Guide for Conducting Statistical Comparisons of RFI/RI Data and Background Data At the Rocky Flats Plant

General

This document is intended to provide guidelines for OU to background comparisons of data, and to explicitly discuss approaches to the issue of determining OU-specific contamination. This document generally follows the "strawman" presented to CDH and EPA, which discussed implementation of Dr. Gilbert's recommended approach for making OU to background comparisons.

Based on comments received on the Draft OU1 RFI/RI, as well as discussion with CDH, EPA, and others, it is important to establish a common approach leading to a common list of possible contaminants for each OU. To this end, the Figure **GENERAL APPROACH TO DETERMINING "CONTAMINANTS"** was developed. In this general technique, a "Tool-Box" approach utilizing Dr. Gilbert's recommendations is employed to arrive at one common list of contaminants for each OU (or subdivision), for all functional aspects of the RFI/RI and CMS/FS.

As indicated, several disciplines such as the Human Health or Ecological Risk Assessors and Regulatory specialists may pare the list of contaminants to "Contaminants of Concern" (COCs) based on factors germane to their application (e.g., toxicity).

The text below follows **TASK 4: FLOWCHART FOR COMPARING OU DATA TO BACKGROUND.**

Start

Determine Background and OU Target Populations

Appropriate geographical, geological, and temporal data sets will be defined for comparison. This is essentially a matching exercise so that Site (OU) data sets are comparable to background sets. Consideration will be given to issues such as:

Geologic materials
Hydrostratigraphic unit
Temporal comparability (waters, air, etc.)
Sample size for statistical tests

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REVIEW WAIVER PER
CLASSIFICATION OFFICE

Confidence in geo/hydrologic regime determination

The objective here is to select, as fitting as possible, data sets that permit comparison and hypotheses testing. The test variable is "impact of Rocky Flats waste-related activities on environmental media". Thus, other potential sources of variability (e.g., geologic materials) should be as closely matched as possible. Tables that cross-reference site media to background media will be provided.

Set DQO's

Data Collection and Validation

Under current IAG schedule conditions, analytical data will not be 100% "validated" when the background comparisons are made in each draft report. The potential impacts of using non-validated data will be discussed on a case-by-case basis.

Data Presentation

Several data presentation techniques were identified by Dr. Gilbert as appropriate for different conditions. To perform them all for all compounds in a standard full suite is not necessary when it is clear from a preliminary review that the vast majority of data points for some compounds are entirely or almost entirely non-detects.

Accordingly, we have refined the methodology as follows:

Box plots will be used when the percentage of non-detects is 50% or less.

Histograms will also be used when the percentage of non-detects is 50% or less. Bars in the histogram will be shaded to indicate the percentage of detects and non-detects within each bar interval.

Probability plots, ordered listings, and other graphics will be used as appropriate.

As indicated by the OU1 process, visual presentation of the data is important. Interpretable graphics will be produced to the extent that they facilitate analysis. In general, graphics will be a central feature of analysis.

BACKGROUND COMPARISON METHODOLOGY TOOL BOX APPROACH

Employing: Bounding-Benchmark Comparison (Hot Measurement), Inferential Statistics, and Professional Judgement

General

The tool-box approach employs a bounding-benchmark comparison, inferential statistics, and professional judgement. This approach was forwarded in the OU1 comment-resolution process, endorsed by Dr. Gilbert, and is widely applied in the hazardous waste industry and environmental business across America. It employs a "weight-of-evidence" framework wherein all three aspects are factored into the determination of what is a Site (OU) contaminant. Statisticians will be used to verify that the methods used are correct.

Bounding Benchmark Comparison "Hot Measurement Test" Component

- A hot-measurement test will be performed that will compare each analyte concentration to an upper-limit value for that analyte.

- The measurement level will be the value at which there is a 99% confidence that 99% of the background distribution will be below this value ($UTL_{99/99}$). If the $UTL_{99/99}$ cannot be calculated or reasonably estimated, then geochemical standards and professional judgement will be used. The resulting geochemical interpretation of data will be subject to Agency review and approval.

- The $UTL_{99/99}$ is required instead of a toxicity-based value because the a single list of potential contaminants must be used by many disciplines (Human Health, Ecological, Regulatory, etc.,) to ensure consistency across the RFI/RI and CMS/FS Reports. The subjective nature of what is "hot", as well as toxicity and ARAR considerations, will be dealt with by the specialists who determine COC's specific to their discipline. See the Figure **UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT** for a comparison of UTL's and Human Health Toxicity-based "Hot-Measurement" values.

- In addition to ensuring that high concentrations do not get overlooked, the $UTL_{99/99}$ is an important tool for identifying locations of suspected elevated concentration in the nature and extent section.

- Credence will be given to the $UTL_{99/99}$ background values by comparing them to literature values. Normally, a $UTL_{99/99}$ should compare with a cited "high-end-of-range" value from the literature. A $UTL_{99/99}$ above the literature range should be used with skepticism, as should a value that is well below the high end of the range documented in the literature.

Background Comparison Using Inferential Statistical Methods

Based on Dr. Gilbert's work, the following inferential statistical tests will be used to compare background data sets to data sets compiled at the Operable Units (OUs). These data sets will be compiled and compared by analyte, and by the correct background data set (i.e., colluvium, alluvium, alluvium + colluvium, surface soils, etc. [See Determine Background and OU Target Populations]).

It should be noted that Dr. Gilbert's recommendations establish a framework that emphasizes using the most appropriate test available. Thus professional judgement will be necessary both in application of inferential tests, as well as their interpretation. Additionally, within the framework of a battery of tests drawn from a "tool box" of methods, it is requested that EPA and CDH remain open to consultation on the use of other tests as appropriate.

The results of all tests (hot-measurement, inferential) will then be evaluated in light of professional judgement. This process is depicted on the figure **BACKGROUND COMPARISONS METHODOLOGY.**

If hot-measurement or inferential statistical tests show that the concentration of a given analyte in the OU data set is not greater than the concentration in the background data set, and if considerations in the professional-judgement arena do not override, then the analyte is considered not to be a contaminant.

If either the hot measurement test or at least one inferential statistical test shows that the concentration of a given analyte in the OU data set may be greater than the concentration in the background data set, then professional judgement (using temporal and spatial analysis, as well as pattern-recognition concepts) is again applied to see if the analyte concentrations in the two data sets are actually different.

After the hot-measurement test and prior to the use of statistical testing, the issue of non-detects must be dealt with for all tests except the Gehan test, which can be applied with non-detects present. For all other tests, nondetects should be replaced with a value of 0.5 times the applicable detection limit, following EPA guidance (Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992), but realizing the performance of simple substitution decreases with an increasing proportion of non-detects.

As addressed in a draft proposal to DOE, memo 93-RF-13945 (FOLLOWUP TO RESPONSE TO TREATMENT OF NONDETECTS-NMH-585-93) dated 11/12/93, the handling of non-detects, and the presence of multiple detection limits in the RFEDS data base, requires the use of good professional judgement along with the general guidance offered here. The use of graphical displays of data will assist in the handling of high-value non-detects.

A discussion of detection limits will be given at this point.

Gehan Test or Nonparametric ANOVA Test

- The Gehan test is a nonparametric test and can be used when multiple detection limits are present. The Gehan test will be applied without replacing non-detects. These are the principal favorable attributes of the Gehan test.

- Standard nonparametric ANOVA tests (Wilcoxon Rank Sum and Kruskal-Wallis) are widely used in environmental assessment, and are discussed in EPA guidance (Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance, July 1992). These tests require replacement of non-detect values, either by simple substitution or maximum-likelihood methods.

- For the Gehan or nonparametric ANOVA test, a p-value will be generated and p-values that are equal to or less than 0.05 will normally be considered indicative of a significant difference from background. Statements of the test and null hypotheses will be given, in both mathematical and narrative terms.

Quantile Test

- The quantile test is also a nonparametric test and can be considered as a rapid screening test.

- Due to limitations in the quantile test, the test will only be used if the largest 20% of the combined background and site data are detects.

- A p-value will be generated and p-values that are equal to or less than 0.05 will indicate a significant difference from background. Statements of the test and null hypotheses will be given, in both mathematical and narrative terms.

Slippage Test

- The slippage test is a nonparametric test and can be considered as a rapid screening test.

- Due to limitations in the slippage test, the test will possibly not be used if the largest background value is a non-detect. If the largest background value is a non-detect, then professional judgement will be applied to determine whether or not the slippage test is applicable.

- A p-value will be generated and p-values that are equal to or less than 0.05 will indicate a significant difference from background. Statements of the test and null hypotheses will be given, in both mathematical and narrative terms.

T-Test

- The t-test is a parametric test and is very commonly used when testing the difference between means of two data sets.

- Due to limitations in the t-test, the test will be applied in cases where both background and OU data are normally or log-normally distributed, and less than 20% of the background and OU data are classified as non-detects.

- A p-value will be generated and p-values that are equal to or less than 0.05 will indicate a significant difference from background. Statements of the test and null hypotheses will be given, in both mathematical and narrative terms.

Due to their wide use in statistical applications, including regulatory settings, it is possible that ANOVA (parametric and non-parametric) tests may qualify as the most appropriate tests, notwithstanding their limitations with non-detects and multiple detection limits. DOE and its contractor shall confer with EPA and CDH, and seek regulatory assistance prior to the use of these tests, and any other tests deemed applicable, as appropriate. For example, see the attached Figure 1-2, **SELECTION OF STATISTICAL METHOD FOR COMPARISON OF BACKGROUND AND NONBACKGROUND POPULATIONS**, from the 1993 Background Geochemistry Report.

