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QUALITY ASSURANCE REPORT

Atlanta Central Laboratory

Denver Central Laboratory

By

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QUALITY ASSURANCE REPORT

INTRODUCTION

Standard reference materials taken from the U.S. Geological Survey Standard Reference Water Sample (SRWS) Program (Schroder and others, 1980; Skougstad and Fishman, 1975), EPA ampuls or other non-Central Laboratory sources are prepared in the Ocala, Florida office, disguised as routine samples, and distributed to Water Resources Division (WRD) offices. The reference materials are then submitted to the Central Laboratories by the WRD offices on a specified schedule for the determination of major constituents, nutrients, and trace metals. The analytical schedule is designed to reflect the frequency of analyses for the various constituents. At least one reference sample is sent to each laboratory each day for constituents that are determined daily. All constituents in reference materials used to date have been in the dissolved phase; data designated as "total" or "total recoverable" are from samples which have undergone a digestion process, rather than from unfiltered or "whole-water" samples.

Once the analysis has passed through the laboratories' quality control and quality assurance routines, the data are permanently stored in WATSTORE. These data reflect the typical quality of results produced by each laboratory and received by each district.

For the period of this report, analyses were limited to major constituents including limited nutrient analyses and trace elements. A full complement of nutrient analyses was begun in January 1982. Submission of organic constituents including pesticides and priority pollutants began in October 1981 on a limited basis. This will be increased in the near future to a frequency of approximately one sample per week, dependent upon the latest production figures. Other types including splits, spikes, and sediment samples will be added to the program beginning in fiscal year 1983.

It should be pointed out that the purpose of this program is not to supply quality control data to the subject laboratories; that is, it is in no way intended to replace the internal quality assurance programs administered by the laboratory chiefs, but rather to document the quality of data that is generated by the laboratories.

Future plans include the addition of a computer routine whereby the laboratory chiefs may retrieve the most recently generated data on a weekly basis. This will then supplement their existing programs and aid in detecting problems at an earlier time.

Data are summarized in the appendix. All data were evaluated using programs developed from standard SAS (Helwig and Council, 1979) procedures.

Tables A1.1. and A1.2. summarize the satisfactory results for the Atlanta and Denver Central Laboratories, respectively. Expectation of a normal distribution implies that about 68 percent of the results would be within 1 standard deviation of the most probable value (MPV) and about 95 percent would be within 2 standard deviations, the acceptable level.

Tables A2.1. through A2.4. tabulate each individual value which exceeded the two most probable standard deviation (MPSD) criteria.

Figures A1.1.1. through A1.2.46. are scatterplots of each constituent with time and give a pictorial view of the accuracy, bias, and possible trends of the data for each laboratory.

Evaluation and statistical criteria

Many of the reference samples were prepared by mixing together two or more SRWSs. The most probable values (MPV) were calculated averaging the known MPVs. Although a theoretical specific conductance which is calculated by simply averaging the individual specific conductance values may not always be accurate, this approach was considered acceptable for these samples, because the MPVs were all less than 2,000 µmhos. There should be no significant difference between the calculated and actual values in this range (Erdmann, personal communication).

In conformance with WRD Memorandum 81.79, an individual value was considered acceptable if it was less than or equal to 2 standard deviations from the most probable value. This is a liberal criterion in most cases because the SRWS mean is based on interlaboratory, multimethod data. As soon as the data becomes available, we will use instead, the means and standard deviations for the specific methods in use. The MPSD for each constituent was calculated using the equation for a straight line with coefficients derived from a regression analysis of the means and standard deviations obtained from the interlaboratory analyses of SRWS #24 through SRWS #76. For nitrate plus nitrite-nitrogen and nitrite-nitrogen, the above equation produced MPSDs in strong disagreement with the standard deviations stated on the individual SRWS reports. A new regression analysis was done using only samples being used in this quality assurance program (#62 through #76) with greatly improved results.

Many of the trace metal analyses can be requested at more than one precision level depending on the analytical method used. For the period of this report, chromium and molybdenum were requested such that they were reported only to the nearest 10 µg/L. Since the computed MPSDs were based on SRWS reports which contained analyses which were reported to the nearest µg/L, it was impossible for many chromium and molybdenum analyses to fall within the acceptable criteria; therefore, a minimum MPSD was set at 7.5 µg/L. This allowed the analyses to be reported to $\pm$ 10 µg/L from the MPV and still be within the acceptable criteria.

In certain other situations, only one or two values were considered acceptable by the general statistical criteria employed (e.g. table A2.1., Sodium, items 1-3, 6). This left little room for analytical error and should be kept in mind when evaluating these data.

As more fully described in WRD Memorandum 81.79, a binomial distribution was used to evaluate the overall analytical precision for each constituent. The criteria used give less than a 1 percent chance that a determination will be considered "unacceptable" solely due to random errors.

Similarly, bias was determined by first examining the number of values which were greater than and less than the MPVs. A binomial probability distribution (at the 50 percent level) was then used such that there was less than a 1 percent chance that a determination would be considered biased solely due to random errors.

ANALYTICAL PRECISION

Determination of the following constituents showed statistically significant lack of precision:

Atlanta Central Laboratory - alkalinity; arsenic; cadmium, total recoverable; calcium; ~~iron, total recoverable,~~ manganese; manganese, total recoverable; mercury; sodium; specific conductance; zinc; zinc, total recoverable.

Denver Central Laboratory - alkalinity; aluminum; cadmium; chloride; copper, total recoverable; ~~iron,~~ mercury; phosphorous; selenium; specific conductance; zinc, total recoverable.

ANALYTICAL BIAS

Determination of the following constituents showed statistically significant bias:

Atlanta Central Laboratory

Positive bias: fluoride;

Negative bias: boron; barium; beryllium; calcium; nickel; nitrate plus nitrite-nitrogen; ~~selenium~~; silver; silver, total recoverable; strontium.

Denver Central Laboratory

Positive bias: chromium, total recoverable; iron; iron, total recoverable; molybdenum; selenium; sodium; specific conductance; sulfate.

Negative bias: aluminum; boron; cadmium, total recoverable; cobalt; cobalt, total recoverable; fluoride; nickel; nickel, total recoverable; silver; silver, total recoverable.

DISCUSSION AND RECOMMENDATIONS

Two of Denver's rejected sulfate values (0.41, 0.42 mg/L) and two rejected chloride values (0.11, 0.11 mg/L) appear to be keypunch or dilution errors. Two additional analyses of the same sample resulted in values 100 times greater (41, 40, mg/L and 11, 11 mg/L, respectively). These latter values agree with the MPV, (see table A2.3.). One Atlanta sample had an obvious transposition error where the calcium and magnesium values were interchanged. These types of errors should be found by the laboratory quality assurance reviewer. The specific analyses mentioned above all failed at least one of the laboratories' computer-generated quality control checks, which should have alerted the data reviewers to the existing problems. More careful attention to the computer-generated messages should alleviate these errors.

Results for rejected mercury values for the Denver Laboratory were generally low. This is probably due to the inadequate preservation techniques used by the Survey. Several investigators have shown that HNO_3 alone is insufficient for preservation of mercury in dilute solutions (El-Awady, Miller, and Carter, 1976; Feldman, 1974). El-Awady and others, and Feldman state that 5 percent HNO_3 plus .05 percent $K_2Cr_2O_7$ added as a preservative is necessary to eliminate mercury losses in polyethylene bottles for a period of up to 10 days. Borosilicate glass containers provided much longer periods of stability. Considering the lag time from collection to analysis and the occasional requests for reanalysis, it is recommended that glass containers and the above stated preservative be considered for mercury samples.

Most of Atlanta's and a few of Denver's rejected mercury values were high. The high values were all from reference samples containing some proportion of SRWS #73. These appear to contain about twice too much mercury relative to the proportion of #73; however, only 25 percent of reported values from samples containing SRWS #73 had high values. Since this phenomenon occurred in both laboratories, it may indicate a nonhomogeneous contamination.

The negative bias for silver may be also due to improper preservation techniques. Earlier investigations have shown that samples to be analyzed for silver at low levels must be preserved below pH 1 (Fishman, personal communication). This problem should be investigated by the Branch of Quality of Water for further action.

Results from boron analyses obtained from different methods do not show good agreement (Fishman, personal communication). The standard deviation used in this report is based on multiple methods, giving a broad range of acceptability. This is probably the reason for the apparent excellent precision but negative bias for this constituent exhibited by both laboratories.

Many values were reported as zero. Quality of Water Branch Technical Memoranda 81.18 and 81.22 require instead, "a less than" remark and the lower limit of detection for the method be used.

Finally, it should be pointed out that in many cases where the analytical precision appears good but bias is statistically significant (for example, see fluoride for Atlanta, fig. A1.1.20.), the bias may have little practical significance. Such bias should serve as a warning to the laboratory that an analytical problem appears to have developed but may have only a minor effect, if any, on data interpretation.

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APPENDIX A

Table A1.1.--Summary of satisfactory results for major constituents

[All constituents were in the dissolved phase]

Determination	Atlanta			Denver		
	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation
Alkalinity	55	45.5	69.1	76	55.3	81.6
Boron	11	90.9	100	12	66.7	100
Calcium	39	64.1	87.2	63	82.5	100
Chloride	55	87.3	98.2	76	64.5	86.8
Dissolved solids	43	88.4	97.6	64	81.3	95.3
Fluoride	55	67.3	100	76	68.4	93.4
Magnesium	41	80.5	92.7	64	96.9	100
Nitrite-nitrogen	10	80.0	90.0	8	12.5	100
Nitrate plus nitrite-nitrogen	55	83.6	89.1	76	81.6	90.8
Phosphorous	45	84.4	93.3	64	50	68.8

Table A1.1.--Summary of satisfactory results for major constituents—Continued

Determination	Atlanta			Denver		
	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation
Potassium	41	90.2	100	64	95.3	100
Silica	55	87.3	98.2	76	94.7	97.4
Sodium	41	58.5	75.6	64	64.1	87.5
Specific conductance	55	65.5	85.5	76	28.9	85.5
Sulfate	55	85.5	100	76	63.2	89.5

Table A1.2.--Summary of satisfactory results for trace metals

[All constituents were in the dissoloved phase; data designated as "total recoverable" are from samples which have undergone a preliminary digestion]

Determination	Atlanta			Denver		
	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation
Aluminum	45	77.8	91.1	48	39.6	81.3
Antimony	23	65.2	95.7	24	70.8	100
Arsenic	73	74.0	83.6	100	91.0	97.0
Barium	37	94.6	100	49	65.3	95.9
Barium, total recoverable	14	85.7	100	25	36.0	100
Beryllium	23	87.0	100	23	87.0	100
Cadmium	59	69.5	91.5	73	64.4	87.7
Cadmium, total recoverable	14	57.1	64.3	26	69.2	100
Chromium	59	76.3	93.2	74	75.7	100
Chromium, total recoverable	14	57.1	85.7	25	56	96

Table A1.2.--Summary of satisfactory results for trace metals—Continued

Determination	Atlanta			Denver		
	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation
Cobalt	37	78.4	94.6	49	57.1	93.9
Cobalt, total recoverable	14	57.1	92.9	26	38.5	88.5
Copper	59	84.7	91.5	72	73.6	94.4
Copper, total recoverable	14	85.7	100	25	52	68
Iron	43	76.7	88.4	31	80.6	96.8
Iron, total recoverable	12	50.0	75.0	14	71.4	78.6
Lead	59	67.8	91.5	73	68.5	95.9
Lead, total recoverable	14	71.4	92.9	26	84.6	96.2
Lithium	23	43.5	91.3	23	82.6	95.7
Manganese	59	62.7	79.7	73	98.6	98.6

Table A1.2.--Summary of satisfactory results for trace metals—Continued

Determination	Atlanta			Denver		
	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation	No. of samples	Percent ≤ 1 standard deviation	Percent ≤ 2 standard deviation
Manganese, total recoverable	14	64.3	78.6	25	100	100
Mercury	73	49.3	72.6	100	19.0	40.0
Molybdenum	45	97.8	100	47	97.9	100
Nickel	59	79.7	100	74	82.4	100
Nickel, total recoverable	14	71.4	85.7	26	73.1	100
Selenium	51	86.3	98.0	76	65.8	84.2
Silver	37	78.4	91.9	50	44.0	100
Silver, total recoverable	14	78.6	100	26	65.4	100
Strontium	25	84.0	100	31	12.9	100
Zinc	59	47.5	76.3	73	78.1	89.0
Zinc, total recoverable	14	21.4	64.3	25	60.0	68.0

Table A2.1.--Tabulation of data over 2 standard deviations from the most probable value for the Atlanta Laboratory: major constituents

[All constituents were in the dissolved phase]

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (mg/L)	Reported value (mg/L)	Most probable value (mg/L)	Most probable standard deviation (mg/L)	Number of standard deviations
Alkalinity/ 30.9	18.2 - 184.6	210	185	11.6	2.2
		84.0	65.3	4.8	3.9
		16.0	22.3	2.3	- 2.7
		17.0	22.3	2.3	- 2.3
		31.0	22.3	2.3	3.8
		1.0	48.8	3.8	-12.5
		130	108	7.2	3.0
		30.0	18.2	2.1	5.7
		27.0	18.2	2.1	4.2
		19.0	24.7	2.5	- 2.3
		17.0	24.7	2.5	- 3.2
		19.0	24.7	2.5	- 2.3
		210	185	11.6	2.2
		210	185	11.6	2.2
		210	185	11.6	2.2
		190	141	9.1	5.4
		12.0	18.2	2.1	- 3.0
Calcium/ 12.8	7.5 - 125	28.0	31.6	1.7	- 2.1
		46.0	52.2	2.6	- 2.4
		47.0	52.2	2.6	- 2.0
		53.0	84.6	4.0	- 7.9
		65.0	84.6	4.0	- 4.9
Chloride/ 1.8	1.4 - 138	160	138	5.4	4.1
Dissolved solids/ 2.4	70.6 - 1,121	153	410	17.7	-14.5
Magnesium/ 7.3	2.0 - 59.5	89.0	54.4	2.7	12.7
		42.0	54.4	2.7	- 4.5
		10.0	13.6	0.8	- 4.3

Table A2.1.--Tabulation of data over 2 standard deviations from the most probable value for the Atlanta Laboratory: major constituents—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (mg/L)	Reported value (mg/L)	Most probable value (mg/L)	Most probable standard deviation (mg/L)	Number of standard deviations
Nitrate plus nitrite-nitrogen/ 10.9	0.71 - 3.5	0.70	1.06	0.14	- 2.6
		1.4	2.6	.34	- 3.5
		2.5	1.4	0.18	5.9
		1.6	2.4	0.32	- 2.6
		1.6	2.4	0.32	- 2.6
		2.0	1.4	0.21	3.3
Nitrite-nitrogen/ 10	0.01 - 0.05	0.49	0.02	0.01	62.7
Phosphorus/ 6.7	0.21 - 1.5	2.4	1.5	0.10	9.2
		0.38	0.30	0.03	3.0
		1.7	1.5	0.10	2.3
Silica/ 1.8	5.1 - 12.2	0.1	10.8	0.9	-11.6
Sodium/ 24.4	2.8 - 129	18.0	16.9	0.5	2.1
		20.0	16.9	0.5	5.8
		19.0	16.9	0.5	3.9
		5.2	4.8	0.2	2.6
		5.2	4.8	0.2	2.6
		19.0	17.7	0.6	2.2
		58.0	66.7	3.4	- 2.6
		110	97.8	5.2	2.4
		4.0	4.8	0.2	- 4.9
		32.0	29.0	1.2	2.5
Specific conductance[1]/ 14.5	103.4 - 1,536	490	430	14.8	4.1
		134	124	3.0	3.5
		134	124	3.0	3.5
		640	569	20	3.5
		636	569	20	3.3
		632	569	20	3.1
		645	569	20	3.8
		111	103	2.2	3.5

[1]Units are μmhos/cm[2] at 25°C.

Table A2.2.--Tabulation of data over 2 standard deviations from the most probable value for the Atlanta Laboratory: trace metals

[All constituents were in the dissolved phase; data designated as "total recoverable" are from samples which have undergone a preliminary digestion]

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Aluminum/ 8.9	211 - 620	90	235	58.3	- 2.49
		560	236	58.4	5.54
		680	490	84.0	2.26
		20	236	58.4	- 3.70
Antimony/ 4.3	1.4 - 8.0	5	8.0	0.7	- 4.31
Arsenic/ 16.4	2.5 - 34.9	48	26.3	6.8	3.2
		3	34.9	7.9	- 4.04
		3	34.9	7.9	- 4.04
		14	34.9	7.9	- 2.65
		2	18.4	5.7	- 2.85
		2	18.4	5.7	- 2.85
		2	18.4	5.7	- 2.85
		43	26.3	6.8	2.47
		47	26.3	6.8	3.06
		4	34.9	7.9	- 3.92
		4	34.9	7.9	- 3.92
		16	34.9	7.9	- 2.40
Cadmium/ 8.5	0.8 - 15.9	22	10.7	2.1	5.35
		2,800	10.7	2.1	1,320
		4,500	15.7	2.6	1,725
		5	9.9	2.0	- 2.41
		12	7.9	1.8	2.23
Cadmium, total recoverable/ 35.7	1.6 - 15.7	0	15.7	2.6	- 6.04
		1	15.7	2.6	- 5.65
		1	9.9	2.0	- 4.37
		4	9.9	2.0	- 2.90
		4	9.9	2.0	- 2.90

Table A2.2.--Tabulation of data over 2 standard deviations from the most probable value for the Atlanta Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Chromium/ 6.8	5 - 23.5	40	23.5	7.6	2.16
		40	23.5	7.6	2.16
		30	10.6	7.5	2.59
		40	10.0	7.5	4.00
Chromium, total recoverable/ 14.3	7.5 - 17.0	30	8.4	7.5	2.88
		40	7.5	7.5	4.33
Cobalt/ 5.4	4.6 - 15.6	2	7.4	1.8	- 2.93
		2	7.4	1.8	- 2.93
Cobalt, total recoverable/ 7.1	7.4 - 15.4	4	9.5	2.1	- 2.64
Copper/ 8.5	18.8 - 297	120	255	19.1	- 7.06
		170	255	19.1	- 4.45
		310	255	19.1	2.88
		21	92.2	9.4	- 7.54
		19	92.2	9.4	- 7.75
Iron/ 11.6	130 - 630	400	630	53.1	- 4.33
		90	130	15.5	- 2.58
		80	130	15.5	- 3.22
		90	130	15.5	- 2.58
		80	130	15.5	- 3.22
Iron, total recoverable/ 25	130 - 313	260	130	15.5	8.37
		200	130	15.5	4.51
		180	130	15.5	3.22
Lead/ 8.5	10.7 - 23.2	0	13.6	6.8	- 2.00
		34	13.6	6.8	3.00
		59	10.7	6.3	7.70
		25	10.7	6.3	2.28
		220	16.5	7.3	27.8
Lead, total recoverable/ 7.1	13.6 - 16.9	1	16.5	7.3	- 2.12

Table A2.2.--Tabulation of data over 2 standard deviations from the most probable value for the Atlanta Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Lithium/ 8.7	55 - 397	190	151	10.9	3.58
		180	151	10.9	2.66
Manganese/ 20.3	35 - 527	480	425	22.4	2.46
		490	425	22.4	2.90
		540	425	22.4	5.14
		470	425	22.4	2.01
		470	425	22.4	2.01
		470	425	22.4	2.01
		260	319	18.7	- 3.16
		270	319	18.7	- 2.63
		410	319	18.7	4.88
		150	188	14.0	- 2.71
		140	188	14.0	- 3.42
		140	188	14.0	- 3.42
Manganese, total recoverable/ 21.4	132 - 481	280	319	18.7	- 2.09
		100	132	12.1	- 2.65
		160	132	12.1	2.32
Mercury/ 27.4	0.34 - 15.6	4.8	2.67	0.52	4.08
		5.4	2.67	0.52	5.23
		18.0	3.76	0.70	20.3
		18.0	3.76	0.70	20.3
		17.0	3.76	0.70	18.9
		19.0	3.76	0.70	21.7
		2.8	1.90	0.40	2.28
		2.9	1.90	0.40	2.53
		2.8	1.90	0.40	2.28
		9.6	15.6	2.65	- 2.27
		0.2	12.6	2.16	- 5.75
		9.4	15.6	2.65	- 2.34
		6.8	15.6	2.65	- 3.32
		2.0	1.33	0.30	2.22
		4.8	2.67	0.52	4.08
		5.4	2.67	0.52	5.23
		19.0	3.76	0.70	21.7
		18.0	3.76	0.70	20.3
		18.0	3.76	0.70	20.3
		19.0	3.76	0.70	21.7

Table A2.2.--Tabulation of data over 2 standard deviations from the most probable value for the Atlanta Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Nickel, total recoverable/ 14.3	11.5 - 12.6	21	11.5	4.7	2.01
		23	12.6	5.0	2.09
Selenium/ 2	4.6 - 14.7	8	4.6	1.3	2.54
Silver/ 8.1	2.3 - 11.0	0	2.7	1.0	- 2.70
		33	3.8	1.7	17.5
		0	4.2	1.9	- 2.20
Zinc/ 23.7	22.5 - 253	240	195	16.0	2.81
		300	253	19.7	2.39
		320	253	19.7	3.40
		210	253	19.7	- 2.18
		390	253	19.7	6.95
		170	242	19.0	- 3.79
		170	242	19.0	- 3.79
		100	137	12.3	- 3.00
		82	137	12.3	- 4.45
		67	137	12.3	- 5.67
		76	137	12.3	- 4.94
		540	238	18.8	16.11
		650	238	18.8	22.0
		200	238	18.8	- 2.03
Zinc, total recoverable/ 35.7	36 - 242	240	195	16.0	2.81
		250	195	16.0	3.43
		50	36	5.9	2.36
		60	36	5.9	4.04
		330	36	5.9	49.5

Table A2.3.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: major constituents

[All constituents were in the dissolved phase]

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (mg/L)	Reported value (mg/L)	Most probable value (mg/L)	Most probable standard deviation (mg/L)	Number of standard deviations
Alkalinity/ 18.4	18.2 - 184.6	13	18.2	2.1	- 2.5
		240	185	11.6	4.8
		150	133	8.6	- 2.0
		150	133	8.6	2.0
		28	21.3	2.3	3.0
		27	21.3	2.3	2.5
		17	22.3	2.3	- 2.3
		61	48.8	3.8	3.2
		15	22.3	2.3	- 3.2
		16	22.3	2.3	- 2.7
		82	65.3	4.8	3.5
		25	18.2	2.1	3.3
		30	18.2	2.1	5.7
		31	18.2	2.1	6.2
Chloride/ 13.2	1.4 - 95	39.0	45.0	2.2	- 2.8
		50.0	45.0	2.2	2.3
		27.0	31.0	1.7	- 2.4
		27.0	31.0	1.7	- 2.4
		25.0	31.0	1.7	- 3.6
		46.0	23.2	1.4	16.1
		110	95.0	3.9	3.9
		11.0	13.3	1.1	- 2.1
		0.1	12.3	1.0	- 11.7
		0.1	12.3	1.0	- 11.7
Dissolved solids/ 4.7	70.6 - 984	87.0	70.6	8.0	2.1
		89.0	70.6	8.0	2.3
		379	420	18.0	- 2.3
Fluoride/ 6.6	0.36 - 1.1	0.2	0.36	0.04	- 3.6
		1.1	0.90	0.09	2.2
		0.1	0.98	0.10	- 8.9
		0.0	0.63	0.07	- 9.2
		0.7	0.90	0.09	- 2.2

Table A2.3.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: major constituents—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (m/L)	Reported value (mg/L)	Most probable value (mg/L)	Most probable standard deviation (mg/L)	Number of standard deviations
Nitrate plus nitrite/ 9.2	0.71 - 3.5	4.7	2.4	0.32	7.1
		0.05	2.7	0.35	- 7.5
		1.2	2.9	0.38	- 4.54
		0.19	3.1	0.41	- 7.22
		0.22	1.3	0.17	- 6.3
		0.90	0.71	0.09	2.1
		0.05	2.4	0.32	- 7.5
Phosphorus/ 31.2	0.2-1.5	1.7	1.5	0.10	2.3
		0.7	1.5	0.10	- 13.9
		1.7	1.5	0.10	2.3
		0.59	0.50	0.04	2.1
		0.59	0.50	0.04	2.1
		0.61	0.50	0.04	2.6
		0.59	0.50	0.04	2.1
		0.60	0.50	0.04	2.4
		0.60	0.50	0.04	2.4
		0.40	0.33	0.03	2.5
		0.49	0.24	0.02	10.6
		0.50	0.24	0.02	11.0
		1.5	1.2	0.09	3.3
		1.5	1.2	0.09	3.3
		1.5	1.2	0.09	3.3
		1.7	1.2	0.09	5.6
		1.5	1.2	0.09	3.3
		1.8	1.2	0.09	6.8
		1.9	1.2	0.09	8.0
		1.8	1.2	0.09	6.8
Silica/ 2.6	6.6 - 10.2	0.6	7.4	0.8	- 8.2
		5.2	8.3	0.9	- 3.6
Sodium/ 12.5	2.8 - 113	2.1	2.8	0.3	- 2.4
		4.5	2.8	0.3	6.3
		4.7	4.3	0.2	2.3
		4.8	4.3	0.2	2.8
		5.1	4.8	0.2	2.0
		5.2	4.8	0.2	2.6
		2.1	2.8	0.3	- 2.4
		2.0	2.8	0.3	- 2.8

Table A2.3.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: major constituents—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (mg/L)	Reported value (mg/L)	Most probable value (mg/L)	Most probable standard deviation (mg/L)	Number of standard deviations
Specific conductance[1]/ 14.5	103.4 - 1,351	109	103.4	2.2	2.6
		109	103.4	2.2	2.6
		274	257.1	8.1	2.1
		130	123.5	3.0	2.2
		131	123.5	3.0	2.5
		610	658	23.5	- 2.0
		1,020	658	23.5	15.4
		261	242	7.5	2.5
		130	123.5	3.0	2.2
		130	123.5	3.0	2.2
		108	103.4	2.2	2.1
Sulfate/ 10.5	14.3 - 446	260	239	10.5	2.0
		200	180	8.6	2.3
		200	180	8.6	2.3
		130	111	6.3	3.0
		140	111	6.3	4.7
		140	111	6.3	4.7
		0.4	38.5	3.8	- 10.0
		0.4	38.5	3.8	- 10.0

[1]Units are μmhos/cm[2] at 25°C.

Table A2.4.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: trace metals

[All constituents were in the dissolved phase; data designated as "total recoverable" are from samples which have undergone a preliminary digestion]

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Aluminum/ 18.7	235 - 620	90	235	58.3	- 2.49
		100	235	58.3	- 2.31
		90	235	58.3	- 2.49
		100	235	58.3	- 2.31
		380	235	58.3	2.49
		310	490	84.0	- 2.14
		310	490	84.0	- 2.14
		320	490	84.0	- 2.02
		280	490	84.0	- 2.50
Arsenic/ 3	2.5 - 34.2	40	26.3	6.8	2.02
		40	26.3	6.8	2.02
		30	18.4	5.7	2.02
Barium/ 4.1	30 - 203	200	61	40.6	3.42
		200	73	41.3	3.07
Cadmium/ 12.3	0.8 - 15.9	11	5.9	1.6	3.10
		23	15.9	2.6	2.71
		22	15.9	2.6	2.33
		18	9.9	2.0	3.98
		0	9.9	2.0	- 4.87
		0	3.8	1.4	- 2.64
		14	9.9	2.0	2.02
		17	9.9	2.0	3.49
		17	9.9	2.0	3.49
Chromium, total recoverable/ 4	5.0 - 17.0	40	15.4	7.5	3.28
Cobalt 6.1	4.6 - 15.6	1	6.4	1.7	- 3.11
		7	14.1	2.6	- 2.73
		0	7.4	1.8	- 4.01

Table A2.4.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Cobalt, total recoverable/ 11.5	6.4 - 14.1	5	14.1	2.6	- 3.50
		8	14.1	2.6	- 2.35
		8	14.1	2.6	- 2.35
Copper/ 5.6	18.8 - 297	210	297	21.6	- 4.03
		240	297	21.6	- 2.64
		130	102	10.0	2.79
		120	92.2	9.4	2.94
Copper, total recoverable/ 32	51. - 297	80	60.4	7.6	2.60
		42	60.4	7.6	- 2.44
		110	60.4	7.6	6.57
		120	60.4	7.6	7.89
		80	60.4	7.6	2.60
		80	60.4	7.6	2.60
		80	60.4	7.6	2.60
		4	297	21.6	-13.56
Iron/ 3.2	134 - 372	80	223	22.5	- 6.35
Iron, total recoverable/ 21.4	223 - 313	320	223	22.5	4.31
		270	223	22.5	2.09
		380	313	29.3	2.29
Lead/ 4.1	7.9 - 23.2	1	16.5	7.3	- 2.12
		31	10.7	6.3	3.24
		28	10.7	6.3	2.76
Lead, total recoverable/ 3.8	13.6 - 23.2	2	23.2	8.5	- 2.49
Lithium/ 4.3	55 - 397	290	341	23.1	- 2.21
Manganese/ 1.4	35 - 527	30	224	15.3	-12.67

Table A2.4.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Mercury/ 60	0.34 - 15.6	3.0	7.8	1.37	- 3.51
		4.3	7.8	1.37	- 2.56
		3.2	7.8	1.37	- 3.37
		3.2	7.8	1.37	- 3.37
		3.4	7.8	1.37	- 3.22
		3.4	7.8	1.37	- 3.22
		3.4	7.8	1.37	- 3.22
		4.0	2.67	0.52	2.55
		4.0	2.67	0.52	2.55
		5.0	2.67	0.52	4.46
		4.0	2.67	0.52	2.55
		7.2	3.45	0.65	5.77
		7.0	3.45	0.65	5.46
		7.0	3.45	0.65	5.46
		2.7	1.90	0.40	2.02
		2.7	1.90	0.40	2.02
		2.7	1.90	0.40	2.02
		1.1	0.68	0.19	2.16
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		8.0	15.60	2.65	- 2.87
		0.9	15.60	2.65	- 5.55
		1.1	15.60	2.65	- 5.47
		8.0	15.60	2.65	- 2.87
		7.0	15.60	2.65	- 3.25
		0.3	15.60	2.65	- 5.78
		0.5	15.60	2.65	- 5.70
		0.0	15.60	2.65	- 5.89
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		0.0	0.34	0.14	- 2.45
		0.1	12.60	2.16	- 5.80
		7.0	12.60	2.16	- 2.60
		7.0	12.60	2.16	- 2.60

Table A2.4.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Mercury/ 60 (cont.)		7.0	12.60	2.16	- 2.60
		6.0	12.60	2.16	- 3.06
		5.0	12.60	2.16	- 3.53
		7.0	12.60	2.16	- 2.60
		1.0	7.80	1.37	- 4.98
		3.4	7.80	1.37	- 3.22
		2.0	7.80	1.37	- 4.25
		3.6	7.80	1.37	- 3.08
		5.0	7.80	1.37	- 2.05
		3.9	7.80	1.37	- 2.86
		3.7	7.80	1.37	- 3.00
		4.8	2.67	0.52	4.08
		4.0	2.67	0.52	2.55
		5.0	2.67	0.52	4.46
		4.0	2.67	0.52	2.55
		4.0	12.60	2.16	- 3.99
		6.0	12.60	2.16	- 3.06
		5.0	12.60	2.16	- 3.53
		1.2	12.60	2.16	- 5.29
		6.0	12.60	2.16	- 3.06
		6.0	12.60	2.16	- 3.06
		5.0	12.60	2.16	- 3.53
Selenium/ 15.8	4.6 - 8.4	0	5.8	2.0	- 2.96
		0	5.8	2.0	- 2.96
		0	6.2	2.2	- 2.86
		0	6.2	2.2	- 2.86
		0	6.2	2.2	- 2.86
		0	4.6	1.3	- 3.43
		1	4.6	1.3	- 2.69
		11	4.6	1.3	4.78
		0	5.8	2.0	- 2.96
		0	6.2	2.2	- 2.86
		0	6.2	2.2	- 2.86
		1	6.2	2.2	- 2.40

Table A2.4.--Tabulation of data over 2 standard deviations from the most probable value for the Denver Laboratory: trace metals—Continued

Determination/ Percent > 2 standard deviations	Concentration range of reference samples (µg/L)	Reported value (µg/L)	Most probable value (µg/L)	Most probable standard deviation (µg/L)	Number of standard deviations
Zinc/ 11	19.8 - 252	230	195	16.0	2.18
		230	195	16.0	2.18
		240	195	16.0	2.81
		230	195	16.0	2.18
		10	28.0	5.4	- 3.31
		50	28.0	5.4	4.05
		41	22.5	5.1	3.64
		51	22.5	5.1	5.60
Zinc, total recoverable/ 32	28.0 - 242	240	195	16.0	2.81
		240	195	16.0	2.81
		240	195	16.0	2.81
		240	195	16.0	2.81
		60	28.0	5.4	5.89
		40	28.0	5.4	2.21
		40	28.0	5.4	2.21
		50	28.0	5.4	4.05

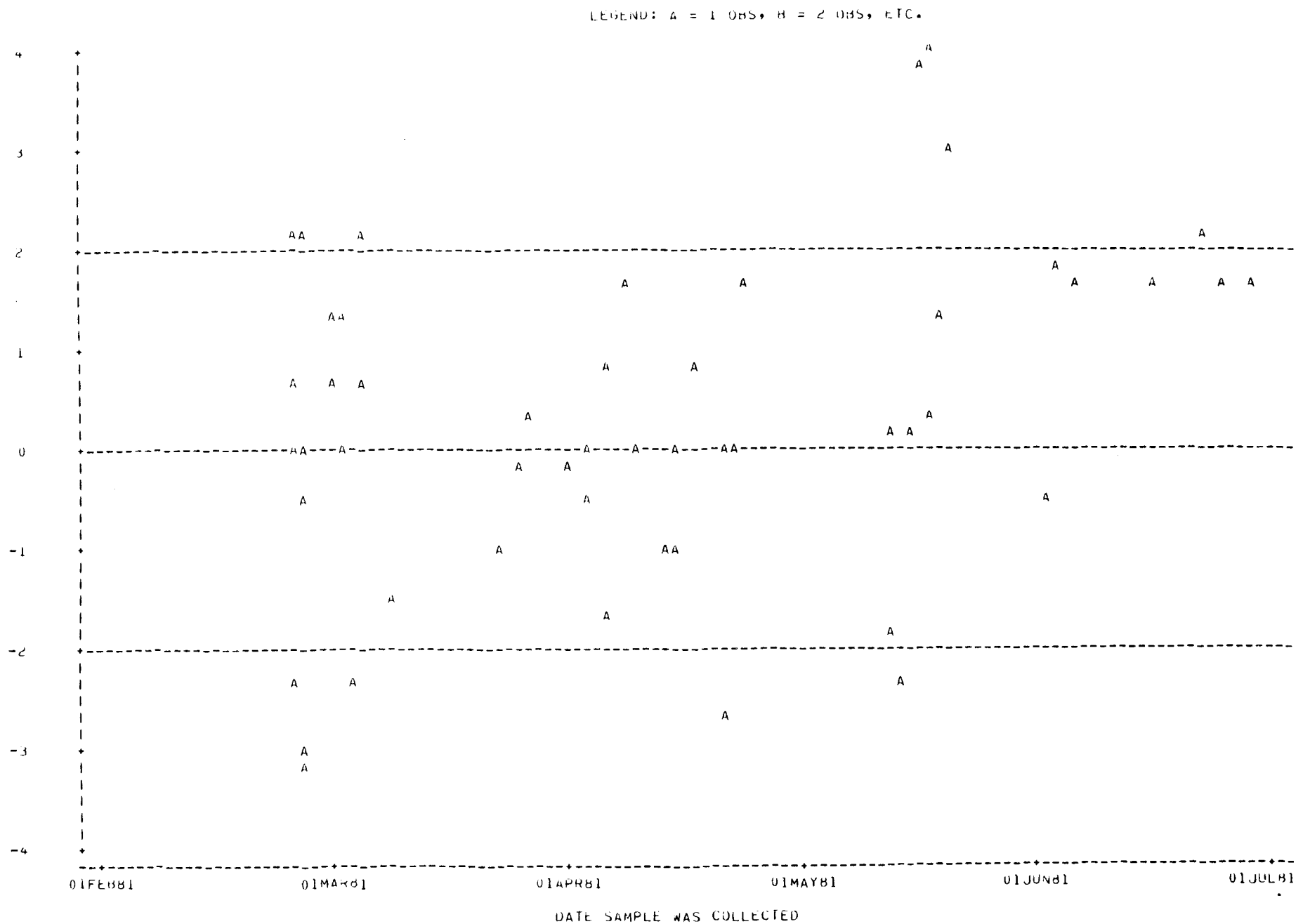

Figure A1.1.1.--Alkalinity data for the Atlanta Laboratory.
(Four observations were out of range.)

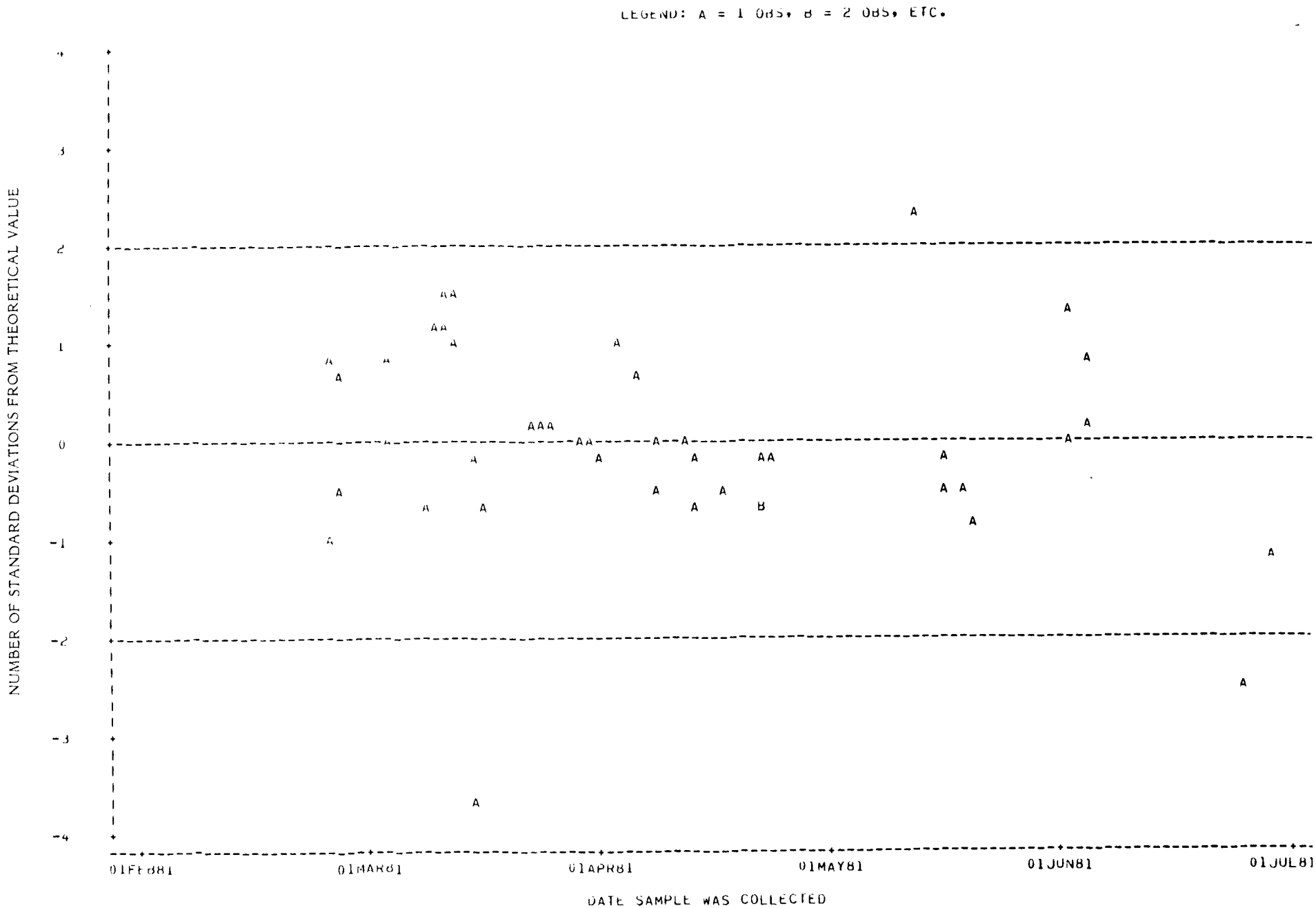

Figure A1.1.2.--Aluminum data for the Atlanta Laboratory.
(One observation was out of range.)

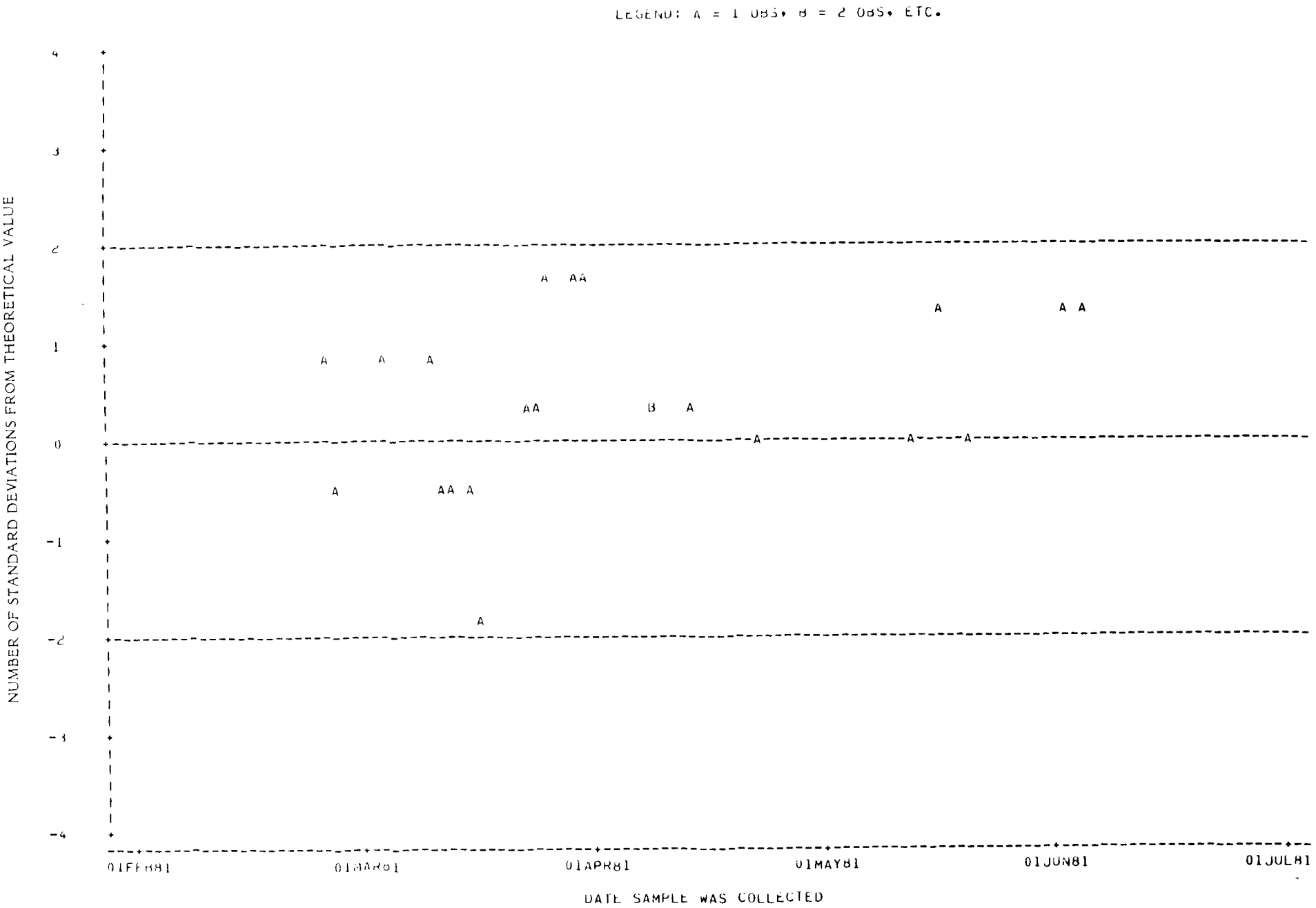

Figure A1.1.3.--Antimony data for the Atlanta Laboratory.
(One observation was out of range.)

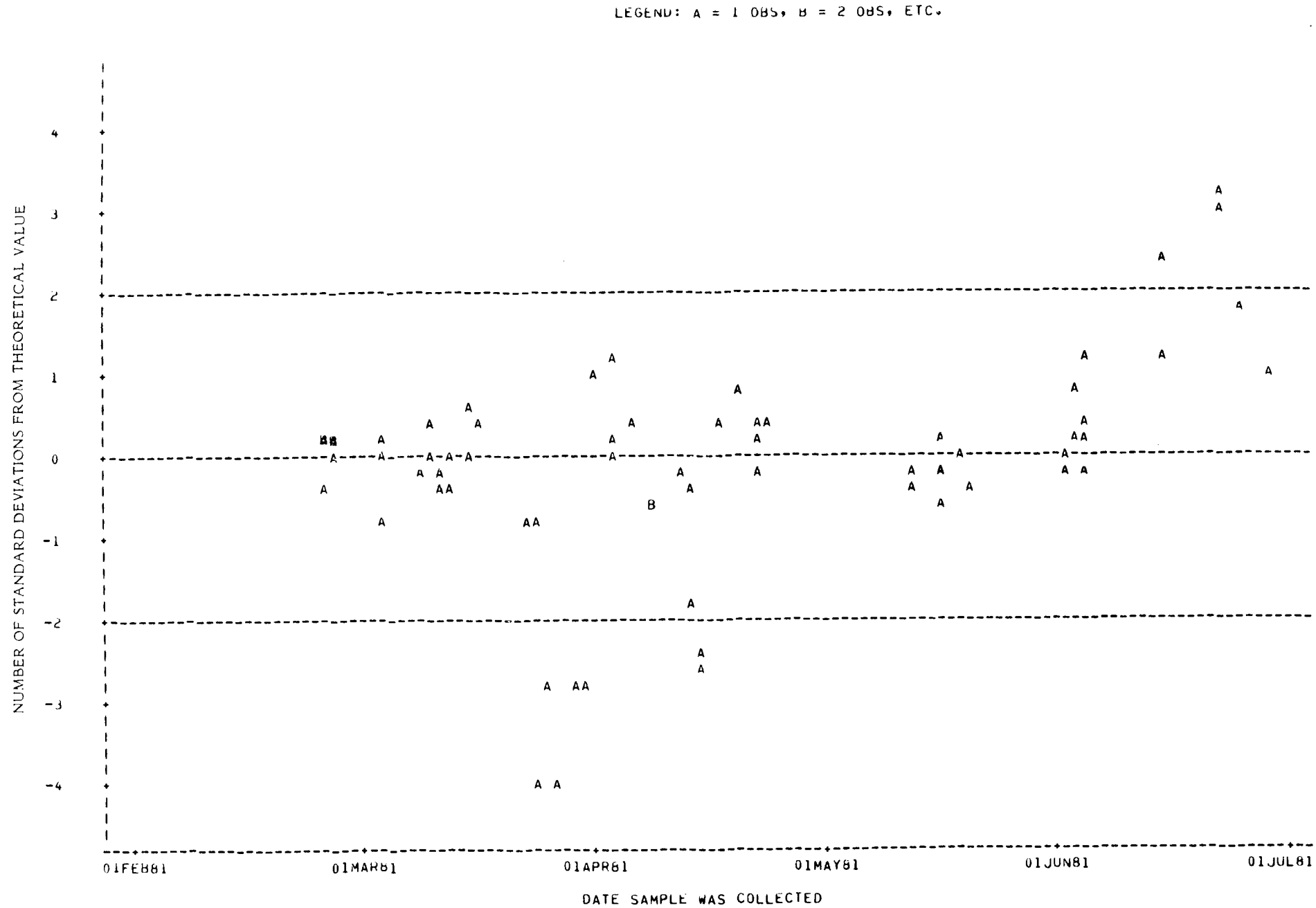

Figure A1.1.4.--Arsenic data for the Atlanta Laboratory.

