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Standard Guide for Collecting Treatment Process Design Data at a Contaminated Site—A Site Contaminated with Chemicals of Interest[1]

This standard is issued under the fixed designation D7294; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide lists the physical and chemical treatment processes design data needed to evaluate, select, and design treatment processes for remediation of contaminated sites. This data is listed in Tables 1 and 2. Much of these data can be obtained and analyzed at the site with instruments and test kits.

1.2 It is recommended that this guide be used in conducting environmental site assessments and Remedial Investigations/Feasibility Studies (RI/FS) and selections of remedy in U.S. Code of Federal Regulations 40 CFR 300.430.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D422 Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)[3]

D1067 Test Methods for Acidity or Alkalinity of Water

D1293 Test Methods for pH of Water

D1498 Test Method for Oxidation-Reduction Potential of Water

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2434 Test Method for Permeability of Granular Soils (Constant Head)

D3590 Test Methods for Total Kjeldahl Nitrogen in Water

D3921 Test Method For Oil and Grease and Petroleum Hydrocarbons in Water (Withdrawn 2013)[3]

D4327 Test Method for Anions in Water by Suppressed Ion Chromatography

D4564 Test Method for Density and Unit Weight of Soil in Place by the Sleeve Method (Withdrawn 2013)[3]

D4611 Test Method for Specific Heat of Rock and Soil

D4943 Test Method for Shrinkage Factors of Cohesive Soils by the Water Submersion Method

D4972 Test Methods for pH of Soils

D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

D5334 Test Method for Determination of Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe Procedure

D5463 Guide for Use of Test Kits to Measure Inorganic Constituents in Water

D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[3]

D6836 Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, or Centrifuge

E953/E953M Practice for Fusibility of Refuse-Derived Fuel (RDF) Ash

2.2 *Other Documents:*

Remediation Technologies Screening Matrix and Reference Guide[4]

U.S. Code of Federal Regulations 40 CFR 300.430[5]

[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available at http://www.frtr.gov.

[5] Available at http://www.gpoaccess.gov/cfr/index.html.

TABLE 1 Water Parameters[A]

NOTE 1—"X" parameters are recommended during early site investigations before any treatment is being considered or has been selected.

NOTE 2—"O" parameters are recommended in addition to "X" if the technology is being considered or has been selected.

Technology[B]	DO (field)	Temperature (field)	Total Suspended Solids (TSS)	Turbidity[C]	CO_2	H_2S	Dissolved H_2	Methane, Ethane and Ethene	pH (field)	ORP (field)	Chloride (Cl-)	Fluoride (Fl-)	Ca^{+2}, Mg^{+2}, Mn^{+2}, Na^{+}, K^{+}[D]	TOC	COD	DOC	Total Dissolved Solids (TDS)	Alkalinity HCO_3^-, CO_3^{-2}	Conductivity (field)[E]	Volatile Fatty Acids	Biological Oxygen Demand (5-day BOD)	Oil/Grease	Ammonia (NH_3)	Phosphorous (total)	Ferrous Iron Fe^{+2}[F]	Total Iron Fe^{+2} + Fe^{+3}[D]	Sulfate/sulfite (SO_4=/SO_3=)	Nitrate/nitrite (NO_3-/NO_2-)	Kjeldahl Nitrogen	Sieve Analysis[G]
IN-SITU TREATMENT																														
Phytoremediation[H]	X	X		X					X	X			O				O		X					O				O	O	X
Permeable Reactive Barriers	X	X	O	X		O			X	X	O	O	X	X			O	X	X					O	X		X	O	O	X
Monitored Natural Attenuation	X	X		X	O	O	O	X	X	X	X			X				O	X	O				O	X		X	X	O	X
Enhanced Bioremediation	X	X		X	O	O	O	O	X	X	X			X				O	X	O				O	X		X	X	O	X
Air Sparging	X	X		X		O			X	X				X	O		O	X	X		O			O	X		O	O	O	X
Hot Water or Steam Flush/Strip	See Soil, Sediment & Sludge Parameters—thermally enhanced SVE																													
Slurry Walls	See Soil, Sediment & Sludge Parameters																													
Bioslurping[I]	X	X		X					X	X				X					X											X
Dual (multiphase) Phase Extraction[J]	X	X		X					X																					X
Chemical Oxidation	X	X		X	O	O			X	X			O	X	O		O	O	X						O	O				X
In-Well Air Stripping	Same parameters as air sparging																													
Free Product Recovery	See Dual (multiphase) Phase Extraction																													
EX-SITU TREATMENT																														
Advanced Oxidation (UV)	X	X	O	X		O			X	X	X		O	X	O		O	X	X			X		O	X	O		O		
Bioreactor	X	X	O	X		O			X	X		X	O	X	O	O		O	X		O			O	O		O	O	O	
Air Stripping	X	X		X					X	X			O	X			O	X	X				O		X					
Ion Exchange	X	X	O	X					X	X	O		X	X		O	O	O	X						O		O	O		
Adsorption (carbon)	X	X	O	X		O			X	X			O	X		O	O	O	X			O		O	O					
Precipitation/Coagulation/Flocculation	X	X	O	X					X	X			O	X				O	X			O			O		O		O	
Constructed Wetlands	X	X	O	X		O			X	X	O	O	O	X		O		O	X					O	O		O	O	O	

