Water Resources Department

Second Class

Drainage

By

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Drainage :- It is the process of reducing the water content to the amount which is essential for successful irrigation

The Purpose of Drainage :-

The main purpose of drainage :-

Supply appropriate environment for growth of plant roots to increasing of production.

Increasing the area, that the roots of plant diffuse with it.

Decreasing the salts that diffused in the root zone.

Decreasing the water that occupied the pores in the root zone.

Drainage Investigation

Topography :-

Supply maps with different scales to using it to performing project, for example maps with scales 1 : 10000 – 1: 25000 showed contour interval equal to 0.25 m for put the final design of a main drainage system. With increasing of leveling degree of land. The contour interval decreased.

Drainage investigation

Observation wells

Piezometer

Ground water movement

Aquifer

Type of aquifer

Drainage investigation

Primary elements that concern the Drainage investigation

- Topographical map of the area.
- Soil investigation
- Investigation of ground water table

Aquifer: is a geological information that can store and transmits a significant amount of ground water.

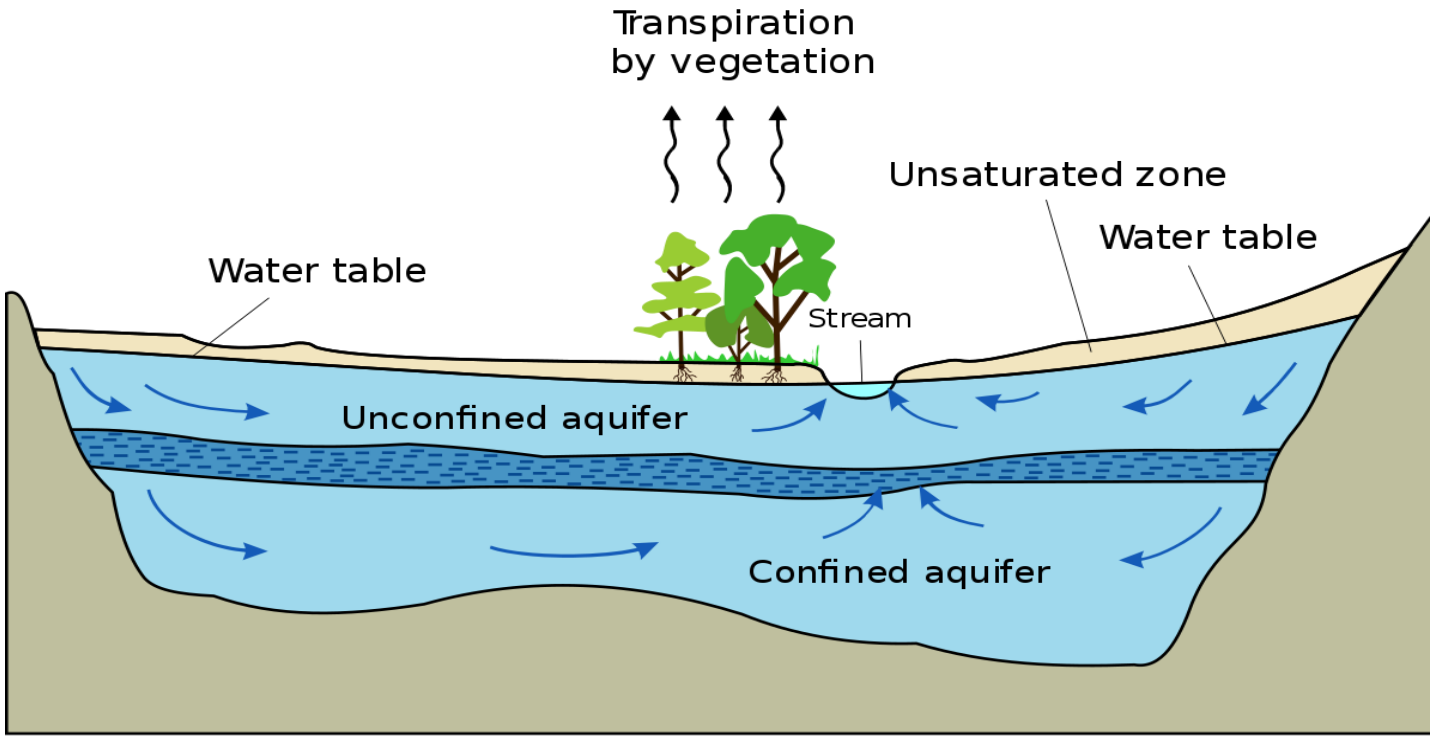
Type of aquifer

- Confined aquifer
- Un confined aquifer
- Semi confined aquifer

A confined aquifer: is an aquifer bounded both at the bottom and at the top by an impermeable layer.

An unconfined aquifer, also called a **water-table aquifer:** is an aquifer which has the water table as its upper boundary and at the bottom bounded by an impermeable layer

