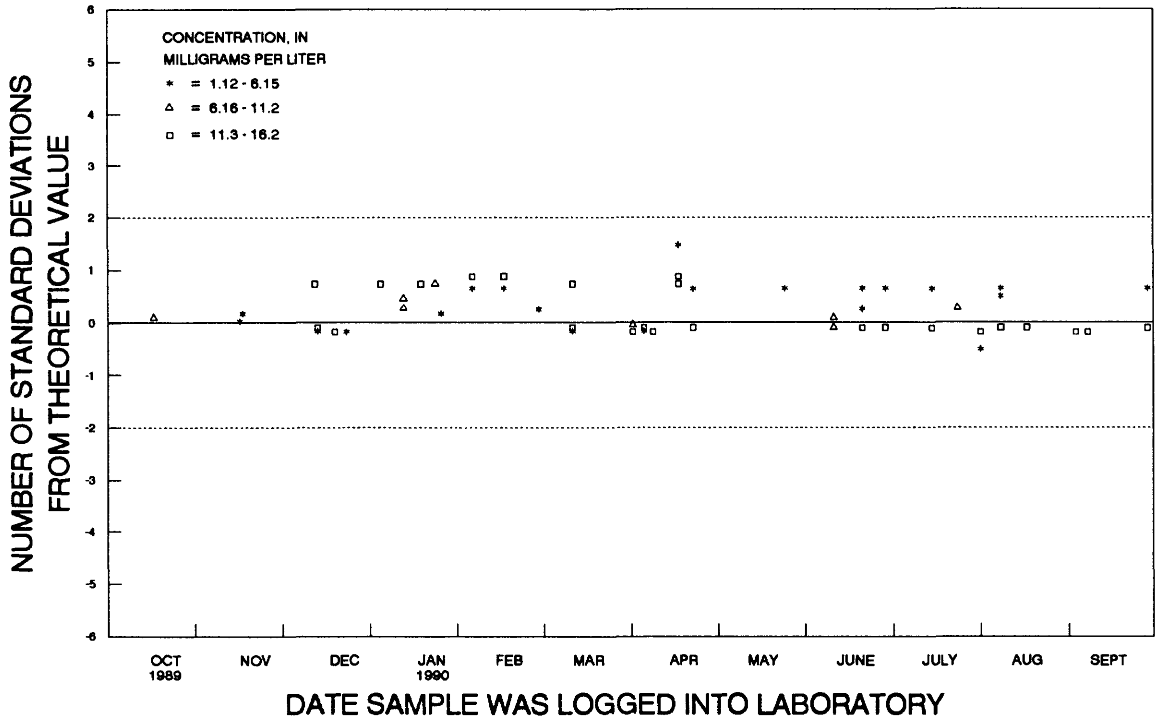

Figure 195. Silica, dissolved, (colorimetric) data from the Quality of Water Service Unit Laboratory.

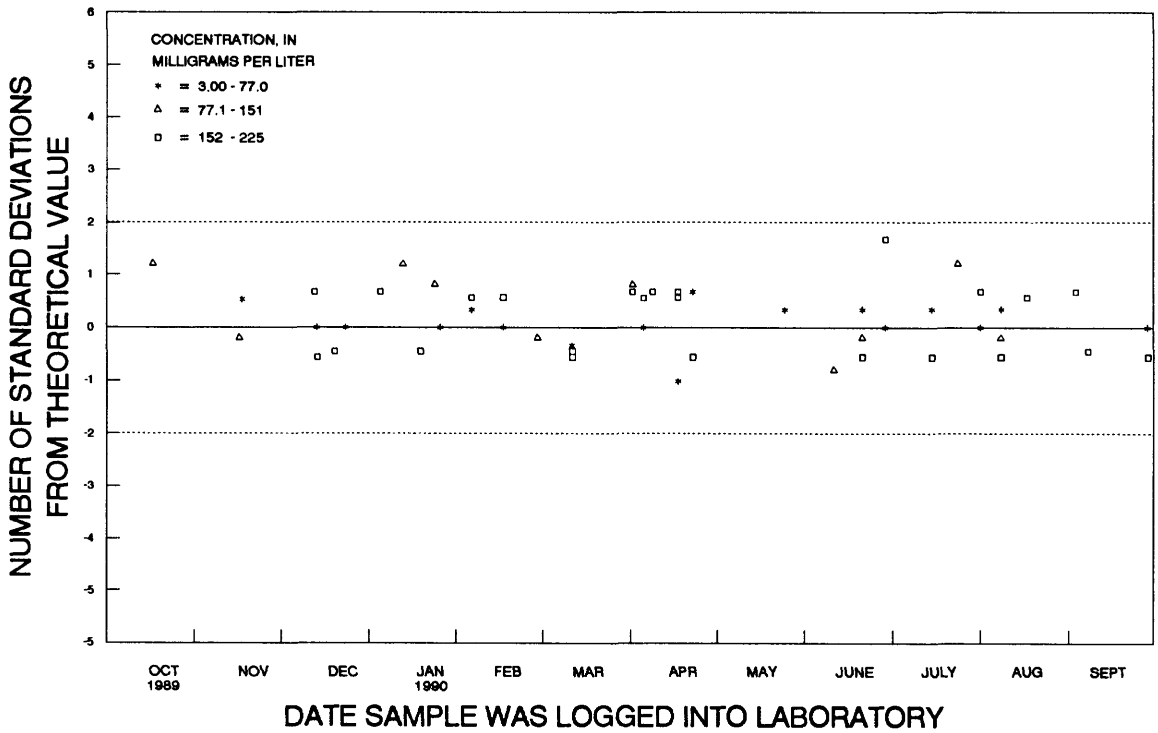

Figure 196. Sodium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

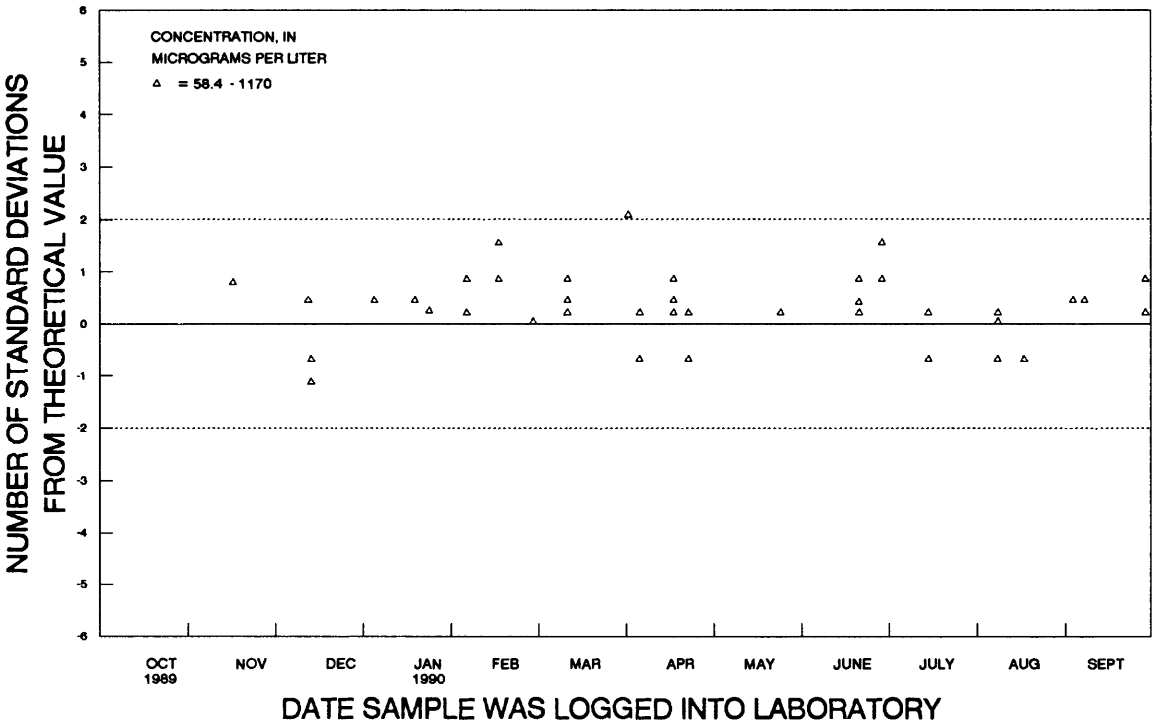

Figure 197. Strontium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

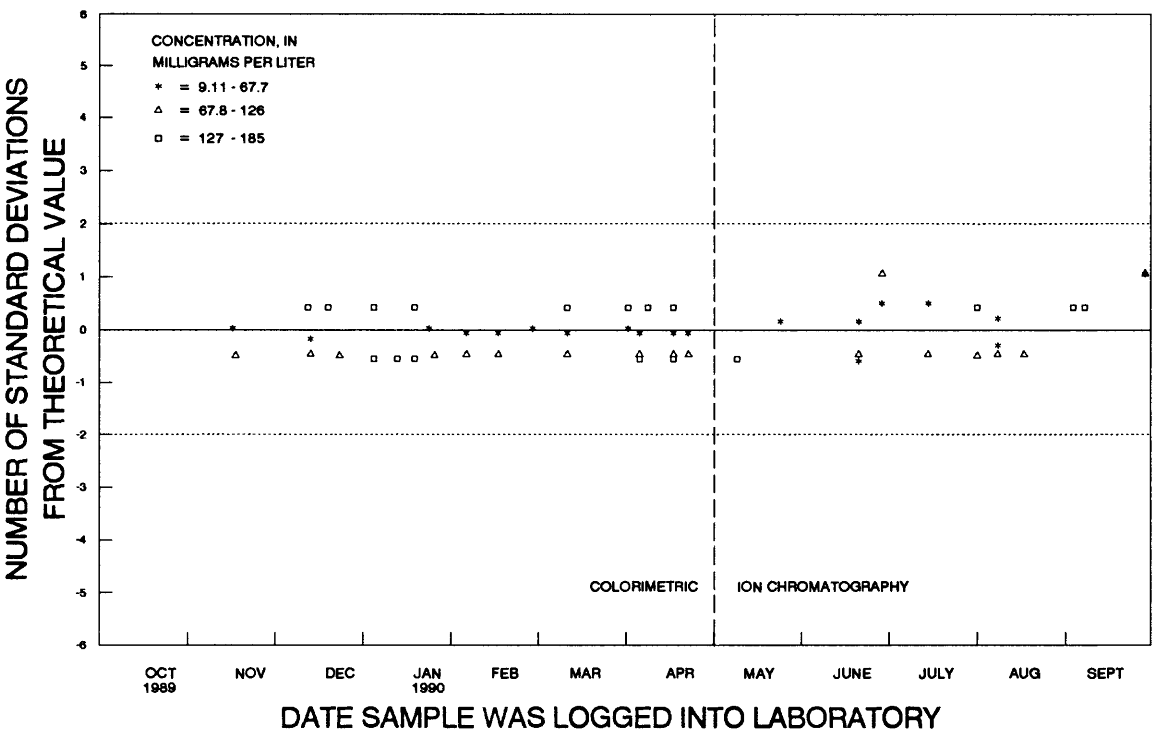

Figure 198. Sulfate, dissolved, (colorimetric and ion chromatography) data from the Quality of Water Service Unit Laboratory.

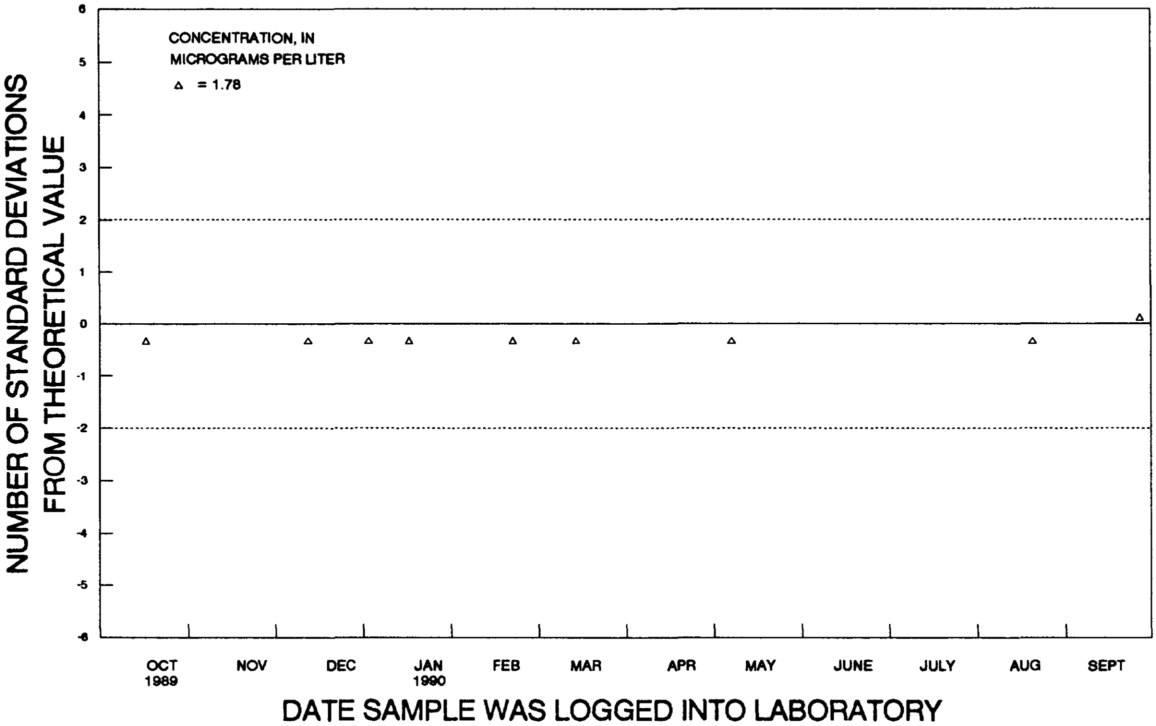

Figure 199. Vanadium, dissolved, (colorimetric) data from the Quality of Water Service Unit Laboratory.

