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# Standard Guide for Selection of Data Elements for Groundwater Investigations[1]

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## 1. Scope

1.1 This guide covers the selection of data elements for the documentation of groundwater sites. The data elements are described in four ASTM standards outlining information that may be collected at groundwater sites. Examples of specific investigations are given with the logic of why to select individual and combinations of data elements to meet the requirements of the studies.

NOTE 1—A groundwater site is any source, location, or sampling station capable of producing water or hydrologic data from a natural stratum from below the surface of the earth. A source or facility can include a well, spring or seep, and drain or tunnel (nearly horizontal in orientation). Other sources, such as excavations, driven devices, bore holes, ponds, lakes, and sinkholes, that can be shown to be hydraulically connected to the groundwater, are appropriate for the use intended.

NOTE 2—The four ASTM standards that describe the data elements for groundwater are Practice D5254 and Guides D5408, D5409, and D5410.

1.2 Systematic and consistent data collection are necessary for the investigation of the availability and the protection or restoration of groundwater resources. The level of detail, precision and bias, and the type of data that need to be collected depend on the objective of the study, the expected complexity of the system, and the resources available for the investigation. This guide presents ideas on what information should be collected for specific studies, why certain data elements are mandatory, and the importance to current and future investigations of maintaining quality control on the collection and retention of these data. This guide focuses on those data elements that are gathered at the field-site location and are used to assist in interpreting the hydrology of the groundwater source and to meet regulatory requirements. Other analytical and quality assurance/quality control (QA/QC) considerations are addressed in other standards and beyond the scope of this guide.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site

D5408 Guide for Set of Data Elements to Describe a Groundwater Site; Part One—Additional Identification Descriptors

D5409 Guide for Set of Data Elements to Describe a Ground-Water Site; Part Two—Physical Descriptors

D5410 Guide for Set of Data Elements to Describe a Ground-Water Site;Part Three—Usage Descriptors

## 3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed as follows, all definitions are in accordance with Terminology D653.

3.1.2 *code*—a suggested abbreviation for a component, for example, "G" is the code suggested for the galvanized iron component of data element casing material. The data element is in the "casing record" record.

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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.

3.1.3 *component*—a subdivision of a data element, for example, galvanized iron is one of 30 components suggested for data element casing material. The data element is in the casing record record.

3.1.4 *data element*—an individual segment of information about a groundwater site, for example, casing material. The data element is in the casing record record.

3.1.5 *record*—denotes a set of related data elements that may need to be repeated to fully describe a groundwater site. For example, a well that consists of several diameters of casing from the top end to the bottom will need more than one casing record record (the record includes data elements depth to top, depth to bottom, diameter, casing material, and casing thickness) to fully describe the construction of the well. However, if only a single size of casing is used in the well, the record is utilized once.

3.1.6 *record group*—a set of related records. For example, the lift record group includes the lift record, power record, and standby record. Some record groups consist of only one record, for example, the spring record group includes only the spring record.

## 4. Summary of Guide

4.1 This guide describes four representative categories of investigations to demonstrate the logic of selecting data elements for the documentation of groundwater data. Included in this guide is a series of four tables that list the records (groups of data elements) used for the examples. The tables cross-reference the sections in this guide where specific explanations for data elements are found. A complete list of the individual data elements for each record is included in the text of this guide. The minimum set of data elements is standard and mandatory with all types of groundwater investigations and is presented in 6.1.3.

## 5. Significance and Use

5.1 Data are gathered at groundwater sites for many purposes. Each purpose requires a different combination of data elements. However, it is mandatory that every groundwater site include a minimum set of data elements to uniquely identify that site by precisely locating with coordinates and political regimes, absolutely identifying the owner and data source, and clearly defining the basic site characteristics. This information is described in Practice D5254.

5.2 As a part of a groundwater project, each site requires additional data elements, beyond the minimum set, to assist in the interpretation of the local and areal hydrology. As an example, for a hydrologic reconnaissance study of a groundwater basin, each well or spring site requires basic information concerning construction, water level, yield, geology, and water chemistry. Additional information is needed if the project is a waste facility investigation, usually to satisfy local, state, and federal environmental regulations.

## 6. Documentation

6.1 *Introduction:*

6.1.1 Four representative hydrologic projects with very different objectives are provided as examples to demonstrate what data elements may be selected for a comprehensive groundwater data file (Tables 1-4). When designing a groundwater data file, data elements from all four ASTM guides should be considered (see Note 2). Agencies or companies that engage in widely diverse projects involving groundwater resources may require nearly all of the data elements described in the four standards. Those organizations should design a permanent file system to their specifications that includes these data.

NOTE 3—A groundwater data file can be stored as various media such as flat files in cabinets or as digital records on a computer. No matter which system is used, the data elements retained are the same information. An advantage of using a computerized file is that the data base containing the groundwater information can be easily displayed, duplicated, and transferred to another computer. Advantages of paper flat files include low cost, easy access without equipment, and transportability to field locations and meetings.

NOTE 4—For the explanation of groundwater investigations in this guide, the term "well" is used to mean any test or finished hole (that is, casing, screen, pump, etc.) that penetrates the surface of the earth to access the groundwater source. These include drilled, bored, driven, and dug holes.

6.1.2 Some agencies or companies may be very specialized in the objective of their projects and require only a finite number of data elements beyond the minimum data set. However, a limited data file may be expanded at a later date by adding additional data elements to satisfy the requirements of more extensive projects.

6.1.3 The minimum set of data elements (see Practice D5254) is mandatory to uniquely locate, identify, and describe each individual groundwater site. In addition, photographs,

**TABLE 1 General Resource Appraisal Investigation of an Area[A]**

| |
|---|
| Minimum Set of Data Elements (see 6.1.3): |
| Geographic Location (see 6.1.3.1) |
| Political Regimes (see 6.1.3.2) |
| Source Identifiers (see 6.1.3.3) |
| Individual Site Characteristics (see 6.1.3.4) |
| Additional Data Elements (see X1.6): |
| Geographic Location Record (see X1.6.1) |
| Owner Record (see X1.6.2) |
| Site Visits Record (see X1.6.3) |
| Other Identification Record (see X1.6.4) |
| Remarks Record (see X1.6.5) |
| Individual Site Characteristics Record (see X1.6.6) |
| Construction Record (see X1.6.7) |
| Casing Record (see X1.6.8) |
| Opening/Screen Record (see X1.6.9) |
| Lift Record (see X1.6.10) |
| Power Record (see X1.6.11) |
| Geophysical Log Record (see X1.6.12) |
| Geohydrologic Unit Record (see X1.6.13) |
| Hydraulics Record (see X1.6.14) |
| Aquifer Parameters Record (see X1.6.15) |
| Well Clusters Record (see X1.6.16) |
| Collector Well/Laterals Record (see X1.6.17) |
| Ponds Record (see X1.6.18) |
| Tunnel or Drain Record (see X1.6.19) |
| Spring Record (see X1.6.20) |
| Measuring-Point Record (see X1.6.21) |
| Water-level Record (see X1.6.22) |
| Discharge Record (see X1.6.23) |
| Water-Quality Record (see X1.6.24) |
| Field Water-Quality Record (see X1.6.25) |

[A] See Appendix X1.

