

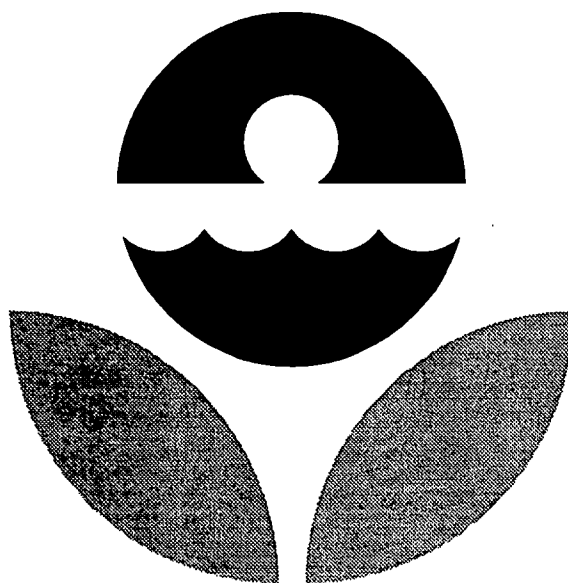


Uranium-Radium in Water Performance Evaluation Study

**A Statistical Evaluation of
the September 12, 1997 Data**



Uranium-Radium in Water
Performance Evaluation Study
September 12, 1997



Environmental Protection Agency
National Exposure Research Laboratory
Environmental Sciences Division
Las Vegas, Nevada



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
NATIONAL EXPOSURE RESEARCH LABORATORY
ENVIRONMENTAL SCIENCES DIVISION-LAS VEGAS
P.O. BOX 93478
LAS VEGAS, NEVADA 89193-3478
(702/798-2100)

Dear Participant,

Enclosed are the results of the Environmental Sciences Division (ESD-LV) Performance Evaluation Study for *Uranium-Radium in Water; September 12, 1997*.

The known value for each analysis was determined by gravimetric methods, checked by chemical analyses performed by ESD-LV's Radiochemistry Laboratory, and compared to the participating laboratories' grand average.

The expected precision, determined by the known value, was taken from "Table 3. Laboratory Precision: One Standard Deviation Values and Control Limits for Various Analyses", which is based on data accumulated over the years by the Performance Evaluation Program, and can be found in the Environmental Radioactivity Performance Evaluation Studies Program and Radioactive Standards Distribution Program information brochure.

Please take a few minutes to review this report and the analytical data your laboratory submitted to us. If there are any apparent discrepancies, please notify us immediately.

We encourage you to make use of the computer-automated data-entry system that has been in place for some time now. As the number of participants increases, and it becomes unrealistic for us to receive results by mail or FAX, the computer system will be our only avenue for accepting data.

If you have any questions or comments, please send a message via the data-entry system or contact Stephen Pia at 702/798-2102 or Patricia Honsa at 702/798-2141.

Sincerely,

A handwritten signature in black ink, appearing to read "Stephen Pia".

Stephen Pia
Team Leader
RADQA Program

Enclosure

NOTICE

This material has been funded wholly by the U.S. Environmental Protection Agency. It has been subjected to the Agency's review, and has been approved for publication as an EPA document.

The following pages consist of separate sections for each of the nuclides in this study with four parts per section. After the first, each part is separated from the next by a new page or a thick horizontal bar. The first page of each section is a statistical summary for the nuclide and starts with a statement of the known value, the control limits, and the warning limits.

The warning limits are placed at two normalized standard deviations above and below the known value and the control limits are three normalized standard deviations above and below the known value. If you keep control charts, these values will be useful for anticipating problems with the accuracy of your analytical methods.

The coin shaped pie chart at the top of the summary page shows the fate of all the samples sent out in number and percentage terms. The pie chart starts at the top and rotates clockwise. The first sector represents those participants who submitted analytical results within both the warning and control limits. The next sector represents those who are in the warning region but not out of control. The third sector represents those who are out of control, but have passed the outlier test. The fourth sector represents those who have failed the outlier test. The last sector represents those participants who have failed to respond properly. This is the case if no analytical results were returned, or less than three determinations were reported, or if the results were received too late. The reeding on the edge of the coin is spaced at one percent intervals, and the sector shading becomes darker as the data reliability decreases. Sectors with zero width are not shown.

The table in the center shows a number of statistical quantities calculated from the submitted data based on the mean and median values in relation to the known value, both before and after outlier removal. The lower pie chart uses the same construction as the upper chart and shows the distribution of properly submitted data in terms of deviation from the known value divided into sectors representing one, two, three, and greater than three normalized standard deviations.

The second part is an alphabetical listing, in lab-code order, of submitted data and several calculated quantities. An entry that is shaded has been rejected because of one of the reasons listed above or failure of the outlier test. The fifth and sixth columns are a measure of laboratory precision. The Range analysis is a normalized value that you may use to keep precision control charts. The eighth and ninth columns are the differences from the mean of all non-outliers and from the known value, respectively. If this value is between 2.0 and 3.0, your analytical process precision is in the warning zone; if it exceeds 3.0 it is out of control. A tag symbol may appear in the last column. Each page with tags has a symbol definition summary at the bottom. If there is no tag symbol, the data is within the control limits, but it may be in the warning zone.

The third part is a three-column listing of result average, tag symbol, and lab-code in average order excluding those labs not responding properly. In this order, all outliers and out-of-control results appear at the top or bottom of the list.

The last part is two bar chart displays showing frequency distributions of responding participants. The first chart places the known value at the center and a bar at each 0.2 unit of expected precision. The second chart places the mean of the reported measurements at the center and a bar at each 0.2 unit of standard deviation. In both cases, a bar includes those results within 0.1 unit up to the maximum of six. Any results more than six units from the center value are shown cumulatively by a shaded bar one past the sixth unit. If the central tendency of the known value distribution falls away from the center, an error in accuracy is indicated. If the distribution is broad, poor precision is indicated. The mean value distribution is similar but uses the average and standard deviation of reported results as its basis.

The Range Analysis($R + SR$) is calculated from the range, mean range and standard error of the range values. The range is the difference between the maximum and minimum results for the laboratory. The mean range is calculated by multiplying the expected precision by 1.693(for three results). The standard error of the range is calculated by multiplying the mean range by 2.575(for three results), subtracting the mean range from this product, and dividing the result by 3. If the range is greater than the mean range, then the range analysis is calculated by subtracting the mean range from the range, dividing the result by the standard error of the range and adding 1. If the mean range is greater than or equal to the range, then the range analysis is calculated by dividing the range by the mean range.

The normalized deviation of the mean from the grand average is calculated from the deviation of the mean from the grand average and the standard error of the mean values. The deviation of the mean from the grand average is calculated by subtracting the grand average from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3(the number of results). The normalized deviation of the mean from the grand average is calculated by dividing the deviation of the mean from the grand average by the standard error of the mean.

The normalized deviation of the mean from the known value is calculated from the deviation of the mean from the known value and the standard error of the mean values. The deviation of the mean from the known value is calculated by subtracting the known value from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3(the number of results). The normalized deviation of the mean from the known value is calculated by dividing the deviation of the mean from the known value by the standard error of the mean.

