ILHAM-EC

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Water abstraction works

Prof. Konstantinos Mattas

Dr. Christos Mattas

Training in Italy

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CULTURE

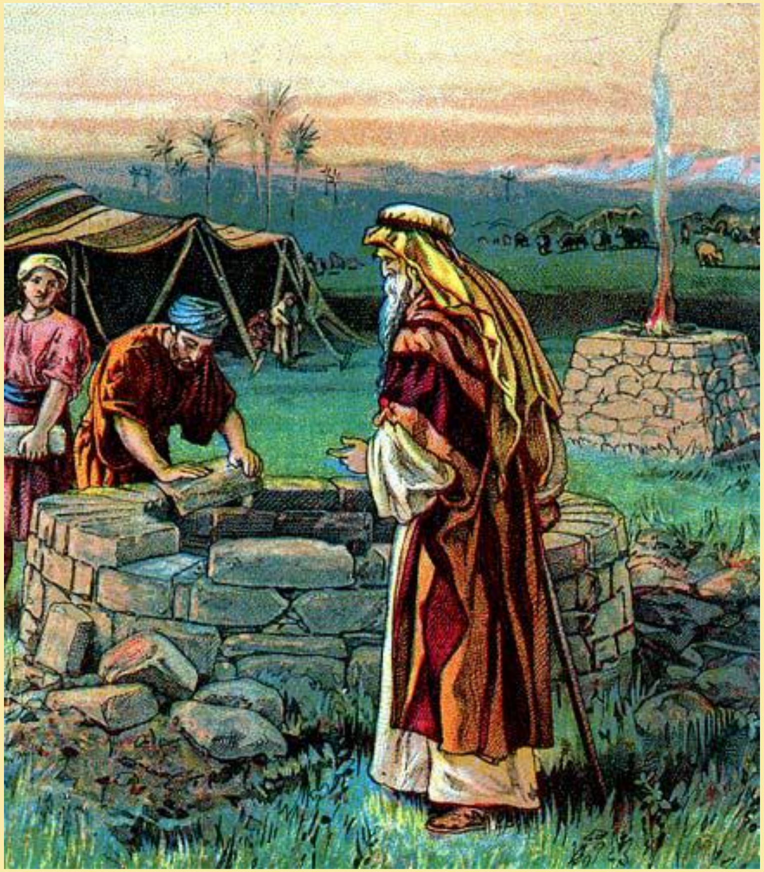

iStock
by Getty Images



WWW.NEWS.CN

https://defence.pk/pdf/threads/near-east-and-indus-river-ancient-pakistan-cradles-of-civilizations-9-000bce.420967/

https://heritageofjapan.wordpress.com/yayoi-era-yields-up-rice/the-advent-of-agriculture-and-the-rice-revolution/
http://www.daviddarling.info/encyclopedia_of_history/R/Rome_early_history.html



http://www.icid.org/res_irrigation.html
https://scotlandablaze.com/2017/04/17/new-podcast-re-dig-the-ancient-wells-andrew-mckie/

WATER ABSTRACTION

Water abstraction is a term that defines the process by which water in its natural environment may be artificially removed through some sort of manmade structure

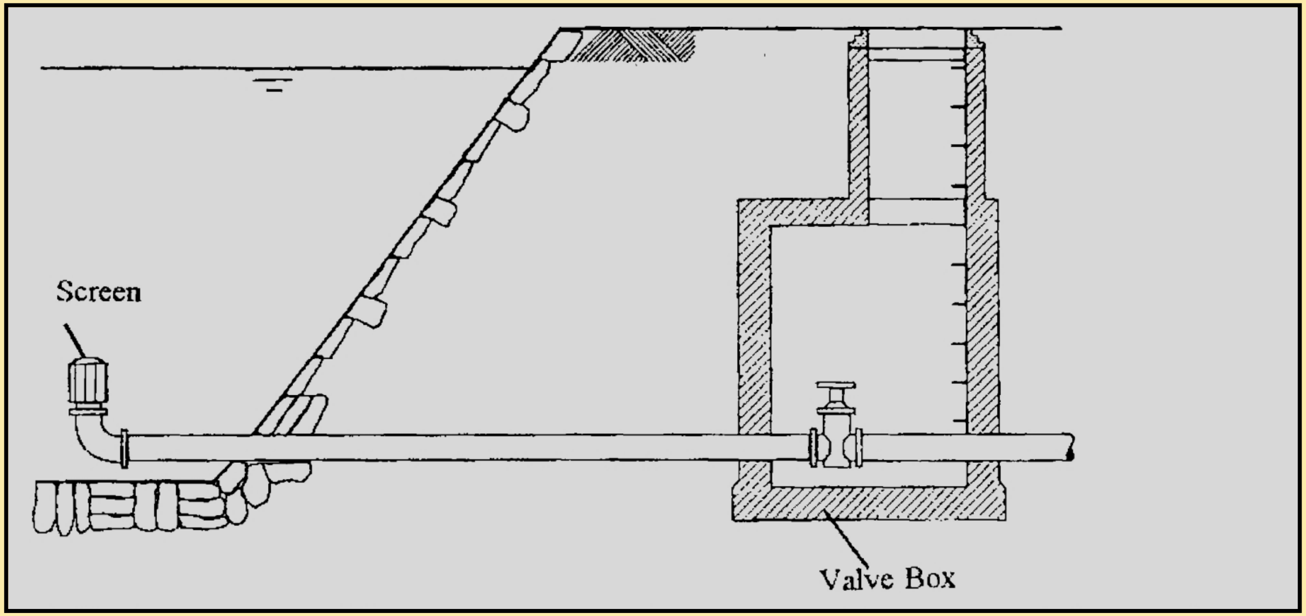
Water abstractions may be taken directly from the flowing waters in the channel (surface water abstraction) or indirectly from wells by pumping water from aquifers that may be closely connected to rivers (groundwater abstraction).

http://wiki.reformrivers.eu/index.php/Surface_water_abstraction
http://www.wisegeek.com/what-is-water-abstraction.htm

TYPES OF WATER ABSTRACTION WORKS

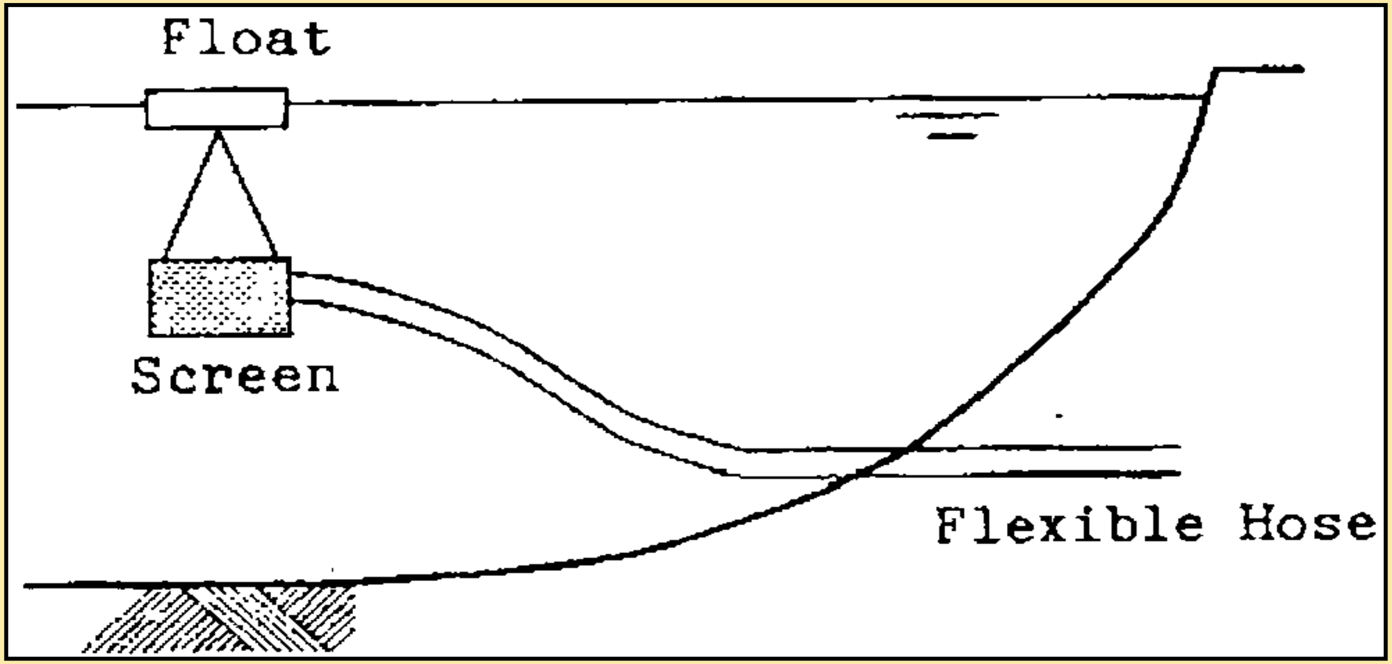
- Point works (boreholes, wells)
- Expanded (dams, trenches, galleries, caissons, combination of galleries with wells etc)

DIRECT ABSTRACTION OF RIVER WATER



- ✓ Direct abstraction usually takes place upstream of permanent human habitation and the water does not require treatment.
- ✓ It is appropriate method for rivers that flow in crystalline rocks and the fine grained suspended material is insignificant
- ✓ In order to achieve permanent water supply during the year a weir might have to be constructed.
- ✓ It is a prerequisite that the flow does not transport boulders or large stones

LAKES



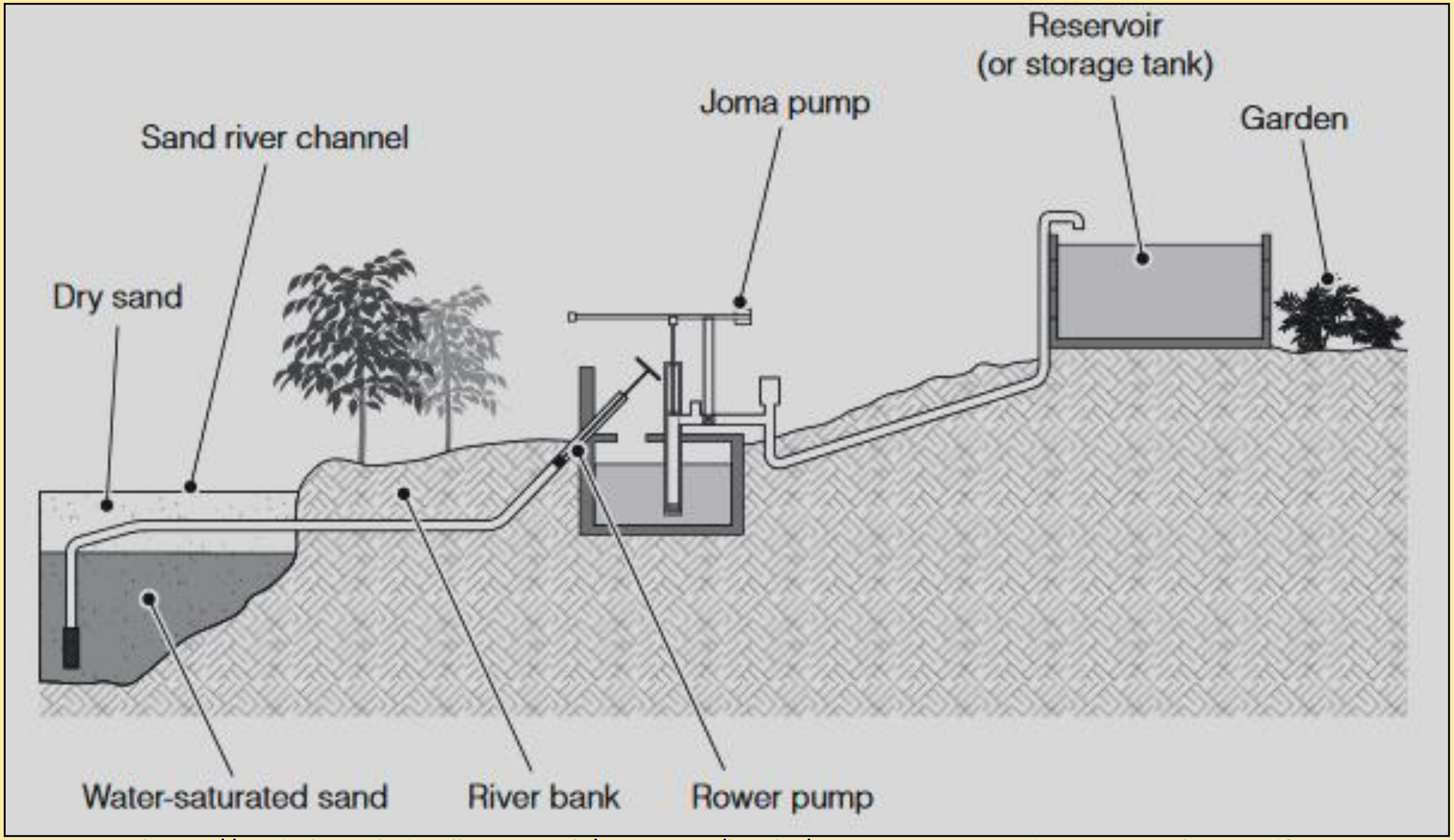
Water abstraction from lakes is of high risk due to the pollution problems that occur.

In deep lakes the intake should be conducted at depths of 3-5m to avoid algal growth that usually occurs at the surface.