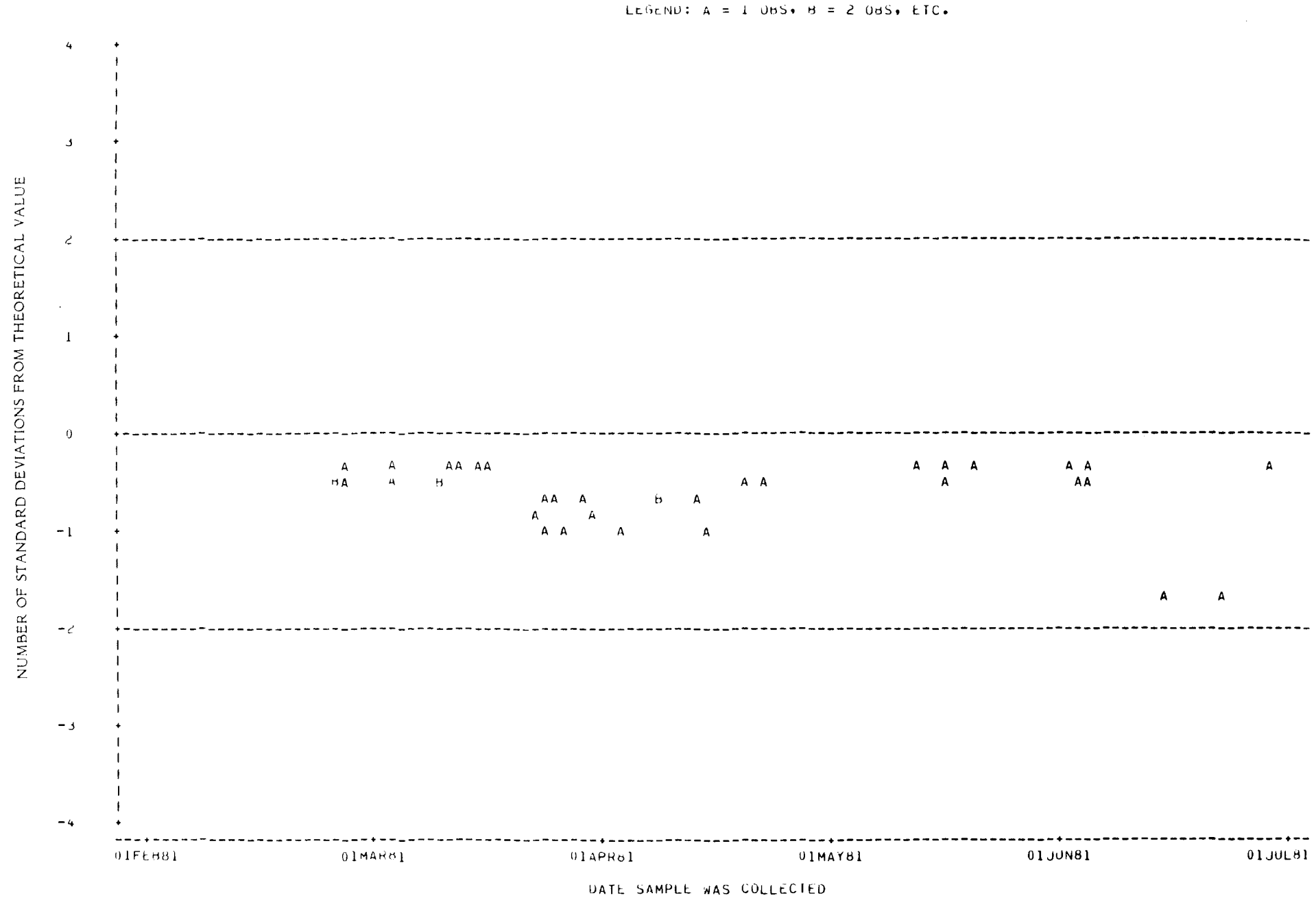

Figure A1.1.5-- Barium data for the Atlanta Laboratory.

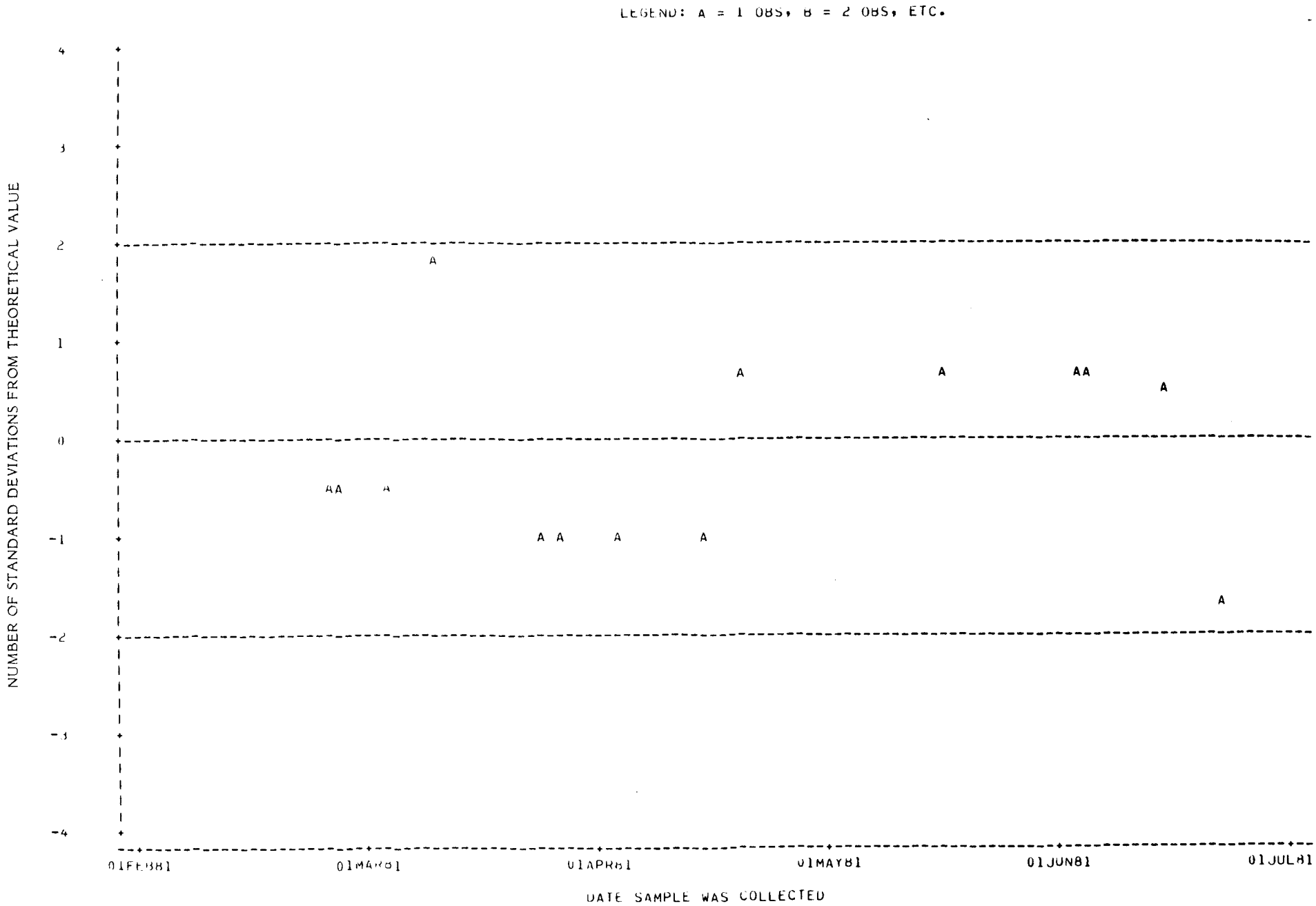

Figure A1.1.6.--Barium, total recoverable data for the Atlanta Laboratory.

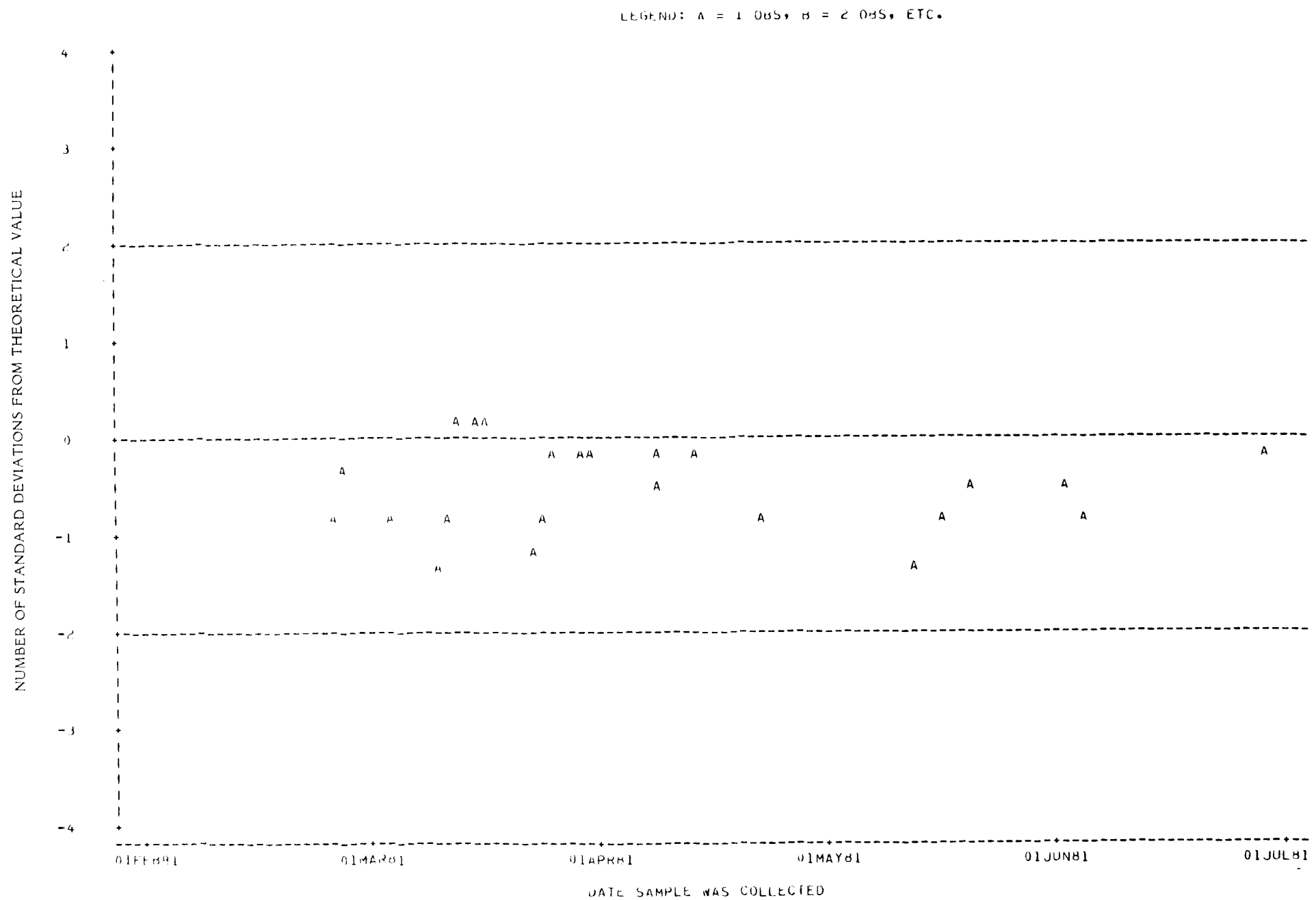

Figure A1.1.7.--Beryllium data for the Atlanta Laboratory.

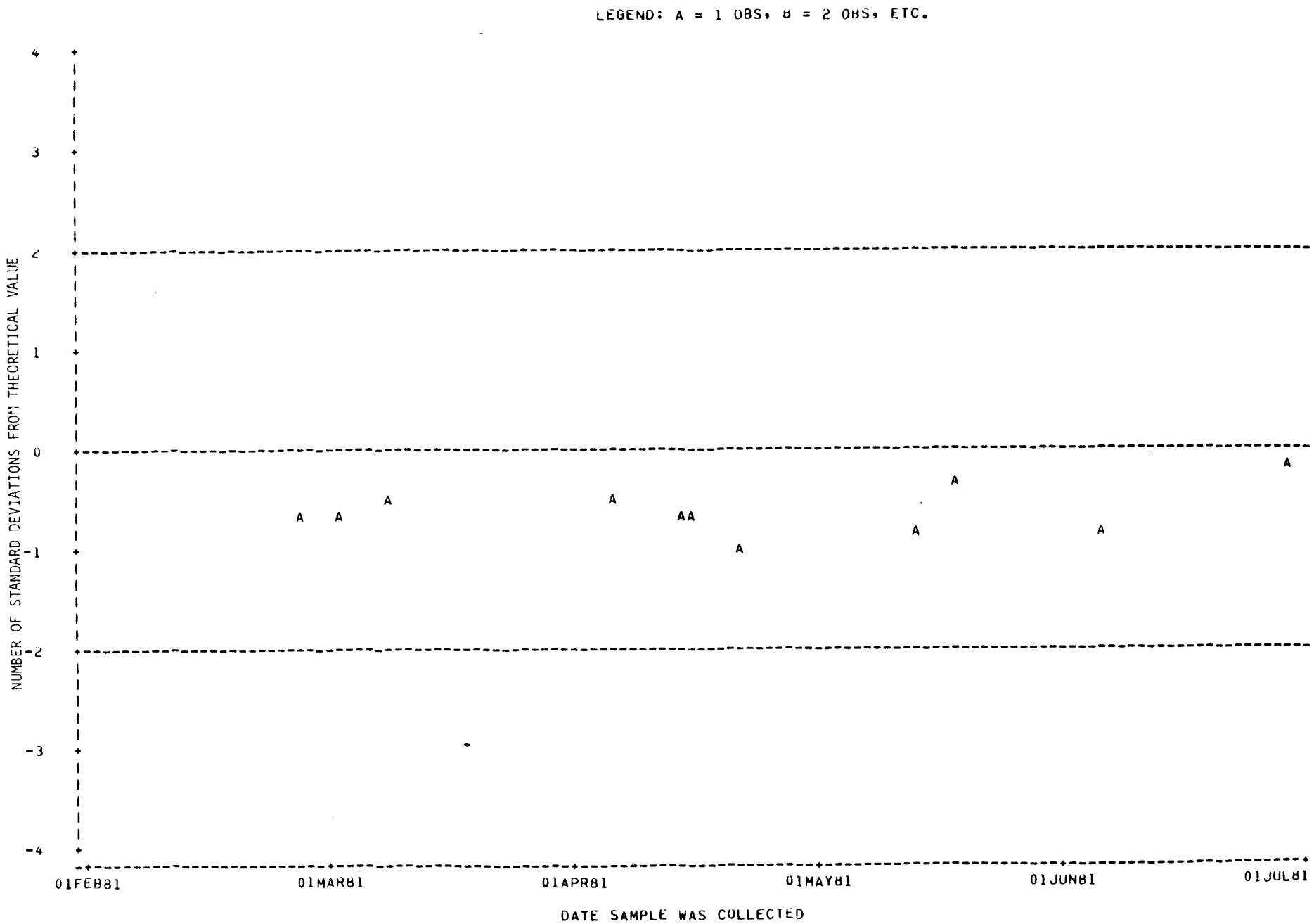

Figure A1.1.8.--Boron data for the Atlanta Laboratory.

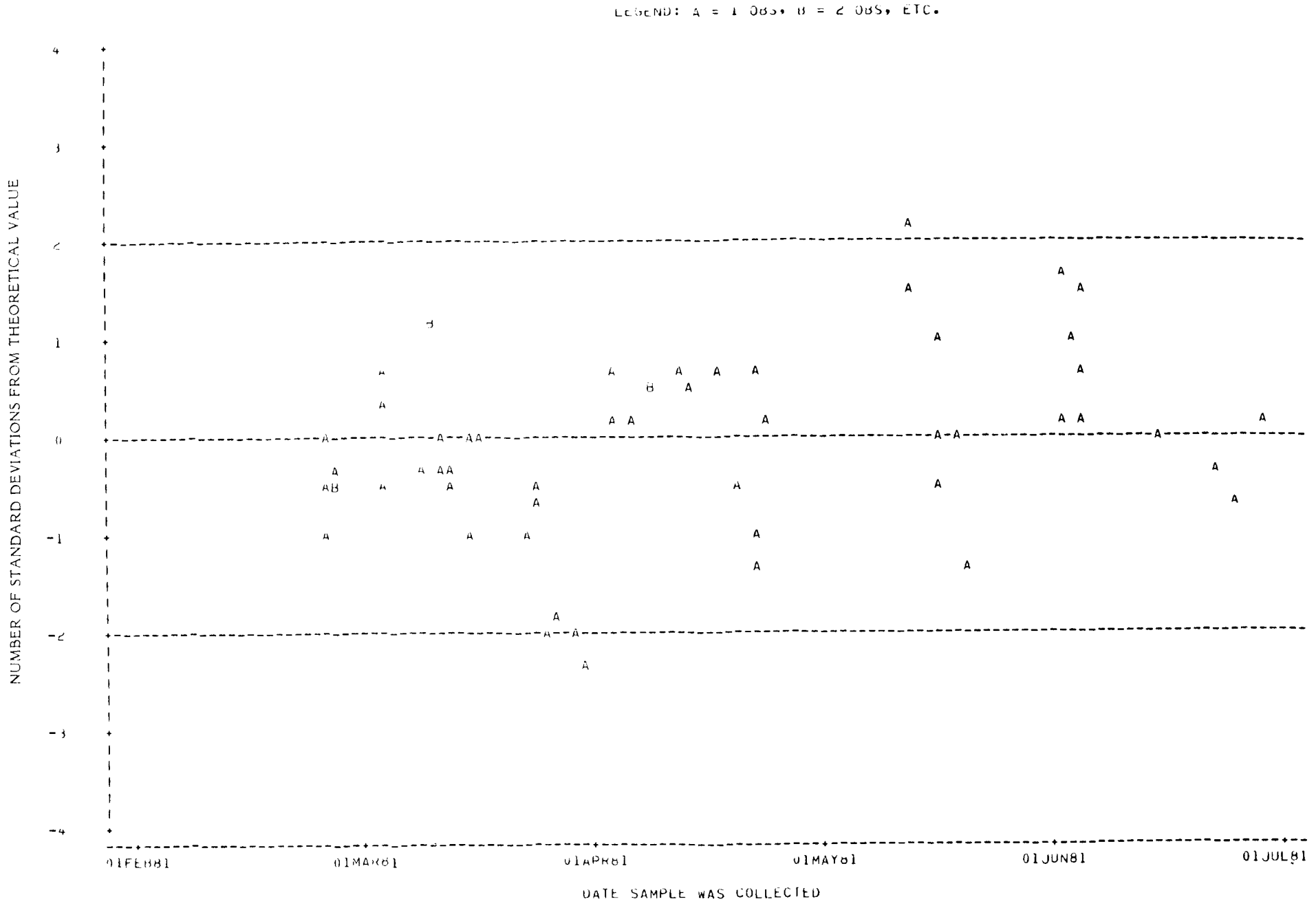

Figure A1.1.9.--Cadmium data for the Atlanta Laboratory.
(Three observations were out of range.)

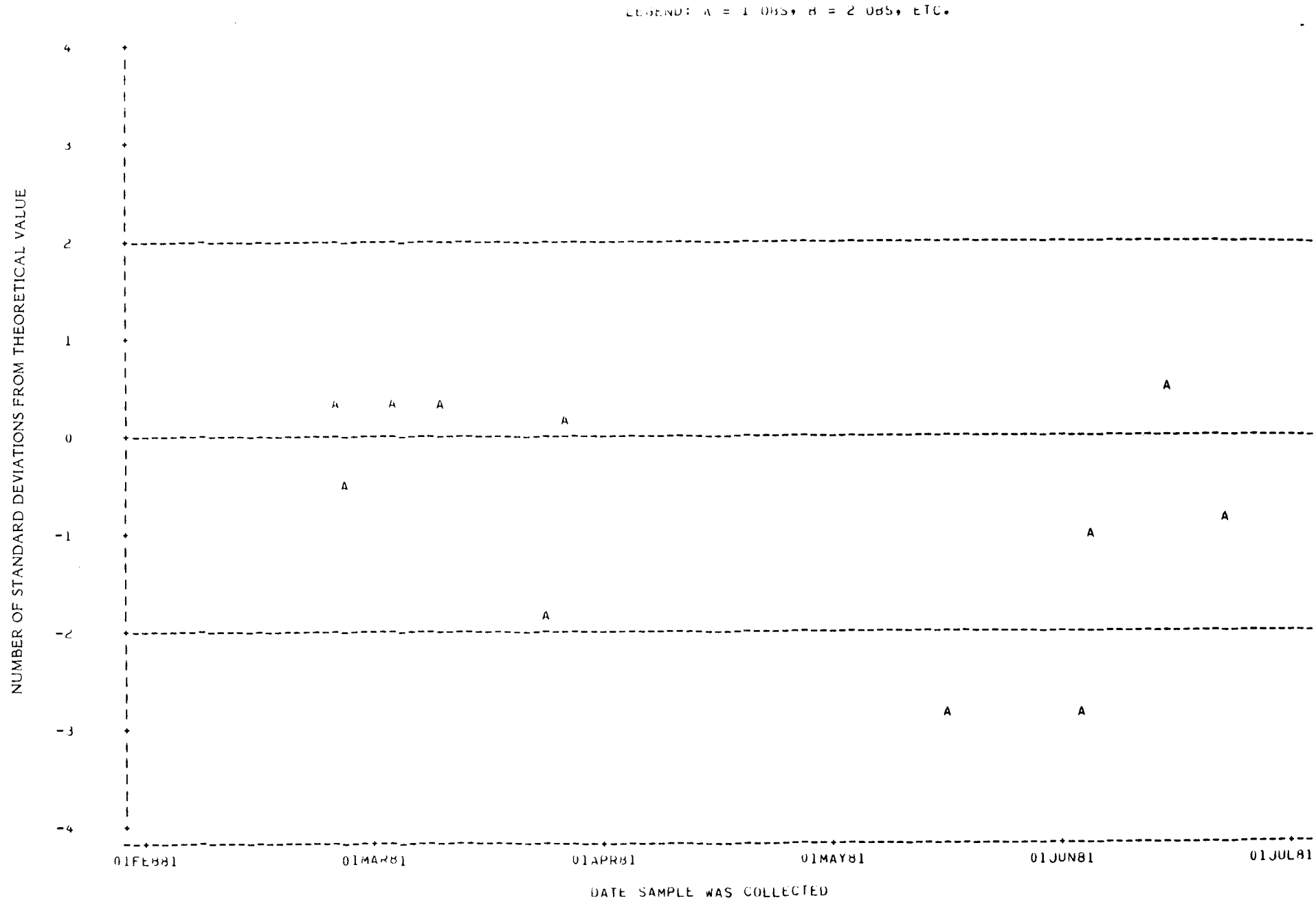

Figure A1.1.10.--Cadmium, total recoverable data for the Atlanta Laboratory.
(Three observations were out of range.)

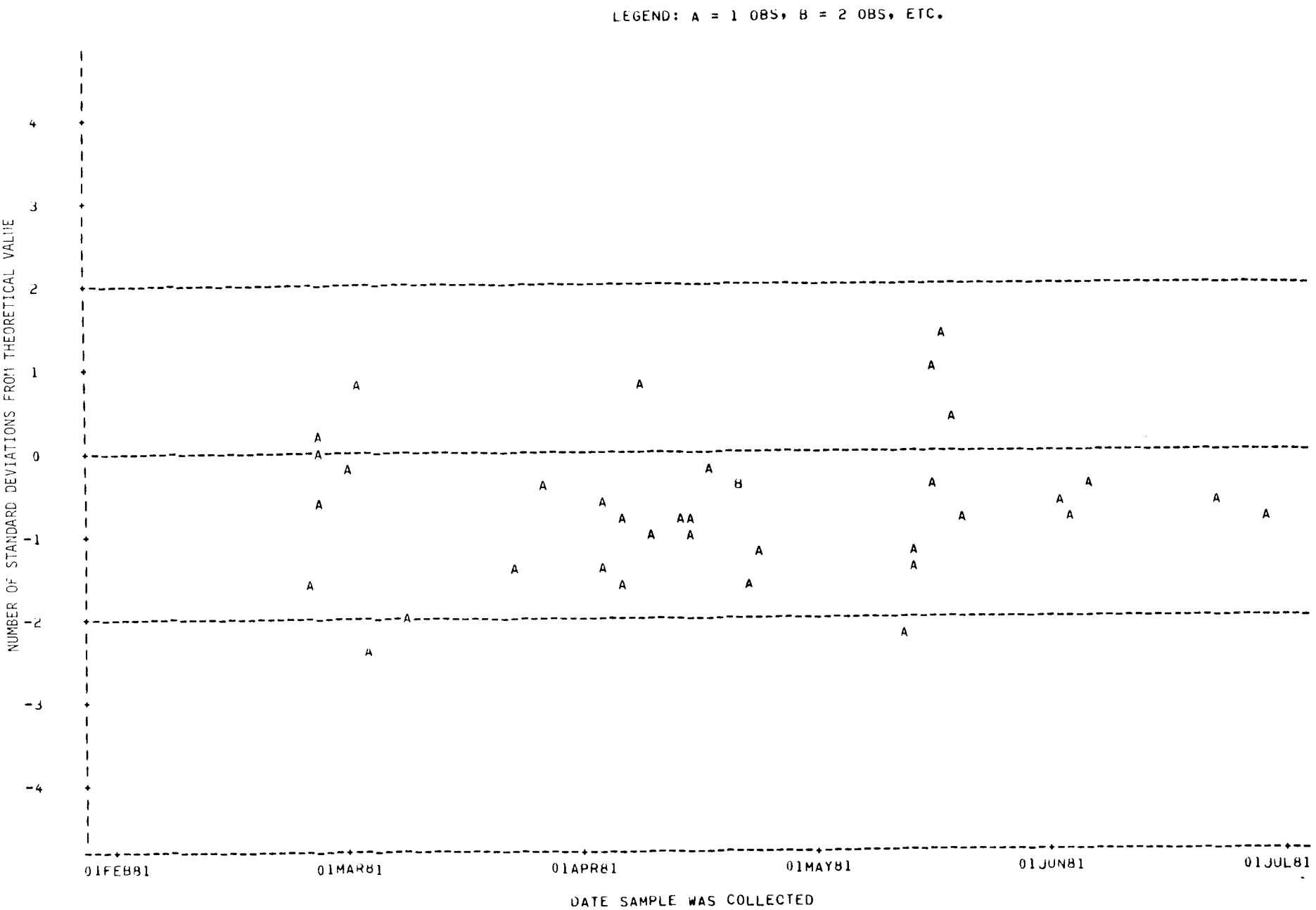

Figure A1.1.11.--Calcium data for the Atlanta Laboratory.
(Two observations were out of range.)

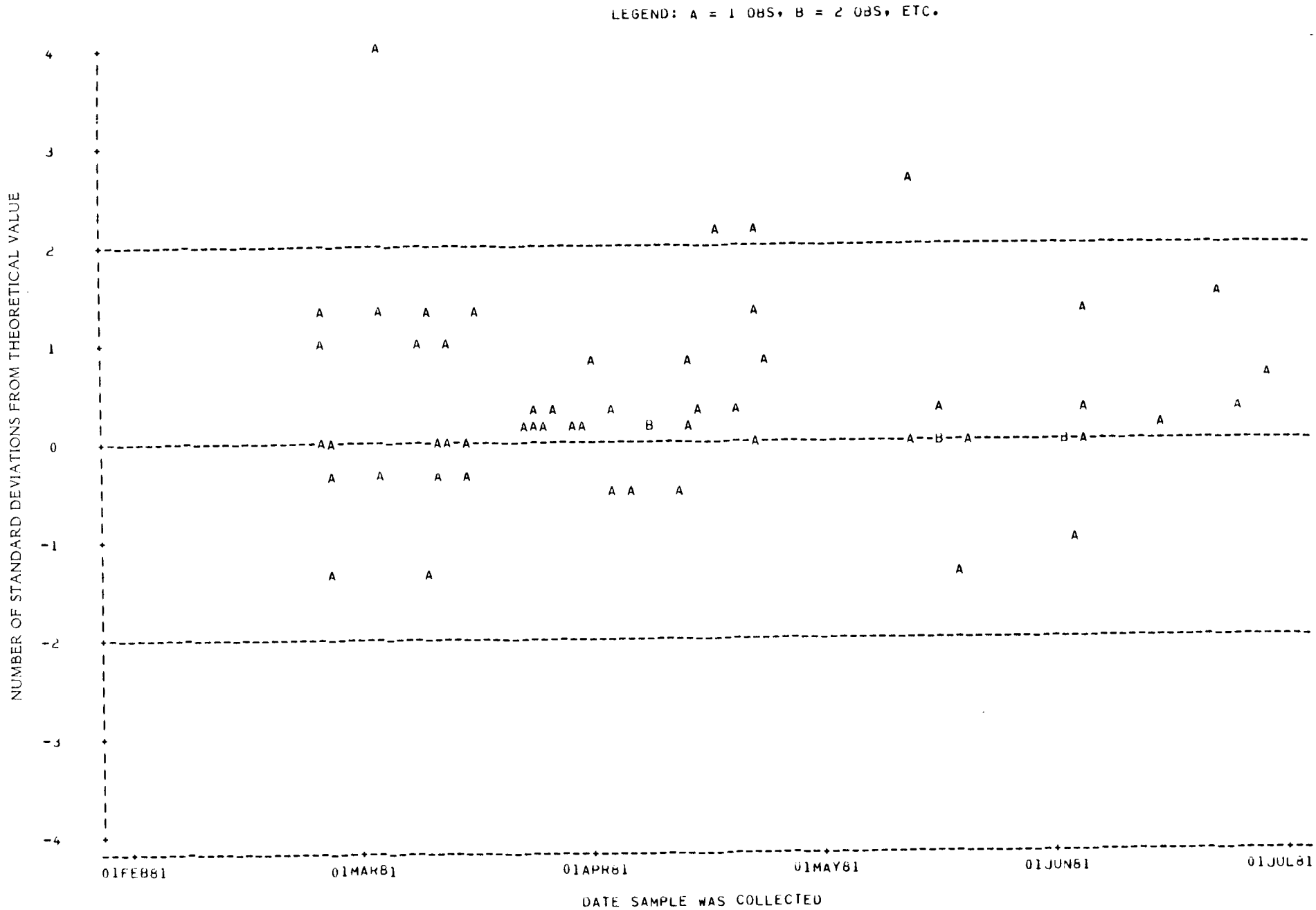

Figure A1.1.12.--Chromium data for the Atlanta Laboratory.

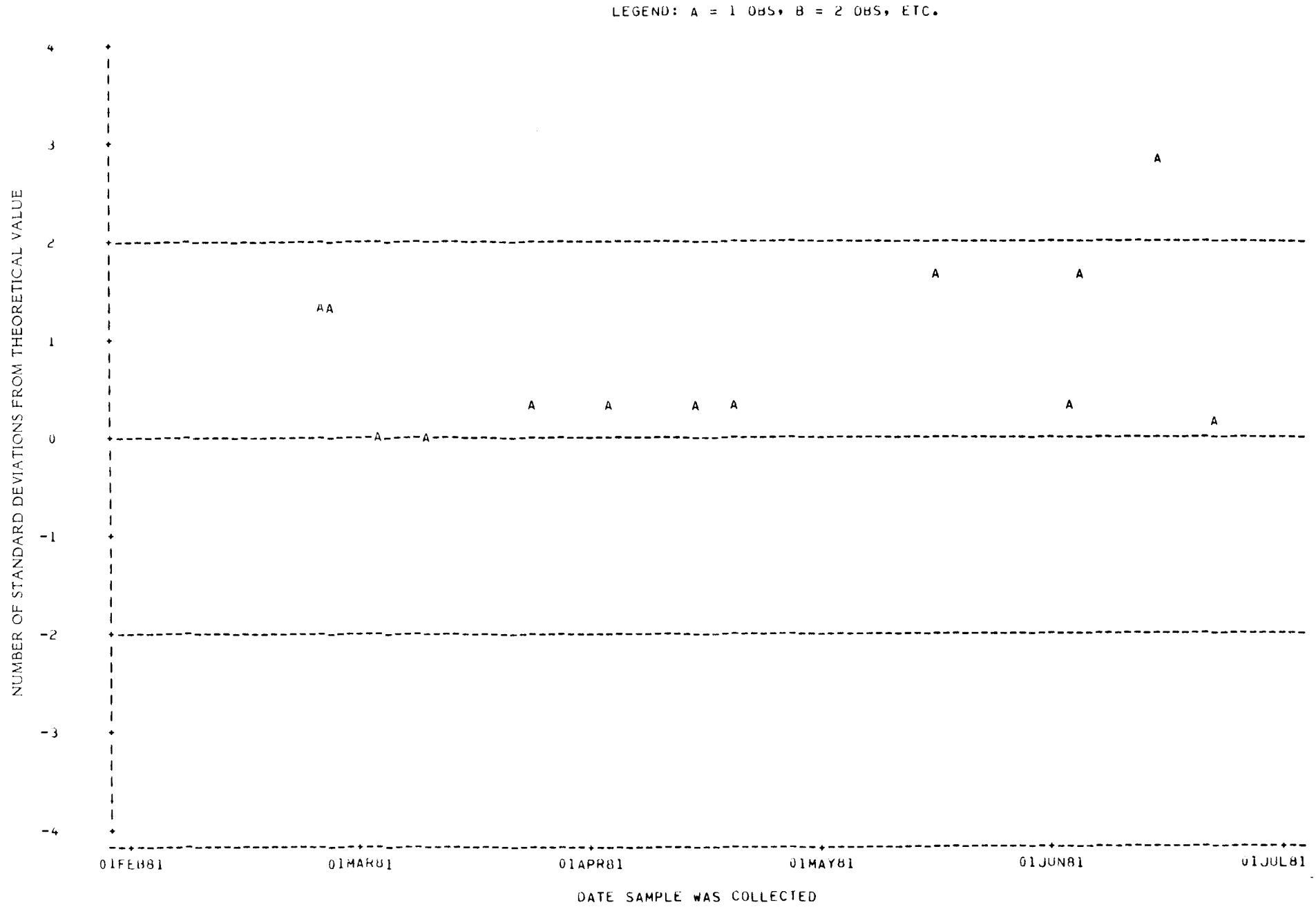

Figure A1.1.13.--Chromium, total recoverable data for the Atlanta Laboratory.
(One obervation was out of range.)

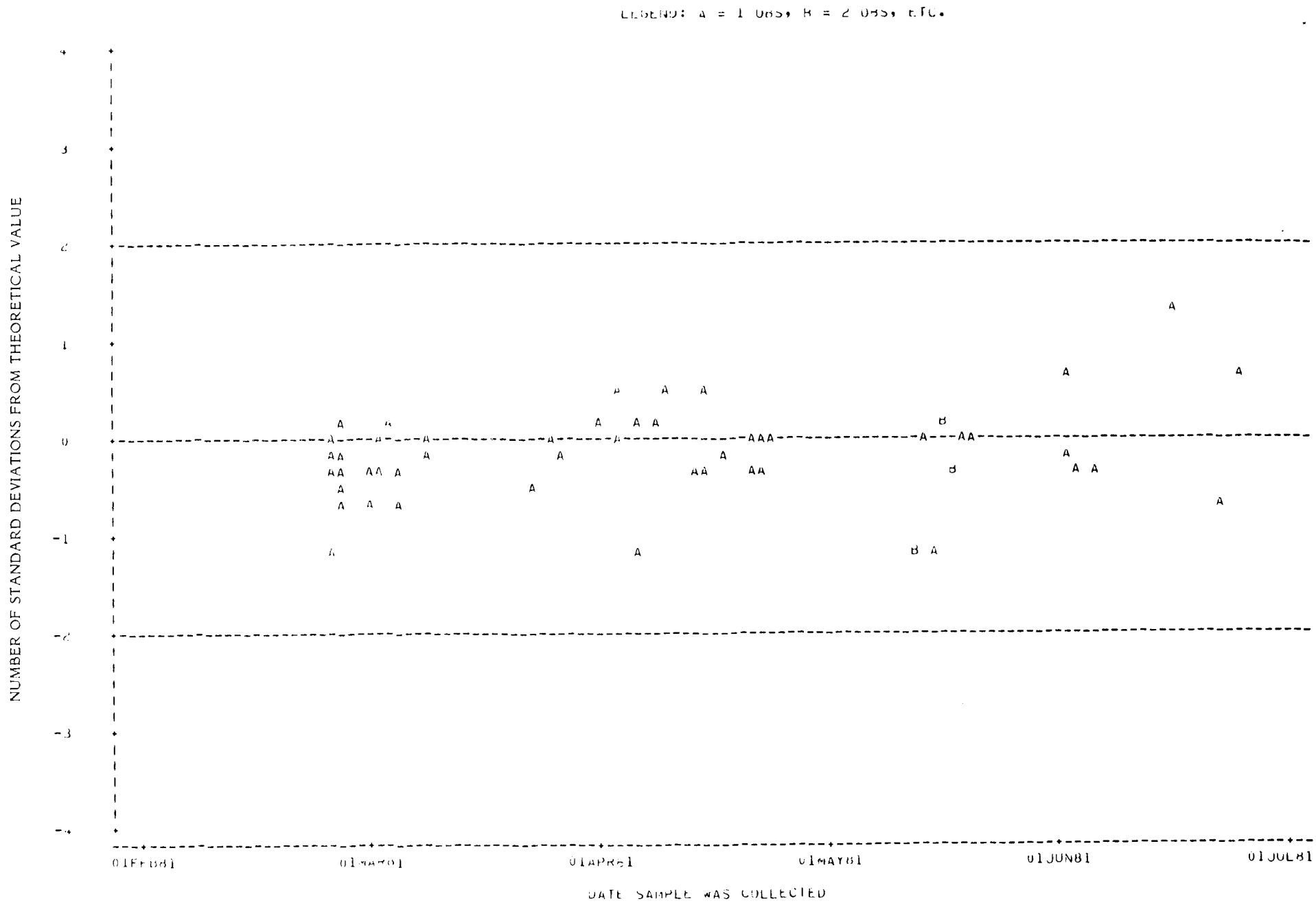

Figure A1.1.14.--Chloride data for the Atlanta Laboratory.
(One observation was out of range.)

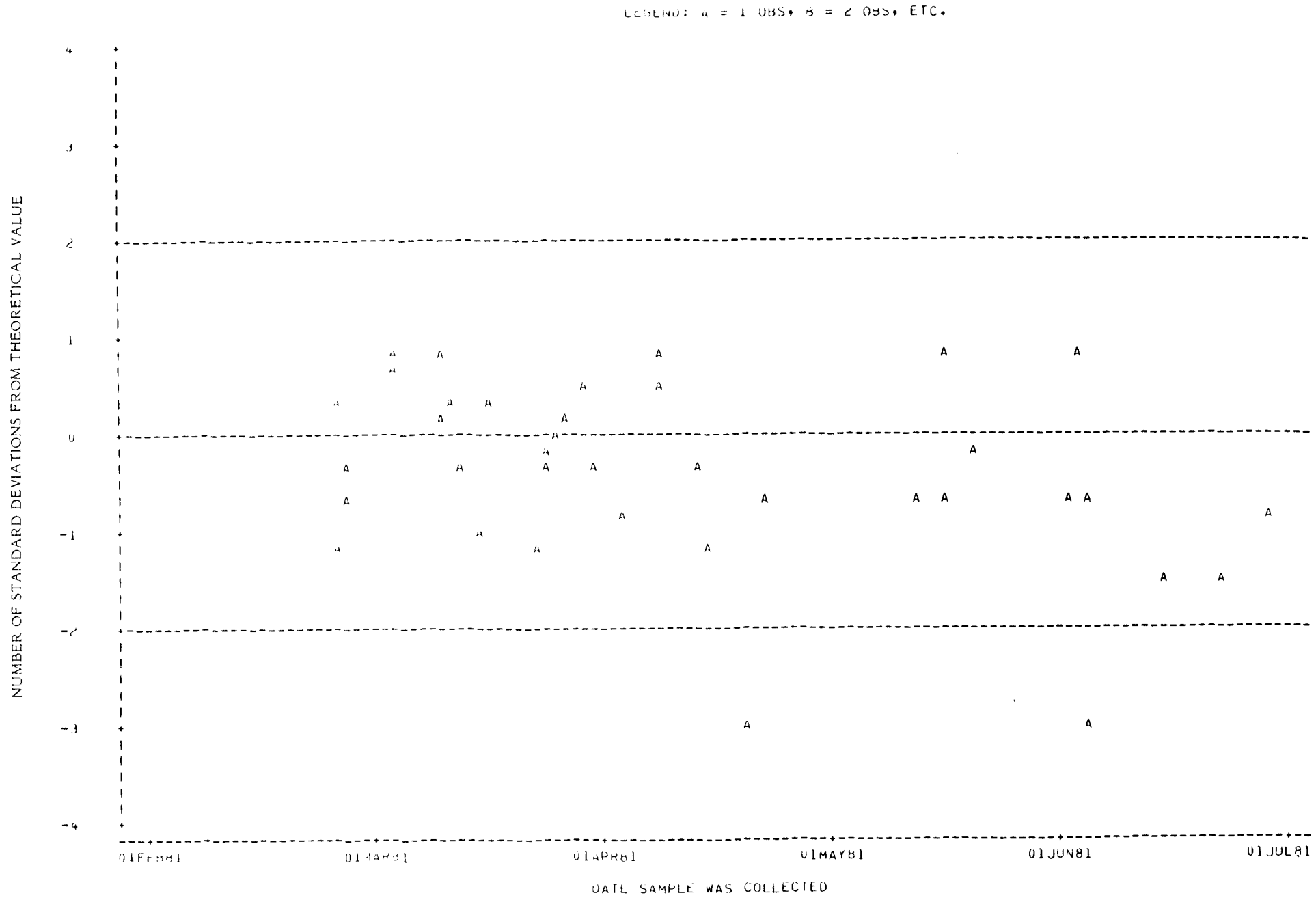

Figure A1.1.15.--Cobalt data for the Atlanta Laboratory.

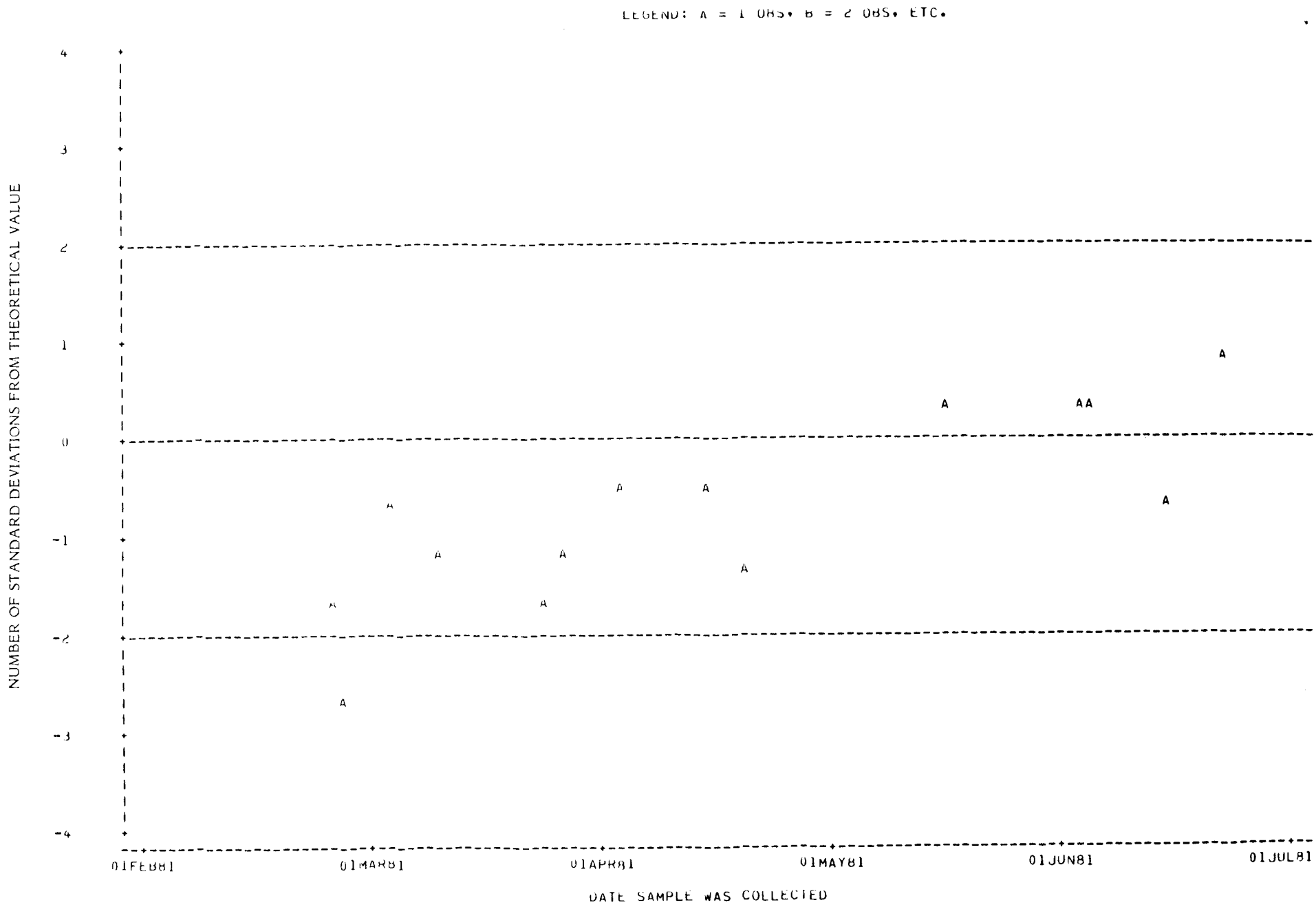

Figure A1.1.16.--Cobalt, total recoverable data for the Atlanta Laboratory.

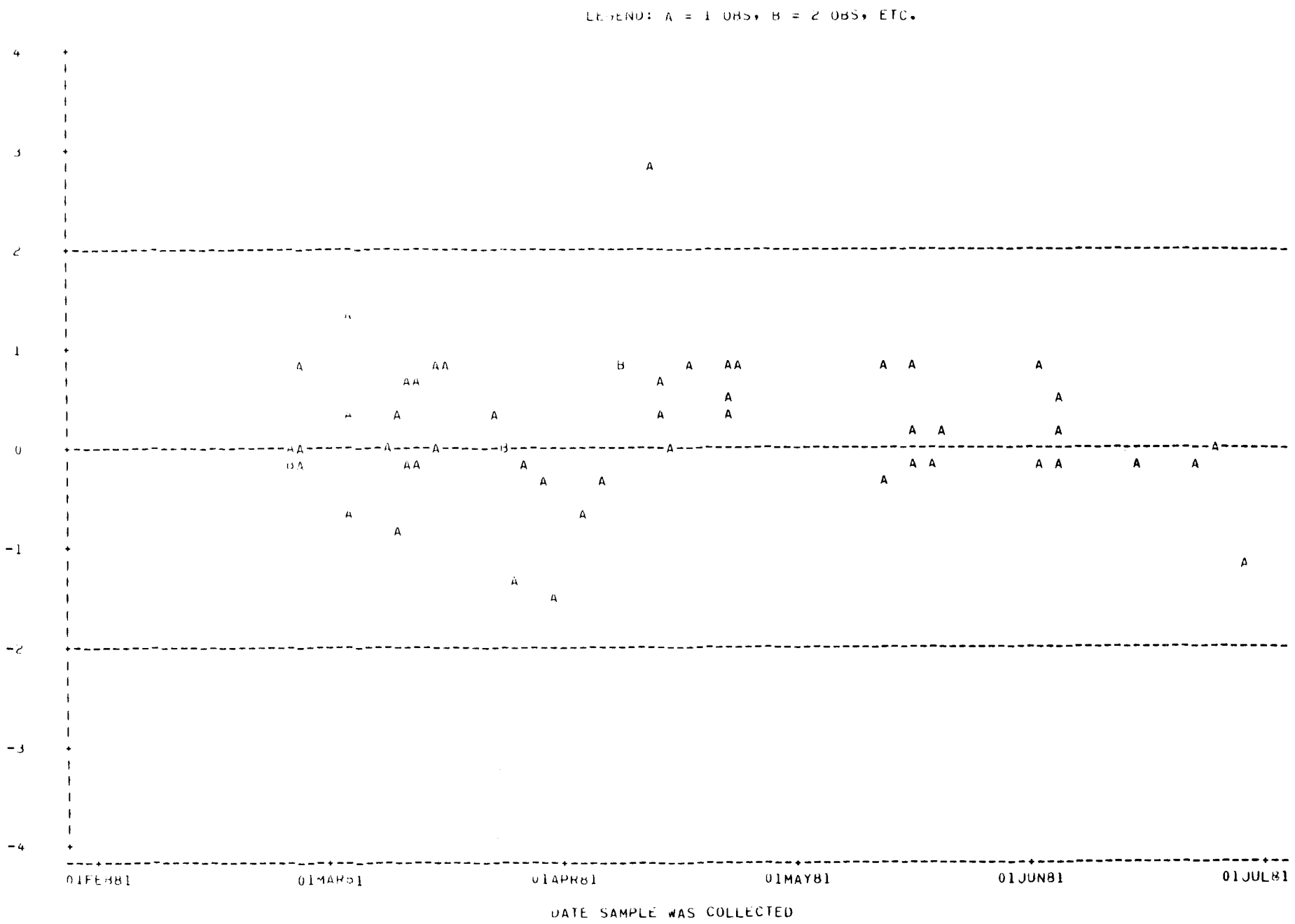

Figure A1.1.17.--Copper data for the Atlanta Laboratory.
(Four observations were out of range.)