**TABLE 2 Monitoring Project for a Waste-Disposal Facility[A]**

| |
|---|
| Minimum Set of Data Elements (see 6.1.3): |
| Geographic Location (see 6.1.3.1) |
| Political Regimes (see 6.1.3.2) |
| Source Identifiers (see 6.1.3.3) |
| Individual Site Characteristics (see 6.1.3.4) |
| Additional Data Elements (see X2.5): |
| Geographic Location Record (see X2.5.1) |
| Political Regime Record (see X2.5.2) |
| Source Identifiers Record (see X2.5.3) |
| Owner Record (see X2.5.4) |
| Site Visits Record (see X2.5.5) |
| Other Identification Record (see X2.5.6) |
| Remarks Record (see X2.5.7) |
| Individual Site Characteristics Record (see X2.5.8) |
| Construction Record (see X2.5.9) |
| Casing Record (see X2.5.10) |
| Opening/Screen Record (see X2.5.11) |
| Lift Record (see X2.5.12) |
| Geophysical Log Record (see X2.5.13) |
| Geohydrologic Unit Record (see X2.5.14) |
| Sample/Unconsolidated Material Record (see X2.5.15) |
| Sample/Consolidated Material Record (see X2.5.16) |
| Hydraulics Record (see X2.5.17) |
| Aquifer Parameters Record (see X2.5.18) |
| Measuring-Point Record (see X2.5.19) |
| Network Record (see X2.5.20) |
| Water-level Record (see X2.5.21) |
| Discharge Record (see X2.5.22) |
| Water-Quality Record (see X2.5.23) |
| Field Water-Quality Record (see X2.5.24) |
| Monitoring Site/Waste-Facility Record (see X2.5.25) |
| Decommissioning Record (see X2.5.26) |

[A]See Appendix X2.

**TABLE 3 Contamination Assessment and Remediation[A]**

| |
|---|
| Minimum Set of Data Elements (see 6.1.3): |
| Geographic Location (see 6.1.3.1) |
| Political Regimes (see 6.1.3.2) |
| Source Identifiers (see 6.1.3.3) |
| Individual Site Characteristics (see 6.1.3.4) |
| Additional Data Elements (see X3.5): |
| Geographic Location Record (see X3.5.1) |
| Political Regime Record (see X3.5.2) |
| Remarks Record (see X3.5.3) |
| Individual Site Characteristics Record (see X3.5.4) |
| Construction Record (see X3.5.5) |
| Casing Record (see X3.5.6) |
| Opening/Screen Record (see X3.5.7) |
| Lift Record (see X3.5.8) |
| Geophysical Log Record (see X3.5.9) |
| Geohydrologic Unit Record (see X3.5.10) |
| Sample/Unconsolidated Material Record (see X3.5.11) |
| Sample/Consolidated Material Record (see X3.5.12) |
| Hydraulics Record (see X3.5.13) |
| Aquifer Parameters Record (see X3.5.14) |
| Ponds Record (see X3.5.15) |
| Measuring-Point Record (see X3.5.16) |
| Water-level Record (see X3.5.17) |
| Discharge Record (see X3.5.18) |
| Water-Quality Record (see X3.5.19) |
| Field Water-Quality Record (see X3.5.20) |
| Decommissioning Record (see X3.5.21) |

[A]See Appendix X3.

sketches, and maps of the site and associated facility, including the measuring point, are valuable pictorial material to enhance the site description.

6.1.3.1 *Geographic Location*—Including latitude, longitude, latitude-longitude coordinate accuracy, altitude, and altitude accuracy.

6.1.3.2 *Political Regimes*—State or country identification, and county or county equivalent.

6.1.3.3 *Source Identifiers*—Owner's name, source agency or company and address, unique identification, and date of first record for the site.

6.1.3.4 *Individual Site Characteristics*—Hydrologic unit, setting, type of groundwater site, use of site, use of water from site, and reason for data collection.

## 7. Keywords

7.1 contamination assessment; data base; data elements; documentation; groundwater; monitoring network; record; resource appraisal; site characterization; underground storage tank; waste disposal facility

**TABLE 4 Underground Storage Tank GroundWater Assessment[A]**

| |
|---|
| Minimum Set of Data Elements (see 6.1.3): |
| Geographic Location (see 6.1.3.1) |
| Political Regimes (see 6.1.3.2) |
| Source Identifiers (see 6.1.3.3) |
| Individual Site Characteristics (see 6.1.3.4) |
| Additional Data Elements (see X4.6): |
| Geographic Location Record (see X4.6.1) |
| Owner Record (see X4.6.2) |
| Site Visits Record (see X4.6.3) |
| Remarks Record (see X4.6.4) |
| Individual Site Characteristics Record (see X4.6.5) |
| Construction Record (see X4.6.6) |
| Casing Record (see X4.6.7) |
| Opening/Screen Record (see X4.6.8) |
| Lift Record (see X4.6.9) |
| Repairs Record (see X4.6.10) |
| Ponds Record (see X4.6.11) |
| Geophysical Log Record (see X4.6.12) |
| Sample/Unconsolidated Material Record (see X4.6.13) |
| Sample/Consolidated Material Record (see X4.6.14) |
| Measuring-Point Record (see X4.6.15) |
| Water-level Record (see X4.6.16) |
| Field Water-Quality Record (see X4.6.17) |

[A]See Appendix X4.

# APPENDIXES

**(Nonmandatory Information)**

## X1. EXAMPLE 1—GENERAL GROUNDWATER INVESTIGATION OF AN AREA

X1.1 General groundwater investigations are commonly funded by local, state, and federal agencies in order to encourage economic development of an area. These investigations are typically conducted where insufficient data are known or documented about the quantity and quality of the groundwater. The areas of concern are usually distinct political jurisdictions (such as municipal utility authority service districts, cities, or counties), groundwater basins, or aquifer units.

X1.2 Groundwater studies commonly define the water container (aquifer), the quantity of water obtainable for withdrawal, the quality of water available for specific uses, and the renewability or recharge rate for water that may be removed.

