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ENGINEERING SERVICES

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No. ES-41.6

Title: GROUNDWATER SAMPLE COLLECTION TECHNIQUES

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Prepared by:	4-26-94 L. F. Graser
Technical Reviewer Engineering Services	Andrew J. Danzig 5-4-94 A. J. Danzig
Technical Reviewer Engineering Services	J. L. Miller J. L. Miller
Technical Reviewer Engineering Services	5-6-94 D. J. Bruggink
Concurred by: QA, Engineering Services	Susan A. Pannell 4-29-94 S. A. Pannell
Approved by: Manager, R. K. Alexander	5/16/94 R. K. Alexander
Concurred by: Manager, Hydraulic Engineering	5/27/94 P. A. March
Concurred by: Manager, Chatt Engineering	5/6/94 J. W. Shupp
Concurred by: Clean Water Initiative	N. E. Carriker
Concurred by: Environmental Chemistry	G. Quintero

TVA 30025 (RD-RBO 8-91)

Title: GROUNDWATER SAMPLE COLLECTION TECHNIQUES			No. ES-41.6 Page 1 of 1	REVISION LOG
Rev. No.	**Date Approved**	**Revision Description**	**Reason for Revision**	
0	4/29/94	Procedure ES-41.6 replaces DS-41.6. Title and organizational changes made.	To reflect reorganization	

TVA 30037 (S&F OPS 5-88)

1.0 OBJECTIVE

To prescribe specific, detailed instructions for Engineering Services (ES) personnel involved in the collection of water samples in accordance with standard practices generally accepted by the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey (USGS), and TVA.

2.0 SCOPE

The techniques described herein are limited to those to be used by ES personnel for routine studies. They do not apply to special studies that may require special apparatus and/or handling or specially trained personnel. For example, the collection of groundwater samples at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites (i.e., "Superfund" sites), certain Resource Conservation and Recovery Act (RCRA) sites, and those activities which fall under the scope of the Superfund Amendments and Reauthorization Act (SARA) of 1986 are not within the scope of this procedure. This procedure applies to collection of routine groundwater samples in connection with TVA's regional water management program activities and assessment of groundwater quality in the vicinity of TVA power facilities.

3.0 REFERENCES

3.1 National Handbook of Recommended Methods for Water Data Acquisition, Chapter 2, "Groundwater" (January 1980), U.S. Geological Survey, Reston, VA, 1977.

3.2 Handbook--Groundwater, Environmental Protection Agency, EPA/625/6-87/016, Cincinnati, OH, 1987.

3.3 A Guide to Groundwater Sampling-Technical Bulletin No. 362, National Council of the Paper Industry for Air and Stream Improvement, Inc., New York, NY, 1982.

3.4 Practical Guide for Groundwater Sampling, Environmental Protection Agency, EPA/600/2-85/104, Ada, Oklahoma, 1985.

3.5 Macrodispersion Experiment Management Policies and Requirements (EPRI RP 2485-05), TVA Engineering Laboratory Report No. WR28-2-520-136, Chapters 4.2.6, "Field Tracer Sampling," and 4.2.7, "Field Monitoring and Sampling," 1987.

3.6 Fletcher G. Driscoll, Groundwater and Wells, Johnson Division, St. Paul, Minnesota, Second Ed., 1982.

3.7 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollution," Table II - Required Containers, Preservation Techniques, and Holding Times.

3.8 Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, EPA-600/4-79-020, Cincinnati, OH, 1979.

3.9 Standard Methods for the Examination of Water and Wastewater, 18th Ed., American Public Health Association, Washington, D.C., 1992.

3.10 Handbook for Sampling and Sample Preservation of Water and Wastewater, Environmental Protection Agency, EPA-600/4-82-029, Cincinnati, OH, 1982.

3.11 Sampling Guidelines for Groundwater Quality, Electric Power Research Institute, EA-4952, Research Project 2485-1, Palo Alto, CA, 1987.

3.12 Groundwater Manual for the Electric Utility Industry, Electric Power Research Institute, CS-3901, Research Project 2301-1 (volumes 1, 2, and 3), Palo Alto, CA, 1985.

3.12.1 Volume 1: Geological Formations and Groundwater Aquifers.

3.12.2 Volume 2: Groundwater Related Problems.

3.12.3 Volume 3: Groundwater Investigations and Mitigation Techniques.

3.13 Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document, Environmental Protection Agency, PB87-107751, OSWER-9950.1, Washington, D.C., 1986.

3.14 ES-41.1, "Collection and Handling of Samples."

3.15 ES-41.2, "Water Sample Collection Techniques."

3.16 ES-41.4, "Trace Organics Sample Collection Techniques."

3.17 ES-42.1, 42.3, 42.4, 42.7, 42.8, and 42.11, "Water Quality Field Analyses."

3.18 ES-43.1, 43.2, 43.3, 43.7, and 43.8, "Standardization of Field Instruments."

3.19 ES-5.20, "STORET - Water Quality Data Management."

3.20 Lysimeter Evaluation Study, American Petroleum Institute, Publication No. 4433, 1986.

3.21 Handbook of Groundwater Development, Roscoe Moss Company, Los Angeles, California, Published by John Wiley and Sons, 1990.

4.0 ABBREVIATIONS AND DEFINITIONS

4.1 Definitions

4.1.1 Definitions of job titles and general responsibilities of managerial and supervisory personnel in ES are given in section 5.0.

4.2 Abbreviations

4.2.1 BOD--Biochemical Oxygen Demand

4.2.2 DO--Dissolved oxygen

4.2.3 CHATT ENGG--Chattanooga Engineering Services

4.2.4 Dw--Depth of well in meters

4.2.5 Dws--Distance to water surface from top of well R.P. in meters

4.2.6 EDM--Environmental Data Management (CHATT ENGG)

4.2.7 ES--Engineering Services

4.2.8 ENVIR CHEM--Environmental Chemistry, Water Management Services

4.2.9 EPA--United States Environmental Protection Agency

4.2.10 MLS--Multilevel sampling well

4.2.11 NPDES--National Pollutant Discharge Elimination System

4.2.12 ORP-Oxidation-reduction potential (REDOX)

4.2.13 pH--Measure of hydrogen ion concentration

4.2.14 QAC--Quality Assurance Coordinator

4.2.15 R.P.--Reference Point

4.2.16 USGS--United States Geological Survey

4.2.17 Vw--Volume of water in well measured in liters

5.0 RESPONSIBILITIES

5.1 Functional Area Manager--The manager responsible for various functions such as field engineering projects in a geographical area (i.e., eastern, central, or western geographical locations). The manager directly supervises project engineers and team members in his geographical area.