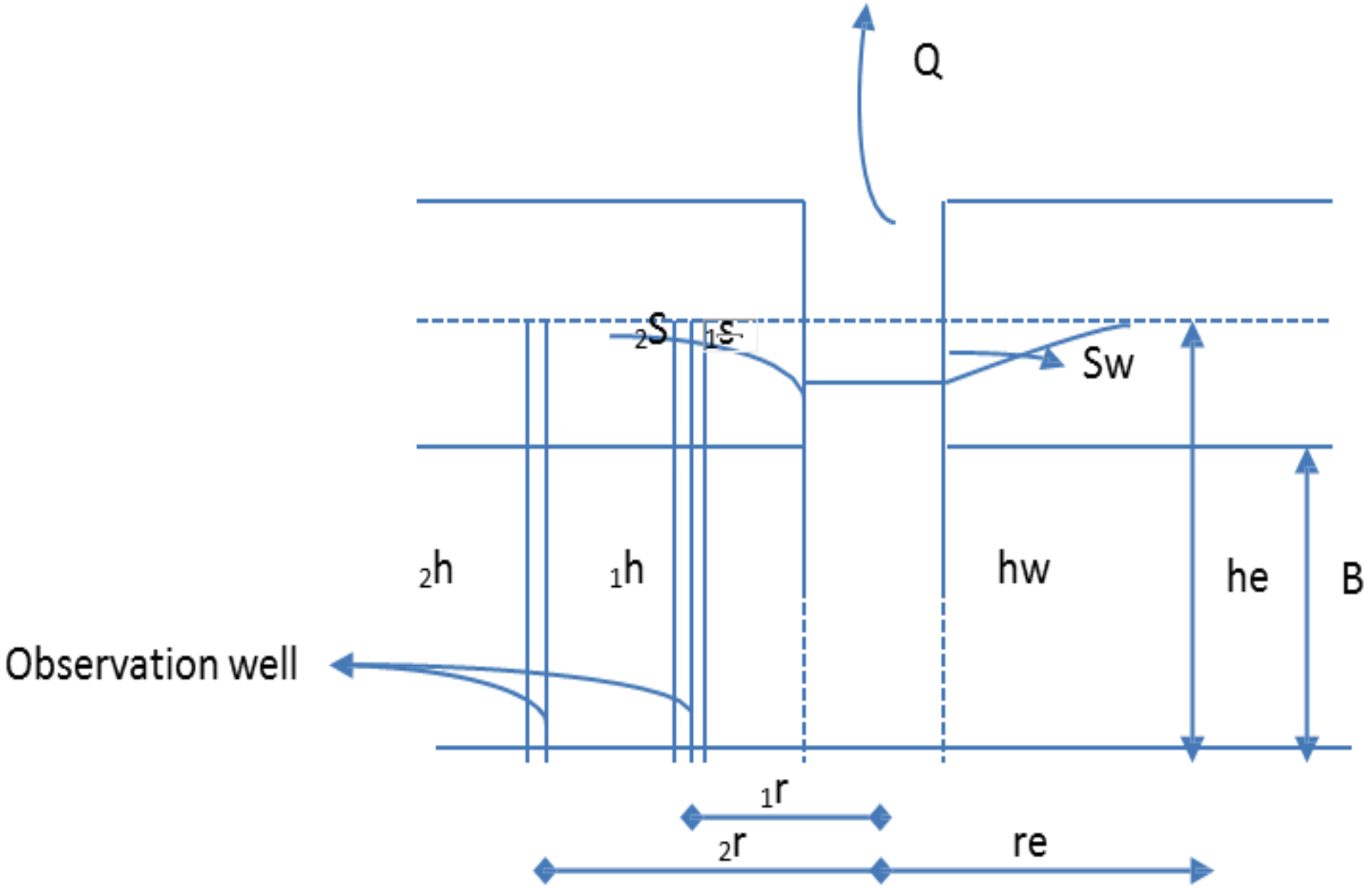
A semi-confined aquifer: is an aquifer bounded at the bottom by an impermeable layer and bounded at the top by semi permeable layer.


Transpiration
by vegetation
Unsaturated zone
Water table
Water table
Stream
Unconfined aquifer
Confined aquifer