X1.3 A general groundwater study may require from a few months to several years to complete, usually depending upon the size of the area, extent of development, urgency of need (that is, severe drought conditions causing a local water supply emergency), complexity of the aquifer system, amount of information available from record-keeping agencies or water-development companies, and total objective of the project. Much of the time is utilized by the project personnel for collecting available information, conducting field surveys, gathering time-related information (that is, water levels), interpreting basic data, and drafting of the report.

X1.4 Additional data elements compiled for groundwater sites, beyond the minimum set of data elements, are a matter of need by the collecting agency or company to meet the objective of the total project. Therefore, the data file should be designed to include all possible information that are collected from all sources and to be retained for current and future groundwater projects. Comparison of the following records and data elements with the three guides will show that some records were not included and several data elements were deleted from the selected records because of the scope of the general groundwater investigation.

NOTE X1.1—The accuracy or confidence level should be documented for each measured data element by the agency or company that gathered and recorded the information.

NOTE X1.2—Specific types of groundwater sites have mandatory information, for example, a depth value is required with a well or bore hole. Some data elements are mandatory when a related data element is used, for example, a water level or water yield requires that the data of measurement be included. In addition, a number of data elements may be designated as mandatory by the agency or company to meet their specific research or management needs.

NOTE X1.3—The list of possible data elements that can be collected for a groundwater study is lengthy, however, an individual site normally will use only part of the total number of elements that can be included in the entire data file, for example, a spring site will not have the geophysical log record.

NOTE X1.4—Several of the data elements are repeated in more than one record (that is, primary aquifer and static water level). This duplication is important so that the key data elements for the record can be directly associated with critical information. For example, the geohydrologic unit record has a description of the lithology of an aquifer, while the hydraulics record defines the basic water-bearing characteristics of the same aquifer.

X1.5 *Minimum Set of Data Elements*—See 6.1.3.

X1.6 *Additional Data Elements*—From Guide D5408:

X1.6.1 *Geographic Location Record*—Including land-net location, location map, map scale, and method altitude determined (see 6.1.3.1).

X1.6.1.1 *Explanation*—Additional information is desirable to further define the location of the site. The land-net location is commonly used, in many areas of the country, as a primary groundwater site identifier and locator. The location map is critical as a spatial locator for groundwater site data and is an absolute necessity for interpretation of the groundwater hydrology (see Note X1.5). A map scale is required with the location map.

NOTE X1.5—Geographical information systems (GIS) are becoming very common for agencies and companies using computer systems for data storage, retrieval, and manipulation. Computerized U.S. Geological Survey topographic maps are available for most of the country. The capability to retrieve data from a computer data base and locate these data precisely on a GIS map is the state-of-the practice.

X1.6.2 *Owner Record*—Including date of ownership and owner's name.

X1.6.2.1 *Explanation*—The documentation of the history of ownership of sites that have had several owners is important in searching for past information and determining management responsibility. For these sites, the date of proprietorship is required with each owner's name. The name of the current owner of the site is one of the components in the minimum set of data elements.

X1.6.3 *Site Visits Record*—Including date of visit and person who made visit.

X1.6.3.1 *Explanation*—Documentation of the identification of the person that gathered information at the site is important for quality control. The date of visitation is required with each site visit record.

X1.6.4 *Other Identification Record*—Including other name, number or identification, and assigner.

X1.6.4.1 *Explanation*—Documentation of site identifications assigned by other agencies or companies that collect data at the site is important in tracing information residing in their files. Data can be gathered from the same site for various purposes (that is, resource evaluation, health control, and pollution detection) by several organizations. Each organization (that is, the owner and state health department) commonly have their own system of site identification for filing purposes.

X1.6.5 *Remarks Record*—Including remark date and remark.

X1.6.5.1 *Explanation*—Many sites have important and unique text information that does not fit as a data element into the file. A space should be reserved in the file for this information.

X1.6.6 *Individual Site Characteristics Record*—Including drainage basin/watershed, hole depth, well depth, source of depth data, and primary aquifer (see Guide D5409).

X1.6.6.1 *Explanation*—The hydrologic unit codes and primary aquifer data elements apply to all groundwater sites and are important components in understanding the hydrology of the project area. Whereas, the hole and well construction data, which indicates the open intervals, are point data that relate to the site where the groundwater aquifer was accessed by penetrating the surface of the earth (see Note 4). For monitoring projects and contamination investigations, the relationship of the site to surface-water bodies is important in understanding nearby water sources that could allow water to flow into or away from the studied area. In addition, the use of land in the vicinity of the contaminated area is critical information needed for determining the method to use for delineating the extent of contamination and the technique to employ for removal of the contaminate (that is, highly developed urban or sparsely populated agricultural area).

X1.6.7 *Construction Record*—Including date construction began, date construction ended, name of contractor, source of construction data, method of construction, type of finish, type of seal, and depth to bottom of seal.

X1.6.7.1 *Explanation*—The construction record applies primarily to wells, however, several of the data elements (construction dates, contractor, source of data, construction method, and type of finish) can be used to describe improvements at ponds, springs, and tunnels. The record, along with the casing and opening records, gives a complete description of construction at the groundwater site prior to and during the project (including resource investigations and contamination studies). This information is important for understanding the origin of the water, method of groundwater development in the project area, and zone of monitoring.

X1.6.8 *Casing Record*—Including depth to top of the cased interval, depth to bottom of the cased interval, diameter of the cased interval, casing material, and casing thickness.

X1.6.8.1 *Explanation*—The casing record applies primarily to wells, however a few of the data elements (casing diameter, material, and thickness) can be used to document the characteristic of the pipes used to extract water from ponds, springs and tunnels. In combination with the construction and opening records, the casing record gives a complete description of construction at the site prior to and during the project (including resource investigations and contamination studies).

X1.6.9 *Opening/Screen Record*—Including depth to top of the open interval, depth to bottom of the open interval, diameter of the open interval, type of material in the open interval, type of openings in the open interval, length of openings, and width of openings.

X1.6.9.1 *Explanation*—The opening or screen data delineates the zone that yields water to the well (see Note 4). However, screens are used in horizontally wide holes (ponds, sinks) that are open to below the water-table surface and can be described by this record. In combination with the construction and casing records, the opening/screen record gives a complete description of construction at the site prior to and during the project (including resource investigations and contamination studies).

X1.6.10 *Lift Record*—Including type of lift, date permanent lift was installed, depth of intake, manufacturer of lift device, serial number, and pump rating.

X1.6.10.1 *Explanation*—The lift record is used to describe the equipment employed to remove water (or water and contaminants) from the aquifer. This record is important in understanding the capacity of the aquifer to yield water, also,

as a means of further identifying the groundwater site. In addition, this record can be used to describe the technique used for removal of contaminated water.