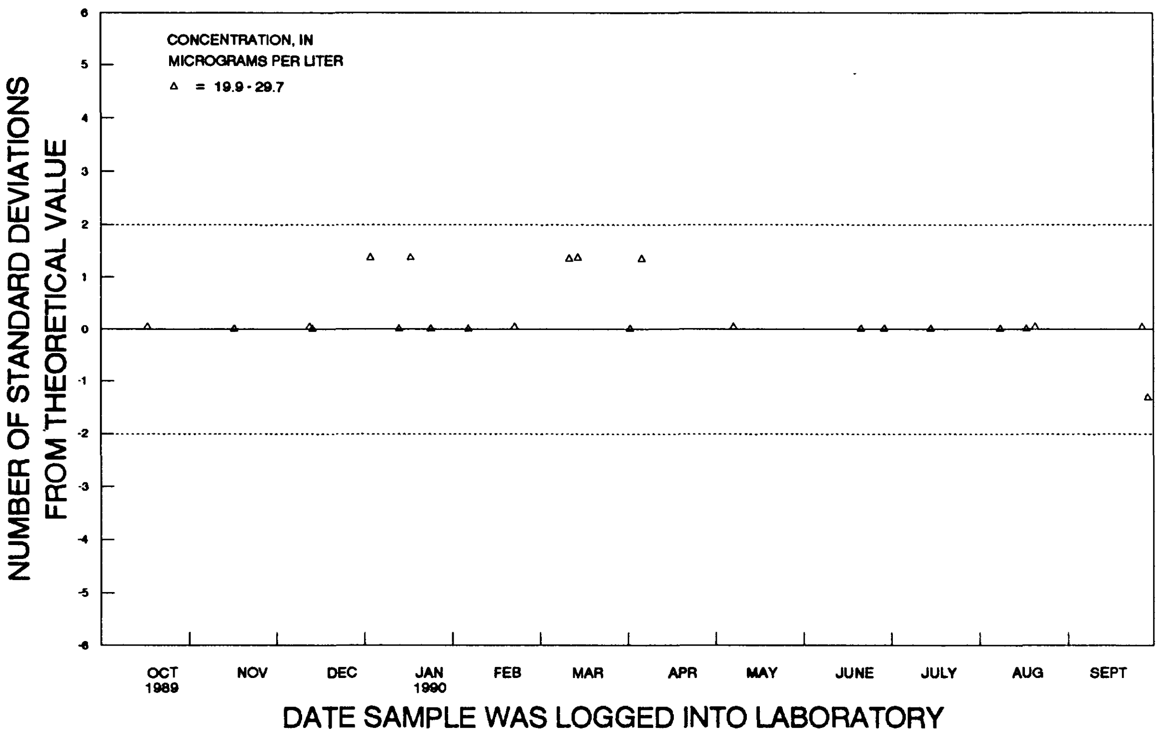

Figure 200. Zinc, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

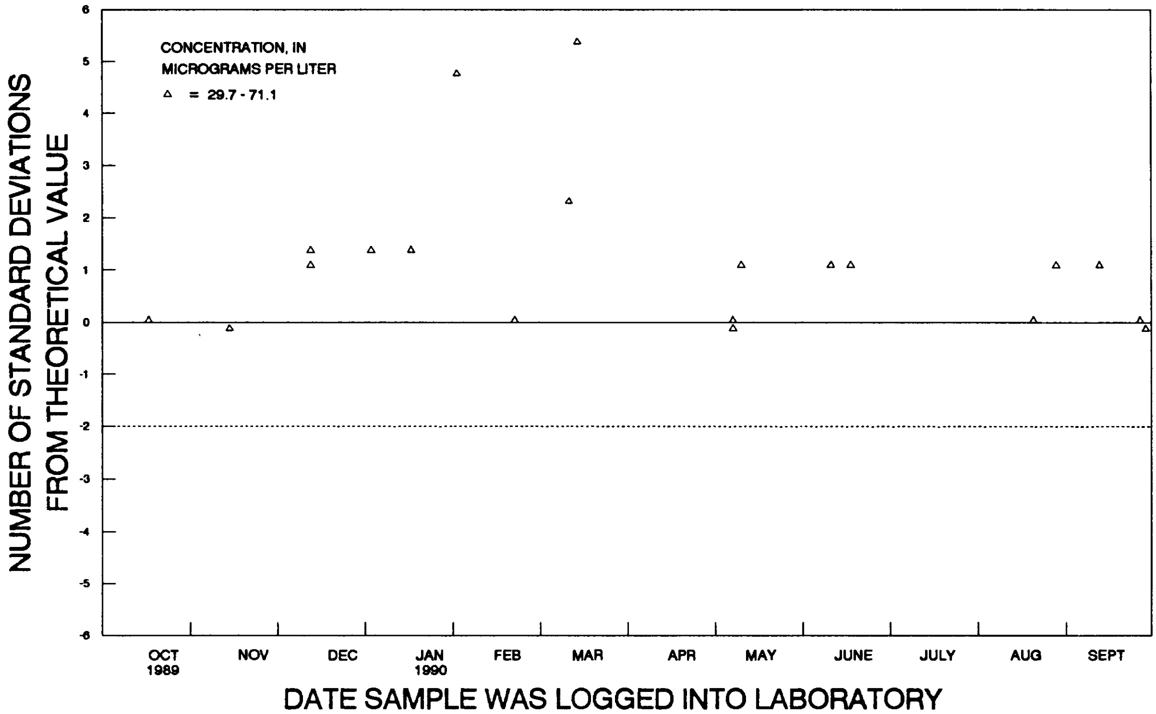

Figure 201. Zinc, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

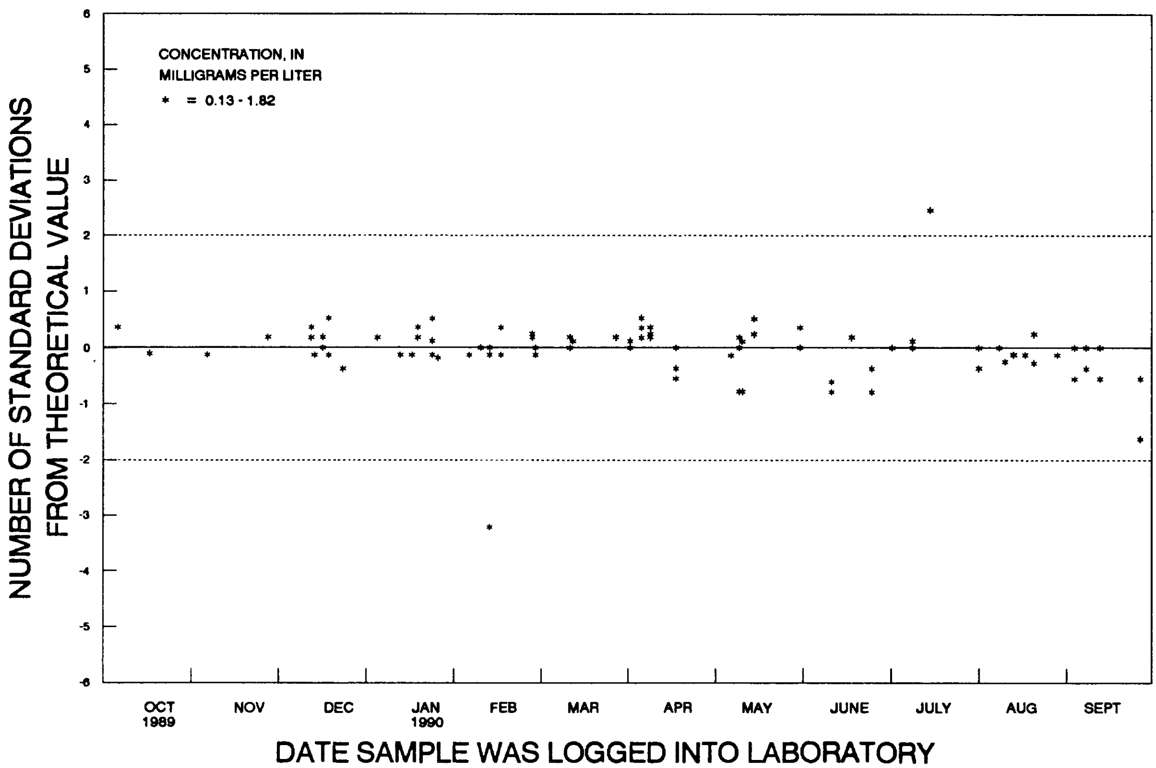

Figure 202. Ammonia as nitrogen, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

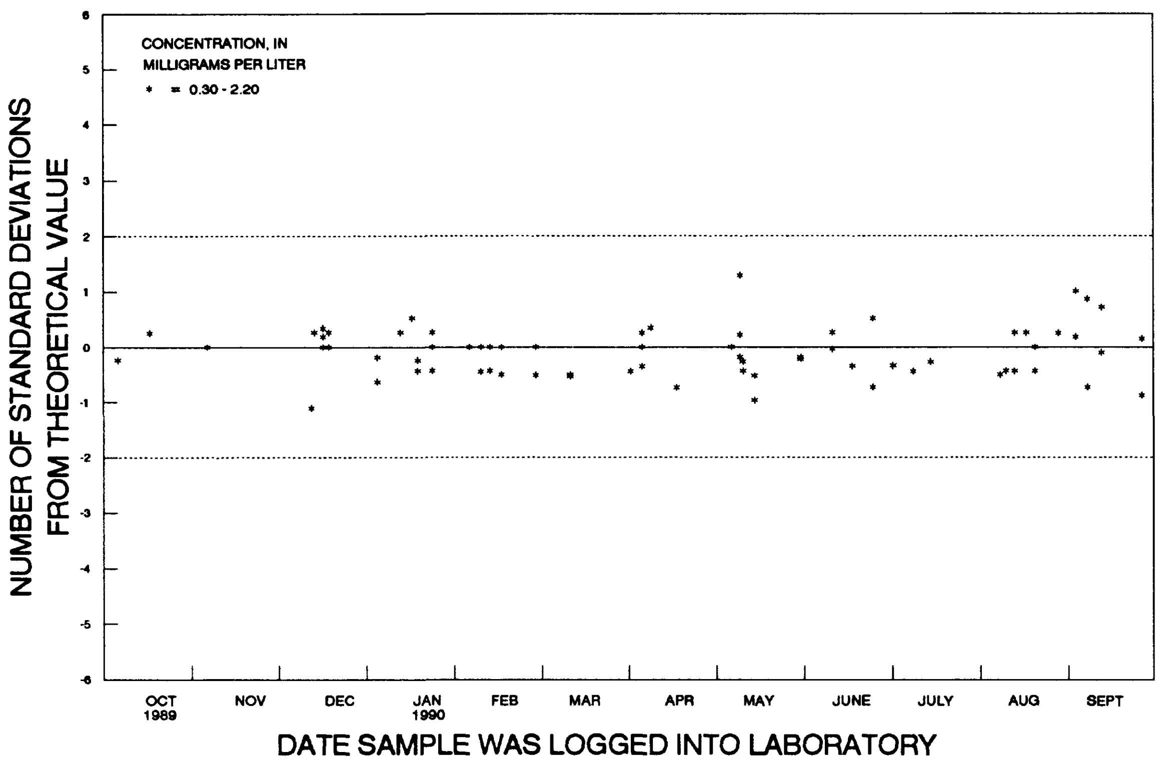

Figure 203. Ammonia plus organic nitrogen, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

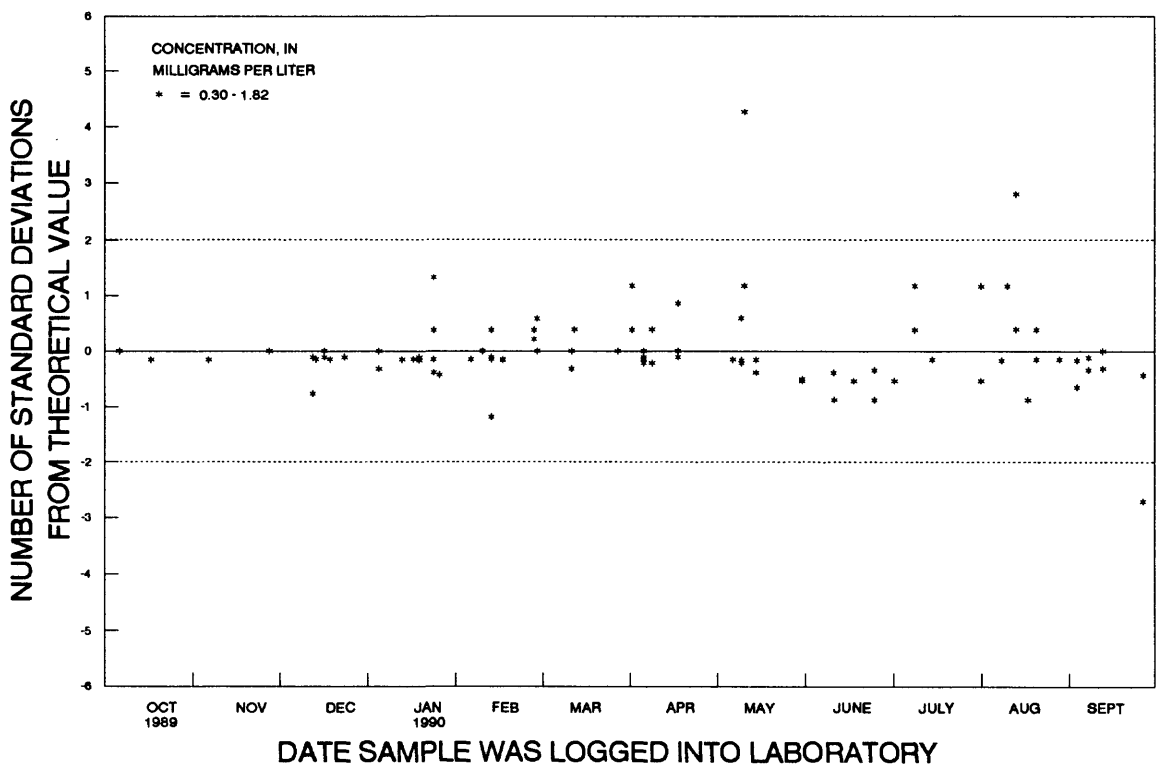

Figure 204. Nitrate plus nitrite as nitrogen, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

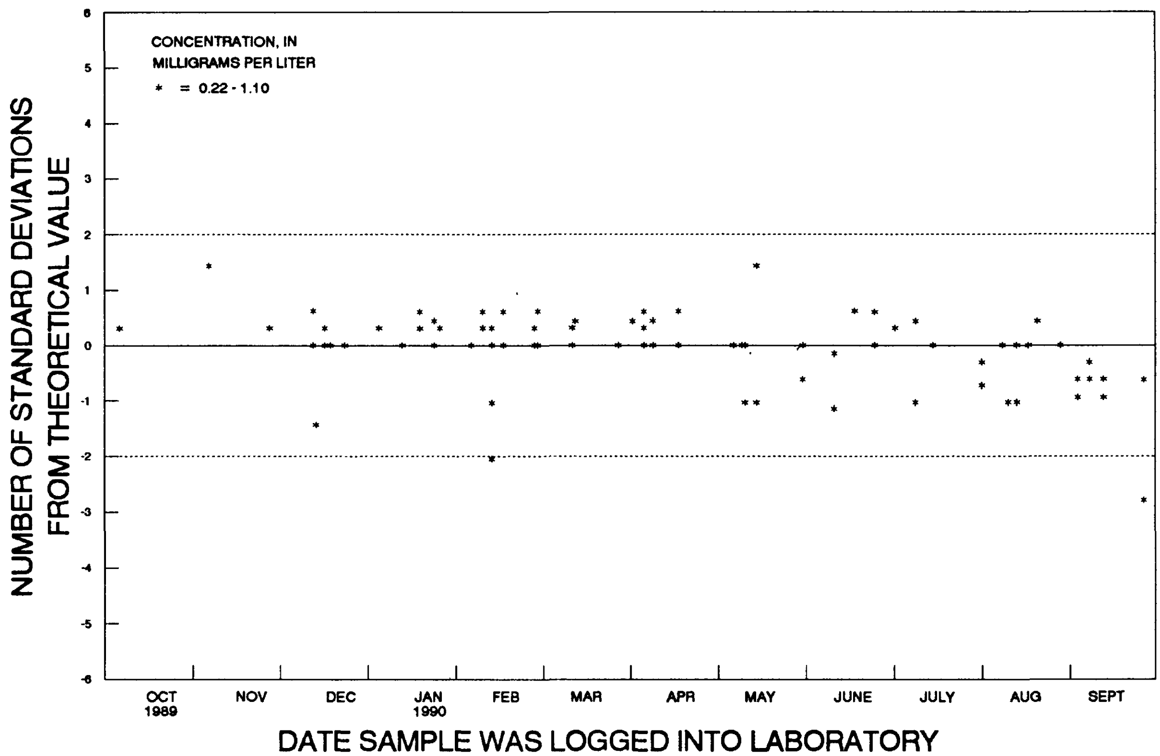

Figure 205. Orthophosphate as phosphorus, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

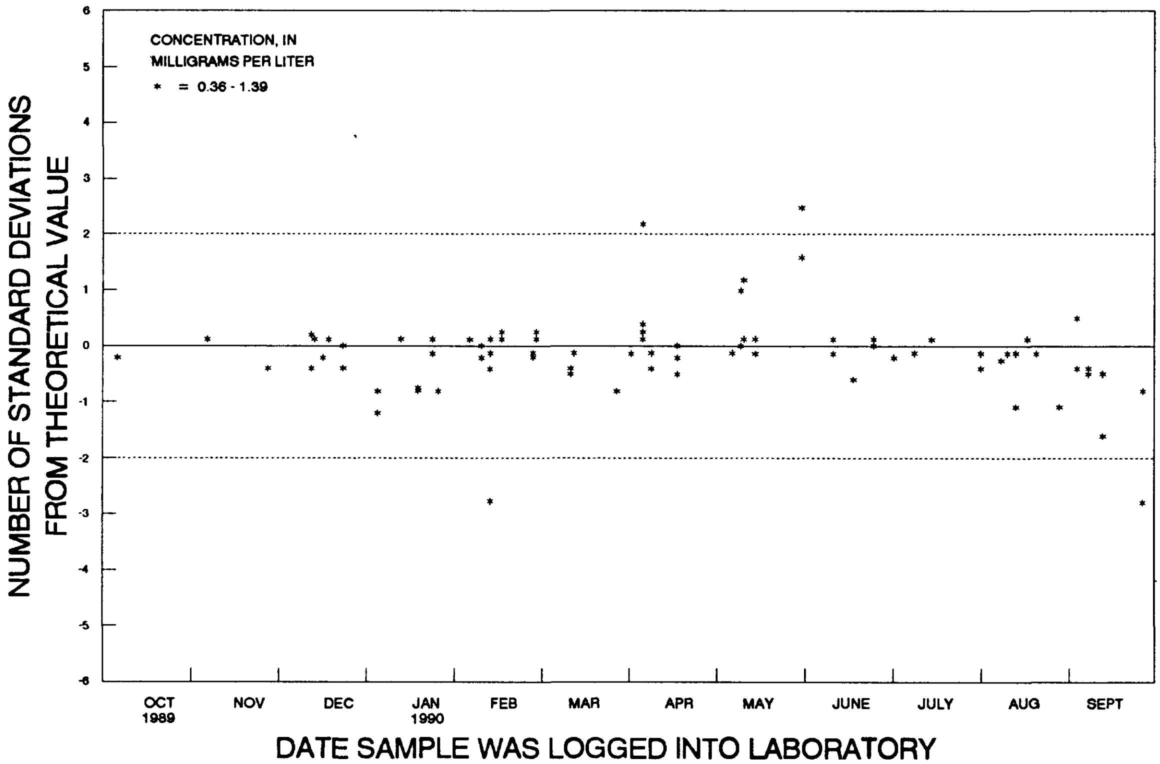

Figure 206. Phosphorus, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

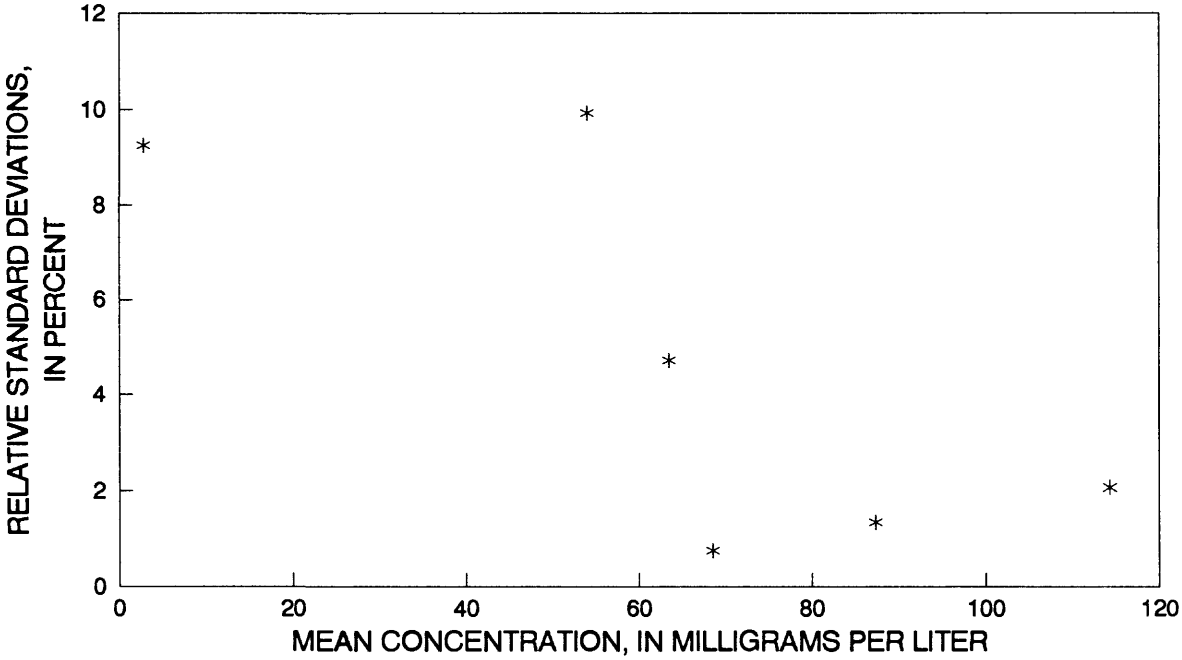

Figure 207. Precision data for alkalinity, dissolved, (electrometric titration) data from the Quality of Water Service Unit Laboratory.