In shallow lakes the intake should be placed near the water surface to prevent the entrance of clay/silt material from the bottom of the lake

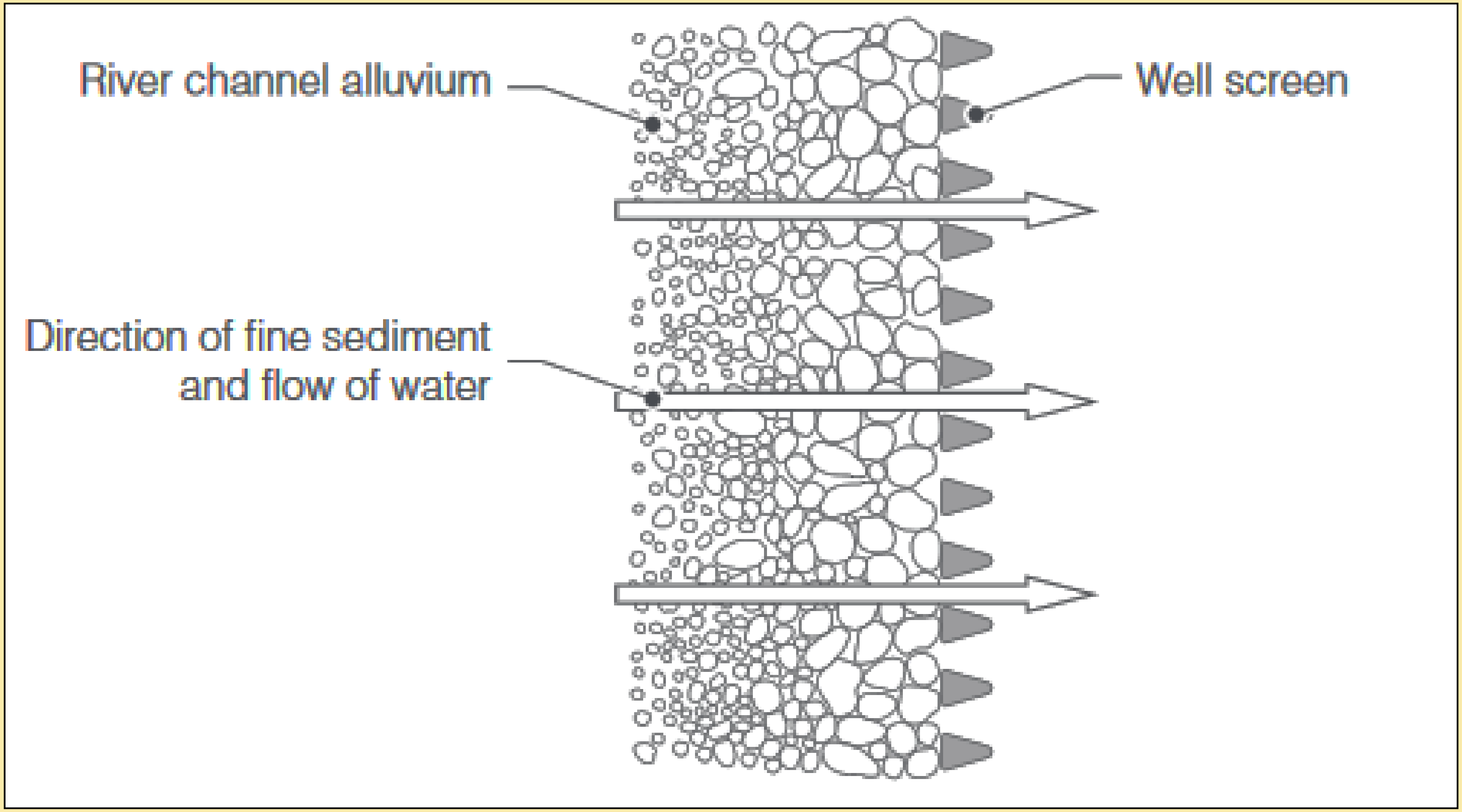
Well-point (water sediment seperation method)

A well-point is a short cylindrical screen installed deep into the sediment in a river channel.
Flow into a well-point is created by a pump that draws water from a sand river channel and pump it to a garden site above.



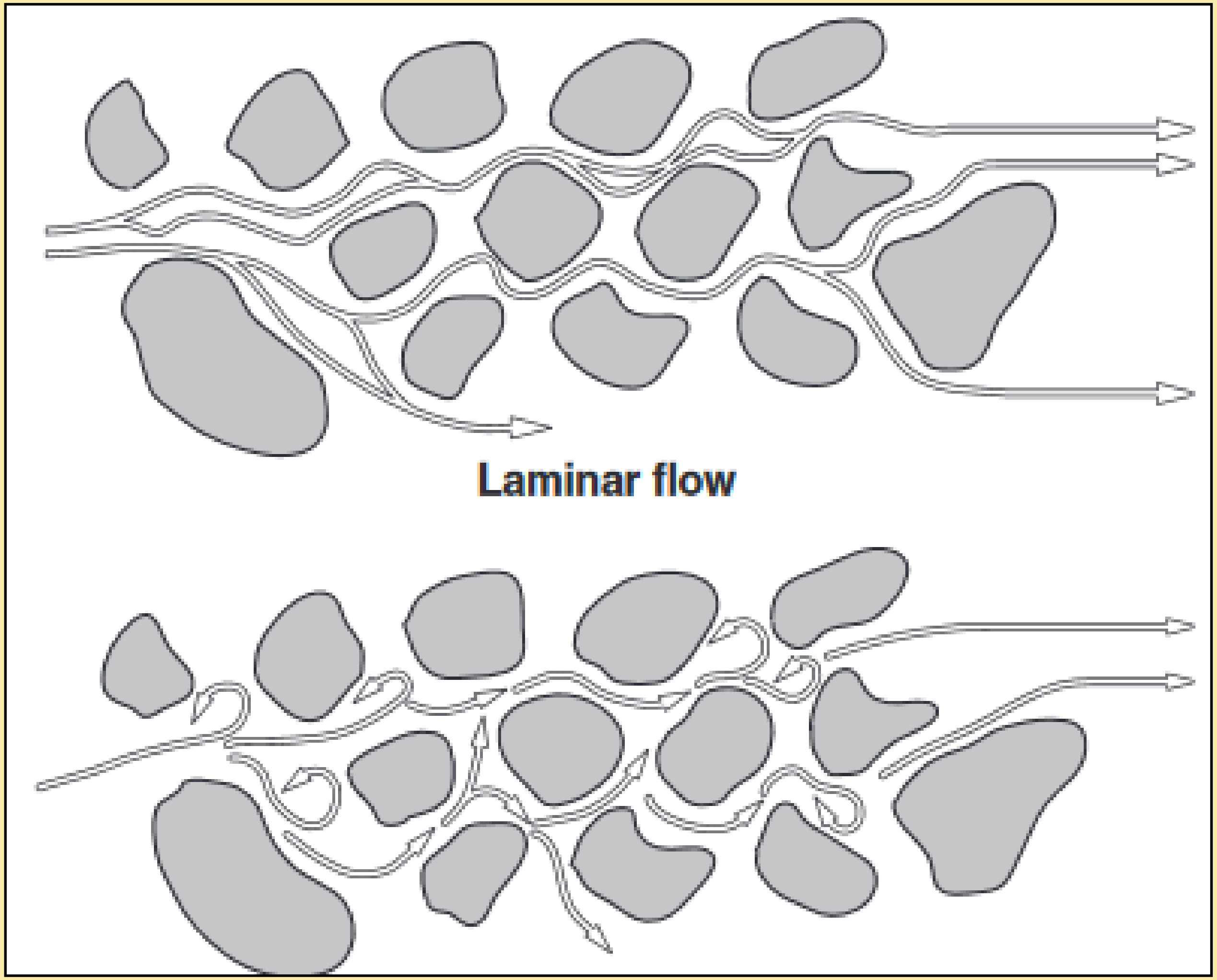
https://wedc-knowledge.lboro.ac.uk/resources/books/Water_From_Sand_Rivers_-_Ch_04.pdf

Naturally developed sand filter



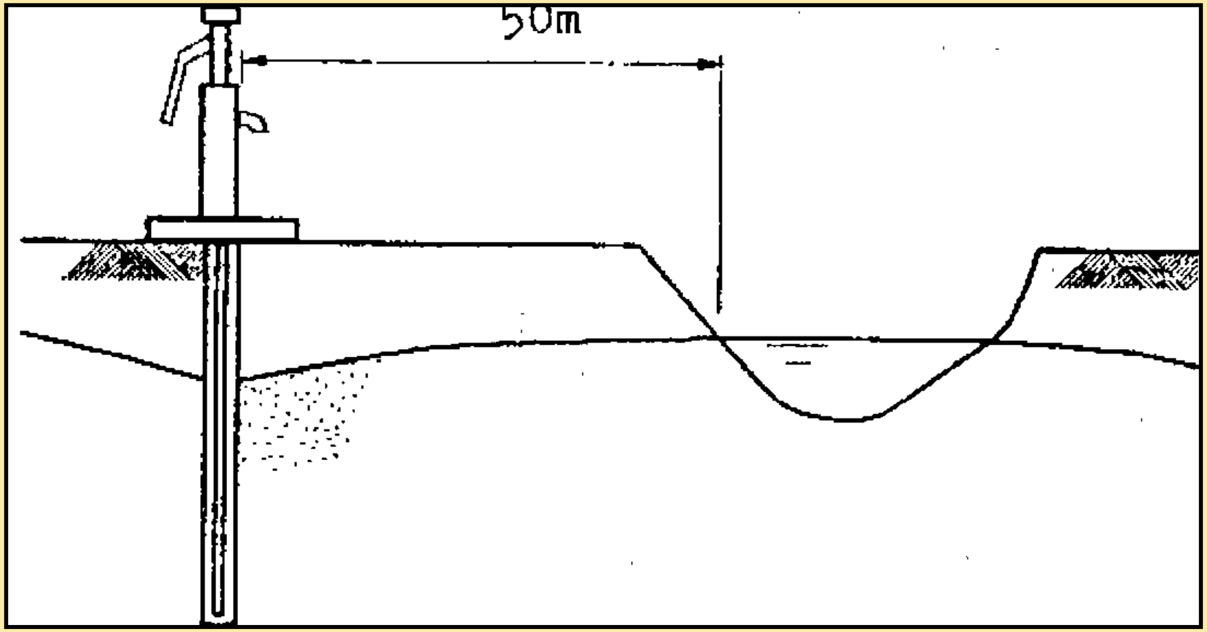
https://wedc-knowledge.lboro.ac.uk/resources/books/Water_From_Sand_Rivers_-_Ch_04.pdf

Flow of water between particles



https://wedc-knowledge.lboro.ac.uk/resources/books/Water_From_Sand_Rivers_-_Ch_04.pdf

A RIVER BANK WELL



ADVANTAGES

- ✓ Cheap
- ✓ The water is filtered in the soil

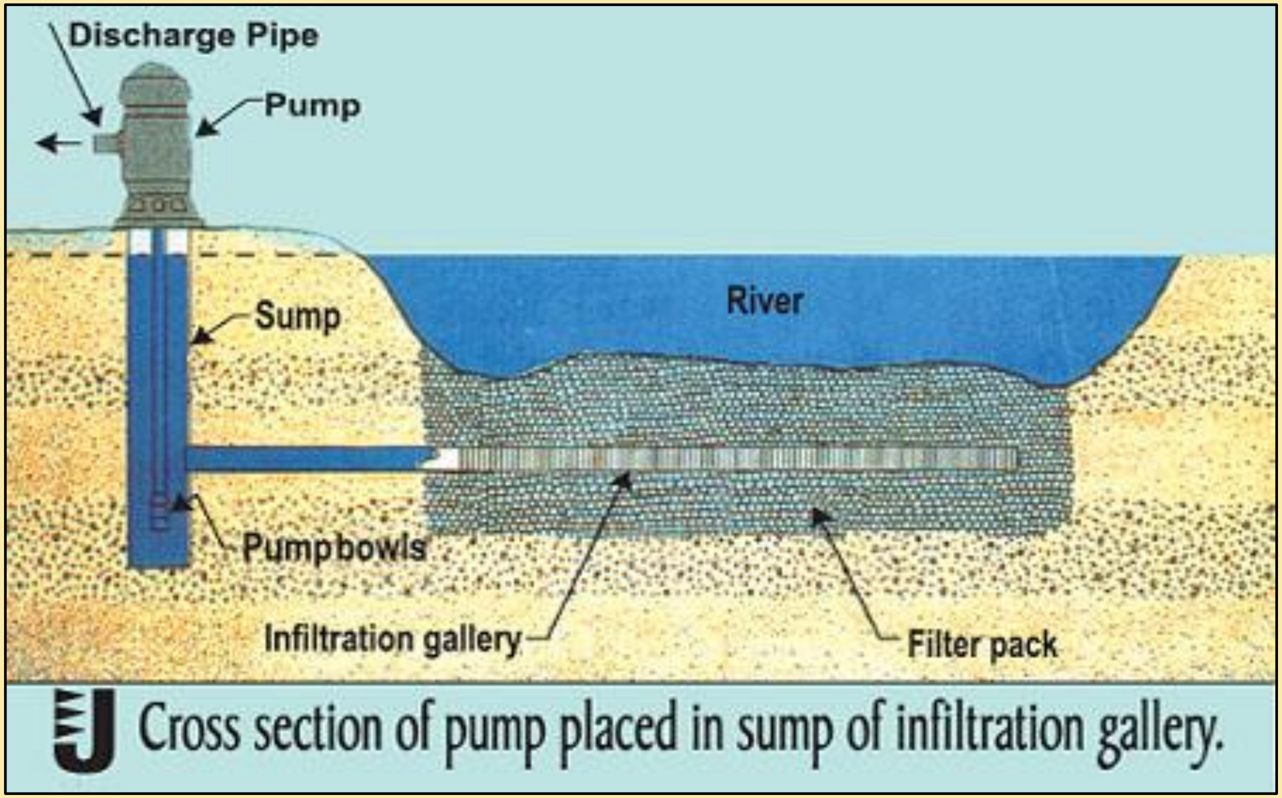
The well should be drilled at an adequate depth that will ensure the continuous water supply throughout the year.