X1.6.11 *Power Record*—Including type of power, horsepower rating, name of power company, power company account number, and power meter number.

X1.6.11.1 *Explanation*—The power record data are needed when gathering power usage information (that is, kilowatts of electricity or gallons of fuel) from the power companies. Power utilization data, in many areas, are used to compute an estimate of the amount of water withdrawn from the site and, in combination with the other sites in the project, for determining the total amount of water withdrawn from the area.

X1.6.12 *Geophysical Log Record*—Including type of log, depth to top of logged interval, depth to bottom of logged interval, and source of log data.

X1.6.12.1 *Explanation*—Geophysical log data are important in interpreting the geology and hydrology at the site and of the project area. Some logs are written records by drillers or hydrologists of materials encountered during the drilling or digging of the hole. Other logs are run by lowering a cablesuspended probe into the well or test hole. The variations in sediment, rock, and water characteristics are detected by the probe and logged by recording equipment at the surface. Usually, the logs are in a graphical format (either on paper or in the computer) and stored in a separate file. This record is a summary of the available log data.

X1.6.13 *Geohydrologic Unit Record*—Including aquifer unit(s), contributing unit, depth to top of interval, depth to bottom of interval, lithology, and description of material.

X1.6.13.1 *Explanation*—The geohydrologic unit record identifies the water-yielding zone by a formal geologic name, locates the vertical position of the unit in reference to the altitude datum, and describes the rock material of the zone. Not only can this record be used to describe the lithology of the aquifer units, but also can be used as a descriptive log of the entire site (that is, well or test hole). This information is critical in correlating and interpreting the geology and hydrology of the project area.

X1.6.14 *Hydraulics Record*—Including hydraulic/aquifer unit, hydraulic/aquifer unit type, depth to top of unit, depth to bottom of unit, static water level, date of measurement, and unit contribution.

X1.6.14.1 *Explanation*—The hydraulics record includes data elements that describe some of the basic water-bearing parameters of the individual aquifers. Although several data elements are the same as in the geohydrologic record, it is important that the water-bearing parameters be associated directly with the individual aquifer unit. The agency or company that maintains the groundwater data file may want to combine the hydrogeologic and hydraulics records for their purpose. These data are critical in correlating and interpreting the hydrology of the investigated area.

X1.6.15 *Aquifer Parameters Record*—Including transmissivity, horizontal hydraulic conductivity, vertical hydraulic conductivity, coefficient of storage, leakance, diffusivity, specific storage, specific yield, barometric efficiency, porosity, specific capacity, method used to determine aquifer characteristics, and availability of file of detailed result.

X1.6.15.1 *Explanation*—The aquifer parameters record includes a summary of field-determined or estimated values. These values are commonly determined by controlled tests conducted at field locations, customarily identified as aquifer tests. However, a number of these data elements can be estimated from previously gathered information concerning the aquifer properties within the studied area and by groundwater studies in adjacent or geologically similar areas. These data are critical for completely understanding the total water-producing potential (also, the path of movement of contaminants) of the investigated area. However, in most basic areal studies, these data only can be obtained at a limited number of sites. Detailed analysis results used for determining these aquifer parameters are usually filed separately in a graphical or tabular format.

X1.6.16 *Well Clusters Record*—Including number of wells in cluster, depth of deepest well in cluster, depth of shallowest well in cluster, and diameter of well cluster.

X1.6.16.1 *Explanation*—This record is for expanding the documentation of a groundwater site that consists of well clusters. Well clusters are specialized arrangements of more than one well with a single centralized pumping system. Normally, this type of multiple-well system is used where the aquifer is thin, near the land's surface or low yielding, or both.

X1.6.17 *Collector Well/Laterals Record*—Including number of laterals in collector well, depth of laterals in collector well, length of laterals in collector well, diameter of laterals in collector well, and mesh of screen in laterals.

X1.6.17.1 *Explanation*—This record is for expanding the documentation of a groundwater site that consists of a collector well. Collector wells (well with a series of lateral collector pipes) are specialized arrangements that have been developed for areas where the aquifer is thin, near the land's surface, or low yielding, or both. The main usage of this type of well has been along river valleys where the aquifer is composed of a thin alluvium that is bounded beneath and at the valley walls by a low-yielding bedrock material.

X1.6.18 *Ponds Record*—Including length of pond, width of pond, depth of pond, and volume of pond.

X1.6.18.1 *Explanation*—The pond record is for expanding the documentation of a groundwater site where the level and quantity of water in the pond is controlled by the groundwater table in the vicinity of the pond. Therefore, water withdrawn from the pond is replaced by water from the adjacent aquifer. For contaminated areas, ponds need to be documented and dealt with the same as any other groundwater site.

X1.6.19 *Tunnel or Drain Record*—Including length of tunnel or drain, width of tunnel or drain, depth of tunnel or drain, bearing (azimuth) tunnel or drain, and dip of tunnel or drain.

X1.6.19.1 *Explanation*—The tunnel or drain record is for expanding the documentation of a groundwater site that consists of a nearly horizontal tunnel or drain. The groundwater table (also a permeable fractured or faulted zone) is intentionally or unintentionally intersected and the downward slope of the tunnel away from the water source allows the

water to flow to the land's surface. However, a pump may be used to move the water from the source to point of usage.

X1.6.20 *Spring Record*—Including name of spring, type of spring, permanence of spring, sphere of discharge, discharge, date of discharge, improvements, number of spring openings, flow variability, accuracy of flow variability, and magnitude of spring.

X1.6.20.1 *Explanation*—The spring record is for expanding the documentation of a groundwater site that consists of naturally occurring springs and seeps. These sites exist where the water table intersects the surface or where the combination of a positive hydraulic head in the aquifer and openings in the confining rock allows the water to flow to the land's surface.

X1.6.21 *Measuring-Point Record (from Guide D5410)*—Including date interval of measuring-point utilization, weight in reference to datum, and description.

X1.6.21.1 *Explanation*—The measuring point is required for a groundwater site where the measured data need to be converted to an altitude value, such as water levels, for direct correlation with other sites in the studied area. Also, an established measuring point allows for consistency in comparing multiple water levels at a single site that are measured over a period of time. The location of the measuring point is usually a convenient and fixed position for conducting the measurements. The height value can be directly related to an altitude datum and would be defined as lower than, equal to, or higher than the datum. The date interval is required because the location of the measuring point can be changed by repairs and general maintenance at the site, therefore requiring establishment of another measuring point having a different height relationship to the altitude datum.

X1.6.22 *Water-Level Record*—Including measurement date, water level, water-level accuracy, status, method of measurement and instrumentation, instrumentation, source of data, and statistics method.