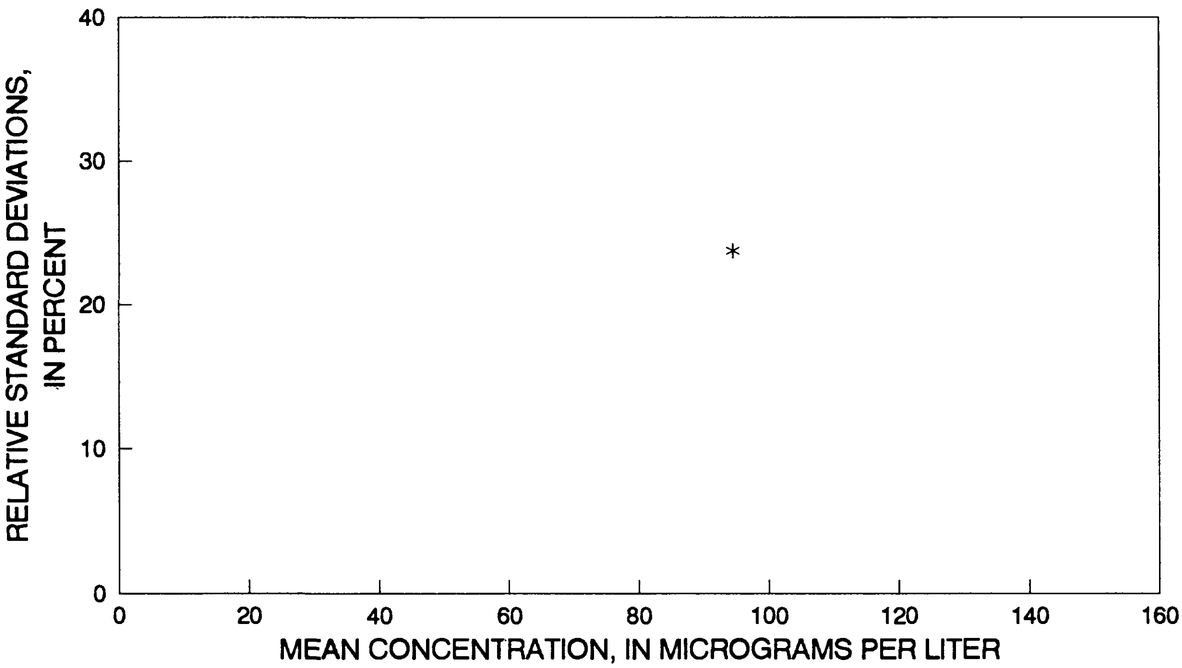

Figure 208. Precision data for aluminum, total recoverable, (atomic absorption spectrometry, chelation-extraction) data from the Quality of Water Service Unit Laboratory.

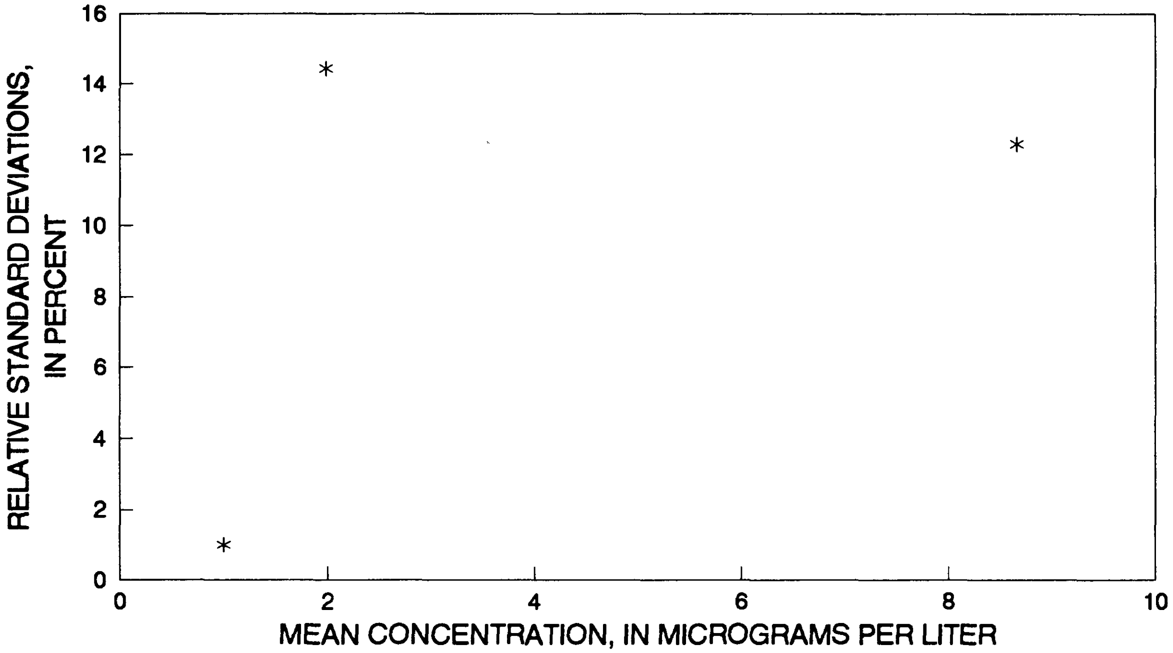

Figure 209. Precision data for arsenic, dissolved and total, (atomic absorption spectrometry, hydride) data from the Quality of Water Service Unit Laboratory.

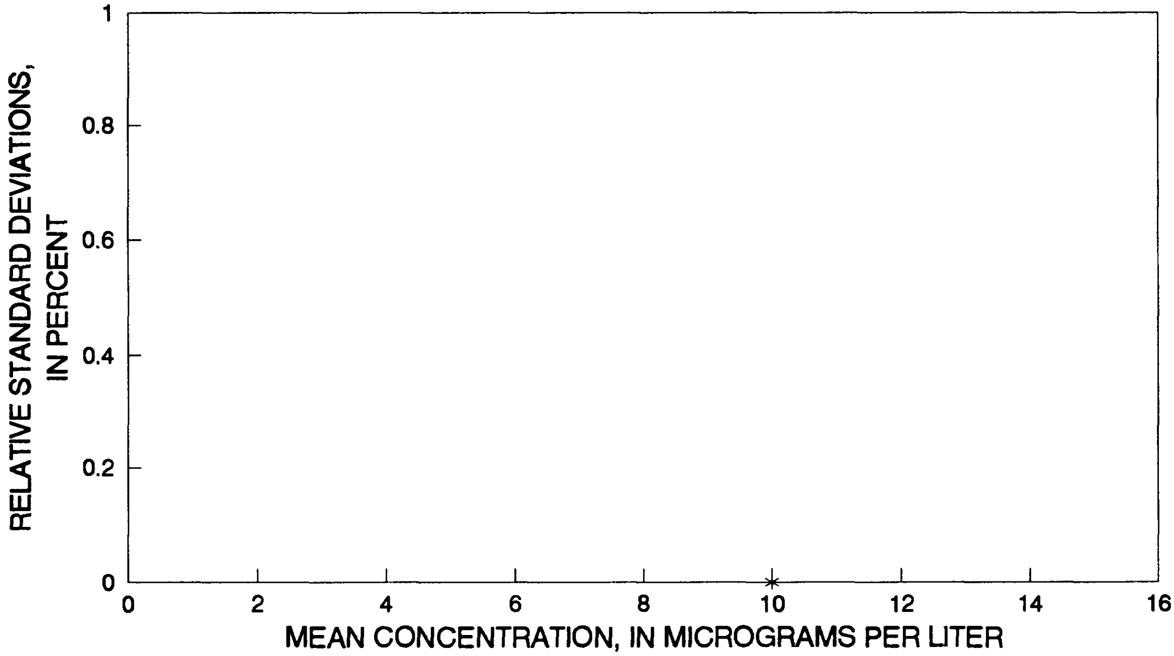

Figure 210. Precision data for beryllium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

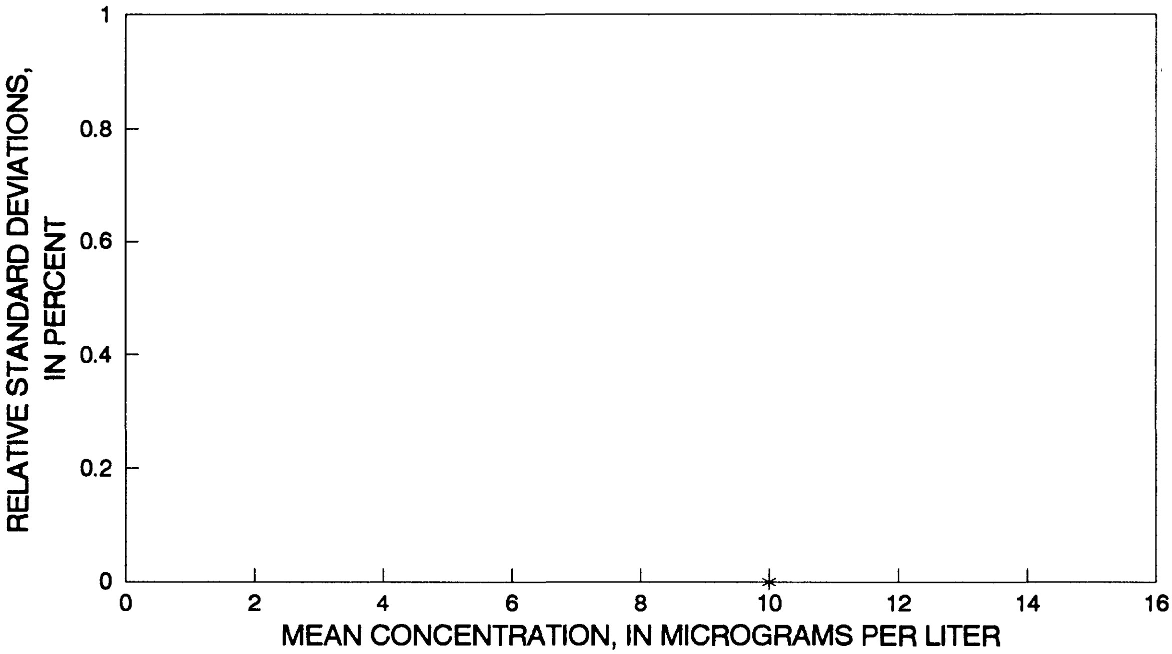

Figure 211. Precision data for beryllium, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

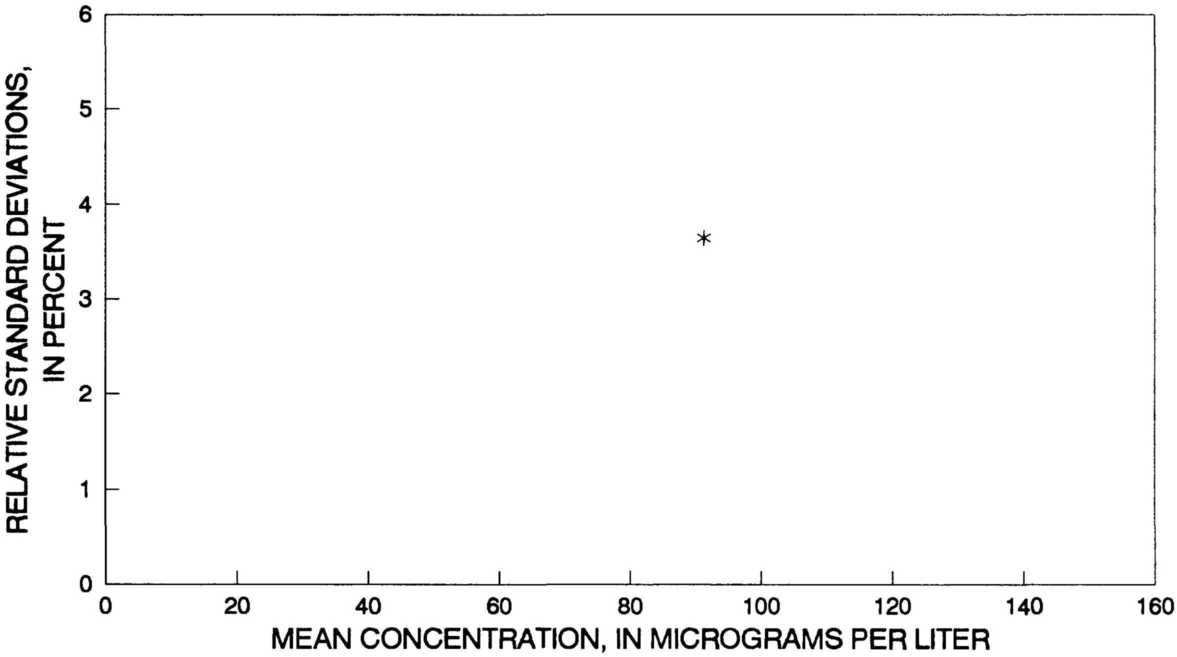

Figure 212. Precision data for boron, dissolved, (colorimetric) data from the Quality of Water Service Unit Laboratory.