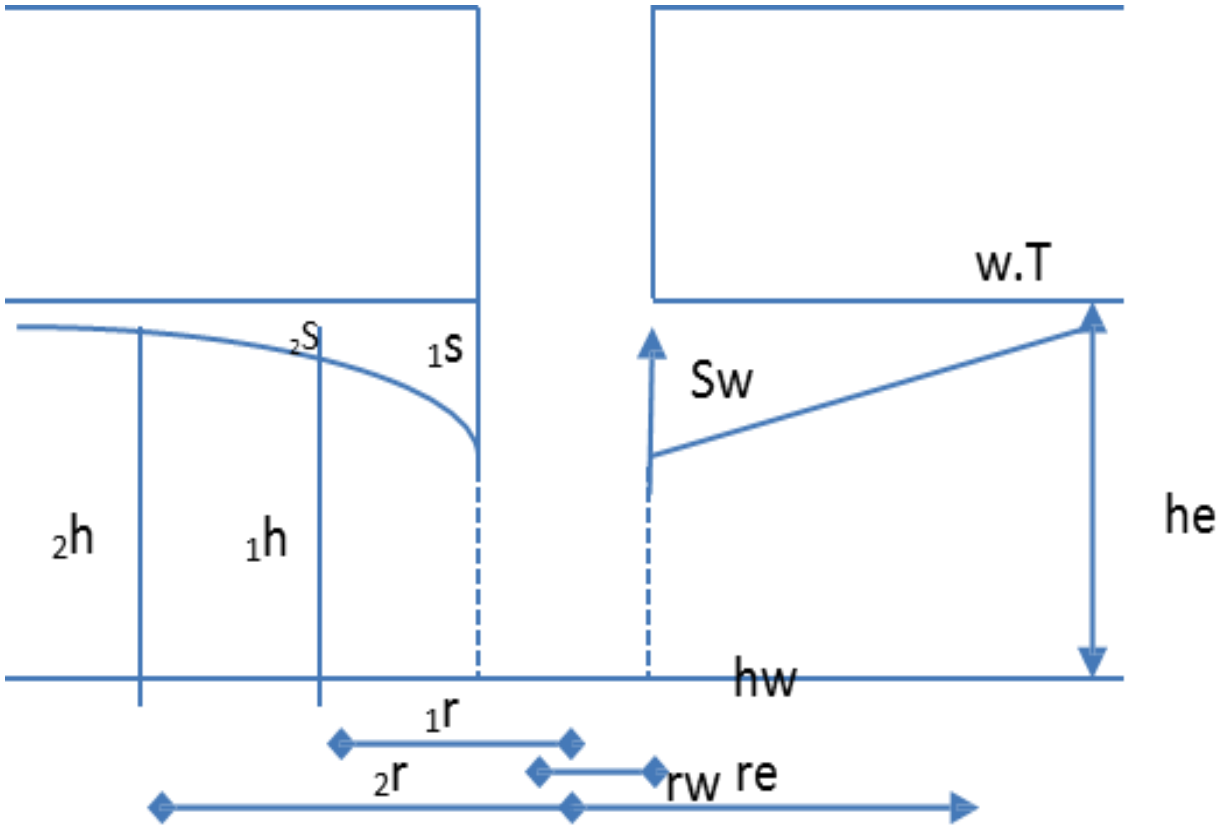
Wells Hydraulics

Steady flow into well :-

A- Confined aquifer



B- Unconfined aquifer



Specific capacity

$Sc =$ Indication for the productivity of the well.

$$Sc = \frac{Q}{Sw}\ , Sw = he - hw$$

a- For confined aquifer

$$Q = \frac{2\pi T}{Ln\frac{re}{rw}}(he - hw)$$

b- For unconfined aquifer

$$Q = \frac{\pi K}{Ln\frac{re}{rw}}\left({h_e}^2 - {h_w}^2\right)$$

Homework a well 0.3m diameter is driven in an aquifer having confined flow. The water level when not being pumped is 30m above the impervious layer. When water is pumped at 36.0m3/h, the drawdown below the ground water level in the observation well at a distance of 30m is 1m and in another well at a distance of 90m is o.6m. Calculate the drawdown at the pumping well, the radius of the circle of influence, and the coefficient of transmissibility of the aquifer.

Permeability

Laboratory measurement.

Factor affecting on soil permeability

Permeability is the property of the soil that allow water and any fluid pass through it.

Permeability related with Darcy law as shown in equation

$$v = K * i$$

V= velocity of water in soil.(velocity discharge)

$i=\Delta h/L$ = hydraulic gradient.

K=coefficient of permeability (hydraulic conductivity)

- Two type to calculate coefficient of permeability.

1- Laboratory measurement.

2- Field measurement.

- Laboratory measurement Two types:-

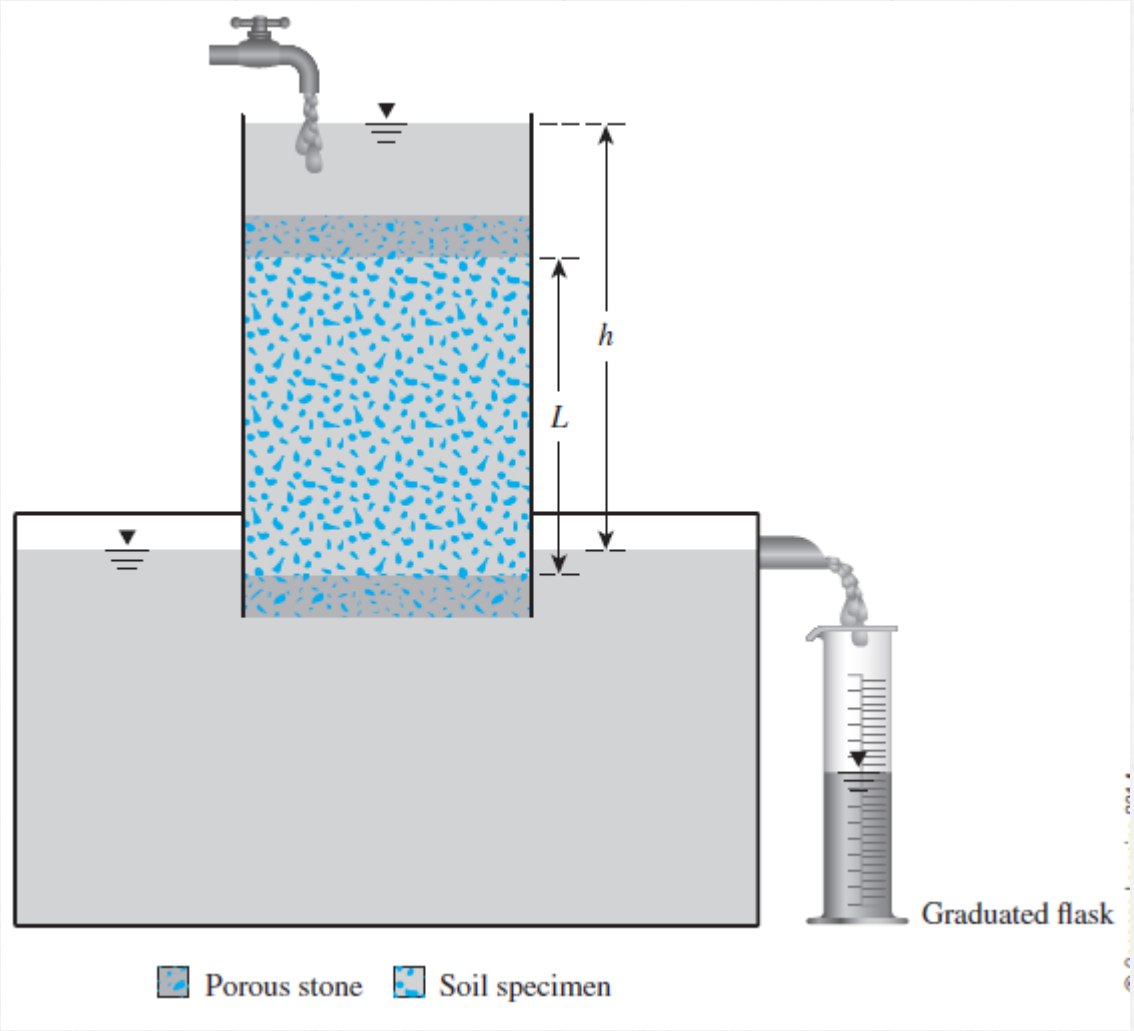
1- Constant head test.

