Helpful Information

The following information is provided to assist the reader in understanding the report. Definitions of technical terms can be found in Appendix B, "Glossary." A public information summary pamphlet is available and may be obtained by following directions given in the Preface.

Scientific Notation

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or by using scientific notation written as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^3, the decimal point should be moved three numbers to the **right** of its present location. The number would then read 2,000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the **left** of its present location. The result would be 0.00002.

Metric Units

The primary units of measurement used in this report are metric. Table H.1 summarizes and defines the terms and corresponding symbols (metric and nonmetric). A conversion table is also provided (Table H.2).

Radioactivity Units

Much of this report deals with levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of curies (Ci) (Table H.3). The curie is the basic unit used to describe the amount of radioactivity present, and concentrations are generally expressed in terms of fractions of curies per unit mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. In some instances in this report, radioactivity values are expressed with two sets of units, one of which is usually included in parentheses or footnotes. These units belong to the International System of Units (SI), and their inclusion in this report is mandated by DOE. SI units are the internationally accepted units and will eventually be the standard for reporting radioactivity and radiation dose in the United States. The basic unit for discussing radioactivity, the curie, can be converted to the equivalent SI unit, the becquerel (Bq), by multiplying the number of curies by 3.7×10^{10}. One becquerel is equivalent to one nuclear disintegration per second.

Radiation Dose Units

The amount of radiation received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of rem or in the SI unit, sievert (Sv) (Table H.4). Rem (sievert) is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation (see "Hanford Public Radiation Dose in Perspective" in Section 5.0 for a more in-depth discussion of risk comparisons). To convert the most commonly used dose term in this report, the millirem, to the SI equivalent, the millisievert, multiply millirem by 0.01.

Additional information on radiation and dose terminology can be found in the glossary of this report (Appendix B). A list of the radionuclides discussed in this report and their half-lives is included in Table H.5
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Table H.1. Names and Symbols for Units of Measure

Symbol	Name	Symbol	Name
Temperature:		**Length**:	
°C	degrees Centigrade	cm	centimeter (1 x 10^{-2} m)
°F	degrees Fahrenheit	ft	foot
Time:		in.	inch
d	day	km	kilometer (1 x 10^{3} m)
h	hour	m	meter
min	minute	mi	mile
s	second	mm	millimeter (1 x 10^{-3} m)
yr	year	µm	micrometer (1 x 10^{-6} m)
Rate:		**Area**:	
cfs (or ft^3/s)	cubic feet per second	ha	hectare (1 x 10^4 m^2)
gpm	gallons per minute	km^2	square kilometer
mph	miles per hour	mi^2	square mile
Volume:		ft^2	square feet
cm^3	cubic centimeter	**Mass**:	
ft^3	cubic foot	g	gram
gal	gallon	kg	kilogram (1 x 10^3 g)
L	liter	mg	milligram (1 x 10^{-3} g)
m^3	cubic meter	µg	microgram (1 x 10^{-6} g)
mL	milliliter (1 x 10^{-3} L)	ng	nanogram (1 x 10^{-9} g)
yd^3	cubic yard	lb	pound
		wt%	weight percent
		Concentration:	
		ppb	parts per billion
		ppm	parts per million

Chemical and Elemental Nomenclature

Chemical contaminants are also discussed in this report. Table H.6 lists many of the chemical (or element) names, and their corresponding symbols, used in this report.

Understanding the Data Tables

Measuring any physical quantity (for example, temperature, distance, time, or radioactivity) has some degree of inherent uncertainty. This uncertainty results from the combination of all possible inaccuracies in the measurement process, including such factors as the reading of the result, the calibration of the measurement device, numerical rounding errors, and the random nature of radioactivity. In this report, individual radioactivity measurements are accompanied by a plus or minus (±) value, which is an uncertainty term known as either the two-sigma counting error or the total propagated analytical uncertainty. Total propagated analytical uncertainty includes counting uncertainty and analytical uncertainty. Because measuring a radionuclide requires a process of counting random radioactive emissions from a sample, the counting uncertainty gives information on what the measurement might be if the same sample were counted again under identical conditions. The counting uncertainty implies that approximately 95% of the time a recount of the same sample would give a value somewhere between the reported value minus the counting uncertainty and the reported value plus the counting uncertainty. Values in the tables that are less than the counting uncertainty indicate that the reported result might have come from a sample with no radioactive emissions. Such values are considered to be below detection. Each radioactive