Professional Judgement

The following general guidelines will be used individually and collectively, in conjunction with the above comparison and statistical "tools" to ascertain if a reported analytical detection(s) constitutes contamination at the OU. When professional judgement is applied, documented and defensible evidence will be furnished, and DOE will bear the "burden of proof".

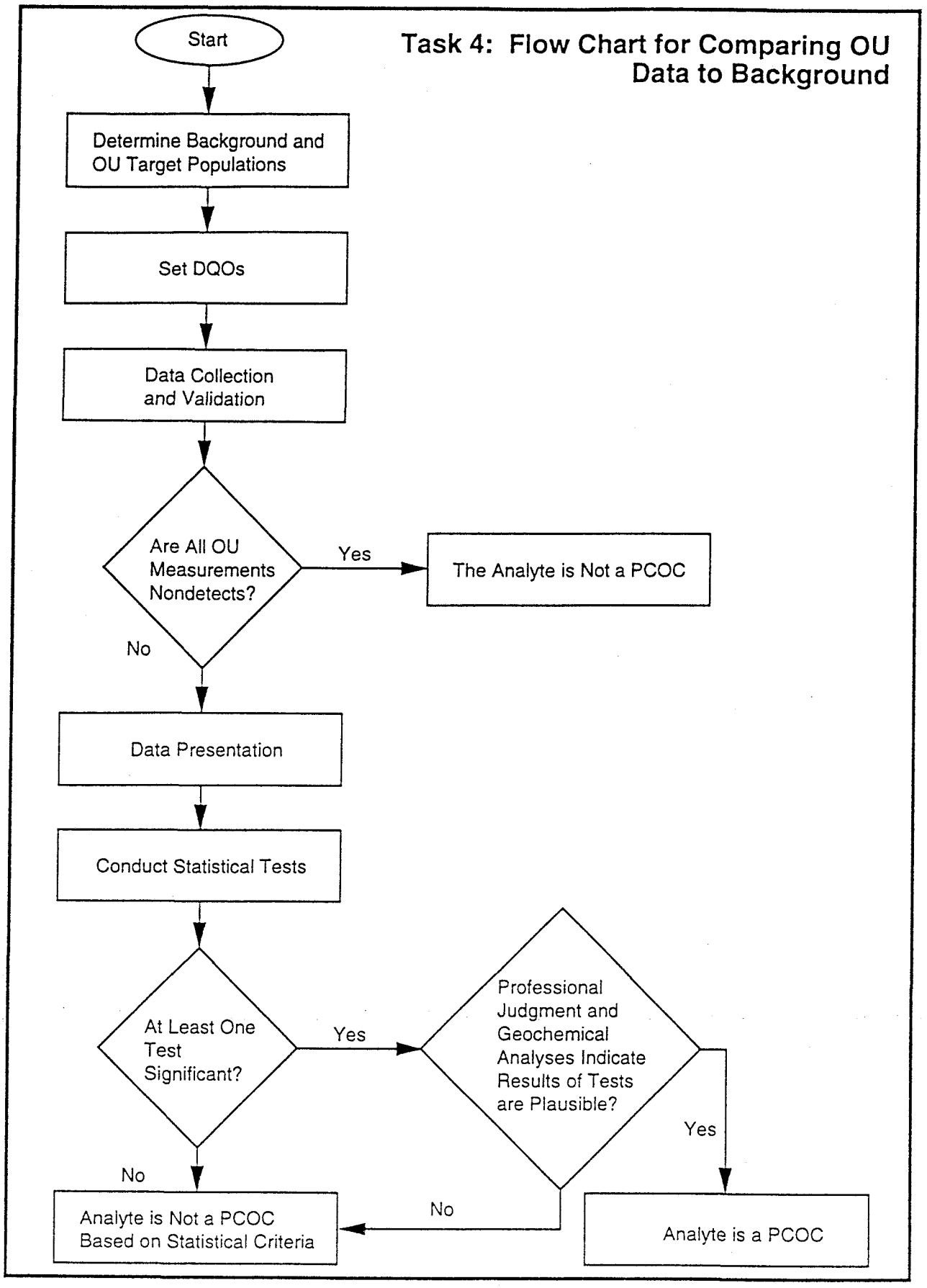
- **Spatial distribution** of analytes above background are or are not indicative of contamination due to waste-related activities at the OU. Spatial plots, interpreted in a source-to-receptor conceptual model, in addition to compound-specific mobility considerations, generally assist in interpretation of inconclusive results.

- **Temporal distribution** of analyte concentrations at a station indicates the "high" value(s) is(are) outlier(s). Time-series plots at wells or surface-water locations can generally be used to link apparently insignificant **outlier** reports to seasonal or hydrological phenomena, and vice versa.

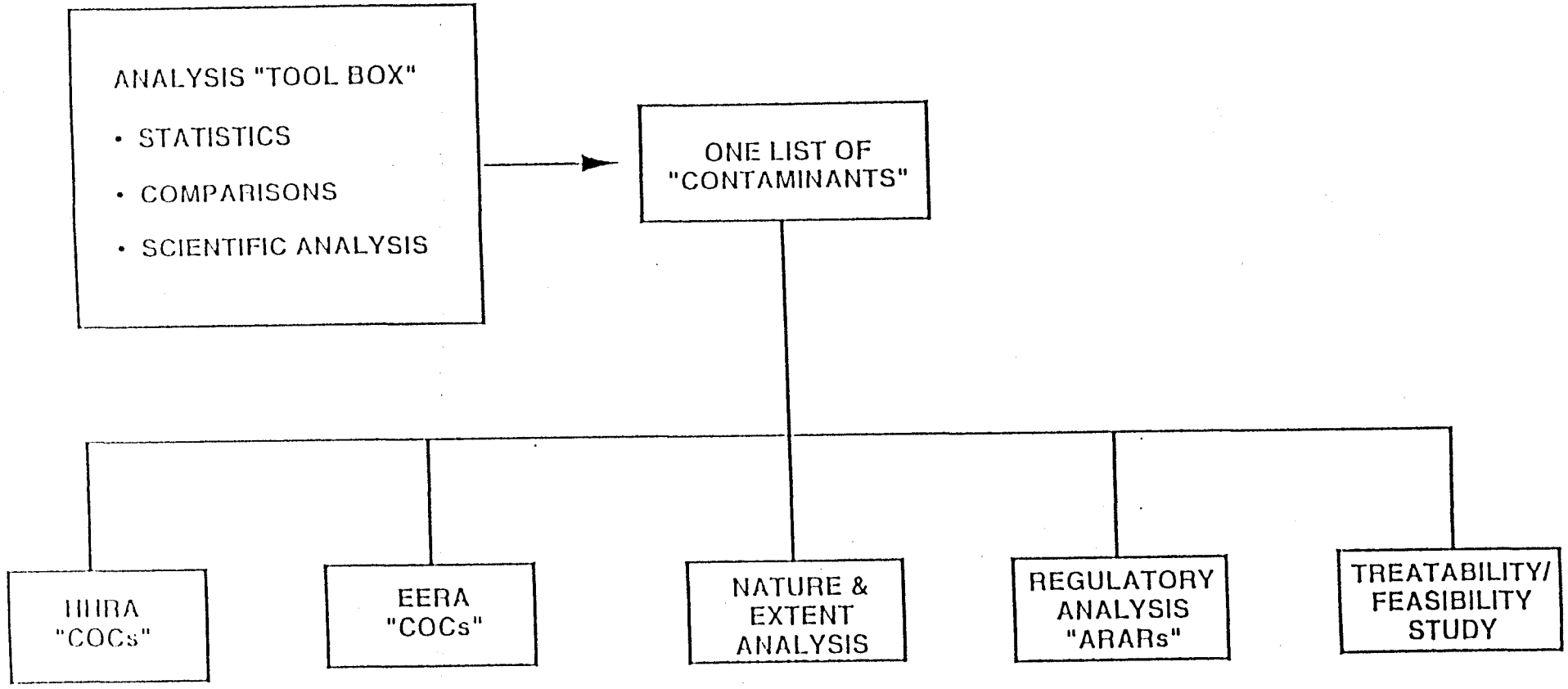
- Other associated analytes are determined not to be contaminants in the sample or at the station. Then this may be added to cumulative evidence ("burden of proof") that the analyte in question is not a potential contaminant of concern. **Pattern recognition**

