WELL DEVELOPMENT AND TESTING

Dr. MARK KING

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THE VILLAGE DRILL

Well development, testing & finalization

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WELL DEVELOPMENT AND TESTING

- WELL DEVELOPMENT
- After drilling some of the *fines* and *drilling fluid additives* remain behind in the borehole and are blocking the pores of the surrounding aquifer and the newly-installed gravel pack.
- 'Well development' is necessary to maximize the yield of the well and optimize the filter capacity of the gravel pack. This is achieved by *removing the fines* and *drilling fluid additives,* and *settlement* of the gravel pack.

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WELL DEVELOPMENT AND TESTING

- After well development, water should be able to move freely from the aquifer into the well.

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WELL DEVELOPMENT AND TESTING

- Some well development has already started during the flushing that was conducted at the end of the drilling process.
- However, more extensive development should be carried out after completing the installation process.
- The remainder of well development takes place after the backfill has been placed and the the sanitary seal has hardened (may takes at least 24 hours for cement grout).

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WELL DEVELOPMENT AND TESTING

- Several techniques are available for well development and sometimes a combination of these techniques is used to get the best development results.
- Useful techniques are:
  - Surge block or plunger
  - Discontinuous pumping (start-stop cycle pumping)
  - Continuous pumping with large flows
- It is preferable to use an external pump, to save wear on the final pump

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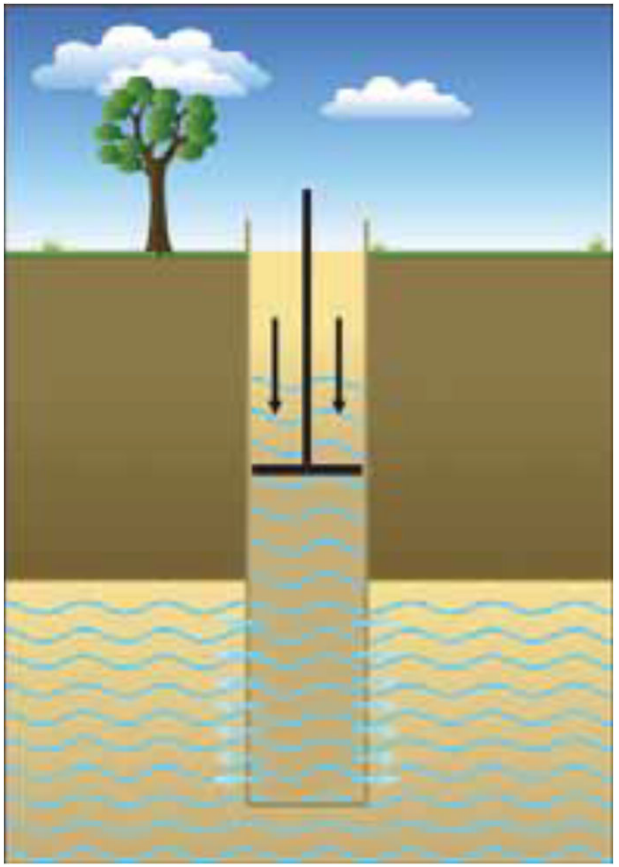
WELL DEVELOPMENT AND TESTING