Table H.2. Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
gal	3.785	L	L	0.2642	gal
ft^2	0.093	m^2	m^2	10.76	ft^2
acres	0.405	ha	ha	2.47	acres
mi^2	2.59	km^2	km^2	0.386	mi^2
yd^3	0.7646	m^3	m^3	1.308	yd^3
nCi	0.001	pCi	pCi	1,000	nCi
pCi/L	10^{-9}	µCi/mL	µCi/mL	10^{9}	pCi/L
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
becquerel	2.7×10^{-11}	curie	curie	3.7×10^{10}	becquerel
becquerel	27	pCi	pCi	0.03704	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1,000	ppb
°F	(°F - 32) ÷ 9/5	°C	°C	(°C x 9/5) + 32	°F
g	.035	oz	oz	28.349	g
metric ton	1.1	ton	ton	0.9078	metric ton

Table H.3. Names and Symbols for Units of Radioactivity

Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1×10^{-3} Ci)
µCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)
aCi	attocurie (1×10^{-18} Ci)
Bq	becquerel

Table H.4. Names and Symbols for Units of Radiation Dose

Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
Sv	sievert
mSv	millisievert (1×10^{-3} Sv)
µSv	microsievert (1×10^{-6} Sv)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
µR	microroentgen (1×10^{-6} R)
Gy	gray

Table H.5. Radionuclide Nomenclature[(a)]

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.3 yr	^{144}Ce	cerium-144	284 d
^{7}Be	beryllium-7	53.4 d	^{147}Pm	promethium-147	2.6 yr
^{14}C	carbon-14	5730 yr	^{152}Eu	europium-152	13.3 yr
^{22}Na	sodium-22	2.6 yr	^{154}Eu	europium-154	8.8 yr
^{40}K	potassium-40	1.3 x 10^{8} yr	^{155}Eu	europium-155	5 yr
^{41}Ar	argon-41	1.8 h	^{208}Tl	thallium-208	3.1 min
^{51}Cr	chromium-51	27.7 d	^{212}Bi	bismuth-212	61 min
^{54}Mn	manganese-54	312 d	^{212}Pb	lead-212	10.6 h
^{57}Co	cobalt-57	270.9 d	^{212}Po	polonium-212	0.3 x 10^{-6} s
^{60}Co	cobalt-60	5.3 yr	^{216}Po	polonium-216	0.15 s
^{63}Ni	nickel-63	96 yr	^{220}Rn	radon-220	56 s
^{65}Zn	zinc-65	243.9 d	^{222}Rn	radon-222	3.8 d
^{85}Kr	krypton-85	10.7 yr	^{226}Ra	radium-226	1600 yr
^{89}Sr	strontium-89	50.5 d	^{228}Ra	radium-228	5.8 yr
^{90}Sr	strontium-90	29.1 yr	^{228}Ac	actinium-228	6.13 h
^{95}Nb	niobium-95	35 d	^{232}Th	thorium-232	1.4 x 10^{10} yr
^{95}Zr	zirconium-95	64 d	U or uranium[(b)]	uranium total	---
^{99}Mo	molybdenum-99	66 h	^{234}U	uranium-234	2.4 x 10^{5} yr
^{99}Tc	technetium-99	2.1 x 10^{5} yr	^{235}U	uranium-235	7 x 10^{8} yr
^{103}Ru	ruthenium-103	39.3 d	^{236}U	uranium-236	2.3 x 10^{7} yr
^{106}Ru	ruthenium-106	368 d	^{238}U	uranium-238	4.5 x 10^{9} yr
^{125}Sb	antimony-125	2.8 yr	^{238}Pu	plutonium-238	87.7 yr
^{129}I	iodine-129	1.6 x 10^{7} yr	^{239}Np	neptunium-239	2.4 d
^{131}I	iodine-131	8 d	^{239}Pu	plutonium-239	2.4 x 10^{4} yr
^{133}Ba	barium-133	10.7 yr	^{240}Pu	plutonium-240	6.5 x 10^{3} yr
^{134}Cs	cesium-134	2.1 yr	^{241}Pu	plutonium-241	14.4 yr
^{137}Cs	cesium-137	30 yr	^{241}Am	americium-241	432 yr

(a) From Shleien 1992.
(b) Total uranium may also be indicated by U-natural (U-nat) or U-mass.

measurement must have the random background radioactivity of the measuring instrument subtracted; therefore, negative results are possible when background counts are high and there are few radioactive emissions from the sample.

Just as individual values are accompanied by counting uncertainties, mean values are accompanied by two times the standard error of the calculated mean (2 standard error of the mean). If the data fluctuate randomly, then two times the standard error of the mean is a measure of the uncertainty in the estimated mean of the data from this randomness. If trends or periodic (for example, seasonal) fluctuations are present, then two times the standard error of the mean is primarily a measure of the variability in the trends and fluctuations about the mean of the data.