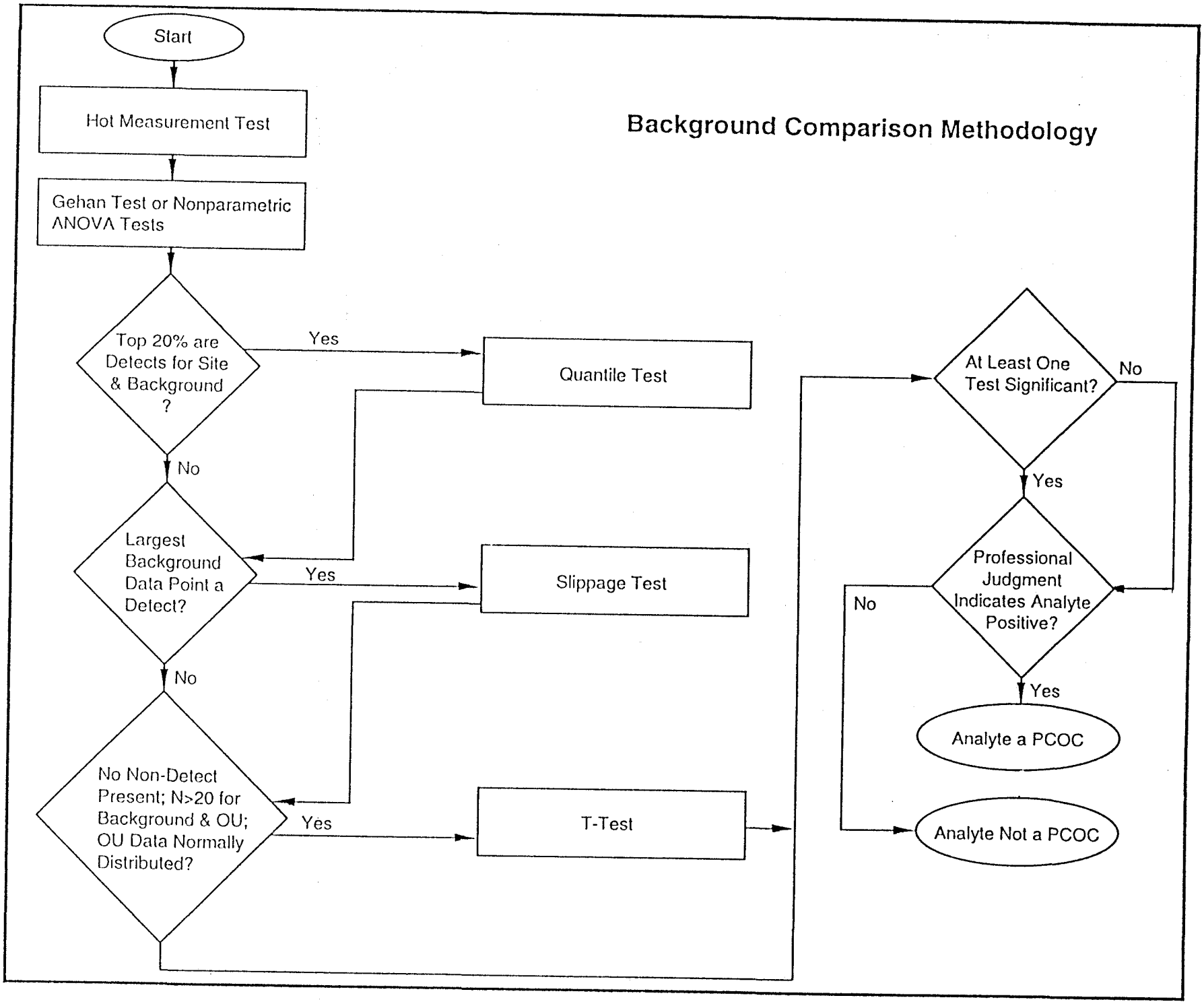
concepts are useful in identifying anomalies as well as confirming "fingerprint" associations.

Task 4: Flow Chart for Comparing OU Data to Background



GENERAL APPROACH TO DETERMINING "CONTAMINANTS"




Background Comparison Methodology
Start
Hot Measurement Test
Gehan Test or Nonparametric ANOVA Tests
Top 20% are Detects for Site & Background ?
Yes
No
Quantile Test
Largest Background Data Point a Detect?
Yes
No
Slippage Test
No Non-Detect Present; N>20 for Background & OU; OU Data Normally Distributed?
Yes
T-Test
At Least One Test Significant?
No
Yes
Professional Judgment Indicates Analyte Positive?
No
Yes
Analyte a PCOC
Analyte Not a PCOC

Flow chart from the 1993 Background Report

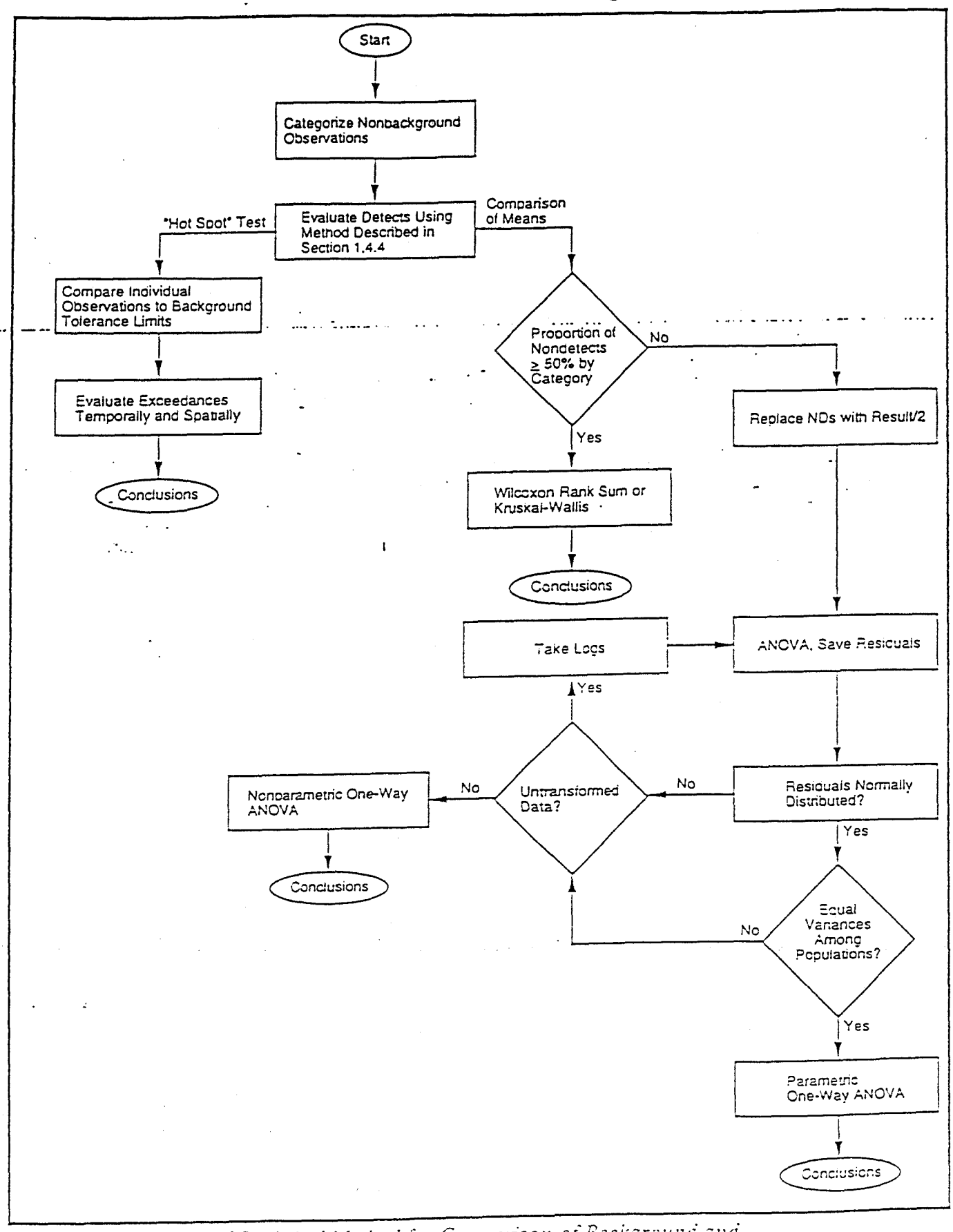


Figure 1-2 Selection of Statistical Method for Comparison of Background and Nonbackground Populations

GWFM
9/28/93

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED METALS

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	COL	35	71.43	59.18	49.50	224.21	229.7		UG/L
ANTIMONY	COL	33	33.33	14.84	9.50	46.92	51.25	15,000	UG/L
BARIUM	COL	34	79.41	77.05	39.03	207.99	199	2,600,000	UG/L
CADMIUM	COL	34	23.53	1.97	1.67	7.57	251.762	37,000	UG/L
CALCIUM	COL	35	100.00	96,314.29	34,355.90	210,868.89			UG/L
CHROMIUM	COL	32	28.12	5.87	5.93	26.03		180,000	UG/L
COPPER	COL	33	36.36	5.08	4.20	19.27			UG/L
IRON	COL	34	61.76	46.38	79.70	313.70	265.9		UG/L
LITHIUM	COL	34	88.24	122.77	84.53	406.30	2,618		UG/L
MAGNESIUM	COL	34	100.00	20,479.41	10,610.71	56,070.91	78,665		UG/L
MANGANESE	COL	35	74.29	32.10	38.69	161.12	747.01	5,100,000	UG/L
MOLYBDENUM	COL	33	42.42	19.35	32.15	127.87	60.68	180,000	UG/L
POTASSIUM	COL	33	84.85	2,086.36	1,903.98	8,513.03	17,187		UG/L
SELENIUM	COL	32	62.50	17.40	42.89	163.12	157.96	180,000	UG/L
SILVER	COL	31	25.81	3.22	2.81	12.84		180,000	UG/L
SODIUM	COL	35	100.00	98,454.29	64,522.31	313,594.26	584,414		UG/L
STRONTIUM	COL	34	97.06	701.88	374.80	1,959.08	5,421.7	22,000,000	UG/L
TIN	COL	31	41.94	44.01	62.59	258.16		22,000,000	UG/L
VANADIUM	COL	32	65.62	8.17	7.85	34.84	15.94	260,000	UG/L
ZINC	COL	35	74.29	11.30	10.64	46.78	50.22	11,000,000	UG/L
ALUMINUM	RFA	104	75.00	68.23	125.93	361.64	229.7		UG/L
ANTIMONY	RFA	113	49.56	18.37	12.98	48.61	51.25	15,000	UG/L
BARIUM	RFA	114	83.33	72.32	24.50	129.39		2,600,000	UG/L
CADMIUM	RFA	107	22.43	1.66	1.13	4.29		37,000	UG/L
CALCIUM	RFA	113	100.00	37,655.53	18,707.96	81,245.08			UG/L
CHROMIUM	RFA	113	41.59	4.86	3.33	12.53		180,000	UG/L
COPPER	RFA	112	43.75	4.79	4.13	14.40			UG/L
IRON	RFA	113	76.99	70.28	157.23	436.62	265.9		UG/L
LEAD	RFA	111	24.32	1.40	3.01	8.41			UG/L
LITHIUM	RFA	109	68.81	12.68	17.36	53.12	12.48		UG/L
MAGNESIUM	RFA	112	91.96	4,266.21	1,369.27	7,456.60			UG/L
MANGANESE	RFA	114	52.63	6.17	15.04	41.21		5,100,000	UG/L
MOLYBDENUM	RFA	106	35.85	19.37	34.13	98.88	60.68	180,000	UG/L
NICKEL	RFA	106	36.79	7.66	7.65	25.49			UG/L
POTASSIUM	RFA	110	79.09	925.94	705.81	2,570.48			UG/L
SILVER	RFA	105	28.57	2.73	1.88	7.11		180,000	UG/L
SODIUM	RFA	112	98.21	7,602.21	1,740.42	11,657.40	40,691		UG/L
STRONTIUM	RFA	112	86.61	132.73	91.06	344.89		22,000,000	UG/L
THALLIUM	RFA	92	21.74	1.68	1.64	5.50			UG/L
TIN	RFA	100	41.00	29.72	34.02	108.98	57.89	22,000,000	UG/L
VANADIUM	RFA	111	62.16	8.36	9.95	31.54	15.94	260,000	UG/L
ZINC	RFA	113	79.65	15.69	19.83	61.88	50.22	11,000,000	UG/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