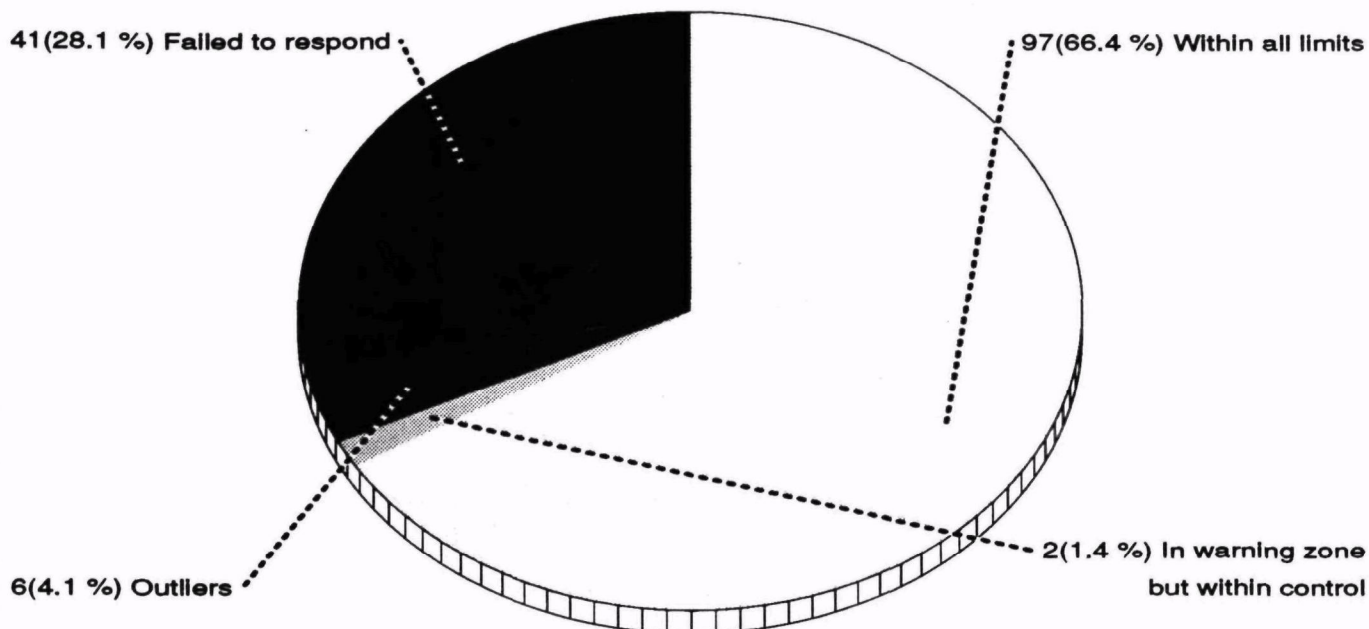
A complete explanation of the statistical calculations involved in the report may be found in the Environmental Radioactivity Performance Evaluation Studies Program information brochure [Draft Revision of EPA-600/4-81-004], available from Patricia Honsa, ESD-LV, 702/798-2141.

Uranium (Natural)

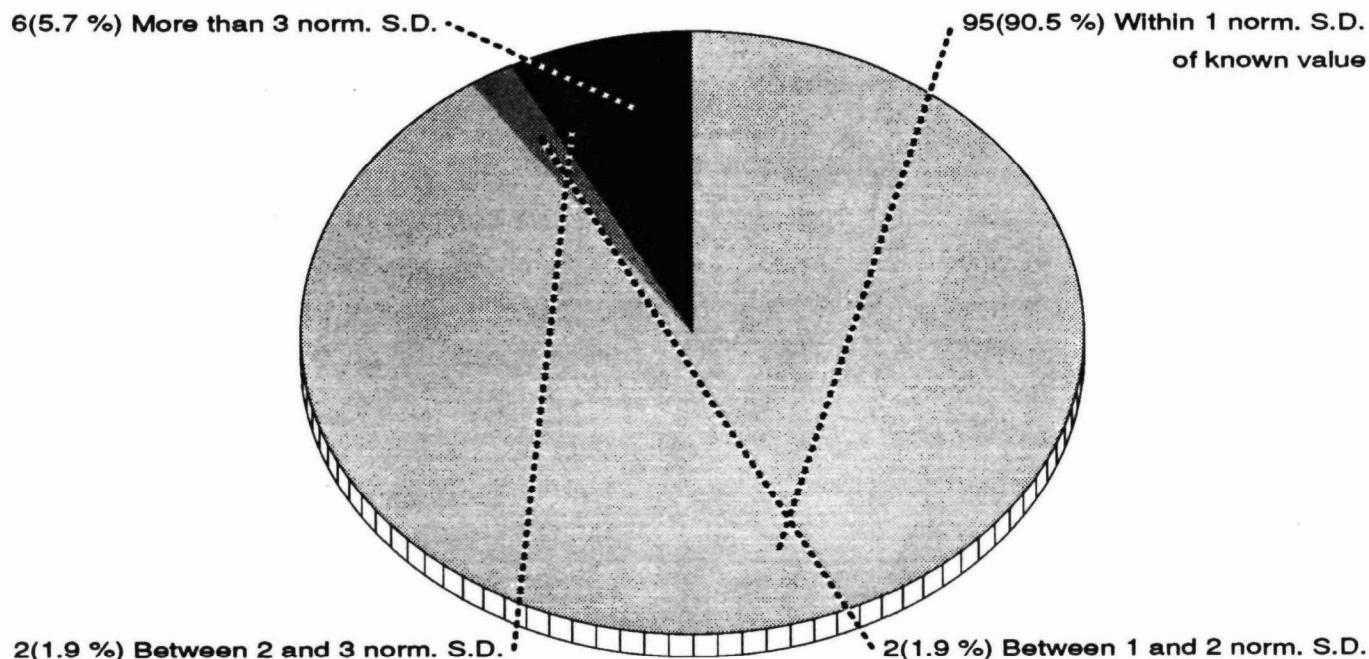
Statistical Summary

146 Participants

The known value of this nuclide is **5.1 pCi/l** with an expected precision of **3.0**; the control limits are 0.0 to 10.3; the warning regions are 0.0 to 1.6 and 8.6 to 10.3



Statistic	Respondents	Non-outliers
Mean	6.86	Grand Avg 5.05
Std. Dev.	9.02	0.85
Variance	81.32	0.72
% Coef. of Var.	131.42	16.85
% deviation of mean from known value	34.54	-0.93
Norm. dev. of mean from known value	0.20	-0.06
Median	5.00	4.97
% deviation of median from known value	-1.96	-2.61
Norm. dev. of median from known value	-0.01	-0.16



Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
A	4.4	4.7	4.8	0.21	0.079	4.63	-0.24	-0.27	
AE	5.4	5.4	5.4	0.00	0.000	5.40	0.20	0.17	
AF	5.4	5.4	5.6	0.12	0.039	5.47	0.24	0.21	
AH	5.1	4.9	4.6	0.25	0.098	4.87	-0.11	-0.13	
AJ	4.7	5.7	5.4	0.51	0.197	5.27	0.12	0.10	
AK	4.5	4.6	4.8	0.15	0.059	4.63	-0.24	-0.27	
AL	5.6	5.4	5.5	0.10	0.039	5.50	0.26	0.23	
AP	6.1	5.7	5.7	0.23	0.079	5.83	0.45	0.42	
AR	4.7	4.7	4.7	0.00	0.000	4.70	-0.20	-0.23	
AU									•
AW	4.5	4.7	4.5	0.12	0.039	4.57	-0.28	-0.31	
AZ	5.0	5.3	5.4	0.21	0.079	5.23	0.10	0.08	
BA	5.3	5.8	5.5	0.25	0.098	5.53	0.28	0.25	
BB									•
BC	4.9	4.9	4.9	0.00	0.000	4.90	-0.09	-0.12	
BG									•
BH	5.2	6.4	5.9	0.60	0.236	5.83	0.45	0.42	
BK	5.3	5.1	5.0	0.15	0.059	5.13	0.05	0.02	
BM	5.3	4.9	4.9	0.23	0.079	5.03	-0.01	-0.04	
BN	2.5	4.7	2.7	1.22	0.433	3.30	-1.01	-1.04	
BO									•
C	5.0	4.9	5.1	0.10	0.039	5.00	-0.03	-0.06	
CA	5.1	5.0	4.9	0.10	0.039	5.00	-0.03	-0.06	
CC	58.3	60.7	60.3	1.29	0.473	59.77	31.59	31.56	×
CE	4.1	4.6	4.3	0.25	0.098	4.33	-0.42	-0.44	
CJ	4.5	4.3	4.4	0.10	0.039	4.40	-0.38	-0.40	
CS	4.6	4.7	4.6	0.06	0.020	4.63	-0.24	-0.27	
CX	5.7	6.0	6.0	0.17	0.059	5.90	0.49	0.46	
D	5.2	4.8	4.9	0.21	0.079	4.97	-0.05	-0.08	
DB									•
DE	4.8	4.8	5.3	0.29	0.098	4.97	-0.05	-0.08	
DI									•
DO	4.9	5.4	4.8	0.32	0.118	5.03	-0.01	-0.04	
DR									•
DT	4.2	4.8	4.0	0.42	0.158	4.33	-0.42	-0.44	
DZ	9.6	9.3	9.9	0.30	0.118	9.60	2.63	2.60	
E	4.8	5.1	4.9	0.15	0.059	4.93	-0.07	-0.10	
EB	4.9	5.1	5.3	0.20	0.079	5.10	0.03	0.00	
EL	4.3	4.4	4.4	0.06	0.020	4.37	-0.40	-0.42	
EO									•
EP									•
ER	4.9	5.0	4.9	0.06	0.020	4.93	-0.07	-0.10	
FE	4.5	4.5	4.4	0.06	0.020	4.47	-0.34	-0.37	
FJ									•
FN									•