[A] This table was developed jointly by the U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise and the U.S. Environmental Project—Engineering Forum.
[B] See Treatment Technology Profiles in www.frtr.gov for a description of the technology.
[C] Quality of sampling indicators.
[D] If these cations are to be analyzed in an offsite laboratory, evaluate analyzing all metal as the cost may be the same.
[E] Conductivity is a good indicator of Total Dissolved Solids (TDS).
[F] Analyze for Fe^{+2} in the field or total iron in the laboratory and estimate Fe^{+2} from turbidity, etc.
[G] Estimate of soil hydraulic properties in the aquifer where the samples were taken. This information may already be available.
[H] See soil parameaters for vadose zone.
[I] Easily converted to conventional bio venting system or SVE after free product is removed to complete the remediation. Include bio/SVE parameters.
[J] Dual (multiphase) extraction is generally combined with technologies such as bioremediation, air sparging, bioventing, and soil vapor extraction. Include parameters for these technologies if they are being considered.

TABLE 2 Soil, Sediment, and Slurry Parameters[A]

NOTE 1—"X" parameters are recommended during early site investigations before any treatment is being considered or has been selected.

NOTE 2—"O" parameters are recommended in addition to "X" if the technology is being considered or has been selected.

Technology[B]	Temperature	Soil pH	Low Volatile Metals (Sb, AS)	Semi Volatile Metals (Hg, Br, Cr, Na, K)	TOC	Kjeldahl nitrogen	Nitrate, Nitrite	Available P (soil), Total P (water)	Plasticity (Atterberg limits)	Sieve Analysis/(Particle Size Analysis)	Specific Heat BTU/lb	Soil Fusion Temperature	Sodium	Moisture Content	Field Capacity	Bulk Density	Potassium	Soil Permeability	Oil and Grease[C]	Cation Exchange Capacity	Alkalinity (HCO_3^-, CO_3^{-2}) (water)	Fe+3, Mn+4 (water)	Oxygen (soil gas)	CO_2 (Soil gas)	Calcium, Magnesium	Soluble Solids (electrical conductivity)	Conductivity (thermal)	Capillary pressure–saturation curve	Stratigraphy[D]	Humic Content	Fluoride, Chloride	Sulfate	Sulfur (total)
IN-SITU TREATMENT																																	
Bioventing[E]	X	X			X	O	O	O		X				X	O	O		O				O	O	X				O	X	O			
Soil Flushing[F]		X			X					X				O				O		O			X							O			
Soil Vapor Extraction[E]	X									X				X		O													X				
Thermally Enhanced SVE[E]	X	X			X	O	O	O	X	X	O		X	X	O	O	O	O			O	O			O		O	X	X				
Monitored Natural Attenuation (See water parameters table)																																	
Solidification/Stabilization[F]		X			X				O	X			O	X		O		O	O											O	O	X	
Hot Water/Steam Flushing/ Stripping See thermally enhanced SVE																																	
Phytoremediation[G,H]	X	X			O	O	O	O		X			O	O	O		O	O		O						O					O	O	
Chemical Reduction/Oxidation (See water parameters table)																																	
Slurry Wall & Sheet Piling		X							O	X				O			O	O			O					O							
EX-SITU TREATMENT																																	
Composting		O			O	O	O	O		X							O																
Landfarming[H]	X	O			O	O	O	O		X																							
Slurry Phase Biological Treatment		X			X	O	O	O		X							O																
Chemical Reduction/Oxidation		X			X					X				O					O		O									O			
Soil Washing		X			X					X																				O			
Soil Vapor Extraction	X									X				O	O	O		O										O		O			
Solidification/Stabilization (Same as in situ)																																	
Thermal Desorption[I]		O	X	X	O	O	O	O	O	X	O	O		X																O	O		O
Incineration (See thermal desorption)																																	
Sediment Technologies applicable to saturated soils will generally also be applicable to sediments.																																	
Biopiles		X			X	O	O	O	O	X				O	O				O			O											