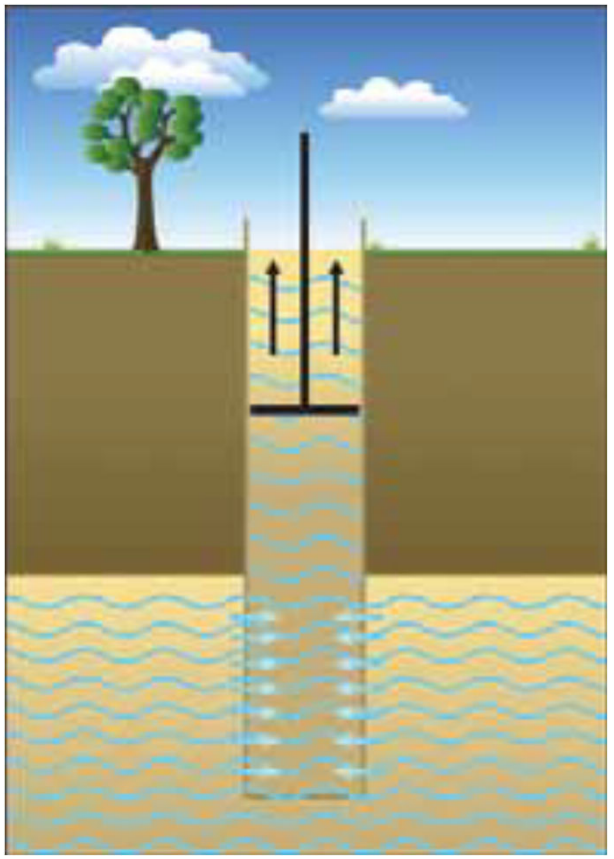
Surge block or plunger

- A surge block or plunger is intended to induce flow into the gravel pack and formation, as water rushes around the block
- In this way, fines and drilling fluid additives are washed loose and enter the well, where they can be removed by pumping



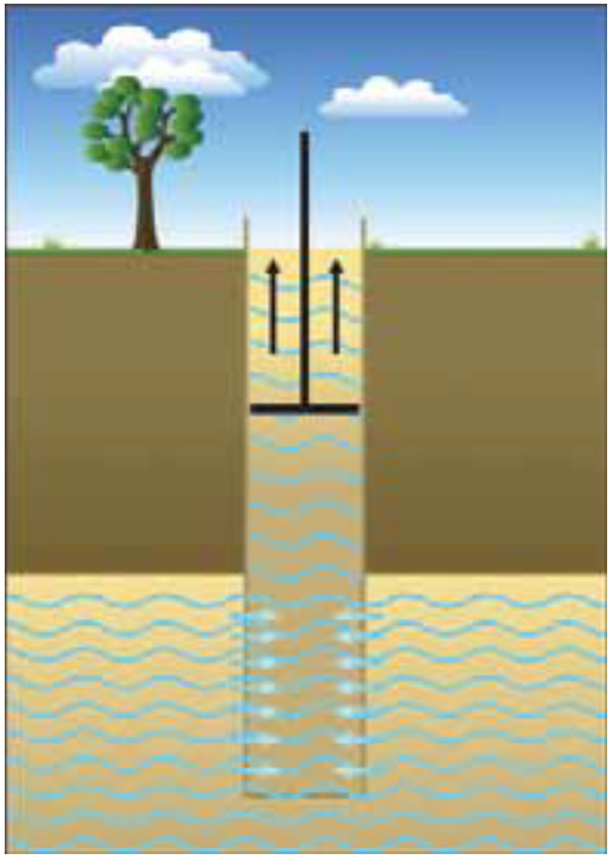
WELL DEVELOPMENT AND TESTING

- Then the water containing the fines is pumped out. A surge block consists of a set of weighted wooden discs with rubber flaps or alternatively a flexible flat seal (for example, made of a thick rubber sheet).
- A surge block closely fits in the PVC casing and is operated as a plunger.
- By moving the surge block up and down, water is forced into and out of the aquifer (shock waves), washing the aquifer and gravel pack, and mobilizing the fines which they contain.



WELL DEVELOPMENT AND TESTING

- The down stroke should be gentle, not forcing the fines and fluid additives further into the aquifer.
- The upstroke should be rapid, with the result that fines and fluid additives end up in the PVC well casing, which then can be cleaned by pumping.



WELL DEVELOPMENT AND TESTING

Discontinuous pumping (start-stop cycle pumping)

- A pump (or pump intake) can be lowered to the bottom of the well to remove the loosened fines and clean the sump.
- Once the water becomes clear, the surge block may be used again.
- This process is repeated until the water clears.
- Discontinuous (start-stop) pumping is then carried out by running the pump run at a high rate (higher than the expected long term pumping rate of the well) for 5 minutes and then shutting off for 2 minutes.