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

∅ = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
GN	3.7	3.5	3.8	0.15	0.059	3.67	-0.80	-0.83	
GQ	4.6	3.9	3.2	0.70	0.276	3.90	-0.67	-0.69	
HE	4.9	4.7	4.8	0.10	0.039	4.80	-0.15	-0.17	
HK	4.3	4.1	4.0	0.15	0.059	4.13	-0.53	-0.56	
HL	5.0	4.6	4.7	0.21	0.079	4.77	-0.17	-0.19	
HP	5.4	5.5	5.5	0.06	0.020	5.47	0.24	0.21	
I	5.2	5.3	4.8	0.26	0.098	5.10	0.03	0.00	
ID	15.1	19.9	12.7	3.67	1.795	15.90	6.26	6.24	×
J									•
JE	4.8	4.8	5.7	0.52	0.177	5.10	0.03	0.00	
JG									•
JK	5.2	5.3	5.1	0.10	0.039	5.20	0.09	0.06	
JN	6.3	5.4	6.0	0.46	0.177	5.90	0.49	0.46	
JS	5.3	5.3	5.5	0.12	0.039	5.37	0.18	0.15	
JX									•
JY	5.3	4.9	4.5	0.40	0.158	4.90	-0.09	-0.12	
K	4.7	4.3	4.4	0.21	0.079	4.47	-0.34	-0.37	
KH	4.9	4.8	4.8	0.06	0.020	4.83	-0.13	-0.15	
KL									•
KT	4.5	4.7	5.0	0.25	0.098	4.73	-0.18	-0.21	
L	5.5	5.1	5.4	0.21	0.079	5.33	0.16	0.13	
LF	4.9	5.1	5.0	0.10	0.039	5.00	-0.03	-0.06	
LH									•
LT									•
LZ	5.2	5.2	5.1	0.06	0.020	5.17	0.07	0.04	
M	16.0	16.3	17.0	0.51	0.197	16.43	6.57	6.54	×
MX	18.5	18.0	18.9	0.45	0.177	18.47	7.74	7.72	×
N									•
NA	4.0	6.0	5.0	1.00	0.394	5.00	-0.03	-0.06	
NH	8.5	8.5	8.2	0.17	0.059	8.40	1.93	1.91	
NJ	4.2	4.9	4.8	0.38	0.138	4.63	-0.24	-0.27	
NK	4.3	4.4	4.7	0.21	0.079	4.47	-0.34	-0.37	
NO	4.9	5.1	5.4	0.25	0.098	5.13	0.05	0.02	
O									•
OB	5.1	5.1	5.1	0.00	0.000	5.10	0.03	0.00	
OF									•
OS	4.4	4.1	4.6	0.25	0.098	4.37	-0.40	-0.42	
OX									•
P									•
PB	6.4	6.0	5.6	0.40	0.158	6.00	0.55	0.52	
PG	4.5	4.8	4.7	0.15	0.059	4.67	-0.22	-0.25	
PQ	4.9	5.1	5.0	0.10	0.039	5.00	-0.03	-0.06	
PW									•
PX	5.4	6.8	6.0	0.70	0.276	6.07	0.59	0.56	
Q	4.9	5.2	5.2	0.17	0.059	5.10	0.03	0.00	

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Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
QM									•
QQ	4.4	4.4	4.9	0.29	0.098	4.57	-0.28	-0.31	
QU	6.3	4.8	5.7	0.75	0.295	5.60	0.32	0.29	
QX	4.0	4.9	3.8	0.59	0.217	4.23	-0.47	-0.50	
QY									•
QZ	67.6	67.1	69.5	1.27	0.473	68.07	36.38	36.35	×
R									•
RD	5.2	5.2	5.1	0.06	0.020	5.17	0.07	0.04	
RF									•
RG	5.0	5.1	5.1	0.06	0.020	5.07	0.01	-0.02	
RK	4.9	4.2	4.5	0.35	0.138	4.53	-0.30	-0.33	
RP	4.3	4.1	4.4	0.15	0.059	4.27	-0.45	-0.48	
RR									•
RX									•
RZ	4.9	4.5	4.9	0.23	0.079	4.77	-0.17	-0.19	
S	4.7	4.7	4.5	0.12	0.039	4.63	-0.24	-0.27	
SC	5.7	5.5	5.1	0.31	0.118	5.43	0.22	0.19	
SD	5.4	5.8	5.7	0.21	0.079	5.63	0.34	0.31	
SF	4.8	5.0	5.1	0.15	0.059	4.97	-0.05	-0.08	
SI	41.5	41.8	41.6	0.15	0.059	41.63	21.12	21.09	×
SL	4.5	4.6	4.2	0.21	0.079	4.43	-0.36	-0.38	
SM	4.9	4.9	4.4	0.29	0.098	4.73	-0.18	-0.21	
SO	8.6	8.7	8.7	0.06	0.020	8.67	2.09	2.06	
SS	4.8	5.2	5.3	0.26	0.098	5.10	0.03	0.00	
SX	5.1	5.0	4.8	0.15	0.059	4.97	-0.05	-0.08	
SZ	5.1	4.7	4.8	0.21	0.079	4.87	-0.11	-0.13	
T	4.1	5.0	6.4	1.16	0.453	5.17	0.07	0.04	
TD	5.2	5.3	5.2	0.06	0.020	5.23	0.10	0.08	
TN									•
TQ	5.0	4.9	5.3	0.21	0.079	5.07	0.01	-0.02	
TS									•
U	4.7	5.0	4.7	0.17	0.059	4.80	-0.15	-0.17	
UP	5.0	5.5	5.1	0.26	0.098	5.20	0.09	0.06	
UQ									•
UZ									•
VA	4.3	4.6	4.8	0.25	0.098	4.57	-0.28	-0.31	
VH	6.0	6.1	7.0	0.55	0.197	6.37	0.76	0.73	
VI	5.0	4.9	5.2	0.15	0.059	5.03	-0.01	-0.04	
W	4.8	5.4	5.1	0.30	0.118	5.10	0.03	0.00	
WC									•
WG									•
WH	3.7	4.5	4.7	0.53	0.197	4.30	-0.43	-0.46	
WI									•
WJ	4.8	4.5	4.4	0.21	0.079	4.57	-0.28	-0.31	
WO	4.6	4.3	3.7	0.46	0.177	4.20	-0.49	-0.52	

• = No data submitted

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Uranium (Natural)

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
WR	4.6	4.9	5.1	0.25	0.098	4.87	-0.11	-0.13	
WX									•
X	4.6	4.8	4.8	0.12	0.039	4.73	-0.18	-0.21	
XA	5.0	4.7	6.0	0.68	0.256	5.23	0.10	0.08	
XC									•
XD									•
XI									•
XK									•
XL	5.1	5.4	5.8	0.35	0.138	5.43	0.22	0.19	
XM	4.0	4.6	4.1	0.32	0.118	4.23	-0.47	-0.50	
Y	4.9	4.9	4.9	0.00	0.000	4.90	-0.09	-0.12	

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
3.30		BN	4.73		X	5.10		Q
3.67		GN	4.73		SM	5.10		OB
3.90		GQ	4.77		RZ	5.10		JE
4.13		HK	4.77		HL	5.10		I
4.20		WO	4.80		U	5.10		EB
4.23		XM	4.80		HE	5.13		NO
4.23		QX	4.83		KH	5.13		BK
4.27		RP	4.87		WR	5.17		T
4.30		WH	4.87		SZ	5.17		RD
4.33		DT	4.87		AH	5.17		LZ
4.33		CE	4.90		Y	5.20		UP
4.37		OS	4.90		JY	5.20		JK
4.37		EL	4.90		BC	5.23		XA
4.40		CJ	4.93		ER	5.23		TD
4.43		SL	4.93		E	5.23		AZ
4.47		NK	4.97		SX	5.27		AJ
4.47		K	4.97		SF	5.33		L
4.47		FE	4.97		DE	5.37		JS
4.53		RK	4.97		D	5.40		AE
4.57		AW	5.00		PQ	5.43		SC
4.57		WJ	5.00		NA	5.43		XL
4.57		VA	5.00		LF	5.47		HP
4.57		QQ	5.00		CA	5.47		AF
4.63		S	5.00		C	5.50		AL
4.63		CS	5.03		VI	5.53		BA
4.63		NJ	5.03		DO	5.60		QU
4.63		AK	5.03		BM	5.63		SD
4.63		A	5.07		RG	5.83		BH
4.67		PG	5.07		TQ	5.83		AP
4.70		AR	5.10		W	5.90		JN
4.73		KT	5.10		SS	5.90		CX

