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**DIRECT IMAGE  
ELECTRICAL SOIL CONDUCTIVITY  
SYSTEM AND PROBING PROCEDURES**

**FIELD PROCEDURES MANUAL**

## **TABLE OF CONTENTS**

Introduction

Background

Equipment

Calibration

Field Methods and Applications

Decontamination Procedures

# **DIRECT IMAGE ELECTRICAL SOIL CONDUCTIVITY SYSTEM AND PROBING PROCEDURES**

## **Introduction**

Electrical soil conductivity logging employed with the use of direct push technology has proven to be a valuable tool when evaluating subsurface geophysical characteristics. The electrical conductivity system provides not only valuable information concerning the subsurface soil characteristics (soil lithologies, bedrock surfaces, etc.), but also provides a more cost effective, less time consuming alternative to performing environmental subsurface investigations. The following sections address the electrical soil conductivity equipment as well as its various applications within the environmental industry.

## **Background**

Electrical resistivity tools have been used quite extensively in the past to perform subsurface geophysical logging to aid in both water well and oil field development. Electrical conductivity (the inverse of resistivity) has been used by agricultural scientists to measure soil salinity during various subsurface investigations.

With the increased use of direct push technology to aid in the cost-effective and less time-consuming approach to conducting subsurface environmental investigations, a demand for an electrical logging system within the environmental industry was greatly needed. The electrical soil conductivity tool was designed and engineered in conjunction with other direct push techniques to aid in performing environmental site assessments such as soil gas, soil, and groundwater investigations.

## **Equipment**

The electrical soil conductivity system consists of five main components. These components include the electrical conductivity probe, the instrumentation, the software, a stringpot, and a direct push probing machine.

The electrical conductivity (EC) probe consists of a steel shaft running through four stainless steel contact rings separated by an engineering-grade plastic. The plastic isolates the rings and the shaft from one another. The rings are connected to a cable which in turn is connected to a wireline that is pre-strung through the entire string of probe rods and connected to a data gathering system. The EC probe is threaded onto the leading probe rod.

The instrumentation consists of a data gathering system in conjunction with a PC notebook computer. The data gathering system is connected to the EC probe utilizing the

wireline. This wireline carries the signal from the EC probe to the data gathering system. The data gathering system allows the user to "test" the EC probe, select the appropriate array, and monitor the real-time data received from the probe on the PC computer.

Two separate arrays are utilized to send the electrical current from the EC probe through the wireline and into the data gathering system. The two arrays are the Schlumberger Array and the Dipole Array. The Schlumberger Array sends an electrical current through the top and bottom contact rings of the EC probe and then is measured by the two middle contact rings. This array yields good vertical resolution in a majority of the subsurface lithological environments encountered. The dipole array utilizes only two contacts of the EC probe. The electrical current within this array is sent through one contact and received through the other. This array creates a narrower field and can be selected if sharper resolution is needed. In certain subsurface environments such as narrow soil "stringers" or impenetrable formations (bedrock), this array may be more effective when identifying the differing lithologies. Although each array may provide information concerning a certain subsurface environment, they both have proven to be extremely effective in determining most soil types encountered within the midwestern U.S.

The PC based software allows access to the most valuable aspect of the conductivity tool, the real time data. While probing is being conducted, the PC displays the soil's electrical conductivity, the probe depth, and the rate of speed in which the probe rods are advancing through the underlying strata. This real time data enables the user to identify and determine within the field, potential contaminant migration pathways, sample intervals, and depths to bedrock. With this valuable real time data, sampling depths may be quickly determined, thus eliminating the need for lengthy consultations and costly return trips to the field.

The stringpot's function is to measure the vertical movement of the probing machine while the EC probe is being advanced downhole. These measurements are sent to the data gathering system (PC) which records the amount of movement and calculates the actual depth of the EC probe in conjunction with the rate of speed in which the probes are being advanced. The stringpot is mounted to the top of the probe unit, while the string itself is connected to the base of the probe unit.

Advancement of the EC probe is conducted utilizing the direct push probing machine. The EC probe, attached to the leading probe rod, is hydraulically advanced into the subsurface utilizing 1" or 1.25" threaded steel probe rods. The probing machine is equipped with percussion if stronger driving forces are needed.