2- Falling head test.

1- Constant head test

Suitable for coarse grained soil such as gravel, coarse medium sand.

The principle of the test is to measure the volume of water flowing through a soil specimen in a given time and determine the permeability from the discharge using Darcy's law.


h
L
Graduated flask
Porous stone
Soil specimen

$$K = \frac{VL}{Aht}$$

V = Quantity of water (Volume of water).

t= Time of test.

A= Area of Sample.

h = Constant head.

L = Length of sample

Ex/ A sand sample of 35 cm^2 cross sectional area and 20 cm long was tested in a constant head permeability. Under a head of 60 cm, the discharge was 120 ml in 6 min. Determine (a) the hydraulic conductivity in cm/sec, (b) the discharge velocity.

$$K = \frac{VL}{Aht}$$

$$K = \frac{120 \times 20}{35 \times 60 \times 6 \times 60}$$

$K = 3.174 \times 10^{-3}$cm/sec

b) The velocity discharge

$$v = K * i$$

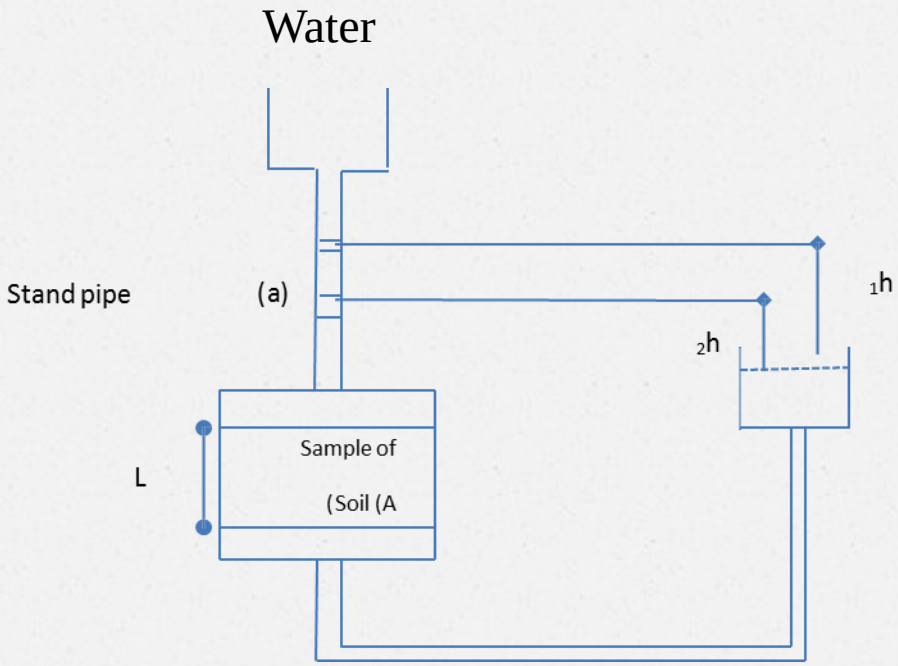
$$v = 3.174 \times 10^{-3} * \frac{60}{20}$$

$$v = 9.52 \times 10^{-3}\text{cm/sec}$$

H.W/ Constant head permeability test results: Length of Sample (L) = 12 cm Sample Diameter (cylindrical sample) = 2.0 cm Constant Head Difference = 2.5 cm Volume of Water Collected in 5 minutes: 20 cm^3 Determine the coefficient of permeability for the tested soil in m/day.

2- Falling head test.

Suitable for fine grained soil such as fine sand and silt, clay. Before the start of the test the soil sample is saturated by allowing the water to flow continuously through the sample from the stand pipe. After saturation is complete, the stand pipe is filled with water up to a height of h_1 and a stop watch is started. Let the initial time be t_1. The time t_2 when the water level drops from h_1 to h_2 is noted. The hydraulic conductivity k can be determined on the basis of the drop in head (h_1 - h_2) and the elapsed time (t_1- t_2) required for the drop as explained below.


Water
Stand pipe
(a)
$_1h$
$_2h$
Sample of
(Soil (A
L

$$K = \frac{a*L}{A*t} \ln \frac{h_1}{h_2}$$

$a=$ cross area of pipe.

$L=$ length of sample of soil.

$A=$ cross area for sample of soil.

t=The time of the water falling from(h_1 to h_2).