5.2 Project Engineer--The person responsible for a particular area of expertise, subfunction, or specific projects within the geographical area. The project engineer assists and reports directly to the functional area manager, advises and acts as a resource to teams within his area of expertise and provides technical help to other teams as needed.

5.3 Technical Lead Engineer--The person responsible for a particular project(s) or tasks. These responsibilities include coordination with client organizaion(s), workplan preparation, budget estimates, scheduling of field studies to meet project deadlines, technical adequacy of the work performed and report preparation. All of these lead engineer responsibilities are assumed by team members for their own support of the team.

5.4 Quality Assurance Coordinator--The QAC is the functional area manager or his designate and is responsible for Engineering Services procedures that are assigned to that functional area. The QAC assigns a technical writer or reviewer for each procedure. The QAC assures that procedures are correct and up-to-date by requiring technical writers and reviewers to certify in writing on a yearly basis that assigned procedures have received a thorough review. The QAC works closely with the organization Quality Assurance Manager.

5.5 Survey Leader--The survey leader is the individual responsible for a particular piece of work. This individual is responsible for seeing that field work is performed in a technically adequate, timely, and safe manner. The survey leader is responsible for the equipment and supplies; technical supervision of personnel while in the field; collection, handling, and shipping of samples. The survey leader, more than any other person, is responsible for being familiar with the procedures. The survey leader reports directly to the lead engineer for which the work is being done.

5.6 Engineering Services personnel--Personnel assigned to a particular work activity or team. Responsible for conducting tasks in a technically adequate manner and for following QA procedures. Any certification must be current for collection or handling samples (i.e., radiological, hazardous waste, water quality, etc.).

5.7 The Environmental Chemistry Lab, Water Management Services (ECHEM), performs chemical, and physical analyses.

5.8 CHATT ENGG EDM is responsible for coding, keypunching, processing, reviewing, validating, retrieving, and reporting field and laboratory data related to ambient groundwater quality.

6.0 PROCEDURES/REQUIREMENTS

6.1 Workplans

6.1.1 A written workplan is usually prepared in advance of the sampling activities. This written workplan must be coordinated with the client organization and other service organizations. The workplan must receive concurrence by all affected organizations and will address, at a minimum, the purpose of the monitoring activities, the choice of water characteristics to be measured, the method or methods to be employed in collection of the samples, the locations and frequency of sampling, project deadlines, schedules, parameters to be analyzed by the laboratory, budget requirements, and collection of auxiliary data.

6.1.2 If special sample collection requirements, handling techniques, or analyses are required (other than the standard procedures contained in this manual), they will be spelled out in detail in the workplan or in supplemental procedures. All items which will affect the quality of the data to be collected must be addressed in the written workplan and/or referenced to the appropriate ES procedures. The written workplan must be approved by the lead engineer prior to any fieldwork. Also, any workplan revisions must be approved by the lead engineer prior to any field activities associated with a particular workplan revision.

6.2 General Requirements and Instructions for Groundwater Sampling

6.2.1 "Collection and Handling of Samples" (reference 3.14) will be followed as appropriate. In addition, particular attention must be given to the following requirements.

6.2.2 The survey leader will review the workplan in detail and consult with his or her lead engineer prior to the first survey to ensure that no misunderstanding exists about how, when, where, and what samples are to be collected.

6.2.3 Before starting a new work activity at a TVA facility (i.e., nuclear, steam, hydro, etc.), the survey leader will contact the facility manager or his/her designee (usually the Results Section supervisor at a steam plant) and inform them of the work to be performed and on what schedule it will be done. To ensure recognition of any situations which may require special safety awareness, the survey leader will communicate with the plant manager or his/her designee and discuss safety procedures which need to be observed, unusual conditions to be aware of, and names of ES personnel working at the TVA facility.

6.2.4 The survey leader will select and assemble the needed equipment (pumps, meters, Hydrolabs, filtration apparatus, tapes/plunkers, compressor, generators, titration equipment, pH/conductance/ORP standards, buckets, etc), sample containers, workplan, maps, well driller logs, and forms and field worksheets. The survey leader will ensure that all equipment and supplies are appropriately cleaned, in good working order and within their laboratory calibration interval as specified in ES-43.1, attachment 1 (reference 3.18). It is recommended that an equipment checklist be prepared on the initial field survey and that it be referred to and updated on each subsequent survey.

6.2.5 The survey leader may obtain a summary of the last four sets of field data for use to validate and compare information at the time it is being collected. A computer printout can be obtained from CHATT ENGG-EDM to facilitate this data validation process.

6.2.6 Generally, the survey leader should monitor the wells in a particular order as determined by their typical pH values. For instance, all wells below a pH of 7.0 should be sampled, then all wells above a pH of 7.0 should be sampled. The monitoring equipment should be restandardized between the two ranges of wells using the appropriate pH buffers.

6.2.7 Also, water levels of the wells and reference points should be measured prior to any sampling and recorded. These measurements should be made in as short of a time interval (hrs.) as possible. These "snapshot measurements" should be converted to water level elevations (meters above MSL). Both values should be recorded in a table and presented with well/R.P. description, time of measurement, and depth to well bottom (in meters) along with any pertinent remarks.

6.3 Groundwater Sample Collection Techniques

6.3.1 Quality Control of Sampling Operations

6.3.1.1 Every effort will be made to collect a representative and uncontaminated sample. After each sample is collected, it will be visually examined for any foreign material that is not representative. If any foreign material is observed, or suspected, the sample will be discarded and new sample recollected in a fresh sample container. Do not immerse anything--even a thermometer--in the sample. Always pour the sample directly into the specified containers one at a time. Transferral to another container will greatly increase the opportunity for contamination and cross contamination.