X1.6.22.1 *Explanation*—Water levels are basic data routinely (usually mandatory) gathered at groundwater sites. Many hydrologic interpretations are based on a project-wide combination of point water-level data, for example, the direction of water movement through the aquifer at a waste disposal site or the effects of withdrawals by wells in the aquifer. The effect of climatic fluctuations on the level of water in the aquifer can be evaluated by a series of water-level measurements over time at a single site. Many of the hydraulic characteristics of the aquifer are determined by the measurement of water levels (and yields) during controlled test procedures.

X1.6.23 *Discharge Record*—Including measurement date, discharge, type of discharge, source of data, method of discharge measurement, instrumentation, production or pumping level, static level, method of water-level measurement, pumping period, specific capacity, drawdown, and source of water-level data.

X1.6.23.1 *Explanation*—The discharge is a value (volume per time unit) for water yield that is routinely (usually mandatory) measured at groundwater sites. The discharge of water can be by artificial means, such as an electrical-powered pump or a hand-powered bailer. Also, some sites, such as springs and artesian wells where the hydraulic head is above the discharge point, yield water by natural flow. The discharge data are important in determining the capacity of the aquifer to yield water for the use intended, and also as a component needed for calculating the hydraulic characteristics of the aquifer.

X1.6.24 *Water-Quality Record*—Including sample date, agency that analyzes samples, type of analyses, sample depth/interval, water-quality file containing analysis, collecting agency or company, sampling purpose, site condition, sample appearance, sample odor, presence of immiscible stratum, thickness of immiscible stratum, sample preservation method, sample filtration material, pumped period, casing volume, amount water purged, sampling method or sampler type, sampler material, and aquifer sampled.

X1.6.24.1 *Explanation*—The water-quality record includes basic data gathered at the groundwater site during the time the water sample was collected. Also, relevant information about the groundwater site and the agencies involved in the collection and sample analysis are retained for additional quality control. The laboratory-determined chemical analysis values are usually stored in a separate file, for example EPA's STORET or the company's own file. The possible water-quality chemical elements and compounds that can be determined number in the hundreds. This is the most important category of information for determining the geochemistry of the water in the aquifer and the evaluation of contamination of the groundwater by numerous anthropogenic constituents created by man's development. Care must be exercised to gather comprehensive information to satisfy regulatory guidelines.

X1.6.25 *Field Water-Quality Record*—Including field sample date, parameter code, value of parameter, unit for parameter, and instrumentation or method of determination.

X1.6.25.1 *Explanation*—The field water-quality record includes chemical and related data that are determined at the field location. Many of these data are parameters that change rapidly after removal from the natural conditions, for example the water temperature, the pH, and volatile compounds. Usually these data are determined at the same time as a water sample is collected for laboratory analysis.

## X2. EXAMPLE 2—MONITORING PROJECT FOR A WASTE-DISPOSAL FACILITY

X2.1 Waste-disposal facilities are land areas developed for the purpose of disposing and storage of various forms of unwanted materials, both hazardous and nonhazardous. The amount of land utilized by these facilities usually is small relative to resource evaluation studies. Before final construction of the facility, it is common for a considerable amount of information to be gathered concerning the proposed disposal area. These data are obtained from land surface surveys, geophysical techniques, and drilling of test holes. Many of the modern facilities that are constructed for the storage of potentially hazardous wastes are underlain with impermeable material, such as a dense clay or plastic liner. These facilities commonly have drains above the impermeable zone to carry off any liquid wastes and have monitoring wells below the impermeable material to identify potential leaks of wastes or leachates into the underlying sediments and eventually, the local groundwater system.

X2.2 Some disposal facilities have no prepared underlying barrier and rely on natural sediments to retard movement of any waste products. Arid-zone facilities have a limited amount of water to serve as a potential carrier for wastes.

X2.3 The amount of groundwater data that are gathered for the range of disposal facilities are quite variable. Thus, a great deal depends upon the materials that are disposed of at the facility as to the amount and refinement of groundwater related data that are gathered at the waste-disposal facility. The following example of groundwater data elements assumes that the facility is for disposal and storage of hazardous wastes and requires enforcement of the appropriate regulations for its long-term containment and monitoring. The accuracy or confidence level should be documented for each measured data element by the agency or company that gathered and recorded the information.

X2.4 *Minimum Set of Data Elements*—See 6.1.3.

X2.5 *Additional Data Elements*—See Guide D5408:

X2.5.1 *Geographic Location Record*—Including land-net location, location map, map scale, and method altitude determined (see 6.1.3.1 and X1.6.1 for explanation).

X2.5.2 *Political Regime Record*—Including congressional district.

X2.5.2.1 *Explanation*—The documentation of the political area of responsibility for the groundwater monitoring sites at waste-disposal facilities and in contaminated areas is important because of legislated regulatory control and intense public interest in these areas.

X2.5.3 *Source Identifiers Record*—Including site data used in report, site information in a computer data base, and photograph/sketch available of site.

X2.5.3.1 *Explanation*—Supporting components add to the extent of knowledge concerning the availability of data for the groundwater site. Each of these components are valuable additions to the general data base.

X2.5.4 *Owner Record*—Including date of ownership and owner's name (see X1.6.2 for explanation).

X2.5.5 *Site Visits Record*—Including date of visit, and person who made visit (see X1.6.3 for explanation).

X2.5.6 *Other Identification Record*—Including other name, number or identification, and assigner (see X1.6.4 for explanation).

X2.5.7 *Remarks Record*—Including remark date and remark (see X1.6.5 for explanation) (from Guide D5409).

X2.5.8 *Individual Site Characteristics Record*—Including land use (in vicinity of site), drainage basin/watershed, relationship to surface stream/lake, hole depth, well depth, source of depth data, and primary aquifer (see X1.6.6 for explanation).

X2.5.9 *Construction Record*—Including date construction began, date construction ended, name of contractor, source of construction data, method of construction, type of finish, type of seal, and depth to bottom of seal (see X1.6.7 for explanation).

X2.5.10 *Casing Record*—Including depth to top of the cased interval, depth to bottom of the cased interval, diameter of the cased interval, casing material, and casing thickness (see X1.6.8 for explanation).

X2.5.11 *Opening/Screen Record*—Including depth to top of the open interval, depth to bottom of the open interval, diameter of the open interval, type of material in the open interval, type of openings in the open interval, length of openings, and width of openings (see X1.6.9 for explanation).

X2.5.12 *Lift Record*—Including type of lift, date permanent lift was installed, depth of intake, manufacturer of lift device, serial number, and pump rating (see X1.6.10 for explanation).

X2.5.13 *Geophysical Log Record*—Including type of log, depth to top of logged interval, depth to bottom of logged interval, and source of log data (see X1.6.12 for explanation).