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UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	VFA	74	82.43	52.02	38.51	169.11	229.7		UG/L
ANTIMONY	VFA	69	52.17	16.63	8.82	43.47	51.25	15,000	UG/L
BARIUM	VFA	74	86.49	98.78	35.33	206.21	214.2	2,600,000	UG/L
CADMIUM	VFA	67	22.39	1.71	1.14	5.18		37,000	UG/L
CALCIUM	VFA	74	100.00	61,597.97	30,967.01	155,768.65	156,795		UG/L
CESIUM	VFA	62	27.42	266.67	415.61	1,530.54			UG/L
CHROMIUM	VFA	72	30.56	4.27	3.40	14.62		180,000	UG/L
COBALT	VFA	65	24.62	5.93	8.12	30.63			UG/L
COPPER	VFA	71	38.03	5.04	4.67	19.23			UG/L
IRON	VFA	74	82.43	47.94	50.37	201.11	265.9		UG/L
LEAD	VFA	74	25.68	1.16	1.34	5.24			UG/L
LITHIUM	VFA	73	78.08	22.36	22.93	92.09	145.99		UG/L
MAGNESIUM	VFA	73	97.26	12,670.14	6,554.47	32,602.27	84,998.9		UG/L
MANGANESE	VFA	73	71.23	57.72	97.91	355.47	2791.6	5,100,000	UG/L
MOLYBDENUM	VFA	70	34.29	16.44	31.55	112.37	60.68	180,000	UG/L
NICKEL	VFA	70	38.57	6.37	6.36	25.72	20.69	730,000	UG/L
PHOSPHORUS	VFA	4	100.00	178.75	31.85	573.25			UG/L
POTASSIUM	VFA	75	84.00	1,455.52	745.03	3,721.17	5,390.8		UG/L
SELENIUM	VFA	66	34.85	3.98	10.30	35.30		180,000	UG/L
SILVER	VFA	68	29.41	2.81	2.21	9.53		180,000	UG/L
SODIUM	VFA	74	100.00	33,841.22	16,286.12	83,367.31	148,389		UG/L
STRONTIUM	VFA	72	97.22	376.61	205.32	1,000.97	2,925	22,000,000	UG/L
THALLIUM	VFA	63	23.57	1.60	1.55	6.32			UG/L
TIN	VFA	72	45.83	27.55	28.07	112.90	57.89	22,000,000	UG/L
VANADIUM	VFA	72	70.83	7.03	7.22	23.98	15.94	260,000	UG/L
ZINC	VFA	74	52.43	13.10	16.73	63.99	50.22	11,000,000	UG/L
ALUMINUM	WCS	33	81.82	49.28	28.70	146.14	229.7		UG/L
ANTIMONY	WCS	33	51.52	17.84	9.68	50.52	51.25	15,000	UG/L
BARIUM	WCS	34	82.35	93.57	42.28	235.38	217.8	2,600,000	UG/L
CALCIUM	WCS	34	100.00	58,876.47	25,771.24	148,675.25	216,219		UG/L
CESIUM	WCS	27	25.93	174.33	195.58	865.25			UG/L
CHROMIUM	WCS	33	36.36	5.04	3.42	16.57		180,000	UG/L
COPPER	WCS	32	28.12	5.68	5.17	23.25			UG/L
IRON	WCS	34	76.47	37.63	43.56	183.75	265.9		UG/L
LEAD	WCS	33	27.27	1.97	3.84	14.93			UG/L
LITHIUM	WCS	34	76.47	38.22	55.05	222.89	197.23		UG/L
MAGNESIUM	WCS	34	100.00	12,960.29	8,069.66	40,028.36	66,356		UG/L
MANGANESE	WCS	33	51.52	29.19	91.63	338.48	132.8	5,100,000	UG/L
MOLYBDENUM	WCS	32	43.75	27.83	40.01	163.76	60.68	180,000	UG/L
NICKEL	WCS	31	22.58	6.99	7.49	32.63		730,000	UG/L
POTASSIUM	WCS	34	82.35	1,933.82	878.64	4,881.04	7,240		UG/L
SELENIUM	WCS	30	60.00	10.04	16.91	68.30	229.33	180,000	UG/L
SILVER	WCS	31	29.03	2.91	1.97	9.66		180,000	UG/L
SODIUM	WCS	33	100.00	40,293.94	55,180.62	226,549.32	197,886		UG/L
STRONTIUM	WCS	34	100.00	461.79	380.86	1,739.31	3,242	22,000,000	UG/L
THALLIUM	WCS	28	21.43	1.79	1.80	8.08			UG/L
TIN	WCS	32	43.75	29.92	32.07	138.87	57.89	22,000,000	UG/L
VANADIUM	WCS	34	58.82	8.11	8.41	36.30	15.94	260,000	UG/L
ZINC	WCS	34	85.29	13.34	19.41	78.43	50.22	11,000,000	UG/L

^ *Example RBCs for illustration of the typical range of a 10E+3 RBC.*

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UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED METALS (CONT')

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	KAR	66	78.79	48.81	44.02	182.67	229.7		UG/L
ANTIMONY	KAR	63	44.44	15.50	9.17	43.37	51.25	15,000	UG/L
ARSENIC	KAR	59	49.15	2.41	1.70	7.77	5.56	49	UG/L
BARIUM	KAR	66	86.36	84.18	21.79	150.44	217.8	2,600,000	UG/L
CADMIUM	KAR	62	22.58	1.76	1.33	5.80		37,000	UG/L
CALCIUM	KAR	67	100.00	34,535.82	23,552.79	106,159.84	206,806		UG/L
CESIUM	KAR	54	29.63	160.88	179.94	728.59			UG/L
CHROMIUM	KAR	65	26.15	3.97	3.15	13.55		180,000	UG/L
COPPER	KAR	65	27.69	4.17	3.83	15.82			UG/L
IRON	KAR	67	79.10	33.67	35.32	141.06	265.9		UG/L
LEAD	KAR	64	20.31	1.80	5.27	17.83			UG/L
LITHIUM	KAR	66	81.82	38.53	27.84	123.21	221.95		UG/L
MAGNESIUM	KAR	67	97.01	6,072.16	4,067.56	18,441.63	35,948		UG/L
MANGANESE	KAR	67	71.64	9.29	7.24	31.31	149.8	5,100,000	UG/L
MOLYBDENUM	KAR	64	53.13	16.86	27.01	99.00	60.68	180,000	UG/L
NICKEL	KAR	65	23.08	5.81	6.26	24.86		730,000	UG/L
PHOSPHORUS	KAR	4	100.00	174.75	85.65	1,235.68			UG/L
POTASSIUM	KAR	67	89.55	2,731.18	1,612.39	7,634.46	14,589		UG/L
SELENIUM	KAR	54	29.63	1.34	1.09	4.78		180,000	UG/L
SILVER	KAR	59	28.81	2.69	2.01	9.03		180,000	UG/L
SODIUM	KAR	67	100.00	142,012.69	135,521.56	554,133.75	912,187		UG/L
STRONTIUM	KAR	66	100.00	383.02	294.27	1,277.90	3,209.8	22,000,000	UG/L
THALLIUM	KAR	56	21.43	1.72	1.87	7.62			UG/L
TIN	KAR	65	40.00	23.07	25.30	100.01		22,000,000	UG/L
VANADIUM	KAR	65	56.92	6.71	7.50	29.81	15.94	250,000	UG/L
ZINC	KAR	67	83.58	10.96	10.20	41.99	50.22	11,000,000	UG/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL METALS