6.3.1.2 Many sample containers contain chemical preservatives. These preservatives may be a source of contamination to other samples, may be ineffective if diluted, or may be harmful if allowed to contact skin or eyes. Use care when handling sample containers with chemical preservatives. Fill sample containers individually, one at a time, to prevent cross contamination of preservatives: uncap the container, fill it directly from the sampler, and recap the sample container immediately. Do not place flexible sample tubing inside the containers unless specifically instructed to do so. Do not lay caps on surfaces that might contaminate them. Do not overfill containers. If any of these potential sources of contamination occur, discard the affected portion of the sample, and collect another portion in a fresh container.

6.3.1.3 Sample collection methods for groundwater may include the use of a submersible centrifugal pump, pneumatic bladder pump, single or 10-channel peristaltic pump, check valve bailer, lysimeter, or perhaps a gas lift pump. The method used to collect a groundwater sample must be compatible with the water quality characteristics of interest. All of these methods, in one or more ways, alter the quality of the sample while it is being collected. In most instances, the submersible centrifugal (low flow, variable speed) pump, the pneumatic bladder pump, or check valve bailer, when used properly, will collect the most representative (least altered) sample for a variety of constituents (particularly volatile organics and reduced/dissolved species). The use of gas lift devices for collection of groundwater quality samples is not recommended. Chapter 6 of reference 3.2 provides additional details.

6.3.1.4 When collecting groundwater samples, the sample should be obtained as close to the discharge of the source or wellhead as possible to reduce the potential for contamination, precipitation of solute, and loss of dissolved gasses. Treated (chlorinated or filtered) or stored groundwater samples, such as from some private or domestic wells are of limited value. Care must be taken to limit sample contact with air and agitation that would interfere with the field determination of pH, ORP, dissolved gasses, acidity, and alkalinity, or the laboratory determination of volatile organics and reduced species.

6.3.1.5 On occasion it may be desirable to determine concentrations of dissolved inorganic constituents (i.e., dissolved minerals or dissolved metals) in groundwater. In such cases, by definition, the sample is filtered through a 0.45 mm average pore diameter cellulose ester membrane filter (Millipore Cat. No. HAWP04700 or equivalent) during (pressure filtration) or immediately after (vacuum filtration) sample collection. Techniques used to filter groundwater samples should be discussed in detail in the project's workplan. In most cases, the preferred method for filtration of groundwater is an "in-line" pressure filtration technique which eliminates sample contact with the atmosphere and utilizes the sampling pump's pressure for filtration. The field worksheets and request for laboratory analysis forms must clearly indicate when samples are filtered in the field. Also, all bottles must be properly marked for which constituent the sample was performed (e.g., DM, dissolved metals and etc.). Samples for field analysis (temperature, DO, pH, conductance, ORP, alkalinity, etc.) and certain laboratory analyses (ferrous and manganous ions, sulfide, organics, turbidity, suspended solids, etc.) are never filtered. Additional details in regard to sample filtration procedures are given in section 6.2.2 of reference 3.15.

Condition the filter prior to sampling with 200 to 300 mL of deionized, distilled water (Super Q). This hydrates the filter to lessen the chance of channelization through the filter during sampling. Collect a filter blank with Super Q water after conditioning at the frquency specified in section 6.3.1.7. If filtration difficulties are anticipated because of high solids concentrations, try to develop the well to reduce the level of solids. If too much mud is still present, measure the Hydrolab parameters and pump up as much sample as possible. Let it stand in a sealed, clean container, and decant enough sample for filtering.

6.3.1.6 Samples collected for extremely low levels (i.e., less than one part per billion) of trace organics and/or trace elements may easily be contaminated by contact with foreign materials. Motor oil, gasoline, soft plastics, etc., may be potential sources of contamination for trace organic/pesticide sampling, while soil and dust, which is ubiquitous at fossil plants, may be potential sources of contamination for many trace elements. Reference 3.16 and section 6.3.3.5 below discuss routine precautions which are taken to minimize potential sources of contamination. The permanent installation of a groundwater sampling device in each monitoring well has many advantages. It will eliminate the possibility of the introduction of foreign material during the lowering of sampling equipment into the well and the potential for cross contamination between wells caused by the possible carryover of contaminants on the sampling equipment from one well to another. In those cases where special attention must be paid to extremely low levels of organics or trace elements, permanent installation of sampling equipment/pumps in each groundwater monitoring well is recommended.

6.3.1.7 Unless otherwise specified in the project's workplan, duplicate groundwater samples will be collected at every 20th well (i.e., five percent site specific of the samples collected). Further details in regard to collection of duplicate samples are given in section 6.15.3 of reference 3.14. Also, filter blanks shall be taken when dissolved samples are collected.

6.3.2 Standardization of Field Equipment and Field Measurements

6.3.2.1 ES procedures for standardization of field instruments (reference 3.18) must be followed, as appropriate, with particular attention given to the following instruments which are commonly used by ES in the collection of groundwater quality samples.

6.3.2.1.1

Field Instruments (reference 3.18)	ES Procedure
Hydrolabs	ES-43.2
YSI Conductance Meters	ES-43.3
Orion pH Instruments	ES-43.7
Thermometers	ES-43.8

6.3.2.1.2 Field instruments will be standardized as specified in the above referenced procedures. At a minimum, instruments will be standardized before and after field measurements are made and whenever the accuracy of the instrument is questioned. Form TVA 30035, "Instrument Standardization, Field Standardization of Instruments," will be completed to document all field standardizations of instruments.

6.3.2.2 ES procedures for water quality field analyses (reference 3.17) must be followed, as appropriate, with particular attention given to the following analyses which are commonly used by ES in the collection of groundwater quality samples.