• ≡ No data submitted

∅ ≡ Insufficient data

TAG SYMBOLS

× ≡ Determined to be an outlier

↑ ≡ Above control limit

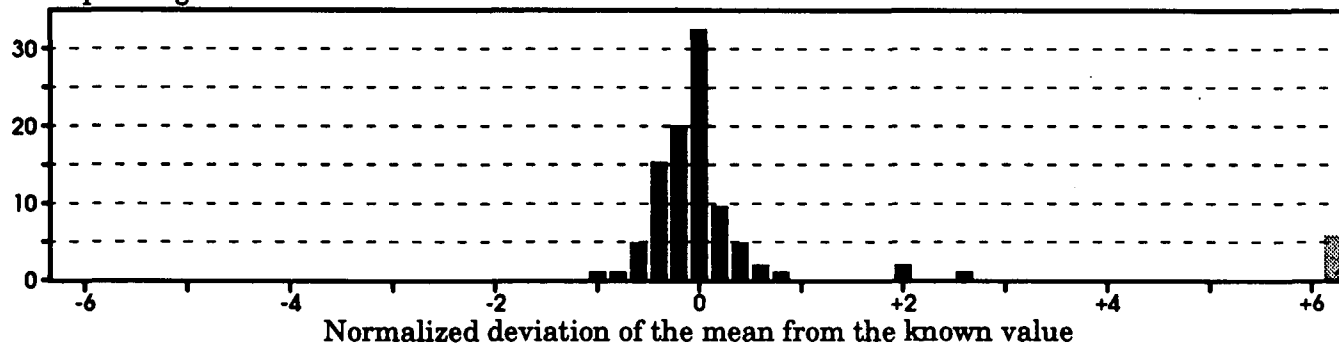
↓ ≡ Below control limit

Uranium (Natural)**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
6.00		PB	8.67		SO	18.47	×	MX
6.07		PX	9.60		DZ	41.63	×	SI
6.37		VH	15.90	×	ID	59.77	×	CC
8.40		NH	16.43	×	M	68.07	×	QZ

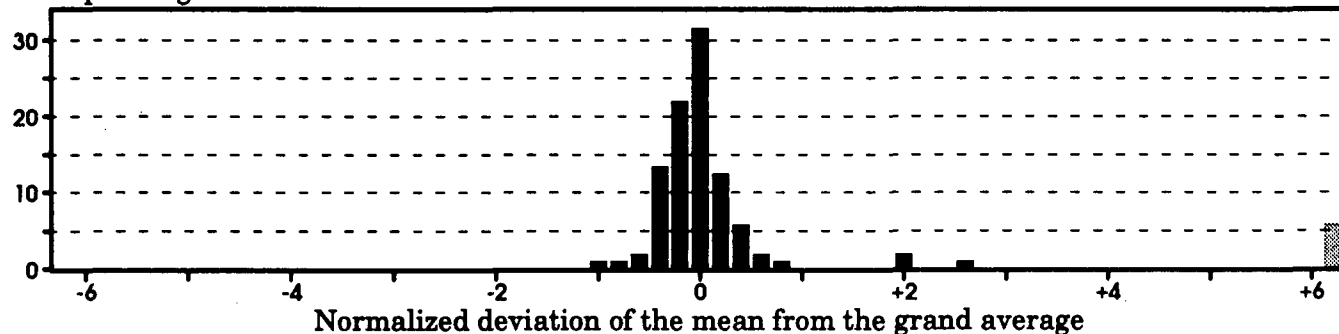
% responding labs

Frequency distribution



% responding labs

Frequency distribution



• ≡ No data submitted

TAG SYMBOLS

↑ ≡ Above control limit

∅ ≡ Insufficient data

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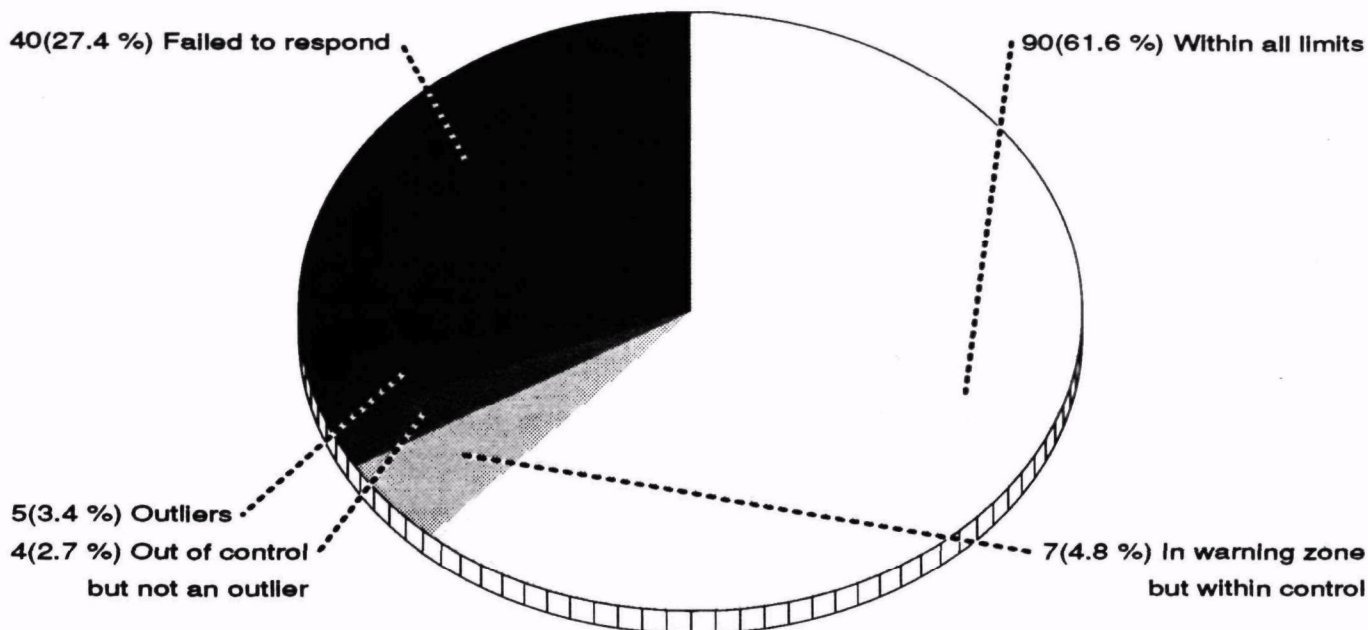
↓ ≡ Below control limit

Radium-226

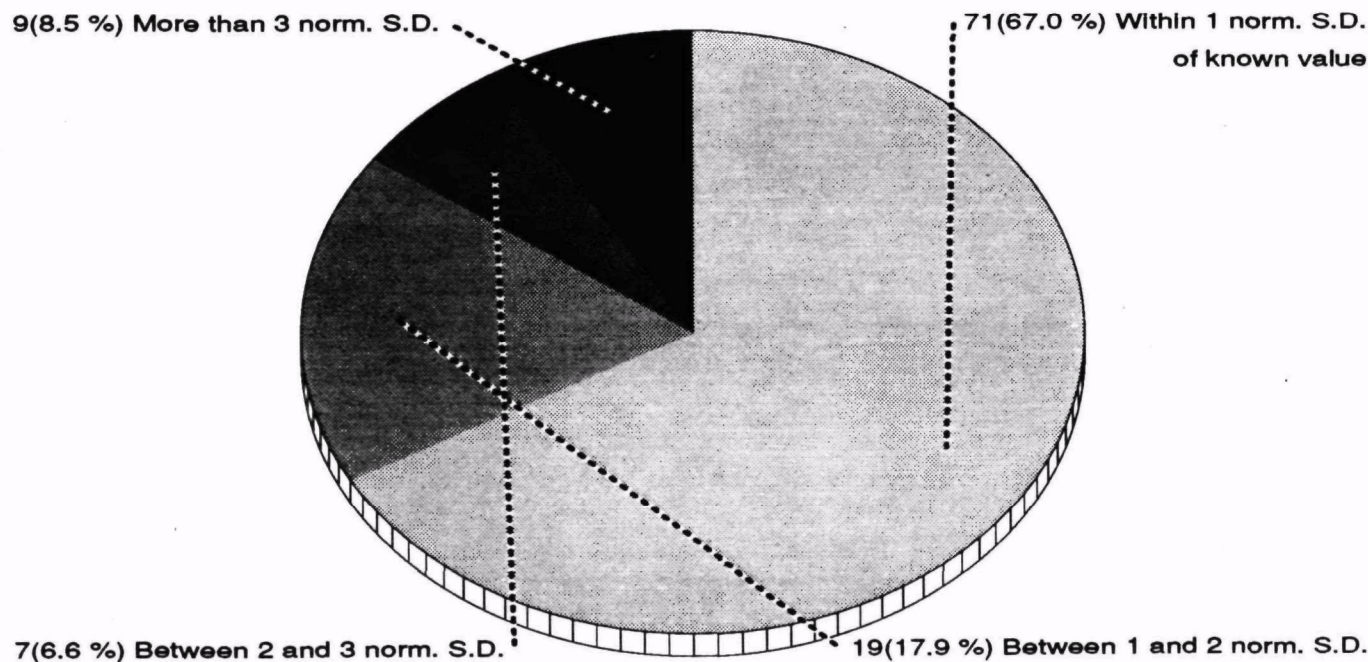
Statistical Summary

146 Participants

The known value of this nuclide is **20.0 pCi/l** with an expected precision of **3.0**; the control limits are 14.8 to 25.2; the warning regions are 14.8 to 16.5 and 23.5 to 25.2