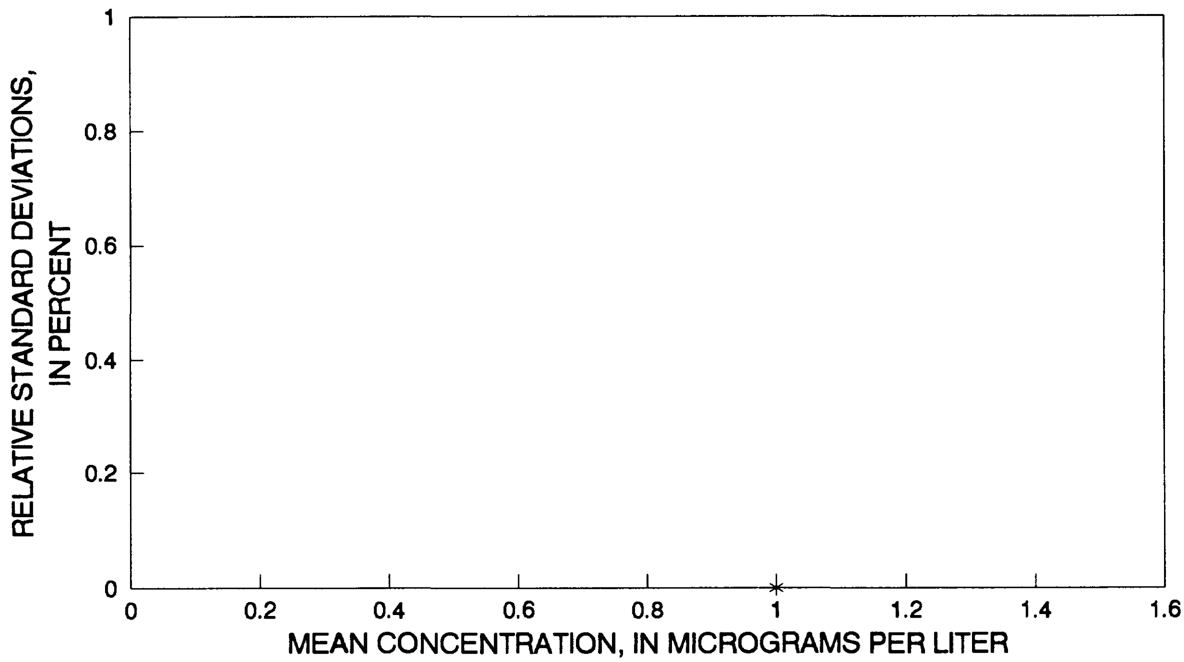

Figure 213. Precision data for cadmium, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

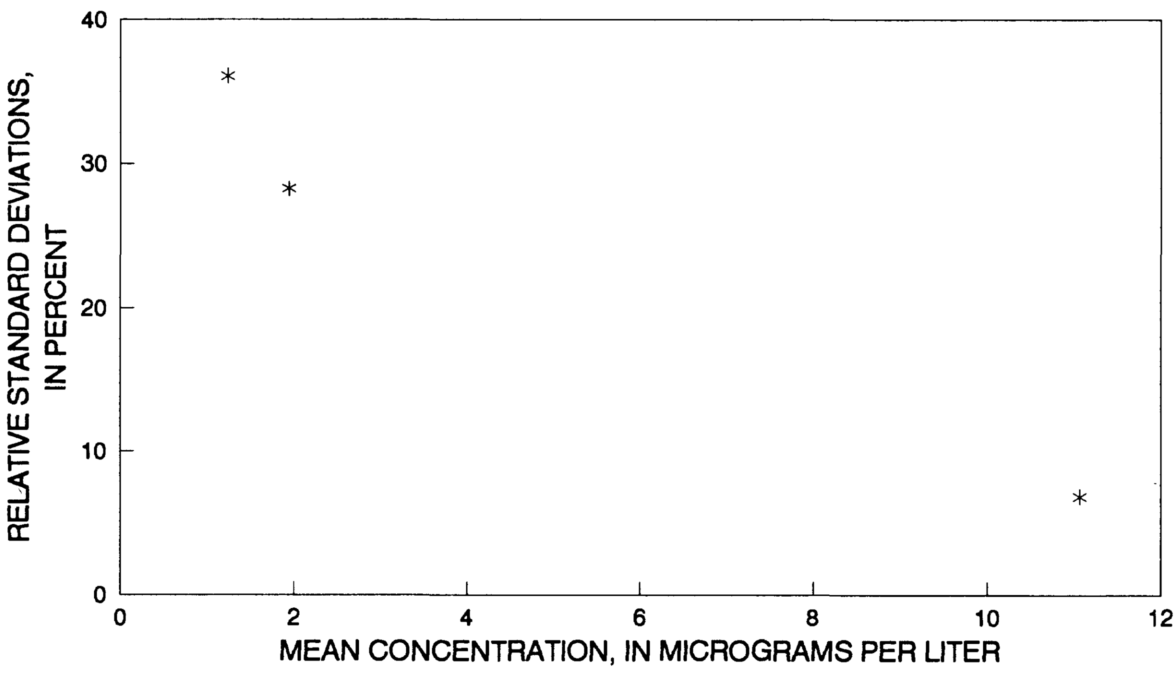

Figure 214. Precision data for cadmium, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

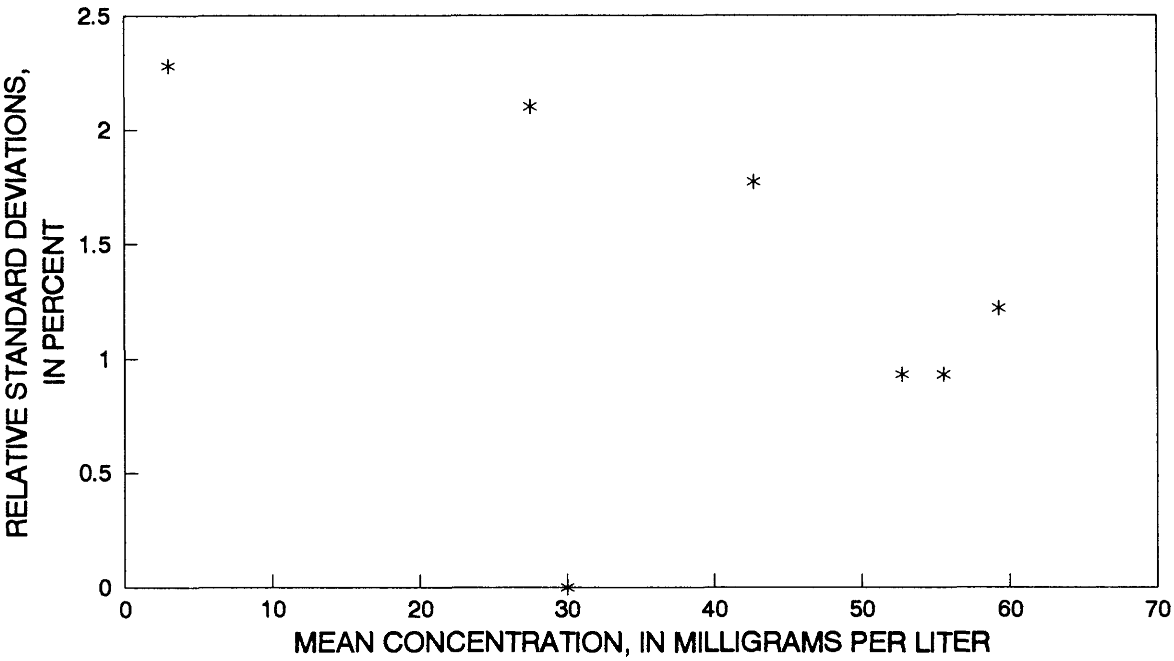

Figure 215. Precision data for calcium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

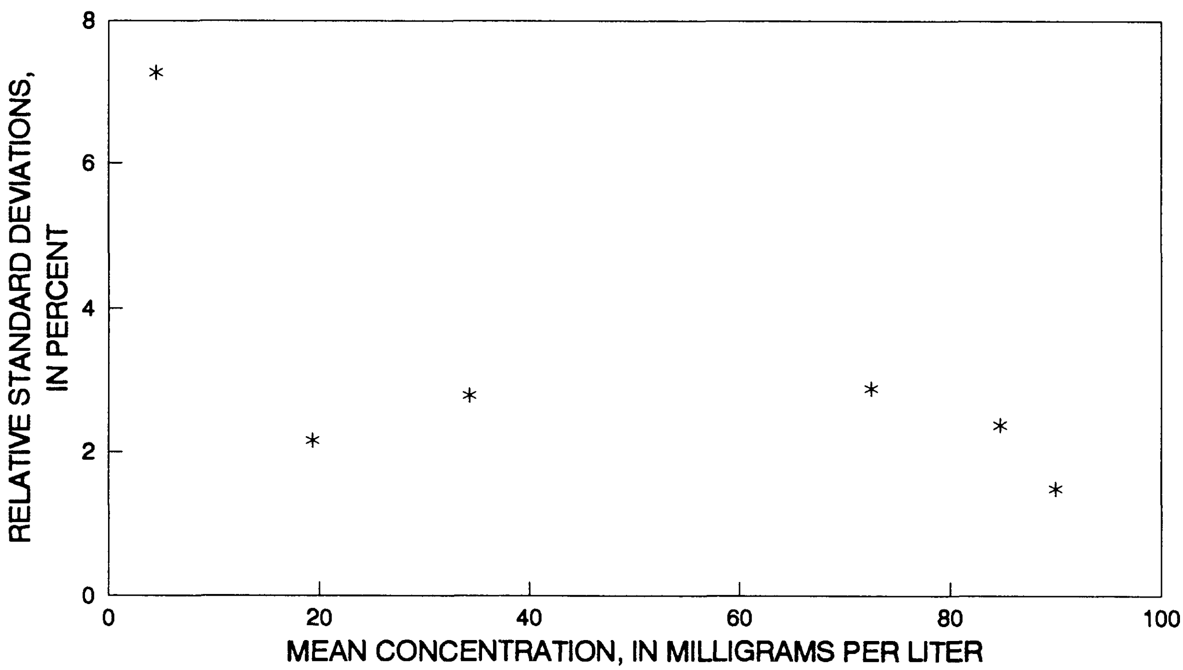

Figure 216. Precision data for chloride, dissolved, (colorimetric and ion chromatography) data from the Quality of Water Service Unit Laboratory.

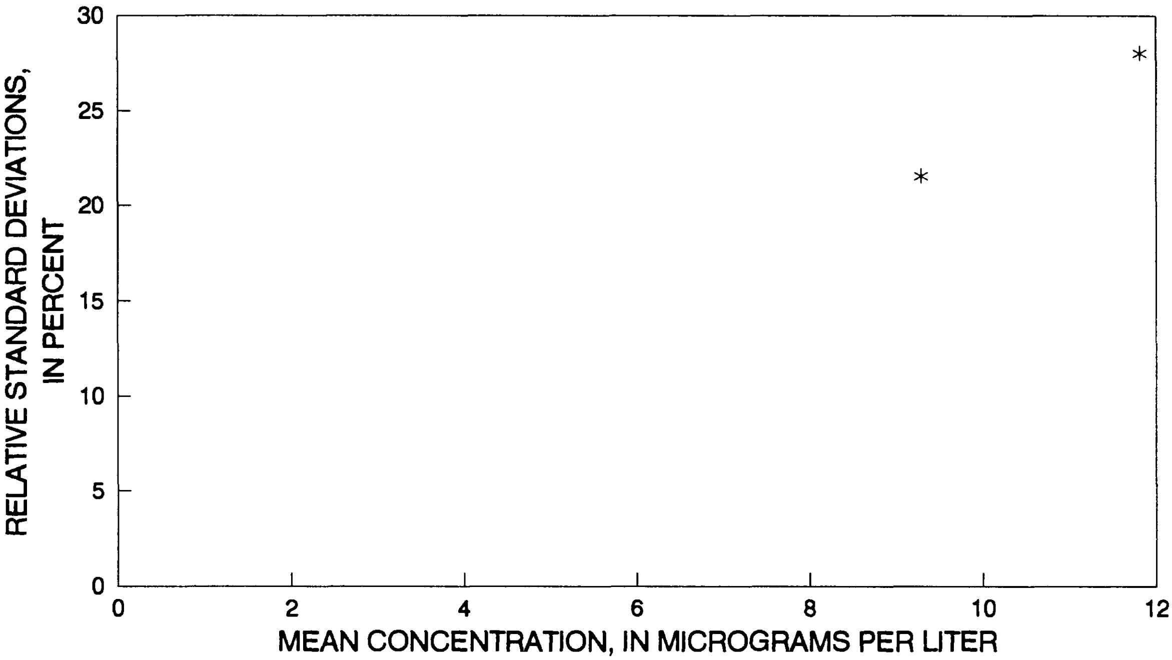

Figure 217. Precision data for chromium, total recoverable, (atomic absorption spectrometry, chelation-extraction) data from the Quality of Water Service Unit Laboratory.

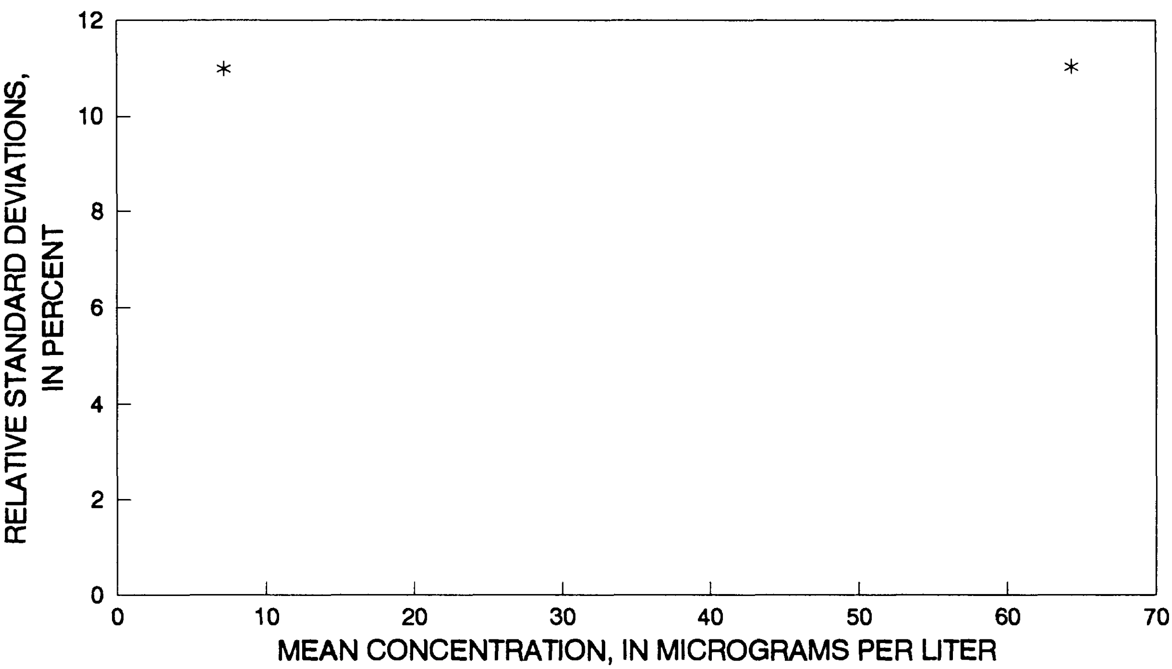

Figure 218. Precision data for copper, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

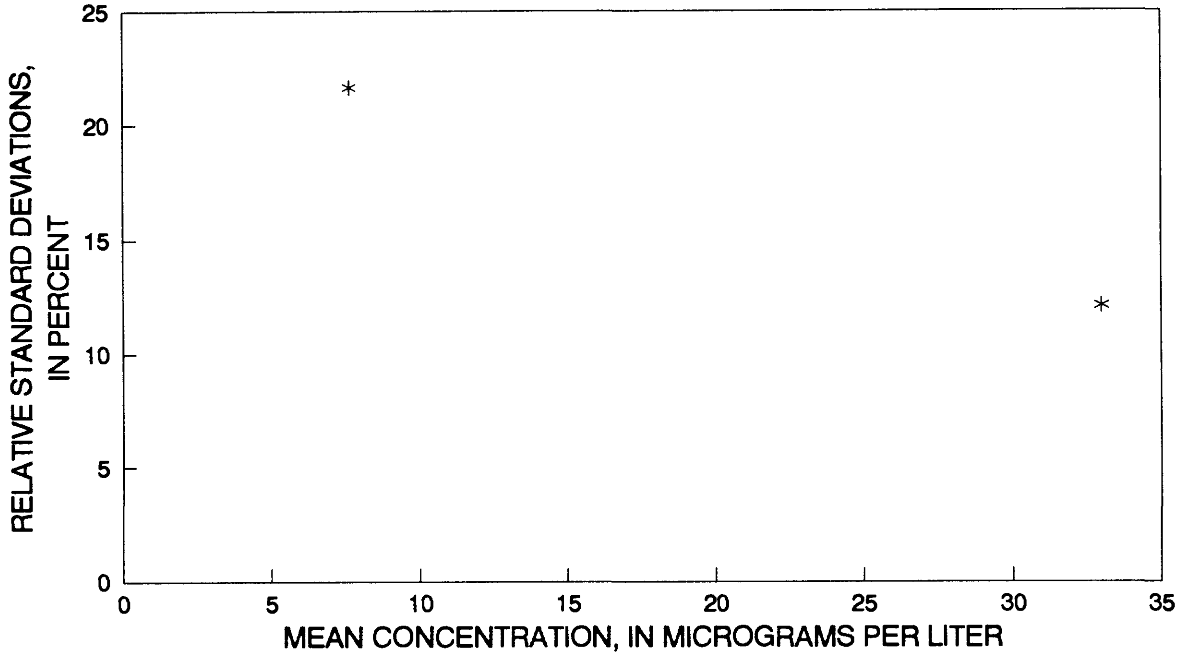

Figure 219. Precision data for copper, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

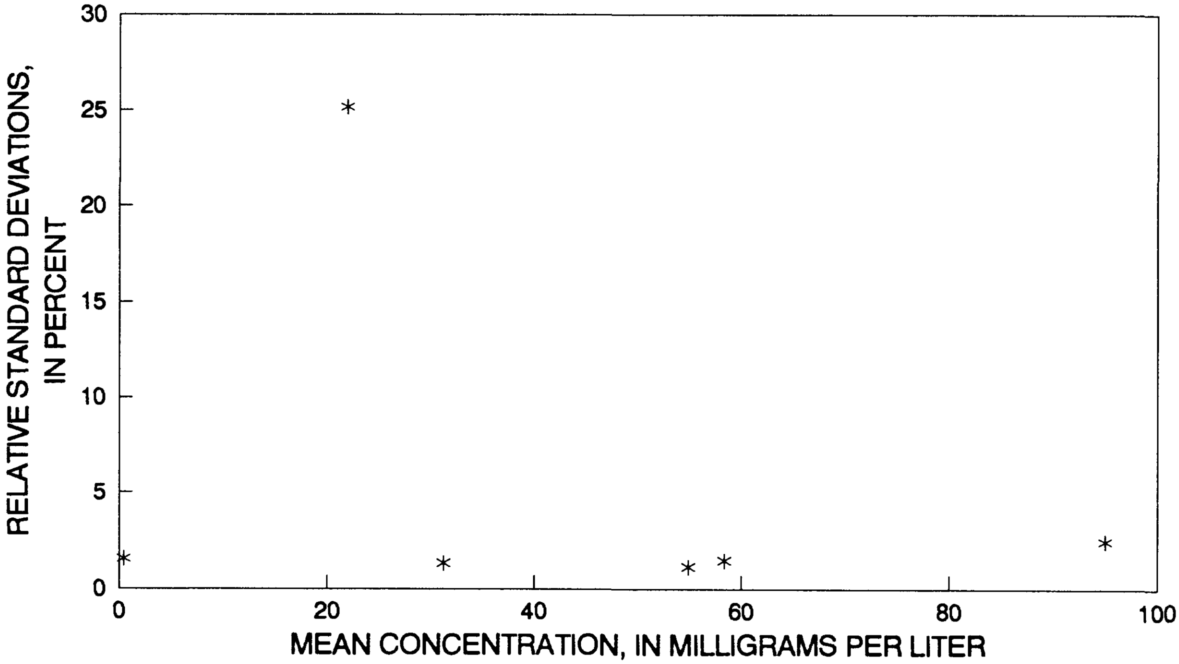

Figure 220. Precision data for dissolved solids, (gravimetric) data from the Quality of Water Service Unit Laboratory.