6.3.2.2.1

Water Quality Field Analyses (reference 3.17)	ES Procedure
Alkalinity and Acidity (Ref. Attachment 6 for summary worksheet)	ES-42.1
Total and fecal coliform bacteria	ES-42.2
Conductance	ES-42.3
Dissolved Oxygen (DO)	ES-42.4
Oxidation-Reduction Potential (ORP)	ES-42.7
pH	ES-42.8
Temperature	ES-42.11

6.3.3 Collection of Well Samples Using a Submersible Pump

6.3.3.1 To obtain a representative sample of groundwater, it must be understood that the composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality at the sampling site. This is due to the possible presence of drilling contaminants near the well, introduction of foreign material from the surface, casing corrosion, and/or because environmental conditions such as the oxidation-reduction potential (ORP or REDOX) may differ drastically near the well from the conditions in the surrounding water-bearing materials. Consequently, each well must be flushed (purged) of standing (i.e., stagnant) water until it contains fresh water from the surrounding aquifer. The recommended length of time required to pump a well and the rate at which a well can be pumped before sampling are dependent on many factors including the physical characteristics of the well, the hydrogeological nature of the aquifer (i.e., hydraulic conductivity), the type of sampling equipment being used, and the water quality parameters of interest.

6.3.3.2 Prior to any sampling or pumping of a well, measure and record the distance to the water surface (Dws) with an acoustic or electric plunker. Also measure and record the depth of the well (Dw) on each survey. Do not rely on past well depth data, since the well may be silting in. Depth measurements (measured to the nearest 0.01 meter i.e. nearest cm.) are usually referenced to the top of the inner well casing and not the outer protective casing. All data, measurements, observations, and computations are to be recorded on form TVA 30066A, "Groundwater Quality Data Field Worksheet (Chemical Data)," attachment 1. In addition, if the well to be sampled is a new well or has never been sampled, form TVA 30066B, "Groundwater Quality Data Field Worksheet (Physical Data)," attachment 2, which documents information about type of well, owner of well, location of well, well drillers log/information, etc., must also be completed.

6.3.3.3 Calculate the volume of water in the well as shown below:

Well Casing ID (mm)	Liters Per Meter
51	2.027
76	4.560
102	8.107
127	12.668
153	18.228

$$V_w \text{ (in liters)} = (D_w - D_{ws}) \times \text{liters/meter}$$

where:

V_w = Volume of well, liters;
D_w = Depth of well, meters; and
D_{ws} = Depth to water surface, in meters

6.3.3.4 If a submersible pump is not already permanently installed, such as might be the case at "dedicated" pump wells, private or domestic wells, the preferred method of purging and sampling a well is to use a low flow (variable speed controlled) centrifugal pump, a pneumatic bladder pump, or a peristaltic pump (shallow wells). However, in situations where large volumes of water must be purged from a well, resulting in long pumping times (i.e., greater than one hour), a centrifugal pump with a higher pumping capacity (4 to 16 liters per minute) may be used for purging only instead of the lower capacity bladder pump (1-3 liters per minute). All such cases should be specifically addressed in each project's workplan. Domestic wells with a submersible pump already permanently installed can be sampled from a convenient tap or faucet after letting the water run for several minutes.

6.3.3.5 Prior to lowering the pump into the well, (when advantageous) a large tarpaulin or heavy sheet of plastic should be spread on the ground to cover the necessary portion of the work area. This "good housekeeping" practice will help minimize the potential for contamination caused by contact of the soil with the pump and/or pump tubing. Immediately prior to placing the pump into the well, rinse the outside of the pump and the first meter of pump tubing with deionized water. Successive lengths of pump/sample tubing shall be rinsed/wiped with deionized (DI) water before insertion into the well casing.

6.3.3.6 Carefully lower the pump intake to approximately 0.6 to 1.3 meters below the water surface (dependent upon the length of the pump head). The pump should not be lowered below the top of the well screen or to the bottom of the well unless specific instructions to do so are given in the workplan. Studies have shown that lowering the pump to the bottom of a well (below the well screen) may result in a poor flushing of the column of water above the pump if the transmissivity of the aquifer is high. In such cases the pump would be primarily removing inflowing water from the lower portion of the well casing and not effectively removing the water in the upper water column. Pumping from near the surface (and lowering the pump with the drop in the water surface) ensures that inflowing water moves up through the water column and that no stagnant water will remain in the well after purging. The past performance of a well should be used to indicate the appropriate steps for lowering the pump. If the well's recharge rate is slow, the pumping rate will need to be reduced to minimize the drawdown of the water level in the well, or in extreme cases the well maybe completely evacuated ("pumped dry") and allowed to recharge overnight before sampling. At no time should the water level be drawn below the top of the well screen, unless dictated by a very slow recharge rate, requiring "next day" sampling.

6.3.3.7 While purging the well, continuously monitor the time, pumping rate, and distance to water surface. The pumping rate should be adjusted (when possible or reasonable) to minimize the drawdown of the water surface in the well. Using a Hydrolab flow-through cell system to avoid groundwater-air contact, also monitor the groundwater's temperature, pH, DO, conductance, and ORP. Record all the stabilization test data on form TVA 30066A, "Groundwater Data Field Worksheet," attachment 1, approximately every five minutes or less if purge time is expected to be of a short duration. At each well, while recording and monitoring the field stabilization test data (i.e., pumping rate, water surface, temperature, pH, DO, conductivity, and ORP), the survey leader will compare the data being collected with previously collected field data. A computer printout of the last four sets of field results, obtained from the CHATT ENGG, will facilitate this comparison and ensure, on the spot, that valid and comparable data are being obtained.

6.3.3.8 Unless otherwise stated in the workplan, when at least two well volumes of water have been purged from the well and the Hydrolab readings (temperature, pH, DO, conductivity, and ORP) have stabilized, (i.e., do not change by more than 5 percent or have essentially ceased any obviously upward or downward trend between readings), samples may be collected. If the water quality readings have not stabilized after removal of two well volumes, remove a third well volume (if conditions permit), then begin sampling. When filling the various sample bottles/containers, care must be taken to minimize sample aeration, and to gently fill each bottle. This will often necessitate the lowering of the pumping rate to less than one liter per minute to avoid the turbulence caused by the high velocity of the water as it is discharged from the pump tubing. Be sure to record the pumping rate, temperature, pH, DO, conductivity, ORP, etc., at the time of sample collection and record the distance to the water surface immediately upon completion of sampling.