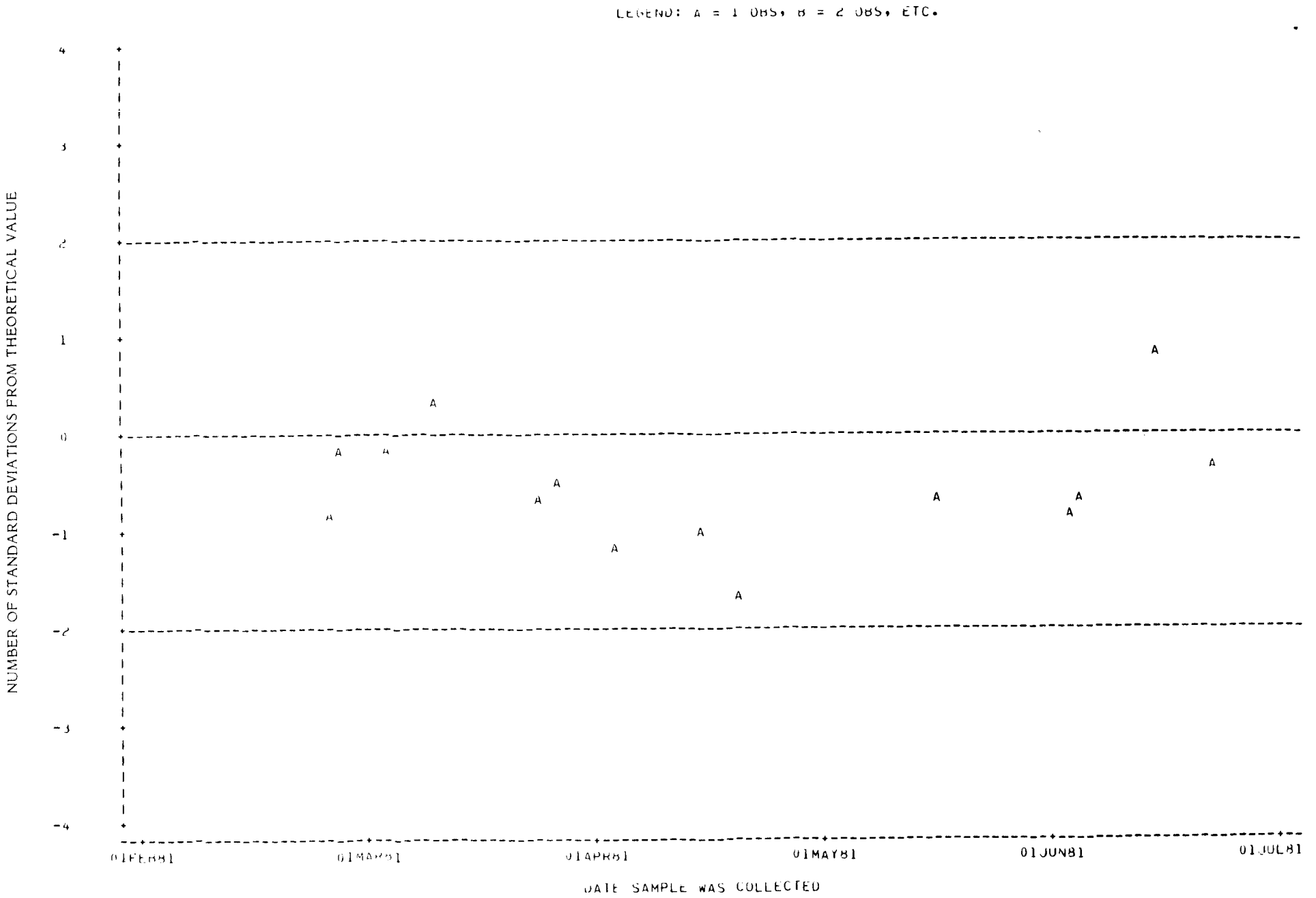

Figure A1.1.18.--Copper, total recoverable data for the Atlanta Laboratory.

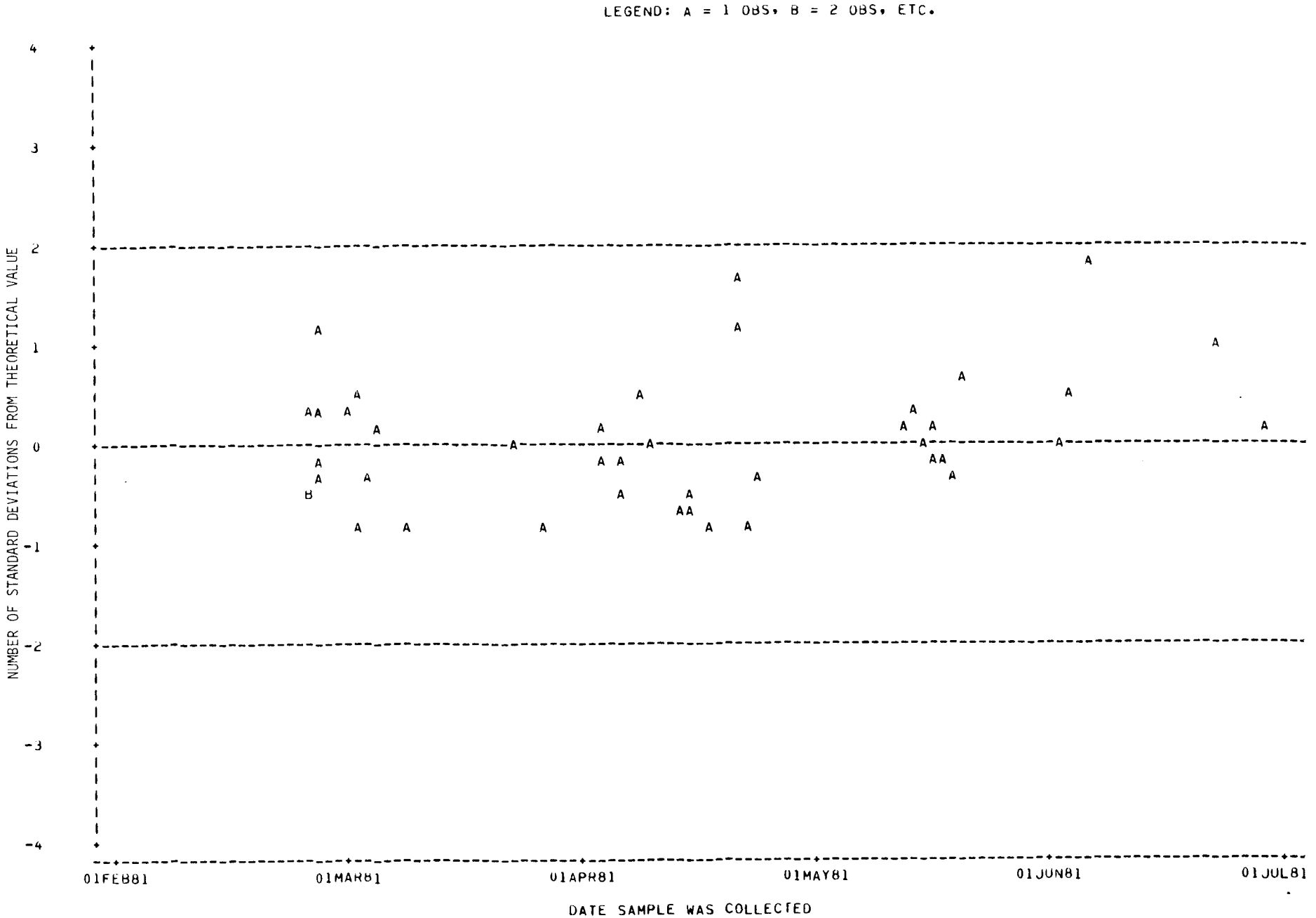

Figure A1.1.19.--Dissolved solids data for the Atlanta Laboratory.
(One observation was out of range.)

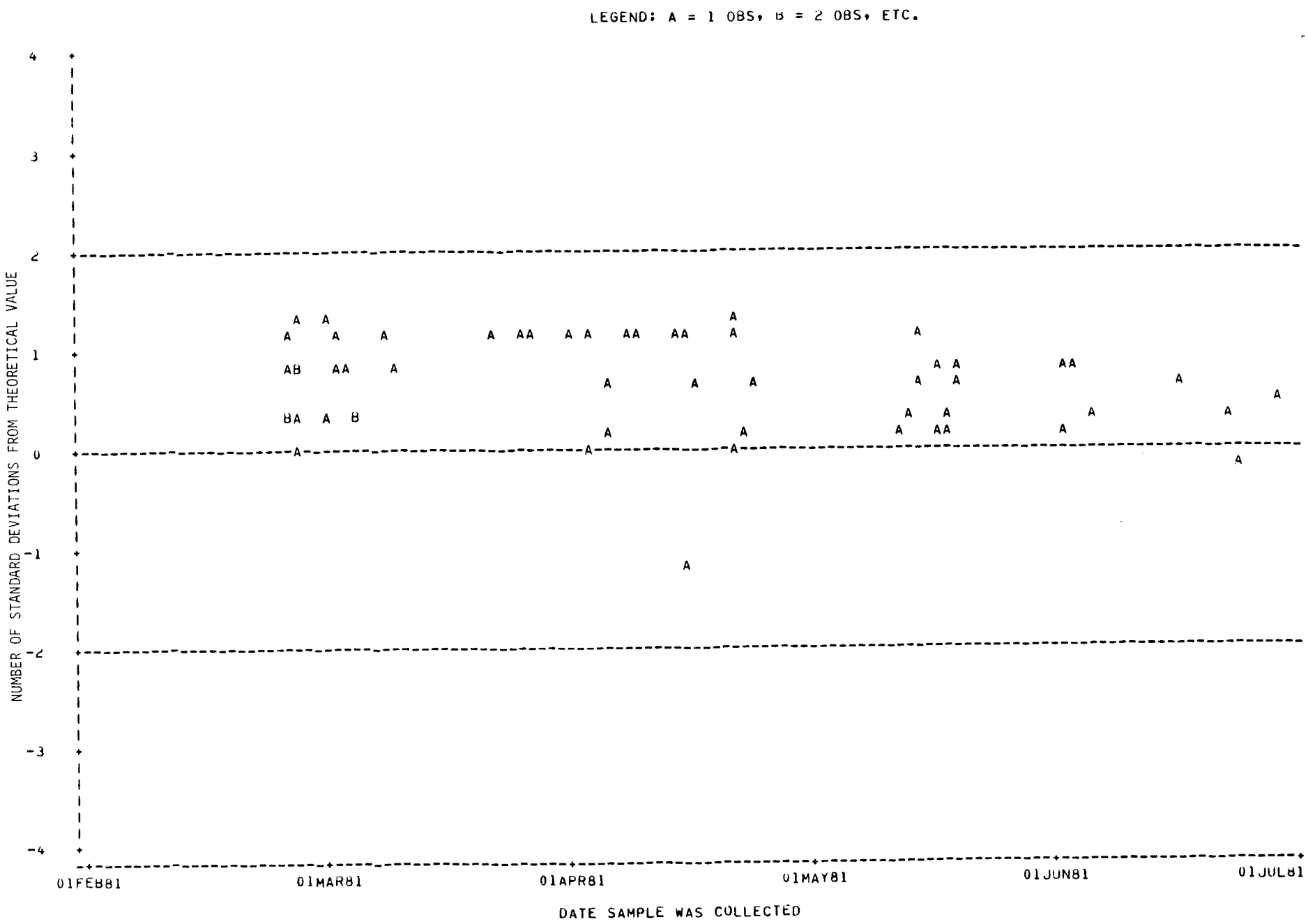

Figure A1.1.20.--Fluoride data for the Atlanta Laboratory.

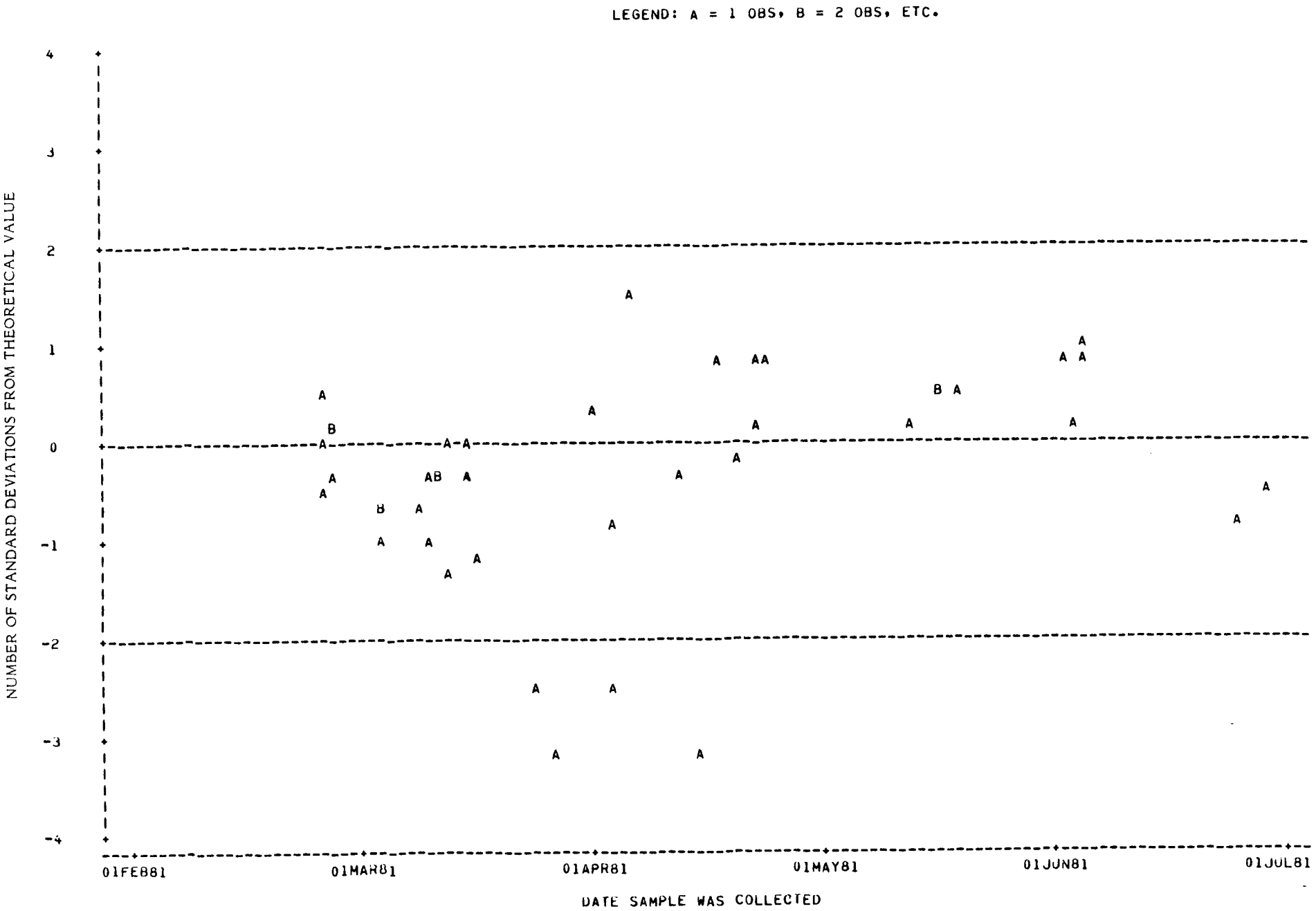

Figure A1.1.21.--Iron data for the Atlanta Laboratory.
(One observation was out of range.)

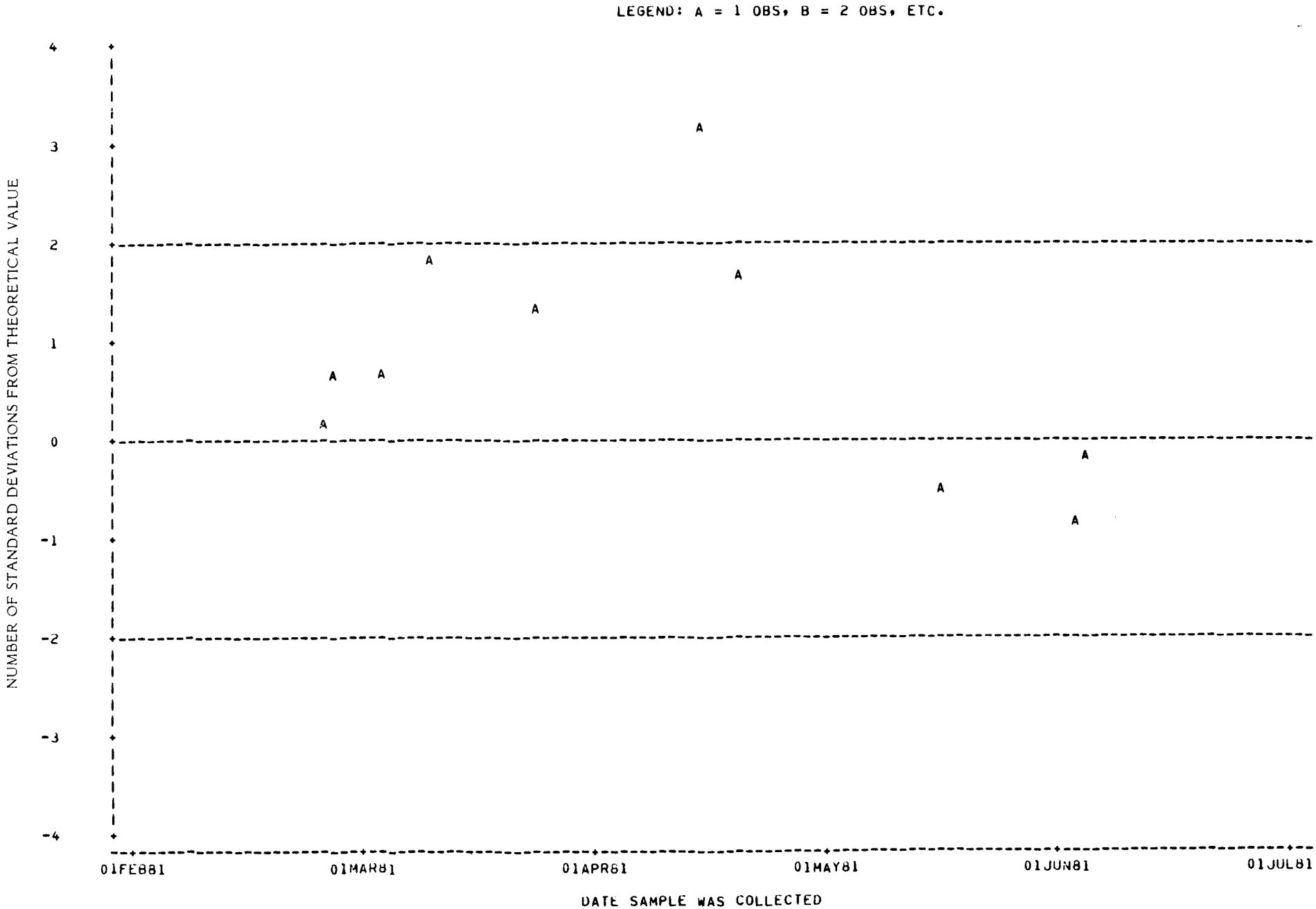

Figure A1.1.22.--Iron, total recoverable data for the Atlanta Laboratory.
(Two observations were out of range.)

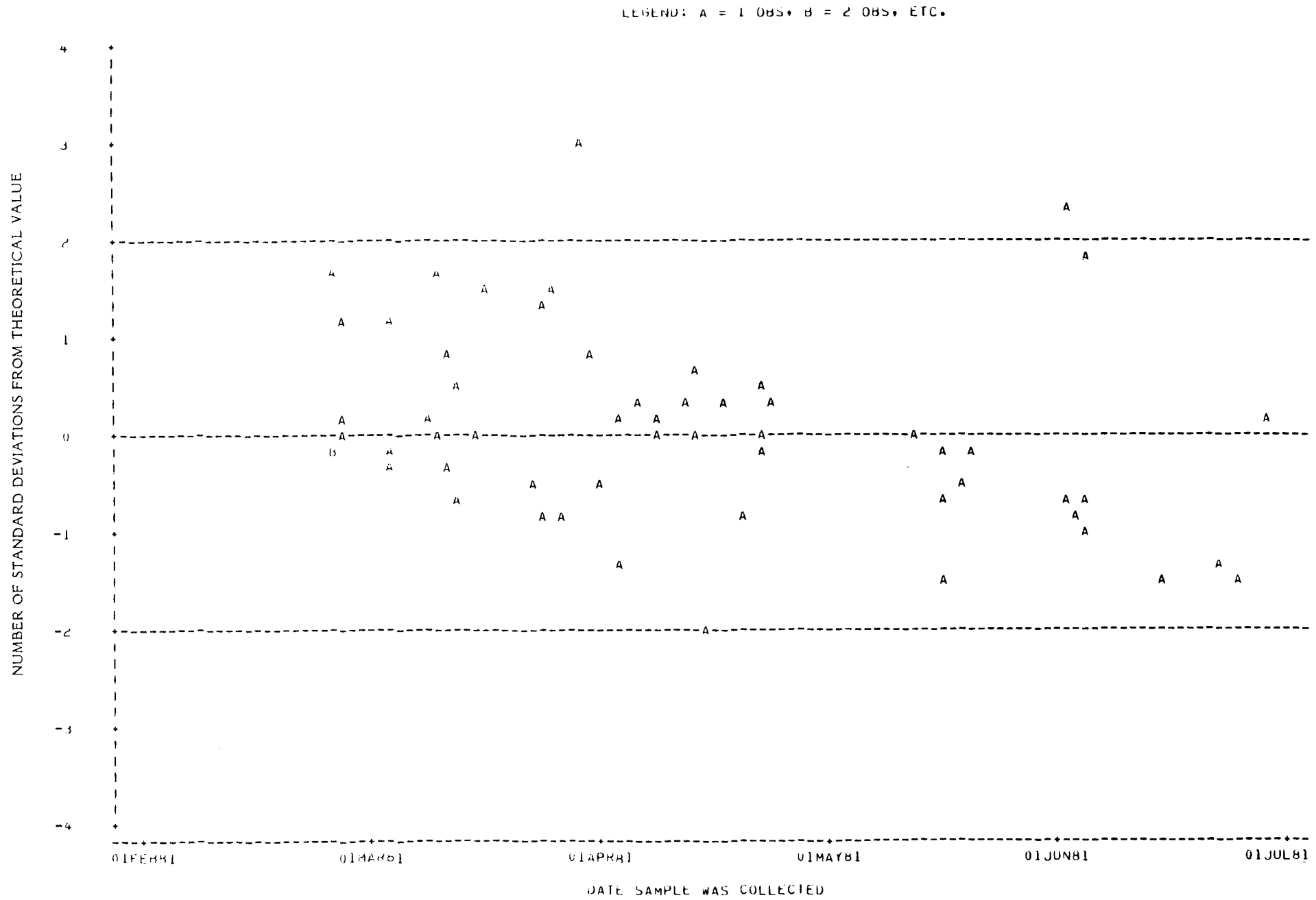

Figure A1.1.23.--Lead data for the Atlanta Laboratory.
(Two observations were out of range.)

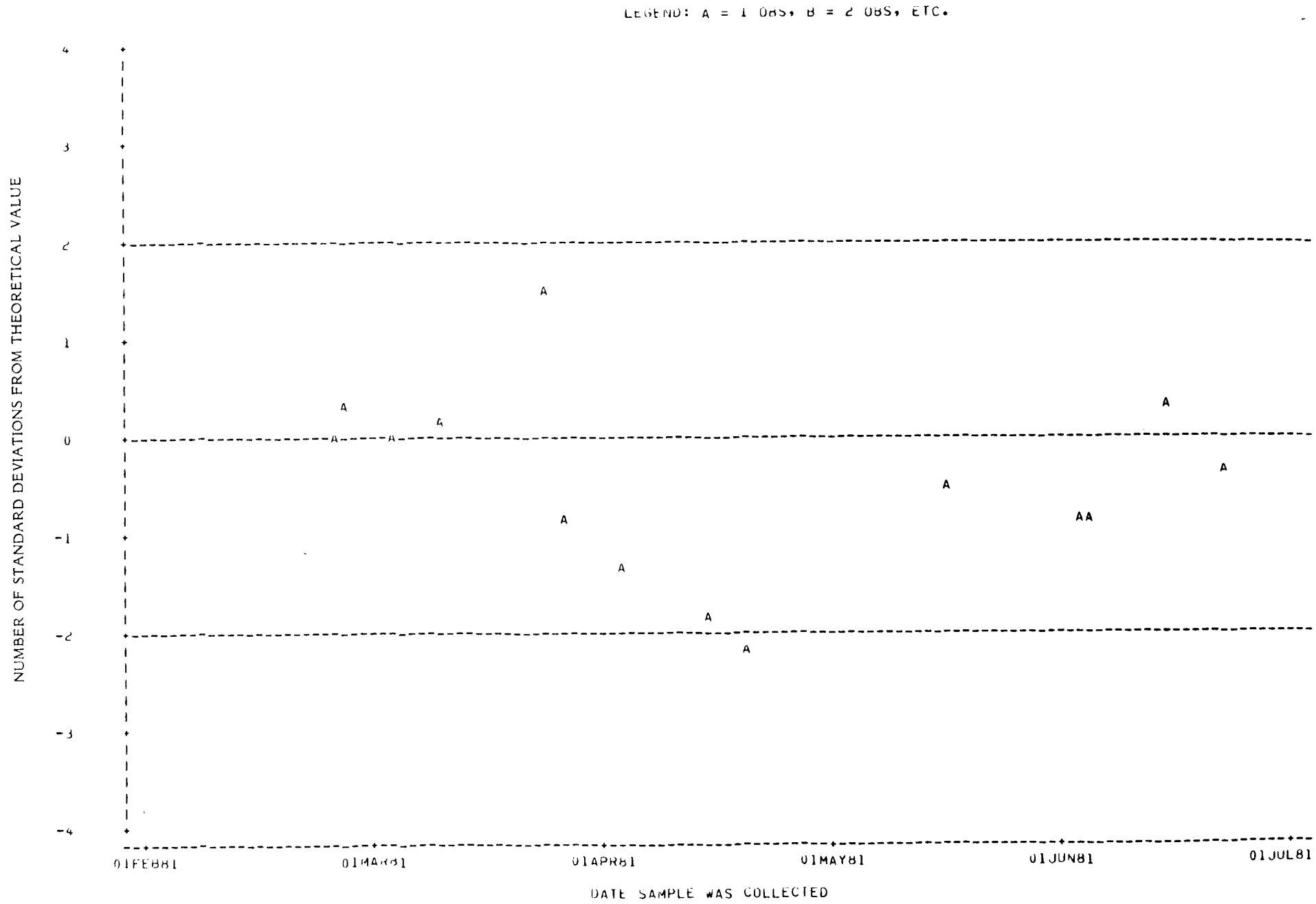

Figure A1.1.24.--Lead, total recoverable data for the Atlanta Laboratory.

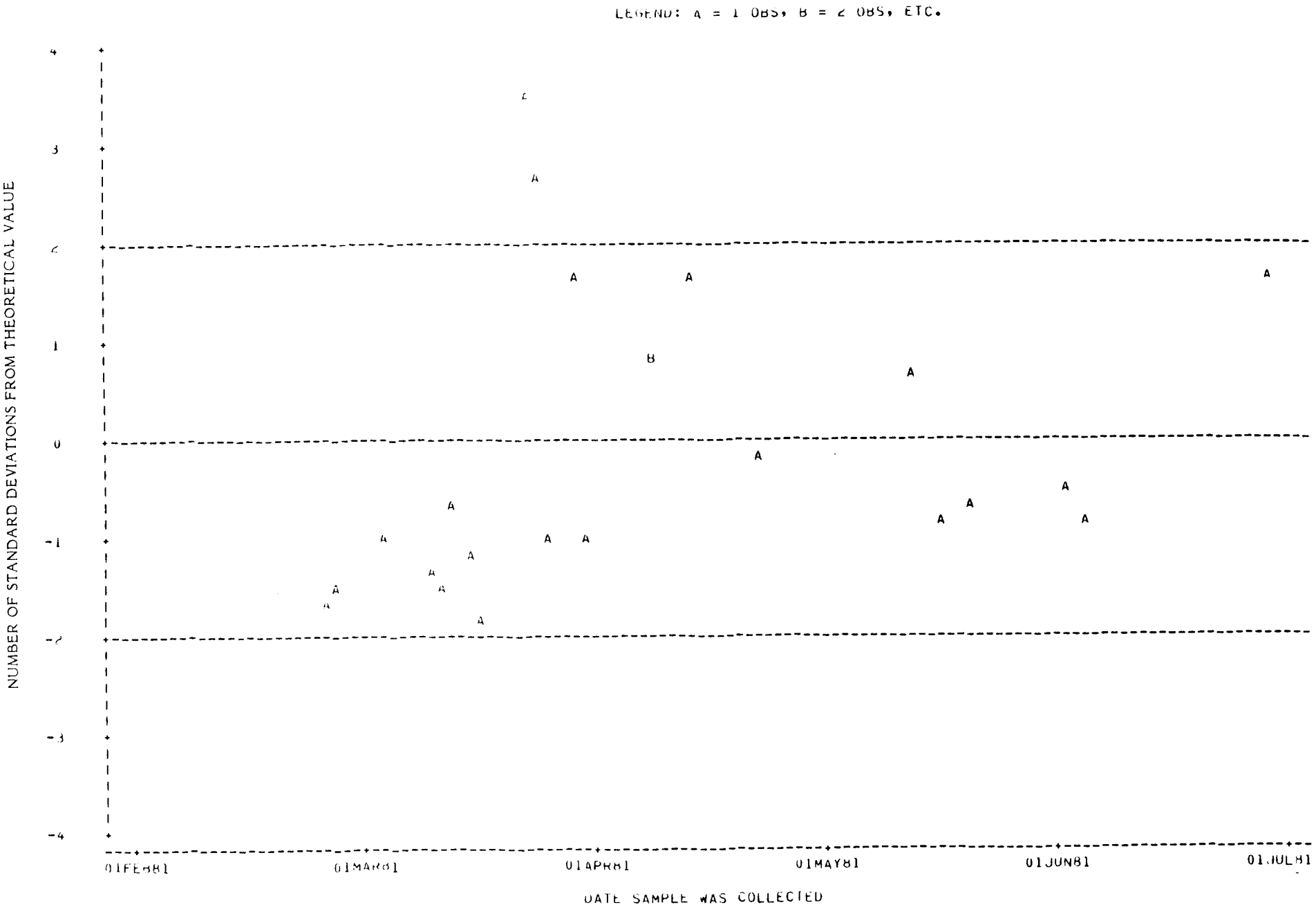

Figure A1.1.25.--Lithium data for the Atlanta Laboratory.

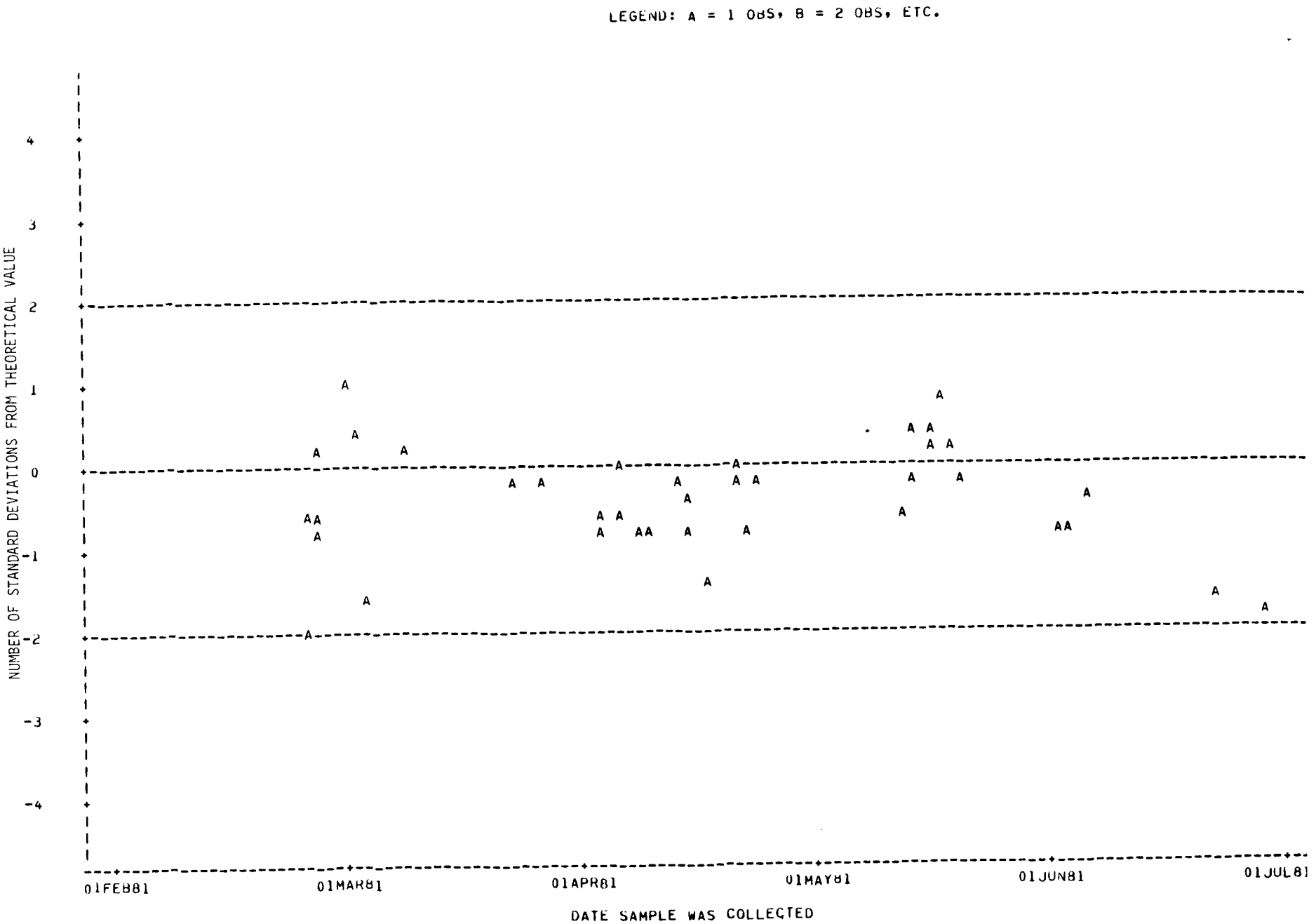

Figure A1.1.26.--Magnesium data for the Atlanta Laboratory. (Three observations were out of range.)

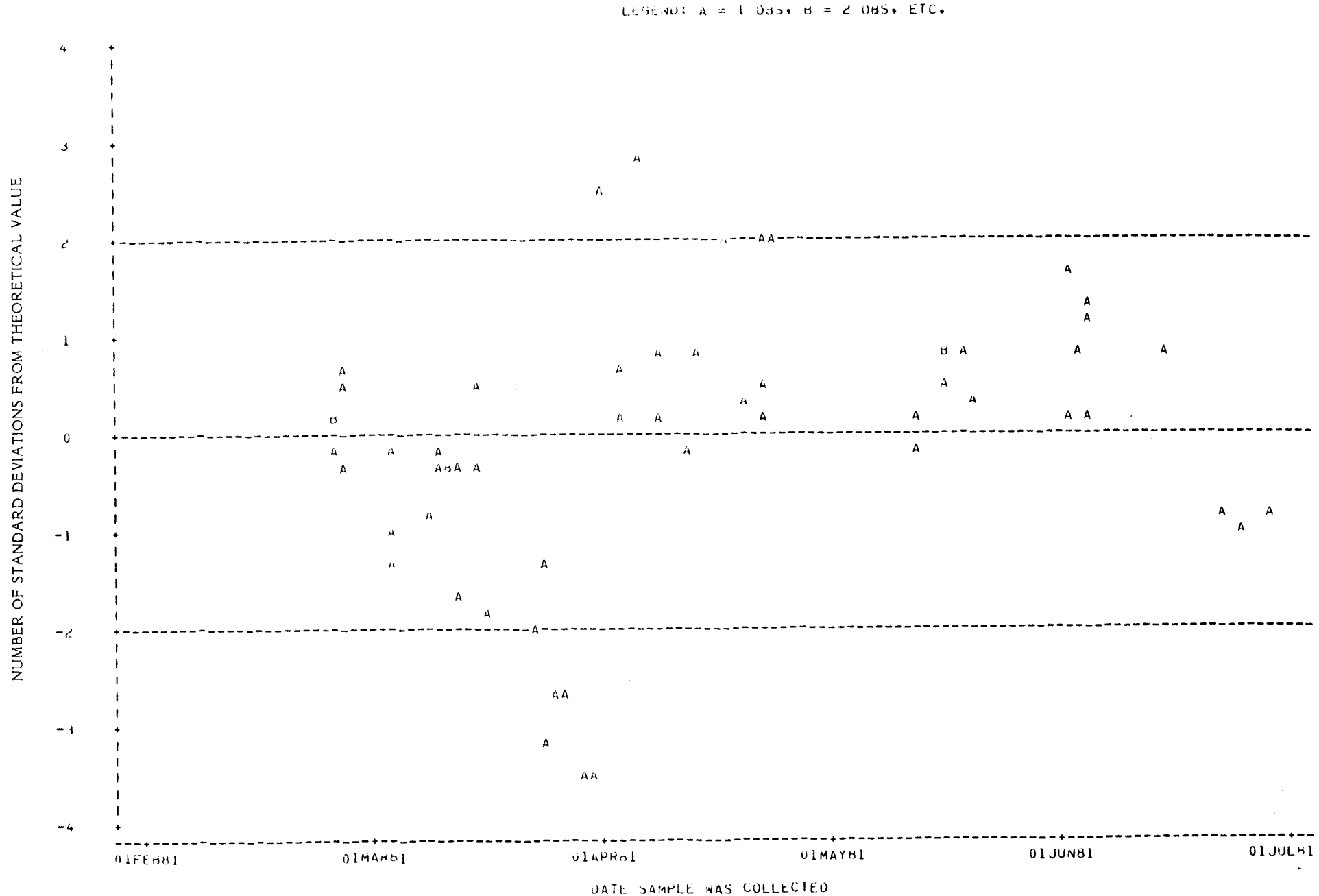

Figure A1.1.27.--Manganese data for the Atlanta Laboratory.
(Two observations were out of range.)

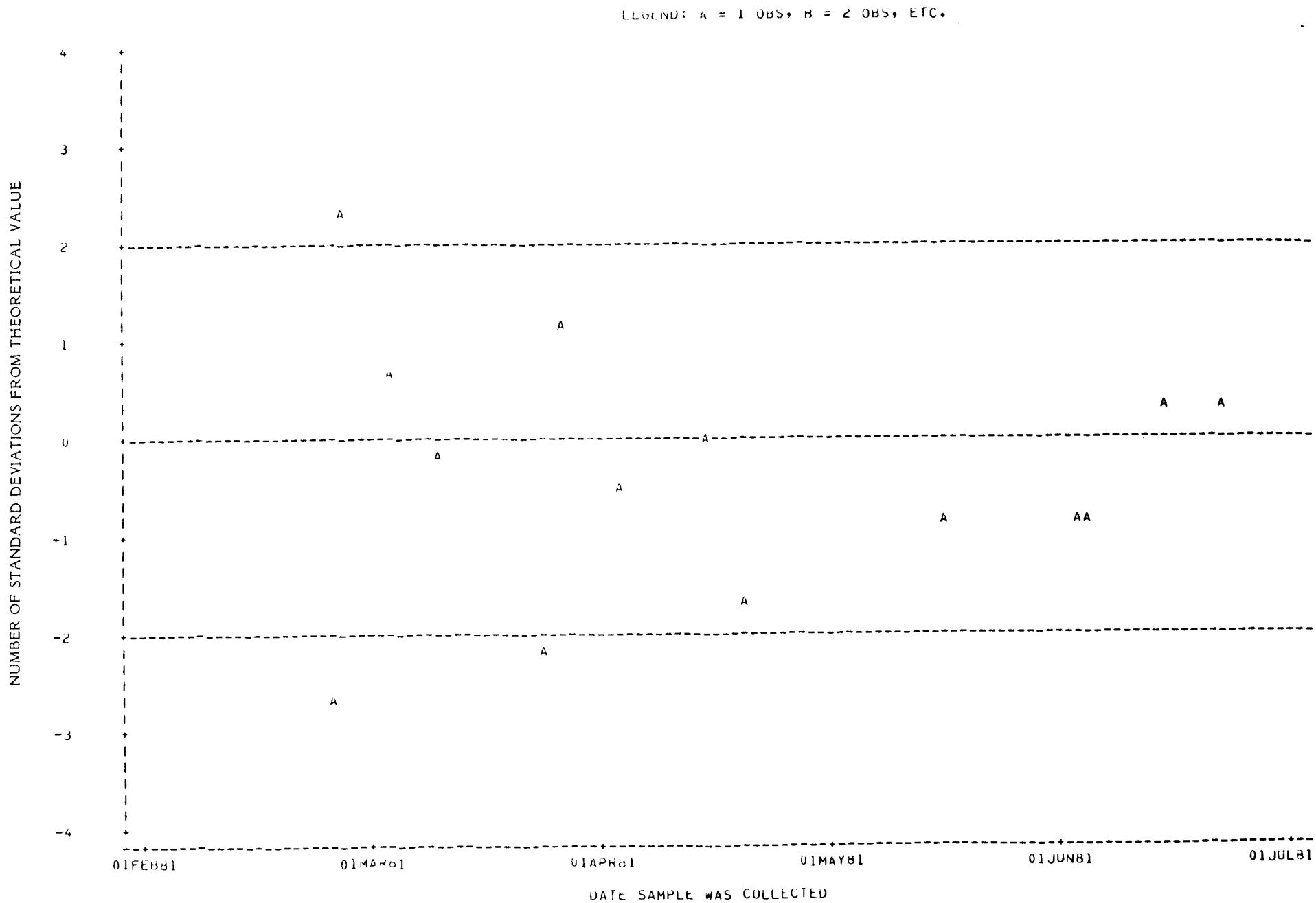

Figure A1.1.28.--Manganese, total recoverable data for the Atlanta Laboratory.

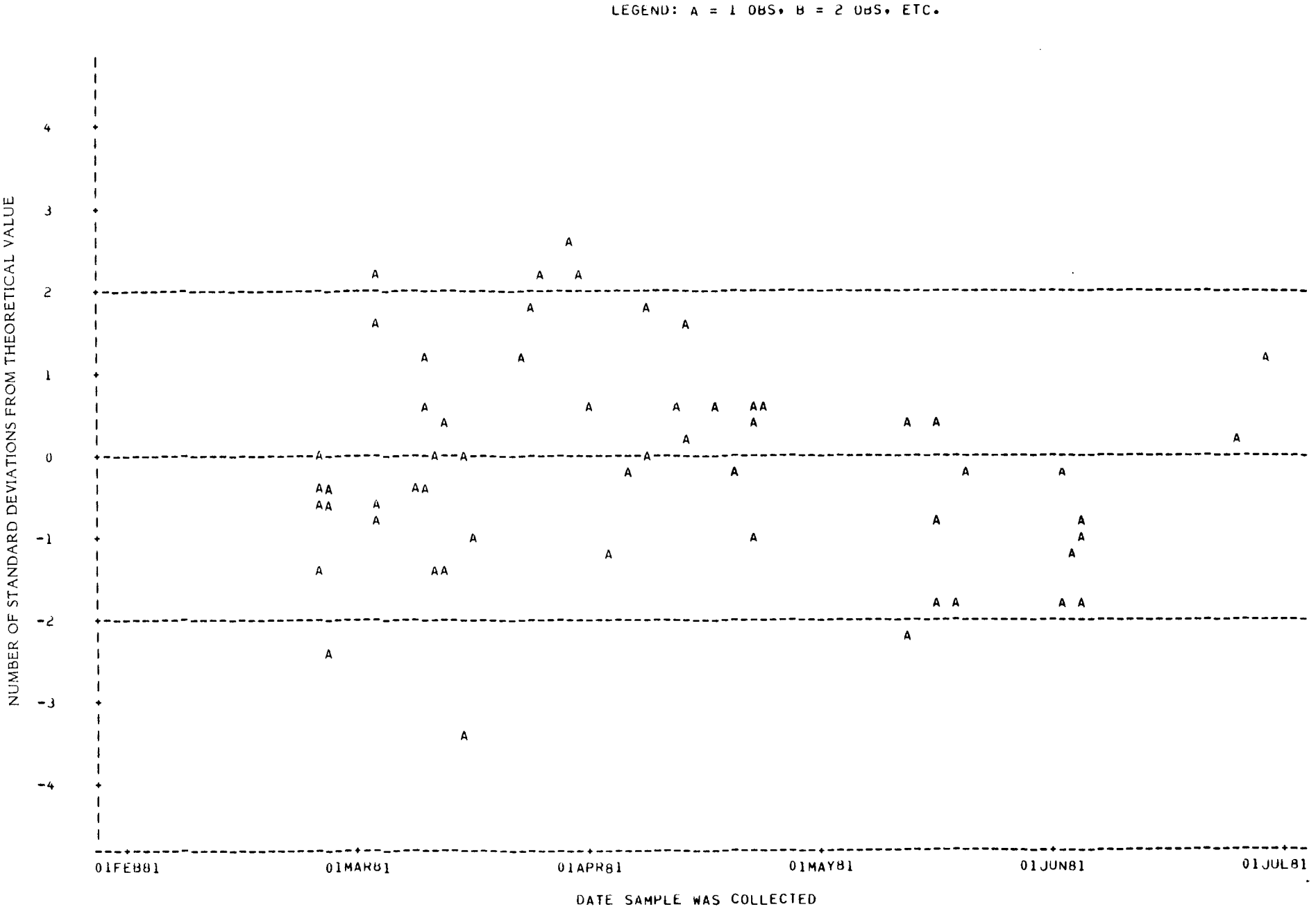

Figure A1.1.29.--Mercury data for the Atlanta Laboratory.
(Thirteen observations were out of range.)

