STANDARD OPERATING PROCEDURE FOR:

SLUG TESTING

TVA-KIF-SOP-42

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for
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December 2009

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the procedures used to conduct slug testing at the Kingston Fossil Plant (KIF) Ash Recovery Project using water-level data loggers. Slug tests are used to determine the horizontal hydraulic conductivity of aquifer materials. Hydraulic conductivity (K) is an important parameter needed to understand groundwater movement.

2.0 GENERAL CONSIDERATIONS

Potential hazards associated with the planned tasks are thoroughly evaluated prior to conducting field activities. TVA's *Site-Wide Safety and Health Plan* (SWSHP) provides a description of potential hazards and associated safety and control measures.

Sampling personnel must wear powder-free nitrile gloves while performing the procedures described in this SOP. Specifically, powder-free nitrile gloves must be worn while handling the testing equipment (transducers and slugs) described in this SOP. At a minimum, nitrile gloves must be changed prior to conducting activities at a new slug testing location.

The equipment required to properly conduct the slug testing is listed on the example checklist in Table 1.

3.0 PROCEDURES

The following sections describe the general operating procedures and methods associated with slug testing. Any variation in these procedures must be approved by the Project Manager and Quality Assurance/Quality Control (QA/QC) Lead and must be fully documented. Field work cannot progress until deviations are approved or resolved.

3.1 Pre-Job Preparation

The information listed below shall be reviewed prior to conducting slug testing activities, if available, and can be beneficial on-site for reference in the field as necessary:

- A list of the monitoring wells on which slug tests are to be performed;
- Information describing well location, using site-specific or topographic maps or Global Positioning System (GPS) coordinates and descriptions tied directly to prominent field markers (positional information or maps are also valuable under severe weather conditions);
- Boring logs and well construction details, if available;
- Survey data that identify the documented point of reference (V-notch or other mark on well casing) for the collection of depth-to-groundwater as well as total well depth information;

- Previous depth-to-groundwater measurements.

The Field Team Leader ensures that the following activities have been completed prior to mobilizing to the site.

a. Obtain equipment necessary for completing the activities (see the example checklist in Table 1).

b. Obtain site-specific maps or GPS coordinates showing clearly marked monitoring well locations.

c. Review the project work control documents (such as the *Quality Assurance Project Plan* [TVA-KIF-QAPP] and applicable SOPs) in an effort to determine project-specific sampling requirements, procedures, and goals. Review manufacturer's manual prior to initiating slug testing.

d. Verify that legal right-of-entry has been obtained and site access has been granted, where required.

e. Instruct the field team to avoid discussing project data with the public and to refer questions to the TVA Outreach Center.

3.2 Falling and Rising Head Slug Test Procedures

A slug test involves the instantaneous injection or withdrawal of a volume or slug of water or solid cylinder. This is accomplished by displacing a known volume of water from a well and measuring the artificial fluctuation of the groundwater level.

This procedure is followed for conducting both a falling-head (slug lowered into a well) and a rising-head (slug removed from the well) slug test. Several steps can be completed before field operations as defined below.

3.2.1 Pre-Field Preparation

a. Review the well construction records for the well specifically focusing on total depth of the well, well diameter, and screen position and length.

b. Connect water-level transducer to the appropriate programmed computer.

c. Synchronize the computer and transducer clocks. Check the battery in the transducer to ensure full power supply.

d. Select a logging rate of one reading per second. Set the transducer to start logging data. Record in the field logbook the transducer ID number being used.

3.2.2 Field Operations

a. Open the well and manually measure the depth to water following procedures described in Section 3.2 of the *Groundwater Sampling* SOP (TVA-KIF-SOP-02). Record this information in the field logbook.

b. Lower the transducer down the well and place it at least two feet deeper than the length of the slug. The depth of the transducer should not exceed the maximum design depth for the transducer used.

c. Fasten the transducer data cable or string holding the transducer at the top of the well so it cannot move.

d. Let the transducer equilibrate to the well for at least 15 minutes.

e. Measure the water level again to see if the level has returned to equilibrium after the insertion of the transducer in the water. If it has not, repeat this step in five-minute intervals until equilibrium is reached. Record this information in the field logbook.

f. Lower the slug into the well and place the slug just above the water level.

g. Lower the slug quickly into the water. Record the time that the slug was placed into the water in the field logbook.

h. Monitor the water level until it has recovered to within 90% of the static water level. This portion of the test is now complete.

i. Allow time for the water level to recover to a static condition. Quickly pull the slug out of the water. Record the time that the slug was pulled from the water in the field logbook.

j. Monitor the water level until it has recovered to within 90% of the static water level.

k. Stop transducer from logging data. Download the data file from the transducer and record the file name in the field logbook. The data collected from the transducer should be reviewed in the field to determine if the test should be repeated.

l. Decontaminate both the transducer, water level meter, and slug in accordance with Section 3.5 of this SOP.