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	COL	19	100.00	745.11	789.02	3,816.32	46,052		UG/L
ANTIMONY	COL	20	30.00	17.74	9.52	54.22		15,000	UG/L
ARSENIC	COL	20	40.00	1.93	1.65	8.24		49	UG/L
BARIUM	COL	20	85.00	90.87	66.40	345.29	603.5	2,600,000	UG/L
CADMIUM	COL	20	25.00	1.97	1.74	8.64		37,000	UG/L
CALCIUM	COL	20	100.00	99,540.00	37,654.79	243,816.53	354,200		UG/L
CHROMIUM	COL	18	22.22	4.59	4.36	21.88	453.9	180,000	UG/L
COPPER	COL	20	65.00	9.29	11.81	54.54			UG/L
IRON	COL	19	100.00	665.11	679.22	3,308.92	63,512		UG/L
LEAD	COL	18	38.89	2.28	4.27	19.18	28.38		UG/L
LITHIUM	COL	20	85.00	117.94	86.49	449.35	15,762		UG/L
MAGNESIUM	COL	20	100.00	21,320.00	11,477.51	65,296.75	115,185		UG/L
MANGANESE	COL	20	95.00	57.46	126.39	541.73	1081	5,100,000	UG/L
MOLYBDENUM	COL	20	40.00	23.88	39.19	174.05		180,000	UG/L
NICKEL	COL	18	33.33	7.25	6.31	32.26		730,000	UG/L
POTASSIUM	COL	20	75.00	2,013.25	1,893.58	9,268.62	8,260		UG/L
SELENIUM	COL	18	66.67	15.04	47.11	201.61		180,000	UG/L
SILICON	COL	12	100.00	8,600.75	2,462.31	20,008.64	32,845		UG/L
SODIUM	COL	20	100.00	101,010.00	68,738.74	364,386.48	2,406,648		UG/L
STRONTIUM	COL	20	100.00	705.85	379.49	2,159.90	4,001.5	22,000,000	UG/L
THALLIUM	COL	20	35.00	1.68	1.76	8.43			UG/L
TIN	COL	20	40.00	35.35	34.62	167.99		22,000,000	UG/L
VANADIUM	COL	20	75.00	16.82	27.37	121.70	146.8	260,000	UG/L
ZINC	COL	20	95.00	31.55	36.14	170.01	711	11,000,000	UG/L
ALUMINUM	RFA	66	93.94	3,844.45	5,057.31	19,223.71	46,052		UG/L
ANTIMONY	RFA	63	42.86	21.40	15.61	68.88		15,000	UG/L
ARSENIC	RFA	61	27.87	2.07	1.76	7.43		49	UG/L
BARIUM	RFA	66	78.79	96.13	36.76	207.92	603.5	2,600,000	UG/L
CALCIUM	RFA	67	100.00	38,690.30	17,954.04	93,288.54	97,251		UG/L
CESIUM	RFA	65	23.08	150.64	202.63	766.84			UG/L
CHROMIUM	RFA	64	56.25	8.21	7.49	30.99	453.9	180,000	UG/L
COBALT	RFA	66	21.21	8.46	10.30	39.78			UG/L
COPPER	RFA	66	77.27	12.25	13.56	53.48			UG/L
IRON	RFA	66	98.48	4,252.08	5,960.89	22,389.15	63,512		UG/L
LEAD	RFA	63	71.43	3.64	3.95	15.64	28.38		UG/L
LITHIUM	RFA	67	76.12	17.15	19.09	75.19	34.28		UG/L
MAGNESIUM	RFA	67	95.52	5,050.67	2,112.57	11,475.30	11,567		UG/L
MANGANESE	RFA	66	90.91	90.09	113.99	436.73	1081	5,100,000	UG/L
MOLYBDENUM	RFA	68	33.82	24.80	40.38	147.60		180,000	UG/L
NICKEL	RFA	66	40.91	13.25	11.32	47.69		730,000	UG/L
POTASSIUM	RFA	68	76.47	1,578.46	1,190.52	5,198.84	16,191		UG/L
SILICON	RFA	37	100.00	19,033.92	11,446.15	56,777.23	32,845		UG/L
SODIUM	RFA	67	97.01	7,797.16	1,995.38	13,665.12	12,460		UG/L
STRONTIUM	RFA	64	78.12	125.27	39.20	244.47	289.4	22,000,000	UG/L
TIN	RFA	68	32.35	34.01	36.65	145.45		22,000,000	UG/L
VANADIUM	RFA	66	78.79	14.87	11.21	48.97	29.7	260,000	UG/L
ZINC	RFA	67	88.06	40.26	67.22	244.69	711	11,000,000	UG/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	VFA	43	97.67	2,560.55	3,909.13	14,893.86	46,052		UG/L
ANTIMONY	VFA	41	31.71	16.54	9.86	47.64		15,000	UG/L
ARSENIC	VFA	41	31.71	1.70	1.57	6.65		49	UG/L
BARIUM	VFA	43	83.72	112.77	30.98	210.51	603.5	2,600,000	UG/L
CADMIUM	VFA	43	25.58	1.79	1.78	7.39		37,000	UG/L
CALCIUM	VFA	43	100.00	60,361.72	30,137.58	155,445.78	314,074		UG/L
CESIUM	VFA	40	30.00	142.06	184.65	741.90			UG/L
CHROMIUM	VFA	42	50.00	6.96	6.89	28.69	453.9	180,000	UG/L
COBALT	VFA	43	20.93	6.73	8.52	33.63			UG/L
COPPER	VFA	43	81.40	10.43	12.48	49.80			UG/L
IRON	VFA	43	100.00	2,732.59	4,579.64	17,181.35	63,512		UG/L
LEAD	VFA	40	77.50	3.39	3.26	13.97	28.38		UG/L
LITHIUM	VFA	43	81.40	22.51	18.95	82.29	120.4		UG/L
MAGNESIUM	VFA	43	97.67	12,865.24	6,410.62	33,090.74	56,291		UG/L
MANGANESE	VFA	43	95.35	92.38	104.18	421.07	1,081	5,100,000	UG/L
MERCURY	VFA	43	23.26	0.12	0.04	0.26		11,000	UG/L
MOLYBDENUM	VFA	43	27.91	18.90	36.26	133.29		180,000	UG/L
NICKEL	VFA	43	44.19	8.41	7.05	30.65		730,000	UG/L
POTASSIUM	VFA	43	81.40	1,785.13	913.58	4,667.48	8,250		UG/L
SELENIUM	VFA	42	42.86	3.42	7.97	28.55		180,000	UG/L
SILICON	VFA	23	100.00	15,831.46	11,777.33	59,186.61	32,845		UG/L
SODIUM	VFA	43	100.00	32,929.90	16,184.58	83,992.25	135,609		UG/L
STRONTIUM	VFA	43	95.35	374.14	206.92	1,025.97	2,051	22,000,000	UG/L
THALLIUM	VFA	43	27.91	1.47	1.59	6.49			UG/L
TIN	VFA	42	38.10	31.89	32.57	134.65		22,000,000	UG/L
VANADIUM	VFA	43	79.07	12.20	10.56	45.52	55.5	260,000	UG/L
ZINC	VFA	43	100.00	39.93	28.56	130.03	711	11,000,000	UG/L
ALUMINUM	WCS	19	89.47	1,326.18	2,630.79	11,566.37	46,052		UG/L
ANTIMONY	WCS	17	47.06	19.09	10.53	61.58		15,000	UG/L
BARIUM	WCS	19	84.21	113.17	66.05	370.27	603.5	2,600,000	UG/L
CALCIUM	WCS	19	100.00	53,731.58	13,527.83	106,387.86			UG/L
CESIUM	WCS	20	35.00	188.32	215.25	1,013.07	117,426		UG/L
CHROMIUM	WCS	19	36.84	5.40	4.02	21.06	453	180,000	UG/L
COPPER	WCS	19	57.89	7.15	4.34	24.03			UG/L
IRON	WCS	19	89.47	1,690.19	3,323.94	14,628.42	63,512		UG/L
LEAD	WCS	19	73.68	2.68	2.62	12.89	28.38		UG/L
LITHIUM	WCS	19	73.68	29.12	15.94	91.18	86.88		UG/L
MAGNESIUM	WCS	19	100.00	11,527.89	3,792.95	26,291.71	32,173		UG/L
MANGANESE	WCS	19	68.42	37.44	56.99	259.28	1,081	5,100,000	UG/L
MOLYBDENUM	WCS	19	42.11	33.49	44.45	206.49		180,000	UG/L
POTASSIUM	WCS	19	73.68	1,858.95	500.67	3,807.76	8,260		UG/L
SELENIUM	WCS	18	50.00	9.10	19.03	84.48		180,000	UG/L
SILICON	WCS	10	100.00	10,474.00	5,966.37	40,745.70	32,845		UG/L
SODIUM	WCS	19	100.00	27,557.89	9,531.60	64,659.09	93,698		UG/L
STRONTIUM	WCS	19	100.00	390.47	150.51	976.33	1,163	22,000,000	UG/L
THALLIUM	WCS	18	27.78	1.95	1.96	9.71			UG/L
TIN	WCS	19	31.58	36.28	39.56	190.25		22,000,000	UG/L
VANADIUM	WCS	19	68.42	10.57	9.20	46.39	145.6	260,000	UG/L
ZINC	WCS	19	84.21	25.91	17.93	95.69	711	11,000,000	UG/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	KAR	37	91.89	1,791.87	2,773.43	10,937.17	46,052		UG/L
ANTIMONY	KAR	35	31.43	15.62	10.40	50.28		15,000	UG/L
ARSENIC	KAR	35	54.29	2.76	2.02	9.51		49	UG/L
BARIUM	KAR	36	86.11	113.95	51.97	286.27		2,600,000	UG/L
CALCIUM	KAR	37	100.00	36,382.43	23,881.47	115,130.79	154,031		UG/L
CESIUM	KAR	35	25.71	131.59	175.16	715.62			UG/L
CHROMIUM	KAR	36	38.89	5.25	4.61	20.54		180,000	UG/L
COPPER	KAR	36	61.11	11.99	21.82	84.34			UG/L
IRON	KAR	37	94.59	2,239.92	3,697.44	14,432.11	63,512		UG/L
LEAD	KAR	36	61.11	3.82	4.29	18.06	28.38		UG/L
LITHIUM	KAR	37	86.49	40.69	29.29	137.26	271.8		UG/L
MAGNESIUM	KAR	37	94.59	6,679.46	5,030.81	23,268.40	26,784		UG/L
MANGANESE	KAR	37	86.49	61.87	125.21	474.75	1081	5,100,000	UG/L
MERCURY	KAR	37	27.03	0.13	0.05	0.28		11,000	UG/L
MOLYBDENUM	KAR	36	47.22	18.59	33.45	129.48		180,000	UG/L
NICKEL	KAR	35	34.29	8.70	7.25	32.89		730,000	UG/L
POTASSIUM	KAR	37	89.19	2,846.38	1,725.69	8,536.77	13,626		UG/L
SELENIUM	KAR	36	33.33	1.19	0.63	3.27		180,000	UG/L
SILICON	KAR	20	100.00	9,427.50	6,631.12	34,835.00			UG/L
SODIUM	KAR	37	100.00	139,228.38	134,404.33	582,422.16	1,751,482		UG/L
STRONTIUM	KAR	37	97.30	399.78	312.58	1,430.50	1,842	22,000,000	UG/L
THALLIUM	KAR	36	27.78	1.40	1.50	6.36			UG/L
TIN	KAR	37	29.73	27.46	31.18	130.28		22,000,000	UG/L
VANADIUM	KAR	36	69.44	10.43	11.26	47.75	2,798	260,000	UG/L
ZINC	KAR	36	97.22	52.45	51.31	222.56	711	11,000,000	UG/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWFR