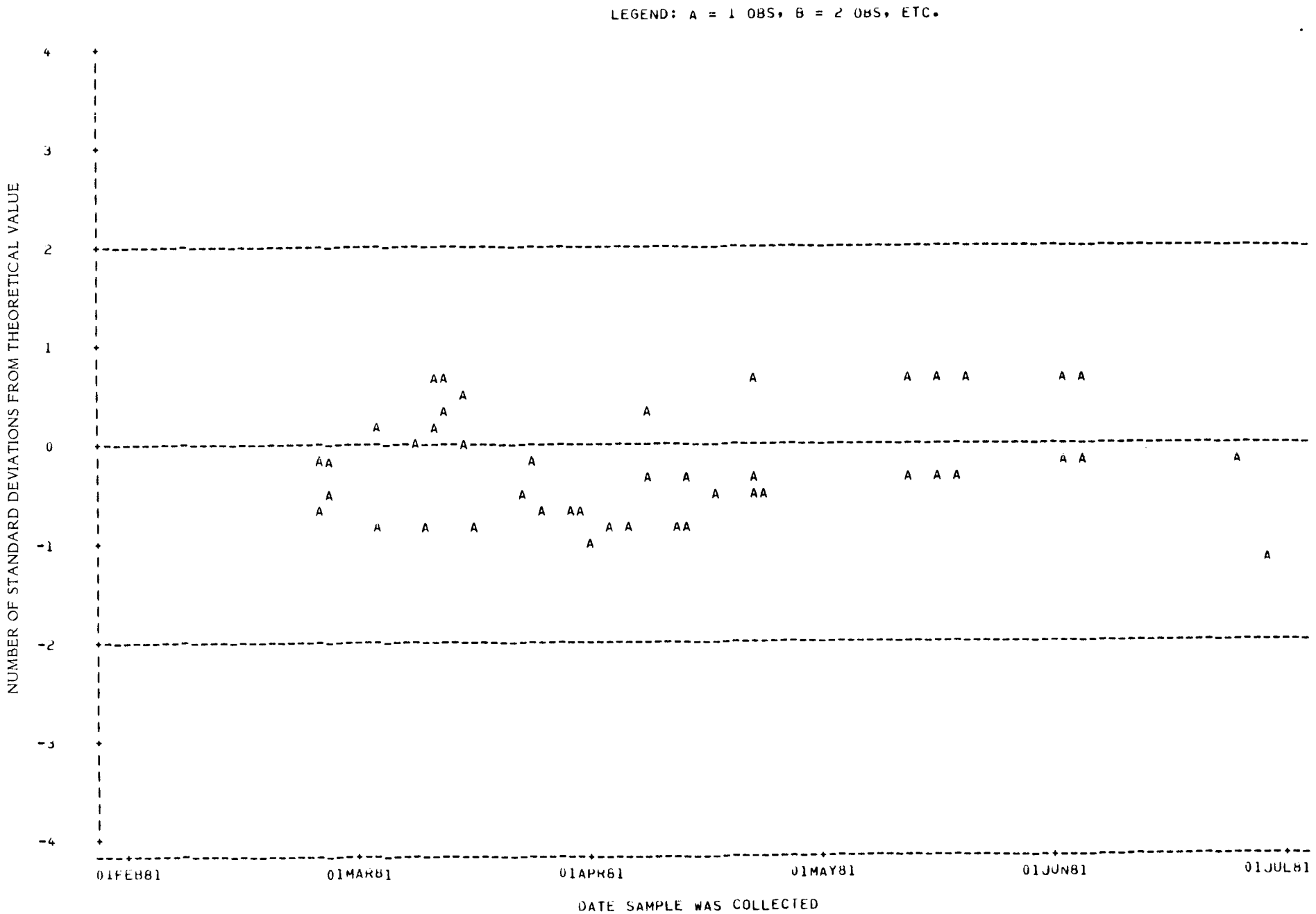

Figure A1.1.30.--Molybdenum data for the Atlanta Laboratory.

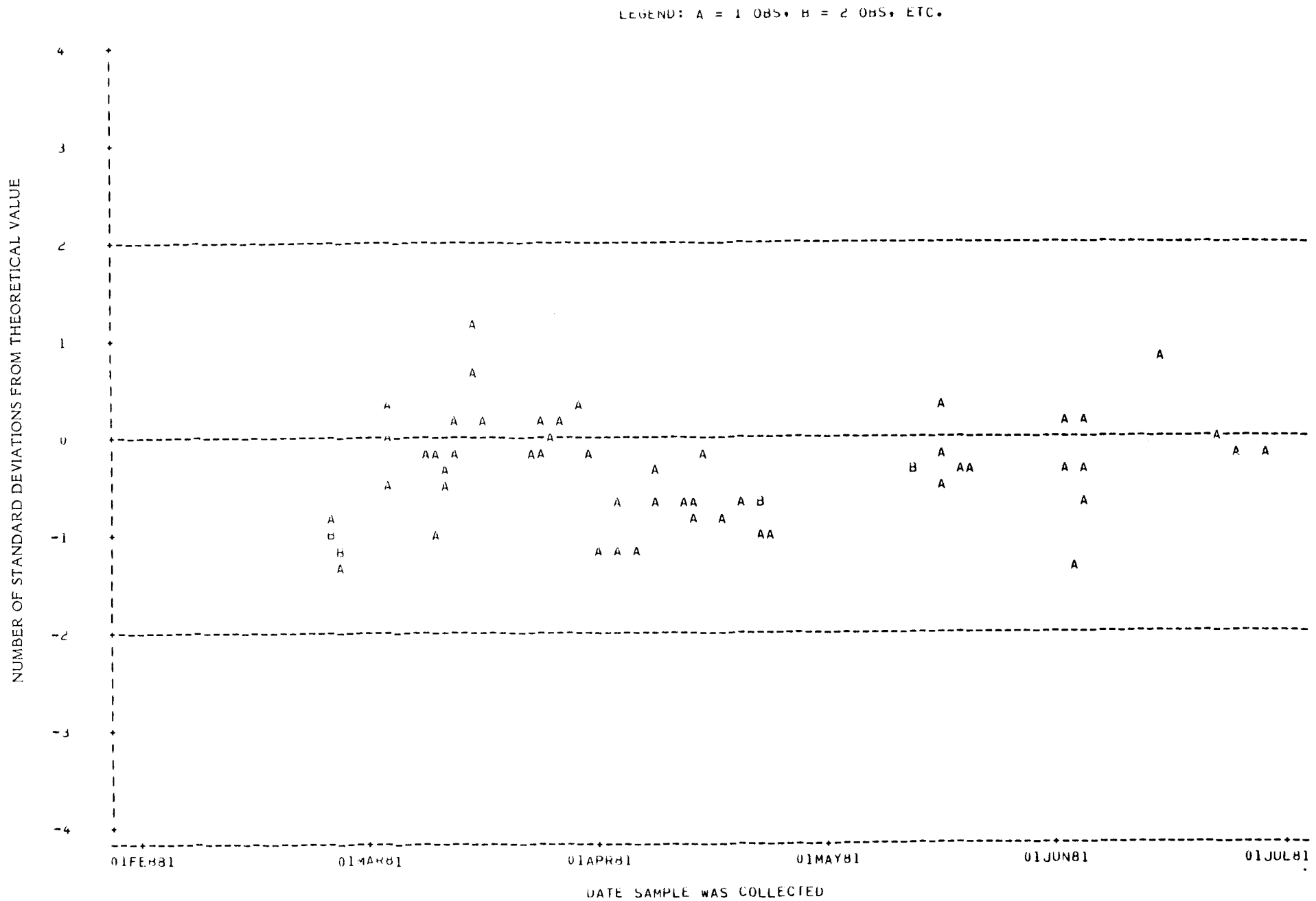

Figure A1.1.31.--Nickel data for the Atlanta Laboratory.

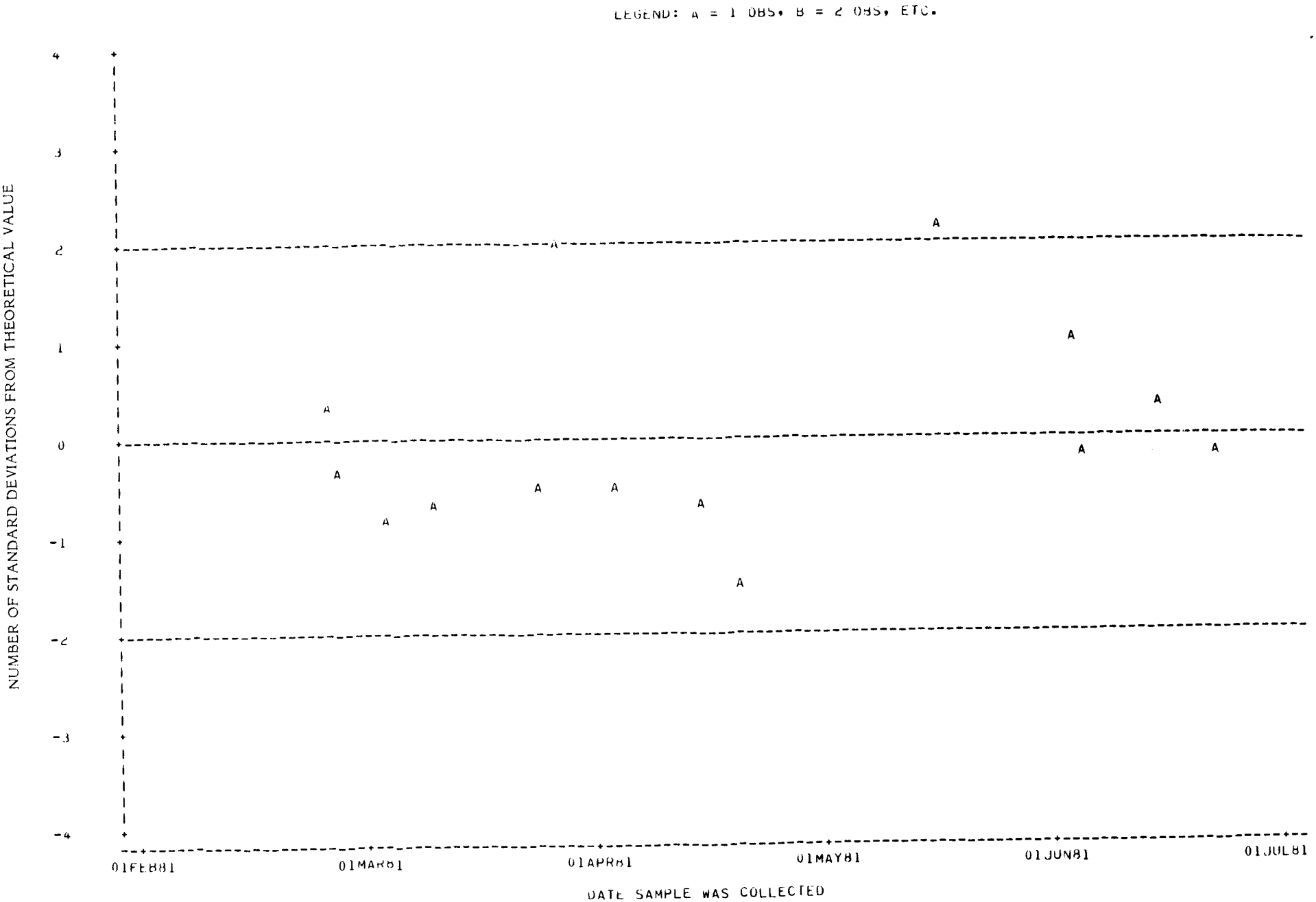

Figure A1.1.32.--Nickel, total recoverable data for the Atlanta Laboratory.

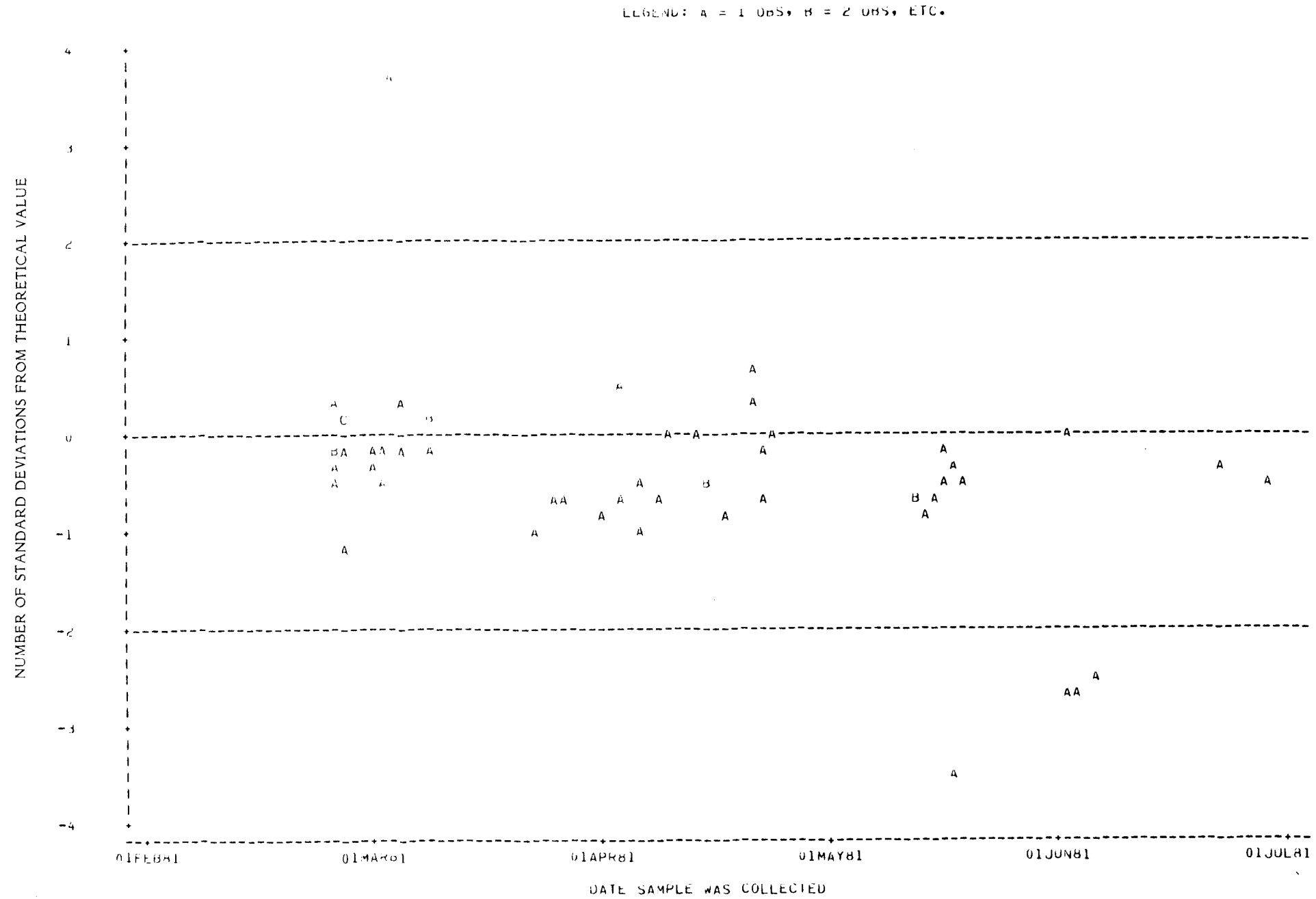

Figure A1.1.33.--Nitrate plus nitrite-nitrogen data for the Atlanta Laboratory.
(One observation was out of range.)

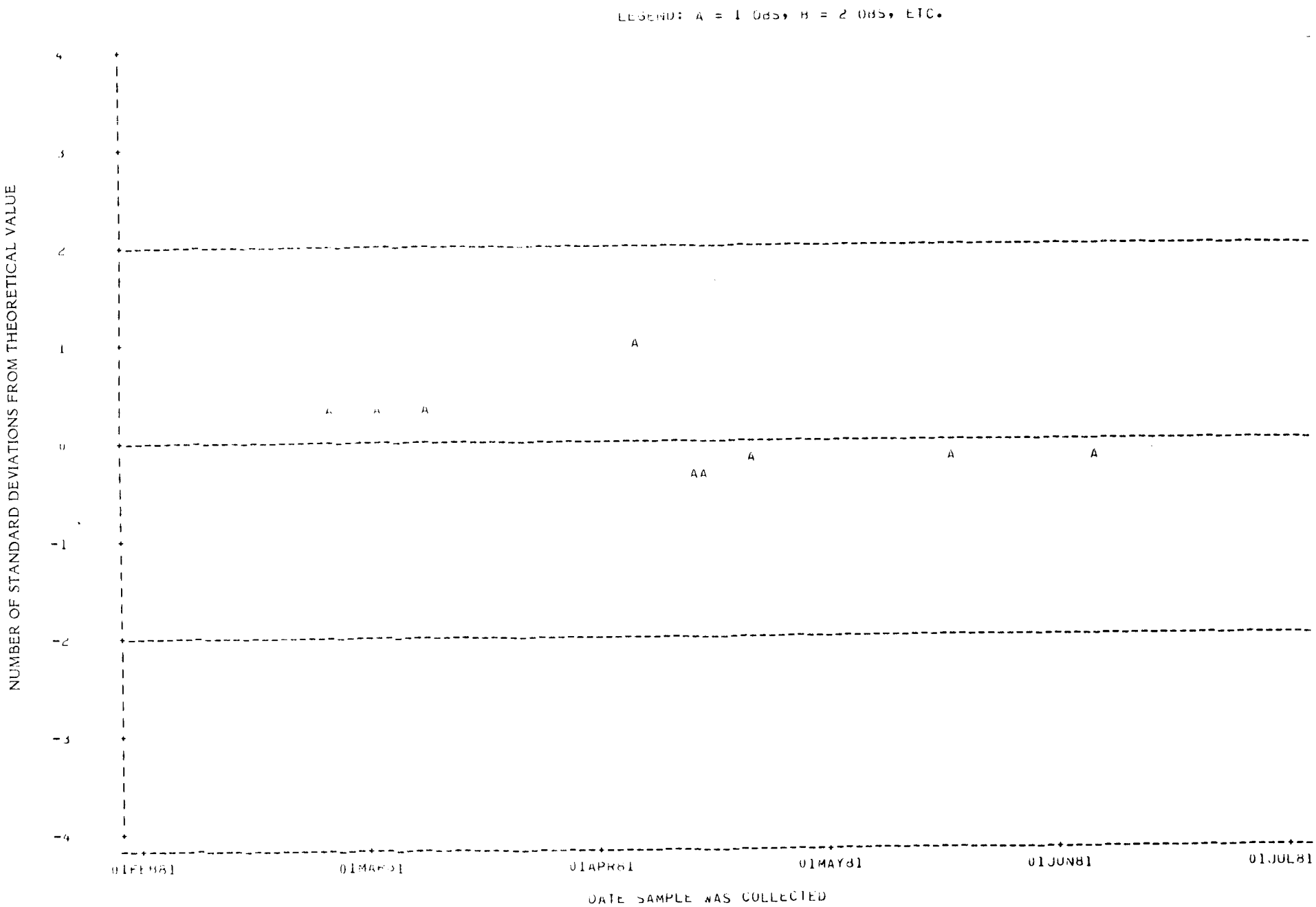

Figure A1.1.34.--Nitrite-nitrogen data for the Atlanta Laboratory.
(One observation was out of range.)

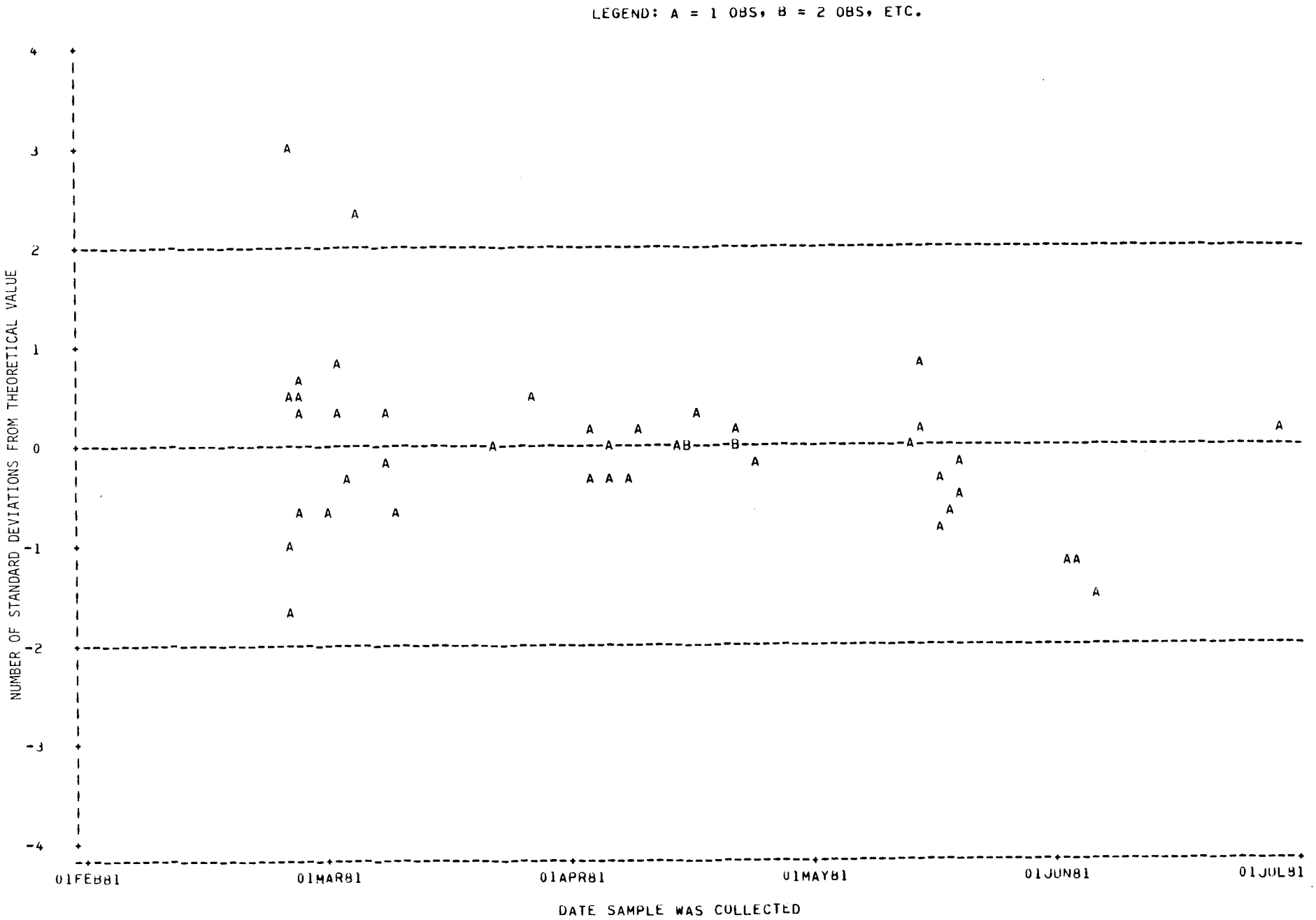

Figure A1.1.35.--Phosphorous data for the Atlanta Laboratory.
(One observation was out of range.)

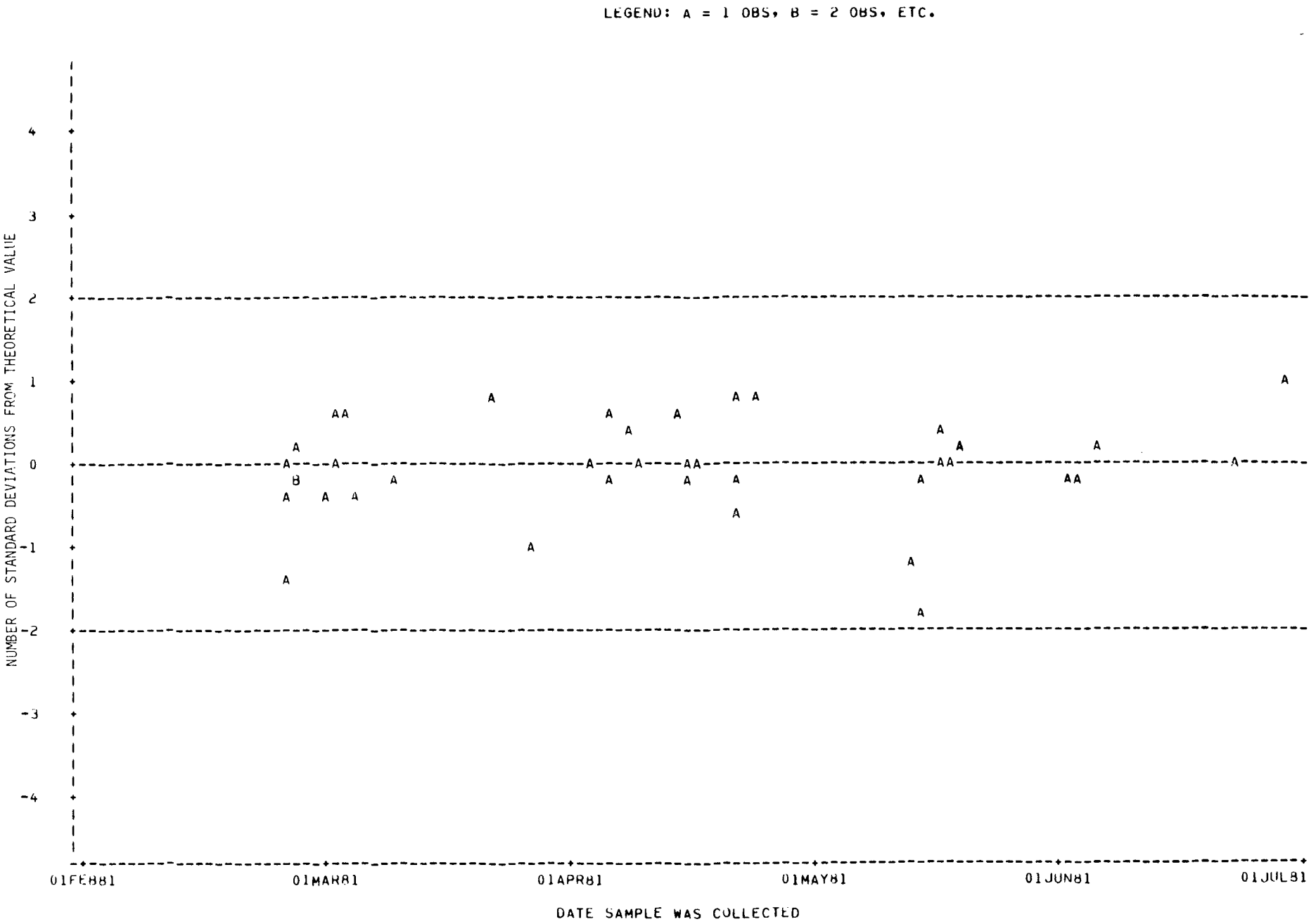

Figure A1.1.36.--Potassium data for the Atlanta Laboratory.

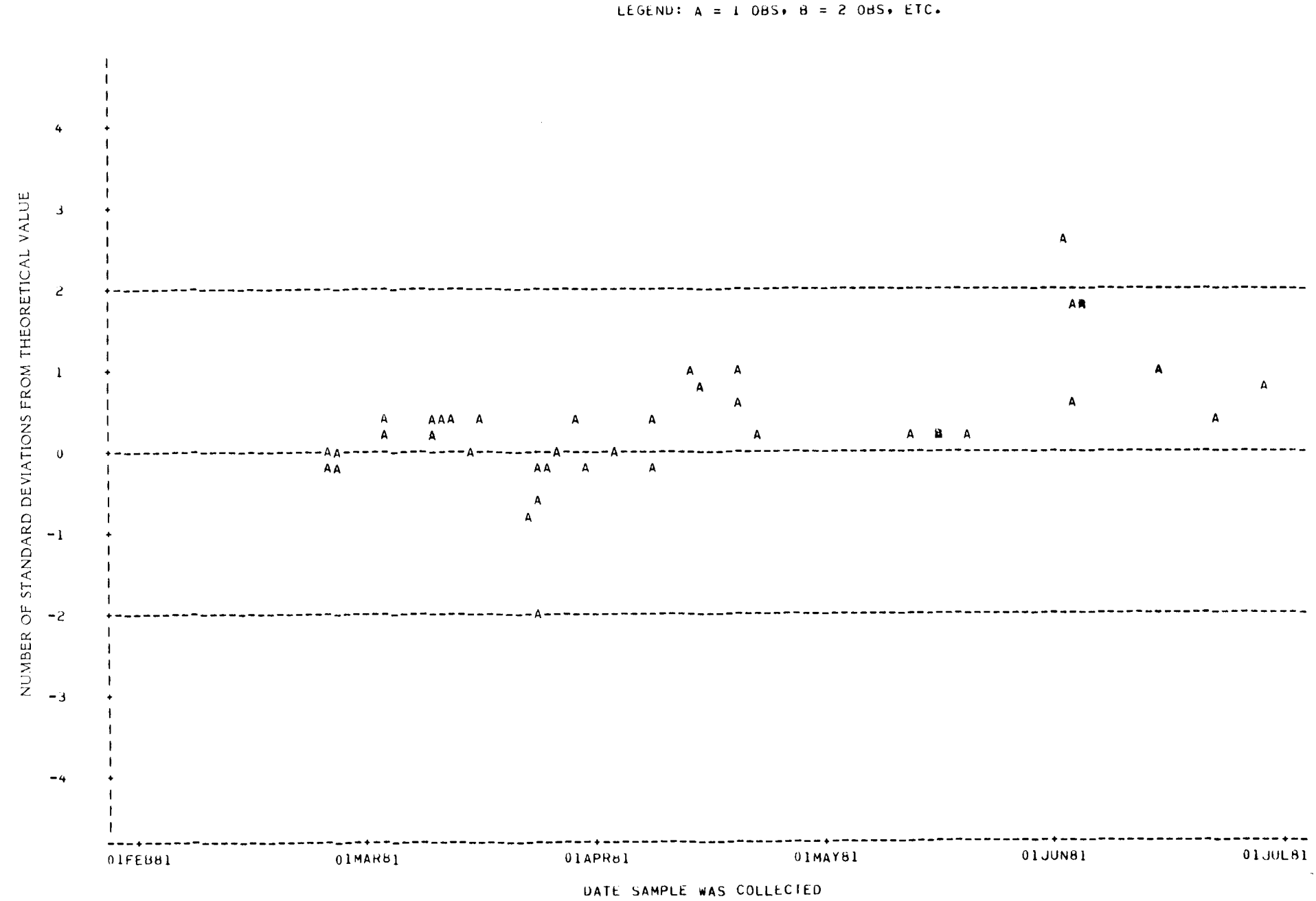

Figure A1.1.37.--Selenium data for the Atlanta Laboratory.

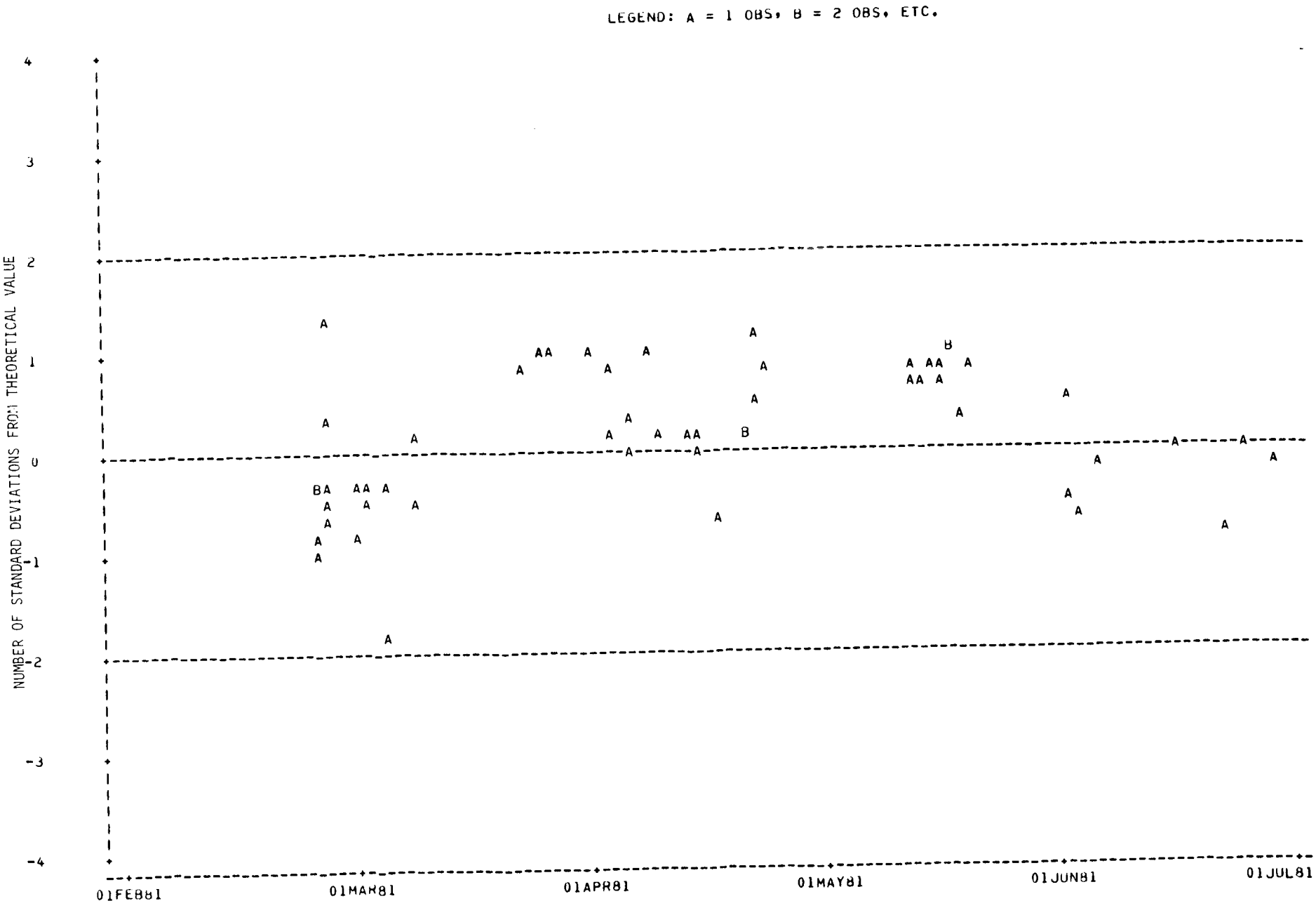

Figure A1.1.38.--Silica data for the Atlanta Laboratory.
(One observation was out of range.)

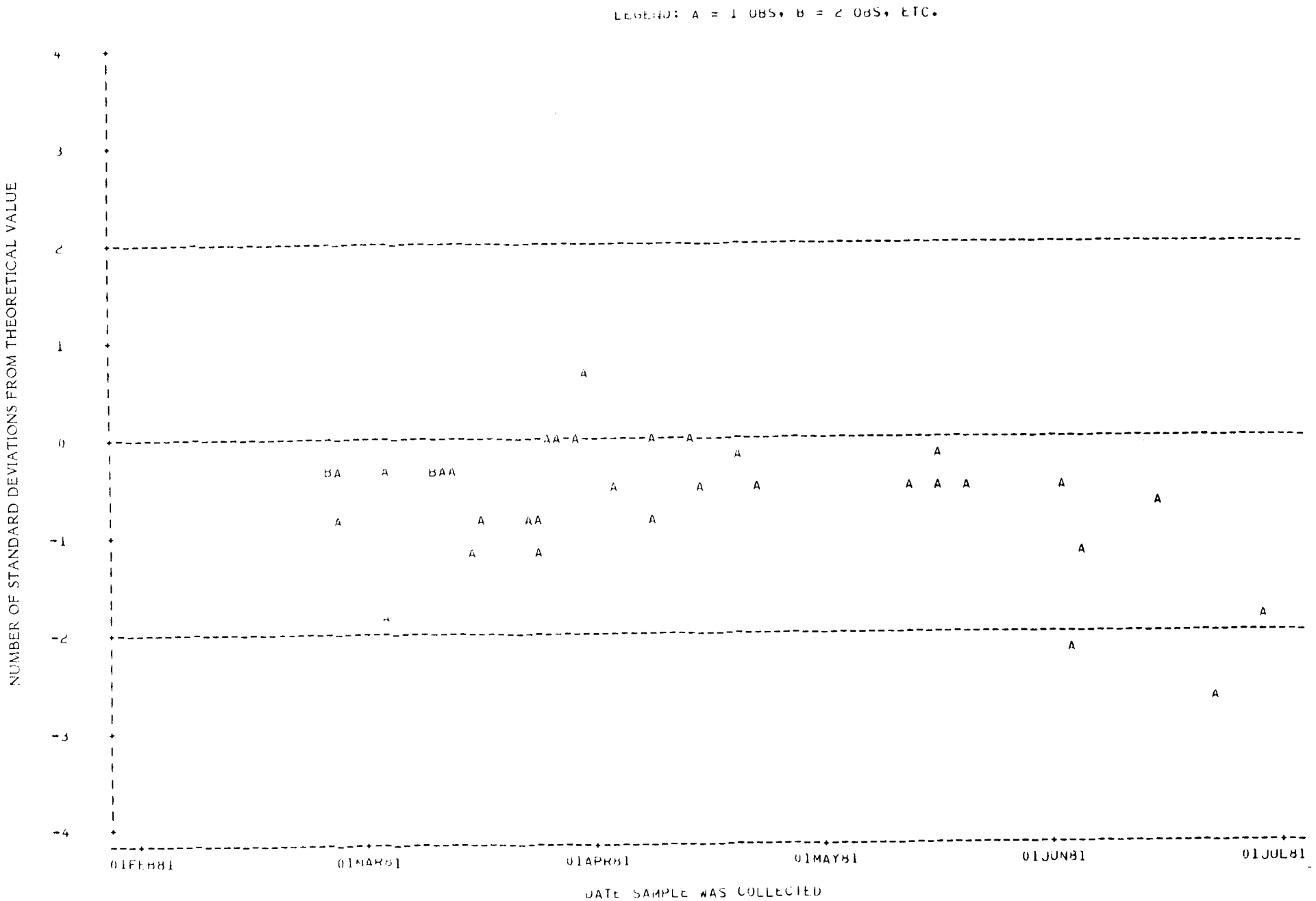

Figure A1.1.39.--Silver data for the Atlanta Labortory.
(One observation was out of range.)

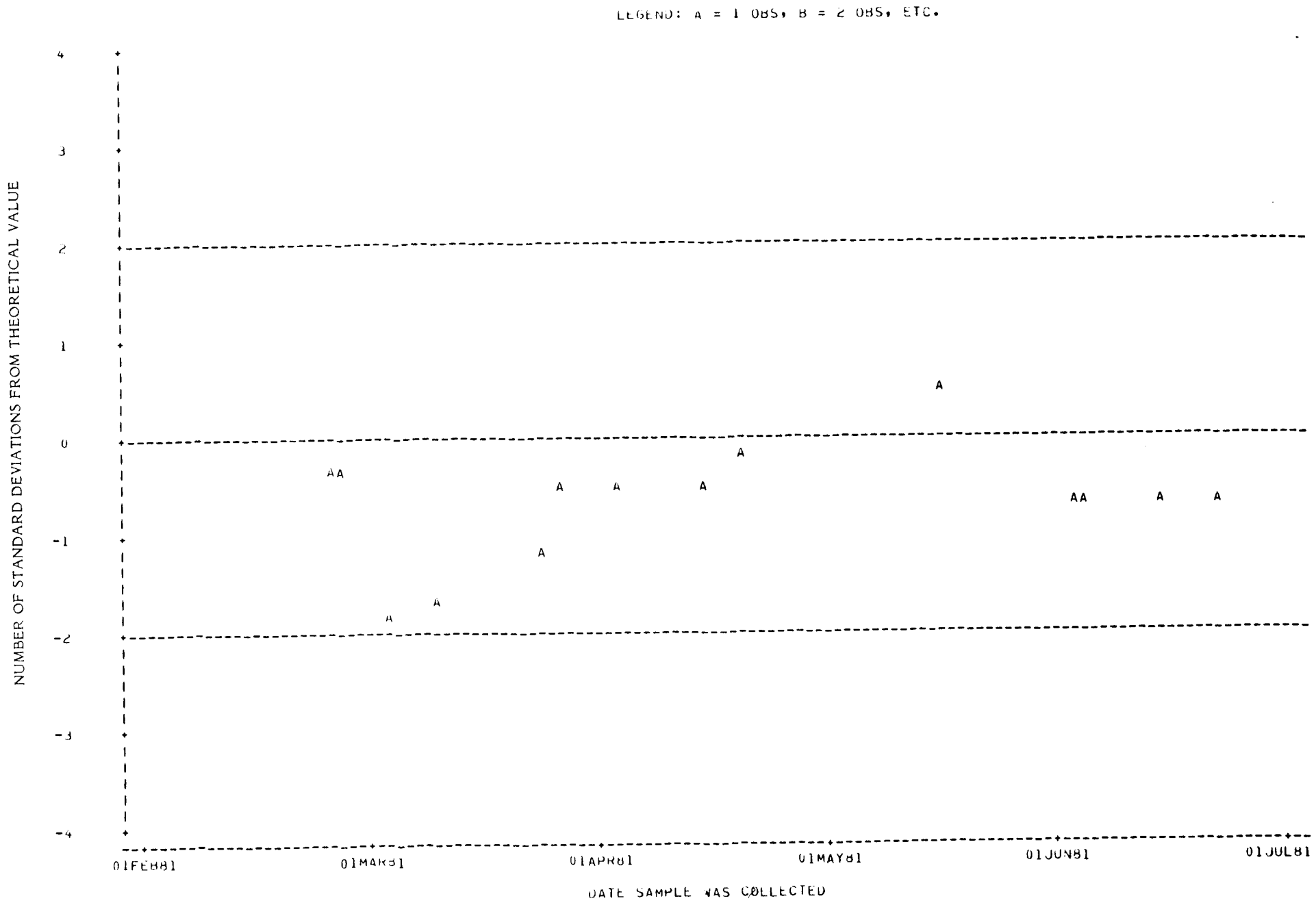

Figure A1.1.40.--Silver, total recoverable data for the Atlanta Laboratory.

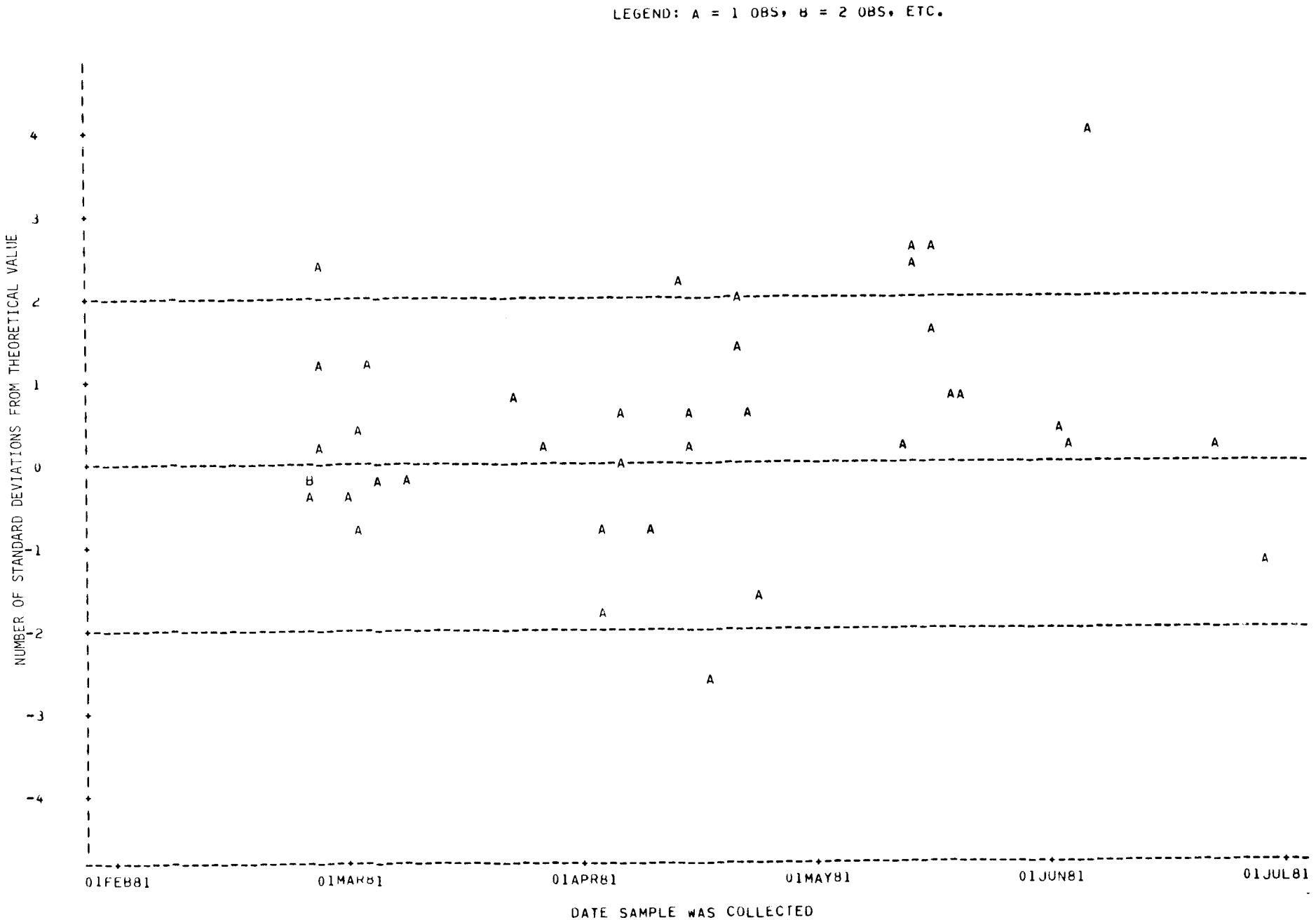

Figure A1.1.41.--Sodium data for the Atlanta Laboratory.
(Two observations were out of range.)

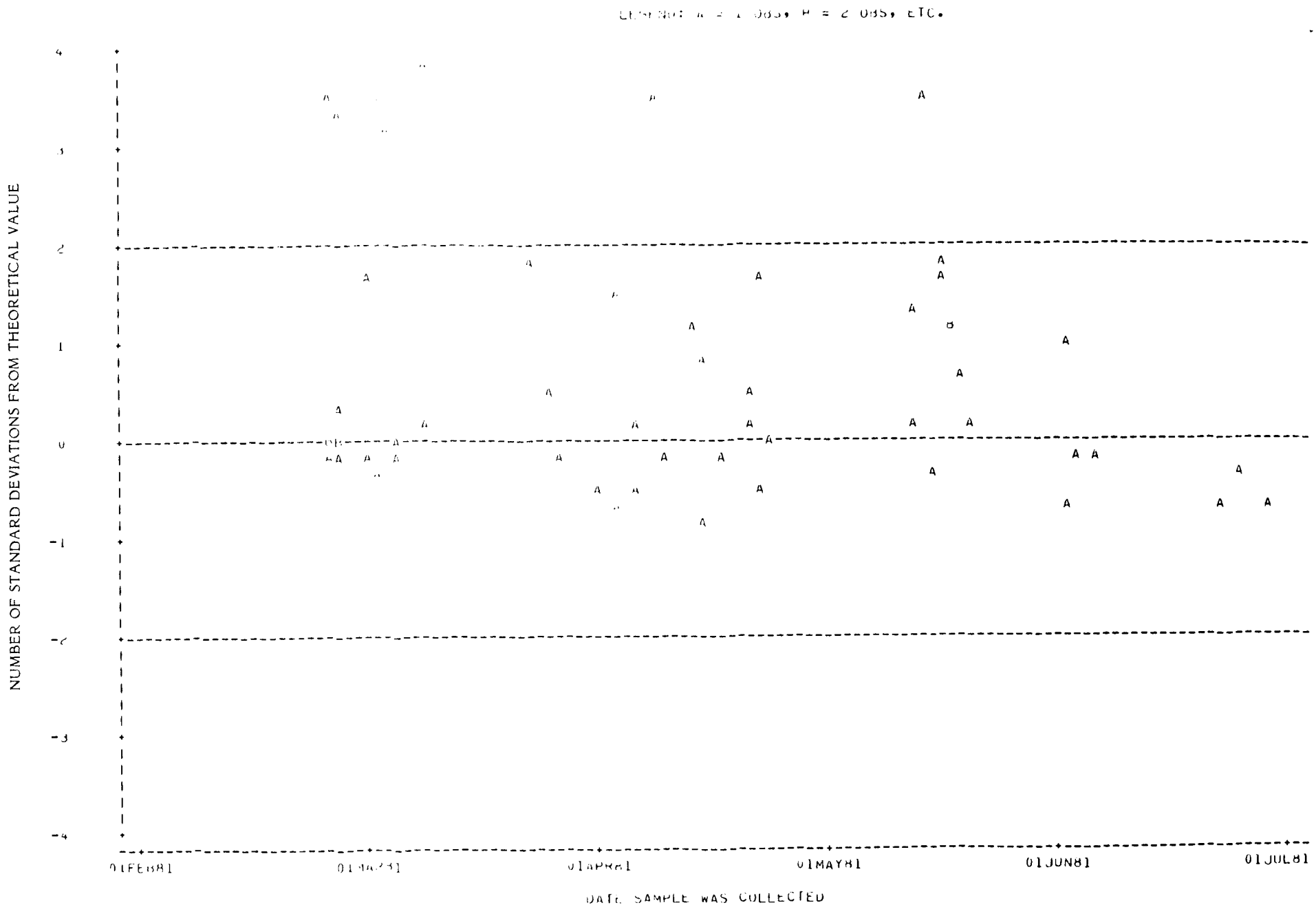

Figure A1.1.42.--Specific conductance data for the Atlanta Laboratory.
(One observation was out of range.)