WELL DEVELOPMENT AND TESTING

- When an electrical pump is used for development, it is advised to pump at least 2-3 times the design discharge for 5 minute intervals (or until the well runs dry).
- When a hand pump is used, the goal is to create a maximum flow rate, until the water is clear.
- Some countries have specific development requirements, as summarized in Practica (2010)

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WELL DEVELOPMENT AND TESTING

Pumps for well development

- The best option for well development is an electric submersible pump
- For this purpose, a submersible pump is now provided with the Village Drill package

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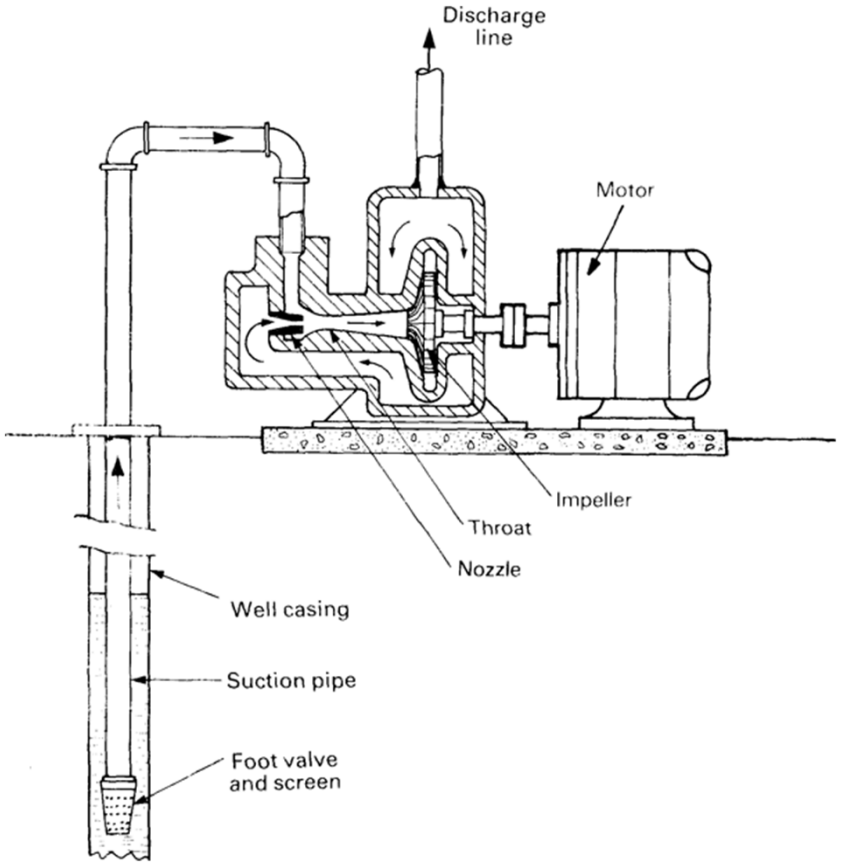
WELL DEVELOPMENT AND TESTING

Pumps for well development

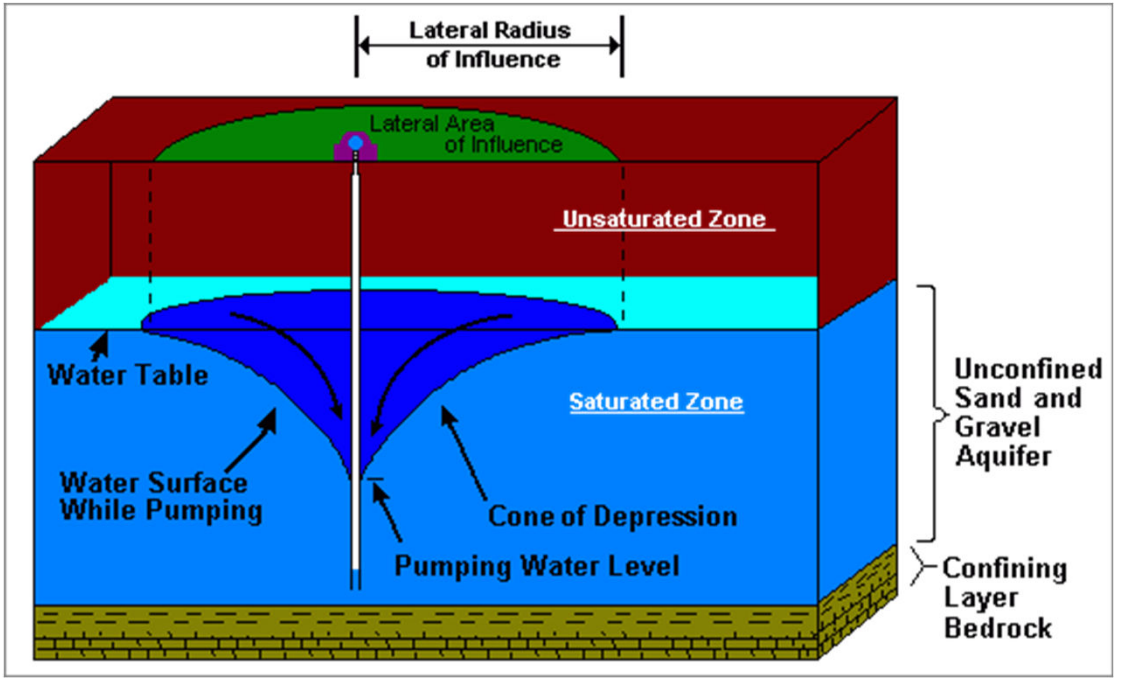
- Motorized centrifugal pumps may be a workable option if the well makes a relatively high yield
- However, since these pumps are based on a suction principle they will only operate if the groundwater depth is less than 7 metres below ground surface.