DISADVANTAGES

- ✓ Requires permeable soil material (such as gravel and sand)

http://www.who.int/water_sanitation_health/sanitation-waste/fs2_7.pdf?ua=1
http://helid.digicollection.org/en/d/Js13461e/2.7.html

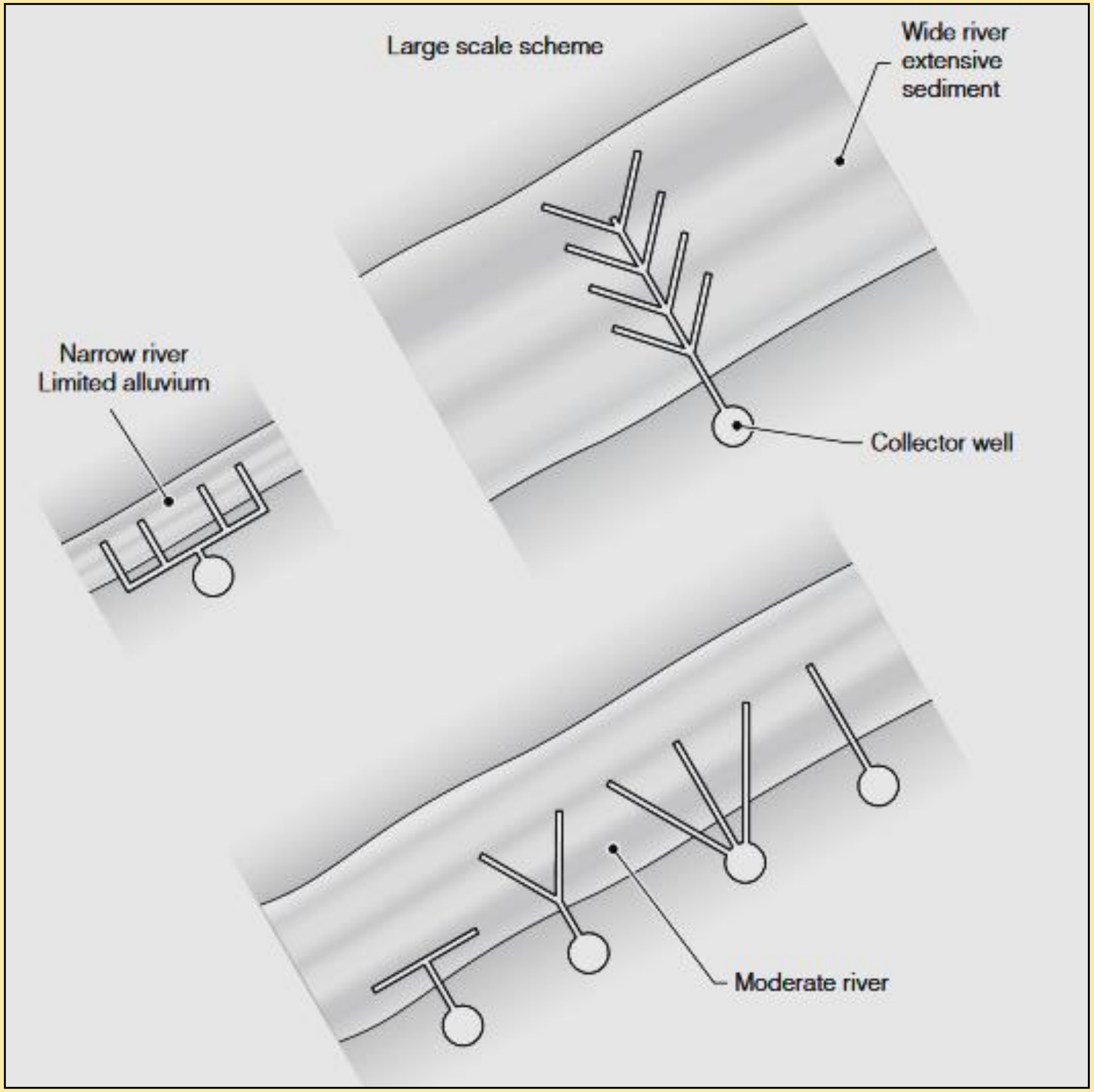
INFILTRATION GALLERY



It is an open jointed pipe below the river bed. The water is pumped and distributed to a supply network. Gravel is placed around the pipe in order to act as a filter to prevent blockage of the joints by fine sediments (silt, clay material).
This method is appropriate for riverbeds with medium to coarse sands.

https://gradeup.co/well-hydraulics-and-aquifers-i-ed587c01-975d-11e6-bf75-9c0e0d13dead

INFILTRATION GALLERY SCHEMES

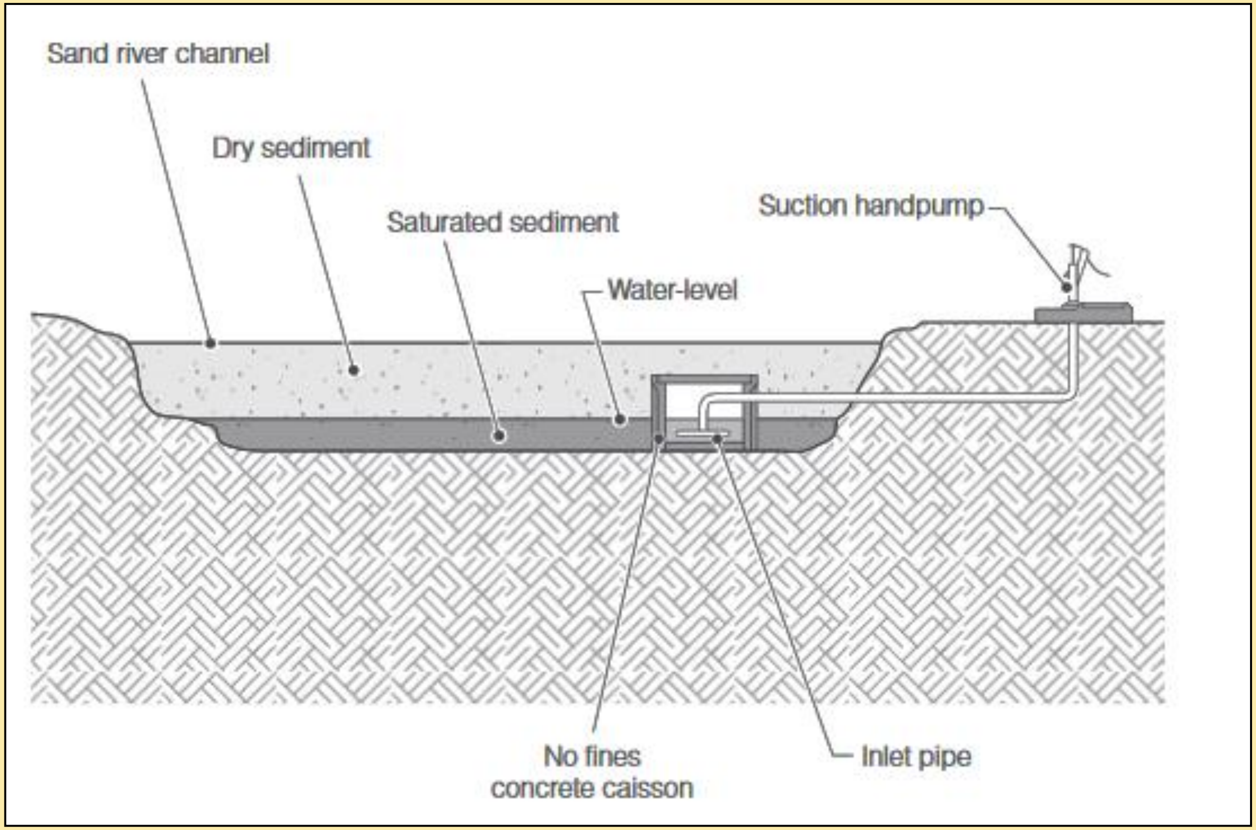


https://wedc-knowledge.lboro.ac.uk/resources/books/Water_From_Sand_Rivers_-_Ch_04.pdf

CAISSONS

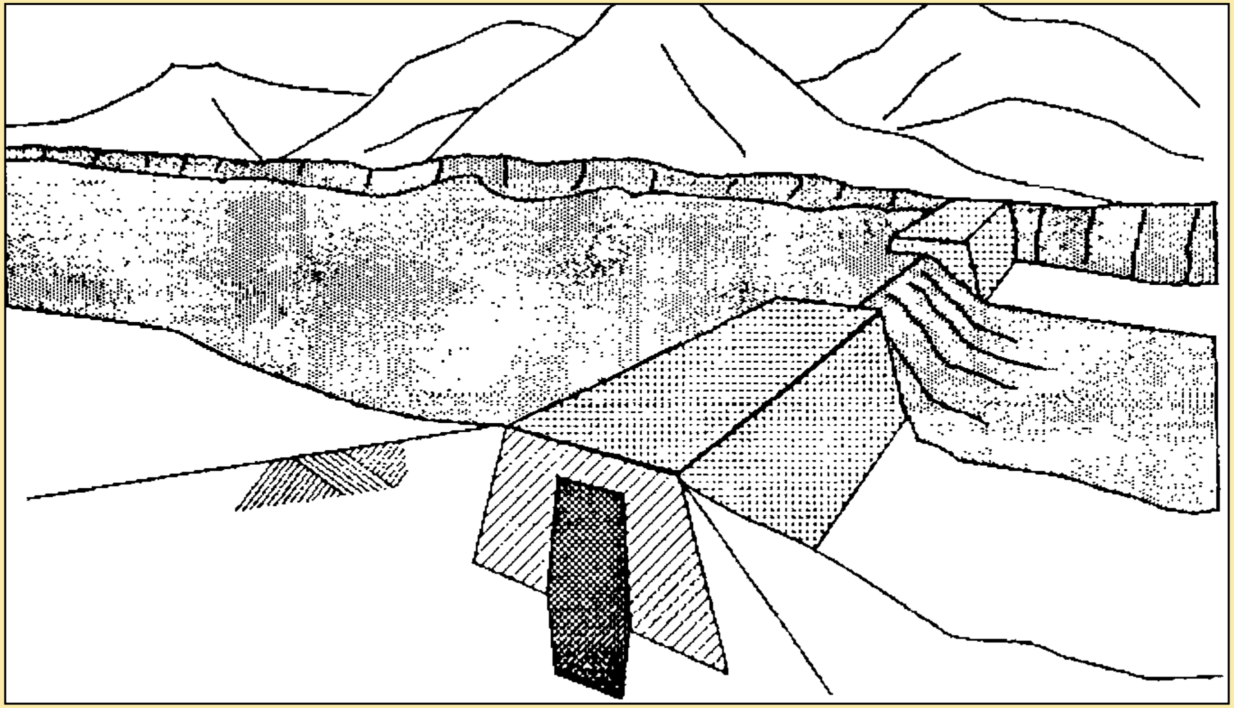
Caissons are installed directly into the riverbed or into alluvial riverbanks where there is high permeability.

The lower sections of the wells are permeable so that water flows from the sediment into the well and eventually creates a graded filter around the base of the caisson or well shaft



https://wedc-knowledge.lboro.ac.uk/resources/books/Water_From_Sand_Rivers_-_Ch_04.pdf

SMALL DAMS



Dams block the water flow and create an artificial reservoir/lake.

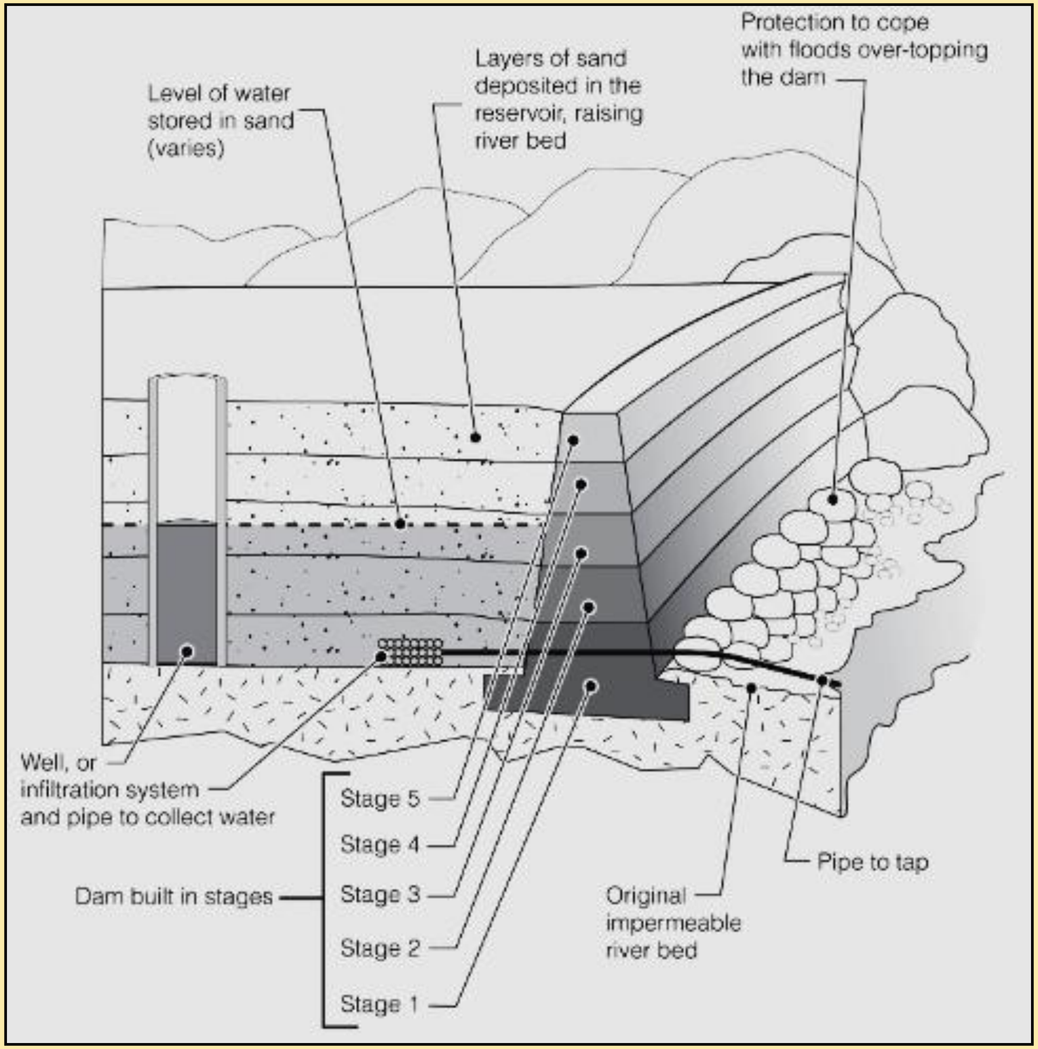
The most suitable location for such a construction is upstream of human habitation in order to reduce the pollution risk.

In hot climates the evaporation is very high. Therefore the proposed minimum dam height is 3m in order to provide year round water supply.

SMALL DAMS (<6m)

- Dams must have secure foundation.
- The core must be impermeable to prevent water seeping. It is usually built by clay material or concrete.
- The slope of the dam embankment should be appropriate to provide stability.
- A minimum amount of water (environmental flow) discharge should be agreed upon by all the downstream communities for environmental reasons.
- The dam must always have an overflow channel .