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, DISSOLVED RADIONUCLIDES

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
CESIUM-137	COL	2	100.00	0.36	0.42	78.73		1,700	pCi/L
GROSS ALPHA	COL	30	100.00	41.31	78.79	312.85	295.23		pCi/L
GROSS BETA	COL	27	100.00	17.51	29.87	123.04	122.20		pCi/L
RADIUM-226	COL	15	100.00	0.21	0.10	0.64	1.88	400	pCi/L
STRONTIUM-89,90	COL	23	100.00	0.25	0.24	1.13	0.97	1,400	pCi/L
TRITIUM	COL	31	100.00	76.12	109.42	450.48	309.84	880,000	pCi/L
URANIUM-233,234	COL	30	100.00	31.82	56.44	226.34	204.43	3,000	pCi/L
URANIUM-235	COL	30	100.00	0.86	1.39	5.63	5.07	3,000	pCi/L
URANIUM-238	COL	24	100.00	26.70	42.13	180.03	143.66	3,000	pCi/L
CESIUM-137	RFA	15	100.00	0.27	0.29	1.48		1,700	pCi/L
GROSS ALPHA	RFA	82	100.00	0.59	0.80	3.02	1.96		pCi/L
GROSS BETA	RFA	76	100.00	1.66	1.52	6.28	4.47		pCi/L
RADIUM-226	RFA	2	100.00	0.17	0.04	7.91		400	pCi/L
RADIUM-228	RFA	2	100.00	2.20	0.42	60.95		480	pCi/L
STRONTIUM-89,90	RFA	81	100.00	0.27	0.23	0.98	0.60	1,400	pCi/L
TRITIUM	RFA	63	100.00	163.03	223.01	841.20	352	880,000	pCi/L
URANIUM-233,234	RFA	78	100.00	0.23	0.21	0.88	0.72	3,000	pCi/L
URANIUM-235	RFA	78	100.00	0.03	0.07	0.23	0.17	3,000	pCi/L
URANIUM-238	RFA	69	100.00	0.14	0.14	0.56	0.48	3,000	pCi/L
CESIUM-137	VFA	17	100.00	0.58	0.71	3.43		1,700	pCi/L
GROSS ALPHA	VFA	60	100.00	2.93	3.17	12.94	65.09		pCi/L
GROSS BETA	VFA	55	100.00	3.20	1.69	8.54	25.77		pCi/L
RADIUM-226	VFA	13	100.00	0.31	0.11	0.81	1.88	400	pCi/L
RADIUM-228	VFA	4	100.00	2.08	0.62	9.76		480	pCi/L
STRONTIUM-89,90	VFA	59	100.00	0.49	0.38	1.68	1.15	1,400	pCi/L
TRITIUM	VFA	42	100.00	115.00	137.64	549.26	392.17	880,000	pCi/L
URANIUM-233,234	VFA	60	100.00	2.05	2.77	10.80	10.47	3,000	pCi/L
URANIUM-235	VFA	60	100.00	0.08	0.12	0.47	0.43	3,000	pCi/L
URANIUM-238	VFA	49	100.00	1.66	2.30	8.92	8.14	3,000	pCi/L
CESIUM-137	WCS	4	100.00	0.32	0.20	2.86		1,700	pCi/L
GROSS ALPHA	WCS	41	100.00	7.70	5.95	26.47	22.31		pCi/L
GROSS BETA	WCS	38	100.00	4.85	3.22	15.41	10.33		pCi/L
RADIUM-226	WCS	6	100.00	0.32	0.06	0.78	1.88	400	pCi/L
STRONTIUM-89,90	WCS	17	100.00	0.24	0.24	1.21	0.91	1,400	pCi/L
TRITIUM	WCS	29	100.00	-23.42	118.54	388.30	274.14	880,000	pCi/L
URANIUM-233,234	WCS	39	100.00	8.59	21.06	77.33	15.18	3,000	pCi/L
URANIUM-235	WCS	39	100.00	0.20	0.51	1.88	0.38	3,000	pCi/L
URANIUM-238	WCS	35	100.00	3.54	3.19	14.17	10.3	3,000	pCi/L
CESIUM-137	KAR	4	100.00	0.22	0.30	3.92		1,700	pCi/L
GROSS ALPHA	KAR	60	100.00	3.13	6.24	22.81	19.59		pCi/L
GROSS BETA	KAR	54	100.00	3.23	2.54	12.19	10.69		pCi/L
RADIUM-226	KAR	2	100.00	1.72	1.78	331.75	1.88	400	pCi/L
STRONTIUM-89,90	KAR	42	100.00	0.47	1.19	4.21	0.91	1,400	pCi/L
TRITIUM	KAR	49	100.00	56.88	135.94	485.77	309.84	880,000	pCi/L
URANIUM-233,234	KAR	57	100.00	1.64	2.85	10.53	9.06	3,000	pCi/L
URANIUM-235	KAR	57	100.00	0.03	0.06	0.23	0.18	3,000	pCi/L
URANIUM-238	KAR	54	100.00	0.77	1.53	5.58	4.76	3,000	pCi/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWTR

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL RADIONUCLIDES

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
AMERICIUM-241	COL	25	100.00	0.00	0.00	0.01	0.032	200	pCi/L
CESIUM-137	COL	23	100.00	0.18	0.35	1.49	0.70	1,700	pCi/L
GROSS ALPHA	COL	6	100.00	150.35	142.75	1,197.38	314.5		pCi/L
GROSS BETA	COL	6	100.00	81.55	85.25	706.79	191.6		pCi/L
PLUTONIUM-239,240	COL	26	100.00	0.01	0.01	0.04	0.028	210	pCi/L
STRONTIUM-89,90	COL	7	100.00	0.26	0.11	0.95	0.84	1,400	pCi/L
TRITIUM	COL	17	100.00	201.15	193.39	981.82	937	880,000	pCi/L
URANIUM-233,234	COL	8	100.00	58.74	66.80	446.99	320	3,000	pCi/L
URANIUM-235	COL	8	100.00	2.14	2.39	16.03	10.94	3,000	pCi/L
URANIUM-238	COL	6	100.00	36.04	46.48	376.92	294	3,000	pCi/L
AMERICIUM-241	RFA	82	100.00	0.01	0.01	0.03	0.032	200	pCi/L
CESIUM-137	RFA	75	100.00	0.08	0.33	1.09	0.70	1,700	pCi/L
GROSS ALPHA	RFA	5	100.00	1.89	1.28	13.30	314.5		pCi/L
GROSS BETA	RFA	5	100.00	2.25	1.48	15.45	191.6		pCi/L
PLUTONIUM-238	RFA	7	100.00	0.00	0.00	0.01	0.028		pCi/L
PLUTONIUM-239,240	RFA	85	100.00	0.00	0.00	0.01	0.028	210	pCi/L
STRONTIUM-89,90	RFA	13	100.00	0.11	0.21	1.04	0.084	1,400	pCi/L
TRITIUM	RFA	21	100.00	226.72	307.18	1,386.83	936	880,000	pCi/L
URANIUM-233,234	RFA	12	100.00	0.48	0.45	2.58	1.72	3,000	pCi/L
URANIUM-235	RFA	12	100.00	0.12	0.20	1.05	0.99	3,000	pCi/L
URANIUM-238	RFA	11	100.00	0.40	0.50	2.53	1.85	3,000	pCi/L
AMERICIUM-241	VFA	56	100.00	0.01	0.01	0.05	0.032	200	pCi/L
CESIUM-137	VFA	44	100.00	0.10	0.30	1.05	0.70	1,700	pCi/L
GROSS ALPHA	VFA	7	100.00	3.66	2.06	16.84	314		pCi/L
GROSS BETA	VFA	7	100.00	4.54	2.83	22.56	199		pCi/L
PLUTONIUM-238	VFA	6	100.00	0.01	0.01	0.09	0.028		pCi/L
PLUTONIUM-239,240	VFA	62	100.00	0.01	0.04	0.12	0.028	210	pCi/L
STRONTIUM-89,90	VFA	8	100.00	0.43	0.37	2.56	0.84	1,400	pCi/L
TRITIUM	VFA	27	100.00	142.98	180.32	779.97	936	880,000	pCi/L
URANIUM-233,234	VFA	7	100.00	1.58	1.00	8.01	156.3	3,000	pCi/L
URANIUM-235	VFA	7	100.00	0.10	0.10	0.75	7.65	3,000	pCi/L
URANIUM-238	VFA	2	100.00	1.23	1.20	223.18	91.98	3,000	pCi/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GWTR