Statistic	Respondents	Non-outliers
Mean	19.18	Grand Avg 19.55
Std. Dev.	3.17	2.04
Variance	10.06	4.16
% Coef. of Var.	16.53	10.43
% deviation of mean from known value	-4.09	-2.25
Norm. dev. of mean from known value	-0.26	-0.22
Median	19.62	19.67
% deviation of median from known value	-1.92	-1.67
Norm. dev. of median from known value	-0.12	-0.16



10 / 20 ESD-LV Performance Evaluation: Uranium-Radium in Water, 12-Sep-1997

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
A	20.7	20.1	16.5	2.27	0.827	19.10	-0.26	-0.52	
AE	17.1	17.6	18.9	0.93	0.354	17.87	-0.97	-1.23	
AF	19.3	19.1	18.7	0.31	0.118	19.03	-0.30	-0.56	
AH	17.0	14.7	16.2	1.17	0.453	15.97	-2.07	-2.33	
AJ	16.5	21.0	18.9	2.25	0.886	18.80	-0.43	-0.69	
AK	18.0	16.9	18.6	0.86	0.335	17.83	-0.99	-1.25	
AL	18.5	17.4	20.9	1.79	0.689	18.93	-0.36	-0.62	
AP	17.9	20.6	19.4	1.35	0.532	19.30	-0.14	-0.40	
AR									•
AU	8.2	7.7	8.8	0.55	0.217	8.23	-6.53	-6.79	×
AW	17.8	18.5	19.7	0.96	0.374	18.67	-0.51	-0.77	
AZ	19.1	19.5	20.3	0.61	0.236	19.63	0.05	-0.21	
BA	22.4	20.1	19.9	1.39	0.492	20.80	0.72	0.46	
BB									•
BC	17.7	20.5	24.4	3.37	1.608	20.87	0.76	0.50	
BG									•
BH	20.2	21.1	19.8	0.67	0.256	20.37	0.47	0.21	
BK	19.0	19.4	19.1	0.21	0.079	19.17	-0.22	-0.48	
BM	20.6	20.0	20.5	0.32	0.118	20.37	0.47	0.21	
BN	19.5	16.5	16.2	1.82	0.650	17.40	-1.24	-1.50	
BO	19.5	19.9	20.9	0.72	0.276	20.10	0.32	0.06	
C	20.0	19.0	18.5	0.76	0.295	19.17	-0.22	-0.48	
CA	20.1	19.2	20.7	0.75	0.295	20.00	0.26	0.00	
CC	18.0	19.5	21.0	1.50	0.591	19.50	-0.03	-0.29	
CE	18.2	19.4	18.1	0.72	0.256	18.57	-0.57	-0.83	
CJ	19.0	22.0	19.0	1.73	0.591	20.00	0.26	0.00	
CS	18.6	18.2	18.6	0.23	0.079	18.47	-0.63	-0.89	
CX									•
D									•
DB									•
DE	18.9	18.9	18.9	0.00	0.000	18.90	-0.38	-0.64	
DI									•
DO									•
DR									•
DT	17.5	17.8	18.1	0.30	0.118	17.80	-1.01	-1.27	
DZ	21.5	19.7	20.5	0.90	0.354	20.57	0.59	0.33	
E	18.7	18.3	19.3	0.50	0.197	18.77	-0.45	-0.71	
EB	16.7	18.1	18.2	0.84	0.295	17.67	-1.09	-1.35	
EL	19.7	19.1	20.6	0.75	0.295	19.80	0.14	-0.12	
EO	18.6	19.2	18.9	0.30	0.118	18.90	-0.38	-0.64	
EP	14.7	14.6	16.4	1.01	0.354	15.23	-2.49	-2.75	
ER	19.5	18.1	17.9	0.87	0.315	18.50	-0.61	-0.87	
FE	22.0	21.0	22.0	0.58	0.197	21.67	1.22	0.96	
FJ									•
FN	18.3	19.6	21.1	1.40	0.551	19.67	0.07	-0.19	

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

∅ = Insufficient data

× = Determined to be an outlier

↓ = Below control limit

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
GN	17.5	18.2	18.0	0.36	0.138	17.90	-0.95	-1.21	
GQ	15.8	10.4	13.1	2.70	1.120	13.10	-3.72	-3.98	↓
HE	20.4	22.1	20.4	0.98	0.335	20.97	0.82	0.56	
HK	20.4	20.5	19.1	0.78	0.276	20.00	0.26	0.00	
HL	20.7	21.0	21.3	0.30	0.118	21.00	0.84	0.58	
HP	20.9	19.6	22.7	1.56	0.610	21.07	0.88	0.62	
I	21.7	20.3	20.1	0.87	0.315	20.70	0.66	0.40	
ID	24.3	16.1	19.5	4.12	2.170	19.97	0.24	-0.02	
J									•
JE	16.8	8.2	21.7	6.83	4.158	15.57	-2.30	-2.56	
JG									•
JK									•
JN									•
JS	20.6	18.7	21.0	1.23	0.453	20.10	0.32	0.06	
JX	21.9	20.5	20.5	0.81	0.276	20.97	0.82	0.56	
JY	23.3	25.0	28.3	2.54	0.984	25.53	3.45	3.19	↑
K	17.5	20.4	19.6	1.50	0.571	19.17	-0.22	-0.48	
KH	20.7	19.7	20.7	0.58	0.197	20.37	0.47	0.21	
KL	24.3	25.2	23.2	1.00	0.394	24.23	2.70	2.44	
KT									•
L	17.0	20.0	16.0	2.08	0.788	17.67	-1.09	-1.35	
LF									•
LH									•
LT	15.4	13.3	20.2	3.54	1.683	16.30	-1.88	-2.14	
LZ	21.9	21.7	21.8	0.10	0.039	21.80	1.30	1.04	
M	19.3	20.9	19.8	0.82	0.315	20.00	0.26	0.00	
MX	8.8	7.5	8.9	0.78	0.276	8.40	-6.44	-6.70	×
N									•
NA									•
NH	20.8	18.1	19.7	1.36	0.532	19.53	-0.01	-0.27	
NJ	22.9	23.1	19.5	2.02	0.709	21.83	1.32	1.06	
NK									•
NO	21.2	22.2	25.0	1.97	0.748	22.80	1.88	1.62	
O	19.2	19.4	19.4	0.12	0.039	19.33	-0.13	-0.38	
OB									•
OF	13.0	14.5	15.0	1.04	0.394	14.17	-3.11	-3.37	↓
OS	21.8	23.4	24.6	1.40	0.551	23.27	2.15	1.89	
OX	19.9	19.9	20.1	0.12	0.039	19.97	0.24	-0.02	
P									•
PB	20.6	20.5	20.5	0.06	0.020	20.53	0.57	0.31	
PG	16.9	16.7	16.1	0.42	0.158	16.57	-1.72	-1.98	
PQ									•
PW	21.4	20.5	19.4	1.00	0.394	20.43	0.51	0.25	
PX	19.9	19.5	20.7	0.61	0.236	20.03	0.28	0.02	
Q	29.9	27.6	27.3	1.42	0.512	28.27	5.03	4.77	×