Example :- By using Falling head test calculate the time required for h_2= 0.9 h_1, cross area for pipe = 1 cm2 , cross area for sample of soil = 100 cm2 , length sample of soil = 10 cm, first head of water h_1 = 100 cm, k = 10^{-7}cm / sec.

$$K = \frac{a * L}{A * t} \ln \frac{h_1}{h_2}$$

$$10^{-7} = \frac{1 * 10}{100 * t} ln \frac{100}{0.9 * 100}$$

t= 1.2 day

Example: In a falling head test, initial hydraulic head was 55 cm after 65 minutes fall down to 18 cm. Length of soil sample 10 cm, soil sample radius 7.5 cm and tube radius 1 cm, Calculate the hydraulic conductivity in cm/sec

T= 65 *60=3900 sec

$$K = \frac{a*L}{A*t} \ln \frac{h_1}{h_2}$$

$$K = \frac{10*\pi*1^2}{\pi \times 7.5^2*3900} \ln \frac{55}{18}$$

$$K = 5.09 * 10^{-5} cm/sec$$

Factor affecting on soil permeability

1- Void Ratio : increase the permeability of the soil lead to increase the ratio voids

2- Particle size : increase Granule size by increase permeability

3- Particle shape: Example, circular permeability it less from angular shape

4-Temperature: increase permeability by increase temperature .

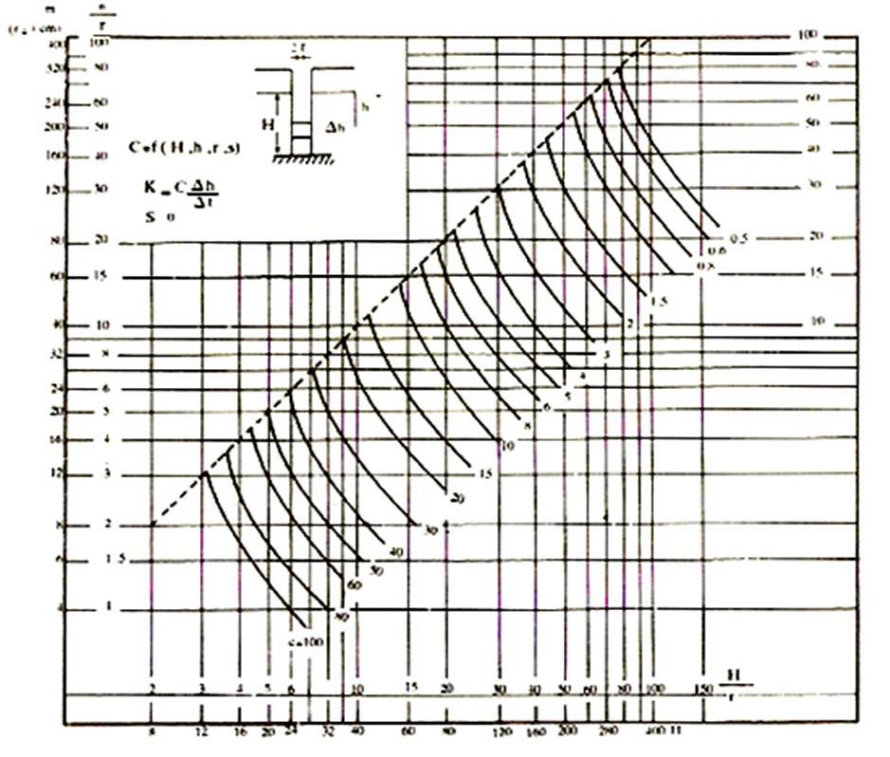
5- Saturation: Saturated soils permeability it is few.

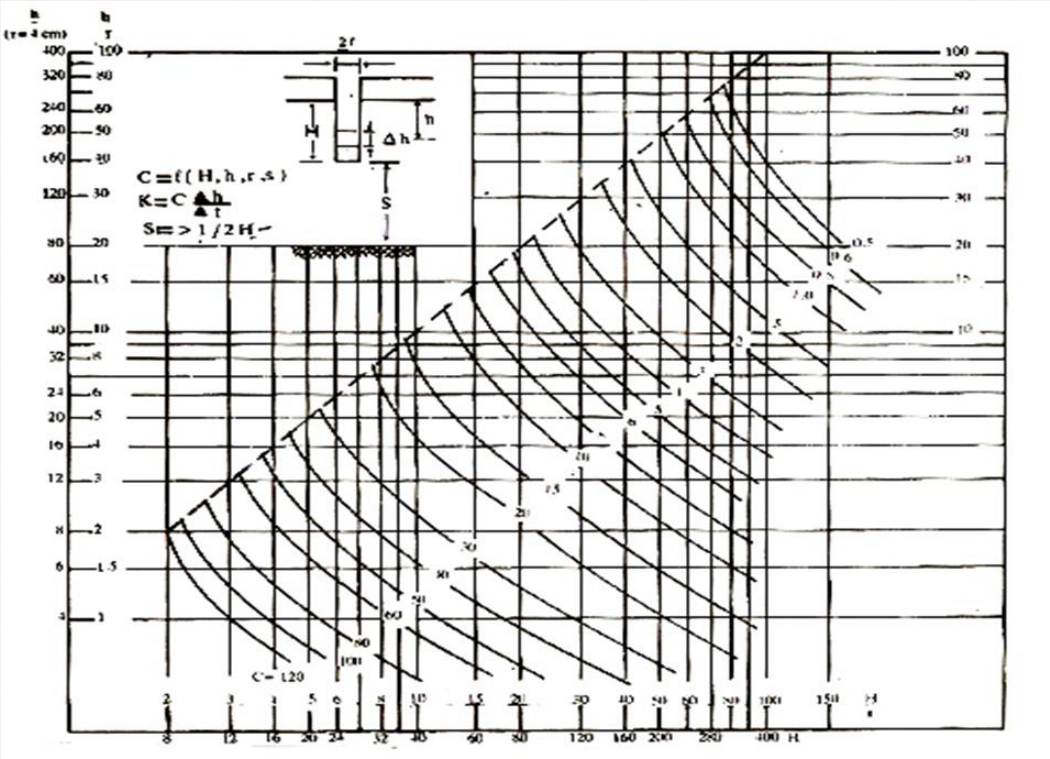
H.W/ The hydraulic conductivity of a soil sample was determined in a soil mechanics laboratory by use a falling head permeameter. The data used and the test results obtained were as follows: diameter of sample = 2.36 cm, height of sample = 5.91 cm, diameter of stand pipe = 0.79 cm, initial head h1 = 17.72 cm. final head h2 = 11.81 cm. Time elapsed = 1 min 45 sec. Determine the hydraulic conductivity in m/day?