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GROUNDWATER, TOTAL RADIONUCLIDES (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE, N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
AMERICIUM-241	WCS	20	100.00	0.01	0.01	0.07	0.032	200	pCi/L
CESIUM-137	WCS	14	100.00	0.28	0.36	1.86	0.71	1,700	pCi/L
GROSS ALPHA	WCS	5	100.00	12.65	12.46	124.04	314		pCi/L
GROSS BETA	WCS	5	100.00	8.27	5.11	53.95	191.6		pCi/L
PLUTONIUM-239,240	WCS	21	100.00	0.00	0.00	0.02	0.028	210	pCi/L
RADIUM-226	WCS	4	100.00	0.36	0.15	2.19		400	pCi/L
STRONTIUM-89,90	WCS	4	100.00	0.05	0.26	3.25	0.84	1,400	pCi/L
TRITIUM	WCS	19	100.00	2,128.76	8,937.88	36,918.91	936.7	880,000	pCi/L
URANIUM-233,234	WCS	8	100.00	7.49	6.30	44.13	27.6	3,000	pCi/L
URANIUM-235	WCS	8	100.00	0.28	0.26	1.81	1.34	3,000	pCi/L
URANIUM-238	WCS	3	100.00	5.11	4.96	123.65	91.98	3,000	pCi/L
AMERICIUM-241	KAR	43	100.00	0.01	0.02	0.07	0.032	200	pCi/L
CESIUM-137	KAR	39	100.00	0.00	0.29	0.96	0.48	1,700	pCi/L
GROSS ALPHA	KAR	6	100.00	11.08	16.63	133.08	314		pCi/L
GROSS BETA	KAR	6	100.00	12.01	13.45	110.67	191.6		pCi/L
PLUTONIUM-238	KAR	5	100.00	0.01	0.01	0.14	0.028		pCi/L
PLUTONIUM-239,240	KAR	48	100.00	0.00	0.01	0.02	0.028	210	pCi/L
RADIUM-226	KAR	3	100.00	0.59	0.45	11.30		400	pCi/L
STRONTIUM-89,90	KAR	4	100.00	0.10	0.26	3.34	0.84	1,400	pCi/L
TRITIUM	KAR	16	100.00	62.93	367.23	1,577.10	936	880,000	pCi/L
URANIUM-233,234	KAR	4	100.00	0.77	0.57	7.79	3.68	3,000	pCi/L
URANIUM-235	KAR	4	100.00	0.03	0.02	0.27		3,000	pCi/L
URANIUM-238	KAR	2	100.00	0.35	0.26	48.13	91.98	3,000	pCi/L

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GMTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GEOLOGIC MATERIALS, TOTAL METALS

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	COL	28	100.00	10,541.43	4,945.95	27,861.88	23,303		MG/KG
ARSENIC	COL	28	85.71	3.57	1.74	9.65	12.1	360	MG/KG
BARIUM	COL	28	100.00	133.20	94.05	462.57	438	9,100,000	MG/KG
BERYLLIUM	COL	28	96.43	5.47	5.47	24.62	18.1	150	MG/KG
CADMIUM	COL	26	57.69	0.86	0.42	2.35		45,000	MG/KG
CALCIUM	COL	28	100.00	9,082.14	6,369.14	31,386.50	23,236		MG/KG
CESIUM	COL	24	75.00	206.24	56.88	413.26			MG/KG
CHROMIUM	COL	28	100.00	13.79	5.86	34.31	42.3	6,800	MG/KG
COBALT	COL	28	25.00	6.11	3.87	19.66			MG/KG
COPPER	COL	28	96.43	14.67	5.48	33.87	32.3		MG/KG
IRON	COL	28	100.00	15,028.07	6,715.26	38,544.51	33,287		MG/KG
LEAD	COL	28	100.00	16.23	4.62	32.40	30.0		MG/KG
LITHIUM	COL	28	28.57	8.52	7.56	34.99	18.5		MG/KG
MAGNESIUM	COL	28	78.57	2,987.32	1,577.90	8,513.05	7,373		MG/KG
MANGANESE	COL	28	100.00	191.87	160.26	753.10	643	10,000,000	MG/KG
MERCURY	COL	27	22.22	0.18	0.20	0.88		80,000	MG/KG
NICKEL	COL	28	92.86	16.97	8.28	45.97	41.9	5,400,000	MG/KG
POTASSIUM	COL	28	35.71	979.61	721.36	3,505.78	3,726		MG/KG
SELENIUM	COL	27	22.22	0.85	0.65	3.15		1,400,000	MG/KG
SILVER	COL	19	42.11	5.85	9.46	42.68		1,400,000	MG/KG
STRONTIUM	COL	28	85.71	55.92	27.04	150.63	131	160,000,000	MG/KG
TIN	COL	23	26.09	87.36	147.51	630.37		160,000,000	MG/KG
VANADIUM	COL	28	100.00	30.31	12.23	73.15	74.3	1,900,000	MG/KG
ZINC	COL	28	100.00	56.13	21.92	132.87	111	81,000,000	MG/KG
ALUMINUM	RFA	62	100.00	13,565.95	13,557.25	55,097.56	46,580		MG/KG
ARSENIC	RFA	62	69.35	4.15	5.70	21.46	12.1	360	MG/KG
BARIUM	RFA	62	83.87	84.46	100.14	388.97	259	9,100,000	MG/KG
BERYLLIUM	RFA	62	87.10	4.65	4.66	18.83	18.1	150	MG/KG
CADMIUM	RFA	46	47.83	0.84	0.48	2.36		45,000	MG/KG
CALCIUM	RFA	62	82.26	6,676.41	19,969.15	67,402.51	16,826		MG/KG
CESIUM	RFA	62	75.81	242.09	337.12	1,267.28			MG/KG
CHROMIUM	RFA	62	100.00	22.08	30.15	113.77	78.9	6,800	MG/KG
COBALT	RFA	62	35.48	8.76	13.16	48.79	76.2		MG/KG
COPPER	RFA	62	87.10	11.68	15.59	59.10	30		MG/KG
IRON	RFA	62	100.00	14,347.10	16,126.79	63,388.67	33,287		MG/KG
LEAD	RFA	62	100.00	9.05	7.07	30.54	24.5		MG/KG
LITHIUM	RFA	62	59.68	14.33	12.85	53.41	18.5		MG/KG
MAGNESIUM	RFA	62	58.06	2,482.38	4,093.78	14,931.58	7,600		MG/KG
MANGANESE	RFA	62	100.00	235.92	417.44	1,505.36	643	10,000,000	MG/KG
MERCURY	RFA	54	42.59	0.29	0.80	2.81		80,000	MG/KG
NICKEL	RFA	59	88.14	23.35	25.45	103.63	72.2	5,400,000	MG/KG
POTASSIUM	RFA	61	27.87	1,545.33	3,036.93	10,780.63	3,726		MG/KG
SILVER	RFA	55	30.91	2.48	5.55	19.99		1,400,000	MG/KG
STRONTIUM	RFA	62	30.65	77.93	87.02	342.55		160,000,000	MG/KG
VANADIUM	RFA	62	96.77	32.03	34.96	138.33	77.1	1,900,000	MG/KG
ZINC	RFA	61	93.44	29.97	61.25	216.23	142	81,000,000	MG/KG

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GMTM

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GEOLOGIC MATERIALS, TOTAL METALS (CONT)