• = No data submitted

TAG SYMBOLS

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↓ = Below control limit

12 / 20 ESD-LV Performance Evaluation: Uranium-Radium in Water, 12-Sep-1997

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
QM	12.3	16.1	16.3	2.25	0.788	14.90	-2.69	-2.94	
QQ	19.0	20.6	19.8	0.80	0.315	19.80	0.14	-0.12	
QU	19.1	20.8	22.2	1.55	0.610	20.70	0.66	0.40	
QX	9.1	9.8	7.2	1.35	0.512	8.70	-6.26	-6.52	×
QY	19.0	19.0	19.2	0.12	0.039	19.07	-0.28	-0.54	
QZ	18.9	17.9	20.6	1.37	0.532	19.13	-0.24	-0.50	
R	17.8	16.0	15.4	1.25	0.473	16.40	-1.82	-2.08	
RD	26.7	25.4	25.1	0.85	0.315	25.73	3.57	3.31	↑
RF									•
RG									•
RK	18.1	17.2	17.5	0.46	0.177	17.60	-1.13	-1.39	
RP									•
RR									•
RX									•
RZ	20.0	19.5	20.3	0.40	0.158	19.93	0.22	-0.04	
S	19.7	19.5	20.2	0.36	0.138	19.80	0.14	-0.12	
SC	19.4	18.7	18.8	0.38	0.138	18.97	-0.34	-0.60	
SD	16.6	21.3	20.1	2.44	0.925	19.33	-0.13	-0.38	
SF	17.5	18.1	18.4	0.46	0.177	18.00	-0.90	-1.15	
SI	20.9	18.1	23.1	2.51	0.984	20.70	0.66	0.40	
SL									•
SM	23.7	23.8	22.8	0.55	0.197	23.43	2.24	1.98	
SO									•
SS	19.8	21.3	16.5	2.46	0.945	19.20	-0.20	-0.46	
SX	21.3	21.1	21.6	0.25	0.098	21.33	1.03	0.77	
SZ	18.8	20.0	17.9	1.05	0.413	18.90	-0.38	-0.64	
T	17.3	20.1	19.2	1.43	0.551	18.87	-0.40	-0.65	
TD	22.5	19.8	18.0	2.26	0.886	20.10	0.32	0.06	
TN	17.6	23.2	19.7	2.83	1.195	20.17	0.36	0.10	
TQ	21.0	20.3	22.3	1.01	0.394	21.20	0.95	0.69	
TS									•
U	18.7	18.6	18.9	0.15	0.059	18.73	-0.47	-0.73	
UP	21.6	22.0	20.6	0.72	0.276	21.40	1.07	0.81	
UQ	19.8	20.4	19.3	0.55	0.217	19.83	0.16	-0.10	
UZ									•
VA	20.5	19.9	21.2	0.65	0.256	20.53	0.57	0.31	
VH	17.9	18.2	16.7	0.79	0.295	17.60	-1.13	-1.39	
VI	20.1	20.1	22.2	1.21	0.413	20.80	0.72	0.46	
W	19.7	19.4	19.7	0.17	0.059	19.60	0.03	-0.23	
WC	3.8	6.8	4.7	1.54	0.591	5.10	-8.34	-8.60	×
WG									•
WH	19.4	19.5	20.1	0.38	0.138	19.67	0.07	-0.19	
WI									•
WJ	18.9	18.7	20.5	0.99	0.354	19.37	-0.11	-0.37	
WO	19.0	20.7	19.8	0.85	0.335	19.83	0.16	-0.10	

• = No data submitted

∅ = Insufficient data

TAG SYMBOLS

× = Determined to be an outlier

↑ = Above control limit

↓ = Below control limit

Radium-226

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
WR								•
WX								•
X	17.7	18.3	17.4	0.46	0.177	17.80	-1.01	-1.27
XA	22.8	21.1	21.4	0.91	0.335	21.77	1.28	1.02
XC								•
XD								•
XI								•
XK								•
XL	20.5	20.8	21.1	0.30	0.118	20.80	0.72	0.46
XM	19.6	19.6	17.9	0.98	0.335	19.03	-0.30	-0.56
Y	22.5	22.3	22.3	0.12	0.039	22.37	1.63	1.37

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
5.10	×	WC	18.87		T	19.97		OX
8.23	×	AU	18.90		SZ	19.97		ID
8.40	×	MX	18.90		EO	20.00		M
8.70	×	QX	18.90		DE	20.00		HK
13.10	↓	GQ	18.93		AL	20.00		CJ
14.17	↓	OF	18.97		SC	20.00		CA
14.90		QM	19.03		XM	20.03		PX
15.23		EP	19.03		AF	20.10		TD
15.57		JE	19.07		QY	20.10		JS
15.97		AH	19.10		A	20.10		BO
16.30		LT	19.13		QZ	20.17		TN
16.40		R	19.17		K	20.37		KH
16.57		PG	19.17		C	20.37		BM
17.40		BN	19.17		BK	20.37		BH
17.60		VH	19.20		SS	20.43		PW
17.60		RK	19.30		AP	20.53		VA
17.67		L	19.33		SD	20.53		PB
17.67		EB	19.33		O	20.57		DZ
17.80		X	19.37		WJ	20.70		SI
17.80		DT	19.50		CC	20.70		QU
17.83		AK	19.53		NH	20.70		I
17.87		AE	19.60		W	20.80		XL
17.90		GN	19.63		AZ	20.80		VI
18.00		SF	19.67		WH	20.80		BA
18.47		CS	19.67		FN	20.87		BC
18.50		ER	19.80		S	20.97		JX
18.57		CE	19.80		QQ	20.97		HE
18.67		AW	19.80		EL	21.00		HL
18.73		U	19.83		WO	21.07		HP
18.77		E	19.83		UQ	21.20		TQ
18.80		AJ	19.93		RZ	21.33		SX

• = No data submitted

TAG SYMBOLS

↑ = Above control limit

∅ = Insufficient data

× = Determined to be an outlier

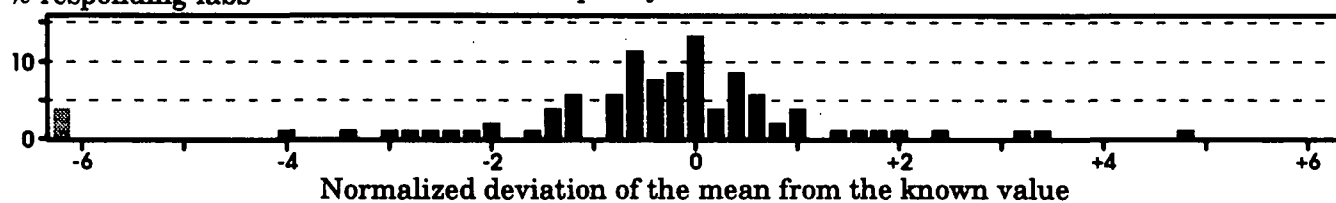
↓ = Below control limit

Radium-226**Data sorted by Laboratory Average**

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
21.40		UP	21.83		NJ	23.43		SM
21.67		FE	22.37		Y	24.23		KL
21.77		XA	22.80		NO	25.53	↑↑	JY
21.80		LZ	23.27		OS	25.73	↑↑	RD
						28.27	×	Q