X2.5.14 *Geohydrologic Unit Record*—Including aquifer unit(s), contributing unit, depth to top of interval, depth to bottom of interval, lithology, and description of material (see X1.6.13 for explanation).

X2.5.15 *Sample/Unconsolidated Material Record*—Including sample weight, sample interval, particle size, percent of total sample, particle shape, and mineralogy.

X2.5.15.1 *Explanation*—The unconsolidated material encountered when drilling the monitor well or test hole is important in understanding the circulation of water in the vadose and saturated zone at the waste facility or spill location. This information is important in proper placement of the waste facility and location of the monitoring sites for detecting liquid and vapor leaks. In addition, there could be a chemical interaction between the sediment and hazardous material and this knowledge could dictate the disposal or remedical technique.

X2.5.16 *Sample/Consolidated Material Record*—Including drill cuttings or core, sample size (weight), sample interval, mineralogy, core length, core diameter, core recovery-percent, bedding, structure, and porosity.

X2.5.16.1 *Explanation*—As with the unconsolidated material, the consolidated material encountered when drilling the monitor well, test hole, or remedial well is important in understanding the circulation of water in the vadose and saturated zone in the project area. Again, this information is important in proper placement of the waste facility and location of the monitoring sites. In addition, there could be a chemical interaction between the rock substance and hazardous material and this knowledge could dictate the disposal or remedial technique.

X2.5.17 *Hydraulics Record*—Including hydraulic/aquifer unit, hydraulic/aquifer unit type, depth to top of unit, depth to bottom of unit, static water level, date of measurement, and unit contribution (see X1.6.14 for explanation).

X2.5.18 *Aquifer Parameters Record*—Including transmissivity, horizontal hydraulic conductivity, vertical hydraulic conductivity, coefficient of storage, leakance, diffusivity, specific storage, specific yield, barometric efficiency, porosity, specific capacity, method used to determine aquifer characteristics, and availability of file of detailed result (see X1.6.15 for explanation) (from Guide D5410).

X2.5.19 *Measuring-Point Record*—Including date interval of measuring-point utilization, height in reference to datum, and description (see X1.6.21 for explanation).

X2.5.20 *Network Record*—Including data type, date interval of network utilization, source agency for network data, frequency of data collection, method of data acquisition, power type of instruments, and network.

X2.5.20.1 *Explanation*—Monitoring networks are normally established at hazardous-waste facilities to systematically gather required data for the evaluation of groundwater movement and for the detection of any unforeseen leaks of wastes into the sediments and groundwater system. Proper placement of each sampling site and selection of the time-frequency interval for data collection is important in management of the monitoring network for regulatory purposes.

X2.5.21 *Water-Level Record*—Including measurement date, water level, water-level accuracy, status, method of measurement and instrumentation, instrumentation, source of data, and statistics method (see X1.6.22 for explanation).

X2.5.22 *Discharge Record*—Including measurement date, discharge, type of discharge, source of data, method of discharge measurement, instrumentation, production or pumping level, static level, method of water-level measurement, pumping period, specific capacity, drawdown, and source of water-level data (see X1.6.23 for explanation).

X2.5.23 *Water-Quality Record*—Including sample date, agency that analyzes samples, type of analyses, sample depth/interval, water-quality file containing analysis, collecting agency or company, sampling purpose, site condition, sample appearance, sample odor, presence of immiscible stratum, thickness of immiscible stratum, sample preservation method, sample filtration material, pumped period, casing volume, amount of water purged, sampling method or sampler type, sampler material, and aquifer sampled (see X1.6.24 for explanation).

X2.5.24 *Field Water-Quality Record*—Including field sample date, parameter code, value of parameter, unit for parameter, and instrumentation or method of determination (see X1.6.25 for explanation).

X2.5.25 *Monitoring Site at Waste-Facility Record*—Including date interval in service, state regulatory agency, state registration identification, EPA registration identification, responsible company, company's site identification, site location in relationship to waste facility, status of site, and sampled interval.

X2.5.25.1 *Explanation*—The record documents data elements that distinctively apply to waste-disposal facilities. This record has some information that is duplicated in other records, whereas, other data are included that are unique to a waste-disposal facility. However, this duplication is important so that the key data elements for the record can be directly associated with critical information.

X2.5.26 *Decommissioning Record*—Including date decommissioned, method used for decommissioning, reason for decommissioning, plugging material, name and address of decommissioner, step-by-step procedures, availability of decommissioning report, and regulations followed, federal, state, local.

X2.5.26.1 *Explanation*—The decommissioning record can be used to document the destruction of wells and test holes at the waste-disposal facility or the contaminated area. This information is important for tracing the history of the locality in order to certify that proper procedures were fulfilled in managing the facility or for remedial action undertaken in the project area.

## X3. EXAMPLE 3—CONTAMINATION ASSESSMENT AND REMEDIATION

X3.1 The contaminated area is highly variable in physical size and commonly has not been intensively evaluated for groundwater resources. Consequently, the area probably lacks information concerning the geologic sediments and hydrologic characteristics, that are needed to estimate the extent of the contamination.

X3.2 The approximate range of contamination can be estimated from nearby hydrologic, geologic, and soil studies (perhaps previous projects in the area). All possible local, state, and federal agencies, as well as private companies with interests in the area, should be contacted in an effort to compile relevant information concerning the contaminated area. As soon as these data are gathered, the contaminated area can be evaluated as to what additional physical information should be gathered to assist in determining the extent of pollution and the proper remedial action to be undertaken.

X3.3 The following arbitrary selection of groundwater data elements assumes that the polluted area requires the removal of the contaminated liquid or material for the enforcement of the appropriate remedial regulations. The accuracy or confidence level should be documented for each measured data element by the agency or company that gathered and recorded the information.

NOTE X3.1—The following list of information may include individual records and data elements that are not essential for the evaluation of some contamination assessment and remediation projects. For example, there may be no groundwater-influenced ponds or streams in the vicinity. The selection of the records and data elements within each record are at the discretion of the project manager and requirements of the regulating agency.

X3.4 *Minimum Set of Data Elements*—See 6.1.3.

X3.5 *Additional Data Elements*—See Guide D5408.

X3.5.1 *Geographic Location Record*—Including location map, map scale, and method altitude determined (see 6.1.3.1) (see X1.6.1 for explanation).

X3.5.2 *Political Regime Record*—Including congressional district (see X1.6.2 for explanation).

X3.5.3 *Remarks Record*—Including remark date and remark (see X1.6.5 for explanation) (from Guide D5409).