ANALYTE	GEOLOGIC UNIT	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	99 / 99 UTL	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
ALUMINUM	WCS	8	100.00	14,181.25	5,023.23	43,375.23	23,303		MG/KG
ARSENIC	WCS	9	77.78	2.94	1.55	11.27	12.1	360	MG/KG
BARIUM	WCS	9	88.89	64.81	26.27	206.40	343	9,100,000	MG/KG
BERYLLIUM	WCS	9	100.00	3.57	1.09	9.45	18.1	150	MG/KG
CADMIUM	WCS	9	22.22	0.63	0.27	2.06		45,000	MG/KG
CALCIUM	WCS	9	66.67	2,213.33	1,356.05	9,520.93	43,000		MG/KG
CESIUM	WCS	9	100.00	214.89	5.99	247.16			MG/KG
CHROMIUM	WCS	9	100.00	20.70	5.93	52.65	32.6	6,800	MG/KG
COPPER	WCS	9	100.00	12.14	5.91	43.99	55.7		MG/KG
IRON	WCS	9	100.00	14,262.22	4,066.80	36,177.70	33,287		MG/KG
LEAD	WCS	9	100.00	6.68	3.15	23.66	69.3		MG/KG
MAGNESIUM	WCS	9	55.56	2,033.89	1,253.36	8,788.12	7,373		MG/KG
MANGANESE	WCS	9	100.00	171.88	99.17	706.30	643	10,000,000	MG/KG
NICKEL	WCS	9	100.00	15.31	6.87	52.31	41.9	80,000	MG/KG
SELENIUM	WCS	9	66.67	1.95	1.25	8.71		1,400,000	MG/KG
SILVER	WCS	9	100.00	24.29	6.94	61.68		1,400,000	MG/KG
TIN	WCS	9	100.00	278.00	65.04	628.52		160,000,000	MG/KG
VANADIUM	WCS	9	100.00	31.42	11.01	90.76	74.3	1,900,000	MG/KG
ZINC	WCS	9	100.00	23.62	8.30	68.34	171	81,000,000	MG/KG
ALUMINUM	KAR	21	100.00	7,482.60	2,581.30	17,608.83	23,111		MG/KG
ARSENIC	KAR	21	66.67	3.72	3.26	16.05	12.1	360	MG/KG
BARIUM	KAR	21	95.24	99.40	55.10	307.51	343	9,100,000	MG/KG
BERYLLIUM	KAR	21	100.00	3.35	3.16	15.29	18.1	150	MG/KG
CADMIUM	KAR	19	57.89	0.63	0.37	2.28		45,000	MG/KG
CALCIUM	KAR	21	100.00	5,477.14	1,831.78	12,395.06	12,740		MG/KG
CESIUM	KAR	16	93.75	223.62	31.26	352.50			MG/KG
CHROMIUM	KAR	21	100.00	8.91	2.98	20.18		6,800	MG/KG
COBALT	KAR	21	23.81	6.74	7.20	33.94			MG/KG
COPPER	KAR	20	100.00	15.76	5.93	38.48	47.8		MG/KG
IRON	KAR	20	100.00	12,963.25	8,753.38	46,502.32	33,287		MG/KG
LEAD	KAR	21	100.00	18.91	6.19	42.29	42.9		MG/KG
LITHIUM	KAR	21	28.57	7.17	8.39	38.84	18.5		MG/KG
MAGNESIUM	KAR	21	66.67	2,053.71	1,213.43	6,636.37	7,373		MG/KG
MANGANESE	KAR	21	100.00	171.90	183.74	865.82	643	10,000,000	MG/KG
MERCURY	KAR	21	33.33	0.23	0.24	1.13		80,000	MG/KG
NICKEL	KAR	19	84.21	18.78	13.39	70.90	72.2	5,400,000	MG/KG
SELENIUM	KAR	19	31.58	0.90	1.01	4.85		1,400,000	MG/KG
SILVER	KAR	16	25.00	3.72	6.22	29.37		1,400,000	MG/KG
STRONTIUM	KAR	21	90.48	69.50	30.95	186.40	314	160,000,000	MG/KG
VANADIUM	KAR	20	90.00	20.70	8.76	54.25	74.3	1,900,000	MG/KG
ZINC	KAR	21	100.00	60.24	19.22	132.82	175	81,000,000	MG/KG

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

GMTR

UPPER TOLERANCE LIMITS BY GEOLOGIC UNIT

GEOLOGIC MATERIALS, TOTAL RADIONUCLIDES

ANALYTE	GEOLOGY	SAMPLE SIZE N	PERCENT DETECTS	MEAN	STANDARD DEVIATION	UTL 99 / 99	LAST YEAR'S 95 / 95 UTLs	1000*RBC ^	UNITS
CESIUM-137	COL	28	100.00	0.01	0.04	0.17	0.08	27,000	pCi/g
GROSS ALPHA	COL	28	100.00	31.95	8.90	63.10	51.3		pCi/g
GROSS BETA	COL	28	100.00	27.00	3.52	39.32	35.1		pCi/g
PLUTONIUM-239,240	COL	28	100.00	0.01	0.01	0.03	0.017	1,900	pCi/g
RADIUM-226	COL	21	100.00	1.07	0.18	1.77	1.50	1,900	pCi/g
RADIUM-228	COL	21	100.00	1.57	0.29	2.65	2.26	7,500	pCi/g
STRONTIUM-89,90	COL	28	100.00	-0.01	0.36	1.24	0.64	23,000	pCi/g
TRITIUM	COL	28	100.00	62.14	106.16	433.90	303	14,000,000	pCi/g
URANIUM, TOTAL	COL	28	100.00	1.86	0.73	4.41			pCi/g
URANIUM-233,234	COL	28	100.00	1.14	1.58	6.66	1.75	5,200	pCi/g
URANIUM-235	COL	28	100.00	0.04	0.06	0.24	0.17	140	pCi/g
URANIUM-238	COL	28	100.00	0.94	0.34	2.15	1.68	5,800	pCi/g
AMERICIUM-241	RFA	28	100.00	-0.00	0.01	0.02	0.013	1,500	pCi/g
CESIUM-137	RFA	62	100.00	0.01	0.04	0.14	0.08	27,000	pCi/g
GROSS ALPHA	RFA	62	100.00	22.32	8.18	47.21	37.8		pCi/g
GROSS BETA	RFA	62	100.00	24.10	6.75	44.62	36.9		pCi/g
PLUTONIUM-239,240	RFA	62	100.00	0.00	0.01	0.02	0.017	1,900	pCi/g
RADIUM-226	RFA	58	100.00	0.63	0.10	0.96	0.85	1,900	pCi/g
RADIUM-228	RFA	58	100.00	1.34	0.31	2.32	1.97	7,500	pCi/g
STRONTIUM-89,90	RFA	62	100.00	0.03	0.35	1.09	0.64	23,000	pCi/g
TRITIUM	RFA	62	100.00	172.90	122.58	545.96	411	14,000,000	pCi/g
URANIUM, TOTAL	RFA	62	100.00	1.29	0.81	3.76			pCi/g
URANIUM-233,234	RFA	62	100.00	0.64	0.46	2.04	1.49	5,200	pCi/g
URANIUM-235	RFA	62	100.00	0.01	0.03	0.11	0.08	140	pCi/g
URANIUM-238	RFA	62	100.00	0.64	0.38	1.79	1.36	5,800	pCi/g
CESIUM-137	WCS	9	100.00	0.01	0.03	0.19	0.08	27,000	pCi/g
GROSS ALPHA	WCS	9	100.00	20.89	5.88	52.59	55.2		pCi/g
GROSS BETA	WCS	9	100.00	21.89	5.53	51.70	34.6		pCi/g
PLUTONIUM-239,240	WCS	9	100.00	0.01	0.01	0.07	0.017	1,900	pCi/g
RADIUM-226	WCS	4	100.00	0.68	0.15	2.53	1.70	1,900	pCi/g
RADIUM-228	WCS	4	100.00	1.42	0.29	4.98	2.19	7,500	pCi/g
STRONTIUM-89,90	WCS	9	100.00	0.17	0.44	2.56	0.64	23,000	pCi/g
TRITIUM	WCS	9	100.00	174.44	114.47	791.30	449	14,000,000	pCi/g
URANIUM, TOTAL	WCS	9	100.00	1.36	0.21	2.50			pCi/g
URANIUM-233,234	WCS	9	100.00	0.60	0.12	1.25	2.20	5,200	pCi/g
URANIUM-235	WCS	9	100.00	0.02	0.07	0.38	0.44	140	pCi/g
URANIUM-238	WCS	9	100.00	0.73	0.12	1.39	1.94	5,800	pCi/g
CESIUM-137	KAR	21	100.00	0.00	0.00	0.00	0.08	27,000	pCi/g
GROSS ALPHA	KAR	21	100.00	29.98	8.42	61.78	53.1		pCi/g
GROSS BETA	KAR	21	100.00	25.76	3.85	40.29	34.6		pCi/g
PLUTONIUM-239,240	KAR	21	100.00	0.00	0.01	0.03	0.017	1,900	pCi/g
RADIUM-226	KAR	14	100.00	1.09	0.12	1.63	1.40		pCi/g
RADIUM-228	KAR	14	100.00	1.30	0.19	2.14	1.80	1,900	pCi/g
STRONTIUM-89,90	KAR	21	100.00	-0.11	0.36	1.24	0.64	7,500	pCi/g
TRITIUM	KAR	21	100.00	65.95	122.69	529.32	300	14,000,000	pCi/g
URANIUM, TOTAL	KAR	21	100.00	1.96	0.64	4.40			pCi/g
URANIUM-233,234	KAR	21	100.00	0.96	0.39	2.42	1.86	5,200	pCi/g
URANIUM-235	KAR	21	100.00	0.04	0.08	0.35	0.10	140	pCi/g
URANIUM-238	KAR	21	100.00	0.98	0.25	1.92	1.51	5,800	pCi/g

^ Example RBCs for illustration of the typical range of a 10E+3 RBC.

DRINKING WATER STANDARDS (EPA, 1976) AND NON-MANDATORY STANDARDS *

ALUMINUM *	50	UG/L	
ARSENIC	50	UG/L	
BARIUM	1000	UG/L	
CADMIUM	10	UG/L	
CHROMIUM	50	UG/L	
COPPER *	1000	UG/L	
LEAD	50	UG/L	(Lead now has a lower DWS; maybe 5 ppb)
MANGANESE *	50	UG/L	
MERCURY	2	UG/L	
SELENIUM	10	UG/L	
SILVER	50	UG/L	
ZINC *	5000	UG/L	
RADIUM-228	5	pCi/L	
GROSS ALPHA	15	pCi/L	