SUB-SURFACE DAMS



https://wedc-knowledge.lboro.ac.uk/resources/books/Water_From_Sand_Rivers_-_Ch_04.pdf

SURFACE WATER ABSTRACTION IMPACTS

- Water abstraction decreases water velocity, water depth, and wetted channel width.
- Flow reduction decreases the water temperature causing changes in the thermal regime and water chemistry.
- Change of instream habitat types.
- Sedimentation process may be affected. Fine sediments delivered by less abstracted tributaries may no longer be flushed downstream but may accumulate on the river bed, reducing its permeability.

http://wiki.reformrivers.eu/index.php/Surface_water_abstraction

LARGE DAMS

Definition (*International Commision on Large Dams*) :

- **A dam with a height of 15 metres or greater from lowest foundation to crest**

or

- **A dam between 5 meters and 15 meters impounding more than 3 million m^3**

http://www.icold-cigb.net/

LARGE DAMS

- Embankment dams
- Gravity dams
- Arch dams
- Buttress dams

http://www.icold-cigb.net/

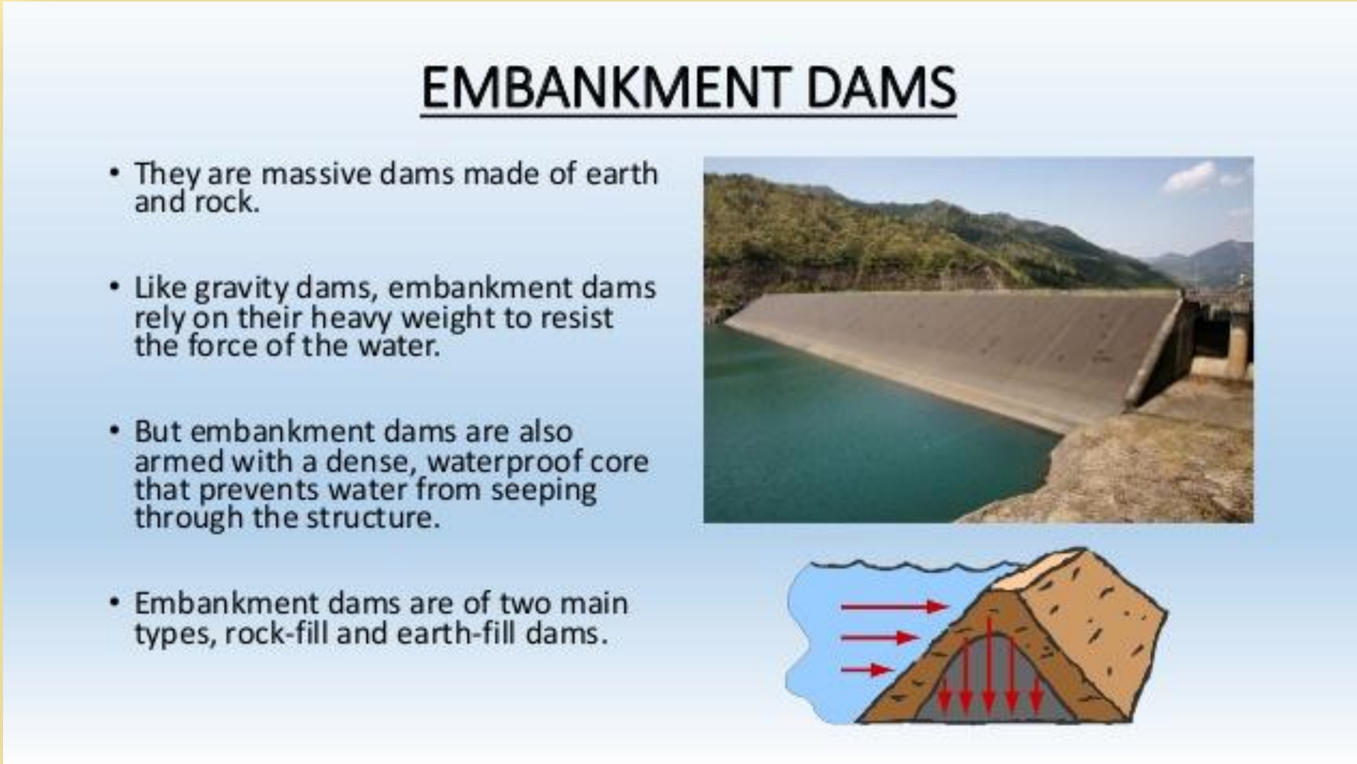
EMBANKMENT DAMS

Aswan Dam

Embankment dams are constructed of either earth fill or a combination of earth and rock fill.

Therefore, embankment dams are generally built in areas where large amount of earth or rocks are available.

They represent 75% of all dams in the world.



Criteria for the selection of an Embankment dam

- ➢ Appropriate for poor quality rock material of high heterogeneity
- ➢ Sensitive to internal erosion
- ➢ Careful selection of the spillway site in case that the slopes are not stable
- ➢ Morphology ratio of height versus length must be >1:2

https://www.google.gr/search?q=embankment+dams&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi3hLmrlq3YAhUGyKQKHVx5ABsQ_AUICigB&biw=1366&bih=636#imgrc=osiUB30RUAQa2M:

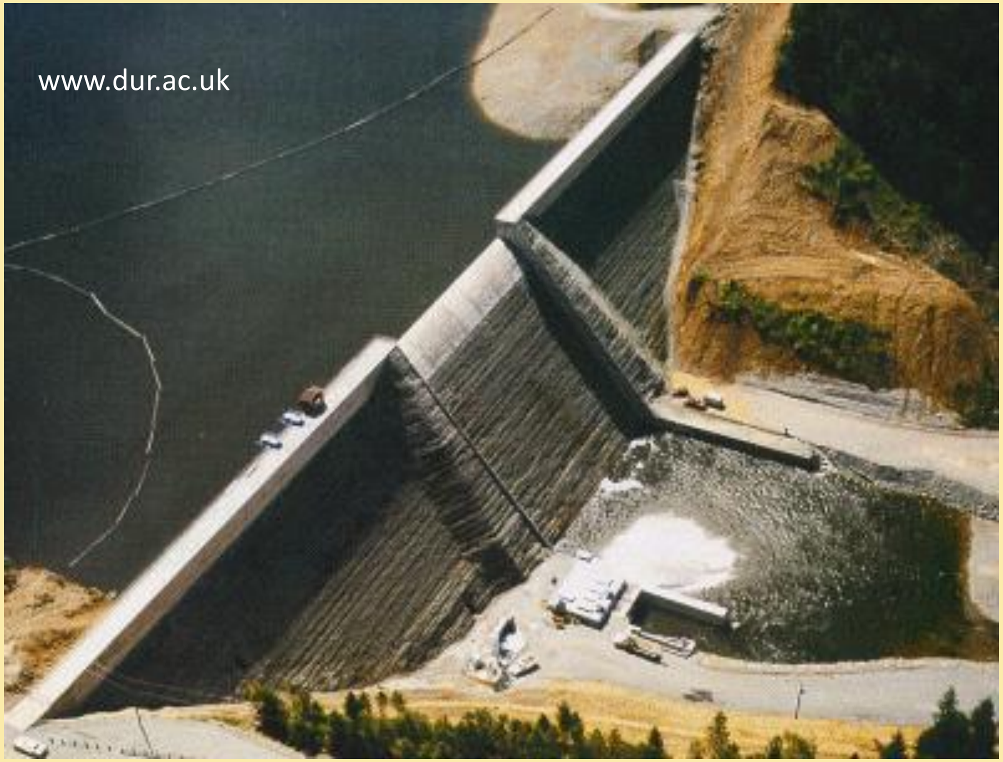
GRAVITY DAMS

Dwordhk Gravity Dam, Idaho

- They are called a gravity dam because gravity holds the dam down to the ground and stops the water from toppling it over.
- They are considered massive in size and made from concrete or stone.
- They are designed to hold back enormous amounts of water.
- The use of concrete allows the dam to resist the horizontal thrust of the water as it pushes against it.

http://civilengineersforum.com/common-types-of-dams/

GRAVITY DAMS



Criteria for the selection of a Gravity dam

- Sensitive to differential settlements. Sound homogenous rockmass is required for this type of dam
- Sensitive to pressures beneath the dam body. The foundation must be drained and an impermeable curtain must be constructed.

GRAVITY DAMS

Advantages

- These are more suitable in steep.
- Surplus water may be discharged through the sluices provided in the body of the dam.
- A gravity dam does not fail suddenly (advance so that loss of life and property may be saved).
- The cost of maintenance is least.

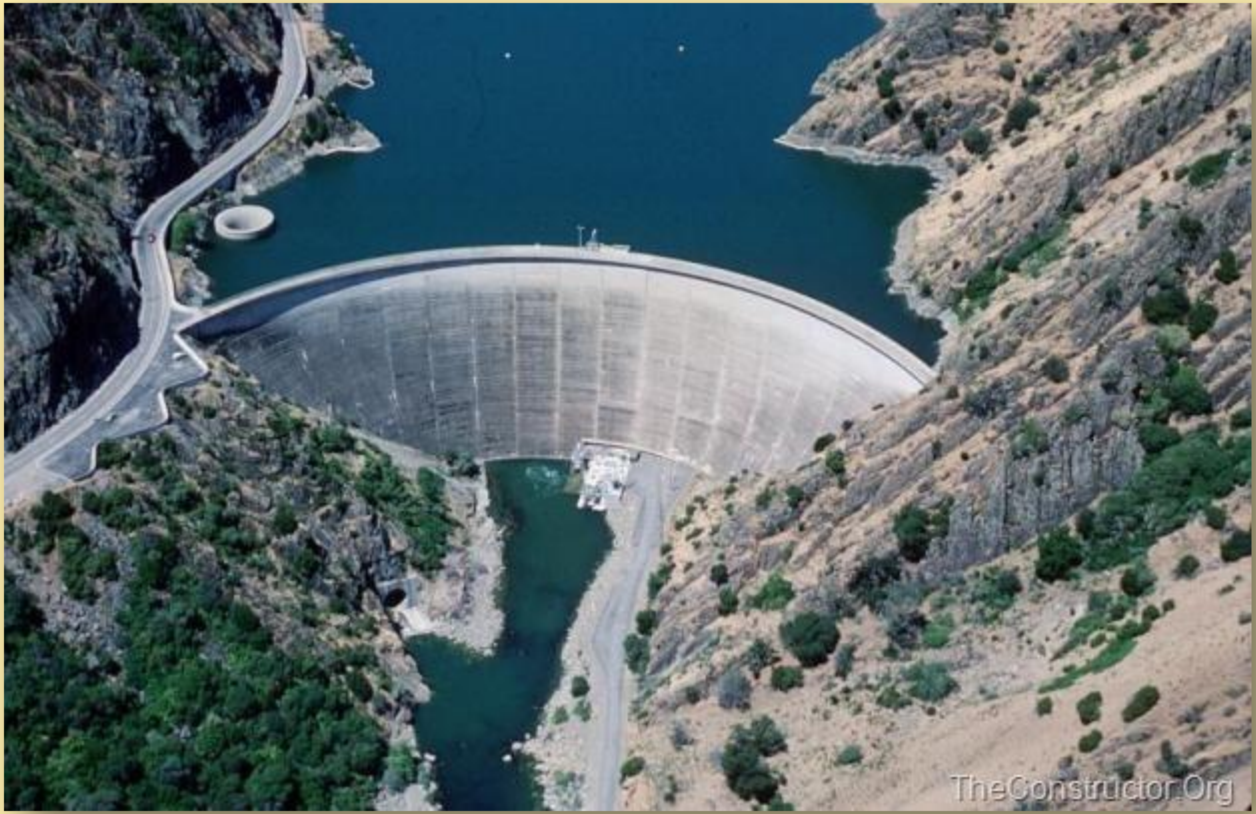
Disadvantages

- Their initial cost of construction is high and the construction period is comparatively more.
- They require a strong and sound foundation.
- Dams once constructed, cannot be raised further.

http://civilblog.org/2015/06/03/what-are-the-advantages-and-disadvantages-of-gravity-dams/

ARCH DAMS

The entire structure is curved with the convexity towards the upstream side. These types of concrete dams are best suited for narrow canyons that have strong flanks capable of resisting the pressure produced by the arch.



Arch Dam – Idukki Dam, Kerala

http://civilengineersforum.com/common-types-of-dams/

ARCH DAMS

Criteria for the selection of site and type of dam

- Sound homogenous rockmass (especially in the slopes) is required.

ADVANTAGES

- It requires 50% to 85% less amount of concrete in comparison to the gravity dams.
- This type of dam has a small sensitivity to pressure exerted in the foundation

DISADVANTAGES

- Morphological constraints :ratio of height versus length must be >1:5
- The assymetry of the valley has a great impact on the dam

http://civilengineersforum.com/common-types-of-dams/

BUTTRESS DAMS

There are three types of buttress dams: deck, multiple-arch and massive-head.

These dams are triangular with concrete walls that transmit the water pressure from the slab to the foundation.