[A] This table was developed jointly by the U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise and the U.S. Environmental Protection Agency Technical Support Project—Engineering Forum.
[B] See Treatment Technology Profiles in www.frtr.gov for a description of the technologies.
[C] Only if visible evidence.
[D] Usually available from geological investigation data.
[E] Vadose zone.
[F] Vadose or saturated zone.
[G] See water parameters table for saturated zone.
[H] Additional data on soil conditioning may be needed to determine the suitability of the soil to support vegetation suitable for phytoremediation.
[I] Includes cement kilns.

3. Terminology

3.1 *Definitions:*

3.1.1 *contaminants of concern, n*—any substance potentially hazardous to human health or the environment and present at the site and above background concentrations.

3.1.2 *remedial treatment process, n—as used in this guide*, physical, chemical, and biological technologies used to destroy, contain, or remove contaminants of concern at contaminated sites.

3.1.3 *treatment process design data, n—as used in this guide*, physical and chemical data that are needed in addition to data on contaminants of concern, characterization of the subsurface, and major factors affecting the surface and subsurface environment that are addressed in Guide D5730 to evaluate and design treatment processes for remediation of contaminated sites. Examples are cations and anions commonly present in water such as calcium, iron, carbonate/bicarbonate, Total Organic Carbon (TOC), pH, temperature, and sieve analysis of the soil. See Tables 1 and 2 for the complete list.

4. Significance and Use

4.1 This guide allows the decision maker to determine which remedial treatment processes are and are not applicable to remediate an area of soil, surface water, or ground water that contains contaminants of concern.

4.2 This guide provides the data to make cost comparisons of the remedial treatment processes.

4.3 Analysis of treatment process design data can often be performed at the site with field instruments and test kits.

4.4 Tables 1 and 2 are a guide to selecting and obtaining physical and chemical treatment process design data. Data marked with an "X" is needed to evaluate alternatives and select a remedial treatment process. Once the remedial process is selected, the additional data that are needed to design the selected remedial treatment process are marked with an "O." It may be advisable to also collect the data marked with an "O" during the initial sampling event to minimize sampling trips to the site.

4.5 Tables 3 and 4 list laboratory and field methods for analyzing this data. More than one analytical method may be listed. The most suitable method must be chosen for each application.

4.6 This guide does not address sampling for contaminants of concern and sampling locations. See EM 200-1-2 Technical Project Planning (TPP) under Engineering Manuals[6] for information on sampling contaminants of concern. It is recommended that the treatment process design sampling be coordinated with the sampling for chemicals of concern to minimize duplicate sampling and trips to the site.

4.7 This guide does not address physical and chemical properties related to contaminant transport. This is addressed in Guide D5730.

4.8 This guide does not address why the data is needed to evaluate each treatment technology. This information is addressed in the Federal Remediation Technologies Roundtable (FRTR) site at http://www.frtr.gov in the U.S. Army Corps of Engineers guidance documents at http://www.usace.army.mil/inet/usace-docs/ and the United Facilities Guide Specifications (UFGS) available at http://www.ccb.org/.