Field methods for measuring hydraulic conductivity under ground water table

- ***Auger hole method :-***

The method of the auger hole is used to measure the hydraulic conductivity under the ground water level. The basis of the method is to dig a hole in the soil by the auger to a depth below the ground water level. When the ground water in the hole reaches a level equal to the level of ground water in the area around the hole, Part of which is still for measurement purposes. Then the ground water begins to seepage into the hole and its rate of rise is determined. The hydraulic conductivity of the soil is calculated using the special equation that we will explain in addition to the use of the diagram showing the relationship between the rate of rise of ground water and the state of ground water conditions and shape and dimensions of the hole geometry .This method gives us a measure rate of the hydraulic conductivity of the soil column which diameter, (30 cm), which extends in the ground water level to a depth of 20 cm below the bottom of the hole or to the depth of the impermeable layer

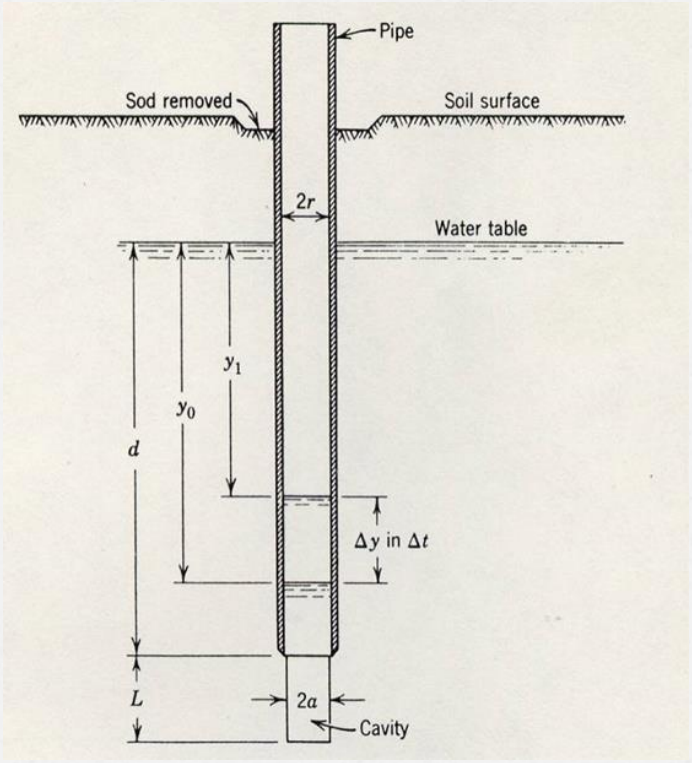

C=f(H,h,r,s)
K = C Δh/Δt
S = 0
H
Δh
h
2r
0.5
0.6
0.8
1.5
2
3
4
5
6
10
15
20
30
40
50
60
80
c=100
H/r


C=f(H,h,r,s)
K=C Δh/t
S=>1/2H
C=120

Piezometer method

Piezometer :is pipe has diameter 1 cm open sides that is fixed in the ground and its purpose is to measure pressure head by measuring the height of the water in the pipe.

The basis of this method is similar to the method of the auger hole method except the tube placed inside the hole, which leaves a small space between it and the bottom of the hole fig (23). Luthin (1978).


Pipe
Sod removed
Soil surface
2r
Water table
y_1
y_0
d
Δy in Δt
L
2a
Cavity

Field methods for measuring hydraulic conductivity above ground water table :-

Shallow well pump – in method طريقة الضخ في الحفر الاسطوانية الضحلة

There are two equations to measure hydraulic conductivity # under two condition :-

First :- $S > 2H$

Second :- $S < 2H$

First :-

$$k = \frac{Q}{2\pi H^2} \left(ln\left(\frac{H}{r} + \sqrt{\left(\frac{H^2}{r^2} - 1\right)} - 1\right)\right)$$

Second :-

$$k = \frac{3Q}{\pi H(3H + 2S)} \; ln\frac{H}{r}$$

In this way, a hole is drilled to a depth selected by the auger. After that, the hole is filled with water to a constant level. It is maintained so that the water flow inside the soil is constant and for the purpose of obtaining good results in this way it is preferable to have the water depth inside the hole at least ten times as much as the hole radius

Pumped bore hole method طريقة ضخ الماء من الحفرة

$$k = \frac{Q}{\bar{\bar{c}} L r}$$

Where

K= hydraulic conductivity (m / day).

Q= constant discharge (m^3 / day).