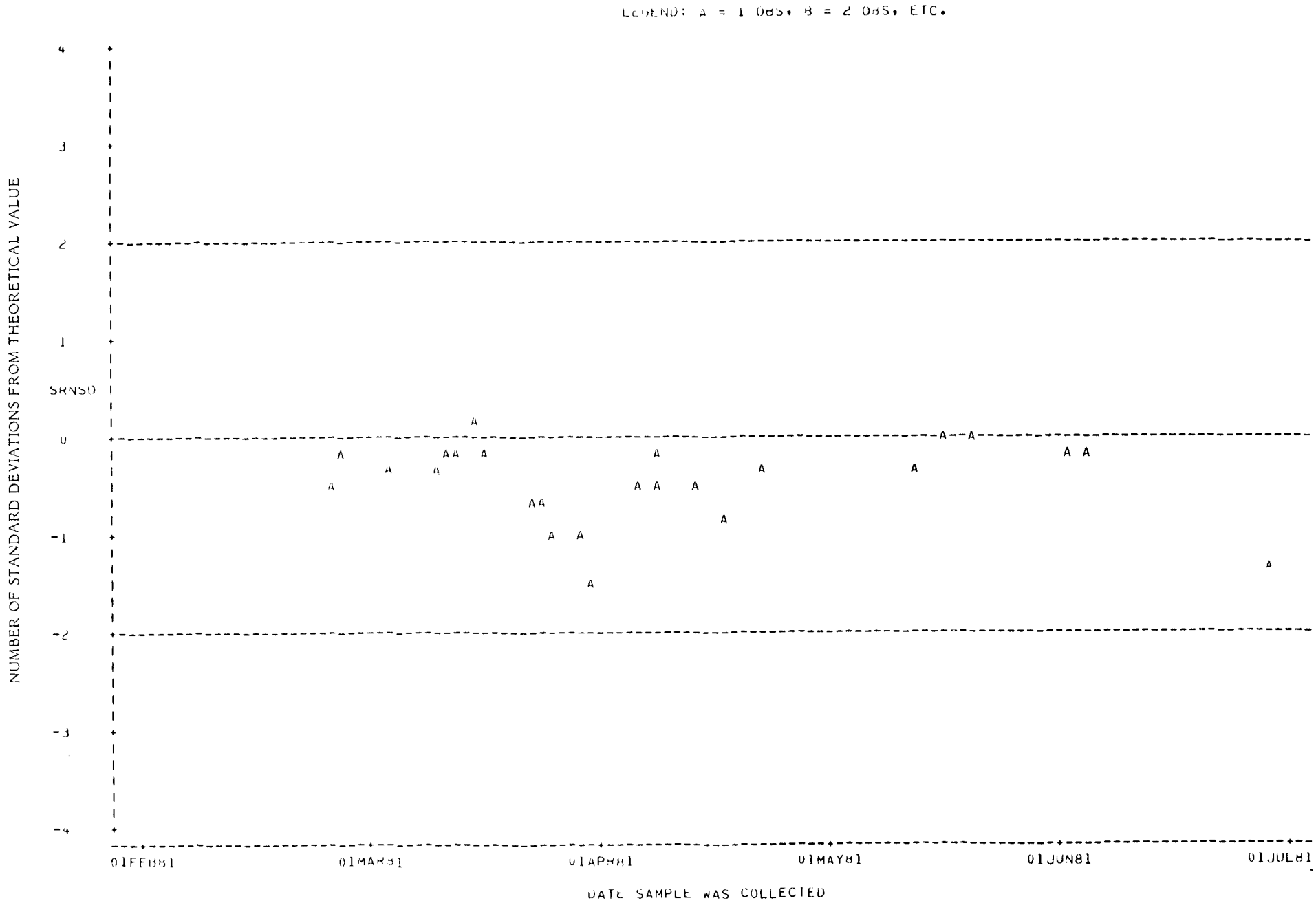

Figure A1.1.43.--Strontium data for the Atlanta Laboratory.

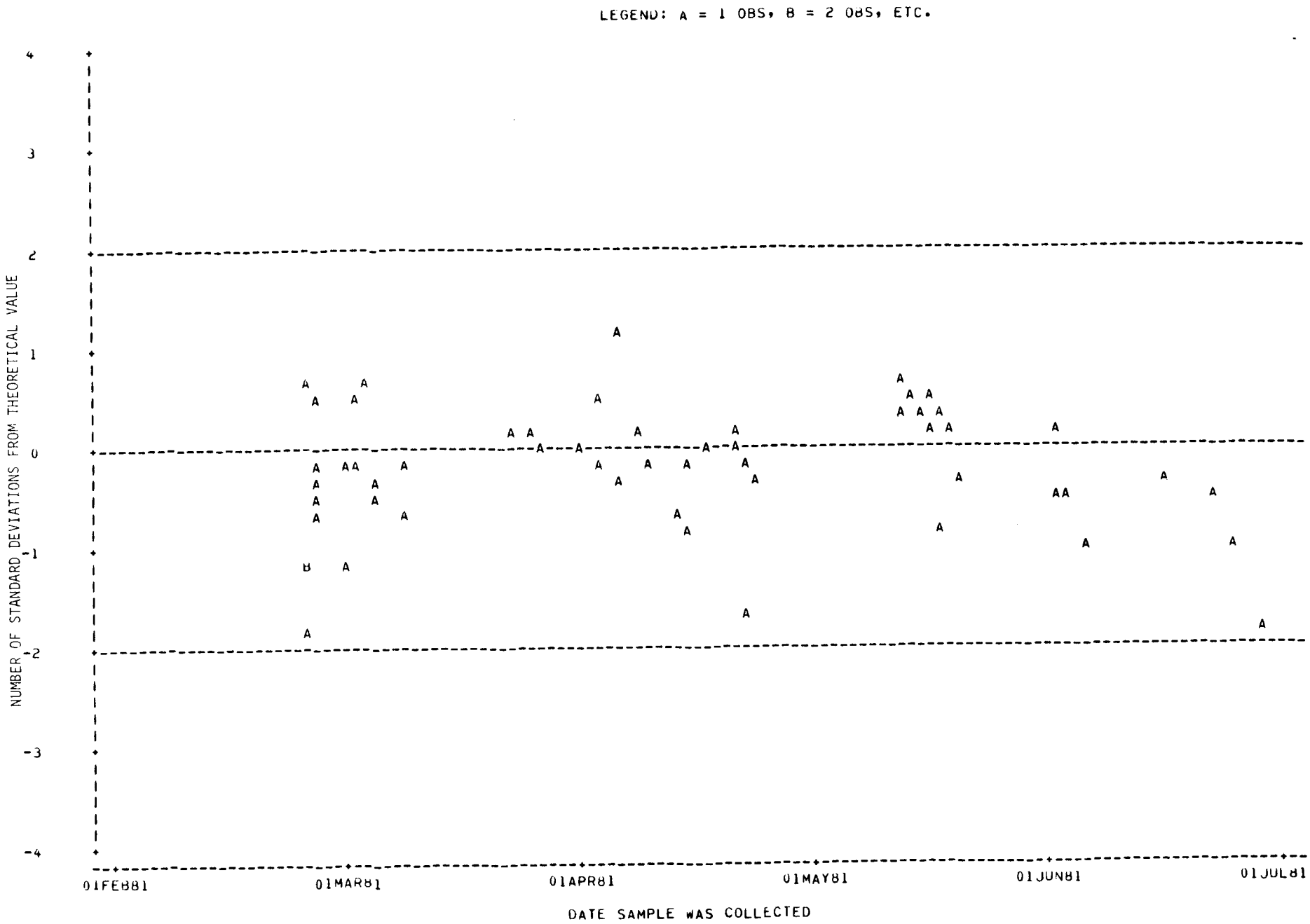

Figure A1.1.44.--Sulfate data for the Atlanta Laboratory.

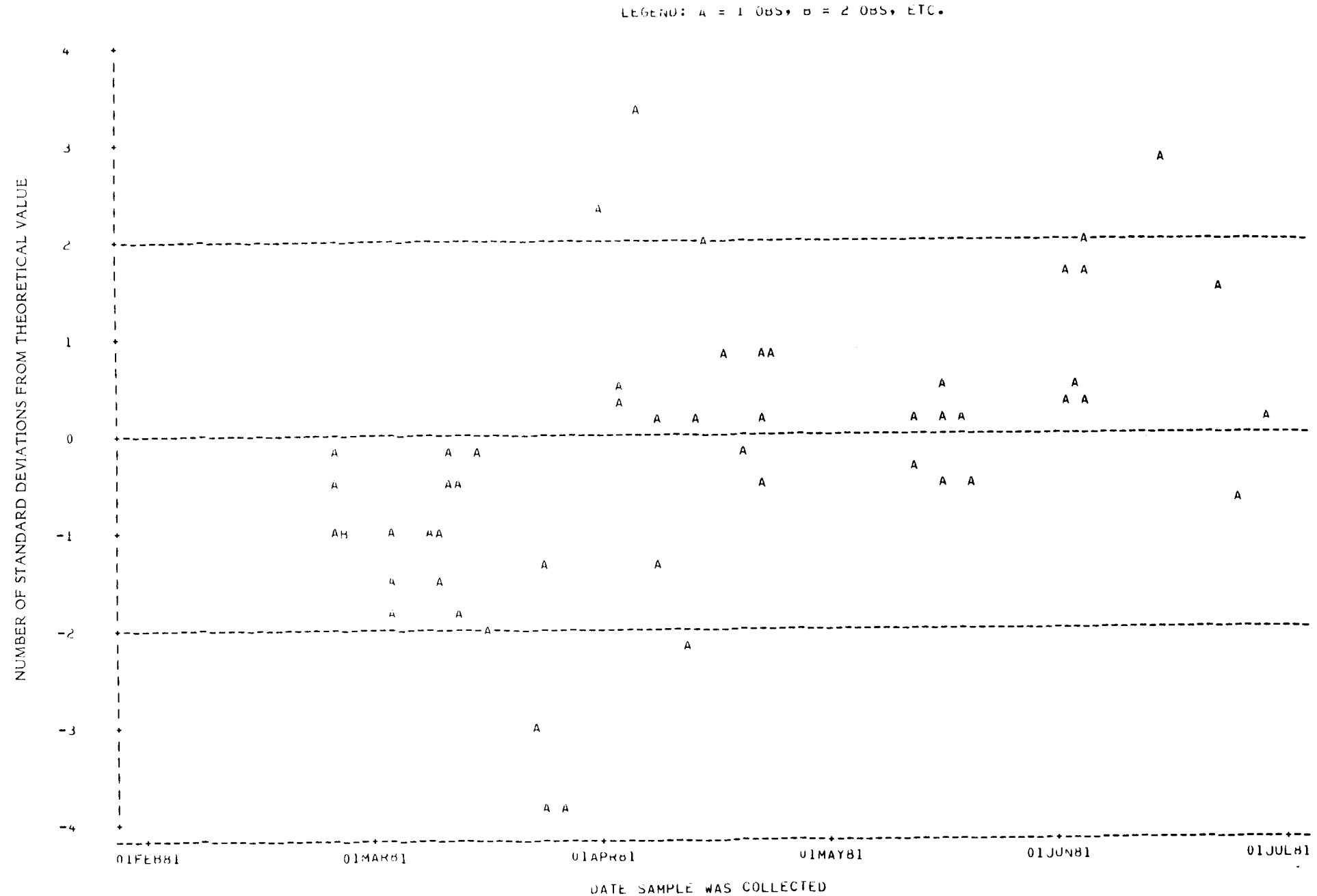

Figure A1.1.45.--Zinc data for the Atlanta Laboratory.
(Six observations were out of range.)

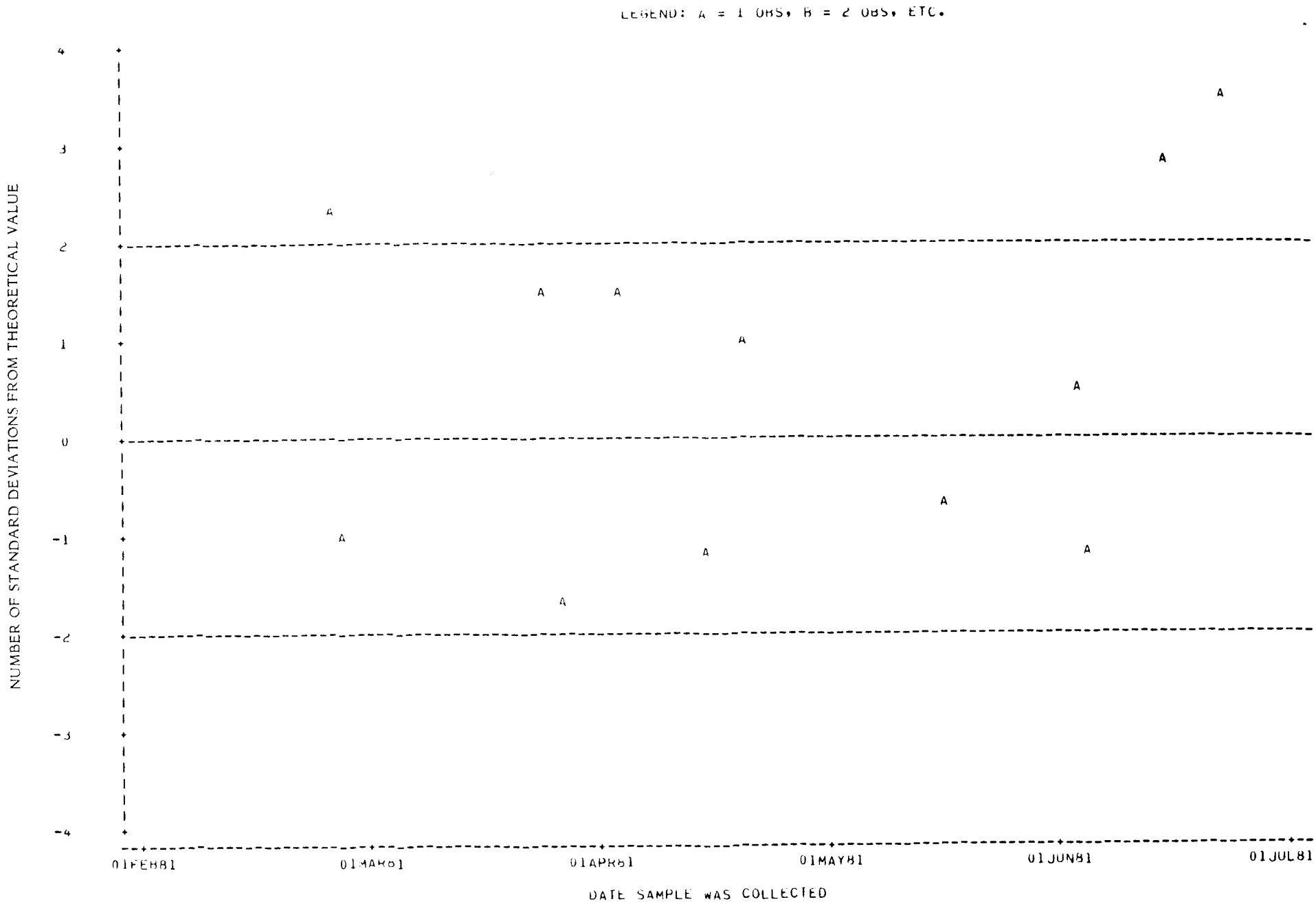

Figure A1.1.46.--Zinc, total recoverable data for the Atlanta Laboratory.
(Two observations were out of range.)

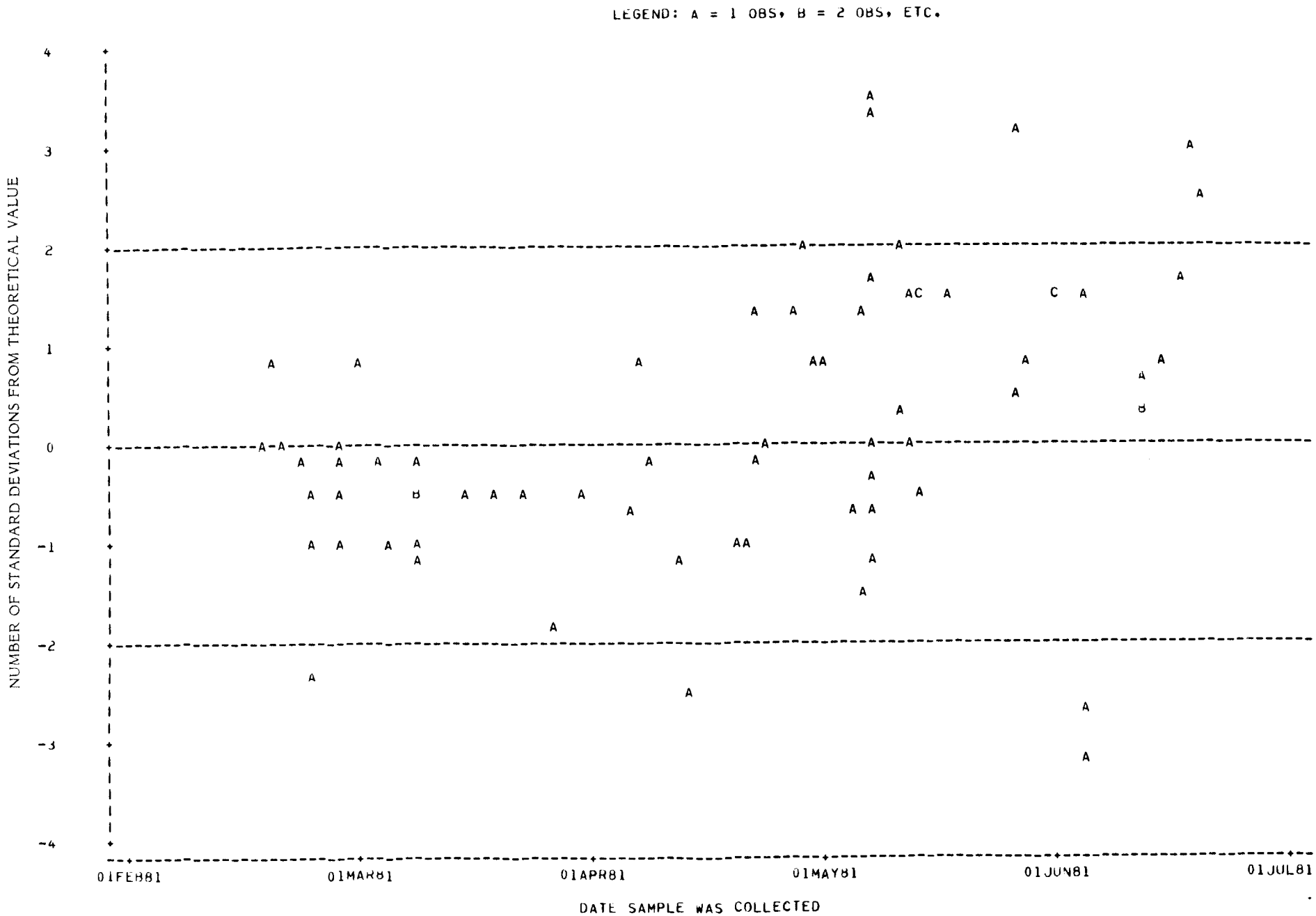

Figure A1.2.1.--Alkalinity data for the Denver Laboratory.
(Three observations were out of range.)

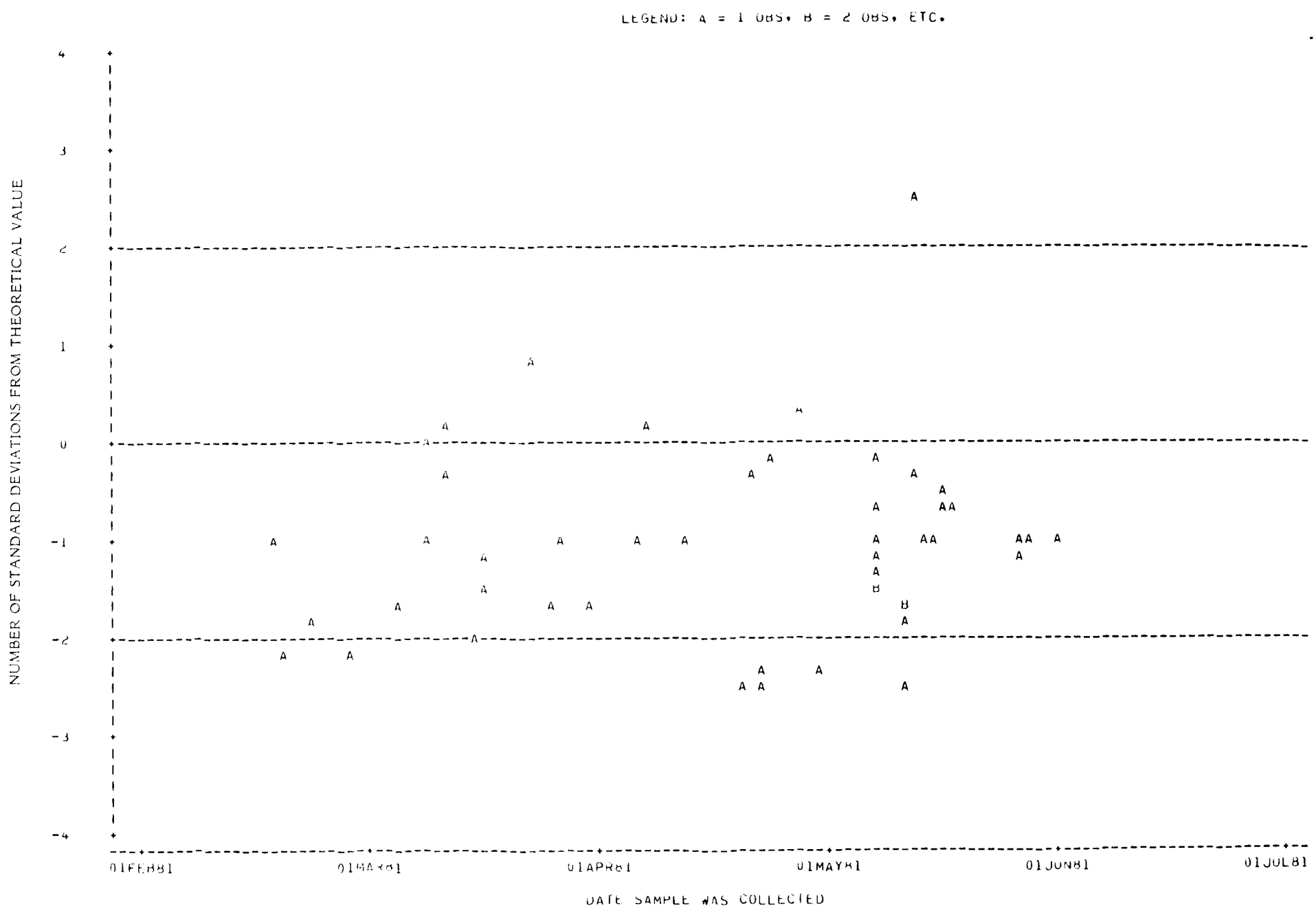

Figure A1.2.2.--Aluminum data for the Denver Laboratory.

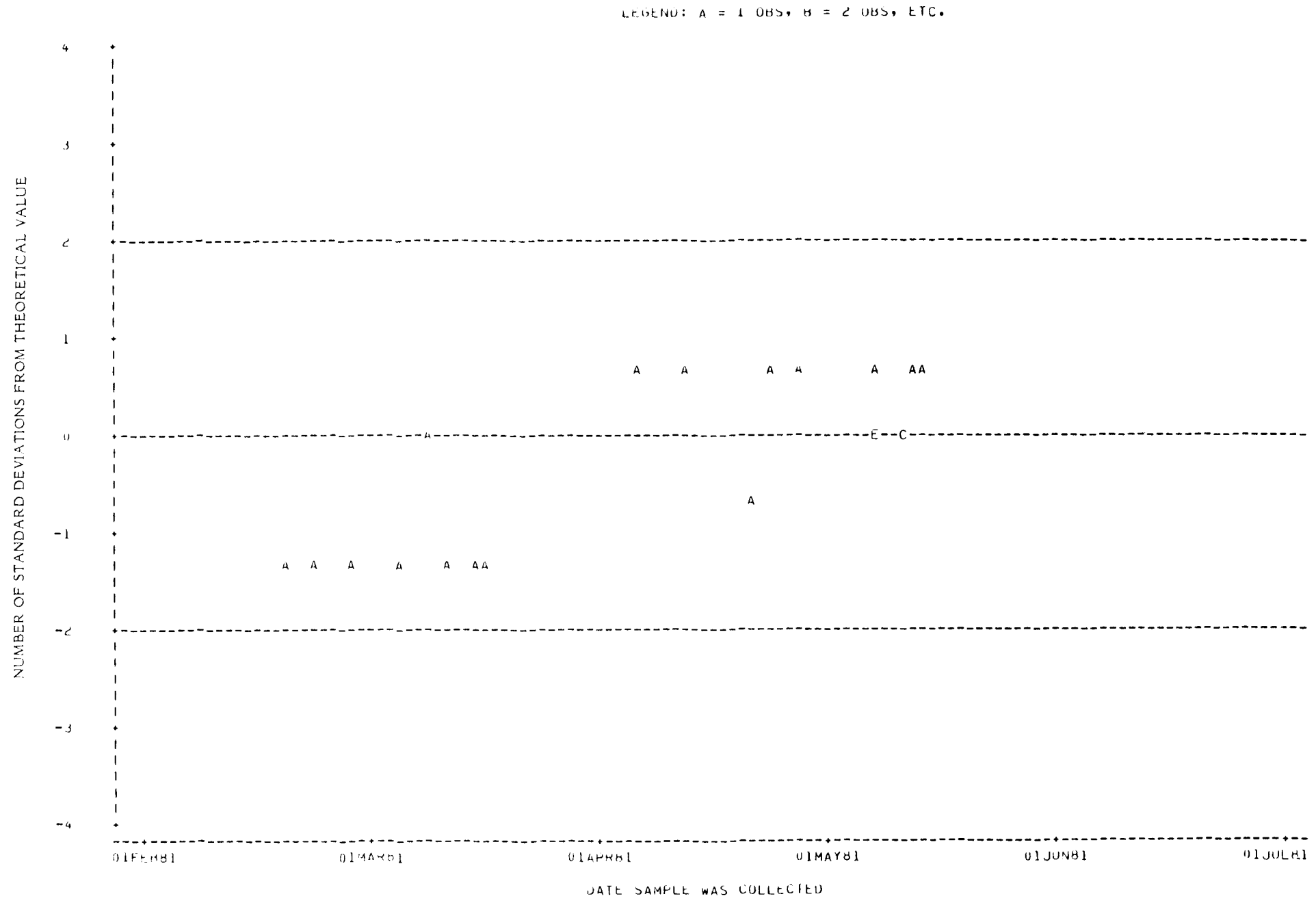

Figure A1.2.3.--Antimony data for the Denver Laboratory.

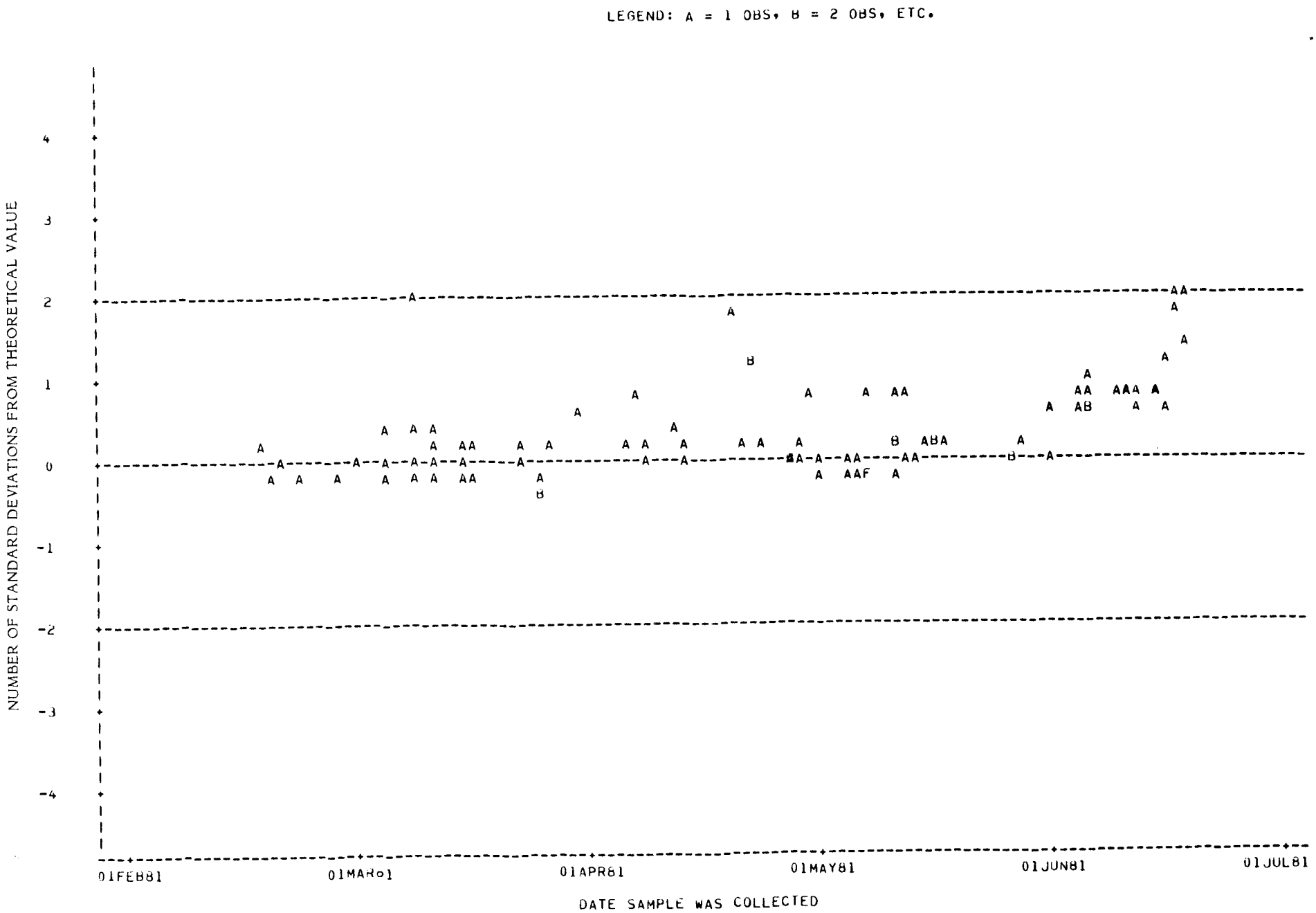

Figure A1.2.4.--Arsenic data for the Denver Laboratory.

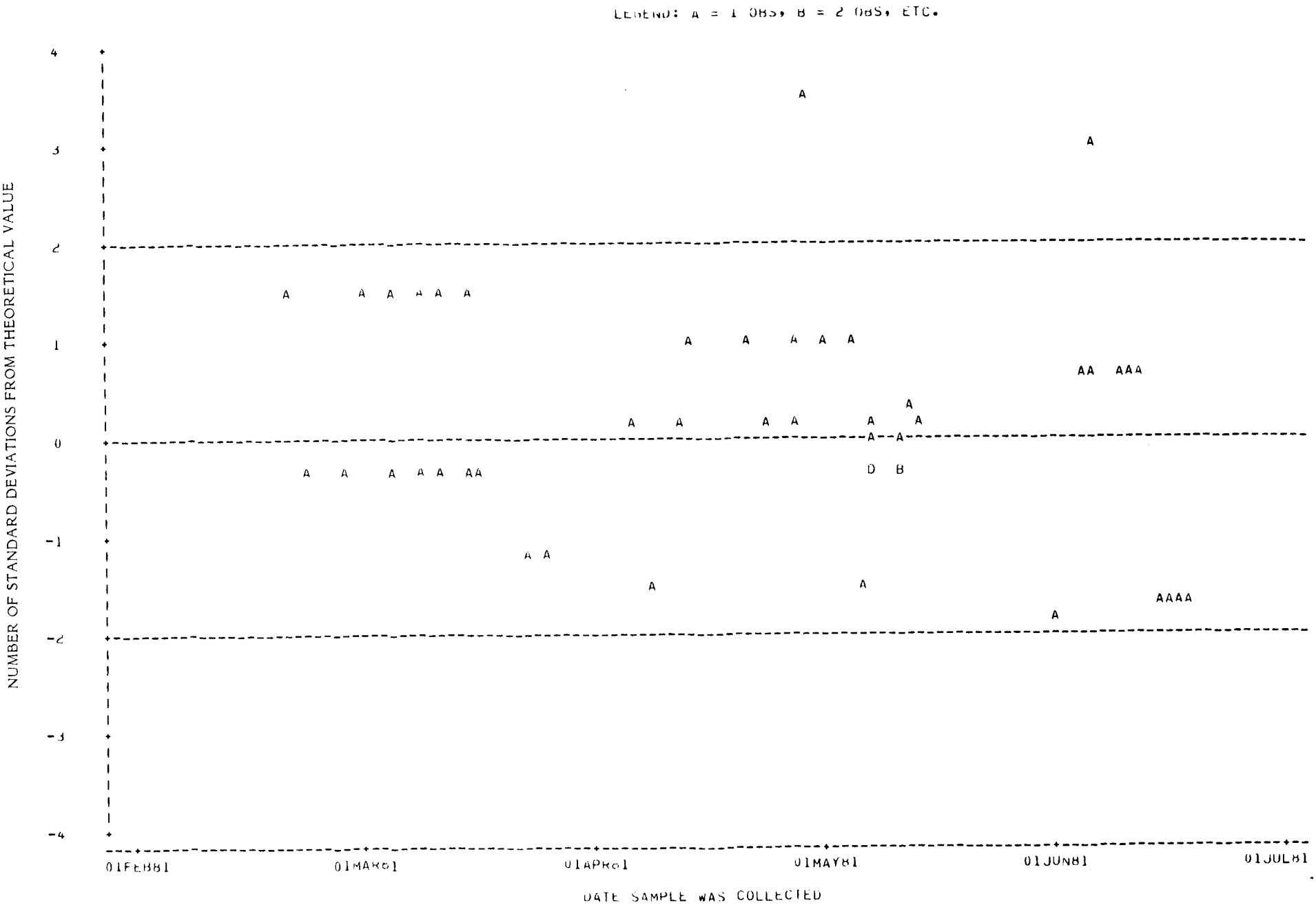

Figure A1.2.5-- Barium data for the Denver Laboratory.

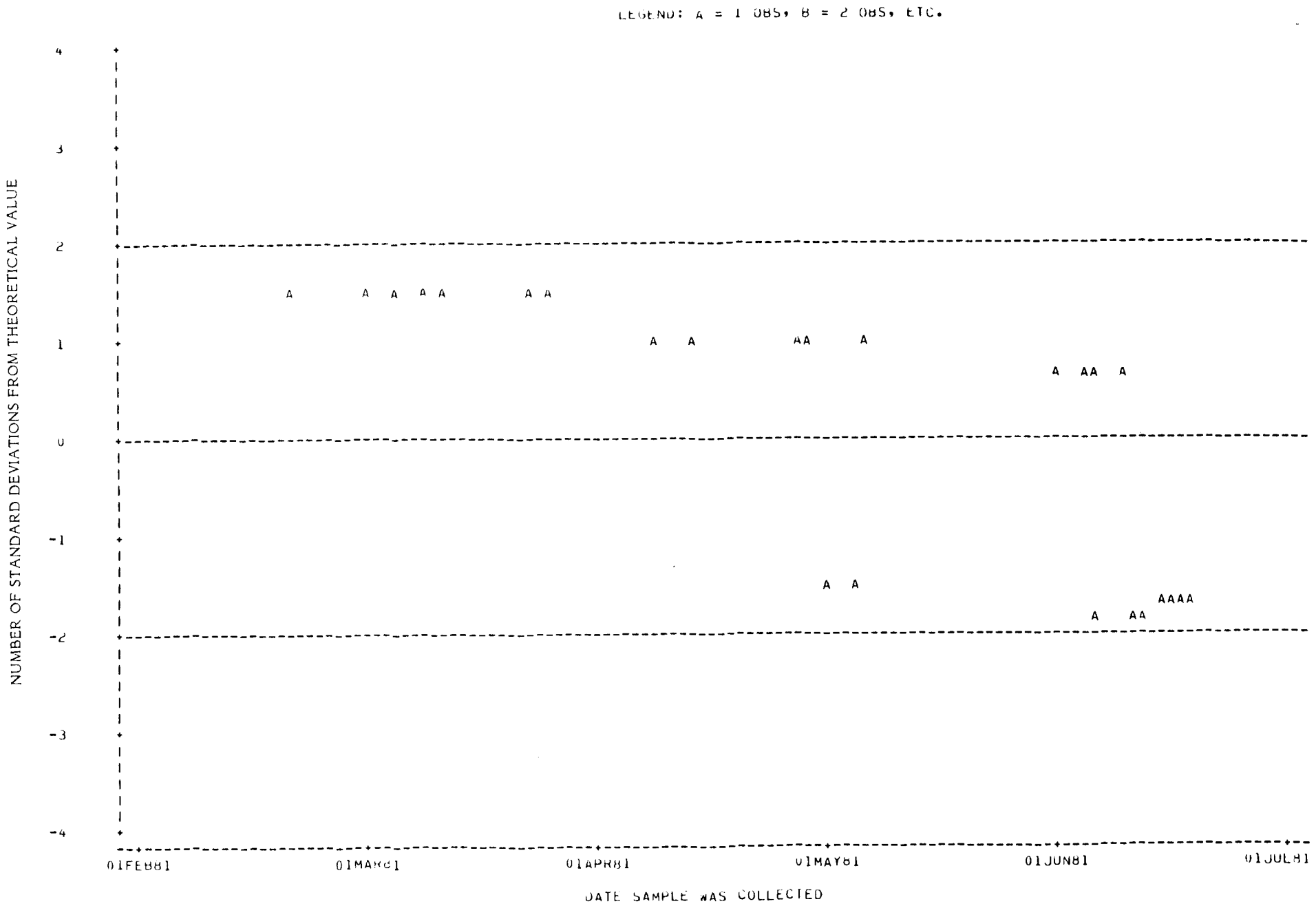

Figure A1.2.6.--Barium, total recoverable data for the Denver Laboratory.

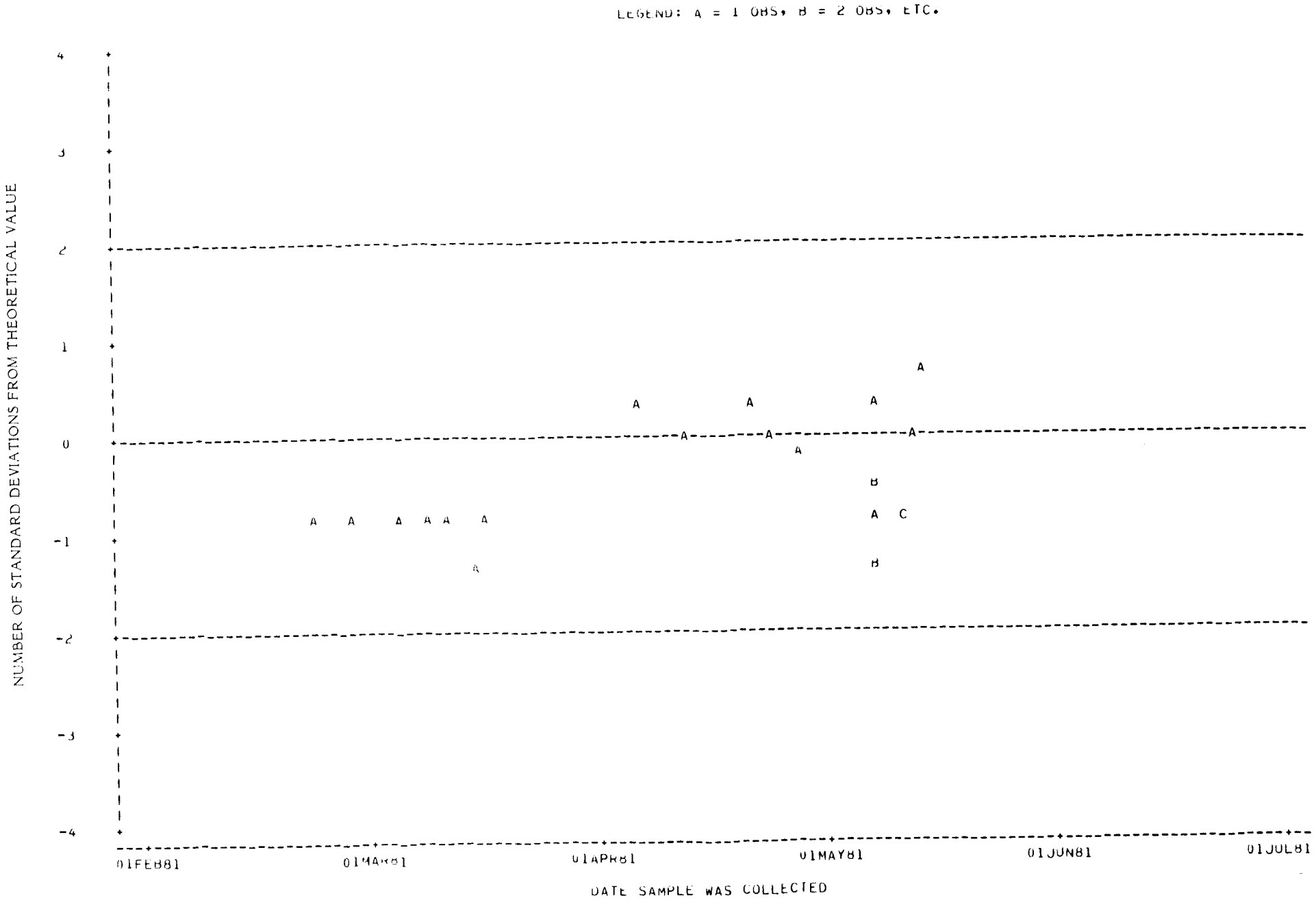

Figure A1.2.7.--Beryllium data for the Denver Laboratory.

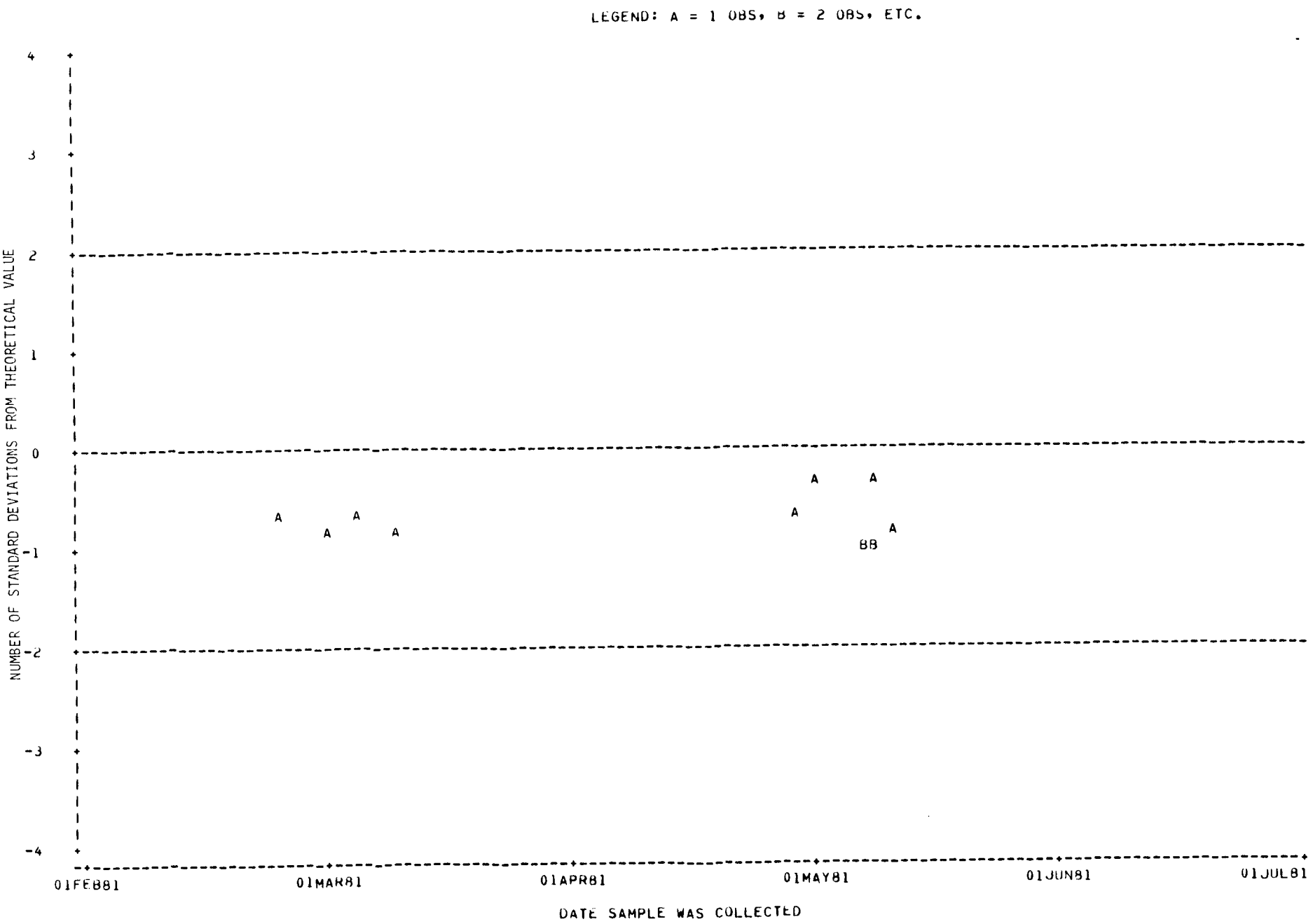

Figure A1.2.8.--Boron data for the Denver Laboratory.