4.9 This guide does not address Quality Assurance / Quality Control (QA/QC) or sampling design strategy. See U.S. Army Corps of Engineers Engineering Regulation ER 1110-1-263 and Engineering Manual EM 200-1-3[6] for information on QA/QC. This needs to be addressed in the Quality Assurance Project Plan (QAPP).

5. Keywords

5.1 assessment; environmental; hazardous waste; remediation; sampling; solid waste; wastewater

[6] United States Army Corps of Engineers, Publications of the Headquarters, available at http://www.usace.army.mil/.

TABLE 3 Water Analytical Methods[A]

Parameters	Laboratory Methods	Detection Range[B]	Field Test Methods Meter/Kit[C]	Detection Range[B]
pH[D,E]	EPA 150.1/150.2[F] ; SM 4500-H^{+}[G] ; Test Methods D1293	0–14 pH units	Meter[H]	
ORP[D,E,I]	SM 2580[G] ; Practice D1498		Meter	
Temperature[D,E]	EPA 170.1[F] ; SM 2550[G]	0–100 °C		
Dissolved Oxygen (DO)[D,E]	EPA 360.1[F] ; SM 4500-O[G] 360.2	0–20 mg/L	Spectrophotometer (spec)/Meter[H]	1–10 mg/L
Conductivity[D,E]	EPA 120.1[F] ; SM 2510[G]	1–1000 µS/cm	Meter	200 mS
Turbidity[D,E]	EPA 180.1[F]	0–40 NTU	Spec/Meter	0–4400 NTU/0.1–100 NTU
Total Dissolved Solids	EPA 160.1[F]	10–20 000 mg/L	Meter	0–200 mg/L
Ammonia	EPA 350.1/350.2/350.3[F] ; SM 4500-NH_3[G]	0.01–2.0 mg/L	Spec/Kit[H]	0–2.5 mg/L
Kjeldahl (TKN)	EPA 351.1/351.2/351.3/ 351.4[F] ; SM 4500-N_{org}[G]	0.05–2.0 mg/L	Spec/Kit	1–150 mg/L
Anions				
F 0013B—electrode^{-}	EPA 340.1/340.2/340.3[F] ; SM 4500-F^{-}[G] 0300	0.1–1000 mg/L	Spec/Kit	0–2 mg/L/0–2 mg/L
Cl^{-}	EPA 325.1/325.2/325.3[F] ; SM 4500 Cl^{-}[G] 0300	1–200 mg/L	Spec/Kit	0–20/5–400
NO_3^{-}	EPA 352.1[F] ; SM 4500-NO3-[G] ; Test Method D4327	0.1–2 mg/L as N	Spec/Kit[H]	0–30/0–10 mg/L
NO_2^{-}	EPA 354.1[F] ; SM 4500-NO2-[G] 0300	0.01–1.0 mg/L as N	Spec/Kit[H]	0–0.3/0–1.0 mg/L
SO_4^{2-}	EPA 375.1/375.2/375.3/ 375.4[F] ; SM 4500-SO_4^{2-}[G] ; Test Method D4327 0300	3–400 mg/L	Spec/Kit[H]	0–70/50–200 mg/L
SO_3^{-}	SM 4500-SO3-B[G] . EPA 377.1[J]		Kit	
Alkalinity (HCO_3^{-}, CO_3^{2-})	EPA 310.1/310.2[F] ; SM 2320[G]	10–200 mg/L as $CaCO_3$	Kit[H]	10–4000 mg/L
Phosphorus (Total)	EPA 365.4	0.01–20 mg/L	Spec/Kit[H]	0–3.5/0–5 mg/L
Cations				
Fe^{2+}[E]	USGS 1-1388-78[K]		Spec/Kit[H]	0–3/0–10 mg/L
Fe total (Fe^{2+} and Fe^{3+})	EPA 6010C/6020/7000B[J] 236.1/.2	5–40 µg/L	Spec/Kit[H]	0–3/0–10 mg/L
K^{+}	EPA 6010C/6020/7000B[J] ; 258.1	10–200 µg/L	Spec	0–7 mg/L
Na^{+}	EPA 6010C/6020/7000B[J] ; 273.1/2	1–200 µg/L	Meter	0–sat
Ca^{2+}	EPA 6010C/6020/7000B[J] ; 215.1/2	50–200 µg/L	Kit[H]	1–350 mg/L
Mg^{2+}	EPA 6010C/6020/7000A[J] ; 242.1/2	1–100 µg/L	Kit	10–4000 mg/L
Mn^{2+}	EPA 6010C/6020/7000B[J] 243.1/.2 SM 3120 B	0.1–1.0 µg/L	Spec/kit	0–0.7/0–3 mg/L
CH_4, C_2H_4, C_2H_6	EPA 8015D Modified[J] ; RSK-175[L]	10–100 µg/L		
Dissolved H_2	EPA NRMRL Ada OK method			
CO_2	SM 4500-CO_2[G]		Spec/Kit[H]	10–1000 mg/L/10–100 mg/L
Volatile Fatty Acid	SM 5560-Organic & Volatile Acids[G]			
H_2S (sulfide)	EPA 376.1/376.2[F] ; SM 4500-S^{2-}[G]	1–20 mg/L		
TOC	EPA 415.1/415.2[F] ; SM 5310B[G]	50 µg/L–10 mg/L		
BOD—5 day	EPA 405.1[F] ; SM 5210B[G]			
Total Suspended Solids (TSS)	SM - 2540 D[G] ; 160.2			
COD	SM 5220[G] ; 410.1/2/3/4			
DOC	SM 5210 B			
Oil/Grease	SM 5220B[G] ; 431.1/2			
Bacteria Count	SM 9000[G]			