WELL DEVELOPMENT AND TESTING

PUMPING TEST – WELL YIELD

- When the well has been developed and is free of fines, a short term pump test should be conducted.
- Test pumping gives useful information about both the well and the aquifer.
- In particular it can indicate whether the well yield will be sufficient for its intended purpose.



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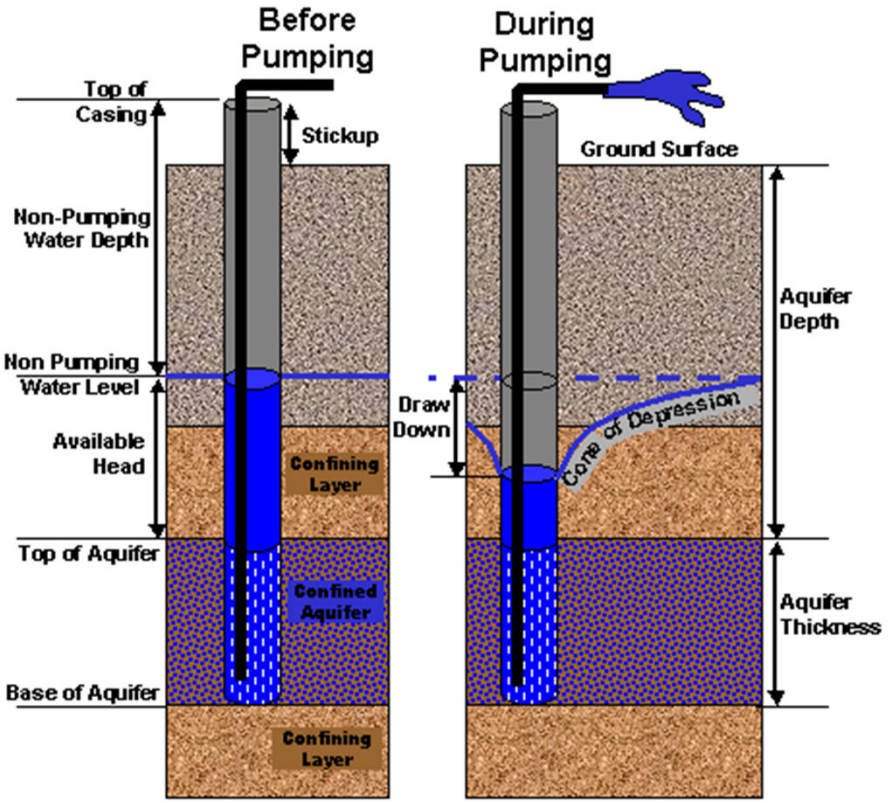
WELL DEVELOPMENT AND TESTING

PUMPING TEST – WELL YIELD

- Reliable pump testing can only be done when the groundwater level has returned to normal after well development. The well should rest for at least 24 hours after development before test pumping is started.



