Appendix L: Borehole Drilling

Introduction

Boreholes, also known as tubewells, refer to narrow shafts that are drilled deep into the ground. Typically, boreholes used for water extraction penetrate underground aquifers ranging anywhere from 30 to 250 feet deep. There are several different ways to drill a borehole, including rotary drilling, cable tool drilling, and auger drilling. Rotary drilling, which requires a drilling rig, is the most common method. Rotary drilling offers several advantages over other drilling methods, including relatively high penetration rates, minimal casing requirements during drilling, and rapid rig mobilization and demobilization.

Rotary Drilling

Using the rotary drilling method, a drilling rig is used to power the rotation and penetration of a drill bit, which is attached to the lower end of a string of drill pipes. Depending on the subsurface formations encountered during drilling, different drill bit types are employed. In soft formations, it is common for temporary casing to be inserted during drilling to support the bore walls. As drilling proceeds, fluid is pumped down through the drill pipe and out through the ports in the drill bit. The fluid then flows upward in the annular space between the hole and the drill pipe, carrying the cuttings and suspension to the surface. Depending on the soil formation encountered, different types of rotary drilling are used. The two types are differentiated by the circulation fluid that is used to flush cuttings to the surface.

> ***(1) Air rotary drilling*** - Air rotary drilling uses air as its circulation material. Using a large compressor, air is forced down into the pipe. Moving from high to low pressure, the air then flows to the surface of the hole, carrying drill cuttings with it. Using air as a circulation fluid is easier than using water, but it has some disadvantages. For example, in soft formations, high air pressure can cause bore walls to erode, causing wall failure.
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> ***(2) Mud rotary drilling*** - Mud rotary drilling uses water as its circulation material. Using a mud pump, water is pumped into the borehole to remove cuttings. When the water mixes with the cuttings, it often becomes muddy, hence the name. Mud rotary drilling is more difficult than air rotary drilling because it requires a supply of water for circulation. It does, however, offer several advantages, including protecting against wall erosion.

Inserting Casing

After drilling is complete, permanent casing must be inserted to prevent the well walls from collapsing. Casing a well involves running pipe down the inside of the bore. In addition preventing the walls from caving in, casing protects the water column from outside contamination. In the water bearing layers of the formation, screens are inserted to simultaneously support the walls and allow water to enter the column. Typically, screens are created by cutting a series of slots into regular borehole casing. In Uganda, it is common for PVC pipe with 5 inch diameter to be used as casing.

Filling the Annular Space

After the casing is inserted, the annular space (the small space between the casing and the sides of the well) must be filled. In the water bearing layers, gravel is poured into the annular space. This gravel pack is permeable to water but protects the well screen from becoming obstructed by small particles, such as silt. Above the gravel pack, a cement seal is added. The remaining annular space is backfilled with cuttings from the borehole. Atop the backfill, a sanitary seal is added to prevent surface contamination.

Supplementary Steps

After the annular space is filled, the primary drilling processes are complete. Before the drilling team leaves the site, they will complete test pumping (Appendix I) to determine an appropriate cylinder depth and estimate well yield. Following drilling, the ground must be given approximately one week to dry and settle before the installation can proceed. After the required wait time, the pedestal is installed. Approximately one day later, the borehole apron and run-off channel are constructed using concrete, brick, and hard core. A wooden fence is erected around the apron and run-off channel to protect the borehole. At the end of the run-off channel, a soak pit is dug to prevent stagnant water from accumulating. After the apron is constructed, a two-week wait time is required to ensure the cement has reached maximum compressive strength. After two weeks, hand pump installation can proceed (Appendix H).