[A] This table was developed jointly by the U.S. Army Corps of Engineers, Hazardous, Toxic, and Radioactive Waste Center of Expertise and the U.S. Environmental Protection Agency Technical Support Project—Engineering Forum. Additional information and methods can be found in 40 CFR 136, EPA SW-846, and Standard Methods for Evaluation of Water and Wastewater, most current edition.

[B] Estimated sensitivity and detection ranges are method/kit specific. Detection ranges are estimates. Verify these methods are suitable for the samples at this site. Consult the method or manufacturer's catalogs for details.

[C] Spectrometers and meters are instruments that can be used to analyze for many parameters. Kits cost much less, but usually analyze for only one parameter. There are many manufacturers of field test equipment. Verify that the field methods are applicable to the medium at this site.

[D] USEPA 600/4-84-017, *The Determination of Inorganic Anions in Water by Ion Chromatography*, March 1984.

[E] Parameters that should be analyzed in the field.

[F] USEPA 600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*, March 1983.

[G] American Public Health Association, *Standard Methods for the Examination of Water and Wastewater*. Use the most recently published methods.

[H] Use of test kits—Guide D5463.

[I] Use Nernst equation to check ORP field data.

[J] USEPA SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods*, 3rd Edition, Updates I, IIA, IIB, III, IIIA, IVA, and IVB.

[K] A USGS method for ferrous iron analysis.

[L] *Analysis of Dissolved Methane, Ethane, and Ethylene in Ground Water by a Standard Gas Chromatohraphic Technique*, developed by USEPA National Risk Management Laboratory, Ada, OK.