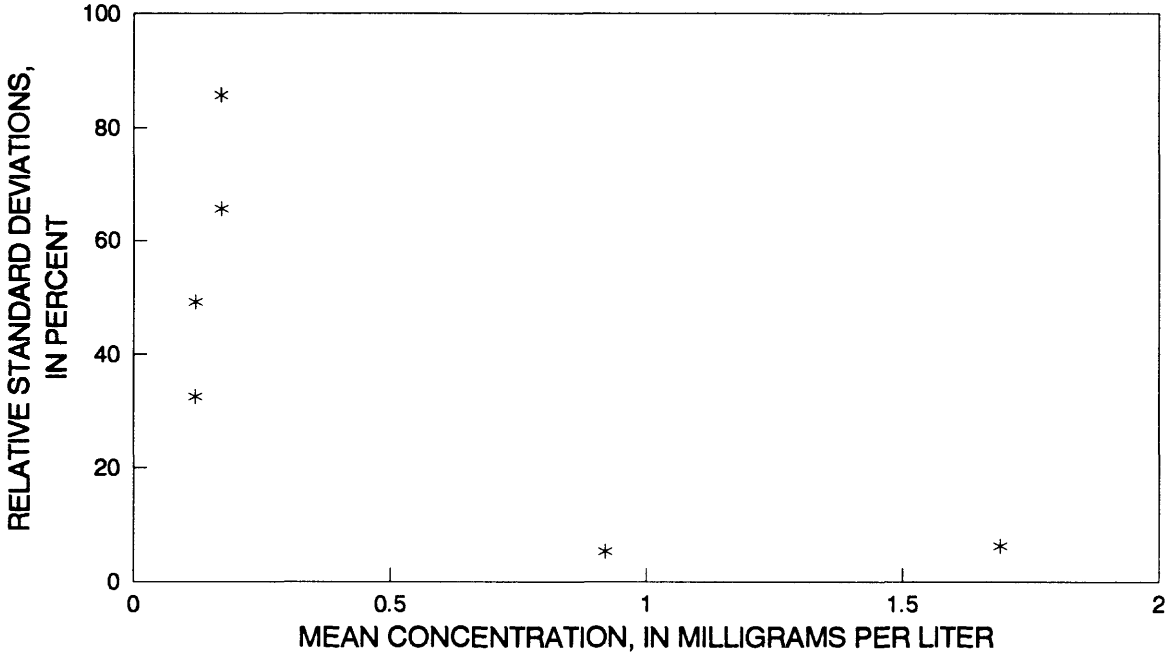

Figure 221. Precision data for fluoride, dissolved, (colorimetric and ion-selective electrode) data from the Quality of Water Service Unit Laboratory.

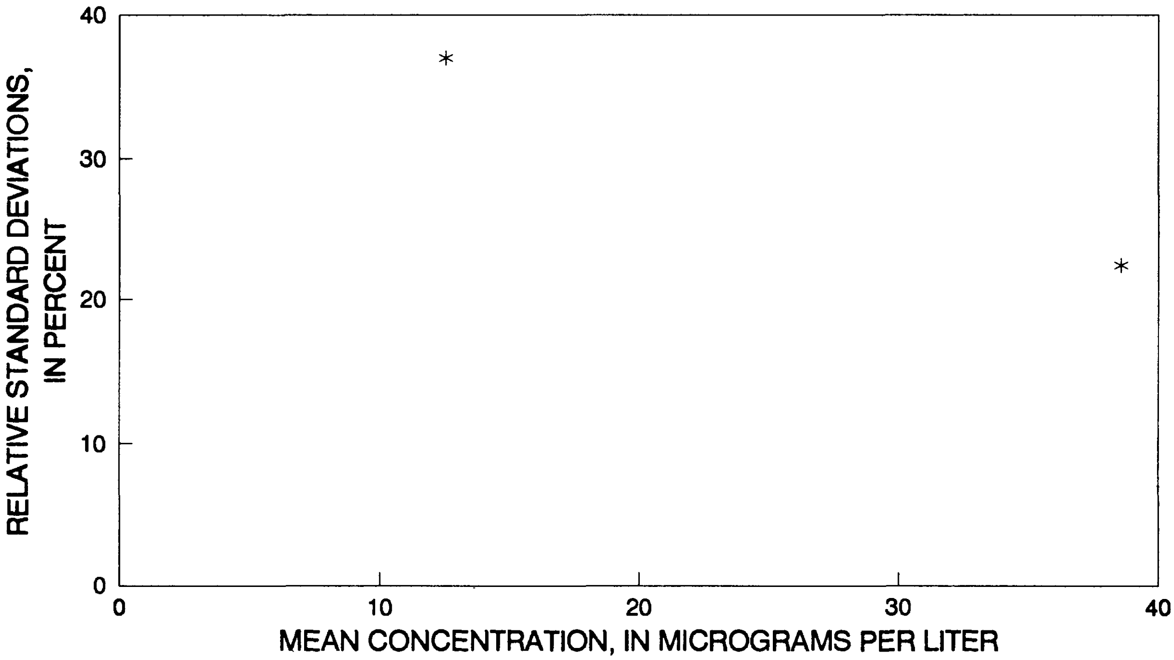

Figure 222. Precision data for iron, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

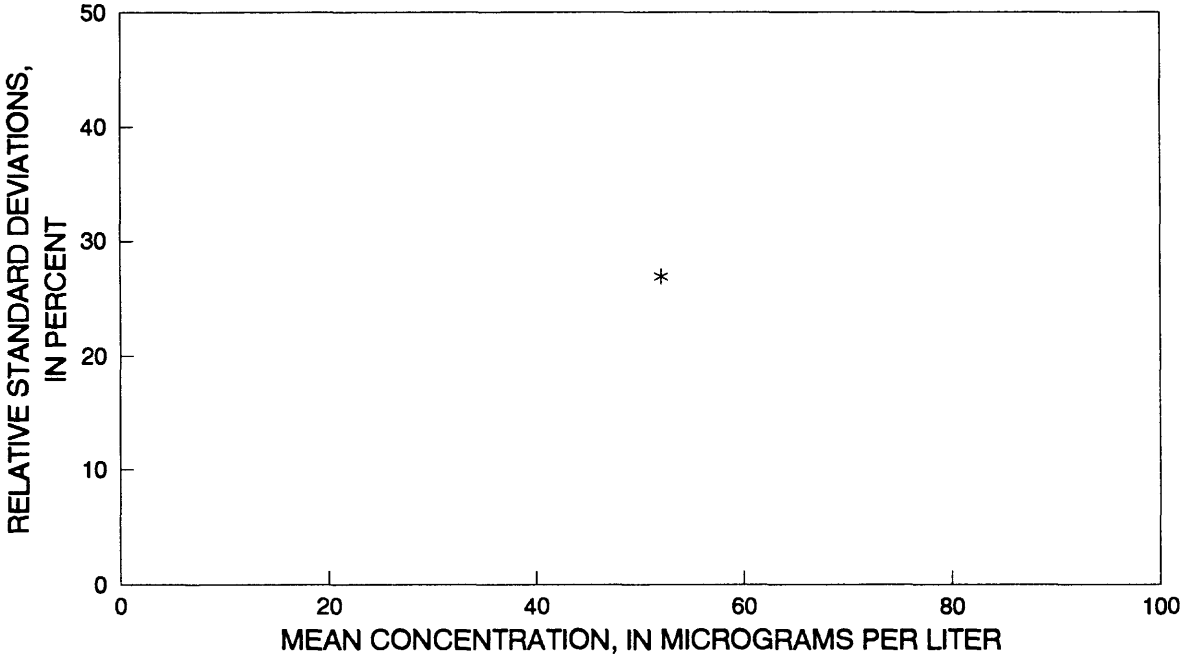

Figure 223. Precision data for iron, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

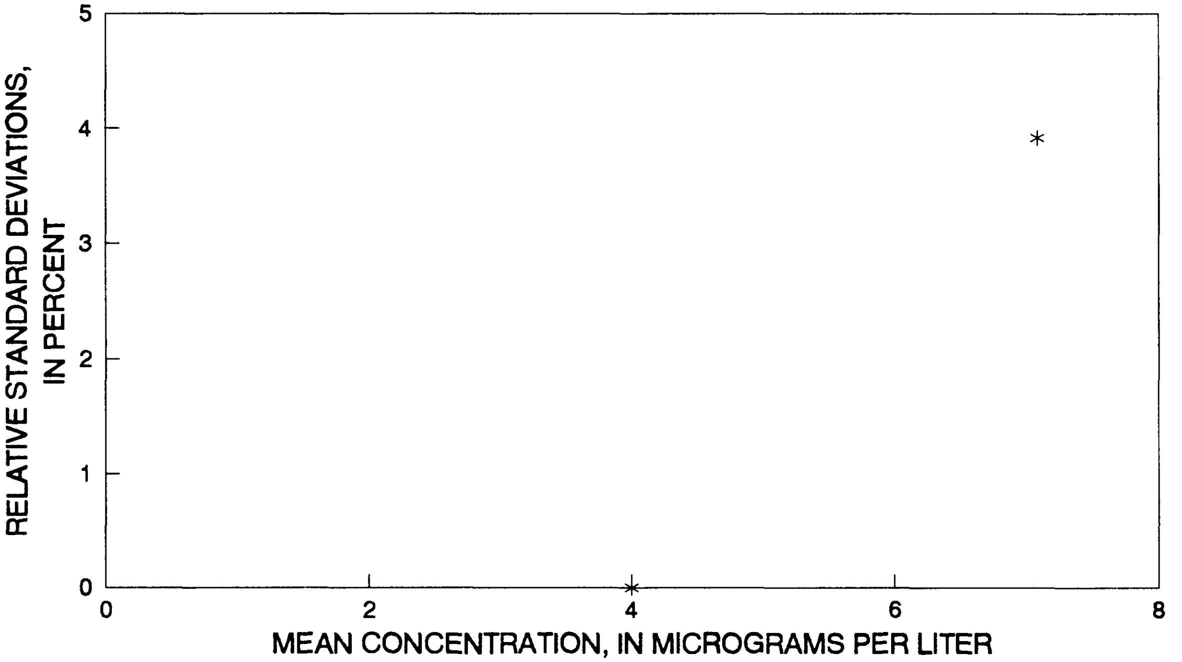

Figure 224. Precision data for lead, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

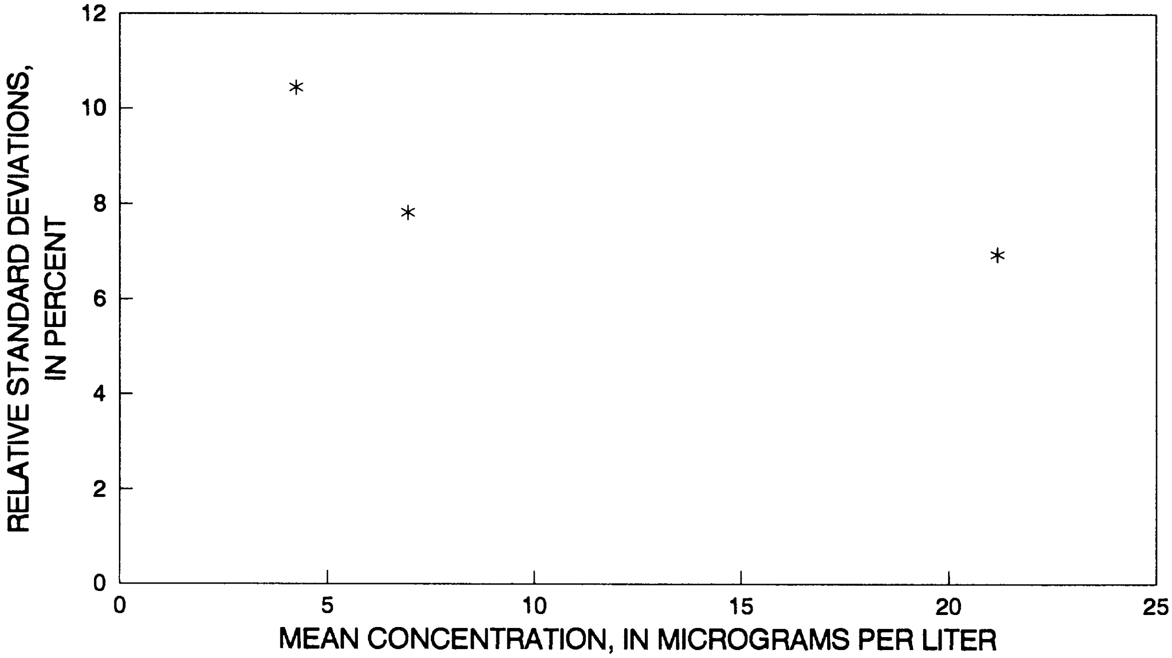

Figure 225. Precision data for lead, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

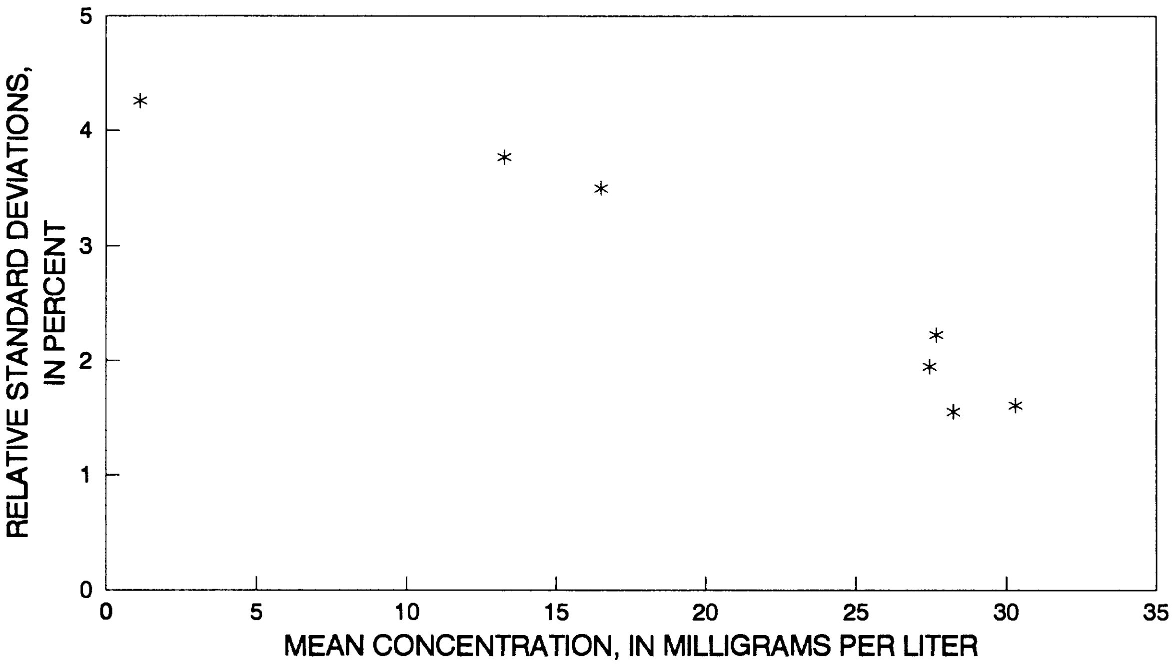

Figure 226. Precision data for magnesium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