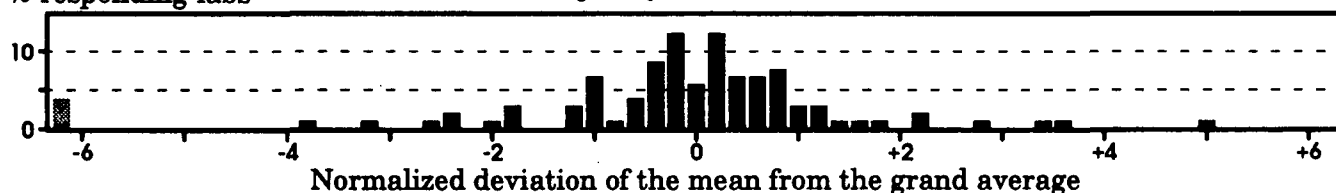
% responding labs

Frequency distribution



% responding labs

Frequency distribution



• ≡ No data submitted

TAG SYMBOLS

↑↑ ≡ Above control limit

∅ ≡ Insufficient data

× ≡ Determined to be an outlier

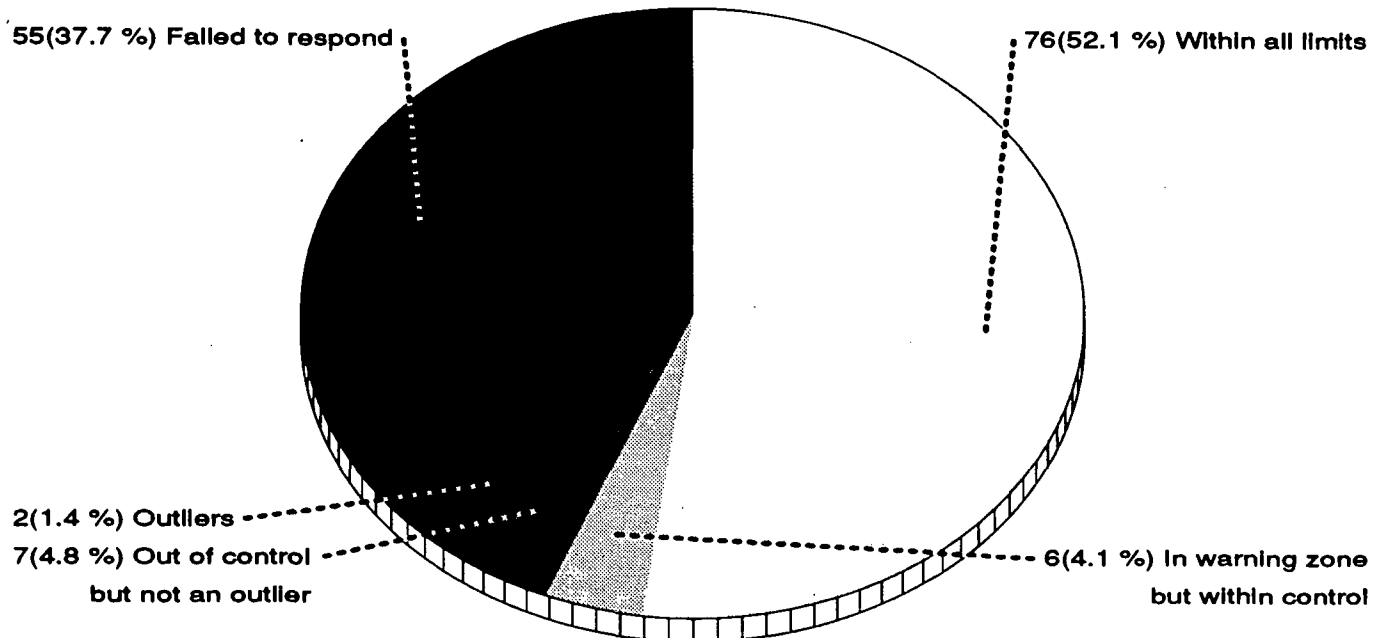
↓↓ ≡ Below control limit

Radium-228

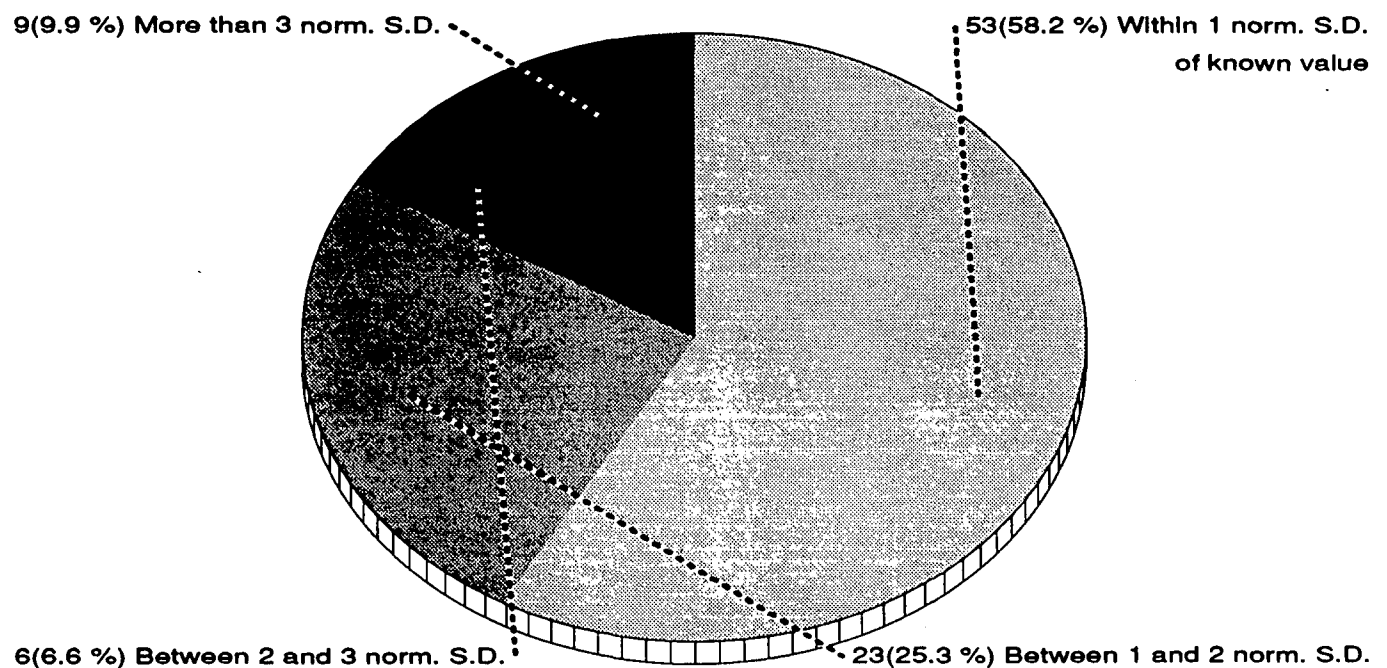
Statistical Summary

146 Participants

The known value of this nuclide is 8.0 pCi/l with an expected precision of 2.0; the control limits are 4.5 to 11.5; the warning regions are 4.5 to 5.7 and 10.3 to 11.5



Statistic	Respondents	Non-outliers
Mean	8.30	Grand Avg 7.99
Std. Dev.	2.82	1.87
Variance	7.98	3.50
% Coef. of Var.	34.04	23.40
% deviation of mean from known value	3.74	-0.07
Norm. dev. of mean from known value	0.11	0.00
Median	8.10	8.00
% deviation of median from known value	1.25	0.00
Norm. dev. of median from known value	0.04	0.00



16 / 20 ESD-LV Performance Evaluation: Uranium-Radium in Water, 12-Sep-1997

Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
A	8.4	9.7	9.1	0.65	0.384	9.07	0.93	0.92
AE	7.1	9.3	9.5	1.33	0.709	8.63	0.55	0.55
AF	9.9	10.2	9.5	0.35	0.207	9.87	1.62	1.62
AH	6.2	6.2	6.8	0.35	0.177	6.40	-1.38	-1.39
AJ	5.5	5.6	5.3	0.15	0.089	5.47	-2.19	-2.19
AK	10.0	9.7	8.9	0.57	0.325	9.53	1.33	1.33
AL	6.7	7.8	7.8	0.64	0.325	7.43	-0.49	-0.49
AP	6.9	8.4	9.0	1.08	0.620	8.10	0.09	0.09
AR								•
AU								•
AW	9.3	9.4	9.4	0.06	0.030	9.37	1.19	1.18
AZ	7.0	7.2	7.1	0.10	0.059	7.10	-0.77	-0.78
BA	5.4	6.0	5.8	0.31	0.177	5.73	-1.96	-1.96
BB								•
BC	7.7	7.1	7.0	0.38	0.207	7.27	-0.63	-0.64
BG								•
BH	7.9	8.2	9.3	0.74	0.413	8.47	0.41	0.40
BK	8.2	8.2	8.4	0.12	0.059	8.27	0.24	0.23
BM	9.2	8.7	8.6	0.32	0.177	8.83	0.73	0.72
BN								•
BO	8.5	9.1	9.3	0.42	0.236	8.97	0.84	0.84
C	8.9	8.4	8.2	0.36	0.207	8.50	0.44	0.43
CA	6.9	7.1	7.0	0.10	0.059	7.00	-0.86	-0.87
CC	24.3	28.0	25.6	1.88	1.177	25.97	15.56	15.56 ×
CE	7.9	6.2	8.7	1.28	0.738	7.60	-0.34	-0.35
CJ	7.6	7.3	7.3	0.17	0.089	7.40	-0.51	-0.52
CS	11.1	11.3	10.2	0.59	0.325	10.87	2.49	2.48
CX								•
D								•
DB								•
DE	9.8	9.9	9.9	0.06	0.030	9.87	1.62	1.62
DI								•
DO								•
DR								•
DT	8.2	7.9	7.3	0.46	0.266	7.80	-0.17	-0.17
DZ	7.3	7.8	7.4	0.26	0.148	7.50	-0.43	-0.43
E	10.3	10.6	9.5	0.57	0.325	10.13	1.85	1.85
EB	7.5	6.4	6.5	0.61	0.325	6.80	-1.03	-1.04
EL	7.7	9.1	8.4	0.70	0.413	8.40	0.35	0.35
EO	7.1	6.7	7.5	0.40	0.236	7.10	-0.77	-0.78
EP	6.9	6.5	7.1	0.31	0.177	6.83	-1.01	-1.01
ER								•
FE								•
FJ								•
FN	7.2	6.5	7.3	0.44	0.236	7.00	-0.86	-0.87