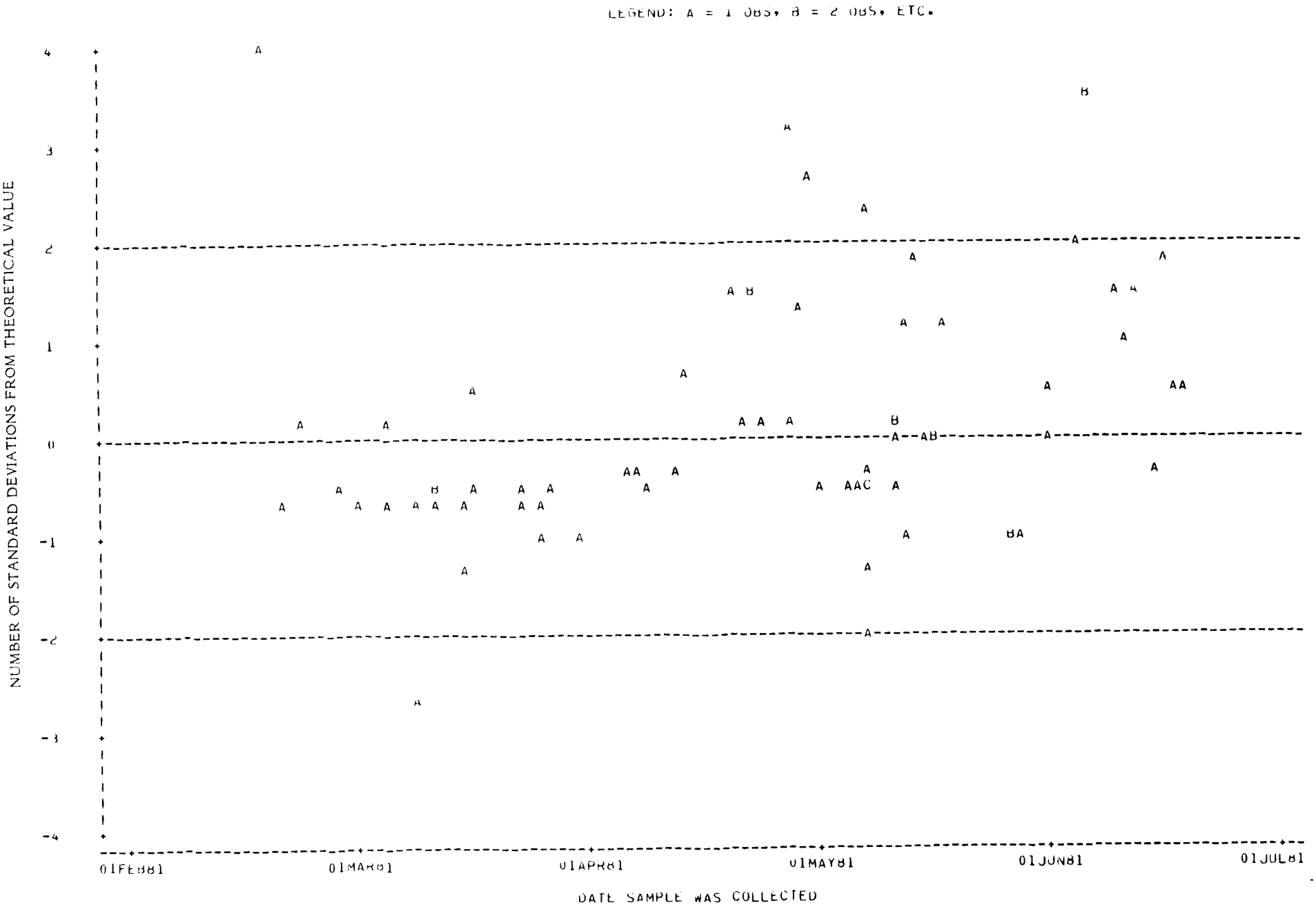

Figure A1.2.9.--Cadmium data for the Denver Laboratory.
(One observation was out of range.)

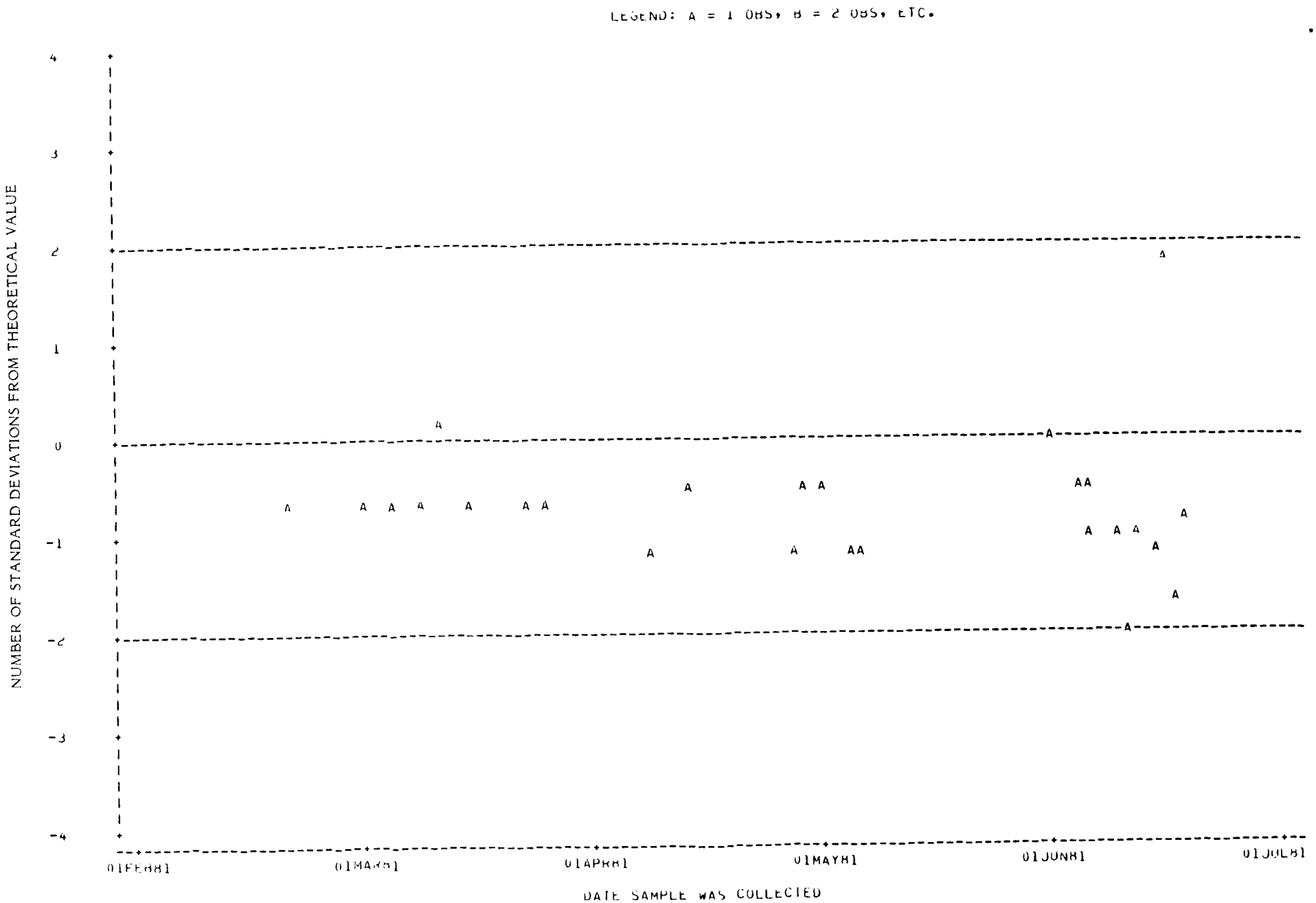

Figure A1.2.10.--Cadmium, total recoverable data for the Denver Laboratory.

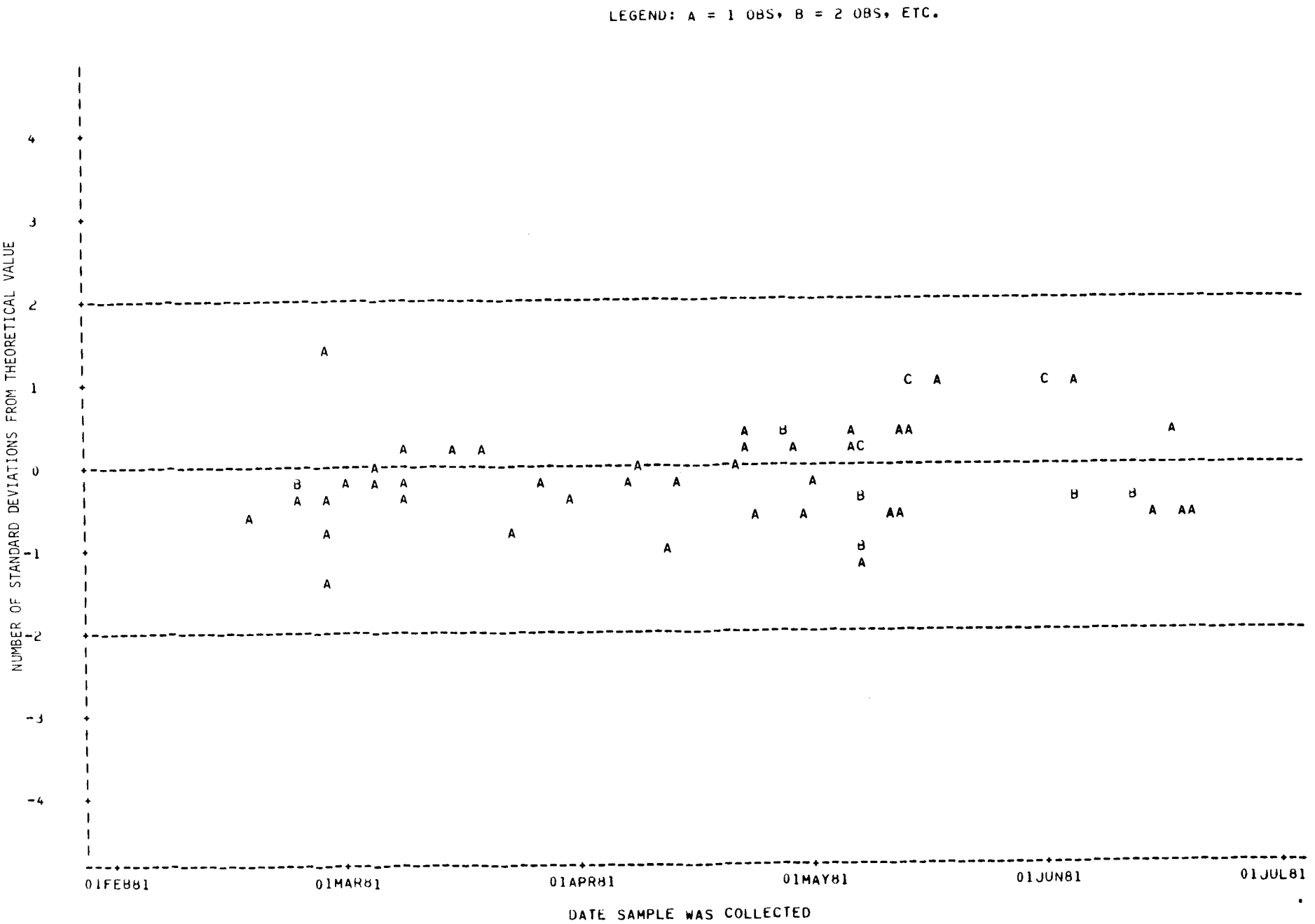

Figure A1.2.11.--Calcium data for the Denver Laboratory.

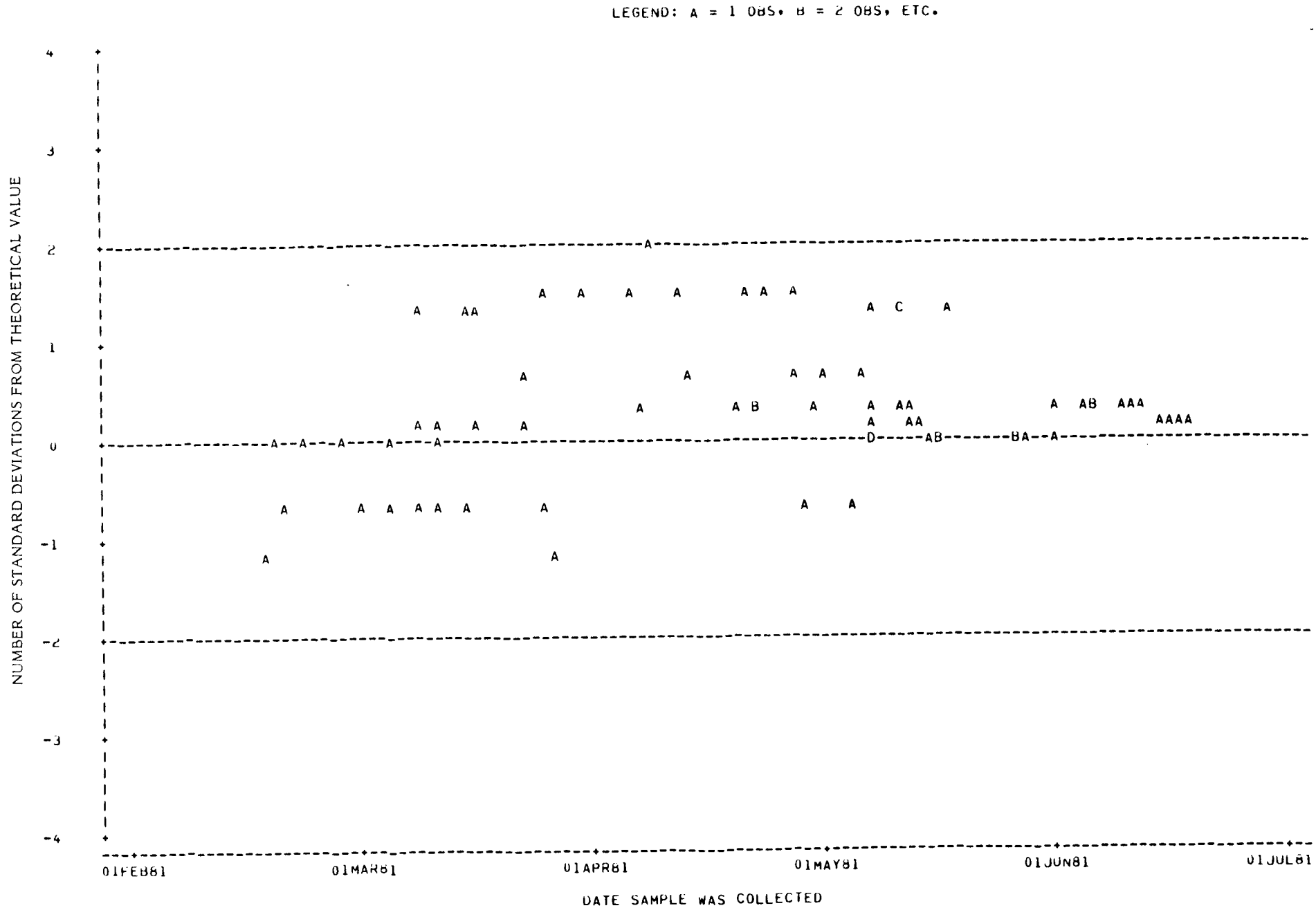

Figure A1.2.12.--Chromium data for the Denver Laboratory.

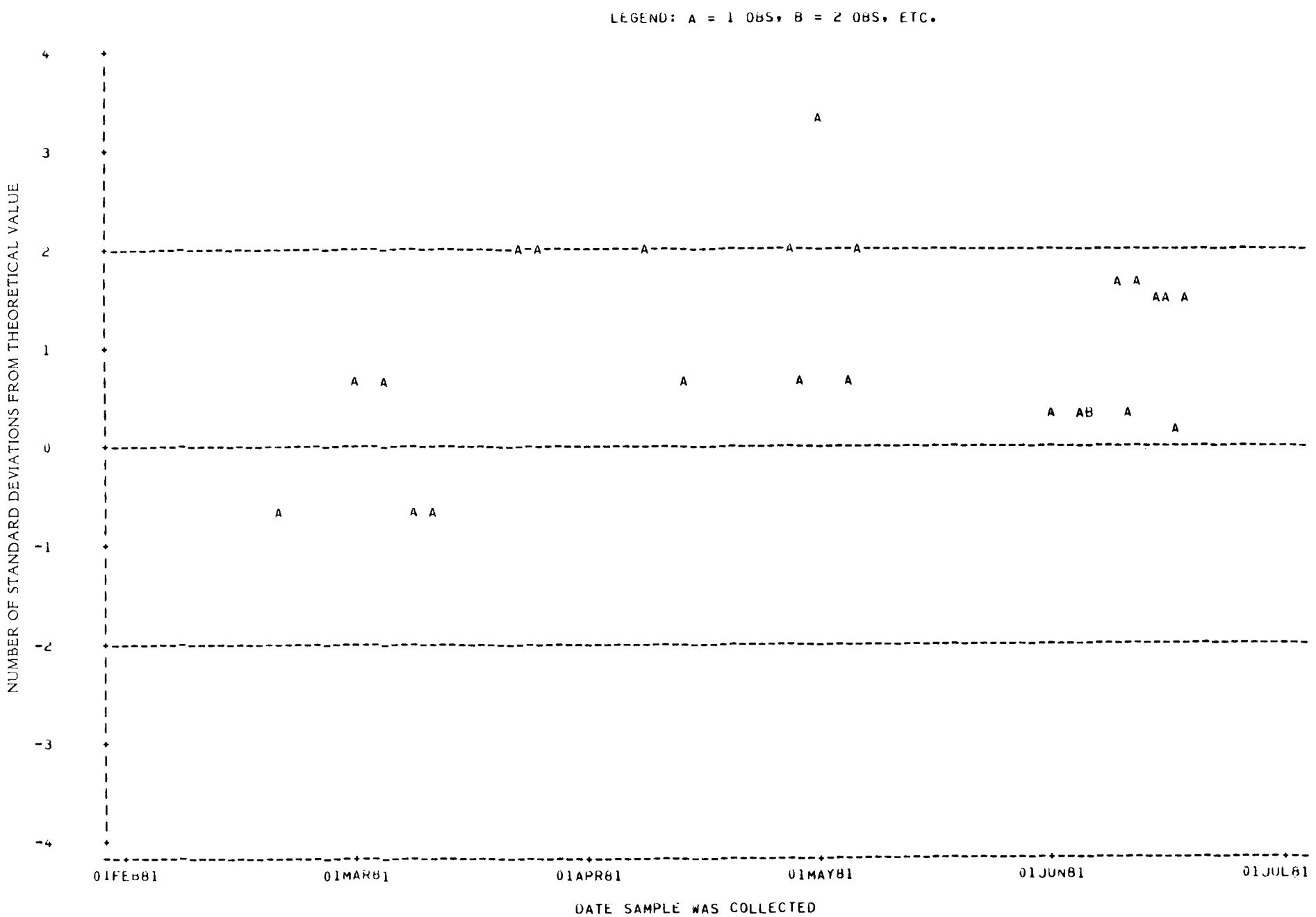

Figure A1.2.13.--Chromium, total recoverable data for the Denver Laboratory.

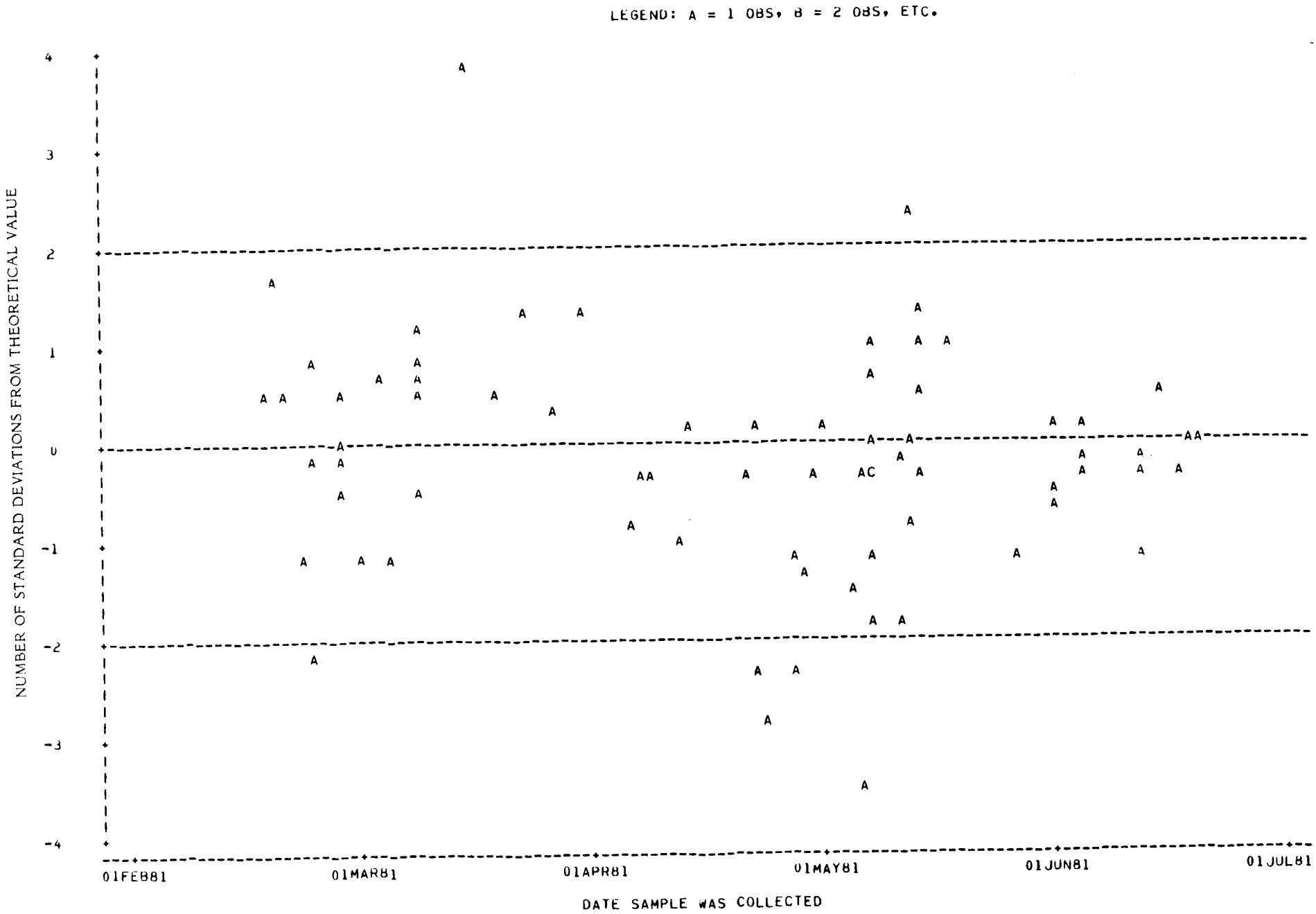

Figure A1.2.14.--Chloride data for the Denver Laboratory.
(Three observations were out of range.)

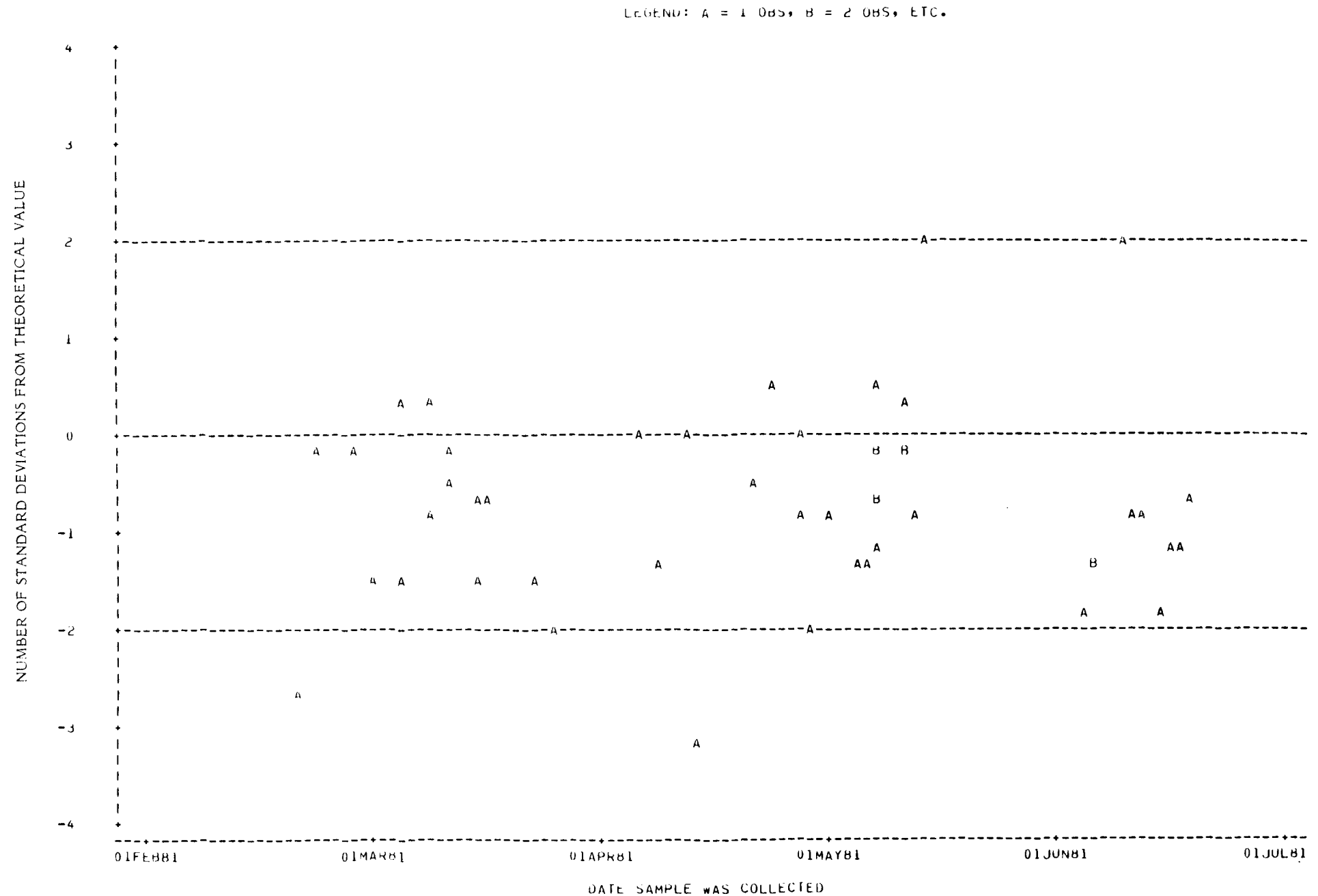

Figure A1.2.15.--Cobalt data for the Denver Laboratory.
(One observation was out of range.)

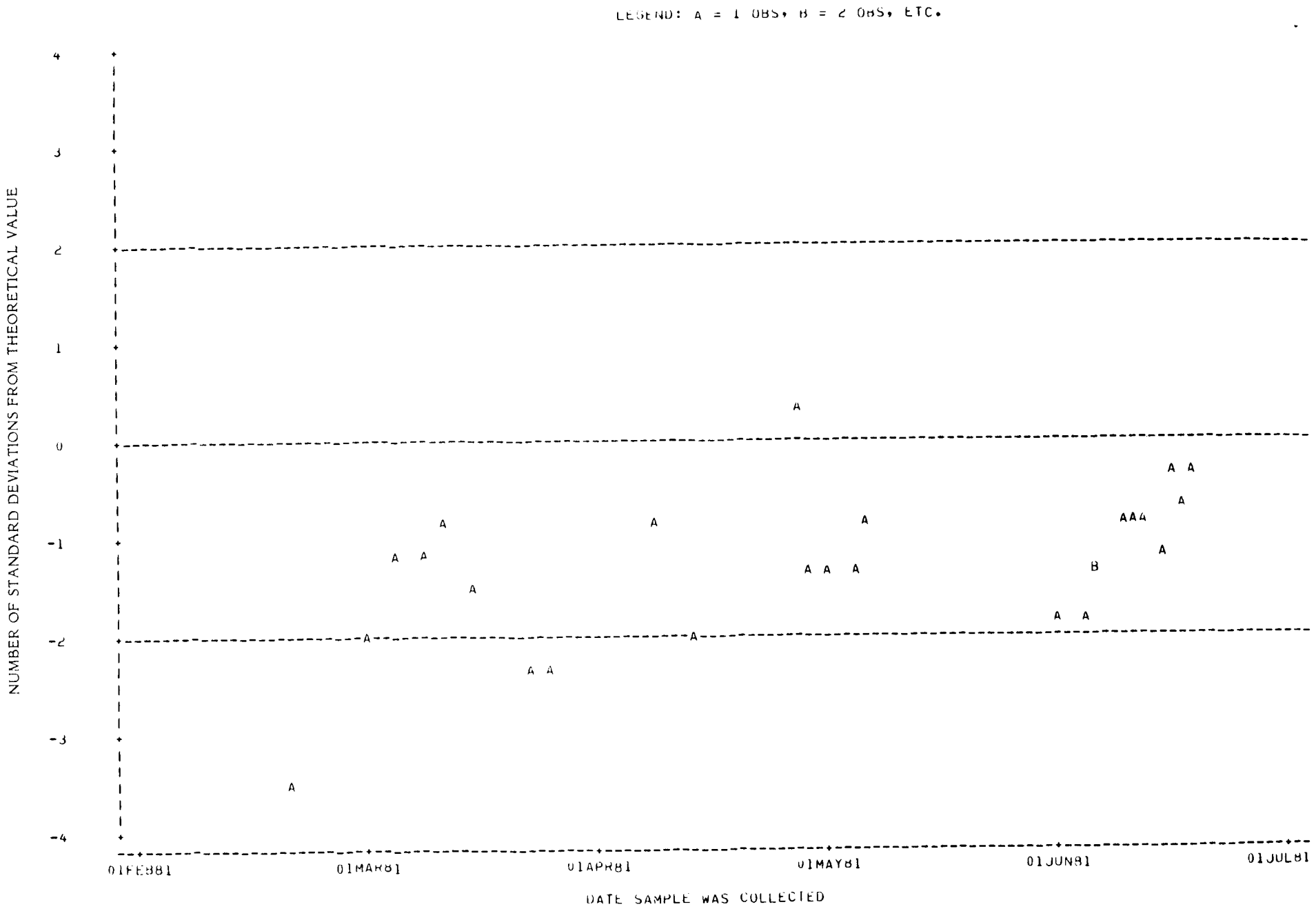

Figure A1.2.16.--Cobalt, total recoverable data for the Denver Laboratory.

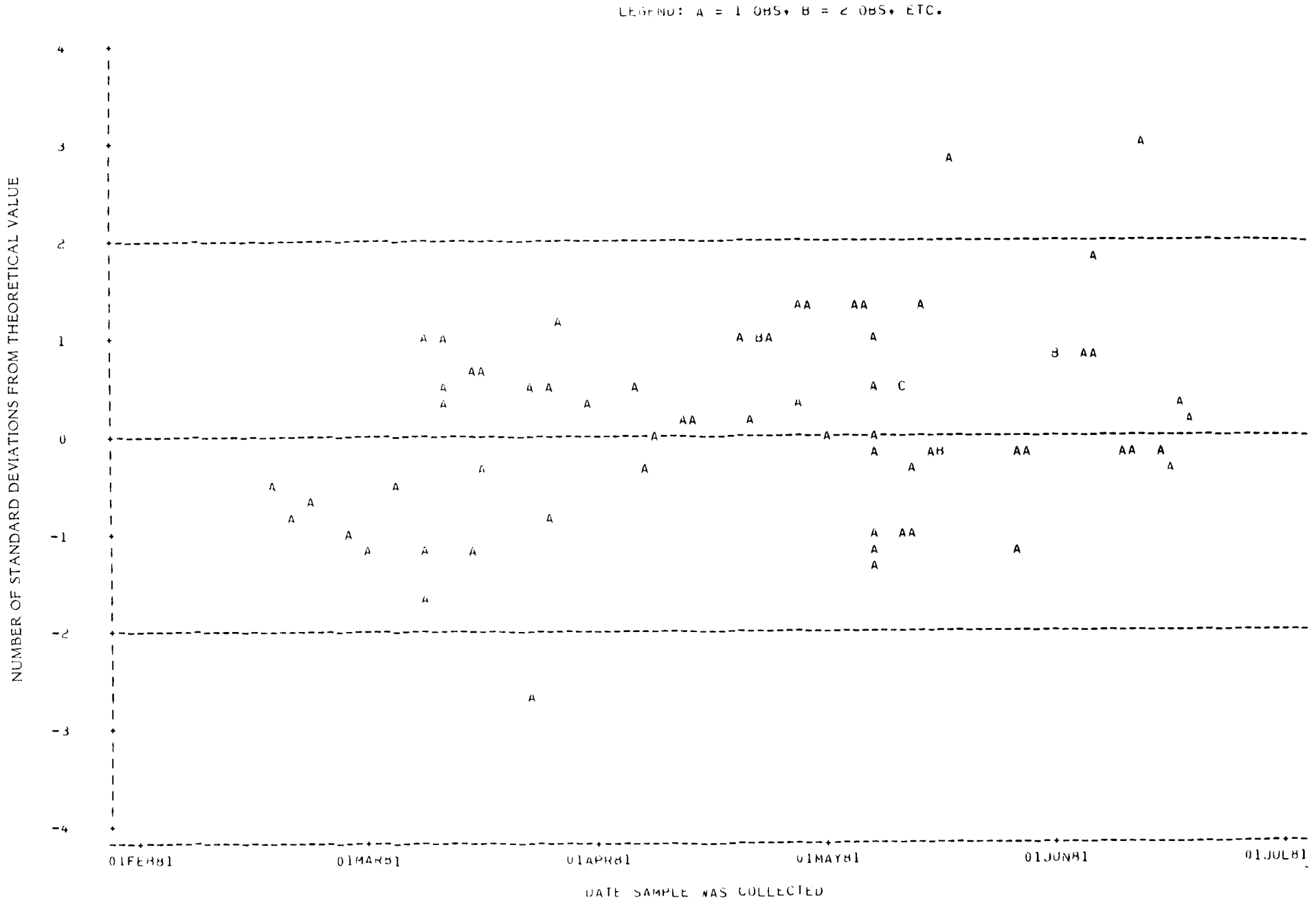

Figure A1.2.17.--Copper data for the Denver Laboratory.
(One observation was out of range.)

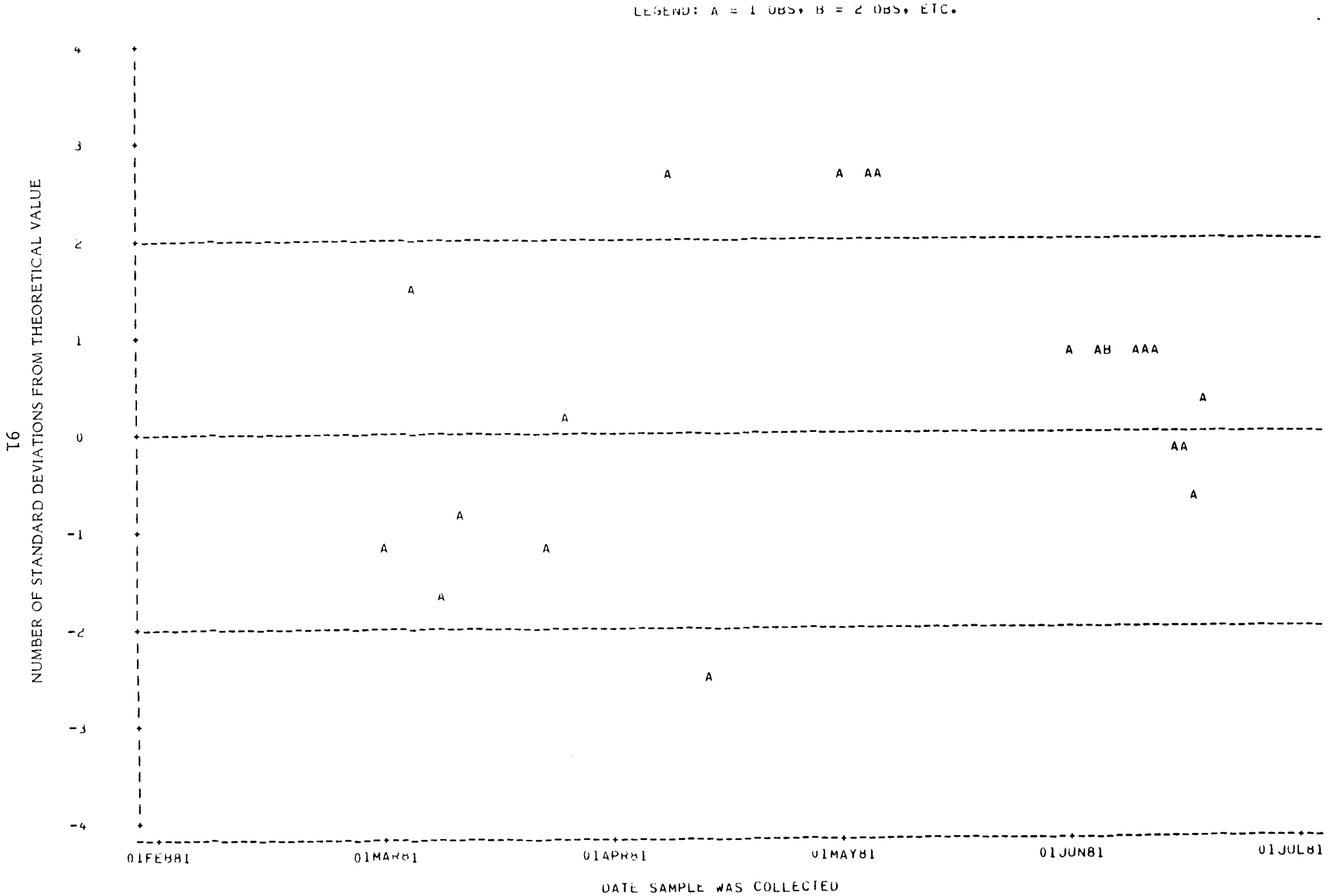

Figure A1.2.18.--Copper, total recoverable data for the Denver Laboratory.
(Three observations were out of range.)

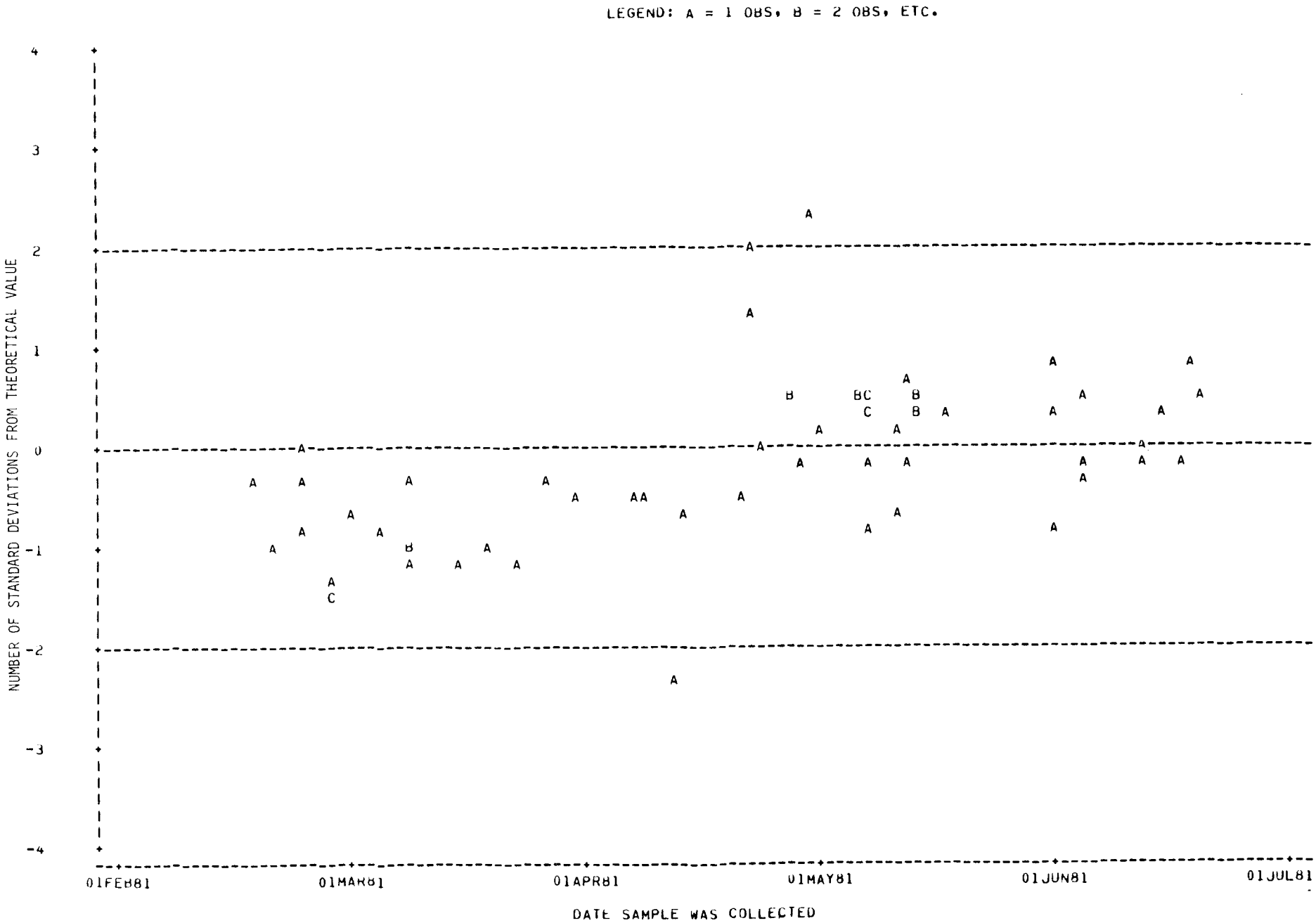

Figure A1.2.19.--Dissolved solids data for the Denver Laboratory.

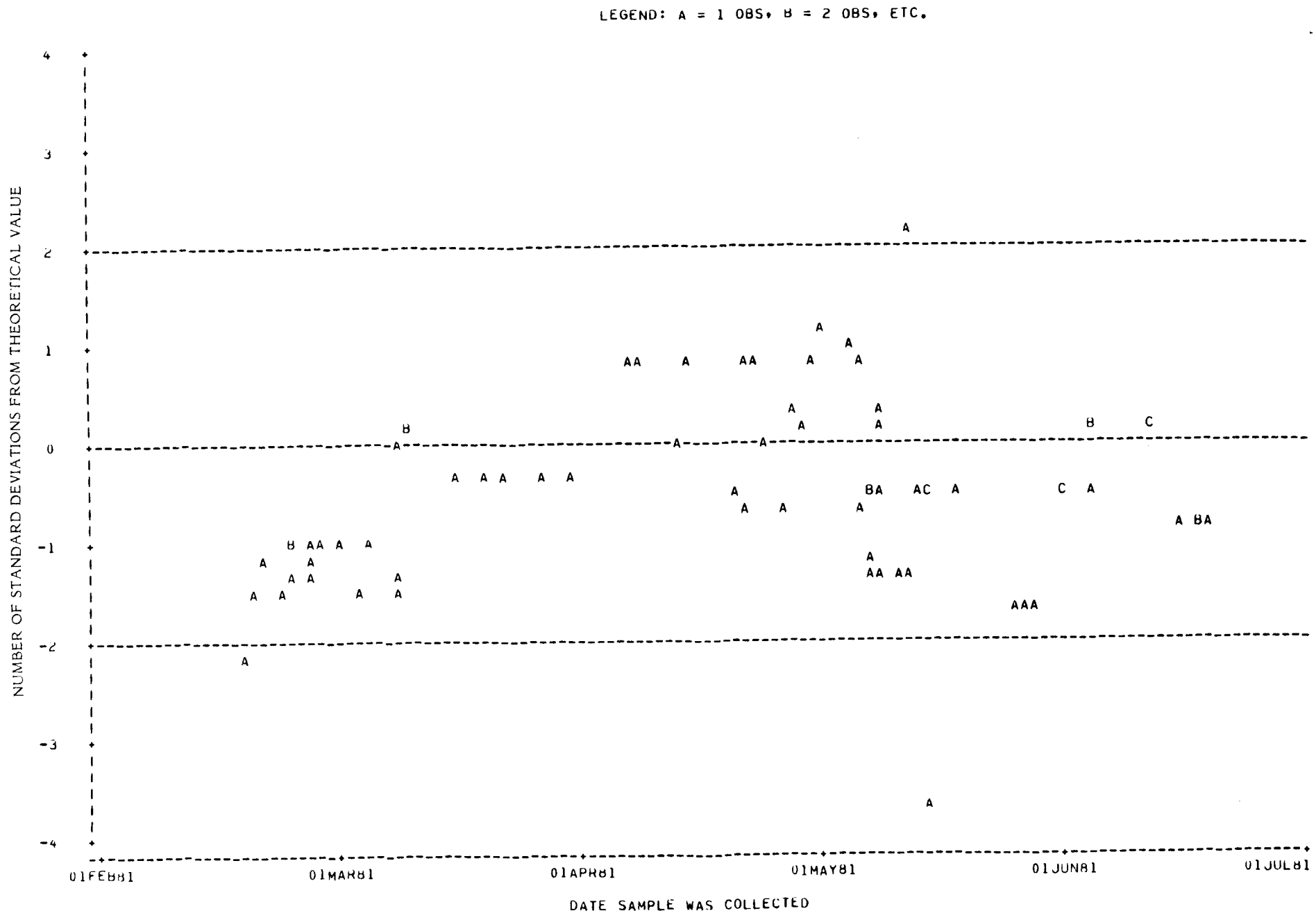

Figure A1.2.20.--Fluoride data for the Denver Laboratory.
(Two observations were out of range.)

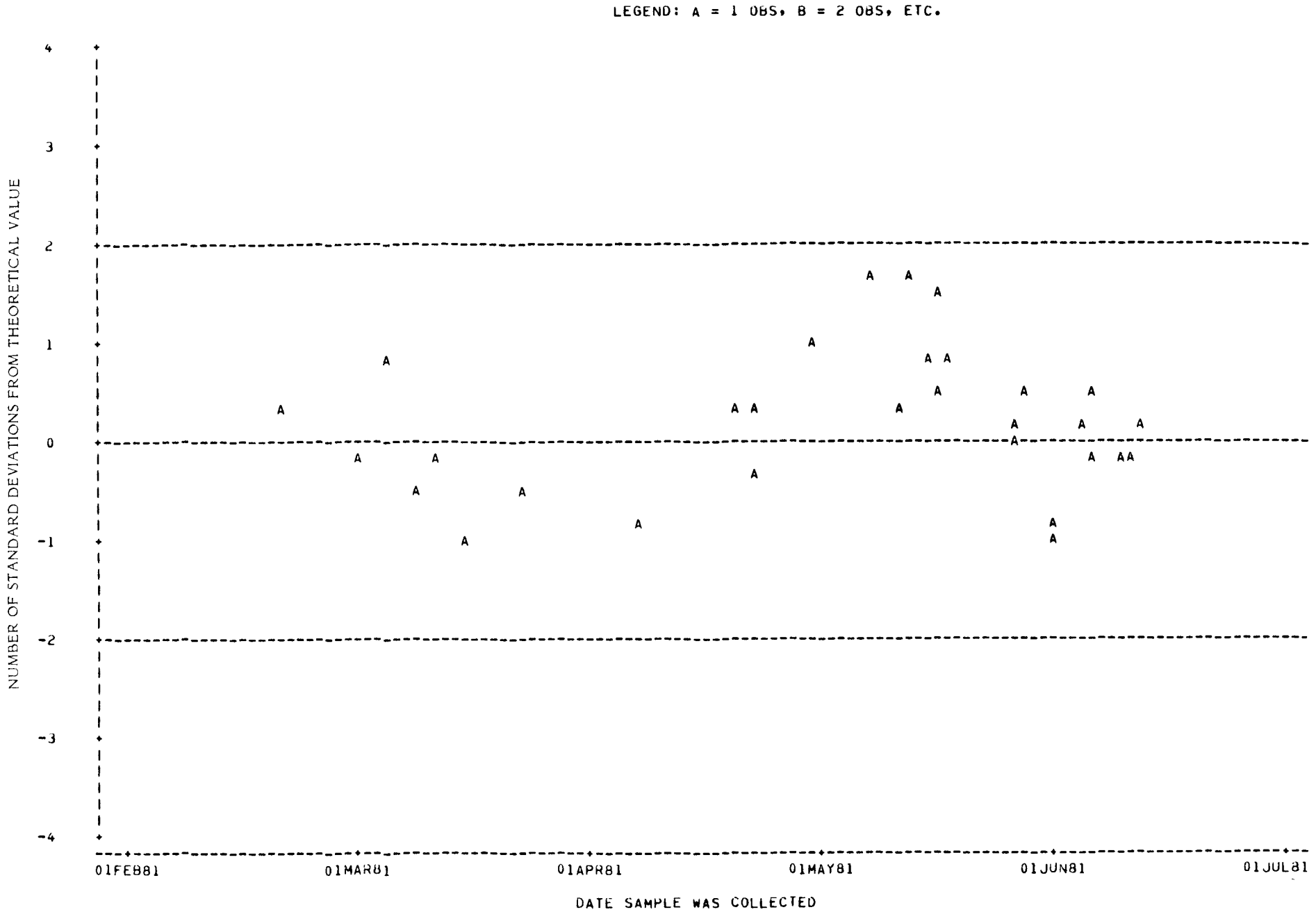

Figure A1.2.21.--Iron data for the Denver Laboratory.
(One observation was out of range.)