X3.5.4 *Individual Site Characteristics Record*—Including land use (in vicinity of site), drainage basin/watershed, relationship to surface stream/lake, hole depth, well depth, source of depth data, and primary aquifer (see X1.6.6 for explanation).

X3.5.5 *Construction Record*—Including date construction began, date construction ended, name of contractor, source of construction data, method of construction, type of finish, type of seal, and depth to bottom of seal (see X1.6.7 for explanation).

NOTE X3.2—The construction record, casing record, and opening/screen record can be combined into one record for most shallow wells and test holes. The purpose intended for separating these records is that in order to describe multiple sizes of casings and opening/screens in a single well more than one record is required.

X3.5.6 *Casing Record*—Including depth to top of the cased interval, depth to bottom of the cased interval, diameter of the cased interval, casing material, and casing thickness (see X1.6.8 for explanation).

X3.5.7 *Opening/Screen Record*—Including depth to top of the open interval, depth to bottom of the open interval, diameter of the open interval, type of material in the open interval, type of openings in the open interval, length of openings, and width of openings (see X1.6.9 for explanation).

X3.5.8 *Lift Record*—Including type of lift, date permanent lift was installed, depth of intake, manufacturer of lift device, serial number, and pump rating (see X1.6.10 for explanation).

X3.5.9 *Geophysical Log Record*—Including type of log, depth to top of logged interval, depth to bottom of logged interval, and source of log data.

X3.5.9.1 *Explanation*—Geophysical log data of groundwater sites constructed before the occurrence of the contamination event are of great value for planning additional data collection and the remediation of the polluted area. All new test holes and wells need detailed log data in order to determine the extent and remedial techniques to use in the removal of the pollution. See X1.6.12 for additional explanation.

X3.5.10 *Geohydrologic Unit Record*—Including aquifer unit(s), contributing unit, depth to top of interval, depth to bottom of interval, lithology, and description of material.

X3.5.10.1 *Explanation*—The geohydrologic unit record is critical for identifying the lithologic material that will allow the contamination to move away from the initial spill or disposal location. Normally, the lithologic units can be traced between sites and the more permeable units are the paths through which the groundwater and contaminants move. See X1.6.13 for additional explanation.

X3.5.11 *Sample/Unconsolidated Material Record*—Including sample weight, sample interval, particle size, percent of total sample, particle shape, and mineralogy (see X2.5.15 for explanation).

X3.5.12 *Sample/Consolidated Material Record*—Including drill cuttings or core, sample size (weight), sample interval, mineralogy, core length, core diameter, core recovery-percent, bedding, structure, and porosity (see X2.5.16 for explanation).

X3.5.13 *Hydraulics Record*—Including hydraulic/aquifer unit, hydraulic/aquifer unit type, depth to top of unit, depth to bottom of unit, static water level, date of measurement, and unit contribution (see X1.6.14 for explanation).

X3.5.14 *Aquifer Parameters Record*—Including transmissivity, horizontal hydraulic conductivity, vertical hydraulic conductivity, coefficient of storage, leakance, diffusivity, specific storage, specific yield, barometric efficiency, porosity, specific capacity, method used to determine aquifer characteristics, and availability of file of detailed result (see X1.6.15 for explanation).

X3.5.15 *Ponds Record*—Including length of pond, width of pond, depth of pond, and volume of pond (see X1.6.18 for explanation) (from Guide D5410).

X3.5.16 *Measuring-Point Record*—Including date interval of measuring-point utilization, height in reference to datum, and description.

X3.5.16.1 *Explanation*—Carefully selected, clearly identified, and datum (altitude or local reference level) correlated measuring points of individual wells and test holes in the area are important for the precision needed in determining the hydraulic gradient and, thus, the direction of pollutant movement. As many of the contaminated zones are small in physical area, the gradient is likely to be slight, therefore accurate water levels converted to the datum are critical in interpreting the direction of water movement. See X1.6.21 for additional explanation.

X3.5.17 *Water-Level Record*—Including measurement date, water level, water-level accuracy, status, method of measurement and instrumentation, instrumentation, source of data, and statistics method.

X3.5.17.1 *Explanation*—The direction of water and pollutant movement through the contaminated aquifer is based on the evaluation of water-level data from individual wells and test holes. These water levels are converted to a common plane (such as altitude) for direct correlation. These data are critical in the evaluation of the extent and determining the method for removal of the contaminate. See X1.6.22 for additional explanation.

X3.5.18 *Discharge Record*—Including measurement date, discharge, type of discharge, source of data, method of discharge measurement, instrumentation, production or pumping level, static level, method of water-level measurement, pumping period, specific capacity, drawdown, and source of water-level data.

X3.5.18.1 *Explanation*—The discharge record is critical for determining the capacity of the aquifer to yield water in order to calculate the time required and amount of water to withdrawal for the complete removal of the contaminate. See X1.6.23 for additional explanation.

X3.5.19 *Water-Quality Record*—Including sample date, agency that analyzes samples, type of analyses, sample depth/interval, water-quality file containing analysis, collecting agency or company, sampling purpose, site condition, sample appearance, sample odor, presence of immiscible stratum, thickness of immiscible stratum, sample preservation method, sample filtration material, pumped period, casing volume, amount water purged, sampling method or sampler type, sampler material, and aquifer sampled.

X3.5.19.1 *Explanation*—This is the most important category of information for determining the background geochemistry of the water in the aquifer and the evaluation of contamination of the groundwater. Care must be exercised to gather comprehensive information to satisfy regulatory guidelines. See X1.6.24 for additional explanation.

X3.5.20 *Field Water-Quality Record*—Including field sample date, parameter code, value of parameter, unit for parameter, and instrumentation or method of determination.

X3.5.20.1 *Explanation*—A large amount of the water-quality data gathered for the evaluation of a contaminated area will probably be analyzed at the field location. Many of these data are parameters that change rapidly after removal from the natural conditions, for example, volatile compounds. Complete documentation of these analyses is a necessity for interpretation of the extent and developing the method of removal of the contaminates. See X1.6.25 for additional explanation.

X3.5.21 *Decommissioning Record*—Including date decommissioned, method used for decommissioning, reason for decommissioning, plugging material, name and address of decommissioner, step-by-step procedures, availability of decommissioning report, and regulations followed, federal, state, local (see X2.5.26 for explanation).

## X4. EXAMPLE 4—UNDERGROUND STORAGE TANK GROUNDWATER ASSESSMENT

X4.1 Groundwater contamination by leakage from and spills adjacent or along associated delivery pipes to underground storage tanks (UST) (usually for petroleum fuels or organic solvents) can cause a considerable amount of damage to nearby water supplies, both ground and surface. Although the contaminated area is usually small in physical size, contaminants from an undetected long-term leak can migrate an extended distance from the source. In arid areas, where development (such as a rural service station) has occurred over limited water source, leaks from UST can easily pollute all of the local potable groundwater supply. On occasion, leaks from UST that are not monitored are first detected by seepage into a residential basement, groundwater sustained pond (such as a gravel pit), or surface stream, thereby creating a hazardous situation.