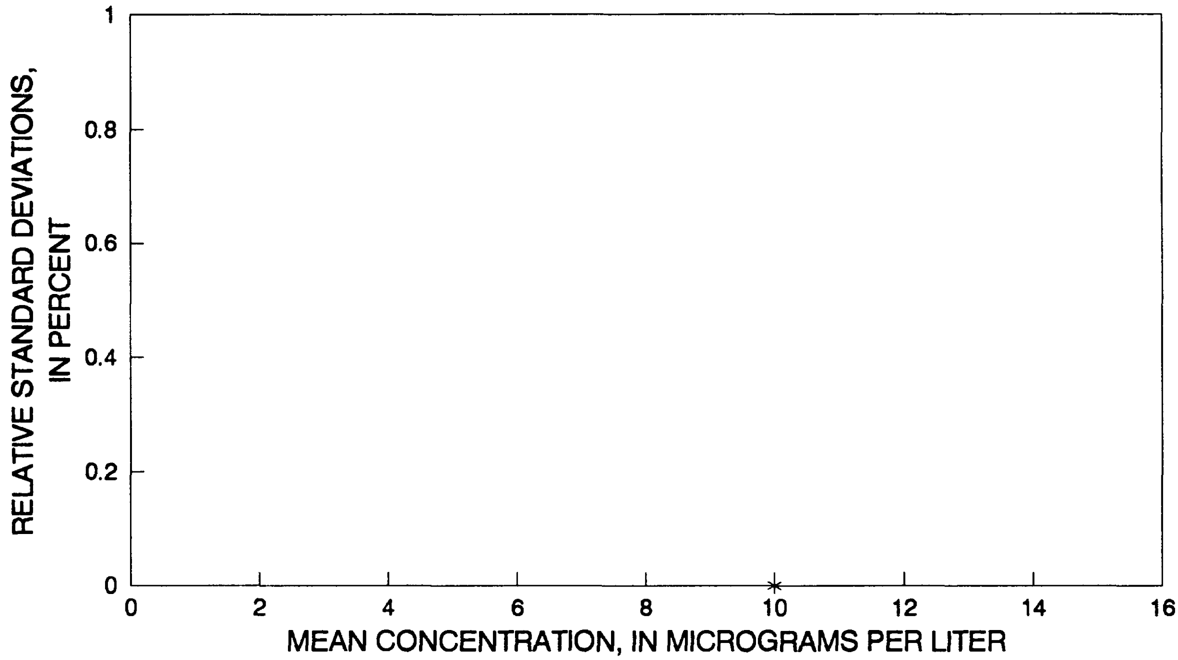

Figure 227. Precision data for manganese, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

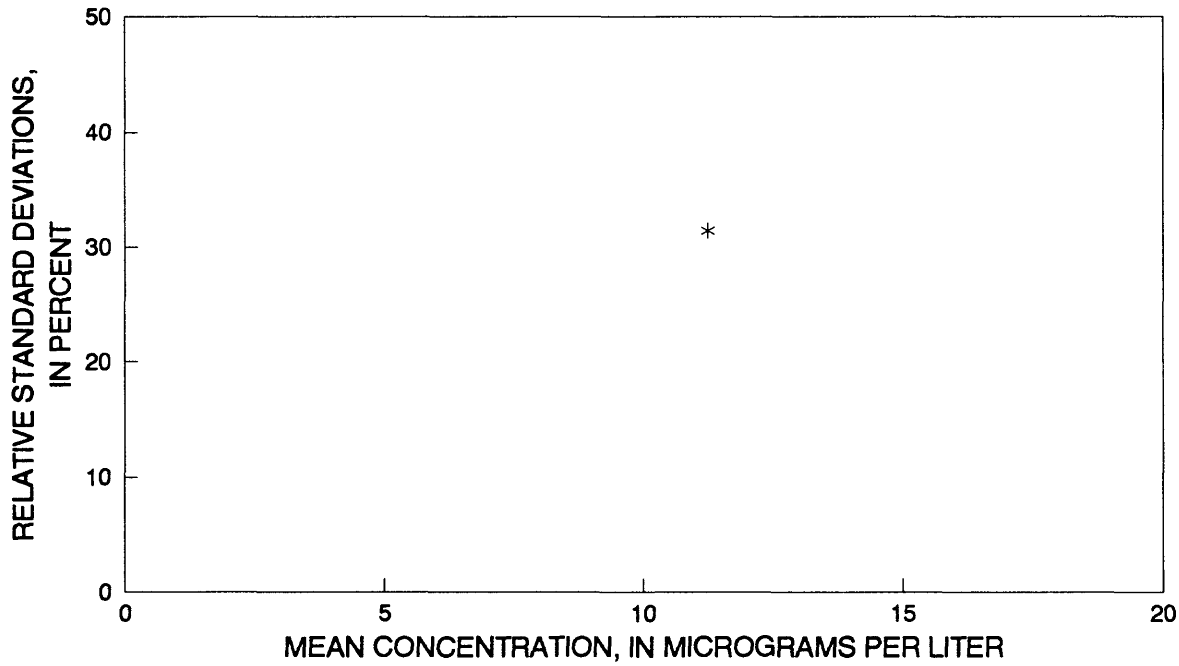

Figure 228. Precision data for manganese, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

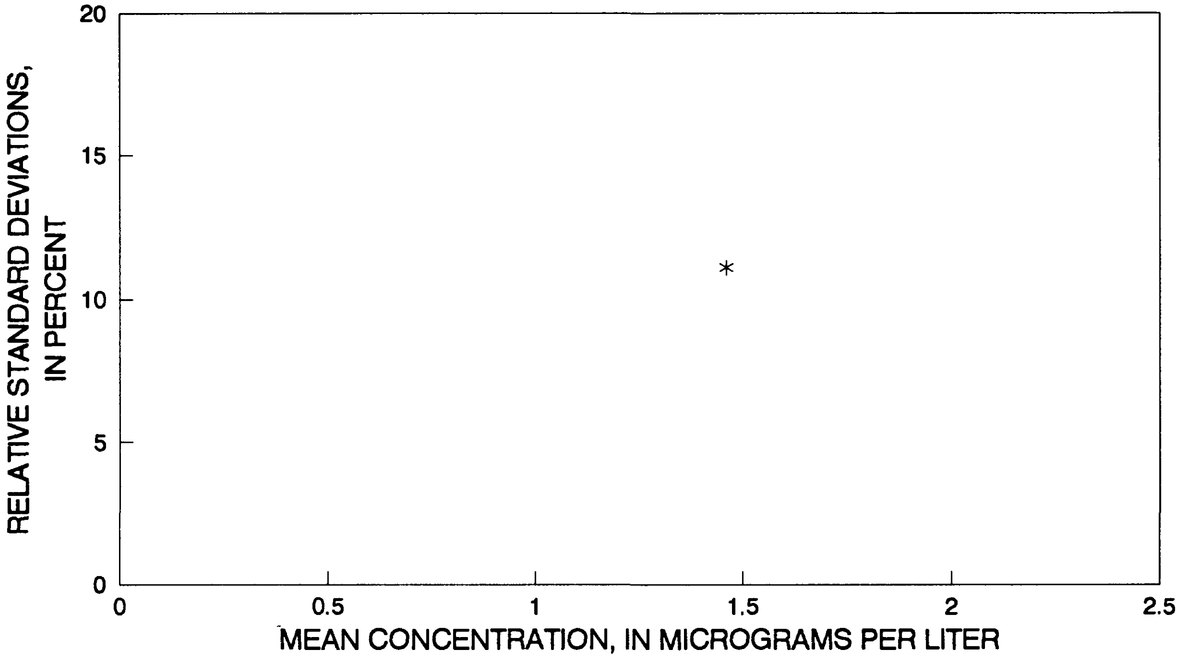

Figure 229. Precision data for mercury, dissolved, (atomic absorption spectrometry, flameless) data from the Quality of Water Service Unit Laboratory.

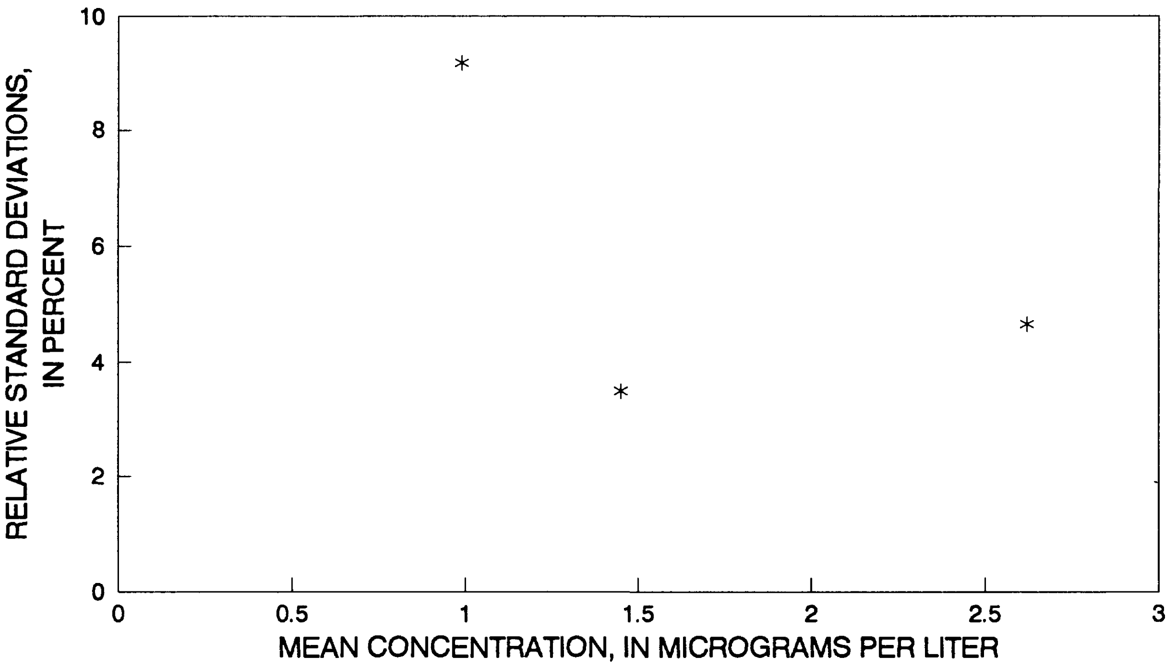

Figure 230. Precision data for mercury, total recoverable, (atomic absorption spectrometry, flameless) data from the Quality of Water Service Unit Laboratory.

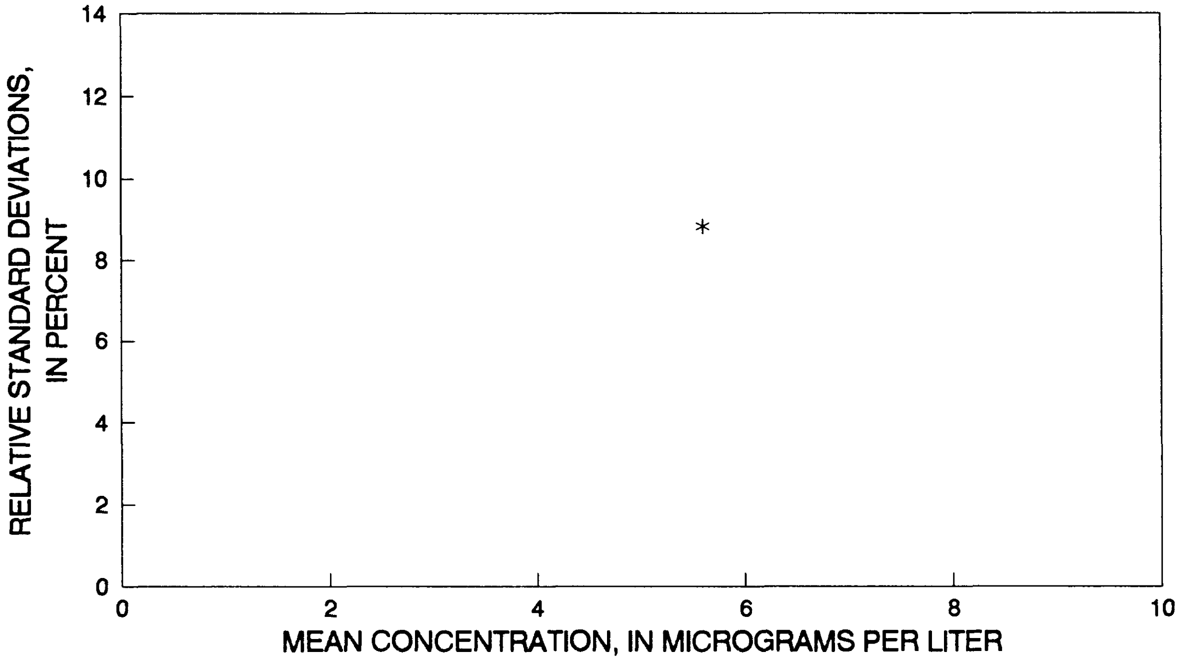

Figure 231. Precision data for nickel, dissolved, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

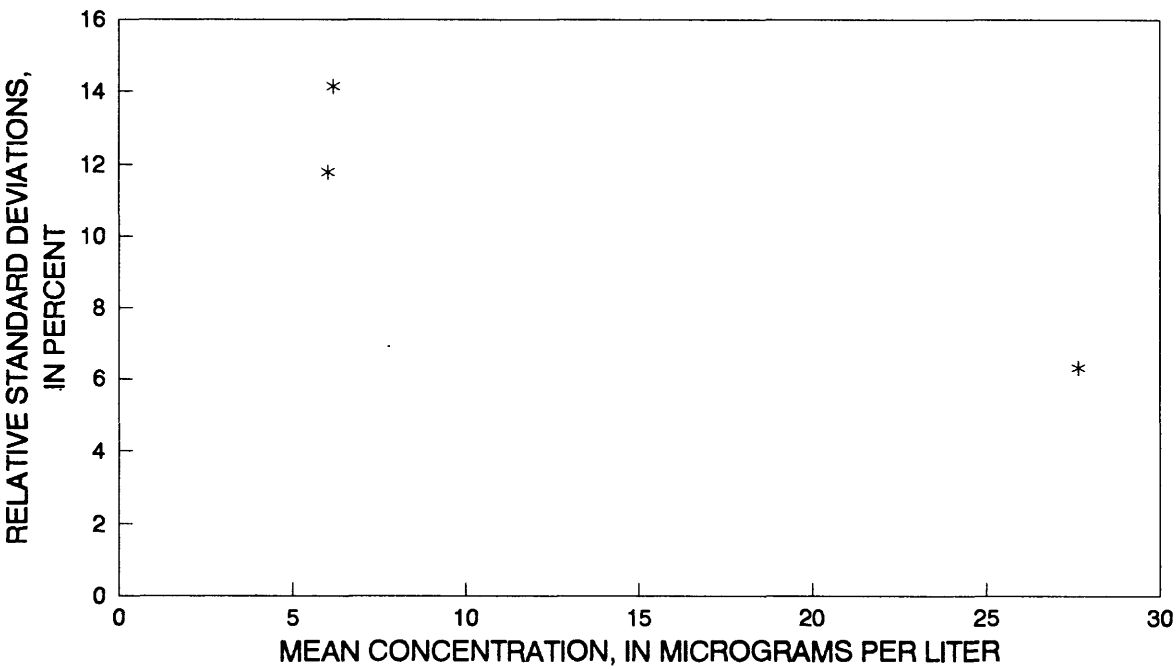

Figure 232. Precision data for nickel, total recoverable, (atomic absorption spectrometry, chelation-extraction and graphite furnace) data from the Quality of Water Service Unit Laboratory.