TABLE 4 Soil, Sediment, and Sludge Analytical Methods

Parameter	Analytical Method[A,B,C]	Field Test Kit Method
Reactivity	SW Chapter 7.3	
Atterberg Limits	Test Method D4943	
Specific Heat	Test Method D4611	
Soil Fusion Temperature	Test Method E953/E953M	
Moisture Content	Test Methods D2216, D6836	
Cation Exch. Cap. (CEC)	SW 9080/9081	Soil test kit[D]
Bulk Density	Test Method D4564	
Soil pH	Test Method D4972; SW 9045C	Soil test kit[D]
TOC (soil)	Walkley-Black; SW 9060 modified	
Field Capacity	Test Method D6836	
Halogen Content (Fluoride,Chloride)	SW 6010B / 6020A / 7000A[E]	
Fe	SW 7380 / 7381 / 6010B / 6020A[E,F]	
Mn	SW 7460/7461/6010B/6020A/7000B[E,F]	
Low Volatile Metals (Sb,As, Be,Cr, Na, K)	SW 6010B / 6020A / 7000B[E,F]	
Semi Volatile Metals (Pb, Cd, Hg)	SW 6010B / 6020A / 7000B[E,F]	Hg SW 7471A
Phosphorous (total)	SW 6010B[E]	Soil test kit[D]
Particle Size Analysis	Test Method D422	
Nitrate, Nitrite	SW 9210	Soil test kit[D]
Soil Permeability	Test Method D2434, Test Methods D5084[G]	
Humic Content	[H]	
Oil and Grease	SW 9071B Test Method D3921	
Alkalinity	SM 4500-CO2 B Test Methods D1067	
Kjeldahl Nitrogen	SM 4500-N, EPA 351.2 with acid dig.[I] Specification D3590	
Potassium	SW 6010B, 6020, 7000A[E]	Soil test kit[D]
Soil Oxygen	Field instrument with probe	Field instrument or detector tube with probe-tube and hand sample pump
Soil CO_2	Detector tubes	Field detector tubes with probe-tube and hand sampling pump
Thermal Conductivity	Test Method D5334	
Capillary Pressure	Test Methods D6836	
Na, Ca, Mg	SW 6010B/6020A	
Sulfate	SW 9035,9036,9038,9056	
Sulfur	Method 0016 in 40 CFR Part 60, Appendix A	
	Commonly done following TOC high temperature methods	

[A] *Standard Methods (SM) for the Examination of Water and Wastewater*, 18th edition, 1992.
[B] Except for soil oxygen and soil CO_2, soil samples can be analyzed in an offsite laboratory.
[C] Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846).
[D] Field test kits are often available that test for multiple parameters. There are several manufacturers of field soil test kits.
[E] Sample digestion required prior to analysis—see water parameters table.
[F] These metals can also be analyzed by atomic adsorption.
[G] Screening level.
[H] Estimate with Walkley-Black TOC and subtract other substances included in the TOC analysis.
[I] USEPA/600/4-79/020, Methods for Chemical Analysis of Water and Wastes, March 1983.

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE APPLICATION

X1.1 Knowing what data to collect relevant to treatment process design is an iterative process. Site history and other early information gathered at the site, and sampling for chemicals of concern and analysis from the contaminated site combined with professional judgment should provide ideas as to the contaminants of concern at the site. This information, combined with the information in the references listed in 4.8, can be used to develop a list of remedial treatment processes that may be applicable to this contaminated site. Tables 1 and 2 can then be used to determine the treatment process design data that should be collected at the site to evaluate which of the applicable treatment process or processes are best for this site. These data are marked with an "X." More extensive data are needed to design the selected treatment process. These data are marked with an "O."

X1.2 An example use of this data is in evaluating activated carbon adsorption as a treatment process for removal of volatile organic contaminants (VOCs) from ground water. It is important to know the concentration of iron and calcium in the ground water, because these chemicals can foul and plug an activated carbon adsorption unit.

X1.3 The number of treatment process design data samples taken for analysis during the initial field sampling events should be kept to a minimum to save time and costs. Data that can be used as estimates for other parameters should be collected. For example, the humic content of the soil may be required for the final design of the selected process. Total Organic Carbon (TOC) soil analysis estimated by the Walkley-Black Method is recommend in Tables 1 and 2 instead of

Chemical Oxygen Demand (COD) or Dissolved Organic Carbon (DOC), as it is fairly easy to obtain and should provide an estimate of humic content and other organic chemical materials. Nitrogen is a nutrient needed for biological treatment processes. The Kjeldahl Method measures much of the nitrogen in the soil and water with the exception nitrate (NO_3-) and nitrite (NO_2-). Nitrate and nitrite should be measured if in-situ reductive dechlorination is being considered. Phosphorous is also a needed nutrient for biological treatment processes. Total phosphorous analysis in water and available phosphorous in soil are good estimators of phosphorous. For metals, consider having a laboratory analyze for all applicable metals as it may not cost much more than analyzing for a selected few. Ferrous iron should be analyzed in the field. Also, analyzing for some parameters in the field may provide immediate information as to other samples to take at that time to eliminate the need for an additional trip to the site. It is recommended that the following water data be routinely analyzed on every contaminated site during an early field-sampling event:

Temperature
pH
Conductivity
Turbidity
Dissolved Oxygen
Oxygen Reduction Potential (ORP)
TOC

X1.3.1 These data provide much information on the water phase and are easily measured with instruments or test kits except for TOC that must be analyzed in the laboratory. It is also recommended that soil samples be collected for sieve analysis during the initial sampling event. Sieve analysis can provide a rough estimate of the following data: plasticity, field capacity, bulk density, particle density, permeability, porosity, and soil classification.