3.3 Field Logbook Documentation

Field logbooks are maintained by the Field Team Leader to record daily activities. In addition to the minimum requirements discussed in the *Field Documentation* SOP (TVA-KIF-SOP-06), the field logbooks document those activities specific to this SOP and as defined in the applicable project work control documents.

The Field Team Leader and/or designee reviews the field logbook entries on a weekly basis at a minimum (daily review is preferred) for completeness and accuracy and indicates this review by initialing the entries. The Field Team Leader is also responsible for the completion of required data collection forms.

3.4 Data Analyses

A computer software package is used to perform graphical analysis and reporting of the slug test data. The program provides the following slug test analysis methods to be used as appropriate.

- *Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers*, ASTM D 4044-96.
- *Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests),* ASTM D 4104-96.
- *Standard Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)*, ASTM D 5785-95.

3.5 Decontamination and Waste Management

Slug testing equipment is decontaminated in a manner consistent with the *Decontamination of Equipment* SOP (TVA-KIF-SOP-08). Decontamination procedures are documented in the field logbook. Investigation-derived wastes produced during decontamination are managed in accordance with *Management of Investigation-Derived Waste* SOP (TVA-KIF-SOP-12).

4.0 REFERENCES

- American Society for Testing and Materials (ASTM). *Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers*, D 4044-96, 2002.
- ASTM. *Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests),* D 4104-96. 2004.
- ASTM. *Standard Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)*, D 5785-95. 2000.
- Bouwer, H. and R.C. Rice. *A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells*, Water Resources Research, Vol. 12, No. 3, pp. 423-428, 1976.
- Cooper, H.H., J.D. Bredehoeft and I.S. Papadopulos. *Response of a finite-diameter well to an instantaneous charge of water*. Water Resources Research, Vol. 3, pp. 263-269, 1969.
- Hvorslev, M.J. *Time Lag and Soil Permeability in Ground-Water Observations*, Bulletin No 36, Waterways Experiment Station corps of Engineers, US. Army, Vicksburg Mississippi, pp. 1-50, 1951
- Tennessee Valley Authority (TVA). *Decontamination of Equipment* SOP (TVA-KIF-SOP-08). 2010.
- TVA. *Field Documentation* SOP (TVA-KIF-SOP-06). 2009.
- TVA. *Groundwater Sampling* SOP (TVA-KIF-SOP-02). 2009.
- TVA. *Management of Investigation-Derived Waste* SOP (TVA-KIF-SOP-12), 2010.
- TVA. *Quality Assurance Project Plan for the Tennessee Valley Authority Kingston Ash Recovery Project* (TVA-KIF-QAPP), December 18, 2009.
- TVA. *Site-Wide Safety and Health Plan for the TVA Kingston Fossil Plant Ash Release Response* (SWSHP), Jacobs, 2010.
- U.S. Environmental Protection Agency (EPA), Environmental Response Team. *Slug Tests*. Standard Operating Procedure No. 2046, October 1994.

Table 1: Suggested Slug Testing Equipment & Material Checklist	
Item Description	**Check**
Health & Safety	
Nitrile gloves	
Hard hat	
Steel-toed boots	
Hearing protection	
Field first-aid kit	
Eyewash	
Safety glasses	
Respirator and cartridges (if necessary)	
Saranex™/Tyvek® suits and booties (if necessary)	
Paperwork	
Health and Safety Plan	
Project work control documents	
Well construction data and location map	
Field logbook	
Measuring Equipment	
Electronic water-level indicator capable of detecting non-aqueous phase liquid	
Photoionization detector	
Sampling Equipment	
Monitoring well keys	
Tools for well access (for example, socket set, wrench, screw driver, T-wrench)	
Water Pressure Transducer	
Laptop computer to program transducer	
Solid Slug or Bailer	
Stopwatch and/or clock	
Decontamination and Waste Management Equipment (see TVA-KIF-SOP-08)	

End of Procedure