Understanding Graphical Information

Graphs are useful when comparing numbers collected at several locations or at one location over time. Graphs

Table H.6. Elemental and Chemical Constituent Nomenclature

Symbol	Constituent	Symbol	Constituent
Ag	silver	K	potassium
Al	aluminum	LiF	lithium fluoride
As	arsenic	Mg	magnesium
B	boron	Mn	manganese
Ba	barium	Mo	molybdenum
Be	beryllium	NH_3	ammonia
Br	bromine	NH_4^+	ammonium
C	carbon	N	nitrogen
Ca	calcium	Na	sodium
CaF_2	calcium fluoride	Ni	nickel
CCl_4	carbon tetrachloride	NO_2^-	nitrate
Cd	cadmium	NO_3^-	nitrate
$CHCl_3$	trichloromethane	Pb	lead
Cl^-	chloride	PO_4^{-3}	phosphate
CN^-	cyanide	P	phosphorus
Cr^{+6}	chromium (species)	Sb	antimony
Cr	chromium (total)	Se	selenium
CO_3^{-2}	carbonate	Si	silicon
Co	cobalt	Sr	strontium
Cu	copper	SO_4^{-2}	sulfate
Dy	dysprosium	Ti	titanium
F^-	fluoride	Tl	thallium
Fe	iron	V	vanadium
HCO_3^-	bicarbonate	Zn	zinc
Hg	mercury		

make it easy to visualize differences in data where they exist. However, while graphs may make it easy to evaluate data, they may also lead the reader to incorrect conclusions if they are not interpreted correctly. Careful consideration should be given to the scale (linear or logarithmic), concentration units, and the type of uncertainty used.

Some of the data graphed in this report are plotted using logarithmic (or compressed) scales. Logarithmic scales are useful when plotting two or more numbers that differ greatly in size. For example, a sample with a concentration of 5 g/L would get lost at the bottom of the graph if plotted on a linear scale with a sample having a concentration of 3,000 g/L (Figure H.1). A logarithmic plot of these same two numbers allows the reader to clearly see both data points (Figure H.2).

The mean (also called average) and median (the middle value when scores are arranged in increasing or decreasing

