Assessing aquifers

Core drilling: an essential approach to understanding aquifers

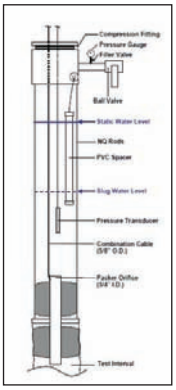
A UDR core rig used to collect continuous cores for the first phase of ROMP monitoring

Water… everyone knows it's a necessity for life, and that water supplies will be of the utmost importance today and in the future. Yet many do not know how water is supplied to their homes or businesses.

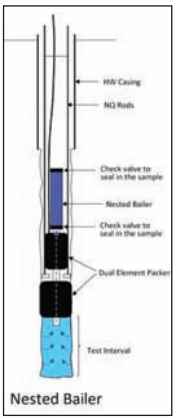
Some may know that drinking water is treated and distributed from surface water, which can be seen in large reservoirs or flowing down a mountainside. But what about drinking water pumped from underground aquifers? You cannot see aquifers or swim in them on a Sunday afternoon. So how do scientists study them?

The key lies in wells drilled deep below the land surface. Scientists use the data collected from these wells to study how much water can be withdrawn from the aquifer without depleting it or causing impacts to the quality of these groundwater resources. A comprehensive understanding of the aquifer systems is a must, and core drilling and testing prior to the design and installation of these wells are essential.

Florida's five water management districts



Slug test design



Nested bailer for water-quality sampling

WATER-MANAGEMENT DISTRICTS

Five water-management districts in Florida, US oversee water withdrawals from aquifers in the state. The Southwest Florida Water Management District, a 16-county state agency headquartered in Brooksville, has had an extensive groundwater investigation and monitoring programme since the 1970s. Due to the foresight of this district, there is now a long record of groundwater data available to help scientists study water-related issues and plan for the future demands of these resources.

In 1974, the district created the Regional Observation Monitor-well Program (ROMP) to explore the hydrogeology below the surface and install wells within the aquifers for long-term monitoring of groundwater levels and quality. Monitor-well sites are located within a 10-mile (16km) grid network to obtain data on a regional basis throughout the district (inland monitoring network) and along transects perpendicular to the coastline for assessing saltwater intrusion (coastal monitoring network).

Since then, the programme has expanded to include the installation of wells at project-specific locations for targeted refinement of hydrogeologic data. More than 200 ROMP sites and 250 project-support sites have been constructed throughout the district.

The ultimate goal of this programme is to develop hydraulic and water-quality profiles for all aquifers and confining units needed for regional mapping, modelling and long-term aquifer monitoring.

The relationship between lithostratigraphic (rock) and hydrostratigraphic (water-bearing) units is complex and requires advanced drilling and hydrogeologic expertise to accurately characterise the groundwater flow system.

The Geohydrologic Data Section at the district oversees this programme and characterises the hydrogeology of a site in three phases.

I: EXPLORATORY CORING/TESTING

The first phase in determining the hydrogeology of the site is exploratory coring and testing. This is the most extensive phase and includes collecting lithologic, water-level, water-quality and geophysical-logging data, as well as determining aquifer properties.

During this phase, continuous cores are collected utilising a Universal Drilling Rig (UDR) 200D LS to the desired depth (a maximum of 3,000ft [914.4m] below surface). This is a hydraulic rotary core rig that uses a continuous wireline recovery system to collect core samples by direct-circulation rotary methods. Fresh water is used as the drilling fluid during coring and reverse air circulation is used to remove cuttings every 20ft. The inner barrel assembly allows a 1.99in (5.1cm) diameter by 10ft section of core to be retrieved from within the drill or core rods by wireline hoist; the core rods do not have to be removed from the core hole.

Lithologic samples

The cores provide a representative lithologic sample of the rock making up the aquifer, compared with conventional drill cuttings, which are lithologic samples that have been crushed by the drill bit. Therefore, the continuous collection of core samples results in a more accurate description of the aquifer. On retrieval, the lithologic samples are examined and logged by a site geologist who describes the lithology, takes photographs and places the samples in core boxes that are shipped to the Florida Geological Survey for further evaluation and long-term storage once the project is completed.

Testing with packers

As the core hole is advanced, aquifer slug testing and water-quality testing are also conducted using off-bottom formation packers. This provides the geologist with hydraulic characteristics at intervals within the aquifers and confining units, as well as water quality. The packer is lowered and inflated with nitrogen. This allows for discrete testing of a particular interval from the packer to the bottom of the core hole and is repeated at several depths. ►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Core barrel

Slug testing

Slug testing is performed using the pneumatic-slug method or the drop-slug method, depending on aquifer formation properties. Moderate to high hydraulic conductivity formations require the pneumatic-slug method due to the need for instantaneous slug initiation. This is performed by using air pressure to depress the static water level within the packer interval. The air pressure is then released and the change in water level is recorded as it rises and reaches equilibrium with the static water level (rising-head test).

For low hydraulic conductivity formations, the drop-slug method is conducted. A cylinder equipped with a valve is used to insert a predetermined amount of water into the core rods. When the valve is opened, the slug of water drops into the core rods, causing the static water level to abruptly rise and subsequently fall. Data are collected as the water level drops back to static level (falling-head test). Slug tests are used to determine estimates of near-borehole permeability only during the exploratory phase. Final aquifer hydraulics are determined after the wells are installed and aquifer performance testing is conducted.

Water-quality testing

Water-quality testing is also performed using the off-bottom packer to collect samples from discrete intervals. The samples are collected with a nested bailer in the core hole after purging multiple volumes of water using reverse air circulation. The samples collected are field tested for temperature, pH, conductivity, chlorides and sulphate.

At intervals determined to be significant, samples are also sent to the district's laboratory and analysed for a suite of major ions and trace metals including: chloride, alkalinity, total dissolved solids, sulphate, silica, pH, specific conductance, calcium, iron, magnesium, potassium, sodium and strontium.

II: WELL CONSTRUCTION

Wells are installed by a drilling contractor with oversight from district personnel. Drilling methods used vary from mud rotary to reverse air. The number of wells to be installed and target depths for each well are determined by geologists and drilling staff from the exploratory data results. Geophysical and video logging are also performed before and after completion of the wells to confirm formation picks and aquifer characteristics, as well as to verify that the wells are constructed to specifications.

III: AQUIFER PERFORMANCE TEST

First, background water levels are collected from the monitor wells for a week to determine the regional groundwater trend. Then, one well is pumped and another is observed during and after pumping. Water-level data collected during pumping and recovery are recorded. These tests typically involve multiple adjacent wells and provide more comprehensive hydraulic parameters of the aquifer.

Following field activities, the data are analysed with software and presented in reports.

The data provide scientists the means to bring aquifers to life in visual depictions of the current state of the groundwater systems. These data are the foundation for groundwater assessments within the district and will be needed for future analyses and planning as population and subsequent demands for groundwater increase. Therefore, continued accurate and defensible data is needed in the future, and core drilling and testing is the essential first step in meeting this need.

Core sample

This article was written by Sandie Will, PG, who is the manager of the Geohydrologic Data Section at the Southwest Florida Water Management District in Brooksville, Florida, US. She would like to thank George DeGroot, Ted Gates, PG, and Jason LaRoche, PG, for their contributions towards this article