They are also sometimes called hollow dams because the buttress does not form a solid wall that stretches across the river valley.

http://civilengineersforum.com/common-types-of-dams/

WELLS AND BOREHOLES

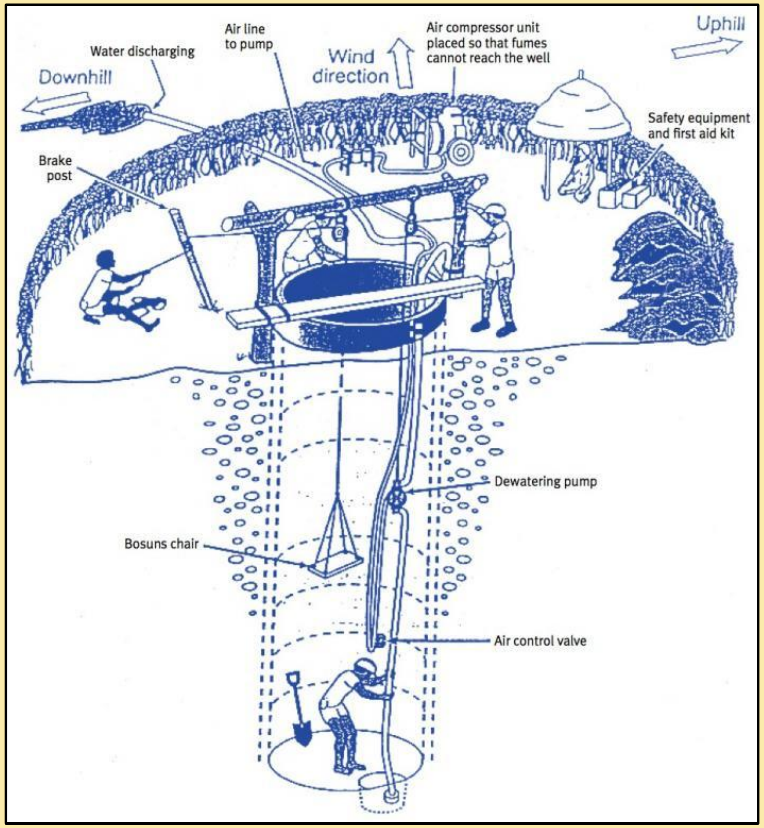
Difference between wells and boreholes **:**

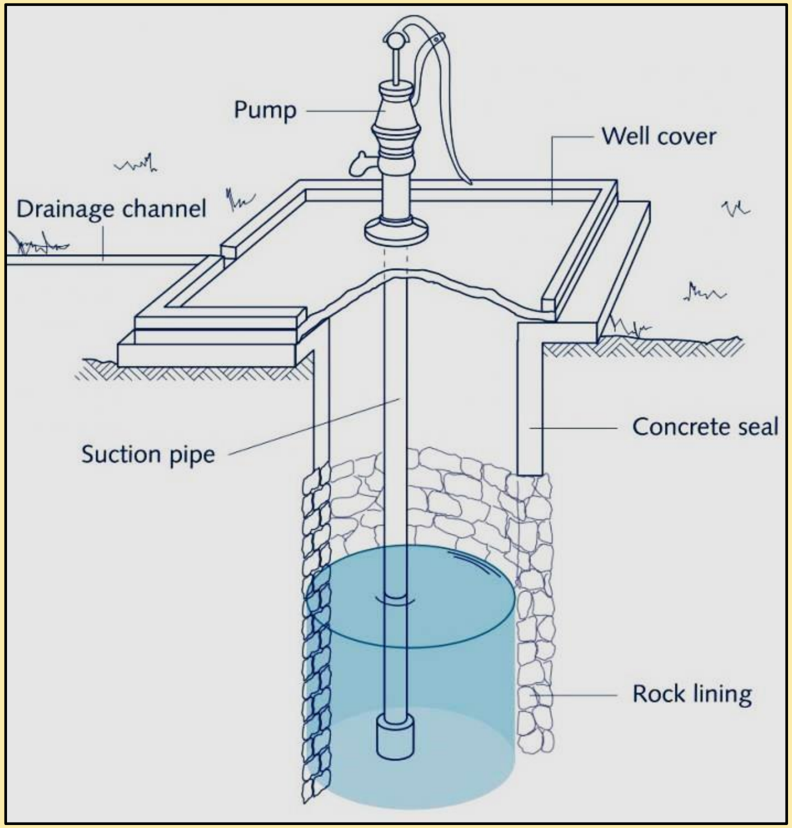
- ✓ Wells have small depth and large diameter
- ✓ Boreholes have large depth small diameter

The wells according to their construction way are distinguished in four categories:

- Dug
- Bored
- Driven
- Jetted

DUG WELLS

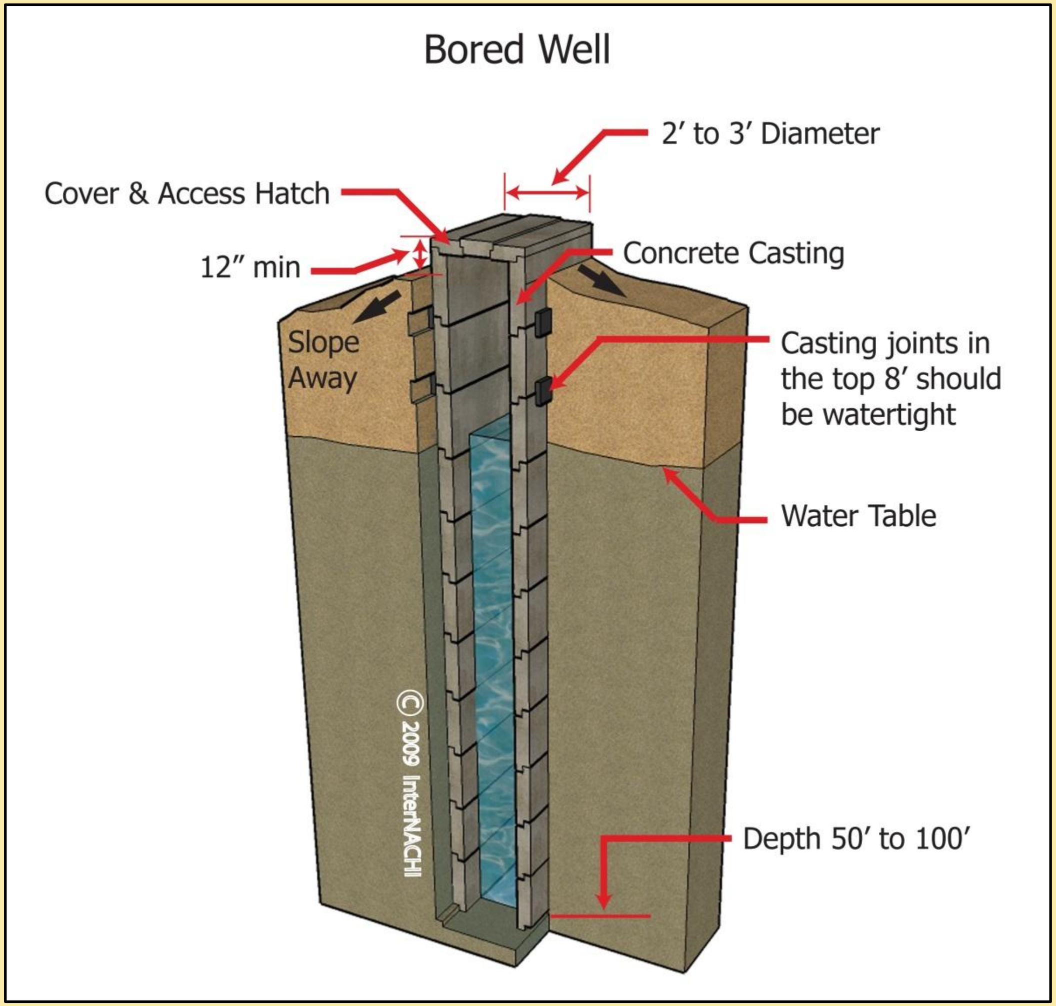




Dug wells are the oldest water capture engineering works.
They have depth up to 20m and large diameter that ranges from 1-10m (usually appr. 3m)

https://inspectapedia.com/water/Hand_Dug_Wells.php
https://www.sswm.info/content/dug-wells

BORED WELLS



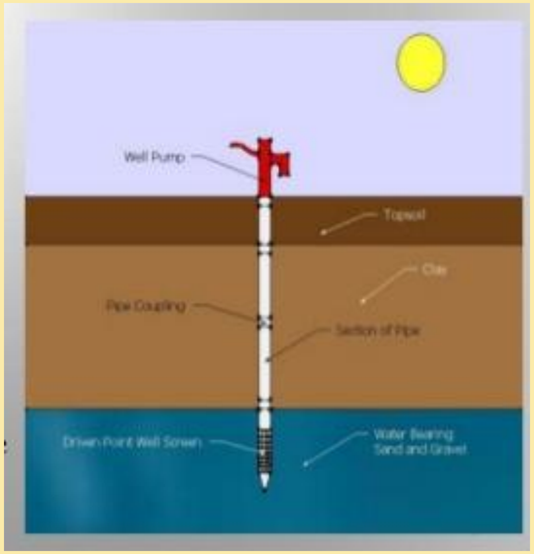
http://vividhomeinspection.com/well-water-testing/

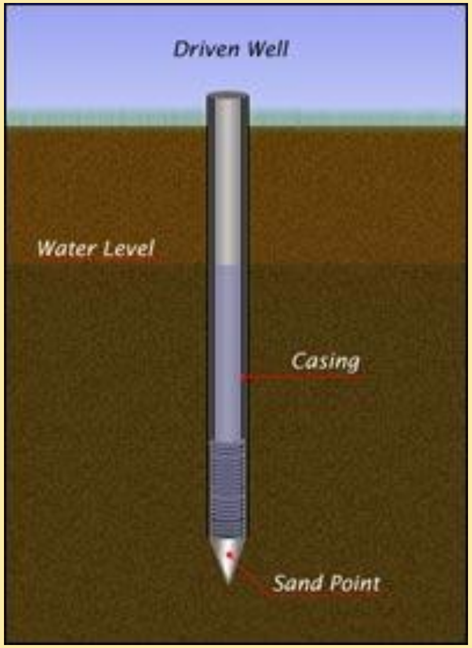
This type of well is constructed in loose geological formations in order to exploit shallow low yielding aquifers.

They are usually handmade. The depth is up to 30m and diameter 1m.

They are constructed with an auger.

DRIVEN WELLS



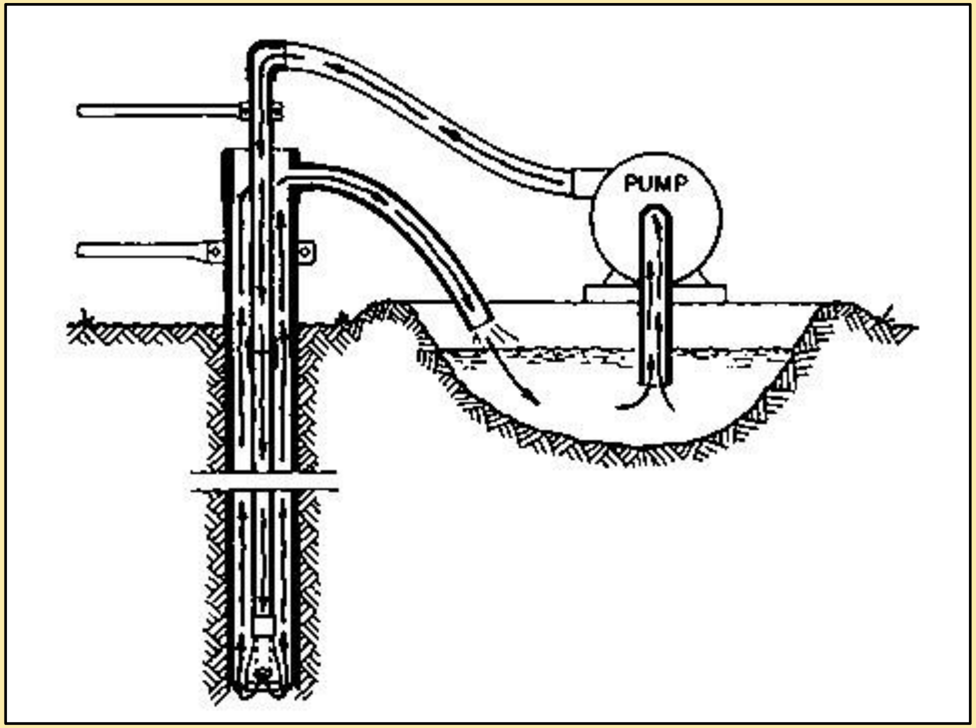


Driven wells are constructed in fine grained loose sediments.

The depth is up to 20m and the diameter ranges from 3 to 10cm.

https://www.slideshare.net/Vaibhavikadu/sources-of-drinking-water-on-earth

JETTED WELLS



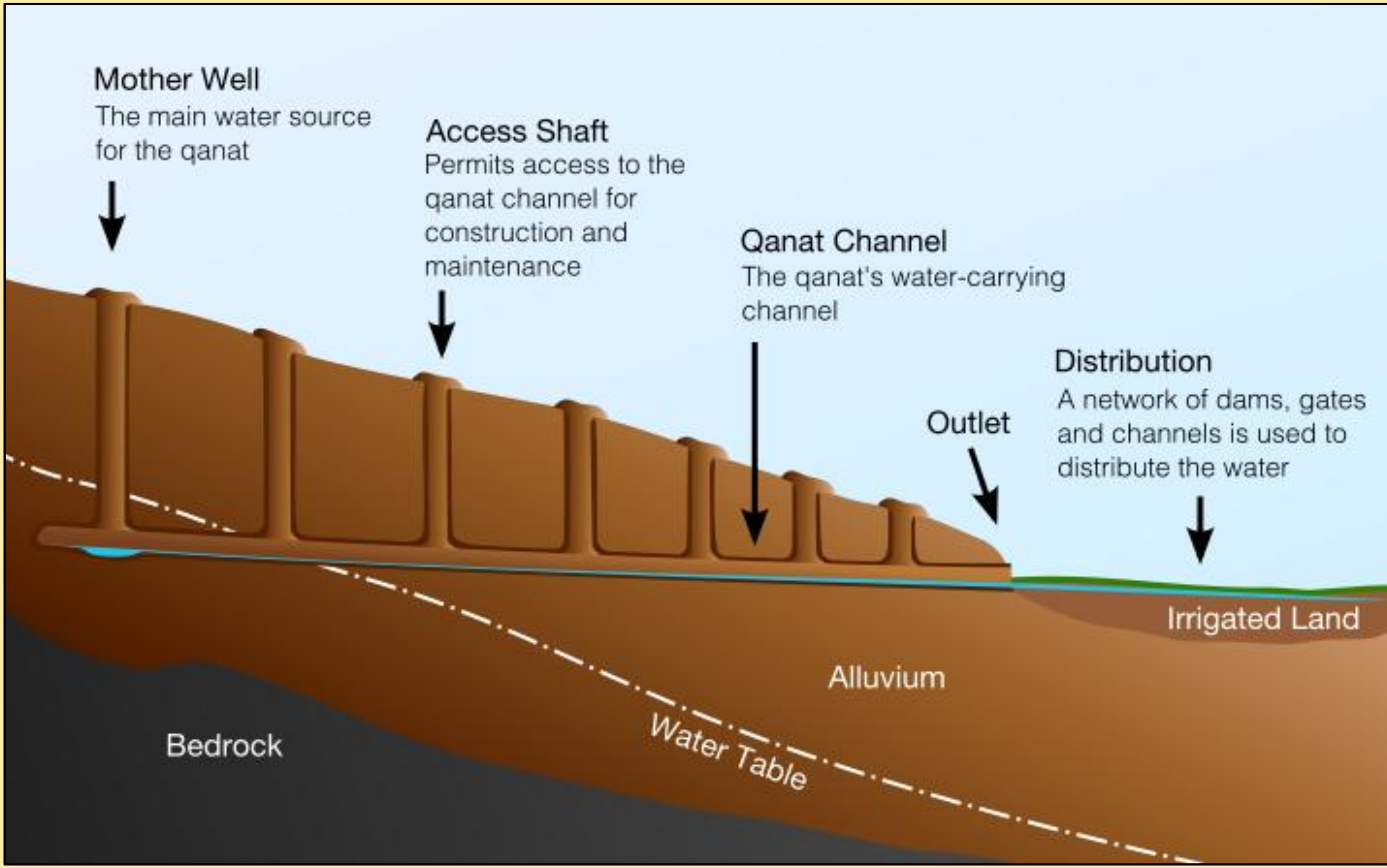
The pipe to be used to obtain water, is forced into the soil using water at high pressure (40 psi for sandy soils, up to 150 psi for clay or gravel) from an existing water source.