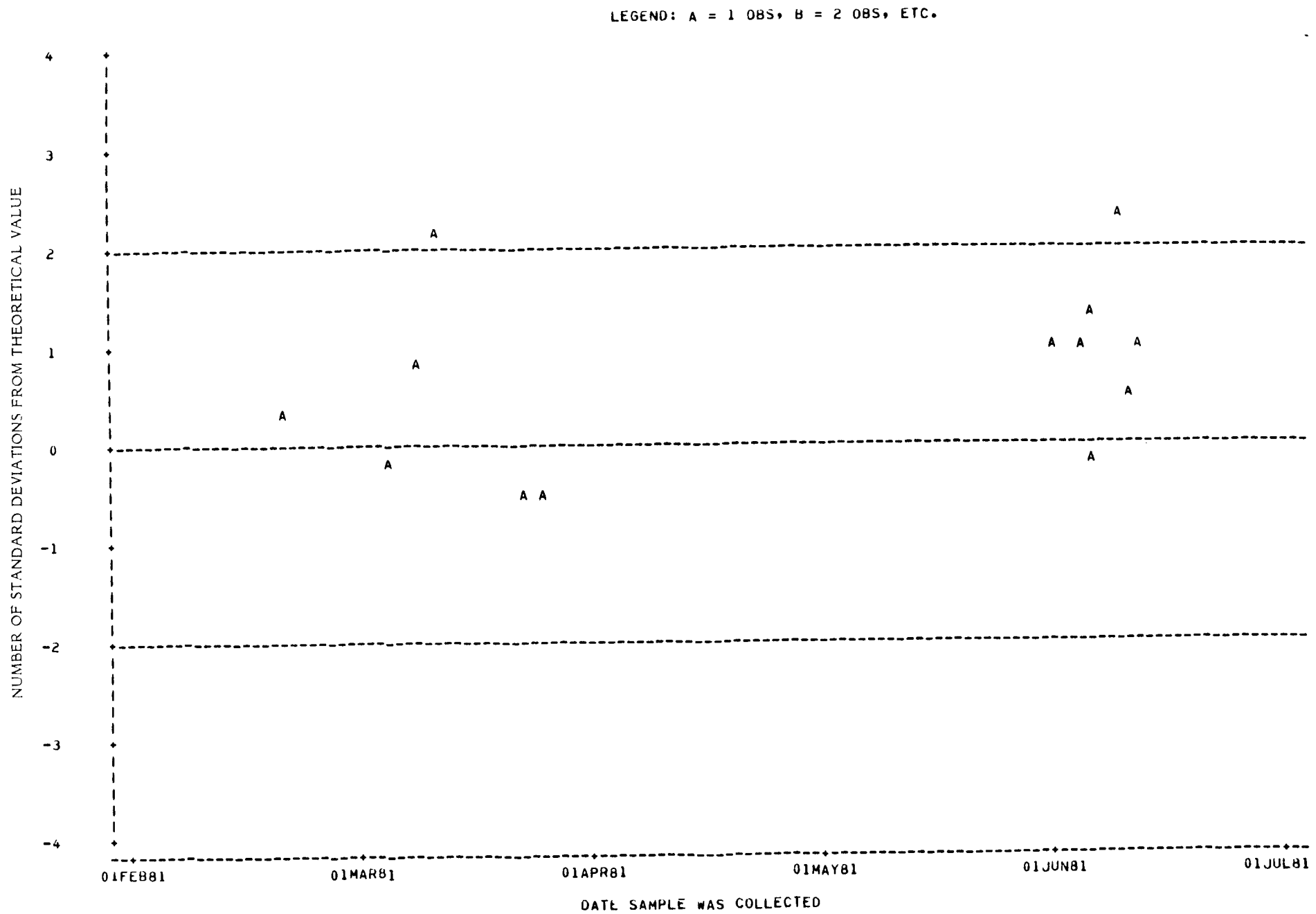

Figure A1.2.22.--Iron, total recoverable data for the Denver Laboratory.
(One observation was out of range.)

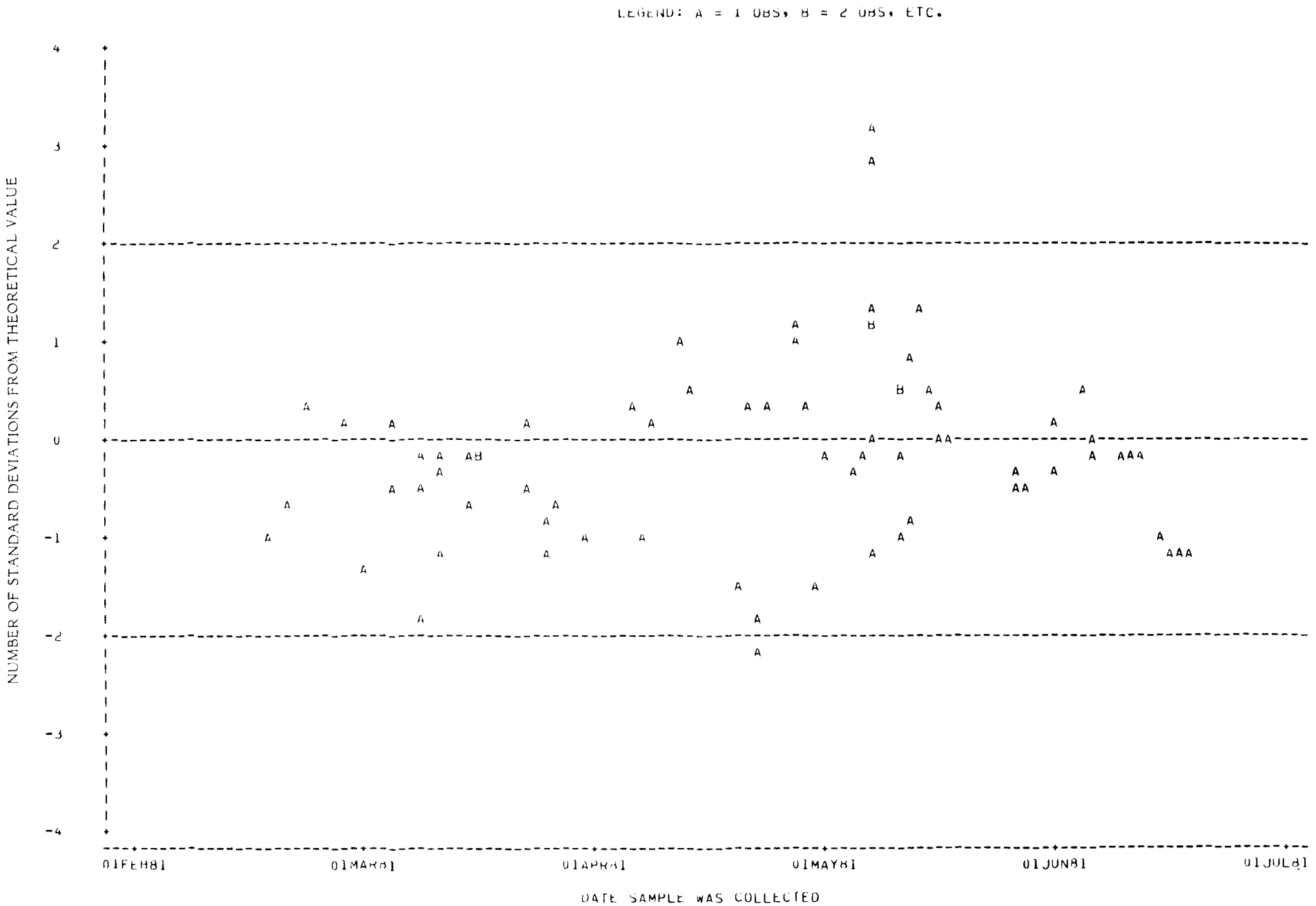

Figure A1.2.23.--Lead data for the Denver Laboratory.

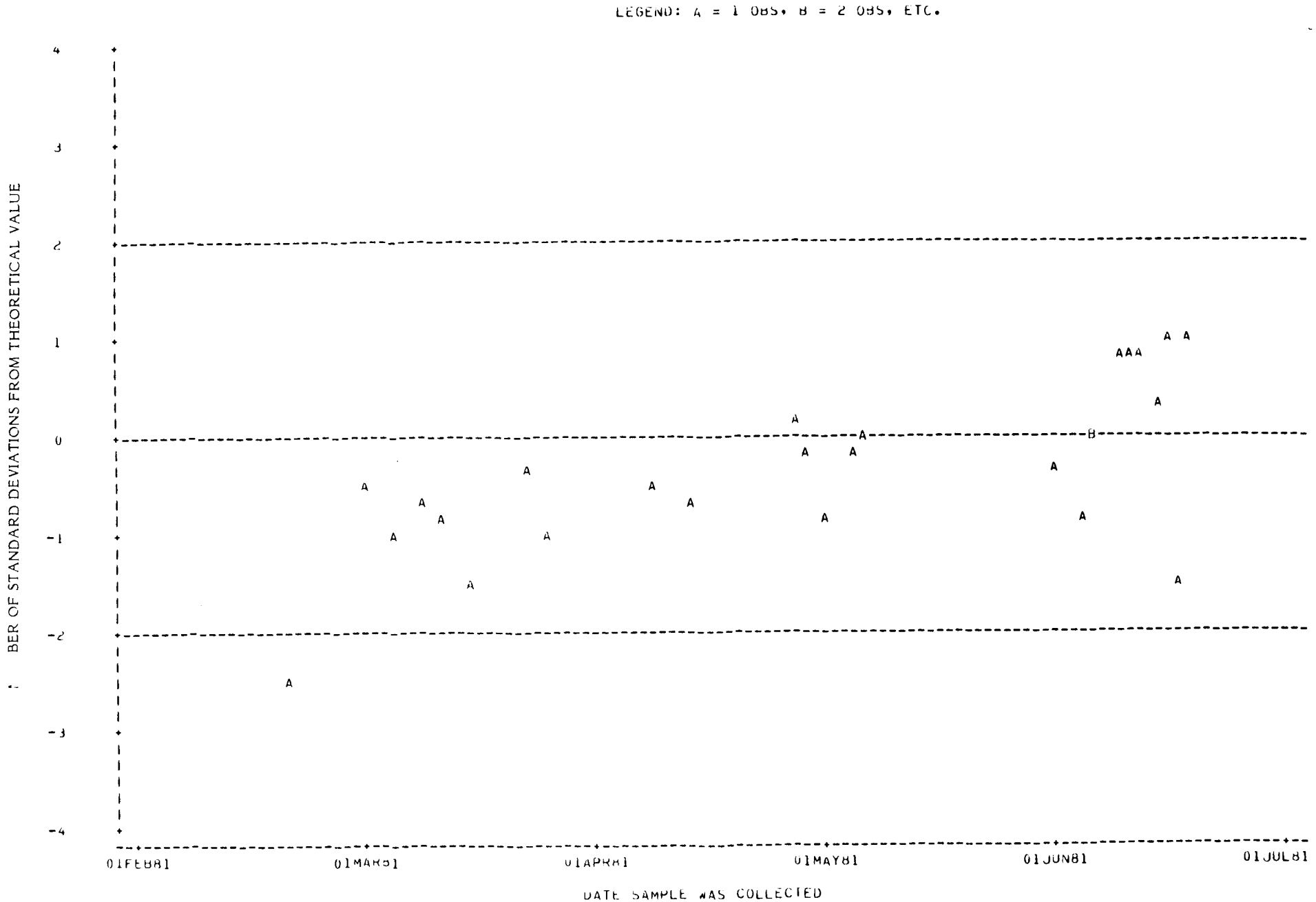

Figure A1.2.24.--Lead, total recoverable data for the Denver Laboratory.

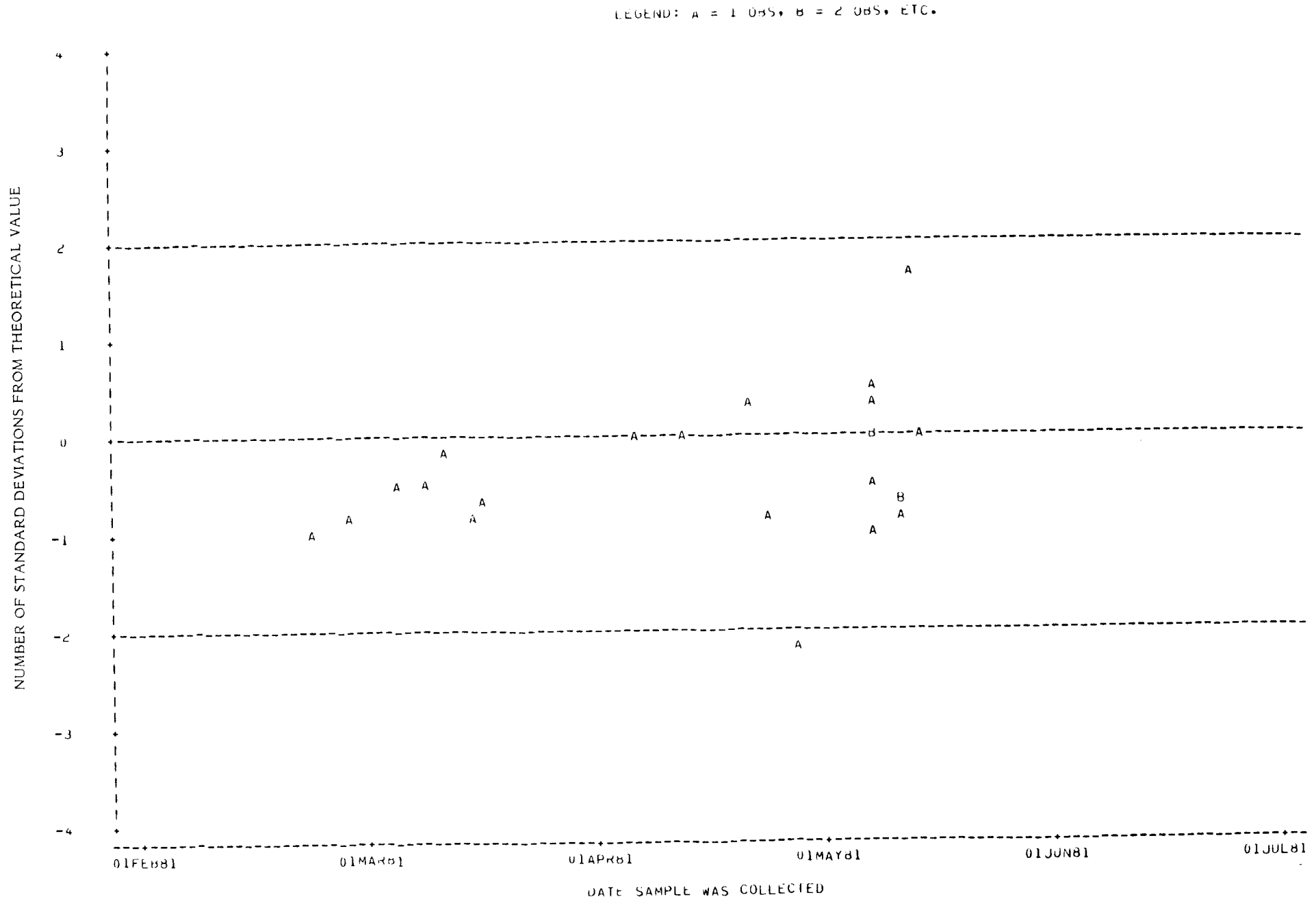

Figure A1.2.25.--Lithium data for the Denver Laboratory.

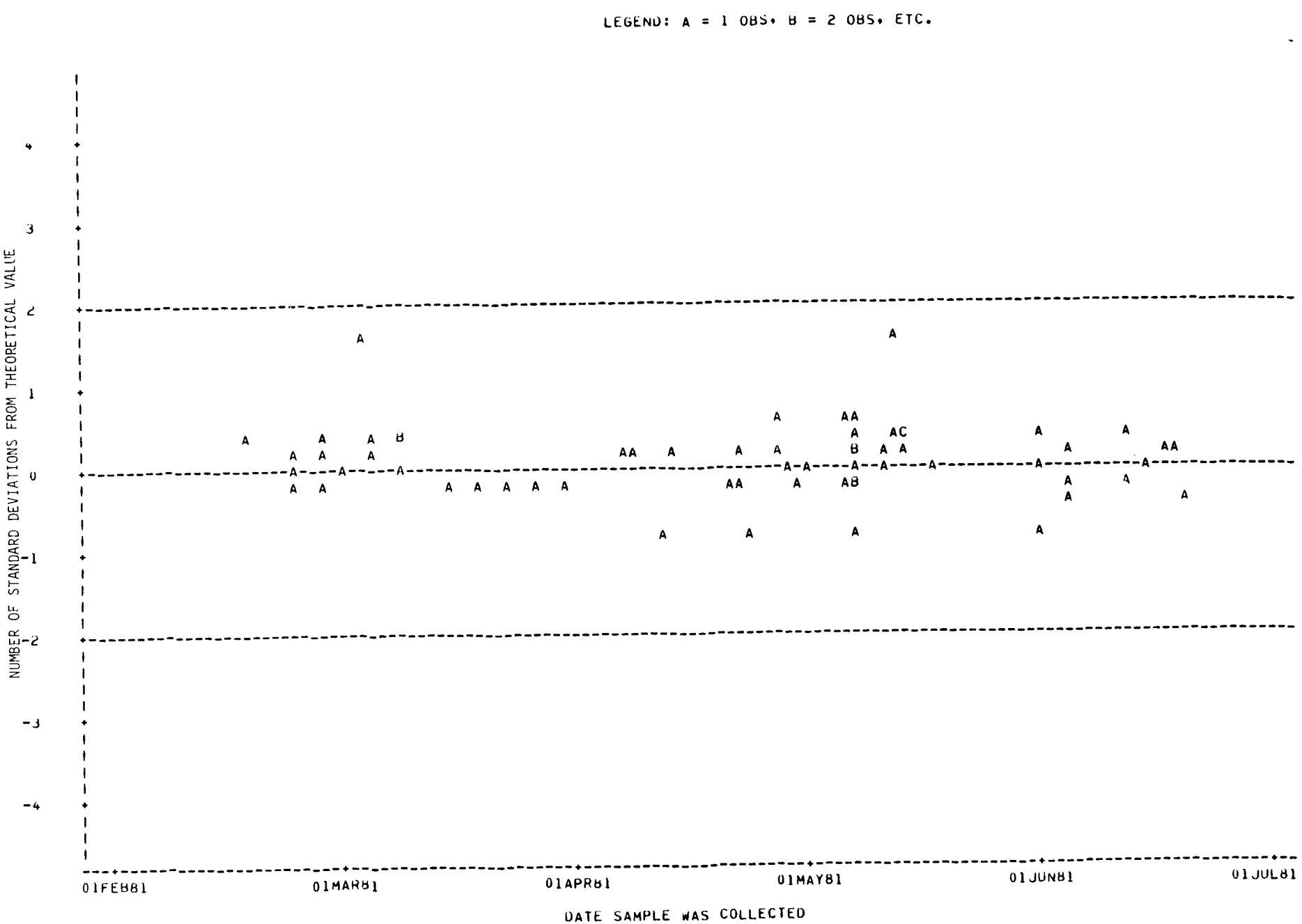

Figure A1.2.26.--Magnesium data for the Denver Laboratory.

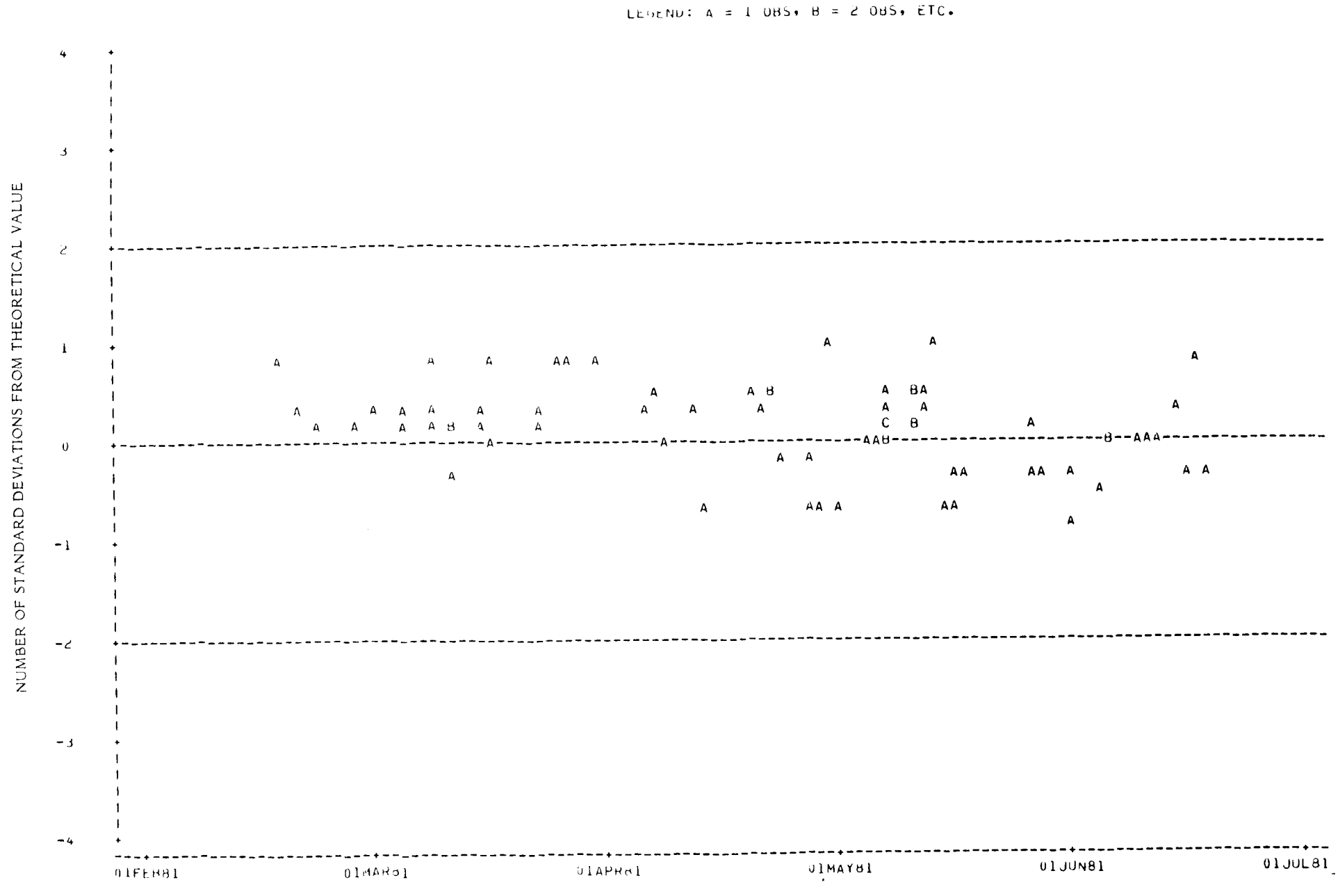

Figure A1.2.27.-- Manganese data for the Denver Laboratory.
(One observation was out of range.)

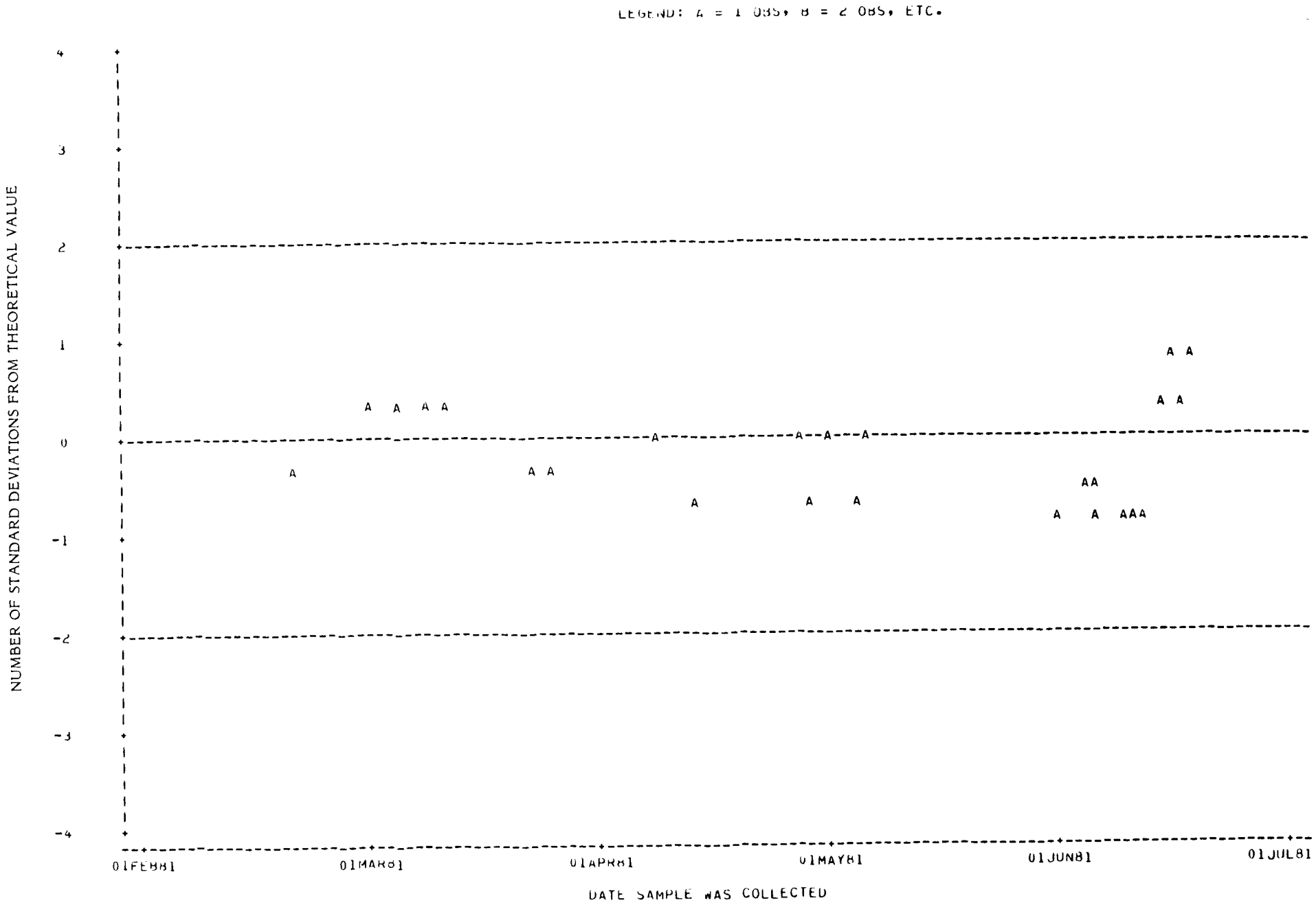

Figure A1.2.28.--Manganese, total recoverable data for the Denver Laboratory.

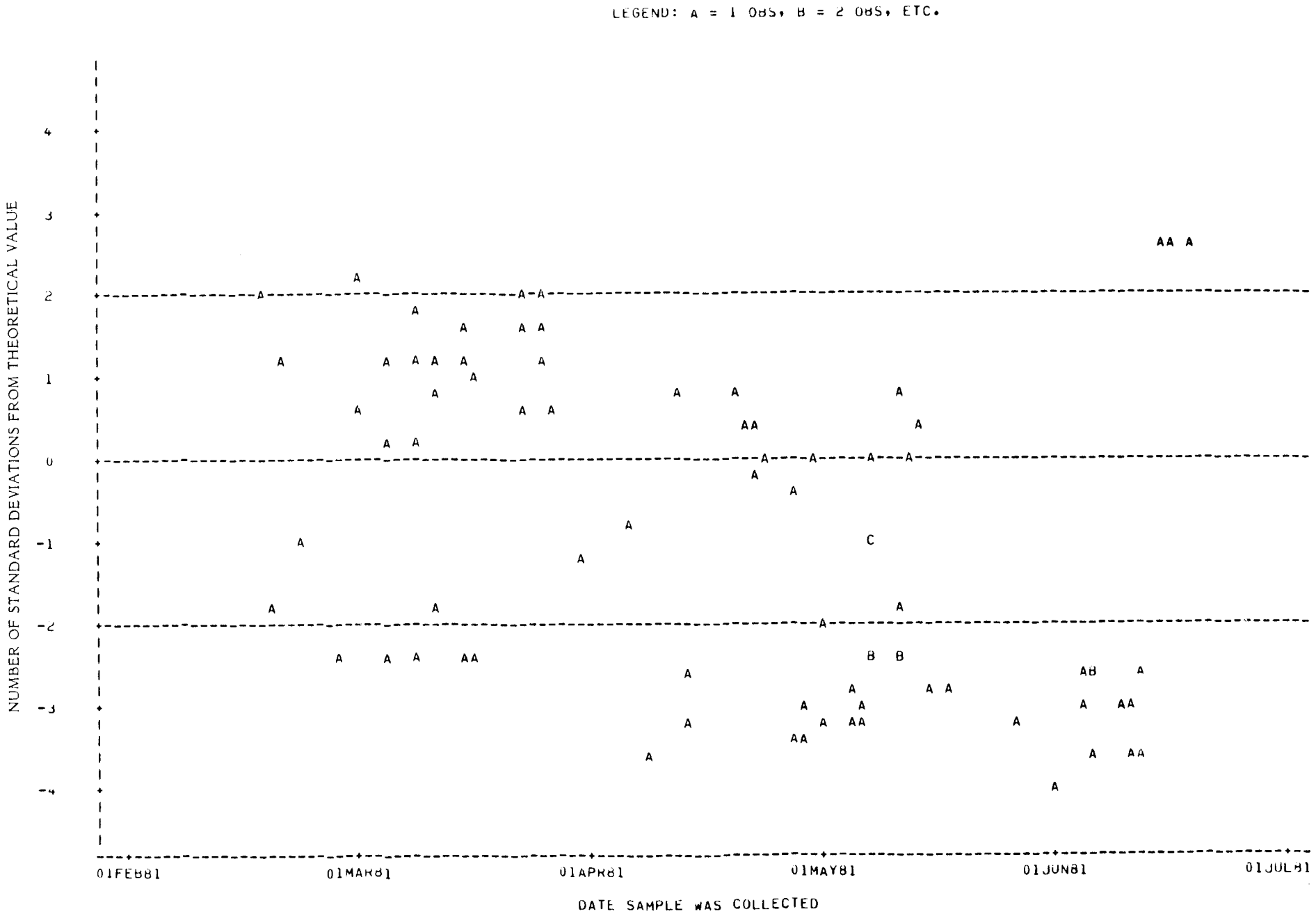

Figure A1.2.29.--Mercury data for the Denver Laboratory.
(Fifteen observations were out of range.)

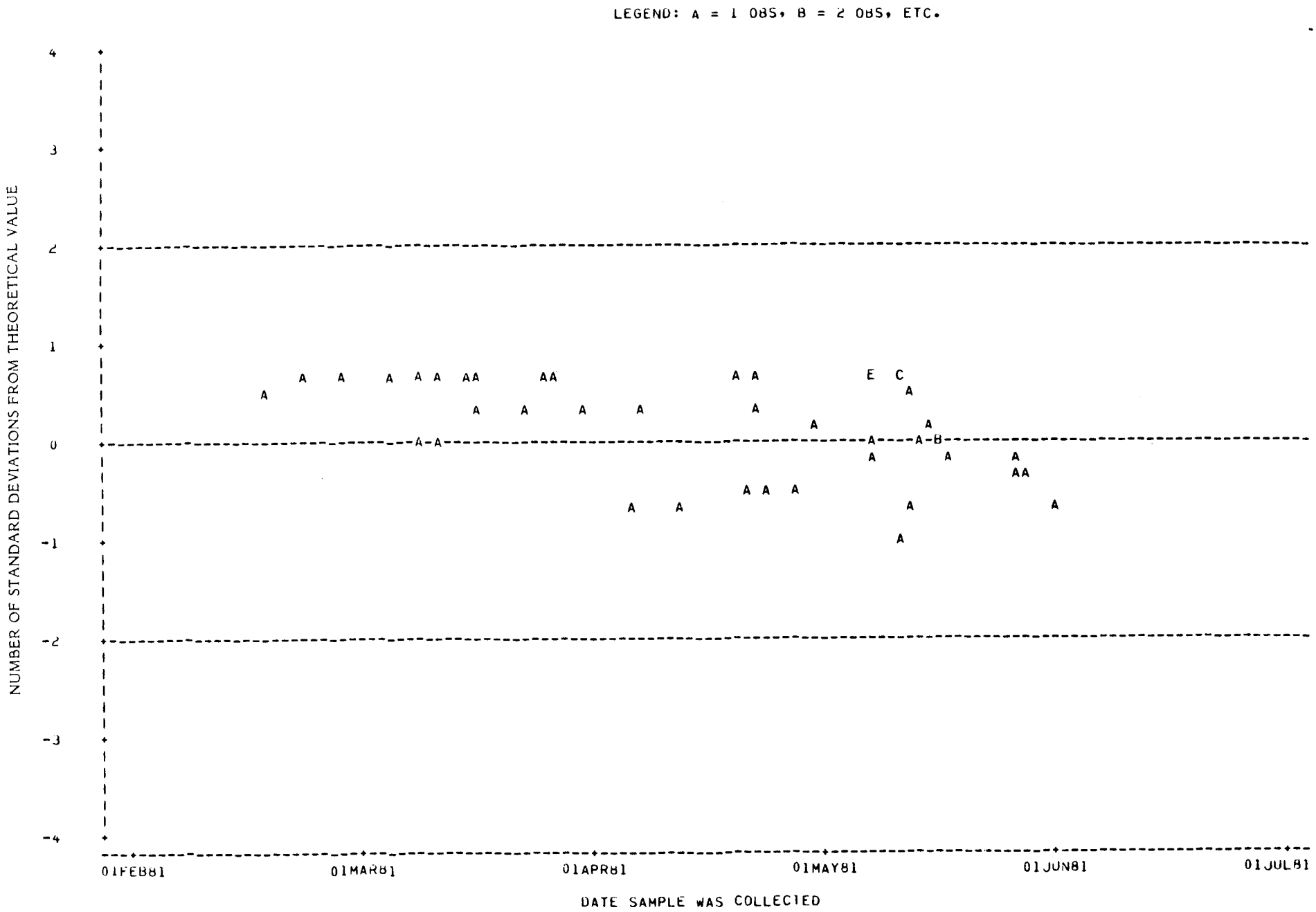

Figure A1.2.30.--Molybdenum data for the Denver Laboratory.

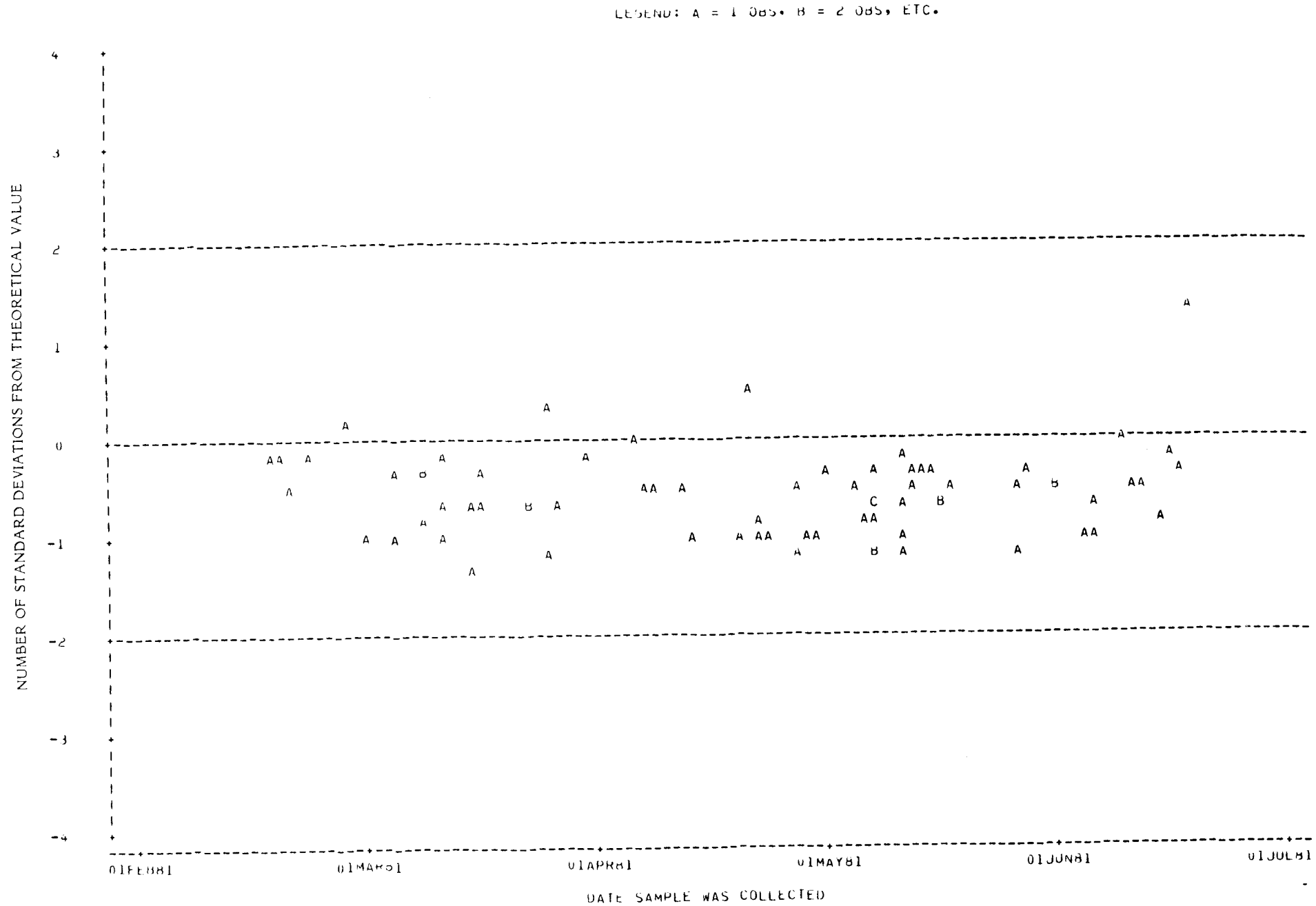

Figure A1.2.31.--Nickel data for the Denver Laboratory.

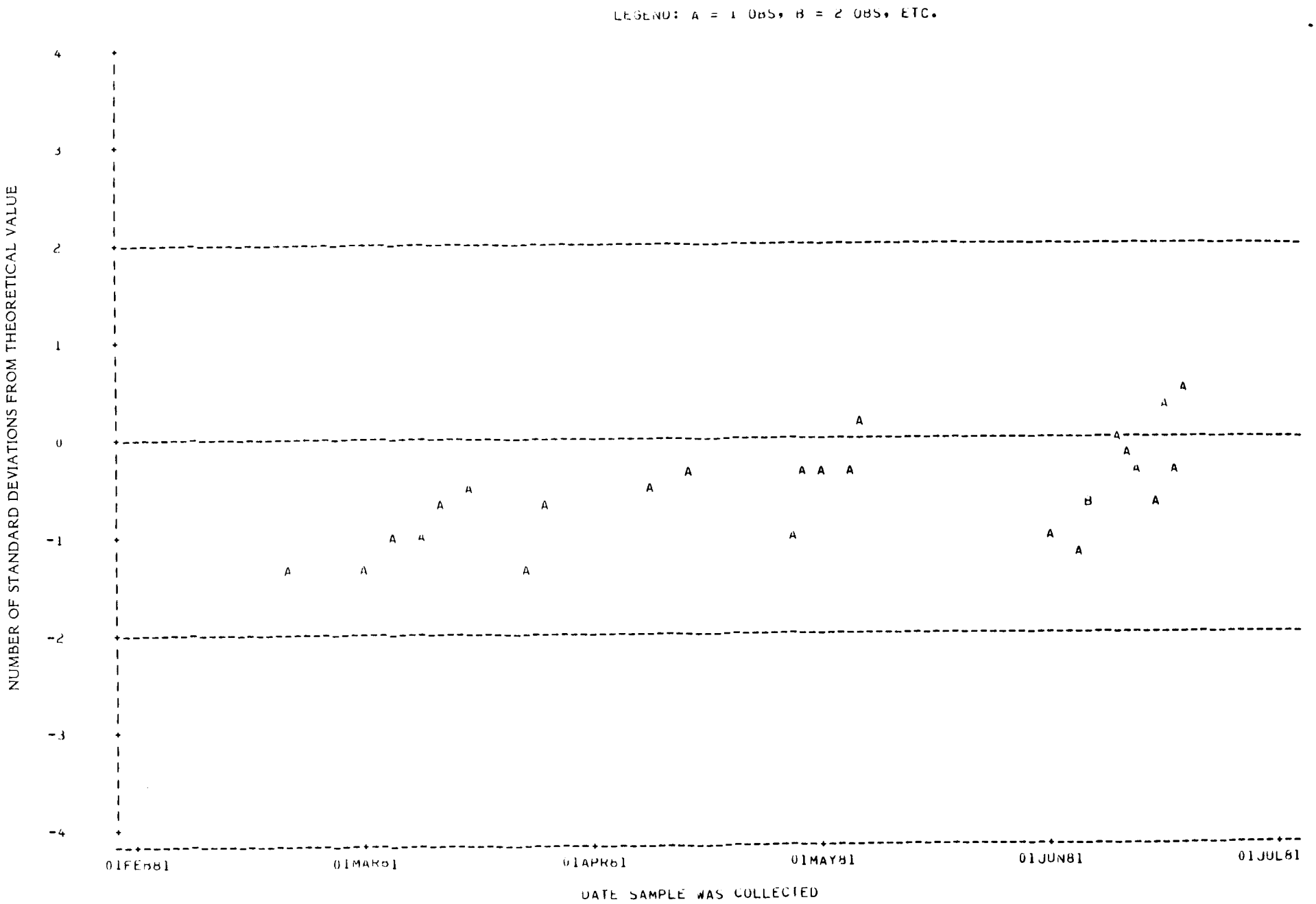

Figure A1.2.32.--Nickel, total recoverable data for the Denver Laboratory.

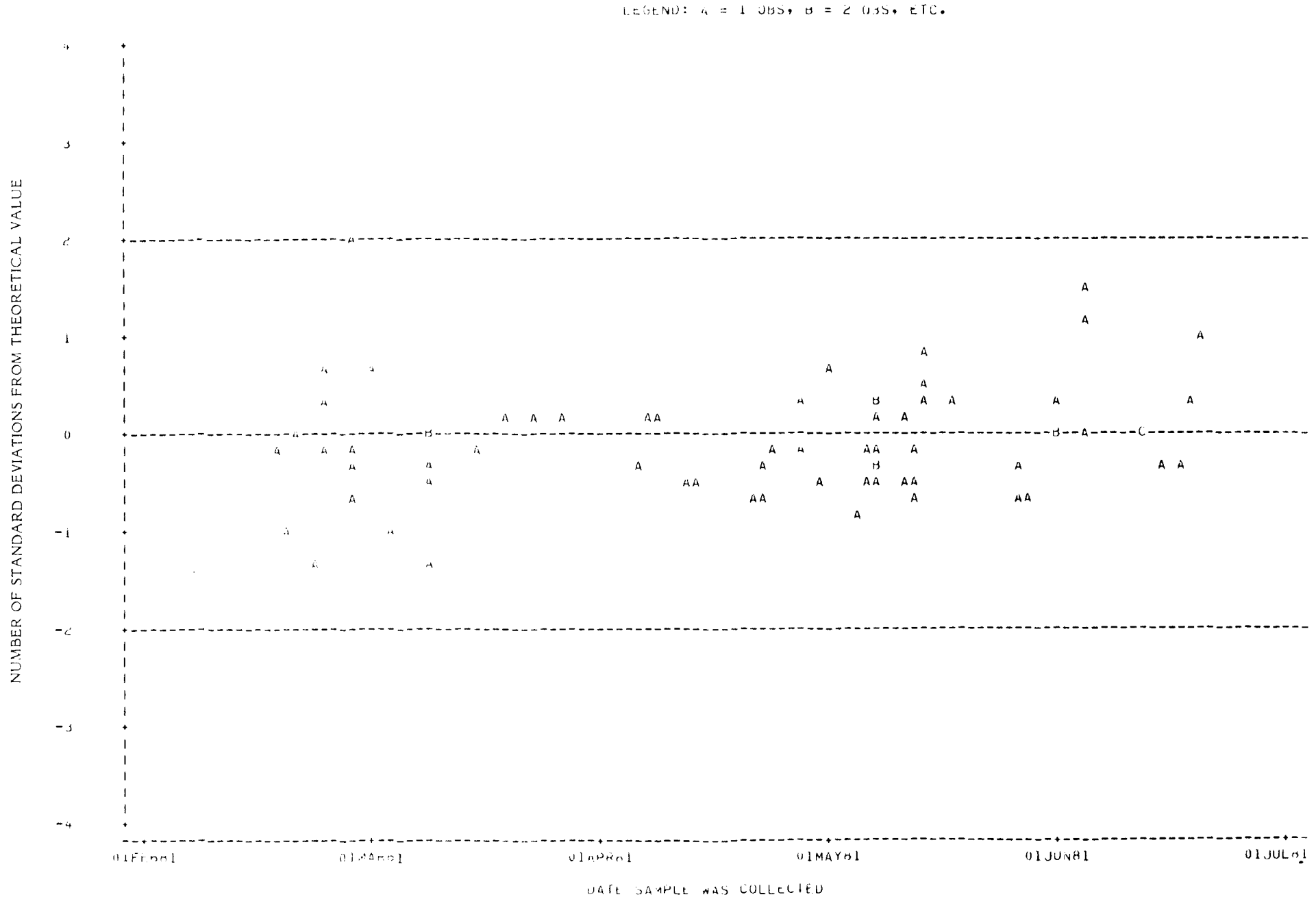

Figure A1.2.33.--Nitrate plus nitrite-nitrogen data for the Denver Laboratory.
(Six observations were out of range.)