6.3.3.9 If the well's recharge is slow, the pumping rate will need to be reduced to minimize the drawdown of the water surface level in the well. If a well becomes dry during the purging, it must be allowed to recover before sampling to avoid taking a nonrepresentative sample. It may be necessary to allow 24 hours or longer for recovery. If circumstances are encountered which are not addressed in this procedure or in the project's workplan, notify the lead engineer immediately for instructions.

6.3.3.10 After purging and sampling, sample water should be removed from the pump and tubing before sampling another well. A centrifugal pump should have the check valve removed so that water will drain back into the well when the pump is turned off. Before reuse of any pump/sample tubing at any successive well, place the pump head in a container of deionized water (Super Q) and pump through two line volumes of Super Q water to flush the pump and lines thoroughly. NOTE: The "DI" flush water must be removed with two line volumes of sample water. The outside of lines should be wiped with a clean rag or paper towel soaked with DI water. This process shall be repeated at each well that is sampled.

6.3.4 Collection of Samples Using a Bailer

6.3.4.1 Prior to sampling a well with a bailer, measure and record the distance to the water surface and the depth of the well as given in section 6.3.3.2.

6.3.4.2 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.4.3 Prior to sampling a well with a bailer, thoroughly flush the sampler with deionized water. (As an alternate method, a pre-cleaned disposable Teflon bailer may be used.) Carefully lower the sampler to the water surface. Do not drop the sampler or let it free fall to the water surface, as this will cause aeration of the sample. Gently lower the sampler into the water. Retrieve the bailer. Repeat this process until two well volumes of water have been removed or as specified in the project's workplan.

6.3.4.4 Collect the samples by carefully lowering the sampler to the well screen or the perforated section of the well casing or to the depth specified in the workplan. Care should be taken to avoid striking the bottom of the well with the sampler.

6.3.4.5 Fill the specified bottles/containers directly from the sampler. Slow and careful transfer is important to minimize sample aeration. When filtered samples are requested, use a bailer fitted with an in-line filter. Measure and record temperature, pH, DO, conductivity, ORP, and the distance to the water surface immediately after collection of the sample.

6.3.5 Collection of Samples From Multilevel Sampling (MLS) Wells

6.3.5.1 A typical MLS well, see attachment 3, will consist of several (often 20 to 30) small diameter, flexible sampling tubes. Each tube will have a filter, usually a nylon mesh, on the intake end of the tube with the intake ends of these tubes spaced at known distances below the ground surface. These flexible sampling tubes are housed and extend to the surface inside a PVC pipe as shown in attachment 3.

6.3.5.2 Groundwater samples will be collected from MLS wells using peristaltic 10-channel pumps (i.e., two 10-channel pumps for 20 flexible sampling tubes, three 10-channel pumps for 30 flexible sampling tubes, etc.). In all sample collections from MLS wells, the 10-channel peristaltic pumps will be used in parallel to purge all tubes and collect all samples simultaneously. Every effort will be made to collect representative and uncontaminated samples. An important consideration in obtaining a valid, representative sample is first the removal of the standing water which has been trapped in the multilevel flexible sample tubing since the last sample collection. However, to avoid stressing the aquifer and perhaps altering its natural movement, this purging of the trapped water in the tubing will be minimized. One of the reasons for using the small diameter flexible tubing is that it minimizes the amount of water which is purged. For example, one meter of 5 mm ID tubing contains approximately 19.6 mL of water. Therefore, the purging of two tubing volumes would result in the purging of approximately one liter of water from each sample tube (assuming 25 meter lengths of 5 mm ID tubing) prior to collection of the samples. Specific purging instructions for individual MLS wells will be detailed in each project's workplan.

6.3.5.3 To collect samples at MLS wells, connect the MLS flexible sampling tubes to the 10-channel peristaltic pump tubes by mating like numbered (colored) tubes number 1 through 30 (assuming there are 30 flexible sample tubes and that three 10-channel pumps are used).

6.3.5.4 Place waste containers beneath each sampling tube, turn on the 10-channel peristaltic pumps, and simultaneously purge all the sample tubes of stagnant water by pumping approximately two volumes of water from each sample tube. (One meter of 5 mm ID tubing contains approximately 19.6 mL of water.) Discard the purge water as appropriate or as outlined in the customer's request documentation. Record on the field worksheets any tubes which do not produce water or produce only small quantities of water.

6.3.5.5 After purging the MLS sample tubes, place sample bottles/containers marked with sample identification numbers and in proper numerical order under each correspondingly numbered sample tube. Fill the bottles/containers to the required volume and repeat this step until all types of sample bottles (i.e., metals, minerals, nutrients, sulfide, etc.) have been collected.

6.3.5.6 During the collection of the MLS groundwater samples, it is important to keep track of the fluid volume in each bottle/container, because each sampling tube will not discharge at the same rate. As a bottle or container reaches the proper volume of sample, the sample collector will clamp off the appropriate peristaltic pump tube while allowing the remaining bottles/containers to continue to fill. Finally, after the last bottle or container has filled and the pump tube has been clamped off, the 10-channel peristaltic pumps can be shut off.

6.3.5.7 Immediately after collection of MLS well samples, make field measurements for those water quality characteristics specified in the project's workplan (e.g., temperature, pH, DO, conductivity, ORP, alkalinity, etc.).

6.3.6 Collection of Samples Using a Peristaltic Pump

6.3.6.1 A peristaltic pump can be used to collect a sample from a shallow well (water surface less than 7.6 meters below ground surface), spring or seep.

6.3.6.2 Prior to sampling a shallow well, measure and record the distance to the water surface and the depth of the well as given section 6.3.3.2.

6.3.6.3 Calculate the volume of water in the well as shown in 6.3.3.3.

6.3.6.4 Lower the tygon or teflon tubing connected to the peristaltic pump into the water. Remove at least two volumes of water before collection of samples from a shallow well. No purging of water is necessary if collecting a sample from a spring or seep, since the water is naturally flowing.

6.3.6.4 Fill the specified containers, process the samples, and make the water quality field measurements as specified in the project's workplan. Measure (or estimate) and record the spring or seep discharge rate (or the pumping rate if sampling a shallow well) on form TVA 30066A, "Groundwater Quality Data Field Worksheet," attachment 1.