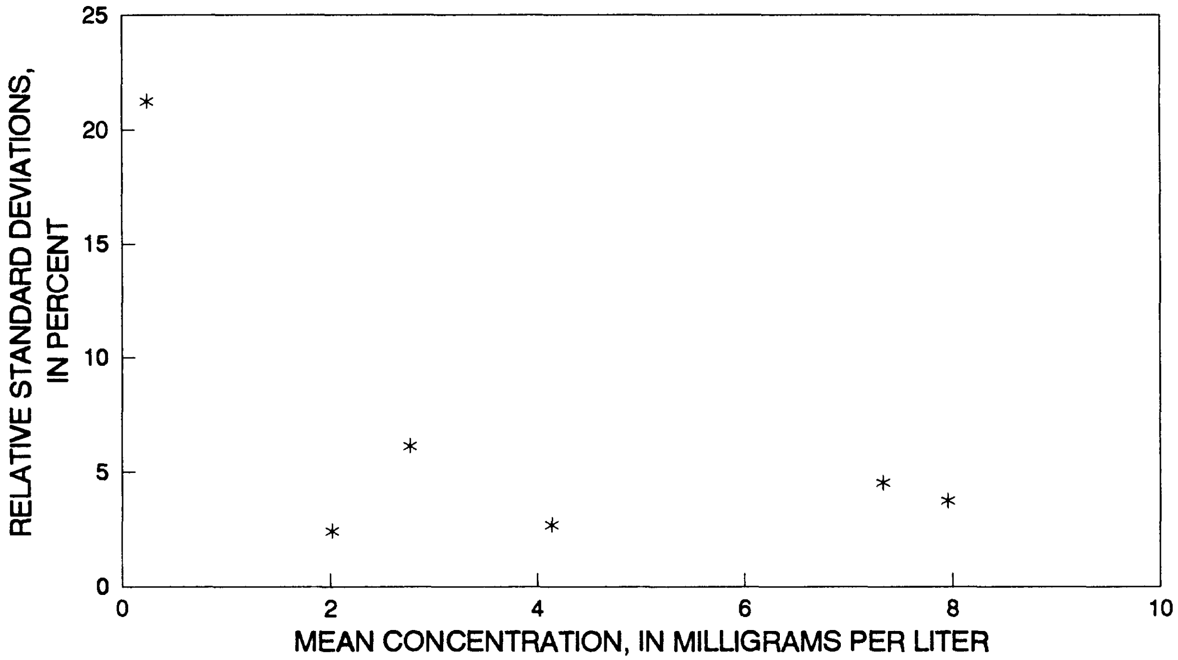

Figure 233. Precision data for potassium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

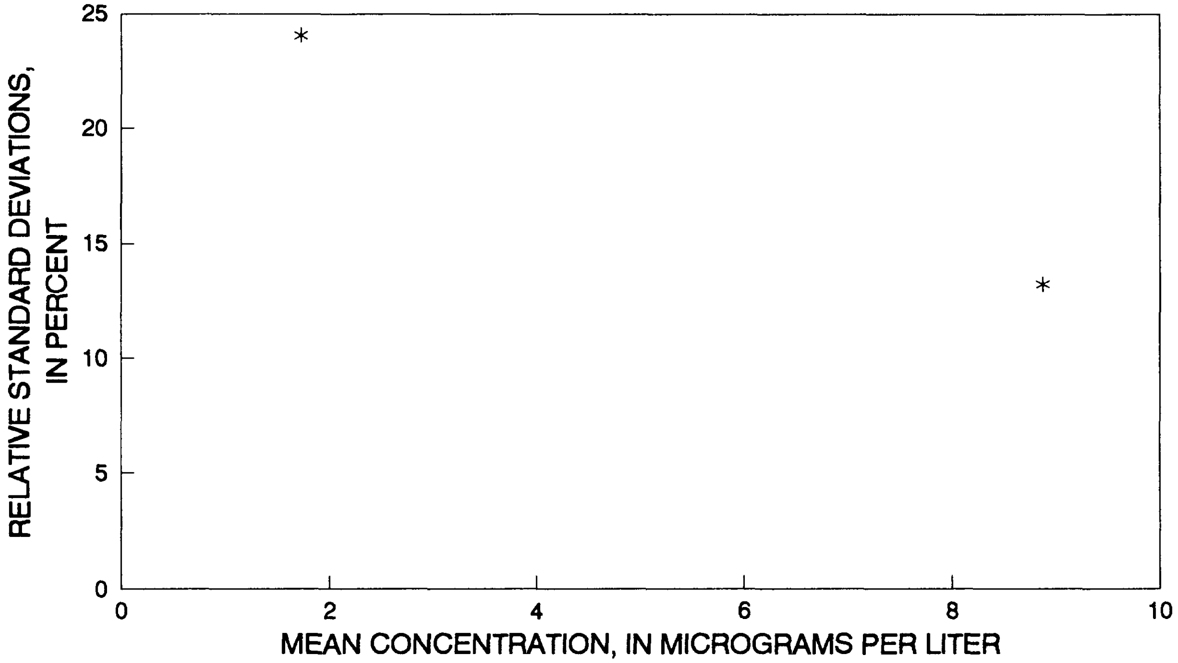

Figure 234. Precision data for selenium, dissolved and total, (atomic absorption spectrometry, hydride) data from the Quality of Water Service Unit Laboratory.

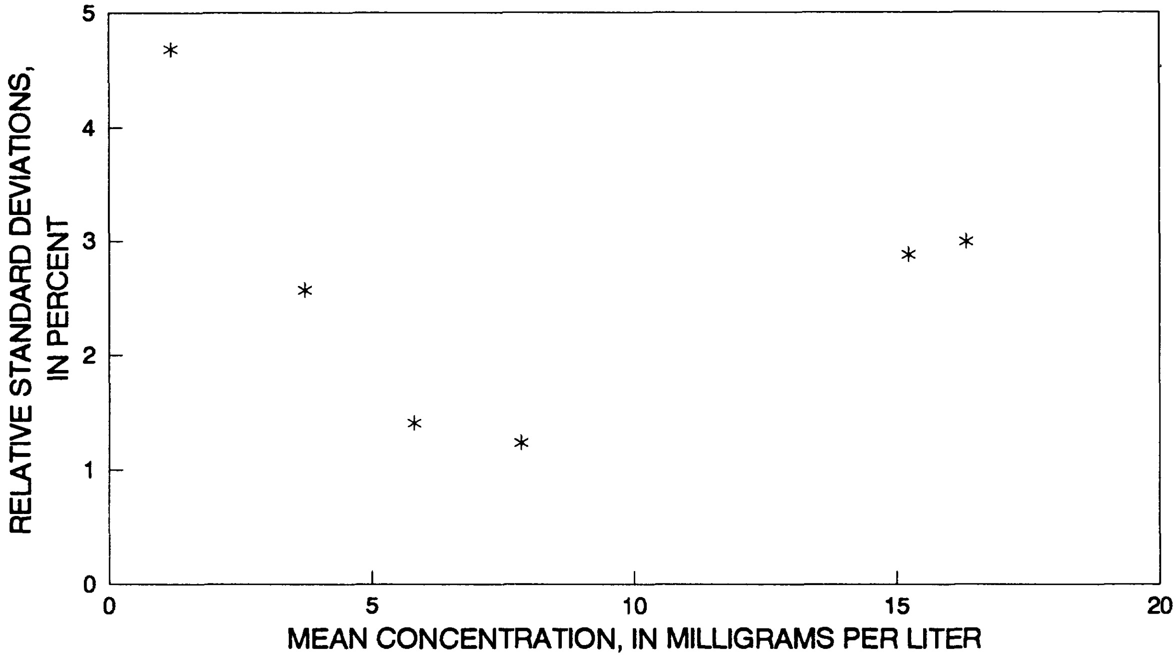

Figure 235. Precision data for silica, dissolved, (colorimetric) data from the Quality of Water Service Unit Laboratory.

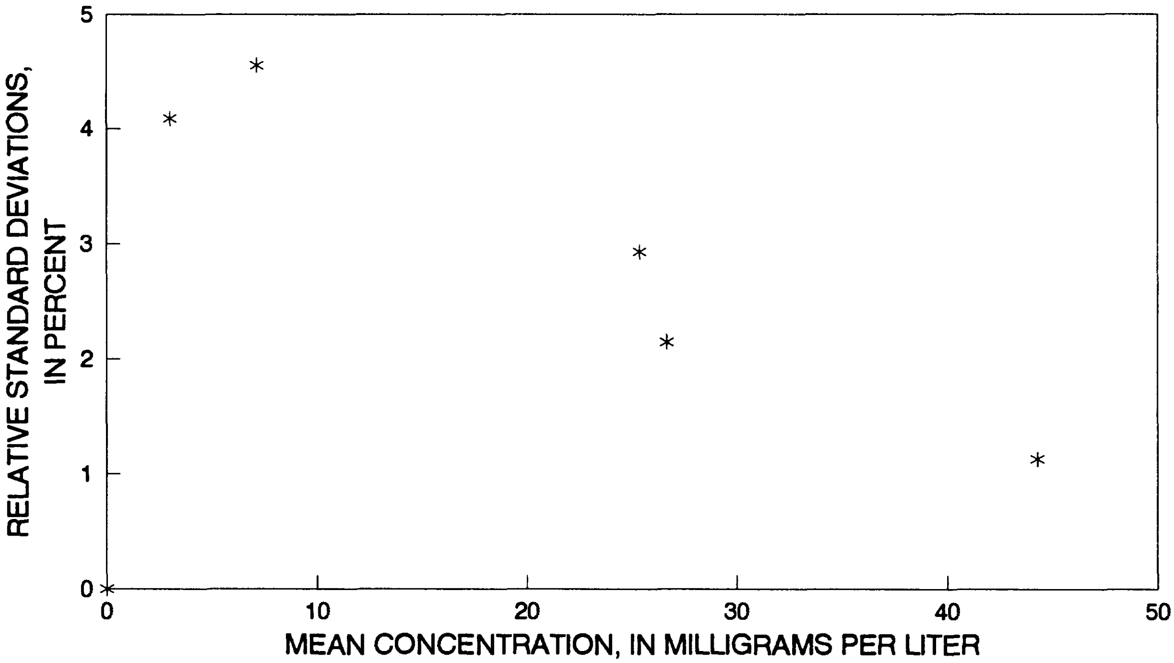

Figure 236. Precision data for sodium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

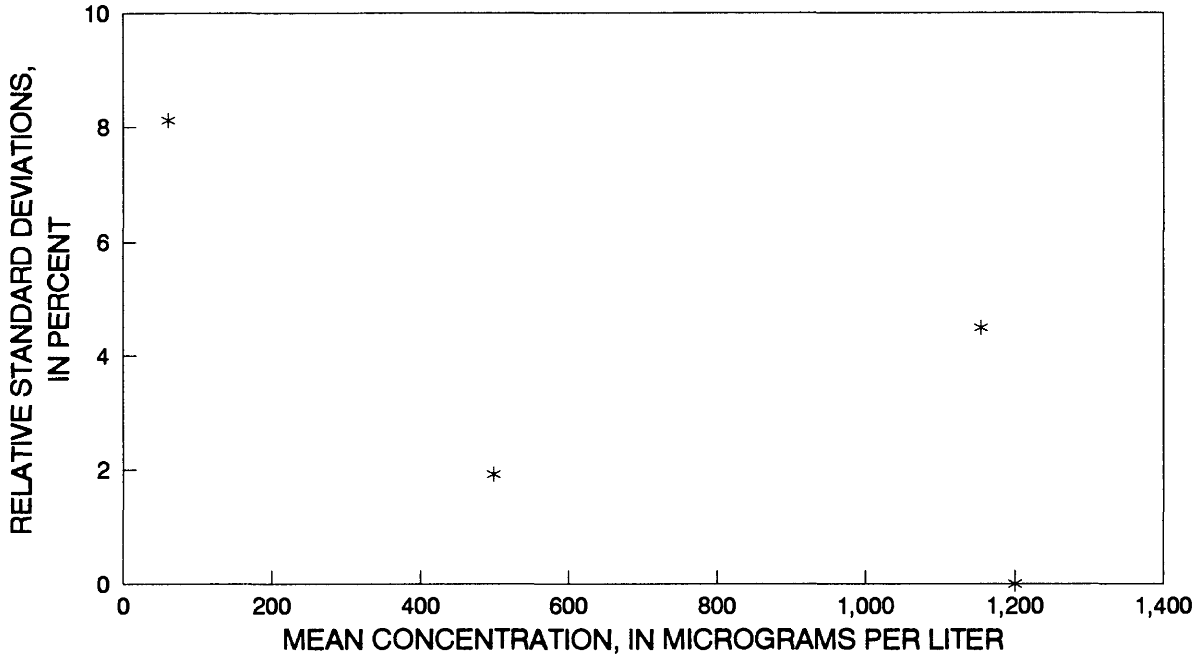

Figure 237. Precision data for strontium, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

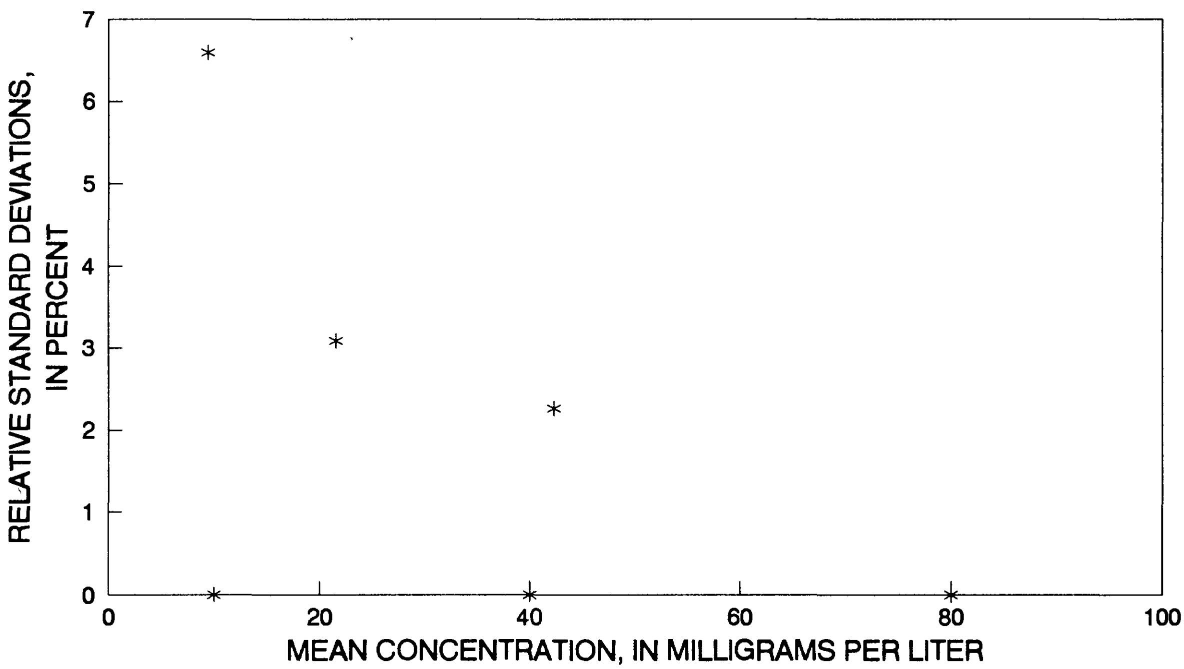

Figure 238. Precision data for sulfate, dissolved, (colorimetric and ion chromatography) data from the Quality of Water Service Unit Laboratory.

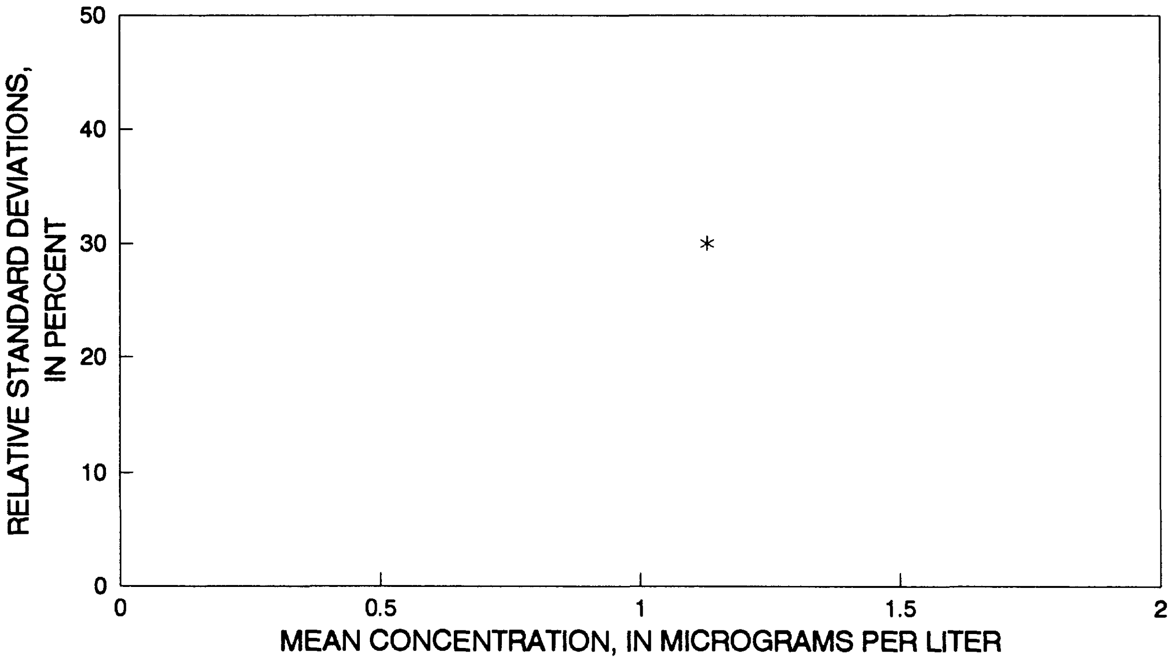

Figure 239. Precision data for vanadium, dissolved, (colorimetric) data from the Quality of Water Service Unit Laboratory.