NOTE X4.1—For an UST assessment, the type of wells and holes considered include: (*1*) production wells in the vicinity of the UST, especially if they produce water from the groundwater aquifer that is most likely to be damaged by a leak or spill; (*2*) test wells constructed to investigate and monitor the groundwater aquifer (saturated zone) contiguous to the UST; and (*3*) test holes to investigate and monitor the vadose zone (unsaturated sediment) adjacent to the UST. In addition, springs and groundwater-influenced surface water bodies (ponds and streams) in the area of the UST must be appraised.

X4.2 UST normally are present at commercial facilities that distribute petroleum products. A number of these facilities have ceased operations or gone out of business leaving behind UST, some with petroleum still remaining in the tanks. Other UST are located at private operations for vehicle and heating fuel (such as large farms) and commercial or public facilities that maintain a fleet of motorized vehicles. A number of UST were installed when fuel was in short supply, quite often as backup rather than a primary source for vehicles and equipment. These emergency supply tanks are easily overlooked if they are not a routine part of a business or operation. The number of UST in

existence, both in use and abandoned, is in the hundreds of thousands.

X4.3 New commercial facilities that have UST require monitoring of the surrounding sediments (that may include both the vadose and saturated zones) to detect vapors and liquid products resulting from accidental spills and leaks. Regulations require that UST at existing facilities be monitored; many of the older tanks are replaced to meet the current regulations. Detailed documentation of the monitoring network is mandatory for satisfying regulatory conditions.

X4.4 For new facilities and UST that have not leaked, the area of concern is very small, perhaps an acre in size. The assumption used to select records and data elements for the following list is that the UST assessment will examine the area in the vicinity of the facility, with no significant leaks or spills expected. If a major leak is detected at an existing facility, then a more extensive investigation should be undertaken and an expanded data element list used, similar to that of the contamination assessment and remediation section (see Note X3.1). The accuracy or confidence level should be documented for each measured data element by the agency or company that gathered and recorded the information.

X4.5 *Minimum Set of Data Elements*—See 6.1.3.

X4.6 *Additional Data Elements*—From Guide D5408.

X4.6.1 *Geographic Location Record*—Including land-net location, location map, map scale, and method altitude determined (see 6.1.3.1).

X4.6.1.1 *Explanation*—The location map is critical as a spatial locator for groundwater site and UST data and is an absolute necessity for interpretation of the groundwater hydrology. For UST, the map could be a local plat map. See X1.6.1 for additional explanation.

X4.6.2 *Owner Record*—Including date of ownership and owner's name (see X1.6.2 for explanation).

X4.6.3 *Site Visits Record*—Including date of visit and person who made the visit (see X1.6.3 for explanation).

X4.6.4 *Remarks Record*—Including remark date and remark (see X1.6.5 for explanation) (from Guide D5409).

X4.6.5 *Individual Site Characteristics Record*—Including land use (in vicinity of site), drainage basin/watershed, relationship to surface stream/lake, hole depth, well depth, source of depth data, and primary aquifer.

X4.6.5.1 *Explanation*—The use of land in the vicinity of the UST is critical information needed for determining how problems can be handled assuming a leak is detected. Whereas, the hole (vapor monitoring point) and well depth data indicates the lowest extent of testing and monitoring at the UST. See X1.6.6 for additional explanation.

X4.6.6 *Construction Record*—Including date construction began, date construction ended, name of contractor, source of construction data, method of construction, type of finish, type of seal, and depth to bottom of seal (see X1.6.7 for explanation).

X4.6.7 *Casing Record*—Including depth to top of the cased interval, depth to bottom of the cased interval, diameter of the cased interval, casing material, and casing thickness (see X1.6.8 for explanation).

X4.6.8 *Opening/Screen Record*—Including depth to top of the open interval, depth to bottom of the open interval, diameter of the open interval, type of material in the open interval, type of openings in the open interval, length of openings, and width of openings (see X1.6.9 for explanation).

X4.6.9 *Lift Record*—Including type of lift, date permanent lift was installed, depth of intake, manufacturer of lift device, serial number, and pump rating.

X4.6.9.1 *Explanation*—This record can be used to describe vapor extraction equipment used at monitoring points. See X1.6.10 for additional explanation.

X4.6.10 *Repairs Record*—Including date of repairs, nature of repairs, and name of contractor who made repairs.

X4.6.10.1 *Explanation*—Periodic maintenance and repairs are required of UST monitoring systems. A complete documentation of these activities is mandatory for quality control and regulatory management.

X4.6.11 *Ponds Record*—Including length of pond, width of pond, depth of pond, and volume of pond (see X1.6.18 for explanation).

X4.6.12 *Geophysical Log Record*—Including type of log, depth to top of logged interval, depth to bottom of logged interval, and source of log data.

X4.6.12.1 *Explanation*—Geophysical log data of groundwater sites and monitoring points are important for understanding the type of material, both unconsolidated and consolidated, that are in the area encompassing the UST. These data are needed in order to assess the UST and to properly design a monitoring system. See X1.6.12 for additional explanation.

X4.6.13 *Sample/Unconsolidated Material Record*—Including sample weight, sample interval, particle size, percent of total sample, particle shape, and mineralogy (see X2.5.15 for explanation).

X4.6.14 *Sample/Consolidated Material Record*—Including drill cuttings or core, sample size (weight), sample interval, mineralogy, core length, core diameter, core recovery-percent, bedding, structure, and porosity (see X2.5.16 for explanation) (from Guide D5410).

X4.6.15 *Measuring-Point Record*—Including date interval of measuring-point utilization, height in reference to datum, and description.

X4.6.15.1 *Explanation*—The measurements of concern for UST's include liquid levels and vapor pressures. See X1.6.21 for additional explanation.

X4.6.16 *Water-Level Record*—Including measurement date, water level, water-level accuracy, status, method of measurement and instrumentation, instrumentation, source of data, and statistics method (see X1.6.22 for explanation).

X4.6.17 *Field Water-Quality Record*—Including field sample date, parameter code, value of parameter, unit for parameter, and instrumentation or method of determination.

X4.6.17.1 *Explanation*—A major portion of the water-quality data gathered for the assessment of leaks from and spills in the vicinity of the UST probably will be analyzed at the field location. Complete documentation of these analyses is necessary for the assessment of conditions in the area of the UST. See X1.6.25 for additional explanation.