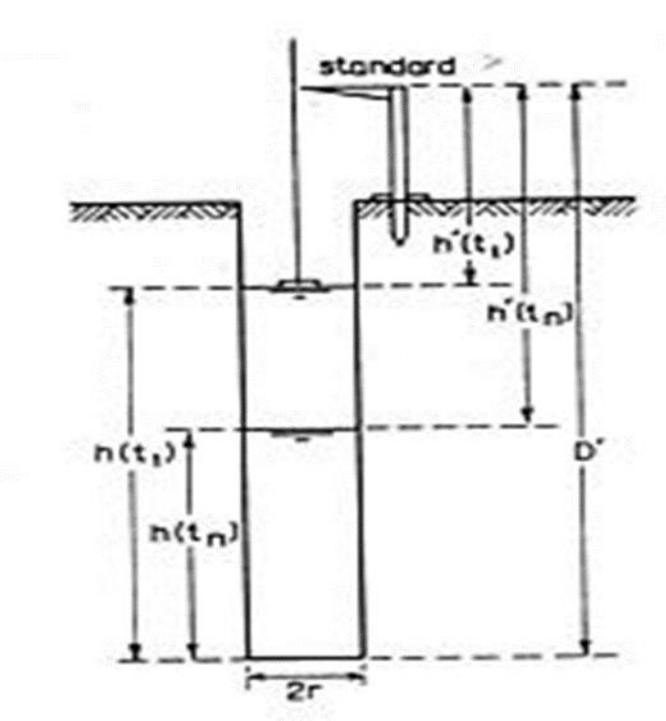
$$L = \frac{H^2 - h^2}{H}$$

H = depth bottom bore hole from initial G.W.T (m).

h = water height in bore hole after constant condition (m).

$\bar{\bar{c}}$ = Geometric coefficient that function to water height in bore hole and its radius that gained from graph.

Inverse bore hole methodطريقة حفر البريمة المعكوسة



This method is used to find the hydraulic conductivity of the dry soil where the ground water is deep and far from the layer where the permeability is measured. Any measurements are above the ground water level. This is called the name because water during the measurement period drops from top to bottom. This experiment to measure hydraulic conductivity under the surface water is also called the porchet method

Draw (ht1 + r / 2) with ti on semi logarithmic paper we obtain a straight relationship through which the value of tan α can be obtained. This relationship should be drawn to the set of measurements taken during the experiment to exclude incorrect readings

Infiltrometer method
طريقة جهاز قياس المغاض

In this method, use two tube different diameters, one inside the other, are placed together inside the hole, in addition to small piezometers that are drilled downwards and include vertical flow of water. The bottom of the hole is usually cleaned by a special device called the hole cleaner. The external tube, whose diameter is the same diameter as the hole for a few centimeters, is pushed into the bottom of the hole and filled with water. The inner tube is placed inside the center of the hole and pushed to a certain depth inside the hole. The depth of water (20-200 cm) should be maintained in both tubes.

Type of drainage

Surface drains: and their purpose is to remove excess water on the surface of the earth, which may be the result of heavy rain or excessive irrigation where the problem increases when the water collects on the surface of the soil, especially if the infiltration rate is so little that the water is not allowed to sink in ,this type of drain is necessary in lands with a high slope. In order to prevent the soil from erosion. In areas with low or no slope, this type of drain raising water pools from low sites

Sub surface drain which are located under the surface of the earth and the purpose of these **drainage** is to reduce the levels of water ground away so as not to interfere with the growth of the plant and not cause salinity in the soil and there are several types of subsurface drains

Open drain : are open channels with deep where cut for ground water and different dimensions depend on several factors, including the soil type. The engineering design of these drains is usually trapezoidal with an equal lateral slope fig. 2

- **B-Pipe drain:** is a pipe ceramic, cement or plastic pipes placed inside the earth in a trench dug for them and then surrounded by a quantity of filter materials prevent the entry of soil into pipe and then dump the pipes with soil to the surface of the earth. fig 3

D-Vertical drain: They are in the form of wells in which groundwater is drawn in two different ways (This is done by drilling wells under the ground water and then placed pipes are perforated in the area below the ground water inside these wells and to different depths according to the nature of the soil, then installed the pumps to pull groundwater from the ground, which leads to a reduction in the level of high ground water then the disposal of water drainage by the main drains to the outlets)

1-**Down wells:** this type of drainage is not common since it is confined to places where there are subterranean layers consisting of materials with high permeability such as gravel or fractured volcanic rocks with wide cracks reaching deep depths. The method is to collect the water drainage in low connection with well where allowed for water to fall in wells to down into the depths fig 6

This wells wasn't need pumps to discharge accumulated water because of presence of crack in rocks

Drainage wells: this type is diffuse in some region where drilled wells with deep connected with strata affecting on root zone. The ground water is lift by the pumps, the water is pumped from these wells and they are all united to the one region where they are remove faraway.

These types of wells are existence in alluvial lands, that geological structures prevent discharge of water through rocks; this type of wells is famous in vertical drainage grids. Fig 7

The disadvantage of vertical drainage comparatively with horizontal drainage :-

The vertical drainage are more complex.

The vertical drainage are less economics than horizontal drainage for small lands.

Not able to removing the excess surface water.

The vertical drainage is effective or successful, when the carrying layer of water are having ability to transmissibility at engineering condition.

At conditions of high rains during growing season that caused increasing of G.W.T, so the vertical drainage should be designed to reducing G.W.T quickly prevent any deformance of crops.

Drainage Network

Drainage network divided into:

1-Field drains

2-Collector drains

3-Lateral drains

4-Main drains

5-Main outlets

Design of open Drains

To calculate the discharge must be known :-

Area

coefficient Drains (CD)

Q = Area * coefficient drain

CD :- Discharge of water through the unit time.

CD (2-4) mm/day.

$* \ Q = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} A$ manning equation

Drainage duty:

For the design of the water sections to public drainage network may be necessary to know the average amount of water that comes from the process of drainage and unit area per day. It know **drainage duty**

Spacing of Drains

The limitation of distances between drains is more important especially infield drains, that's depend on several factors :-

The factors effects on water permeability in soil as, soil texture, porosity, and its physical and chemical properties.

Impermeable layer depth from drains, ground water movement, land slope that desired to drain.

Irrigation water quality, irrigation interval and irrigation frequency.

Climate conditions as rains and its intensity.