The depth is up to 15 m and the diameter ranges from 3 to 10cm.

A gravel filter is usually installed around the well.

https://inspectapedia.com/water/Jetted_Wells.php

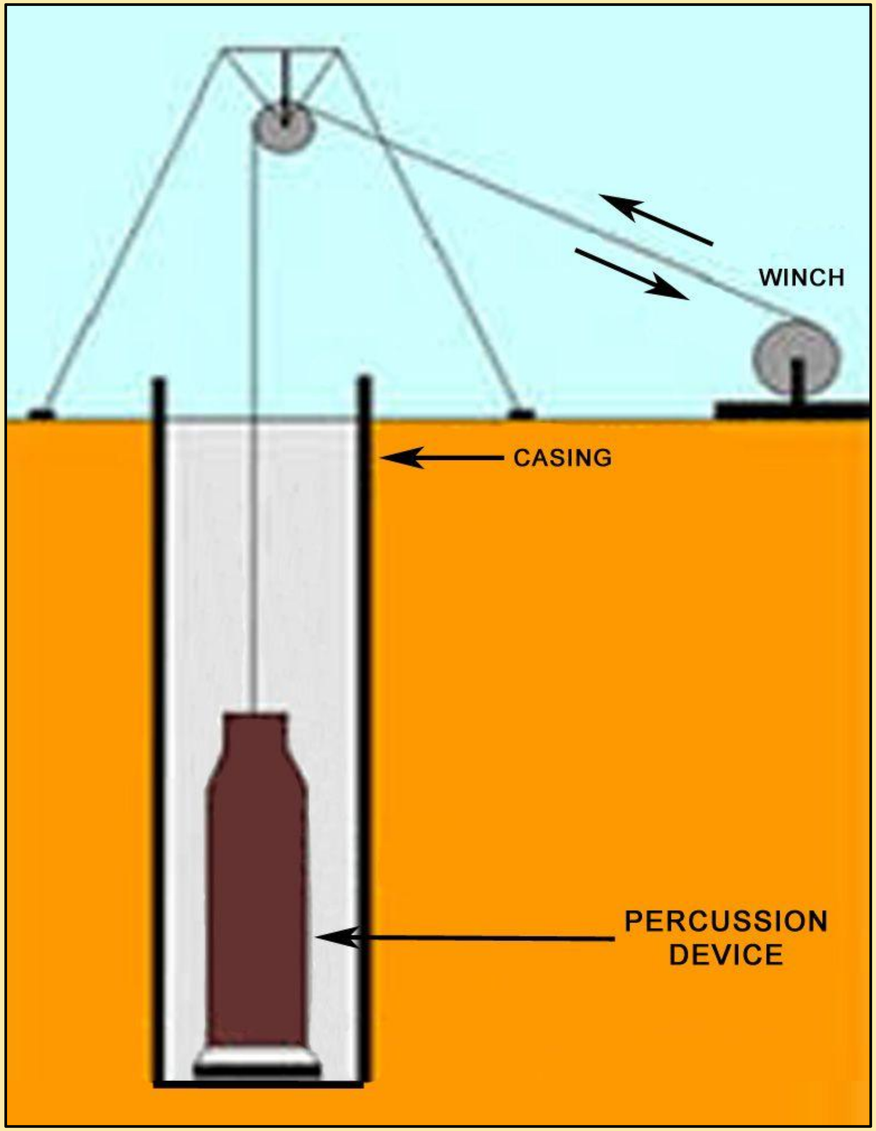
QANATS



https://en.wikipedia.org/wiki/Qanat#/media/File:Qanat_cross_section.svg

BOREHOLE DRILLING METHODS

PERCUSSION



ADVANTAGES

- Small cost
- Small amount of water required

DISADVANTAGES

- Slow drill rate
- Continuous casing of the hole
- Inability to implement geophysical methods

This system is used for medium-large diameter and low-medium depth drilling works.

Optimal depth: from 0 up to 100 m
Optimal diameter: from 0.4 up to 1.2 m

ROTARY METHOD

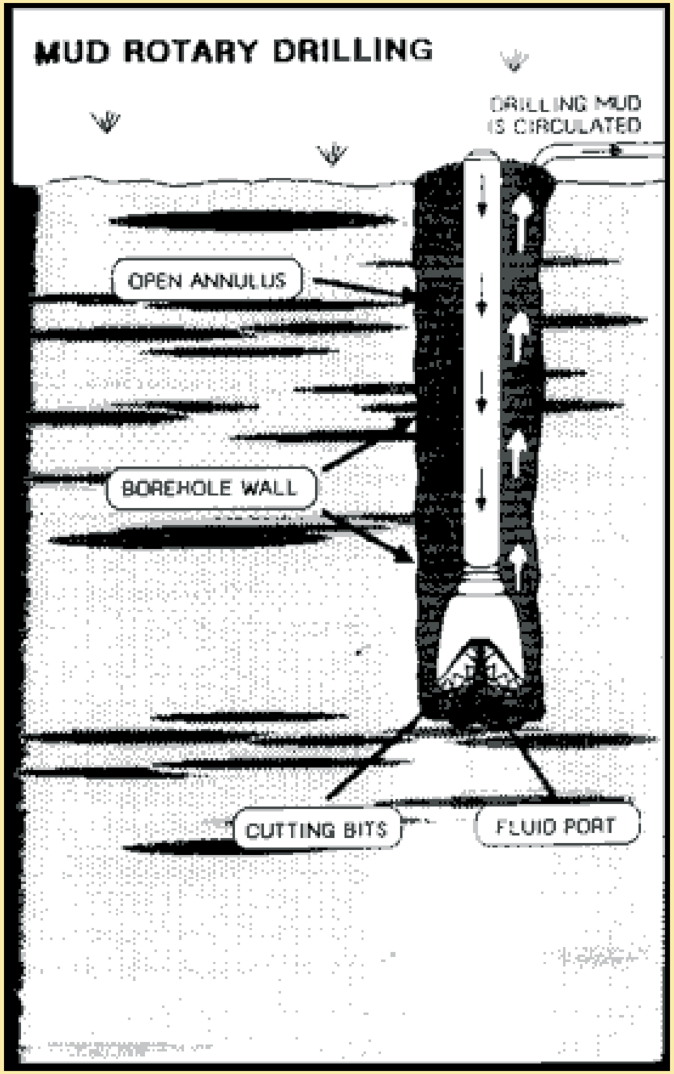
ADVANTAGES

- ✓ High drill rate
- ✓ Rotary methods effectively advance through hard and soft lithology
- ✓ Rotary advances to deeper depths than direct push and auger, and is capable of larger diameter holes
- ✓ Geophysical investigations can be implemented
- ✓ Casing is not always required

DISADVANTAGES

- ✓ High cost for the maintanance of the equipment
- ✓ Cleaning of the borehole is required
- ✓ Large amount of water is demanded in the mud rotary method

MUD ROTARY



ADVANTAGES

- ✓ High drill rate
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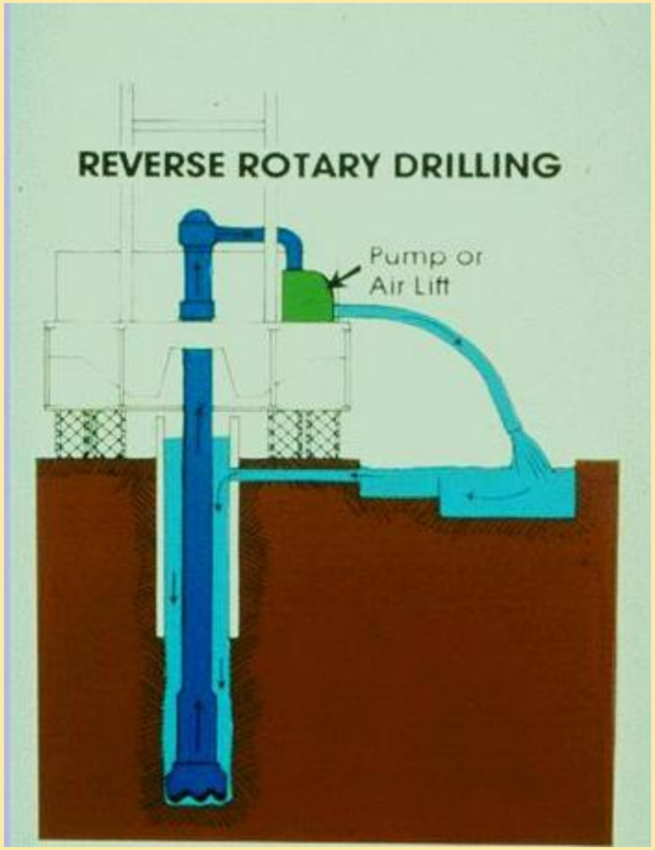
- ✓ Geophysical investigations can be implemented
- ✓ <u>Casing is not always required</u>

DISADVANTAGES

- ✓ High cost for the maintanance of the equipment
- ✓ Cleaning of the borehole is required
- ✓ Large amount of water is demanded
- ✓ <u>The sampling depth is not representative</u>

http://www.groundwaterresearch.com.au/reference_files/tbazen/gwmonitoring

MUD ROTARY (REVERSE CIRCULATION)

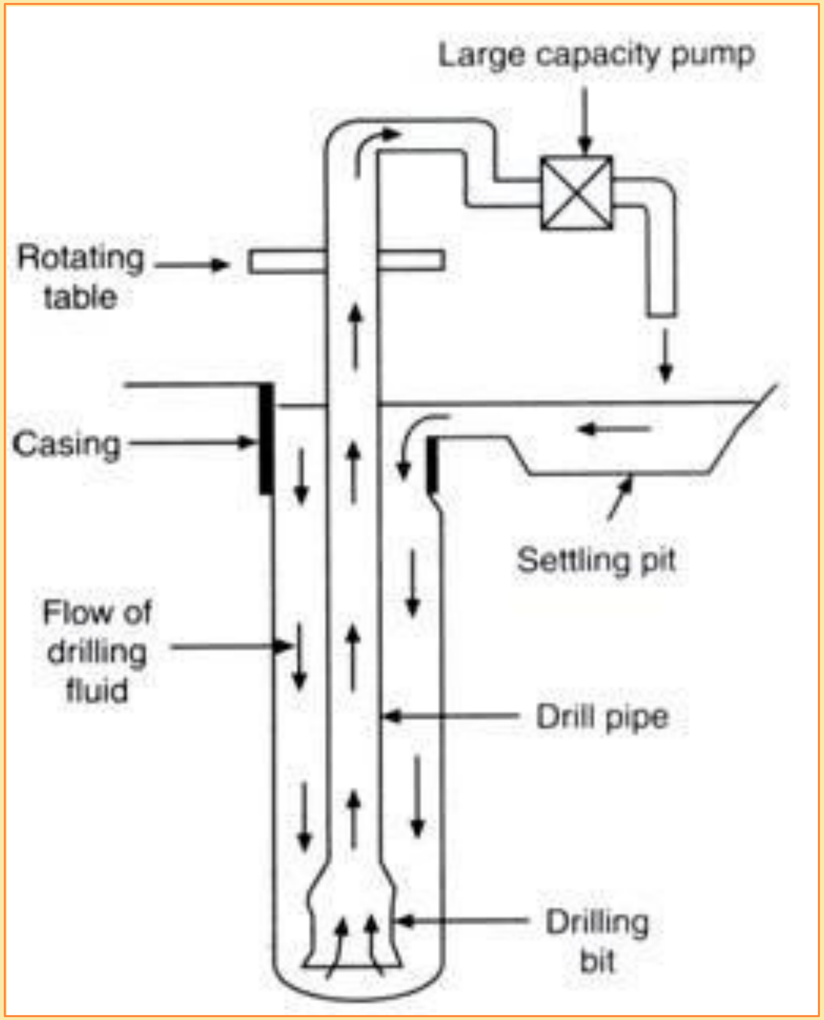


An alteration of this method is the reverse circulation method.

The drilling fluid is pumped through the drill pipe and send to the borehole through a pipe in the annulus between the drill pipe and borehole.

The method is not appropriate for competent rocks and is suitable for loose formations.

MUD ROTARY (REVERSE CIRCULATION)



ADVANTAGES

- ✓ A thinnest film is formed on the hole and therefore the cleaning of the borehole is easier
- ✓ Provides better stability in loose formations
- ✓ The diameter of the drilling has not an important impact on the cost

DISADVANTAGES

- ✓ Weakness to drill competent rocks
- ✓ Larger amount of water is demanded in comparison to the positive circulation method

http://www.yourarticlelibrary.com/water/tube-well/drilling-methods-for-tube-wells-and-its-selection/61098

AIR ROTARY

Air rotary drilling is a method used to drill deep boreholes in rock formations.

Borehole advancement is achieved by rapid rotation of a drill bit which is mounted at the end of the drill pipe.

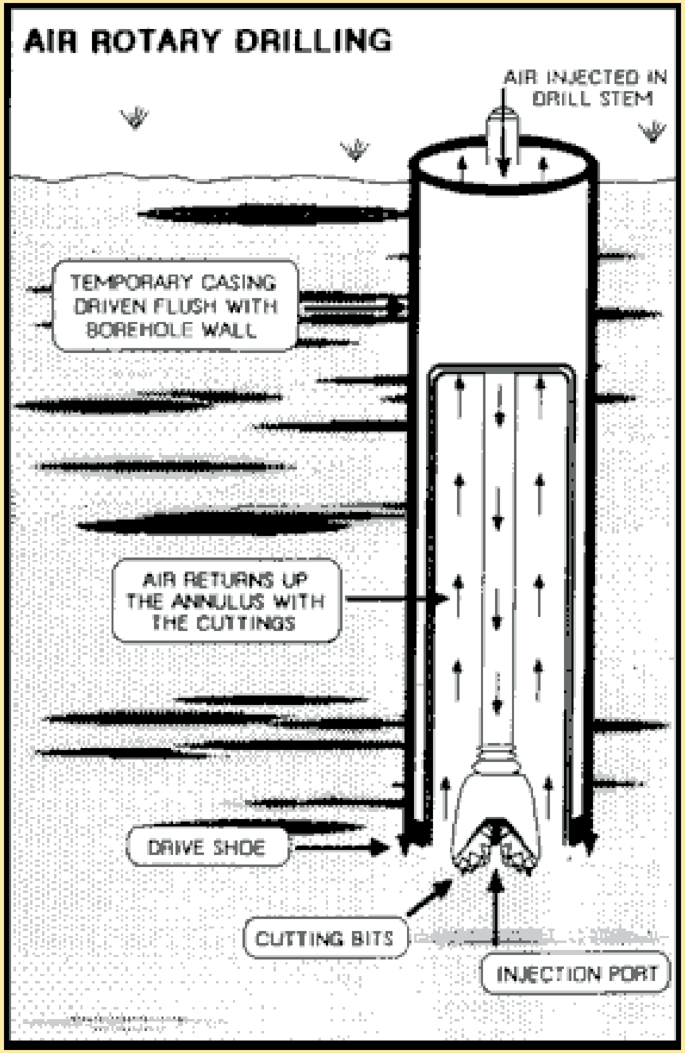
The drill bit "cuts" the formation into small pieces, called cuttings.