• ≡ No data submitted

TAG SYMBOLS

↑ ≡ Above control limit

∅ ≡ Insufficient data

× ≡ Determined to be an outlier

↓ ≡ Below control limit

Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
GN									•
GQ	11.0	14.6	12.8	1.80	1.120	12.80	4.16	4.16	↑
HE	5.9	4.9	6.7	0.90	0.532	5.83	-1.87	-1.88	
HK	7.6	7.2	7.3	0.21	0.118	7.37	-0.54	-0.55	
HL	9.5	9.3	9.2	0.15	0.089	9.33	1.16	1.15	
HP	2.6	2.5	3.9	0.78	0.413	3.00	-4.32	-4.33	↓
I	8.4	9.6	8.7	0.62	0.354	8.90	0.78	0.78	
ID	3.3	4.0	3.7	0.35	0.207	3.67	-3.75	-3.75	↓
J									•
JE	9.5	10.1	9.9	0.31	0.177	9.83	1.59	1.59	
JG									•
JK									•
JN									•
JS	7.6	8.0	6.6	0.72	0.413	7.40	-0.51	-0.52	
JX	8.0	8.6	8.1	0.32	0.177	8.23	0.21	0.20	
JY	9.2	9.2	9.7	0.29	0.148	9.37	1.19	1.18	
K	9.6	11.3	7.8	1.75	1.064	9.57	1.36	1.36	
KH	7.0	7.2	7.5	0.25	0.148	7.23	-0.66	-0.66	
KL	11.2	12.1	10.2	0.95	0.561	11.17	2.75	2.74	
KT									•
L	7.9	7.9	8.2	0.17	0.089	8.00	0.01	0.00	
LF									•
LH									•
LT	6.4	5.4	7.4	1.00	0.591	6.40	-1.38	-1.39	
LZ									•
M	8.4	8.6	8.4	0.12	0.059	8.47	0.41	0.40	
MX	9.3	9.0	8.5	0.40	0.236	8.93	0.81	0.81	
N									•
NA									•
NH	21.3	23.7	8.3	8.29	7.758	17.77	8.46	8.46	×
NJ	8.4	9.0	8.6	0.31	0.177	8.67	0.58	0.58	
NK									•
NO	7.3	8.6	9.8	1.25	0.738	8.57	0.50	0.49	
O	6.1	6.6	6.2	0.26	0.148	6.30	-1.47	-1.47	
OB									•
OF	4.6	7.5	7.8	1.77	0.945	6.63	-1.18	-1.18	
OS									•
OX	7.9	7.8	7.8	0.06	0.030	7.83	-0.14	-0.14	
P									•
PB	8.8	8.6	9.0	0.20	0.118	8.80	0.70	0.69	
PG									•
PQ									•
PW	8.0	8.3	8.4	0.21	0.118	8.23	0.21	0.20	
PX									•
Q	7.3	6.9	6.5	0.40	0.236	6.90	-0.95	-0.95	

• = No data submitted

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18 / 20 ESD-LV Performance Evaluation: Uranium-Radium in Water, 12-Sep-1997

Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known)		Tag
QM									•
QQ									•
QU	6.5	7.9	7.2	0.70	0.413	7.20	-0.69	-0.69	
QX	8.1	9.1	9.8	0.85	0.502	9.00	0.87	0.87	
QY									•
QZ	8.2	8.1	8.2	0.06	0.030	8.17	0.15	0.14	
R									•
RD	12.1	13.5	15.4	1.66	0.975	13.67	4.91	4.91	↑
RF									•
RG									•
RK	5.3	4.4	5.5	0.59	0.325	5.07	-2.54	-2.54	
RP									•
RR									•
RX									•
RZ	8.2	8.0	8.4	0.20	0.118	8.20	0.18	0.17	
S	7.7	7.0	7.4	0.35	0.207	7.37	-0.54	-0.55	
SC	9.3	8.1	9.0	0.62	0.354	8.80	0.70	0.69	
SD	11.9	11.3	11.6	0.30	0.177	11.60	3.12	3.12	↑
SF	6.6	6.9	7.4	0.40	0.236	6.97	-0.89	-0.89	
SI	7.4	8.0	6.5	0.75	0.443	7.30	-0.60	-0.61	
SL									•
SM	7.4	7.3	9.1	1.01	0.532	7.93	-0.05	-0.06	
SO									•
SS	9.7	8.5	10.2	0.87	0.502	9.47	1.28	1.27	
SX	7.0	5.8	9.2	1.72	1.008	7.33	-0.57	-0.58	
SZ	5.4	7.1	9.0	1.80	1.120	7.17	-0.72	-0.72	
T	9.2	10.0	9.3	0.44	0.236	9.50	1.30	1.30	
TD	10.0	6.8	7.1	1.77	0.945	7.97	-0.02	-0.03	
TN	2.9	2.5	2.6	0.21	0.118	2.67	-4.61	-4.62	↓
TQ	7.0	8.3	7.7	0.65	0.384	7.67	-0.28	-0.29	
TS									•
U	7.3	7.1	7.3	0.12	0.059	7.23	-0.66	-0.66	
UP	10.6	10.2	9.5	0.56	0.325	10.10	1.82	1.82	
UQ	8.2	8.9	9.3	0.56	0.325	8.80	0.70	0.69	
UZ									•
VA	9.1	8.9	7.8	0.70	0.384	8.60	0.52	0.52	
VH	12.1	10.3	8.5	1.80	1.120	10.30	2.00	1.99	
VI	9.6	9.5	9.2	0.21	0.118	9.43	1.25	1.24	
W	7.8	8.1	7.6	0.25	0.148	7.83	-0.14	-0.14	
WC	2.7	3.1	3.0	0.21	0.118	2.93	-4.38	-4.39	↓
WG									•
WH	7.7	7.2	6.9	0.40	0.236	7.27	-0.63	-0.64	
WI									•
WJ									•
WO	4.1	4.9	4.9	0.46	0.236	4.63	-2.91	-2.92	

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Radium-228

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg) (known) Tag	
WR	5.2	6.6	6.6	0.81	0.413	6.13	-1.61	-1.62
WX								•
X	11.0	9.7	10.9	0.72	0.384	10.53	2.20	2.19
XA								•
XC								•
XD								•
XI								•
XK								•
XL	8.5	8.6	8.6	0.06	0.030	8.57	0.50	0.49
XM	6.7	7.8	7.5	0.57	0.325	7.33	-0.57	-0.58
Y								•

Data sorted by Laboratory Average

Average	Tag	Lab	Average	Tag	Lab	Average	Tag	Lab
2.67	↓	TN	7.33		SX	8.80		UQ
2.93	↓	WC	7.37		S	8.80		SC
3.00	↓	HP	7.37		HK	8.80		PB
3.67	↓	ID	7.40		JS	8.83		BM
4.63		WO	7.40		CJ	8.90		I
5.07		RK	7.43		AL	8.93		MX
5.47		AJ	7.50		DZ	8.97		BO
5.73		BA	7.60		CE	9.00		QX
5.83		HE	7.67		TQ	9.07		A
6.13		WR	7.80		DT	9.33		HL
6.30		O	7.83		W	9.37		JY
6.40		LT	7.83		OX	9.37		AW
6.40		AH	7.93		SM	9.43		VI
6.63		OF	7.97		TD	9.47		SS
6.80		EB	8.00		L	9.50		T
6.83		EP	8.10		AP	9.53		AK
6.90		Q	8.17		QZ	9.57		K
6.97		SF	8.20		RZ	9.83		JE
7.00		FN	8.23		PW	9.87		DE
7.00		CA	8.23		JX	9.87		AF
7.10		EO	8.27		BK	10.10		UP
7.10		AZ	8.40		EL	10.13		E
7.17		SZ	8.47		M	10.30		VH
7.20		QU	8.47		BH	10.53		X
7.23		U	8.50		C	10.87		CS
7.23		KH	8.57		XL	11.17		KL
7.27		WH	8.57		NO	11.60	↑	SD
7.27		BC	8.60		VA	12.80	↑	GQ
7.30		SI	8.63		AE	13.67	↑	RD
7.33		XM	8.67		NJ	17.77	×	NH
						25.97	×	CC

• = No data submitted

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Radium-228