6.3.7 <u>Collection of Samples Using a Lysimeter</u> (Pressure-Vacuum Soil Water Sampler)

6.3.7.1 General Instructions--Lysimeter (pressure/vacuum soil water samplers) can generally be installed and used at any depth up to approximately 15 meters. The access tubes (i.e., pressure/vacuum tube and sample discharge tube) from the lysimeter can extend above the ground surface directly above the lysimeter, or if conditions require, the access tubes can be laid in a trench, terminating above the ground surface at some distance from the lysimeter. The ends of the access tubes should be installed so that they will be protected from damage by mechanical equipment, livestock, etc. The tube ends should be covered or plugged to prevent debris from entering the tubes and later contaminating the samples. The ground surface directly above the lysimeter should not be covered in any manner that would interfere with the normal percolation of soil moisture down to the depth of the lysimeter. Attachment 4 shows a typical lysimeter installation.

6.3.7.2 Access Tubes--The "pressure/vacuum" access tube and the "sample discharge" access tube are usually small diameter polyethylene tubes (e.g., 5 mm I.D.) that extend from the porous ceramic collection device to the ground surface. Typically the tubes are inserted through a cap or plug at the open end of the porous collection cup as shown in attachment 4. One end of the "sample discharge" tube extends nearly to the bottom of the porous ceramic collection cup with the other (discharge) end extending to the ground surface. The discharge end of this tube must be marked and identified as the tube from which the samples are collected. The "pressure/vacuum" access tube is installed slightly differently. One end of the "pressure/vacuum" tube is inserted only about an 2.5 cm past the cap or plug with the other end also extending to the ground surface. The fit of the tubing through the cap or plug and the fit of the cap or plug at the open end of the porous collection cup must be tight and well seated so as to be able to maintain a pressure-vacuum seal.

6.3.7.3 Installing a Soil Water Sampler--Installation of a lysimeter can be performed in several ways. Methods for installation of a lysimeter must be specified in the project's workplan. Typically a 102 mm hole is cored using a T-handle bucket auger. The augered soil should be sifted through a 6.0 mm mesh screen to remove any larger rocks and pebbles. This sifted soil will provide a reasonably uniform backfill for filling in around the inplaced lysimeter. The following discussion details some of the more common methods for installation of a lysimeter. The primary concern in all the methods is that the porous ceramic cup of the lysimeter be in tight, intimate contact with the soil so that soil moisture can move readily from the soil through the pores of the ceramic cup where it can then be withdrawn through the sample discharge tube.

6.3.7.3.1 Native Soil Backfill Method--After the hole has been cored to the desired depth, insert the lysimeter and backfill the hole with native screened (sifted) soil, tamping continuously with a small-diameter rod to ensure good soil contact with the porous ceramic cup and to prevent surface water from channeling down the cored hole.

6.3.7.3.2 Soil Slurry Method--After the hole has been cored, mix a substantial quantity of the sifted soil from the bottom of the hole with water to make a slurry which has a consistency of cement mortar. This slurry is then poured into the bottom of the cored hole. Immediately after the slurry has been poured, push the lysimeter into the hole so that approximately the bottom third of the lysimeter is completely embedded in the soil slurry. Backfill the remaining voids around the lysimeter with sifted soil, tamping lightly with a small-diameter rod to ensure good soil contact with the lysimeter. Backfill the remainder of the hole, tamping firmly, to prevent surface water from running down the cored hole. The first set(s) of soil water samples collected after installing a lysimeter by this soil slurry method may need to be discarded to avoid differences in water chemistry between the water used to prepare the slurry and the natural soil water.

6.3.7.3.3 Sand and Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about 51 mm, crushed 200 mesh pure silica sand of almost talcum powder consistency (commercially available under trade names of Super-Sil and Silica Flour). Insert the lysimeter and pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill the remainder of the hole with sifted native soil, tamping to ensure good soil contact with the lysimeter and to prevent surface water from channeling down between the lysimeter and the soil.

6.3.7.3.4 Bentonite-Sand-Soil Method--Core hole to the desired depth. Pour into the hole, to a depth of about 51 mm, a small quantity of wet bentonite clay. This will isolate the lysimeter from soil below. Next, pour in a small quantity of 200 mesh silica-sand and insert the lysimeter. Pour in additional sand until at least the bottom third of the lysimeter is covered. Backfill with sifted native soil to a level about 51 mm above the lysimeter, tamping lightly. Again add about two inches of wet bentonite clay as a plug to further isolate the lysimeter and guard against possible channeling of water down the hole. Finally, backfill the remainder of the hole slowly with sifted native soil, tamping continuously. Allow sufficient time for the wet bentonite clay to harden before using the lysimeter to collect soil water samples.

6.3.7.4 Collecting a Soil Water Sample--After the lysimeter has been installed, a pinch clamp is securely tightened on the sample discharge tube, and a vacuum is applied to the pressure/vacuum tube. A vacuum of approximately 60 centibars (46 cm of mercury) is applied. A pinch clamp is then securely tightened on the pressure/vacuum tube. The lysimeter is then left undisturbed for a predetermined period of time, determined by experience and trial and error or as set forth by work plan instructions.

6.3.7.4.1 The vacuum within the lysimeter causes the soil moisture to move from the soil through and into the porous ceramic cup. The rate at which the soil water will collect in the lysimeter depends on the capillary conductivity of the soil and the amount of vacuum that has been created within the lysimeter. In most soils of good conductivity, substantial soil water samples can be collected within a few hours. Under more difficult conditions it may require several days to collect an adequate volume of sample.

6.3.7.4.2 In general, vacuums of 50-85 centibars (38 cm - 64 cm of mercury) are normally applied to the lysimeter. However, in very sandy soils it has been shown that high vacuums may result in a slow rate of sample collection. In coarse, sandy soils, the high vacuums may deplete the soil moisture in the immediate vicinity of the porous ceramic cup and, hence, reduce the capillary conductivity, which results in lower sample collection rates. In loam and gravelly clay loam, collection rates of 300-500 mL/day at 50 centibars (38 cm of mercury) are common. On waste water disposal sites, collection rates of up to 1500 mL/day have been observed.