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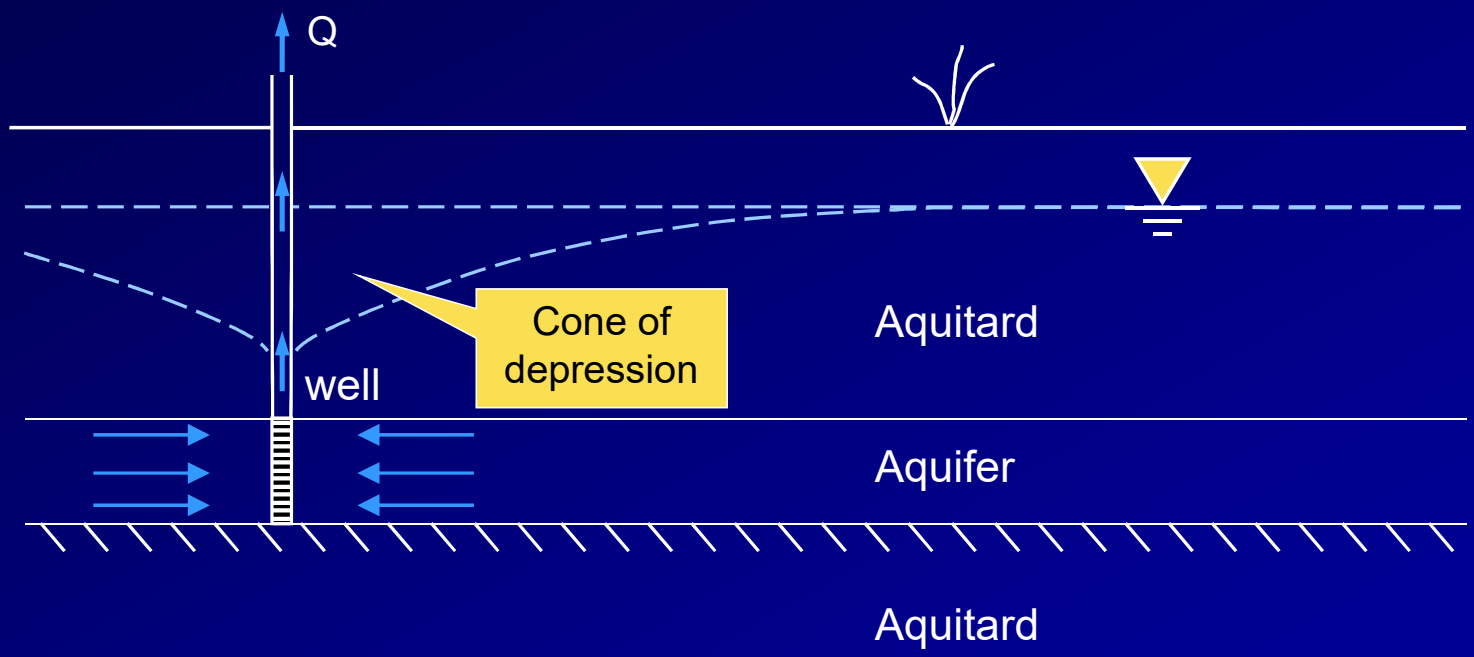
Pumping effects on aquifer head



- Induces drawdown, i.e. reduction of head in the aquifer

WELL DEVELOPMENT AND TESTING

Dip tape

- For a mechanized pumping test, water level can be measured with a (relatively expensive) electrical *dip tape,* which produces an electrical signal when the water level is reached.
- For low cost pumping test with hand operated pumps a simple *measuring tape* or self-made *measuring rope* can be used (next slide)

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WELL DEVELOPMENT AND TESTING

Simple water level measuring rope

- Take a 6 cm long piece of ¾-inch galvanized pipe. Close one end by welding or capping, and attach an eye on the closed end.
- Attach the eye to a rope, which is knotted every metre or every 3 feet.
- Move this tool up and down, as it is lowered in the well. When the pipe touches the water level a ‘popping’ sound will be heard.
- Count the knots to measure the depth.

WELL DEVELOPMENT AND TESTING

- **Yield test with submersible pump**

Step 1

- Before the test, *measure the resting water level* in the well (static level).
- When measuring, use a fixed reference point (possibly the top of the well casing or a point on the pump, depending on what is accessible.