This method utilizes air as a circulating medium to cool the drill bit, bring drill cuttings to the surface and maintain borehole integrity.

https://geoprobe.com/articles/air-rotary-drilling-7822dt

http://cascade-env.com/technologies/rotary/

AIR ROTARY



ADVANTAGES

- ✓ High drill rate
- ✓ Water saving method

DISADVANTAGES

- ✓ High cost for the operation of the air compressor
- ✓ Dust and noise

http://www.groundwaterresearch.com.au/reference_files/tbazen/gwmonitoring

ROTARY-PERCUSSION DRILL WITH AIR

A **rotary-percussion drill** is a type of rock drill that uses both rotary and percussive action in order to produce a hole.

It is a fast, effective and money saving method.

It can be used for hard rocks.

The main disadvantage of the method is the small diameter of the produced hole and the weakness to uplift the water in case that high yielding aquifers are encountered.

DRILLING PROBLEMS-SOLUTIONS

One of the most prevalent drilling problems include:

→ ***Hole instability***

→ ***Drilling mud losses***

http://petrowiki.org/PEH:Drilling_Problems_and_Solutions

COMPLETION OF THE BOREHOLE

The completion takes place after the drilling and includes the following works:

1) Casing of the borehole
2) Cementation of the upper part
3) Gravel pack installation
4) Piezometer installation
5) Pumping equipment installation

1. CASING OF THE BOREHOLE

A. Conductor casing

It usually takes place at the beginning of the drilling procedure and reaches at depths that range from 10 to 30m. The aim is to stabilize loose formations, to prevent polluted waters to enter the borehole and to reduce the drilling mud looses.

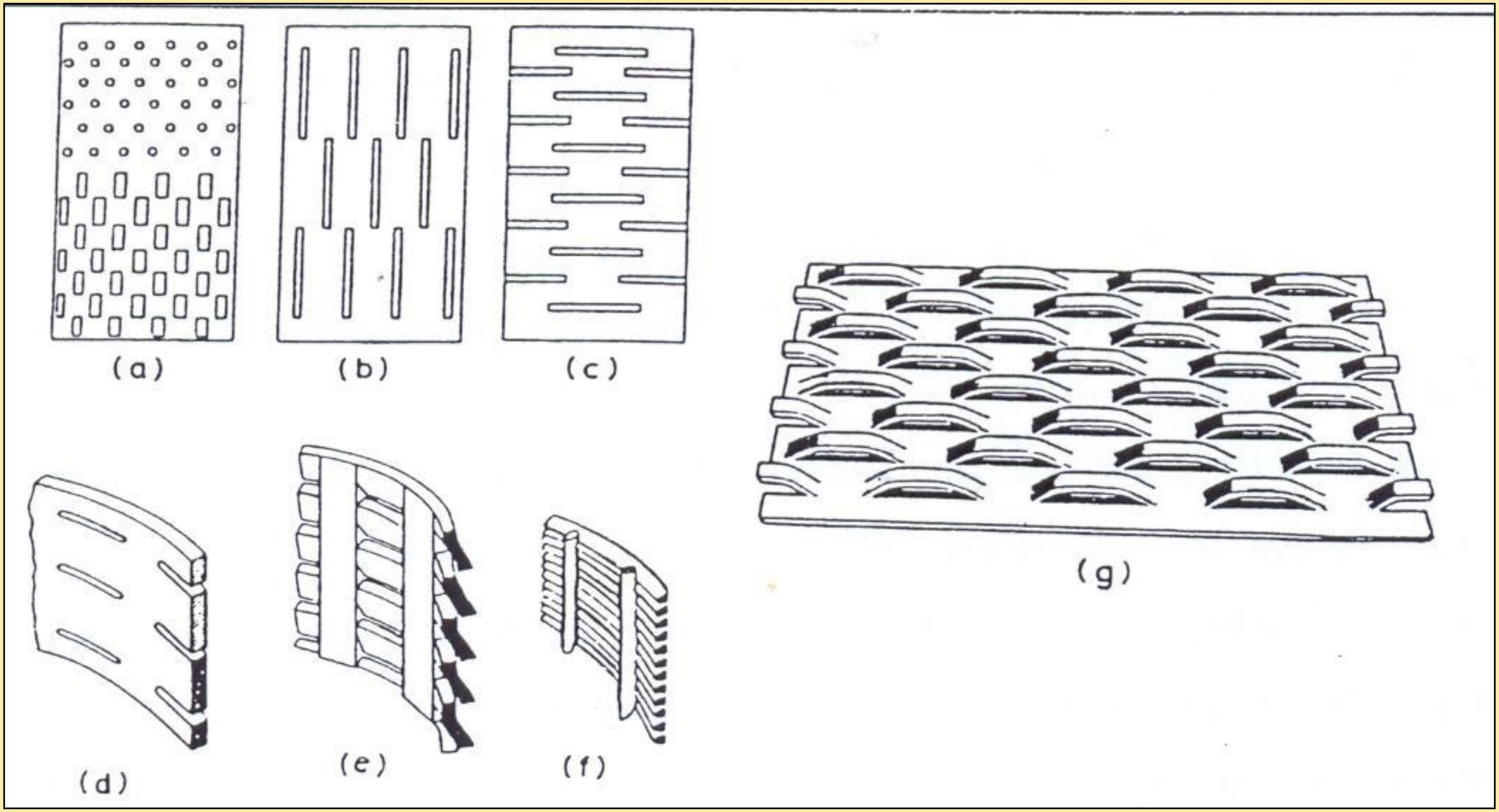
B. Permanent casing (blank and screen)

Blank casing does not allow the entrance of water. The pump is always installed in a blank casing. Screen casing allows the entrance of water through its perforations.

The prerequisites that a screen casing must fulfill are the following:

- Block the entrance of sand
- To create the smallest resistance to the water flow
- To be resistant to oxidation
- Not to clog easily
- To withstand to the pressures exerted laterally
- To have small cost

SCREEN CASING



2. CEMENTATION

Cementation is the space filling around the permanent casing or from the top of the well screen till the surface with cement products.

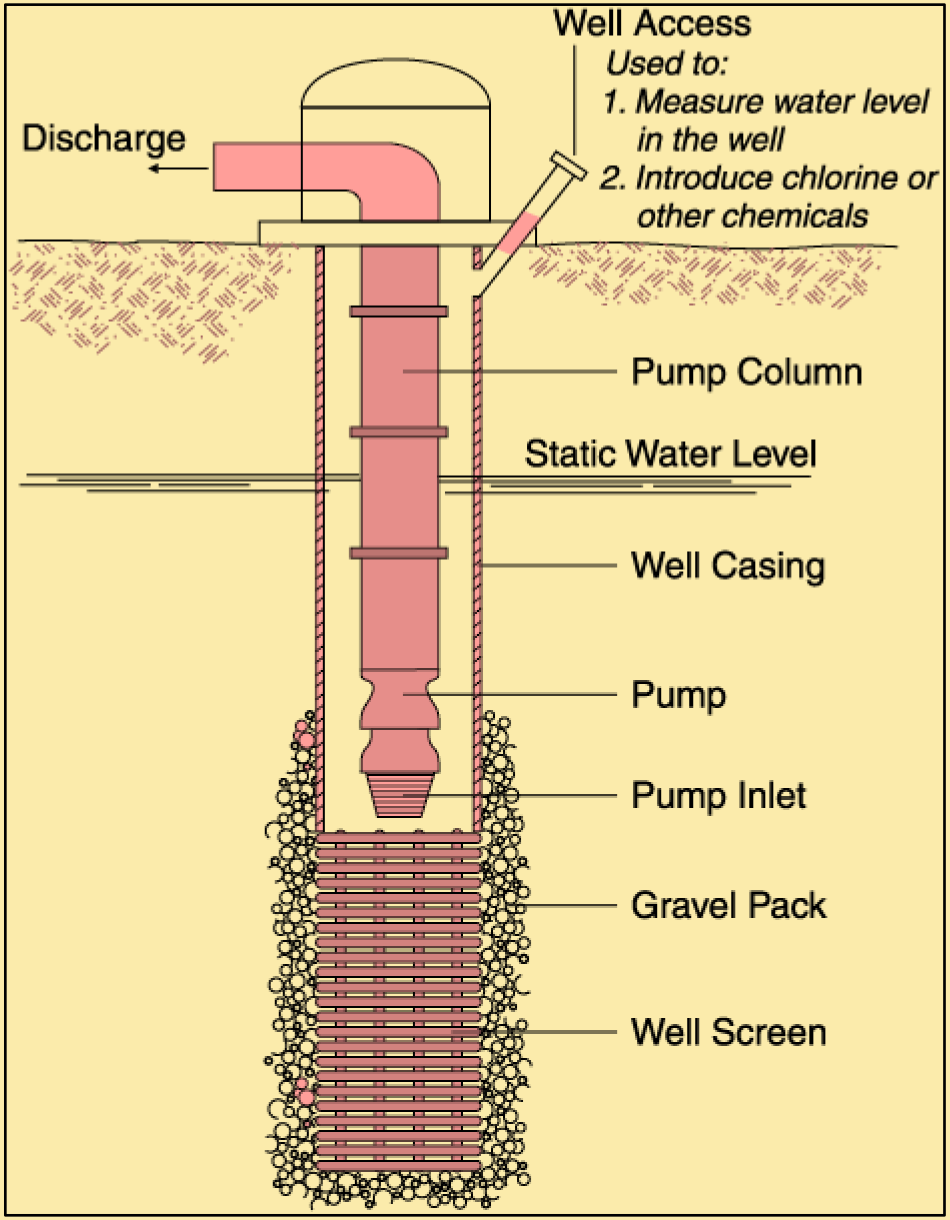
Cementation aims to:

- Prevents the entrance of quality degradaded water in the borehole
- Stabilize the loose formations
- Keep the casing string steady and prevent casing oxidation
- Provides a zone of increased strength against the exerted pressures

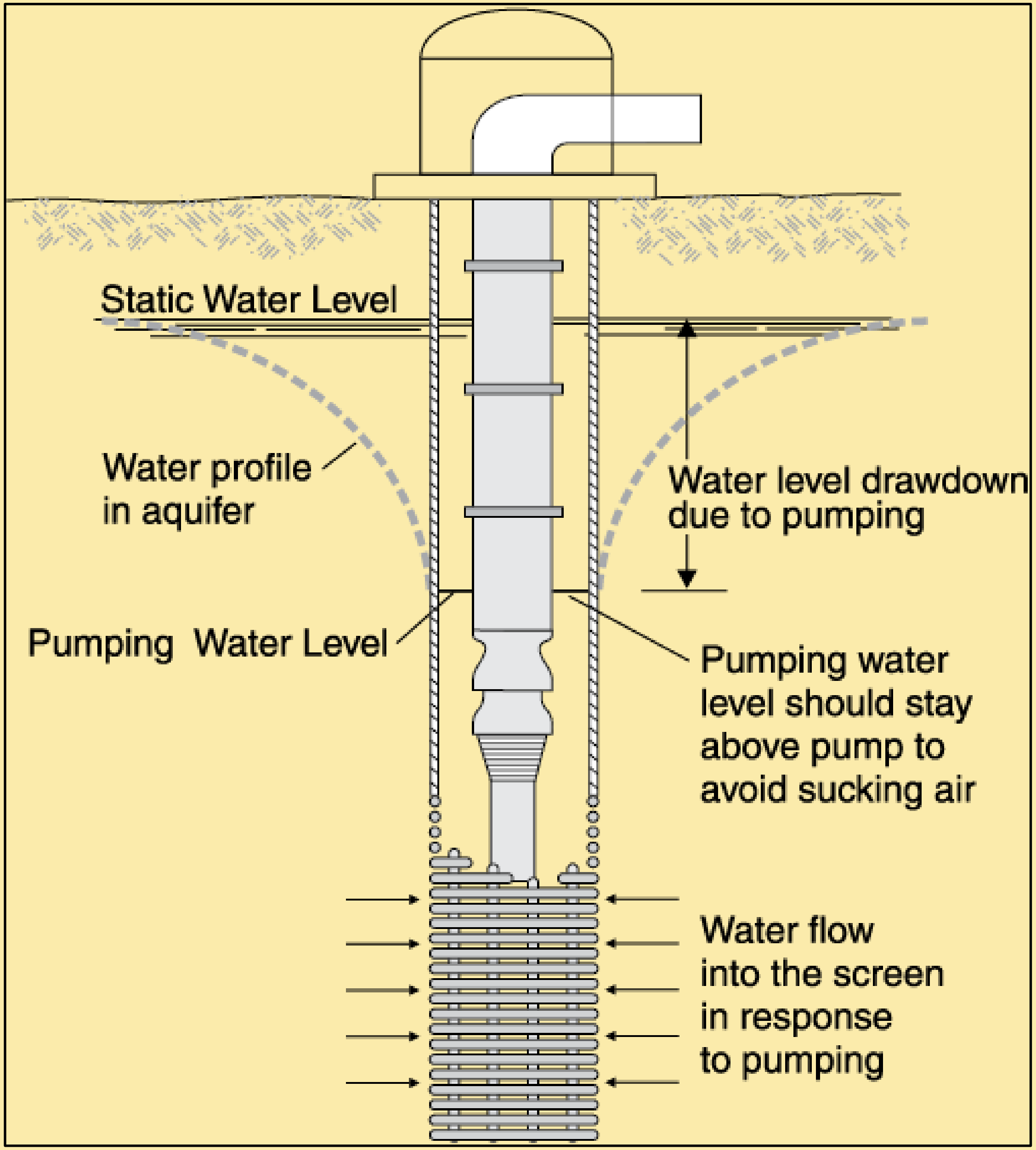
3. GRAVEL PACK INSTALLATION

The gravel pack achieves to:

- Increase the effective radious of the borehole and therefore the discharge rate
- Stabilize the hole
- Reduce the flow velocity and prevents the change of flow from laminar to turbulent
- Block the entrance of fine grained suspended material



https://www.ag.ndsu.edu/publications/crops/care-and-maintenance-of-irrigation-wells



https://www.ag.ndsu.edu/publications/crops/care-and-maintenance-of-irrigation-wells

BOREHOLE DEVELOPMENT

The main objective is to repair damage done to the formation by the physical operation of drilling.