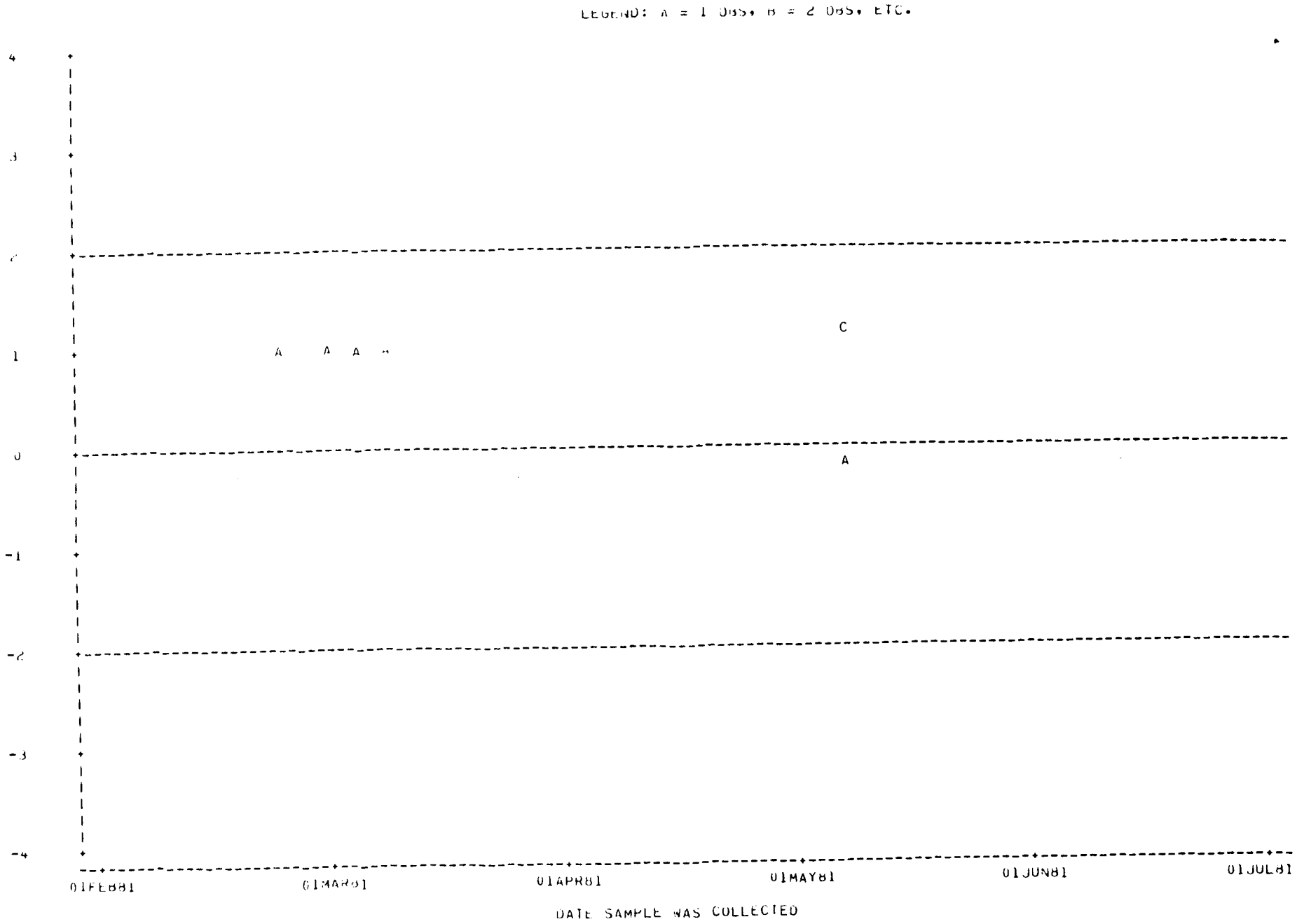

Figure A1.2.-34.--Nitrite-nitrogen data for the Denver Laboratory.

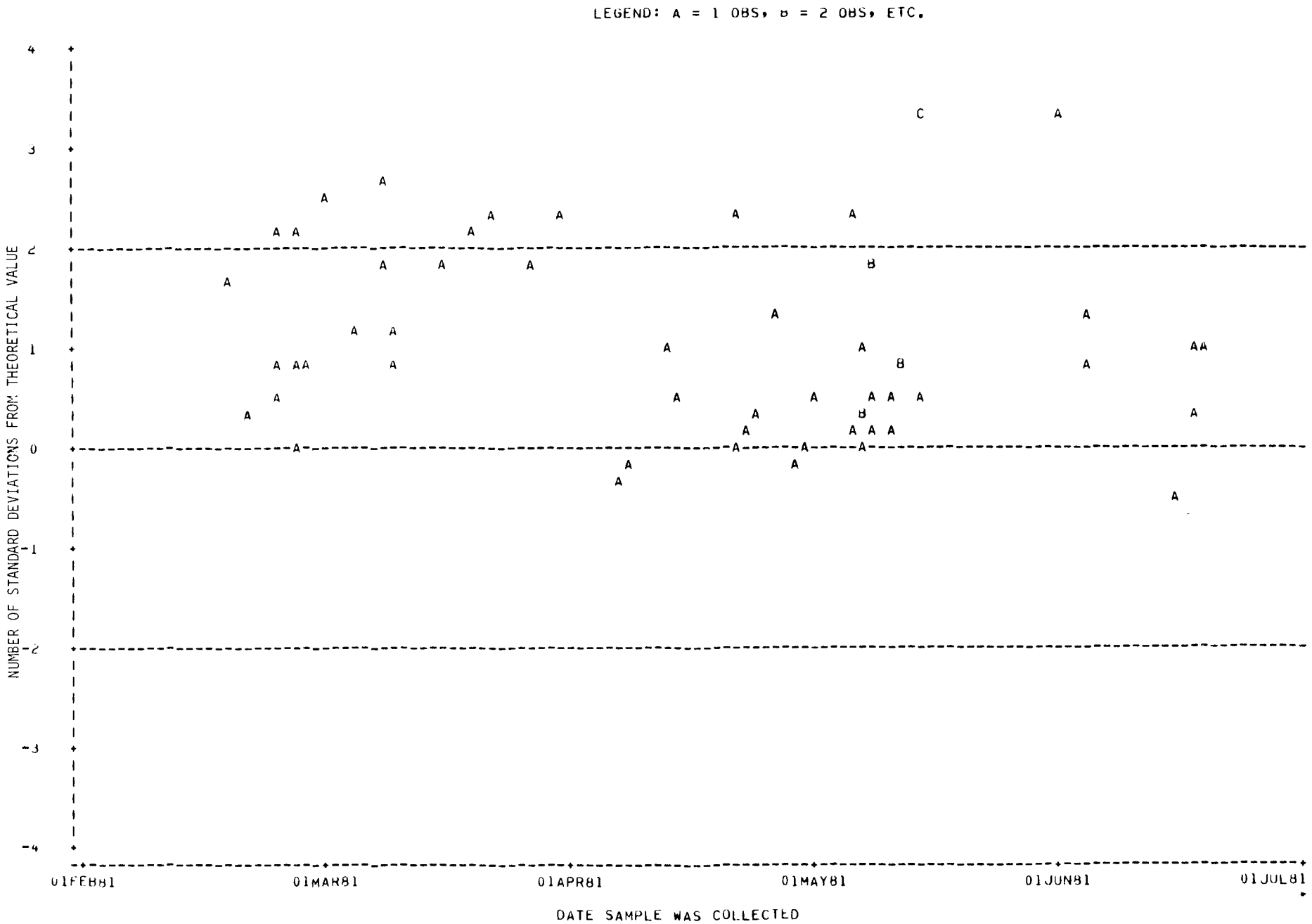

Figure A1.2.35.--Phosphorous data for the Denver Laboratory.
(Seven observations were out of range.)

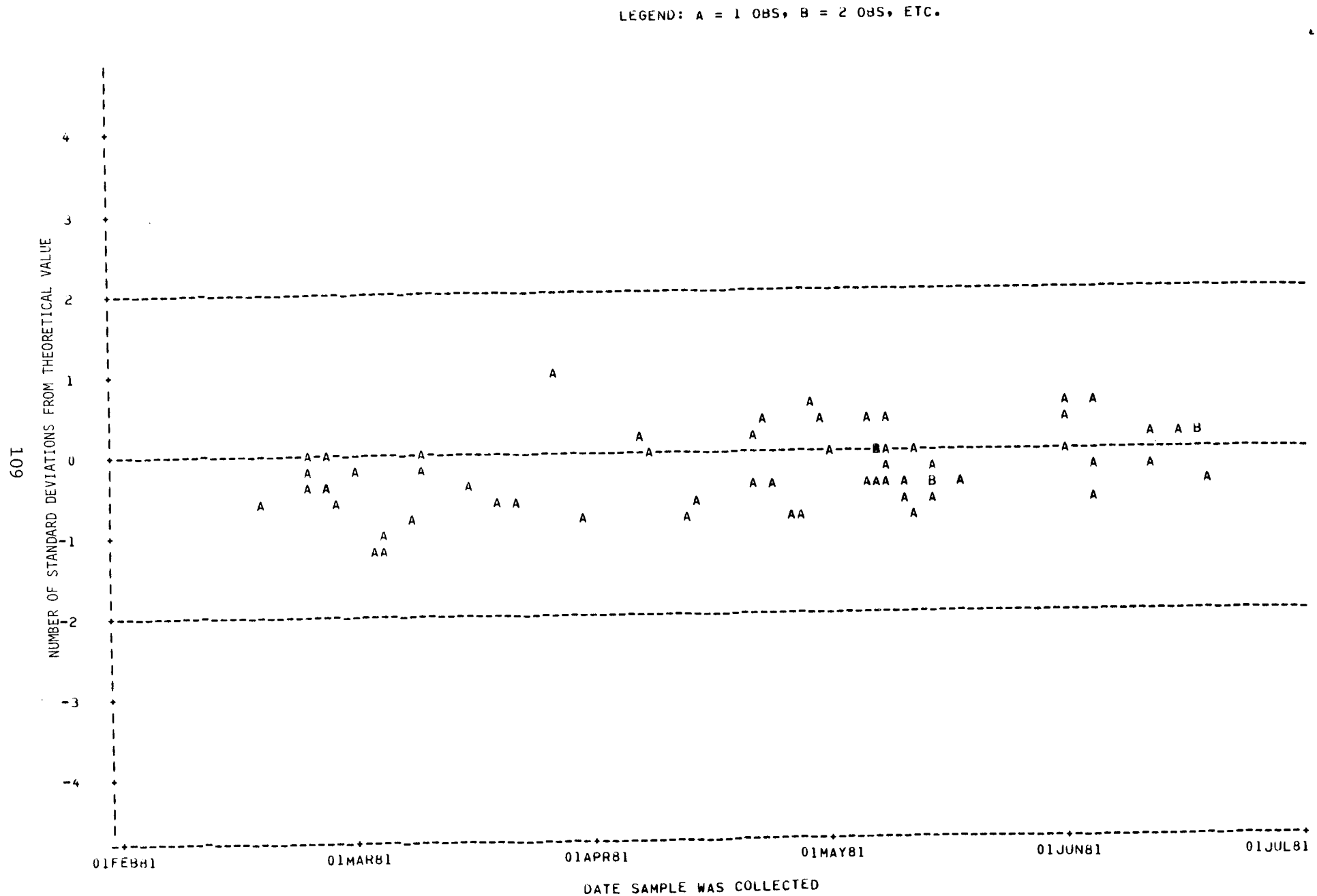

Figure A1.2.36.--Potassium data for the Denver Laboratory.

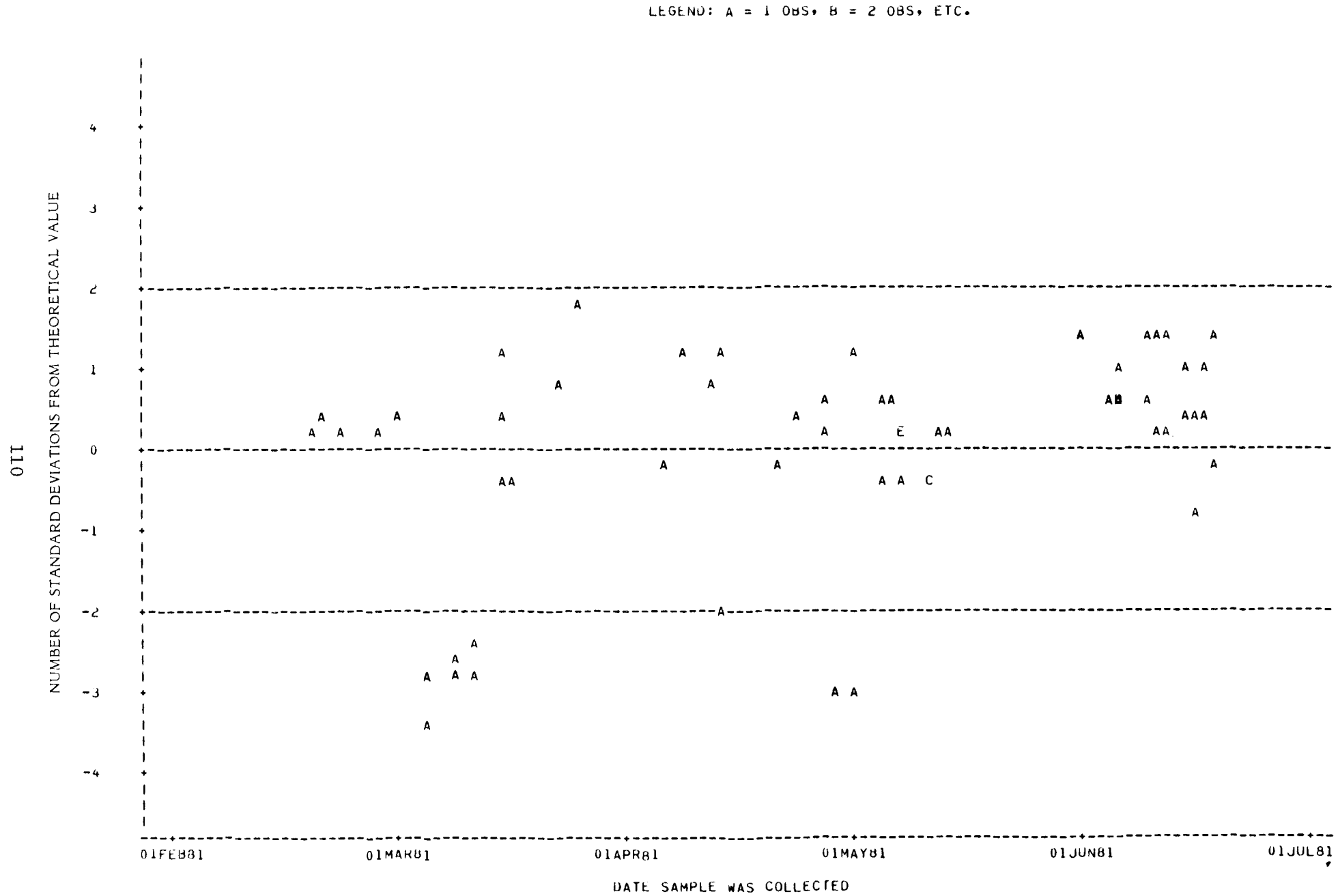

Figure A1.2.37.--Selenium data for the Denver Laboratory.
(One observation was out of range.)

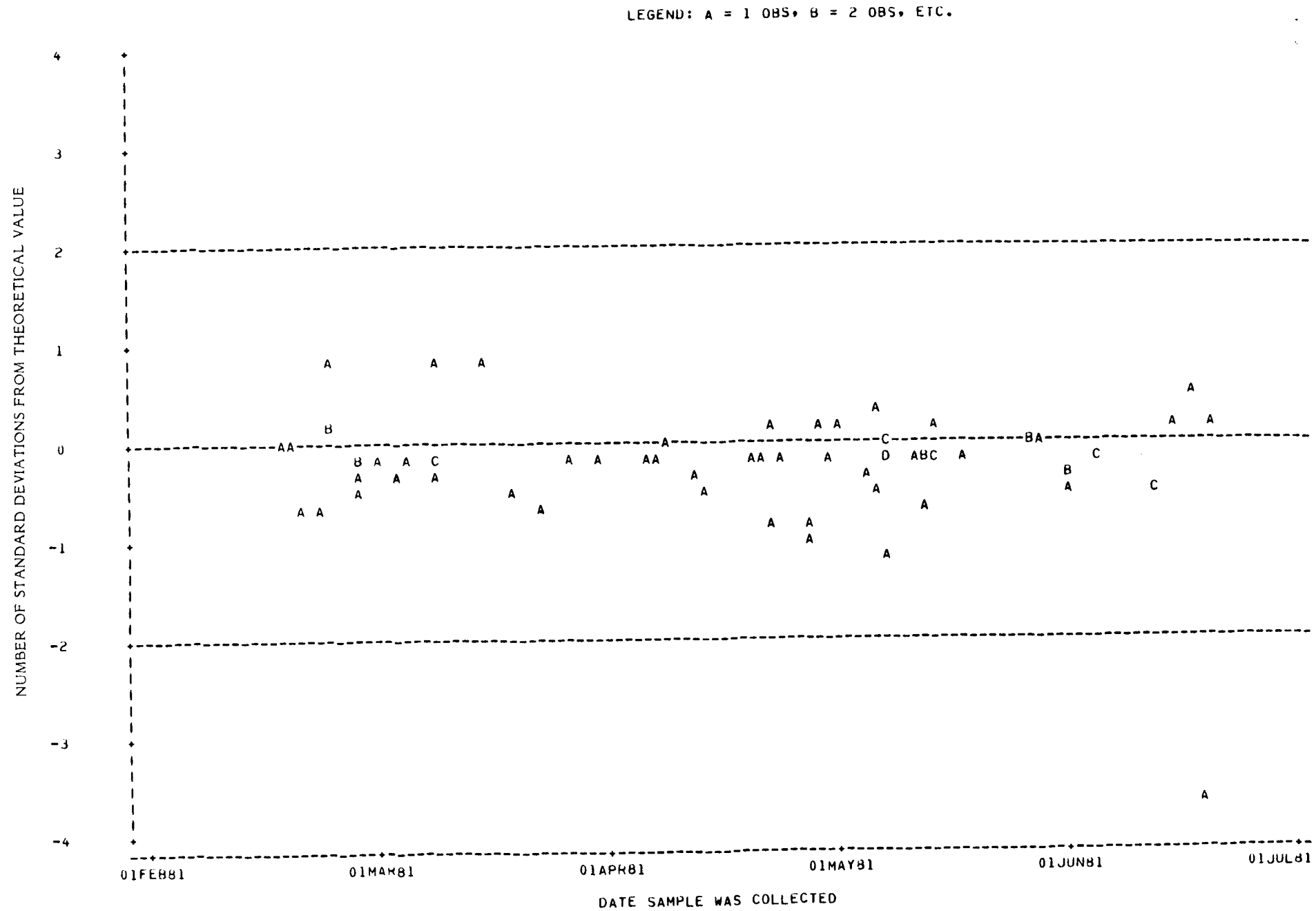

Figure A1.2.38.--Silica data for the Denver Laboratory.
(One observation was out of range.)

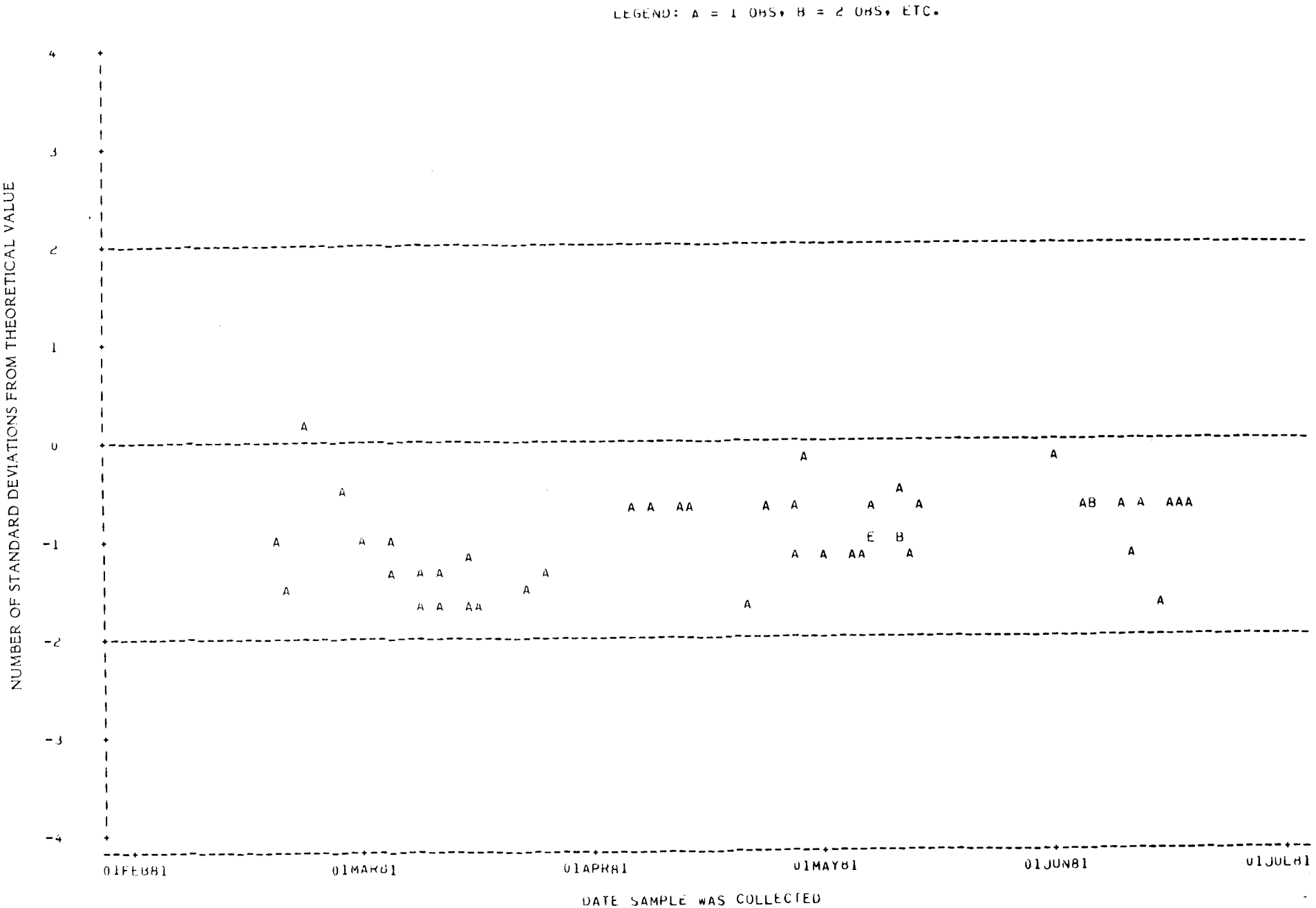

Figure A1.2.39.--Silver data for the Denver Labortory.
(One observation was out of range.)

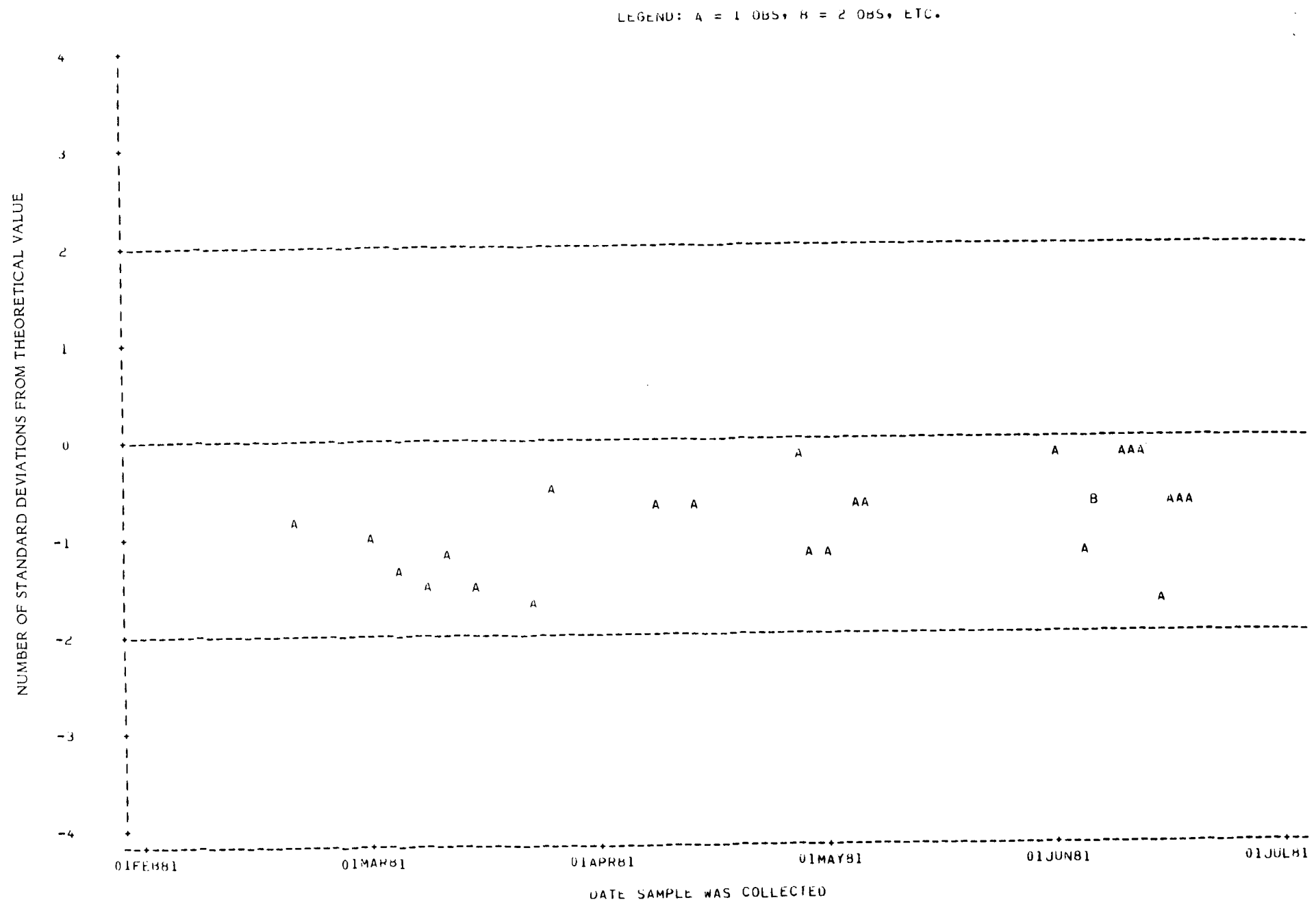

Figure A1.2.40.--Silver, total recoverable data for the Denver Laboratory.

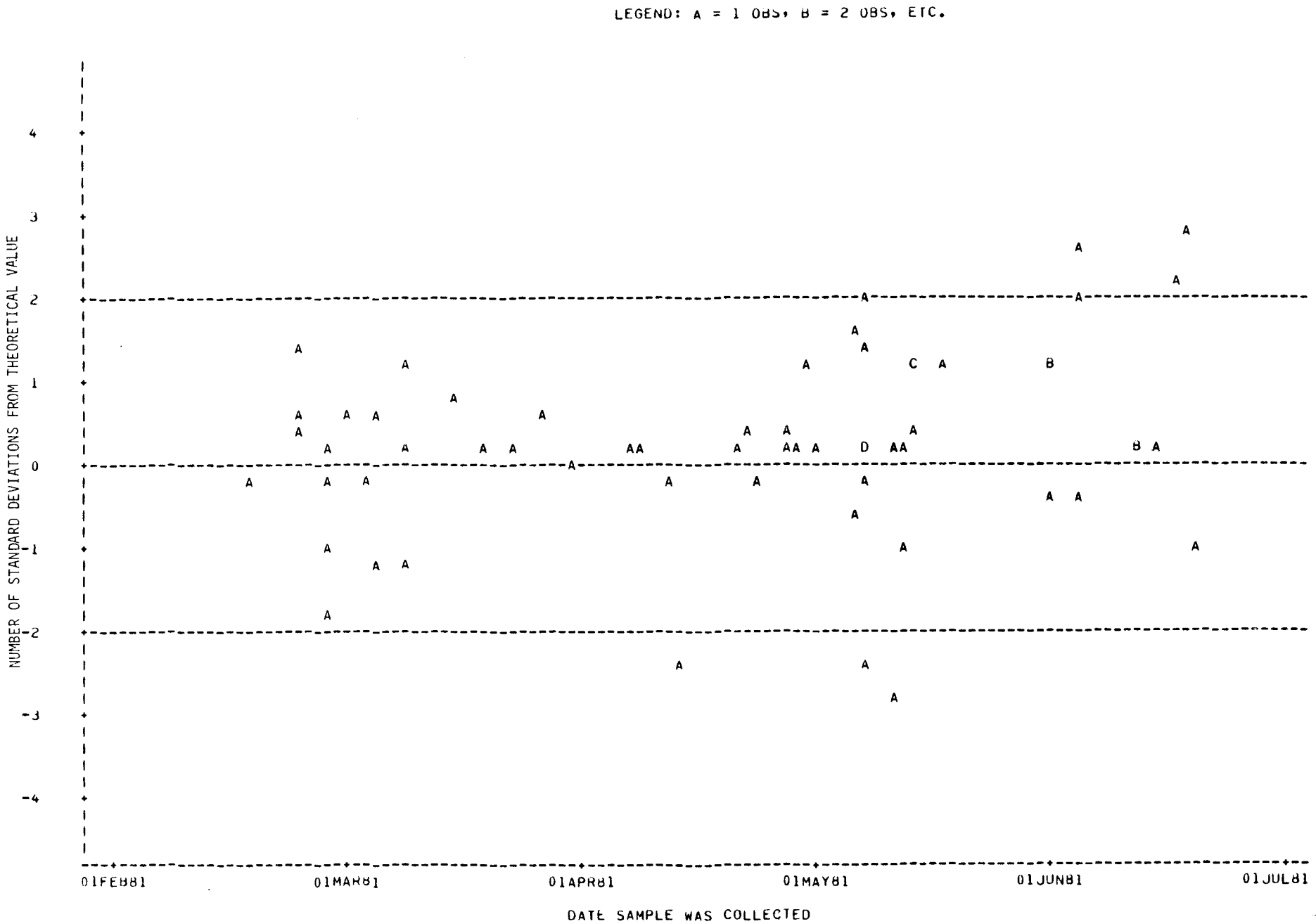

Figure A1.2.41.--Sodium data for the Denver Laboratory.

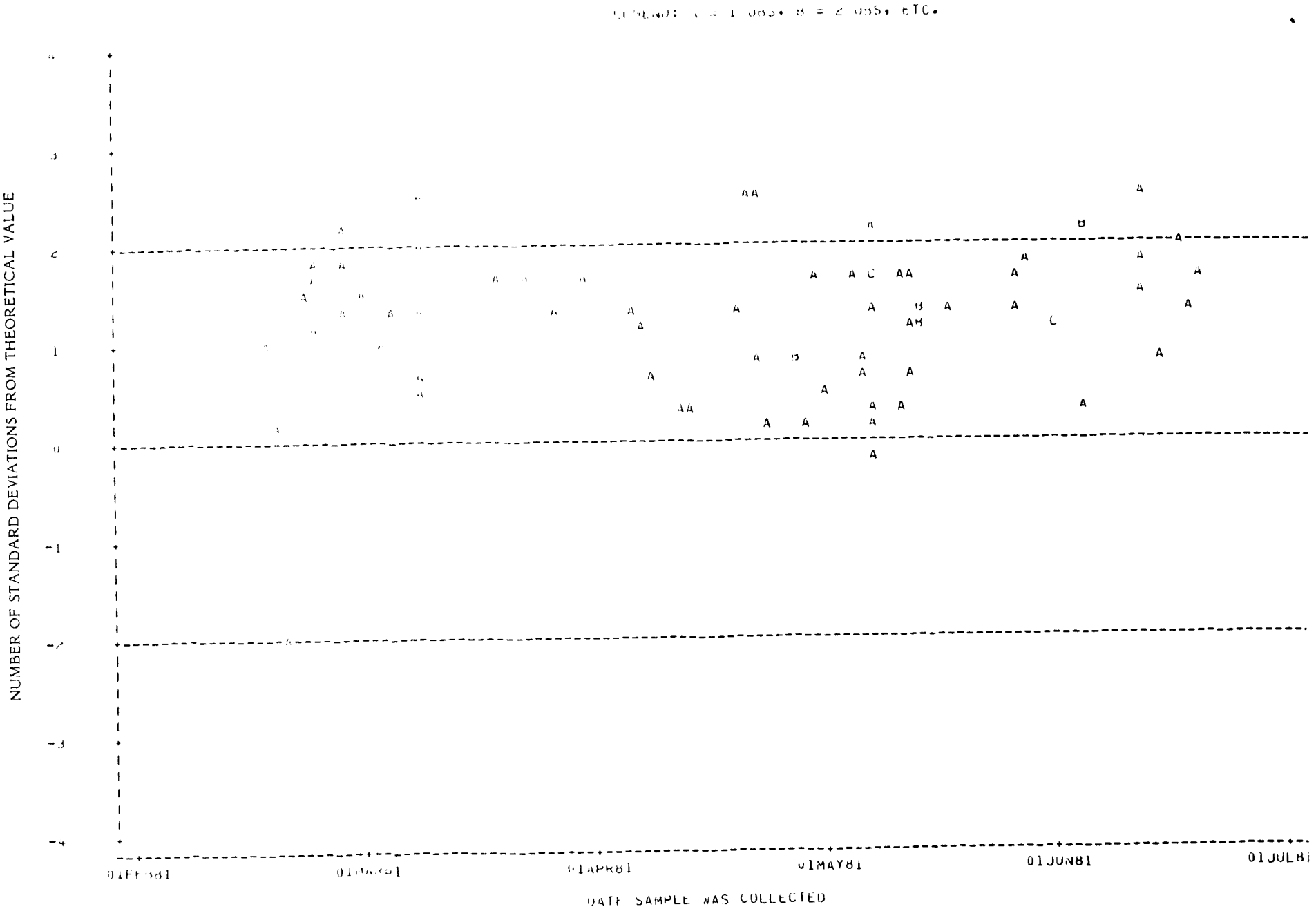

Figure A1.2.42.--Specific conductance data for the Denver Laboratory.
(One observation was out of range.)

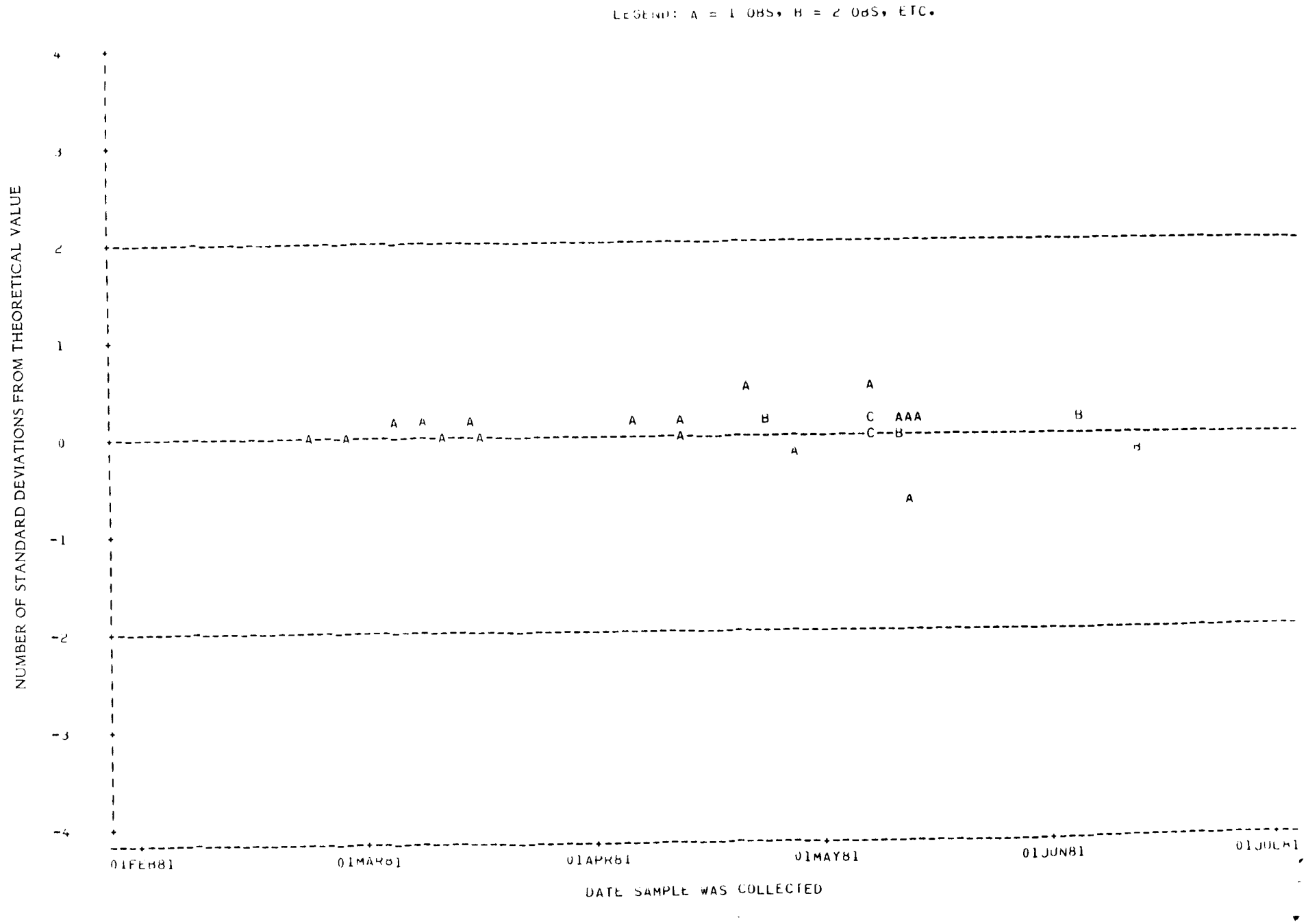

Figure A1.2.43.--Strontium data for the Denver Laboratory.

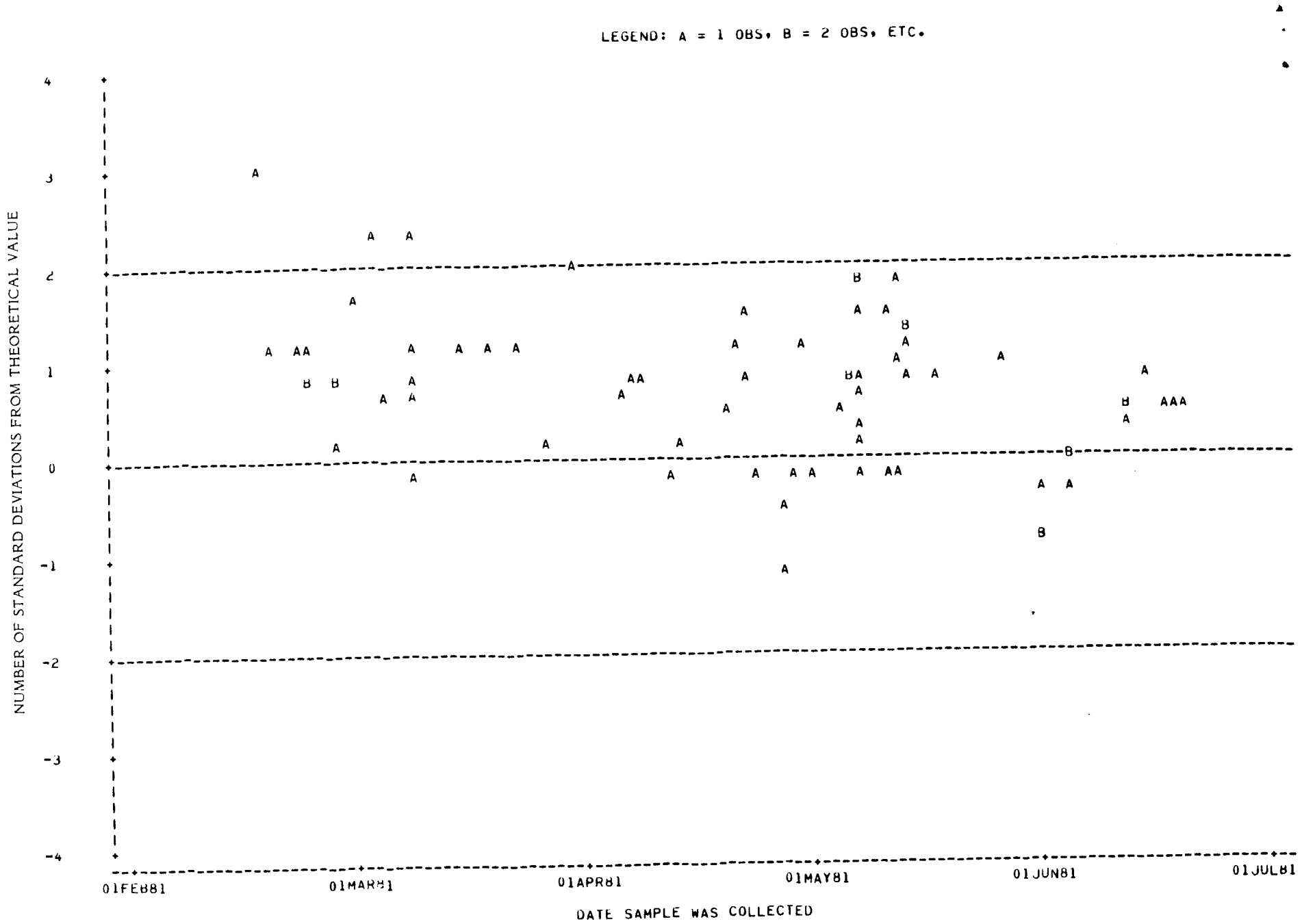

Figure A1.2.44.--Sulfate data for the Denver Laboratory.
(Four observations were out of range.)

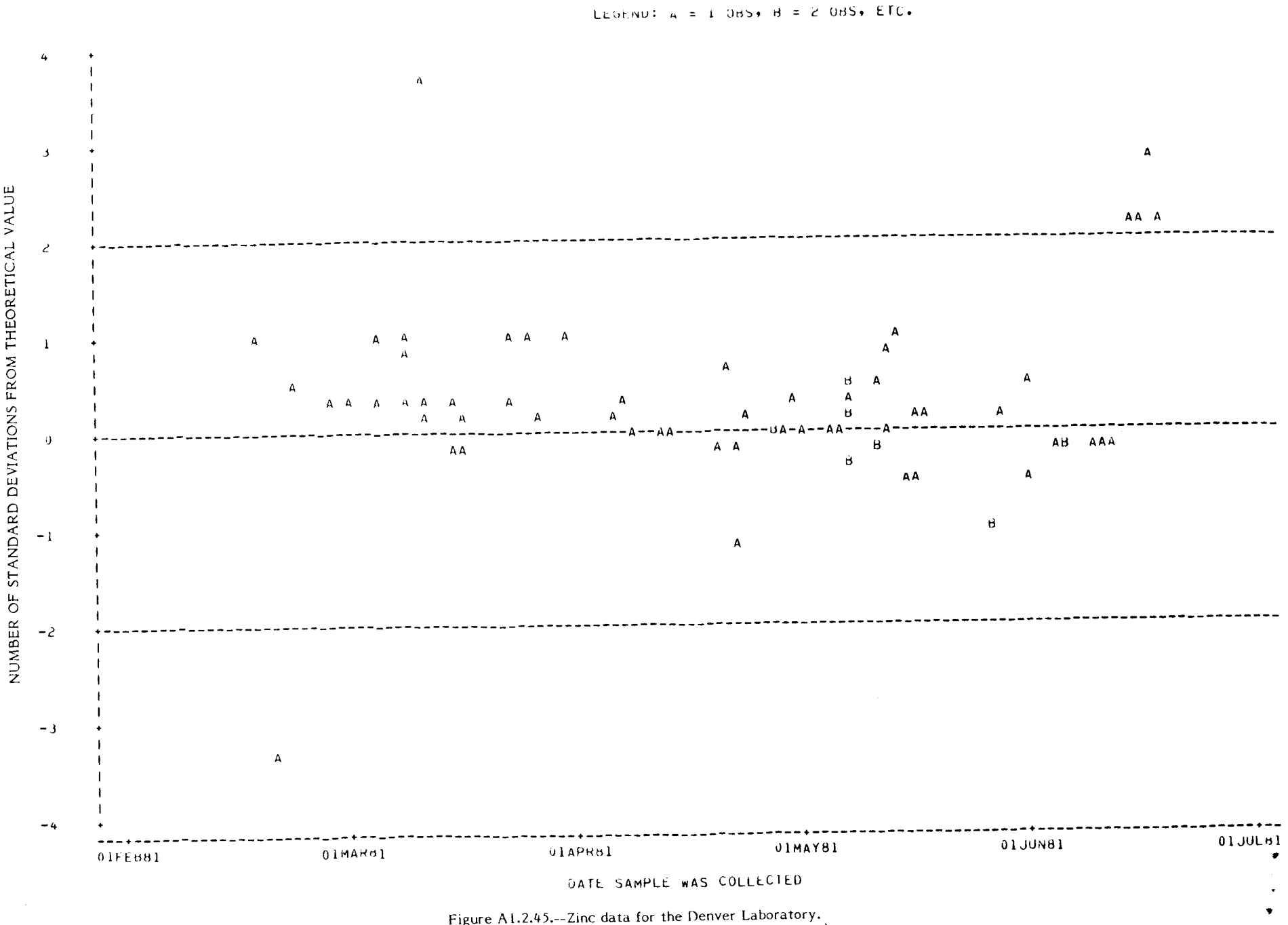

Figure A1.2.45.--Zinc data for the Denver Laboratory.
(Two observations were out of range.)

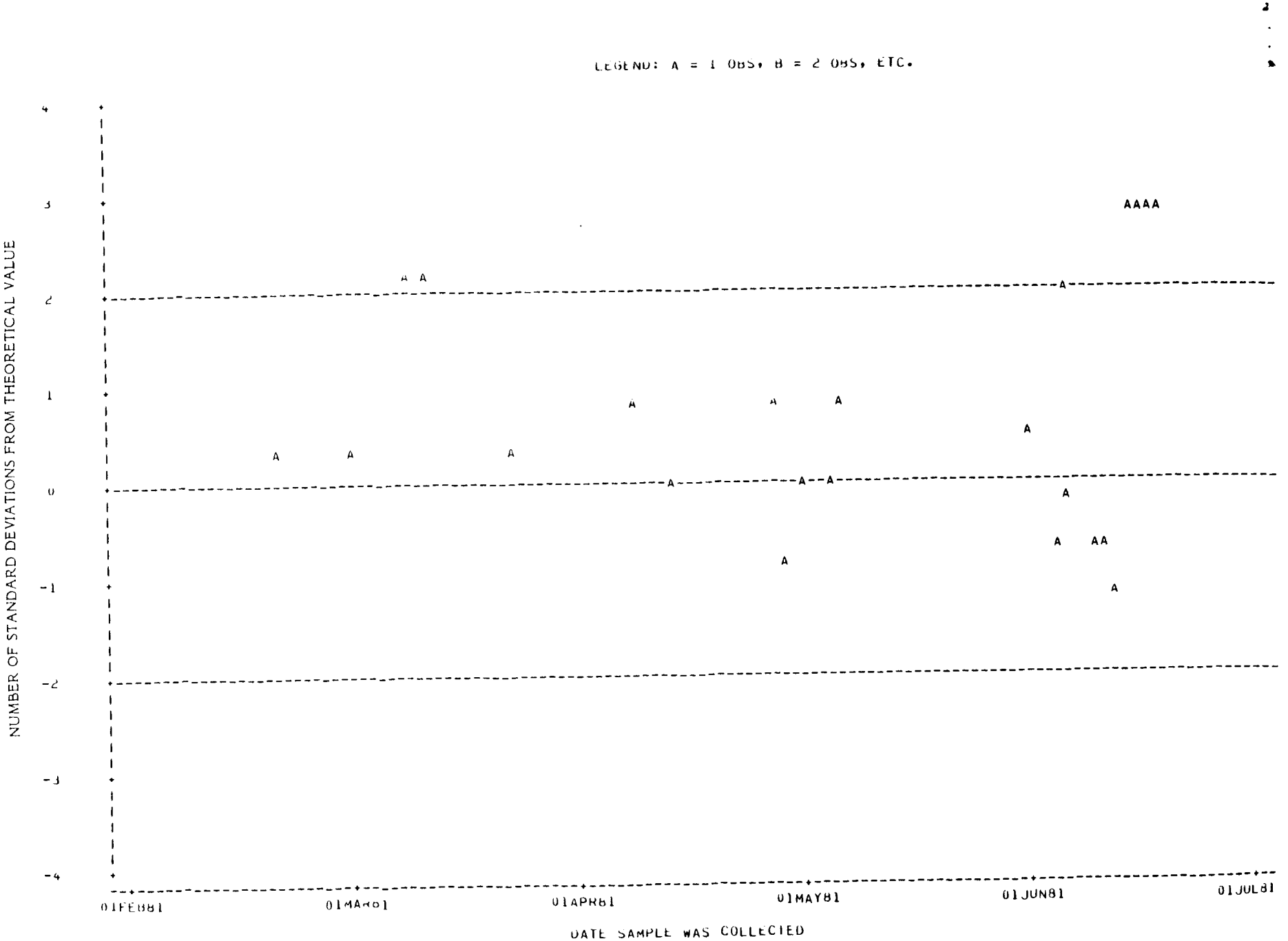

Figure A1.2.46.--Zinc, total recoverable data for the Denver Laboratory.
(Two observations were out of range.)