WELL DEVELOPMENT AND TESTING

Yield test

Step 2

- Install the pump with the intake at or near the top of the well screen.
- Pump at a steady, sustainable rate, preferably for four hours
- Re-measure the flow rate (with bucket and stopwatch) and water level every hour 10 minutes

WELL DEVELOPMENT AND TESTING

Yield test

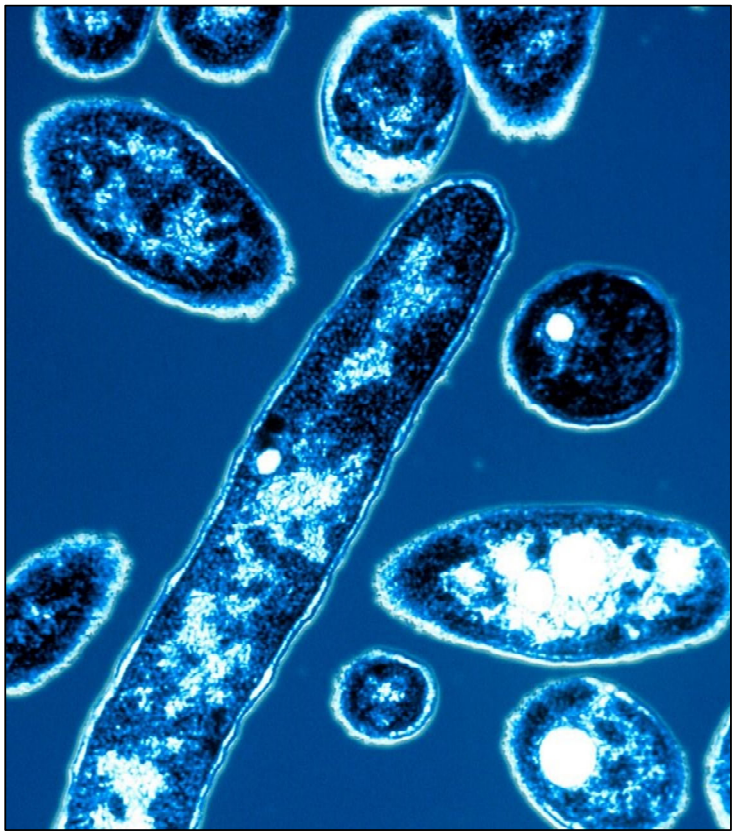
Step 3

- At the end of the pumping period, continue to measure the water level at 10 minute intervals until it returns almost to the static level
- The shorter time it takes to return to the static level, the better the aquifer
- If the well did not run dry during pumping. and the water level returns to static level (measured before the test) within 6-12 hours, then the flow rate should be sufficient for the installation of a permanent hand pump.

WELL DEVELOPMENT AND TESTING

Well disinfection – chlorination

- After development and flow testing of the well, it should be disinfected through chlorination; this will typically be the responsibility of the party that commissioned the well
- The purpose of disinfection is to kill harmful organisms (pathogens) that may have entered the well during construction
- An acceptable approach for chlorination will be locality-specific



WELL DEVELOPMENT AND TESTING

WATER QUALITY TESTING

- After development and chlorination, the well water should be tested to confirm final quality; this will typically be the responsibility of the party that commissioned the well
- Good quality (potable) drinking water is free from pathogens (disease causing bacteria, etc.) and excessive (above the standard) amounts of harmful chemicals.
- The taste and smell should be good and the water should be clear and free of color.

WELL DEVELOPMENT AND TESTING

Initial testing should include a large set of parameters, including:

- 1. **Chemical parameters;** Hardness (calcium, magnesium), pH (acidity), electrical conductivity (to indicate the total salt content), iron, heavy metals (cadmium, lead, etc.) nutrients (nitrogen, phosphorus), artificial threats (pesticides from farms, hydrocarbons from fuel, etc.) and natural chemicals (chloride, sodium, fluoride, arsenic, etc.).
- 2. **Biological parameters;** pathogens (bacteria (E-coli form), viruses (Hepatitis), parasites (worms, Amoeba), etc.) Often E-coli bacteria are analyzed to indicate a faecal contamination (latrines).
- 3. **Physical parameters;** Turbidity, color, odor

WELL DEVELOPMENT AND TESTING

- Detailed water quality analyses must be done by an accredited laboratory
- For more information on country-specific testing requirements, well proponents should refer to the Water Resources Ministry applicable to the well site

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FINALIZATION OF THE WELL

CONCRETE SLAB/APRON

- After pump testing the head works or concrete apron should be installed.
- This apron will prevent surface water and contamination from flowing into the borehole directly.
- The apron also provides a solid and clean base for the hand pump and the collection of water.
- The apron is typically 2-3 metre in diameter with a (small) wall around the outside.