The following steps must be followed:

- Flushing out of the borehole drilling fluids, which were introduced during the drilling process to allow the gravel pack to settle and consolidate.
- Reverse any chemical or physical changes to the formation surrounding the borehole, which was brought on by the drilling activities and or drilling fluids.

https://www.sswm.info/content/well-development-rehabilitation

SMET, J. (Editor); WIJK, C. van (Editor) (2002): Small Community Water Supplies: Technology, People and Partnership: Groundwater Withdrawal - Chapter 10. The Hague: International Water and Sanitation Centre (IRC). URL [Accessed: 29.02.2012]

http://welldrillingschool.com/courses/pdf/WellDevelopment.pdf

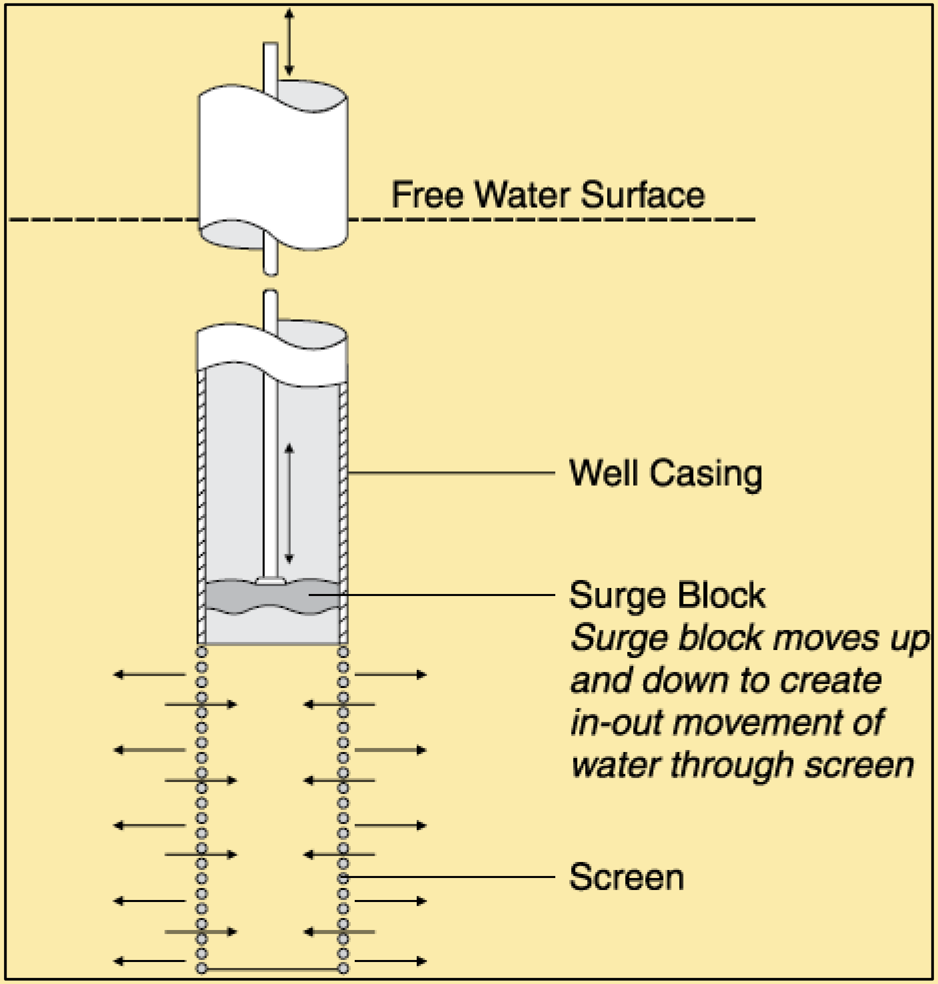
BOREHOLE DEVELOPMENT

Over-pumping: This method entails pumping the well at a rate greater than in normal operation.
This is the simplest but least effective method.
It generally only develops the more permeable sections of the aquifer.
Since water only flows inwards toward the borehole it can draw excessive material against the screen openings, creating a condition termed bridging, in which the formation is only partially stabilised.
Formation material may subsequently enter the hole if the formation is agitated and the bridges collapse.

Surging: This very common method flushes water backwards and forwards through the screen, as to prevent any bridging behind the screen and moving fines through into the hole.
The surge effect can be generated by intermittent pumping and repeatedly allowing the water column to fall back into the hole, or preferably by mechanical means using a close-fitting plunger/bailer (surge block) moved up and down on the hole by the drilling rig. The bailer acts as a piston in the screen to pull loose material into the well for subsequent removal (WURZEL 2001).

https://www.sswm.info/content/well-development-rehabilitation

BOREHOLE DEVELOPMENT



Mechanical surging with a surge block

https://www.ag.ndsu.edu/publications/crops/care-and-maintenance-of-irrigation-wells

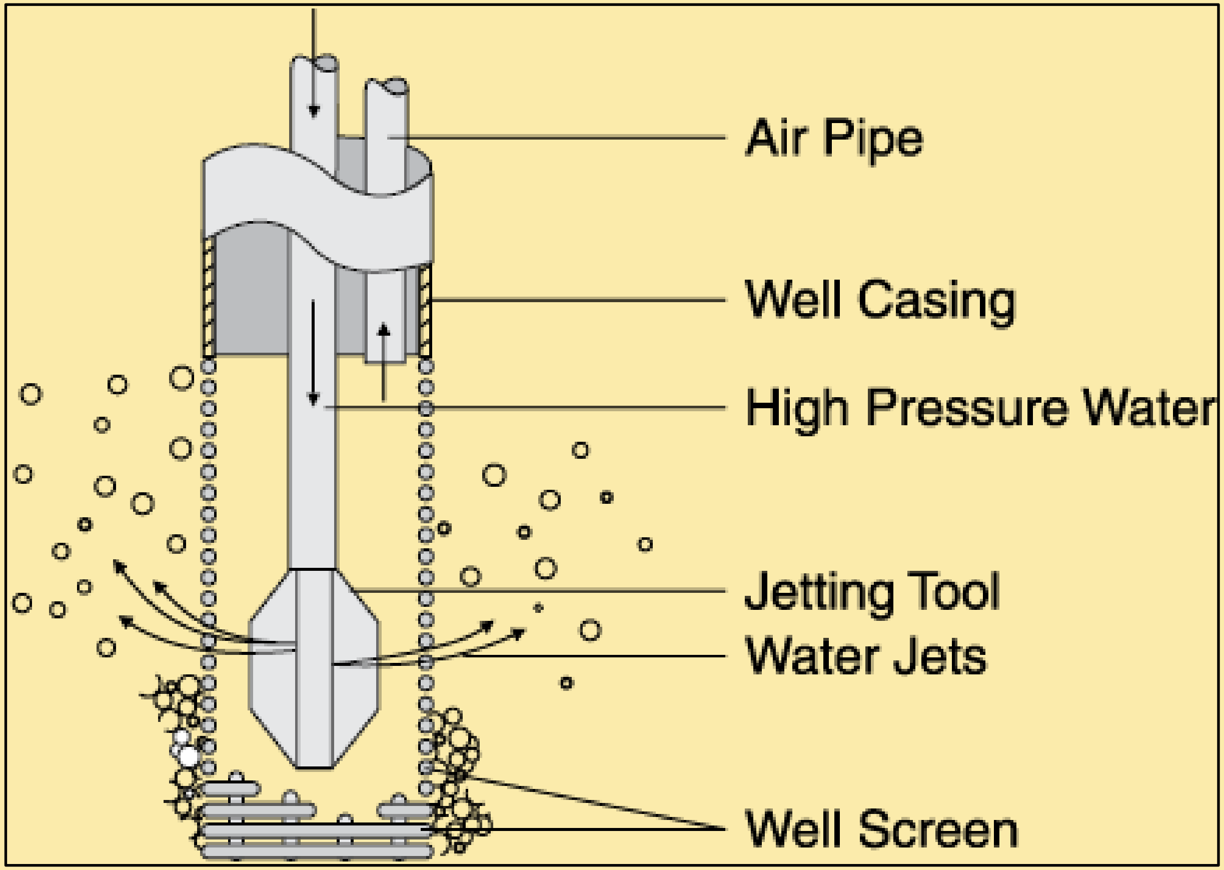
BOREHOLE DEVELOPMENT

Air surging and pumping: This technique uses an airlift pumping action in combination with the surging effect described above. Air is injected into the hole to lift the water column, and then shut off such that the column falls back into the hole.

Jetting: This development method uses the injection of high-pressure air or water through the screens to remove fines and drilling fluids. It uses a special jetting tool that directs horizontal jets onto the screens to break up any filter cake and agitate and flush the adjacent gravel pack or formation. This method is most appropriate with rotary rigs.

Jetting and simultaneous pumping: This method combines high pressure water jetting with pumping (usually using an airlift system) and is particularly applicable in unconsolidated sands and gravel. Essentially the jetting process loosens the fine material and the pumping action draws it through the screen and directly to the surface.

BOREHOLE DEVELOPMENT



High-velocity water jetting

w.ag.ndsu.edu/publications/crops/care-and-maintenance-of-irrigation-wells

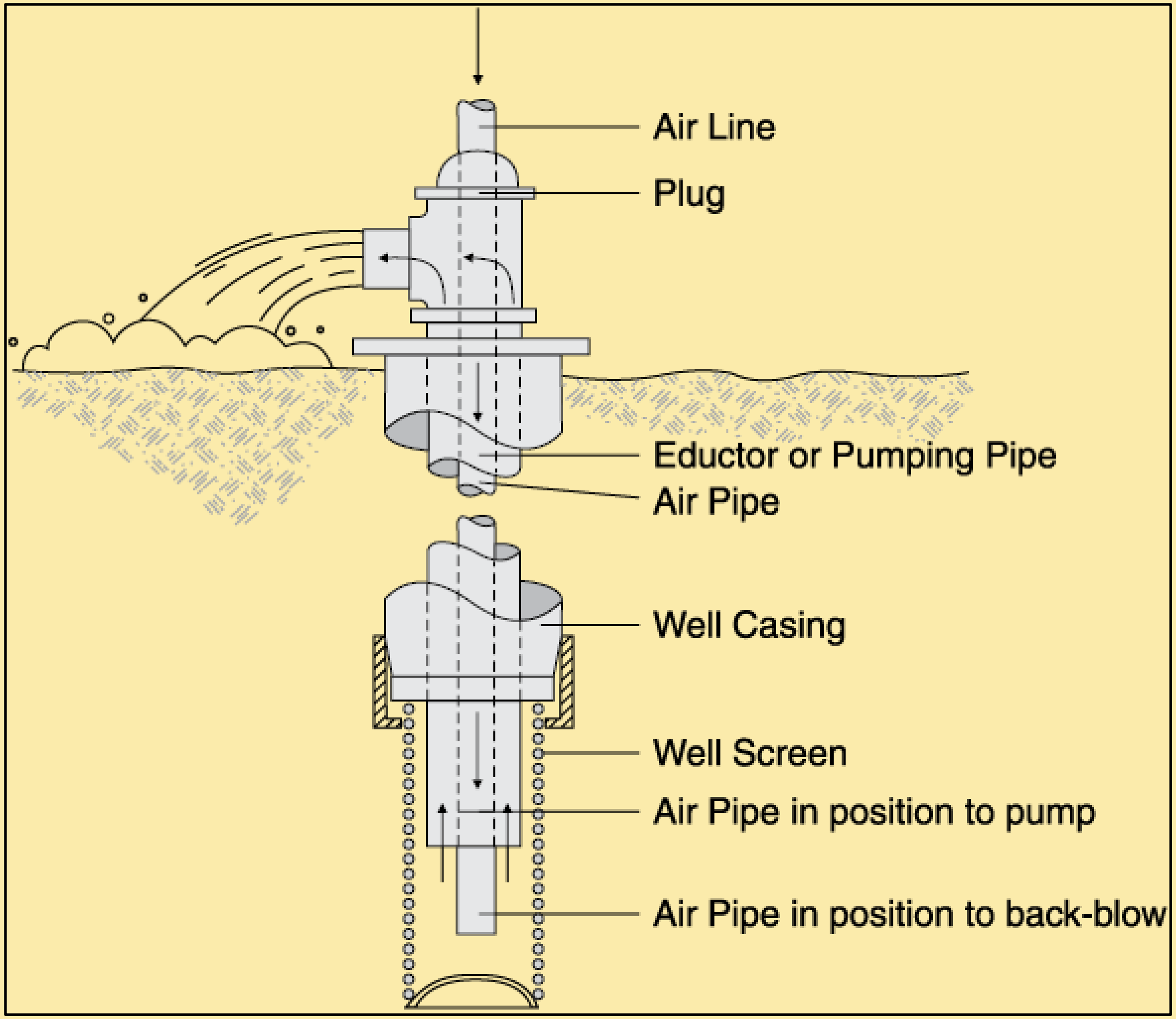
BOREHOLE DEVELOPMENT

Hydro-fracturing: high-pressure pumps are used to inject fluid to overcome the overlying rock pressure and open up existing and new fractures that will enable water movement into the borehole. Considerable pumping pressure is required.

Supplementary development methods: Other development or stimulation methods include the use of acid injection in carbonate aquifers to enlarge fissures by dissolution of aquifer material, and "shooting" in hard-rock terrain using explosive charges placed in the borehole to increase the number of fractures around the hole.

Such methods are very specialized techniques and are not commonly used in the majority of water borehole drilling work.

BOREHOLE DEVELOPMENT



Airlift pumping

https://www.ag.ndsu.edu/publications/crops/care-and-maintenance-of-irrigation-wells

WELL REHABILITATION

Typical Causes for Reduced Well Yield

- Mechanical Blockage (e.g. fine-grained soil materials, corrosion by products)
- Chemical Encrustation (e.g. iron/manganese oxides, calcium/magnesium carbonates, sulphates)
- Bacteriological Plugging (e.g. iron *bacteria*)