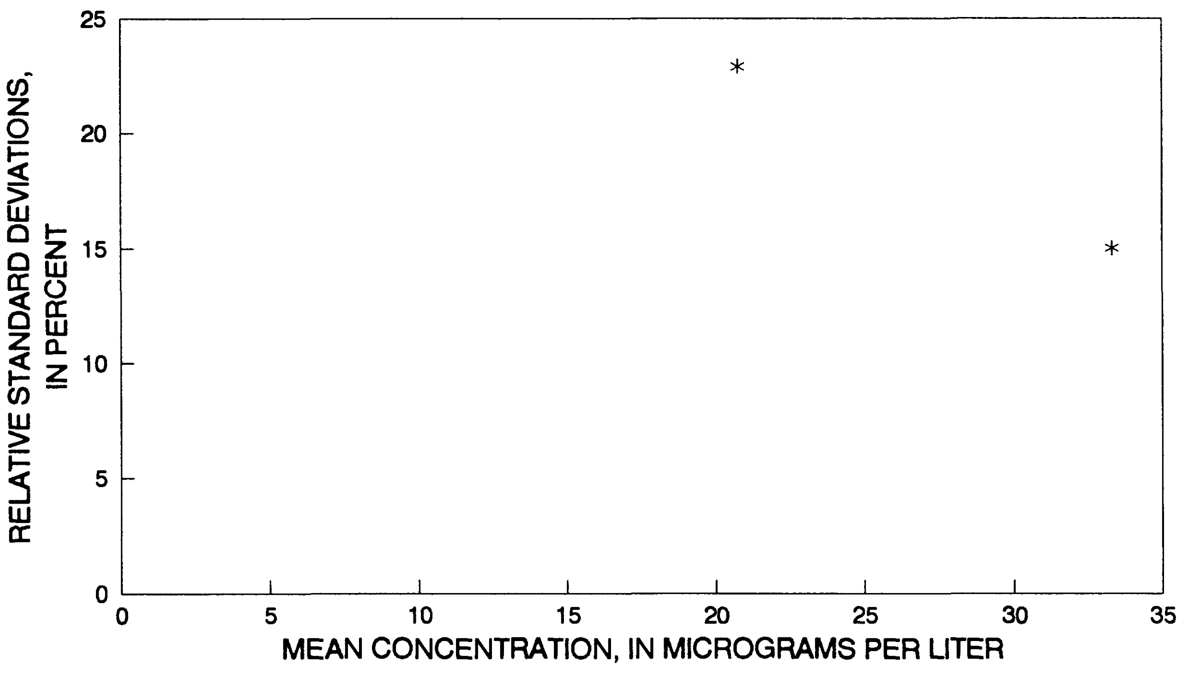

Figure 240. Precision data for zinc, dissolved, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

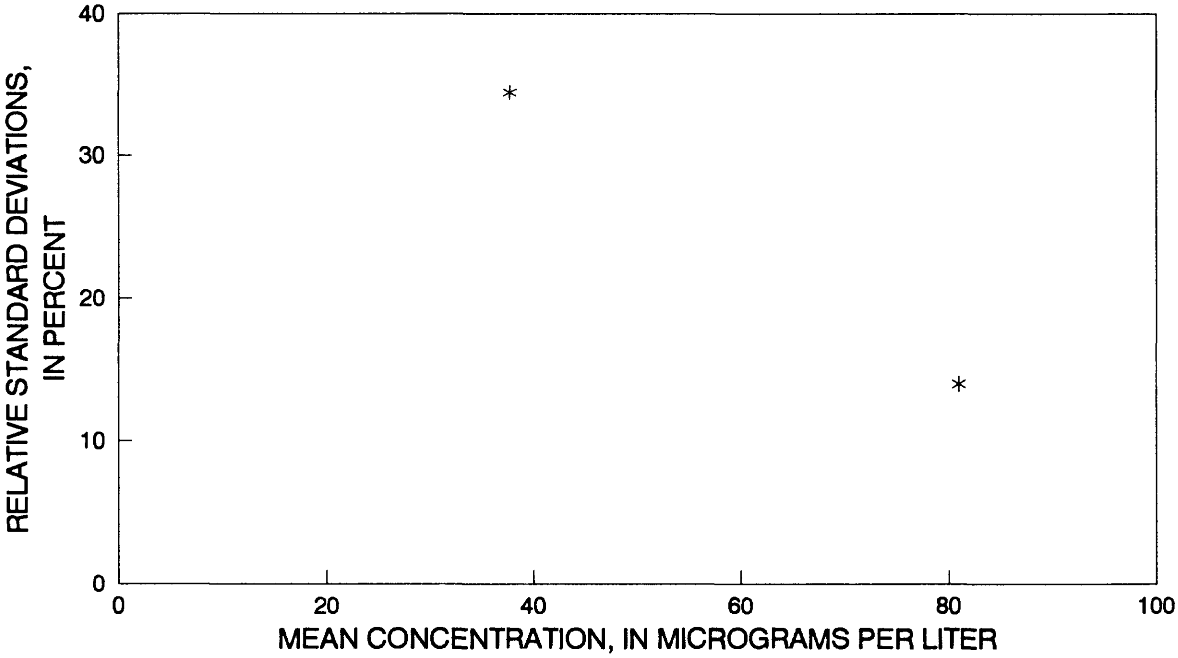

Figure 241. Precision data for zinc, total recoverable, (atomic absorption spectrometry) data from the Quality of Water Service Unit Laboratory.

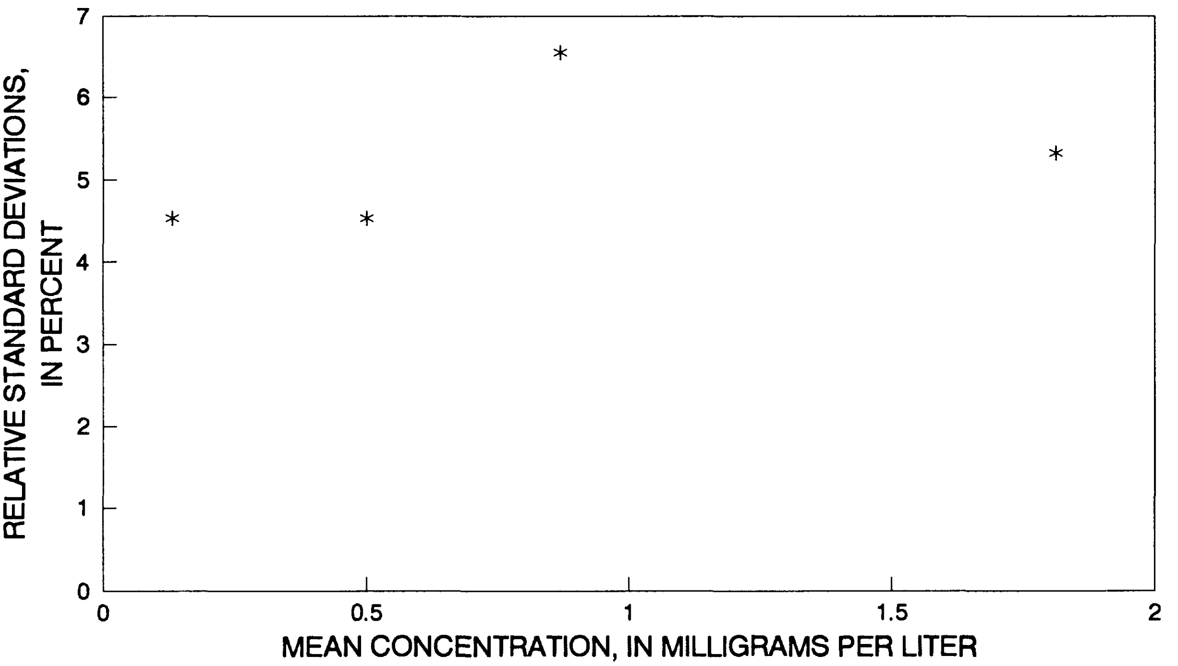

Figure 242. Precision data for ammonia as nitrogen, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

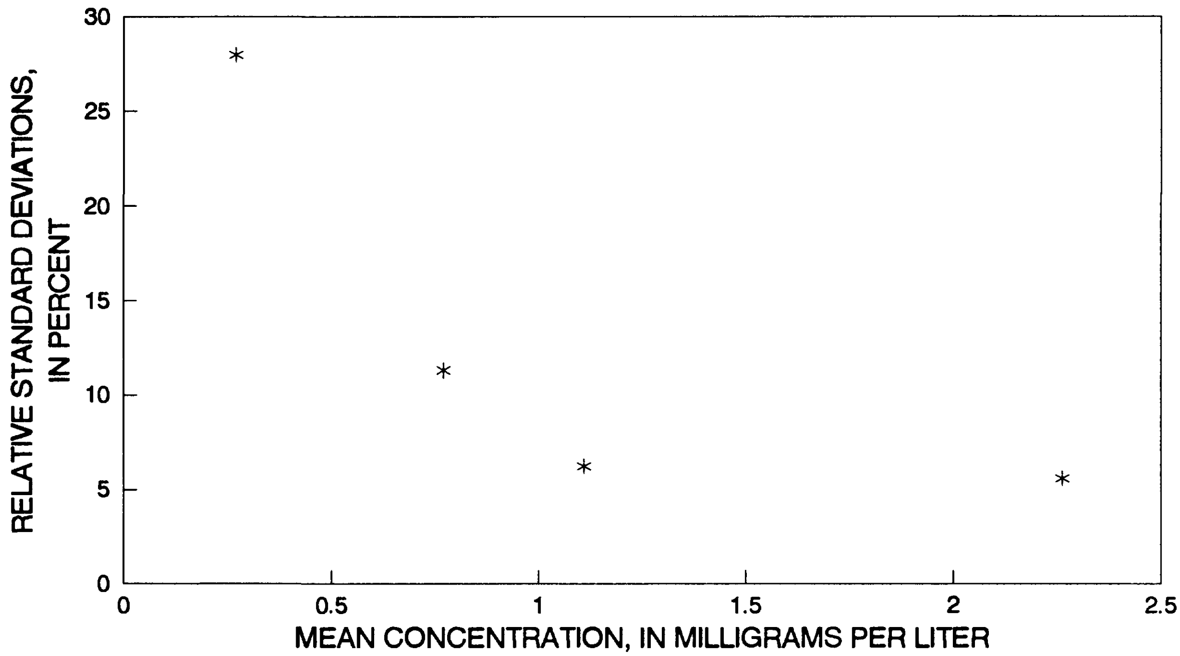

Figure 243. Precision data for ammonia plus organic nitrogen, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

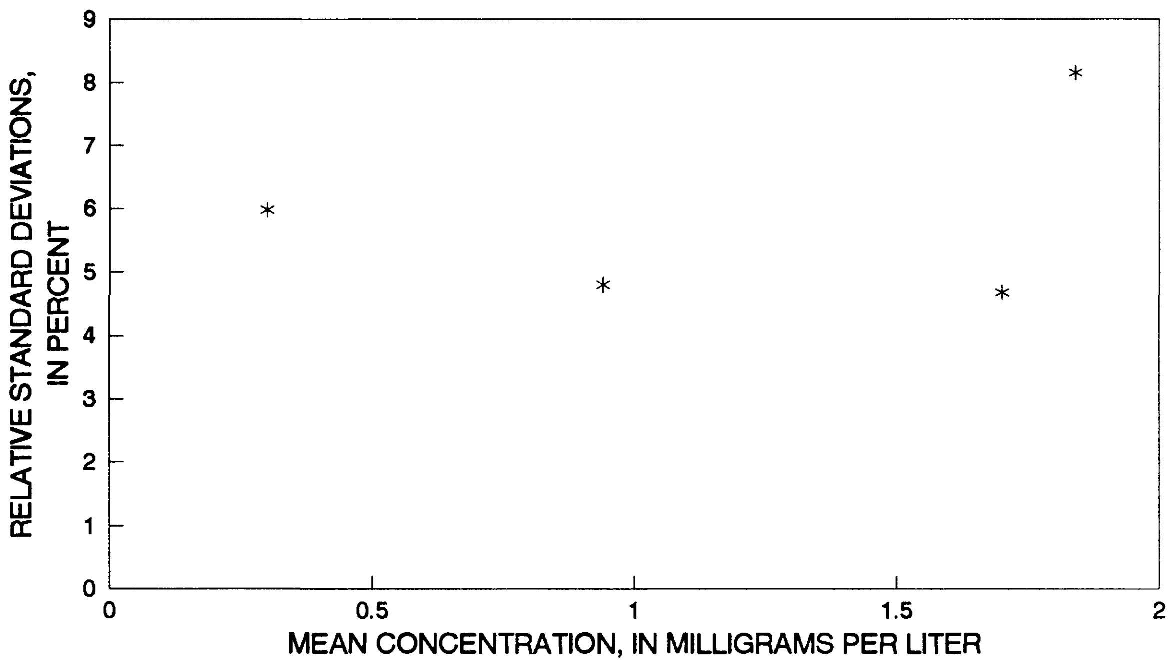

Figure 244. Precision data for nitrate plus nitrite as nitrogen, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

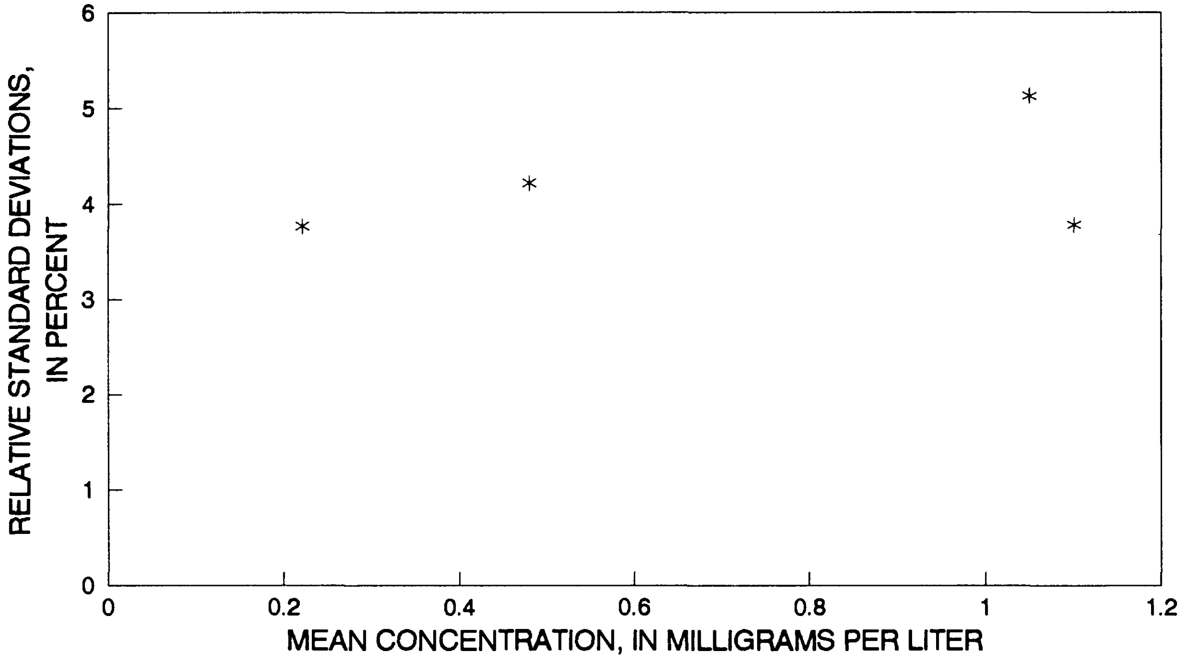

Figure 245. Precision data for orthophosphate as phosphorus, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

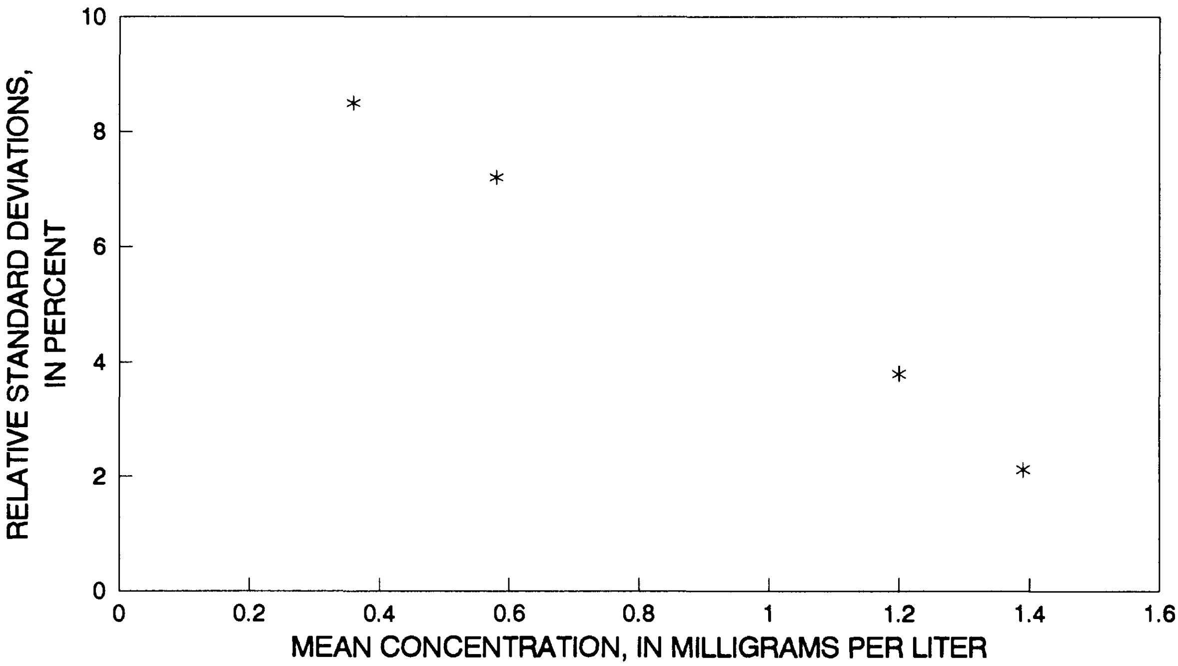

Figure 246. Precision data for phosphorus, dissolved and total, (colorimetric) data from the Quality of Water Service Unit Laboratory.

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