6.3.7.4.3 To recover the soil water from the lysimeter, attach the pressure/vacuum access tube to the pressure port on a pump. Place the sample discharge tube into the sample bottle or container being careful to avoid and minimize sample contamination from the surrounding soil excavation. Open both pinch clamps (one on the pressure/vacuum tube and one on the sample discharge tube) and gently apply pressure to develop enough pressure within the lysimeter to force the collected soil water out of the lysimeter and into the sample bottle or container.

6.3.7.4.4 Subsequent samples are collected by again creating a vacuum within the lysimeter and repeating the above steps, sections 6.3.7.4 through 6.3.7.4.3

7.0 HANDLING OF SAMPLES

7.1 Sample Identification--All sample bottles and sample containers shall be labeled with a permanent sample identification number. This sample identification number or tag number must be unique for each sample collected and must be cross referenced on all field sheets (forms TVA 30066A and 30066B), and Analysis Request and Custody Record forms (TVA 30488). Prior to packaging and shipping of samples, all containers and bottles shall be inspected for tag numbers and cross checked against all field sheets, and Analysis Request and Custody Record forms. Additional explanation of sample identification requirements are given in section 6.11, reference 3.14 .

7.2 Packing and Shipping of Samples--Sample containers should be closely protected against contamination while transporting them to the survey site, during sampling, field handling and analysis processes, and while transporting them back to the laboratory. Detailed instructions for packing and shipping the various kinds of samples are given in reference 3.7. These requirements are summarized in attachment 1 of reference 3.15. As soon as possible, samples shall be packed on ice. To avoid breakage, care must be taken when packing bottles and containers in shipping chests. Copies of the Analysis Request and Custody Record forms must be sent to the laboratory with the samples. Check to make sure all paperwork has been accurately completed and sealed in a plastic bag to prevent water damage. All shipping containers shall be clearly addressed and shall be sealed and closed with strapping tape.

7.3 Holding Times--The time which elapses between sample collection and sample analysis is critical for many constituents (e.g., BOD, ortho-phosphorus, turbidity, nitrite, etc.). So that the laboratory can complete the analyses within the appropriate holding times, samples must be shipped or transported so as to arrive within the time limits given in attachment 1, reference 3.15. (ES 41.2) Any time samples are to be collected with holding times less than 48 hours, the laboratory must be notified in advance. All collections of samples should be coordinated with the laboratory.

7.4 Chain-of-Custody--The sample collector is responsible for the care and custody of the samples until they are properly dispatched to the receiving laboratory. The sample collector will ensure that each sample is under his/her control at all times. When samples are dispatched to the laboratory for analyses, the sample collector will retain a copy of the completed Analysis Request and Custody Record form(s), the originals of which accompany the samples. All samples shipped to the laboratory will be listed on the custody record form and cross referenced with their unique sample tag (identification) number. The custody record form should reveal the name and telephone number of the sample collector/shipper and the date of shipment. Shipping record receipts for shipments (UPS, Greyhound bus, etc.) will be retained by the sample collector/shipper as part of the permanent chain-of-custody documentation. Upon receipt, the laboratory will inspect for the shipping container for broken seals and will inspect the samples for breakage, missing samples, tampering, etc. The laboratory will verify all samples by cross referencing tag numbers between the custody record and the sample bottles received to ensure that all samples which were shipped have been received complete and intact. The laboratory will immediately notify the sample collector/ES/shipper of any discrepancies. For non-routine sampling or if shipping after Wednesday of a given week, the shipper should verify the arrival of the samples at the laboratory.

7.5 Field Data Worksheets--Copies of all field data worksheets will be sent to the CHATT ENGG-EDM in Chattanooga. Section 8.3 gives additional details.

8.0 RECORDKEEPING

8.1 Project Notebooks

8.1.1 A project field notebook and/or file shall be maintained by the ES survey leader to record pertinent information and observations. The project field notebook accompanies the survey leader to the field. The survey leader shall record and/or file all physical measurements and field analyses performed in the project notebook/file. In addition, auxiliary data often prove very useful in the interpretation of the results. Thus, water surface elevations of nearby ash ponds, basins, lakes, streams, etc., gas bubbles in the sample line, rapid development of turbidity or color in the sample, equipment problems, clogged sampling ports at MLS wells, weather conditions, deviations from workplans or this procedure, or any number of other observations could prove very helpful and should be recorded. Project field notebooks, should there be a change in personnel, should include all information necessary to properly conduct the field survey. At a minimum this would include: the original project workplan with all approved revisions; sample identification (tag) numbers and descriptions of the well locations; copies of past survey field worksheets and groundwater level observations; computer printouts of prior field data; a survey equipment checklist; and all field instrument calibration records. Also included in the field notebook might be maps, sample collection and handling instructions, bus schedules, names and telephone numbers of project personnel, and any miscellaneous notes to aid in conducting the survey.

8.1.2 A project office notebook and/or file are maintained by the lead engineer. The project office notebooks remain in the office at all times and are available for reference by ES, client, and other project organizations. In addition to containing the original approved project workplan and all approved revisions, it should contain information relating to the project such as memoranda, budget estimates, progress reports, data reports, correspondence with client organizations, etc.

8.2 <u>Survey Reports</u>--Following completion of each groundwater field survey, the ES survey leader will prepare a draft report to the client organization which will be finalized by the lead engineer. The report shall contain:

a. A cover letter addressed to the client from the lead engineer which describes the field activities and notes any unusual conditions (weather, equipment problems, breach of well security, etc.);
b. The Ground Water Quality Data Field Worksheets;
c. Special worksheets (e.g., Acidity and Alkalinity);
d. Instrument Standardization Forms;
e. Groundwater Level Measurements Form; and
f. Analysis Request and Custody Record Form.
g. Other Forms (i.e. bacterial organism worksheet)

Note: The survey leader is responsible for proper routing of the five (color coded) field sheets).