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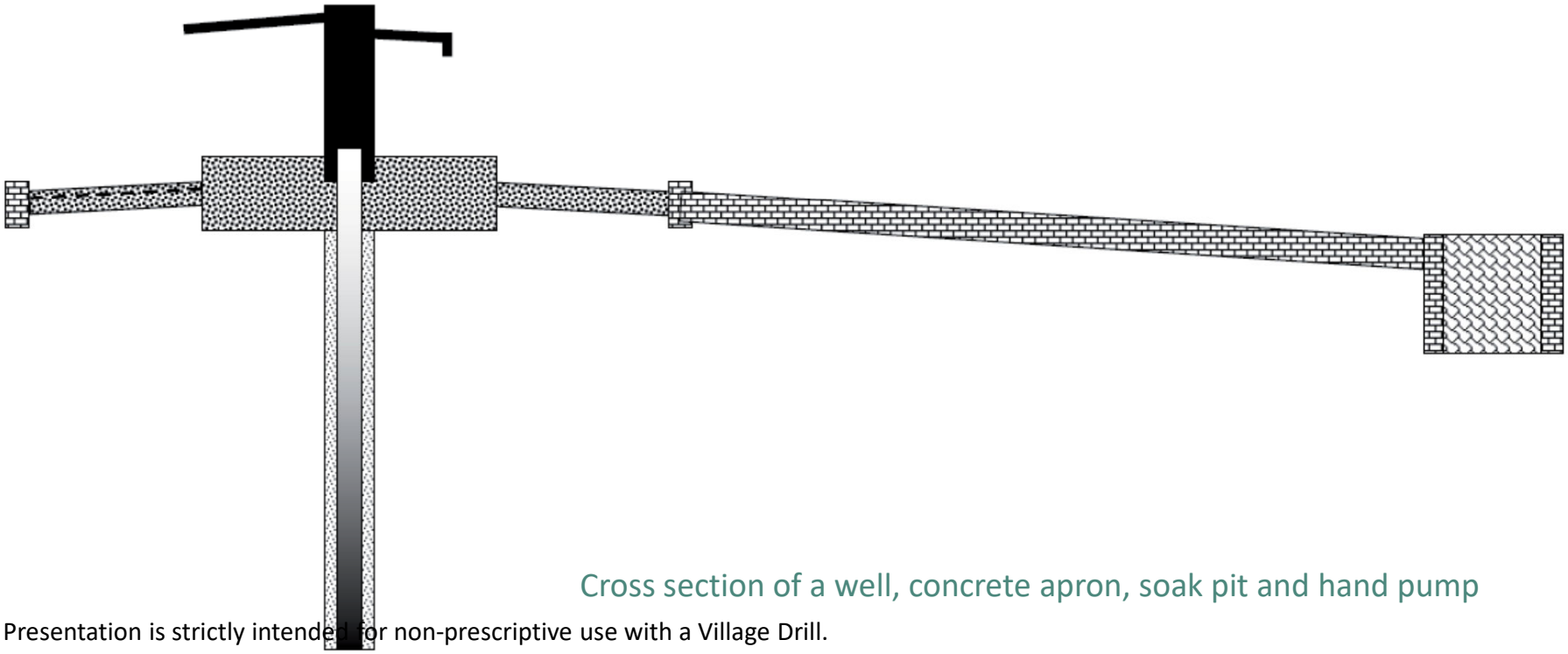
FINALIZATION OF THE WELL

CONCRETE SLAB/APRON

- It is important for hygienic reasons that the apron is free draining and dries up between uses. In this way, sunlight will *disinfect* the apron and limit microbial growth.
- To promote drying, the apron surface should have a gentle slope. A drain (small outlet) should be constructed in the apron, to carry excess water away from the well.
- The drained water should be directed to a soak pit, 4-6 metres away from the well. The soak pit is a simple 1 by 1 by 1 metre pit filled with coarse gravel.

FINALIZATION OF THE WELL

CONCRETE SLAB/APRON



Cross section of a well, concrete apron, soak pit and hand pump

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FINALIZATION OF THE WELL

PUMP CHOICE

- In most cases, Village Drill wells will be completed with hand pumps
- Exceptions could occur in cases where the yield characteristics of the well are extremely good
- There are many types and models of hand pumps
- Critical selection factors include the availability of spare parts, the ease of maintenance, cost, and well depth
- Pumps will generally be selected by the well proponent

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