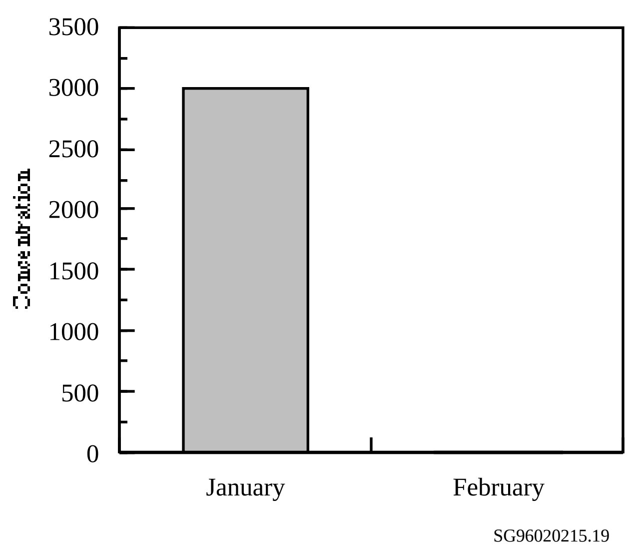

Figure H.1. Data Plotted Using a Linear Scale

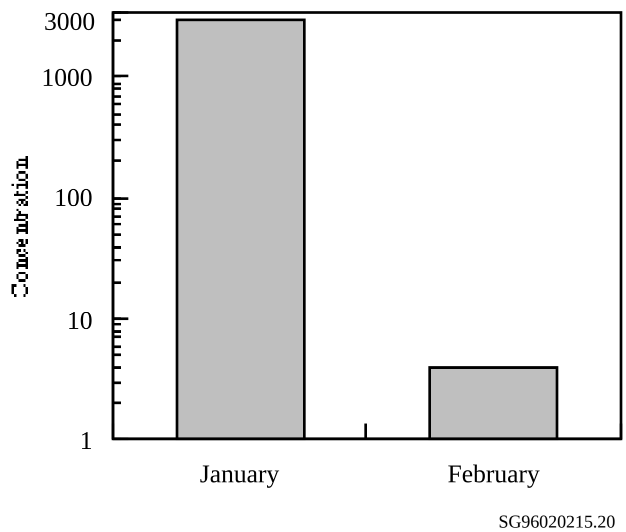

Figure H.2. Data Plotted Using a Logarithmic Scale

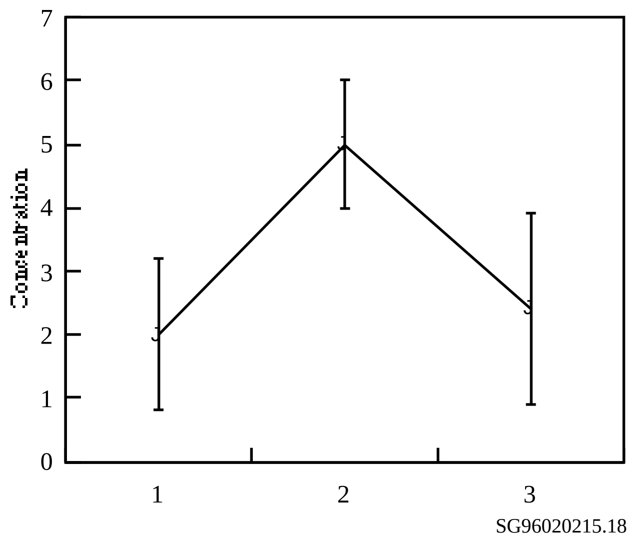

Figure H.3. Data with Error Bars Plotted Using a Linear Scale

order) values graphed in this report have vertical lines extending above and below the data point. When used with a mean value, these lines (called error bars) indicate the amount of uncertainty (±2 standard error of the mean) in the reported result. The error bars in this report represent a 95% chance that the mean is between the upper and lower ends of the error bar and a 5% chance that the true mean is either lower or higher than the error bar.[a] For example, in Figure H.3 the first plotted mean is 2.0 ± 1.1, so there is a 95% chance that the actual result is between 0.9 and 3.1, a 2.5% chance it is less than 0.9, and a 2.5% chance it is greater than 3.1. Error bars are computed statistically employing all of the information used to generate the mean value. These bars provide a quick visual indication that one mean may be statistically similar to or different from another mean. If the error bars of two or more means overlap, as is the case with means 1 and 3 and means 2 and 3, the means may be similar, statistically. If the error bars do not overlap (means 1 and 2), the means may be statistically different. Means that appear to be very different visually (means 2 and 3) may actually be quite similar when compared statistically.

When vertical lines are used with median values, the lower end of each bar represents the smallest (minimum) concentration measured, and the upper end of each bar represents the maximum concentration measured. Median, maximum, and minimum values are used in place of mean and standard error values when there are too few analytical results to accurately determine the error of the mean.

Greater Than (>) or Less Than (<) Symbols

Greater than (>) or less than (<) symbols are used to indicate that the actual value may either be larger than the number given or smaller than the number given. For example, >0.09 would indicate that the actual value is greater than 0.09. An inequality symbol pointed in the opposite direction (<0.09) would indicate that the number is less than the value presented. An inequality symbol used with an underscore (≤ or ≥) indicates that the actual value is less-than-or-equal-to or greater-than-or-equal-to the number given, respectively.

Acronyms and Abbreviations

Most acronyms and abbreviations have been deleted from this report. Commonly recognized acronyms that are used are defined in Table H.7.

(a) Assuming the Normal statistical distribution of the data.

Table H.7. Acronyms and Abbreviations

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
DDT	dichlorodiphenyltrichloroethane
DHHS	U.S. Department of Health and Human Services
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
EPA	U.S. Environmental Protection Agency
FR	Federal Register
HAMMER	Hazardous Materials Management and Emergency Response (Training Center)
ICP	inductively coupled plasma (method)
ICRP	International Commission on Radiological Protection
IT	International Technology Corporation
LEPS	low-energy photon spectra
NASQAN	Natural Stream Quality Accounting Network
NCRP	National Council on Radiation Protection and Measurements
NRC	U.S. Nuclear Regulatory Commission
NTU	nephelometric turbidity unit
PCB	polychlorinated biphenyl
PSD	prevention of significant deterioration
PUREX	Plutonium-Uranium Extraction (Plant)
RCW	Revised Code of Washington
REDOX	Reduction-Oxidation (Plant)
SE	standard error
SEM	standard error of the mean
SI	International System of Units
TLD	thermoluminescent dosimeter
UNSCEAR	United Nations Science Committee on the Effects of Atomic Radiation
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	Washington Administrative Code
WDSHS	Washington Department of Social and Health Services