8.3 <u>Disposition of Forms</u>

8.3.1 Forms TVA 30066A and B, Groundwater Quality Data Field Worksheets, attachments 1 and 2, are used any time physical and/or chemical groundwater measurements are made. The original (white copy) is sent to and is filed by CHATT ENGG-EDM. Copies are retained by ES field office per attachment 7 (distribution) and may be sent to the client organization(s) at their request.

8.3.2 Form TVA 11552 (or similar project specific form/table), Groundwater Level Measurements (Field), attachment 5, is used as required, when groundwater elevations are observed or recorded at ash ponds, coal pile runoff ponds, metal cleaning waste ponds, rivers, lakes, groundwater wells, etc. The original (white copy) is sent to and is filed by CHATT ENGG (EDM). Copies are retained by ES field office per attachment 7 (distribution) and may be sent to the client organization(s) at their request.

8.3.3 Form TVA 30488, Tennessee Valley Authority, Water Management Services, Environmental Chemistry Analysis and Custody Record, is used to ship samples to the ECHEM Laboratory and identify the desired analyses. It is to be used anytime samples are shipped or delivered to the ECHEM Laboratory to ensure that the proper number and types of samples as specified in the approved project workplan, are in fact received by the

ECHEM Laboratory. The original (white copy) is sent with the samples to the laboratory. Copies are retained by ES field office per attachment 7 (distribution) and one copy (pink) is sent to CHATT ENGG-EDM. Reference 3.15 contains an example of form TVA 30488.

8.3.4 Form TVA 11064, Sample Custody Record, is only used when samples are shipped or delivered to an <u>external TVA</u> laboratory to aid ES in its internal record keeping functions, or as an aid for shipping/record keeping, for sample custody to an external TVA laboratory. Reference section 3.15 of ES-41.2, contains an example of form TVA 11064.

8.3.5 Form TVA 991, Request for Analysis, is only used for samples requiring <u>external TVA</u> laboratory analyses. It specifies which analyses are to be performed or which workplan is to be followed for sample analyses. The original is sent with the samples to the external TVA laboratory, additional copies will be retained by ES. Reference 3.15 contains an example of form TVA 991.

8.3.6 Form TVA 30533, Acidity and Alkalinity Field Worksheet is to be used by ES, the original is sent to CHATT ENGG-EDM and copies distributed per attachment 7 (distribution).

8.3.7 Retention periods and file locations for these forms are given in attachment 7.

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LIST OF ATTACHMENTS

1. Groundwater Quality Data Field Worksheet (Chemical Data), form TVA 30066A.
2. Groundwater Quality Data Field Worksheet (Physical Data), form TVA 30066B.
3. Schematic Drawing of a Multilevel Sampling (MLS) well.
4. Typical Lysimeter Installation.
5. Groundwater Level Measurements (Field), form TVA 11552.
6. Acidity and Alkalinity Field Worksheet, TVA Form 30533.
7. Records (Use, Distribution, and Retention).

ATTACHMENT 1
GROUNDWATER QUALITY DATA FIELD WORKSHEET (CHEMICAL DATA), FORM TVA 30066A

GROUNDWATER DATA FIELD WORKSHEET

SHEET OF

PRELIMINARY DATA

PROJECT/SITE

PURGE DATE ▶ YEAR / MONTH / DAY

WELL NO.

DEPTH TO WATER (m) 4195

BOTTOM OF WELL (m) 4194

SURVEY LEADER

FIELD CREW

WELL DIAM (mm) 4188

DEPTH OF SCREEN OR OPEN BORE HOLE (CIRCLE) (m) 4191 TO (m) 4190

[BOTTOM OF WELL - DEPTH TO WATER] x VOL. FACTOR = WELL VOLUME

[( )m - ( )m] x ( ) l/m = 4187 (l)

TARGET PURGE VOL. (l)

ACTUAL PURGE VOL. 4186 (l)

SAMPLE TAG NO. (Circle) UNFLT FLT BOTH

FILTER TYPE/SIZE

PURGE PUMP (Circle) BLADDER CENTRIFUGAL PERISTALTIC BAILER OTHER (list) __________

SAMPLE PUMP (Circle) BLADDER CENTRIFUGAL PERISTALTIC BAILER OTHER (list) __________

NOTES AND WQ OBSERVATIONS	ET CT TIME (mil)	PUMP RATE (l/min)	DEPTH TO WATER (m)	PUMP DEPTH (m)	TEMP (°C)	pH (units)	DO (mg/l)	COND (µs/cm)	(+/-) ORP (mV)	
BEGIN PURGE ⟶										

REMARKS:

Reviewed by:

Survey Ldr: Date

FE Proj. Eng: Date

SAMPLE READINGS ⟶

SAMPLE DATE YR / MO / DAY

PUMP DURATION min

"mm" x 2 DAYS

	(mil) TIME	(l/min) SAMPLE RATE	(m) WATER SURFACE	(m) SAMPLE DEPTH	(°C) TEMP	pH	(mg/l) DO	(µs/cm) CONDUCTIVITY	(mV) ORP (+/-)	
		4193		4192	10	400	300	84	90	

ADDITIONAL SAMPLE DATA

TURBIDITY 1350 (circle): CLEAR 1 SLIGHTLY TURBID 2 TURBID 3 HIGHLY TURBID 4

COLOR:

ODOR:

PHENOL ALK. mg/l 415

TOTAL ALK. mg/l 431

MINERAL ACIDITY mg/l 436

CO_2 ACIDITY mg/l 437

WELL DIAM mm		VOL. FACTOR l/m
51	(2 in)	2.027
76	(3 in)	4.560
102	(4 in)	8.107
127	(5 in)	12.668
153	(6 in)	18.228

BOTTLES REQUIRED (circle)

BOD	TIC	FERROUS	MINERAL	PHENOL	OTHERS (list): __________
COD	SOC	METALS	DIS MINERAL	FILT TIC	__________ __________
TOC	O&G	DIS METALS	NUTRIENT	TSS/TDS	__________ __________

DISTRIBUTION: (1) Original - Data Mgt (2) Pink - Lab With Samples (3) Blue - Unit Leader (Office Notebook) (4) Green - Survey Leader (Field Notebook) (5) Yellow - F.E. Project Engineer

TVA 30066A (RD BUS 1-93)