X1.4 Tables 3 and 4 provide laboratory and test kit analysis methods. The laboratory methods are well defined. They consist primarily of analytical methods in *Standard Methods for the Examination of Water and Wastewater*, EPA SW-846, EPA 600 methods, and ASTM methods. The field methods are not as well defined as laboratory methods. Manufacturers' literature, the internet, and other information should be used to select the test kits that best meet the analytical and cost needs for a site. See Guide D5463 for more information. Additional information on the selection of various ASTM standards that are available for the investigation of soil, rock, the vadose zone and ground water for environmental purposes can be found in Guide D5730.

X1.5 *Appendix A—Example*:

X1.5.1 This example illustrates the use of Tables 1-4 in obtaining and analyzing the data needed to select a treatment process for a site where ground water near a former dry cleaner is contaminated with perchloroethylene (PCE). Monitoring wells will be installed to determine the extent of the contamination in the ground water and in the vadose zone. The Remediation Technologies Screening Matrix and Reference Guide contains information that will help in developing a list of in-situ and ex-situ treatment processes that may be applicable to treating halogenated VOCs (such as PCE) in the vadose zone and in the ground water at this site. The site is in an urban setting where excavation and ex-situ treatment of soil is difficult. A few of the processes discussed in the above reference have been selected to show how to use Tables 1-4 to evaluate remedial processes. For an actual site, all applicable processes should be evaluated. Actual sites can be very complex. Therefore, the data collection recommendations in this guide must be combined with professional judgment and expertise must be used to determine the actual data to collect. The processes being evaluated in this example are as follows:

X1.5.1.1 *Soil—In-Situ Treatment:*

Soil vapor extraction
Thermally enhanced SVE

X1.5.1.2 *Ground Water—In-Situ Treatment:*

Phytoremediation
Permeable reactive barriers (passive treatment walls)
Monitored natural attenuation
Enhanced bioremediation
Air sparging
Bioslurping
Dual (multiphase) phase extraction
In-well air stripping

X1.5.1.3 *Ground Water—Ex-Situ Treatment:*

Air stripping
Adsorption (carbon)

X1.5.2 The data needed to evaluate the above processes is shown in boldface type in Tables X1.1 and X1.2. The details are as follows: DO, temperature, turbidity, pH (field), ORP (field), chlorides, Ca, Mg, Mn, Na, K, TOC, alkalinity, conductivity, ferrous iron, sulfate/sulfite, nitrate/nitrite, and sieve analysis. Tables 3 and 4 list analytical methods used to obtain this data. Many of these parameters can be analyzed at the site with probes or analytical field kits.

X1.5.3 The above data in conjunction with information in Guide D5463 and U.S. Army Corps of Engineers and Support Center Engineering Publications[7] are used in the evaluation and selection of a treatment process for the ground water and the vadose zone. For purposes of this example, assume that monitored natural attenuation has been selected for remediation of the ground water and assume that in-situ SVE has been selected for remediation of the vadose zone. Assuming the treatment processes have already been selected, the additional data needed to design these two processes are marked with an "O" in Tables X1.1 and X1.2. These are as follows:

X1.5.3.1 *Monitored Natural Attenuation for the Ground Water*—CO_2, H_2S, dissolved H_2, alkalinity (already sampled), volatile fatty acids, phosphorous, and Kjeldahl nitrogen (from Table 2—in situ).

X1.5.3.2 *In-Situ SVE for the Vadose Zone*—TOC and bulk density.

[7] United States Army Engineering and Support Center Engineering Publications, available at http://www.hnd.usace.army.mil/techinfo/engpubs.htm.