## Calibration

Prior to arrival on a job site, it is desirable to make sure the EC system is operating properly. Several steps are followed at the beginning of each project to determine if the conductivity system is in calibration. Steps 1 thru 9 are the procedures as follows:

- Step 1)** Run conductivity software selecting "Probe Test and Log".
- Step 2)** Check the calibration values (C1-C4 on instrument panel) in the continuity test but skip the isolation test.
- Step 3)** Give it a "dummy" file name and tab to "OK" and hit "Return."
- Step 4)** Select the Wenner Array in the software (SC-200 W).
- Step 5)** Switch the "Function" switch to "Continuity" and the Continuity/Calibration" switch to C1.
- Step 6)** With the hammer in the upward position, turn the trigger ON and simulate the probing activity. At this point the probe should be lowered as the log begins to show on the computer screen. For C1 the conductivity reading should be 43mS/m.
- Step 7)** After the motion of driving one rod, switch the "Continuity/Calibration" switch to C2 and continue. The value of continuity for C@ will change to 17mS/m.
- Step 8)** Repeat this sequence for C3 and C4, leaving the trigger switch ON the entire time. The conductivity value for C3 is 3mS/m and for C4 is 2mS/m.
- Step 9)** When finished, turn the trigger OFF and press "F5" to stop.

Once it has been determined that the EC system is in calibration, the conductivity probe is placed into a test jig. The test jig is utilized to determine whether the contact rings within the conductivity probe are working properly. Once the test jig has determined that the contact rings are working properly, the EC system is ready for operation. The test jig is utilized prior to probing each testhole to determine the condition of the conductivity probe.

When questions arise as to the validity of the conductivity data or when local lithologic logs are not available to determine soil types, then physical soil samples are collected by vertically profiling the soil column directly adjacent to the conductivity testhole. Soil samples may then be compared and correlated to the conductivity logs. One other method of calibration to determine the instrument's repeatability capabilities is to perform 2 or 3 conductivity probes within a few feet of one another. The EC logs may then be overlain onto one another and a comparison made.

## Field Methods and Applications

Field methods focus on the ability of the EC probe to define potential pathways for the migration of contaminants within the subsurface. The EC logs are used to determine the contacts between differing lithologies, to identify areas of low or high conductivity (high/low permeability) within the soil and underlying groundwater, and to define bedrock surfaces. The real time data that the EC logs provide allows the consultant to determine sampling depths, monitoring and recovery well locations and screen intervals quickly while in the field.

Contacts between lithologies can often be difficult to distinguish when utilizing conventional subsurface soil sampling techniques, such as continuous or split spoon sampling during drilling, probing, and/or augering. This is especially true when the soils are continuously sampled below the groundwater table surface. Usually when drilling and augering below the water table surface, the subsurface soils can be disturbed or displaced in such a manner that distinct contacts cannot be accurately defined. Heaving sands, borehole slough, and sample recovery problems are all examples encountered when soil sampling below the water table surface. Fortunately, the EC probe provides a detailed log illustrating the gradual and sharp lithologic changes with minimal disturbance to the subsurface, thus eliminating the aforementioned problems that do exist with conventional sampling.

By identifying areas of low or high conductivity, the consultant may determine potential migration pathways, bedrock depths, and sample intervals. The ability of the EC system to define these lithologic areas of concern enables the consultant to make quick decisions while in the field. The consultant not only receives hydrogeologic information about the subsurface, but also may correlate differing lithologies between existing borehole locations. With this information, the consultant may optimize the placement of soil gas, soil, and/or groundwater sampling locations as well as pinpoint locations for future monitoring and/or recovery wells.

Electrical conductivity may also be useful when determining bedrock depths. Bedrock conductivities show sharp contrasts to the overlying soils, and can be easily identified. Depth to bedrock is extremely useful when dealing with DNAPL's or "sinking" contaminants. The chlorinated solvents (sinkers) are heavier than water and will eventually migrate (if enough contamination is present) to the bottom of the aquifer, usually upon a bedrock surface. As the contaminants migrate down within the water table, they usually tend to migrate towards areas of least resistance until they have reached a confining layer below. During the migration process, the contaminants will travel at higher rates of speed through more porous soils (i.e. gravel or sand lenses), and much slower rates when traveling through less porous soils (i.e. clay and till). Once the "sinkers" have reached the bedrock surface, they migrate laterally down-gradient following the undulating surface. The EC logs can be utilized to create bedrock contour maps in areas where bedrock is known to have extensive undulating or dipping surfaces, thus providing

information as to the most obvious contaminant migration pathways or soil zones of least resistance.

Accurate sampling depths, well placement, screen depths, and screen lengths may be difficult and costly to determine when utilizing data gathered from soil samples collected below the water table, especially when the decisions must be determined while in the field. The ability of the soil electrical conductivity system to visually identify soil lithology changes, areas of low/high conductivity within the soil, and bedrock surfaces prior to commencing drilling activities is an obvious cost-effective solution and advantage when conducting environmental investigations.

#### Decontamination Procedures

Prior to commencing field probing and between all EC probes, all probe rods, wirelines and EC probes are thoroughly washed utilizing a high-pressure, high temperature power washer. This procedure is followed prior to probing each EC testhole. All decon fluids are self-contained within holding tanks within our mobile decon trailer. Our decon unit includes a 5' x 10' trailer equipped with a generator, a high temperature-high pressure power washer (Hotsi), a water tank, probe rod wash racks and containment tanks.