Depth of covered drains and its diameter and its construction method, and its effect on drainage efficiency.

Factors related with crop production as seeding method, crop kinds, roots depth, leaching requirement

Drain spacing formulas

Steady state flow

(Hooghoudts formula)

$S^2 = (4k_aH^2+8k_bDH)/q$ .....(A)

q = irrigation or drainage rate (2.5 – 3) mm/day.

تستخدم معادلة (A) في حالة (Field drainage) هو (open drain).

أما في حالة (closed drain) فتفترض وجود عمق مكافئ (d).

$$d = \frac{D}{1+\frac{8D}{\pi S} ln \frac{D}{u}}$$ .....(B).

d = Hooghoudts equivalent depth

u = effective perimeter of field drain

Non – steady state flow حالة الجريان غير المستقر

(Glover and Dumm formula)

في هذه الحالة يعني منسوب (drain level) يبقى ثابت.

Water table مقداره (H_t) وبعد فترة ينزل ويكون (H_0)

$$S^2 = \frac{\pi^2 \frac{k*d*t}{\rho}}{\ln(\frac{1.16H_0}{H_t})} \text{.....}$$

$$k = \frac{k_a d_1 + k_b d_2}{d_1 + d_2} \text{.....}$$

Ernst's Equation

total change hydraulic (H) = Summation of hydraulic changes of three component

-

Soil salinity

Soil salinity is the salt content in the soil; the process of increasing the salt content is known as **salinization**

Causes of soil salinity

The excess accumulation of salts, typically most pronounced at the soil surface, can result in salt-affected soils. Salts may rise to the soil surface by capillary transport from a salt-laden water table and then accumulate due to evaporation. They can also become concentrated in soils due to human activity, for example the use of potassium as fertilizer, which can form sylvite, a naturally occurring salt. As soil salinity increases, salt effects can result in degradation of soils and vegetation

Dry land salinity

Salinity in dry lands can occur when the water table is between two to three meters from the surface of the soil. The salts from the groundwater are raised by capillary action to the surface of the soil. This occurs when groundwater is saline (which is true in many areas), and is favored by land use practices allowing more rainwater to enter the aquifer than it could accommodate. For example, the clearing of trees for agriculture is a major reason for dry land salinity in some areas, since deep rooting of trees has been replaced by shallow rooting of annual crops.

Salt problem in soil and waters:(source of salinity)

Soil type

Management of soil

Salinity of irrigation water and (sea water)

Shallow water table will reduce leaching and introduce salts to the root zone

The Effect salinity of plants .

salt in the soil water may inhibit plant growth for two reasons

1- the presence of salt in the soil solution reduces the ability of the plant to take up water and this leads to reduction in the growth rate

2- if excessive amount of salt enter the plant in the transpiration stream there will be injury to cells in the transpiring leaves and this may cause further reduction in growth.

Water requirement for leaching salty soils

Water requirement for leaching salty soils: is that part required passage of water through the pores of the root zone to reduce the concentration of dissolved salts in the ground moisture to limit required

Thus, the amount of water required for washing depends on the:

1 - the degree of concentration of salts in the ground moisture

2 - the degree of concentration of salts in the water used in the washing

3 - the degree of concentration of salts in the ground moisture allowed and required accessible

The leaching efficiency (F)

Leaching efficiency: is the effective portion of the water used in the washing process for each of the amount of water used for the same purpose

Problem drainage in Iraq

Problems of Sedimentation in the drainage Iraq

Weakness of soil stability is one of the most important dangers facing the covered drains, and the topography of the flat land is determined by giving enough slope for drains and thus making it a Clogging with sediments is great probability .

Piping phenomenon :Is the movement of water quickly under the pipes of drainage through the soil of the trench formed small channels are called piping and which lead to drift amounts from dust into the drains, And this phenomenon leads to the closure of the pores of the cover drains and the destroy of the pipes with soil

Methods of land Reclamation

Reclamation of land : Is the treatment of one or more factors that negatively affect on the productivity of the soil using the methods of reclamation for exploit it and increase productivity

Type of lands that need to Reclamation operations

Reclamation of soils affected by salinity

Reclamation of acid soils

Reclamation of wet soils and marshy soils

Reclamation of sandy soils.

Reclamation of land limestone and gypsum

Reclamation of clay land

The Pumps

Is a mechanical machine that raises the water and pump it through the channels dedicated to irrigation, the work of the pump depends on to trouble the pressure in the suction pipe and inside the pump, which works to raise the liquid to overcome air pressure on the surface of the water on pressure inside the pump so it works to pull the water to the top

Type of The Pumps

Variable displacement pumps divided into :

Centrifugal pumps divided into:

Turbines pumps

Diffuser pumps

Volute pumps

Jet pumps

Axial flow pumps

Mixed flow pumps

Air lift pumps

Postive displacement pumps divided into :

Rotary pumps

Reciprocating pumps

Reciprocating pumps

The discharge of this type of pump is determined by the positive displacement of two or more spaces.

The movement of the piston inside the cylinder causes the displacement of the water,

so the discharge of these pumps depends on the cylinder , the speed of the piston movement, the number of pistons and the movement courses,

are characterized by low discharge , high maintenance cost, And cannot discharge turbid water,

It cannot operate at very high speeds and discharge is not continuous

requires great attention when operating but its efficiency is higher than the centrifugal pumps_

Drainage machine:

Grader – It can be a self-contained power unit or a towed vehicle by a tractor. A grader does not excavated but it levels and grades out to fine loose or deposit materials. A centrally mounted blade much narrower and f latter than a bulldozer's serves the purpose. It skims the surface of soil evening out the bumps and hollows. The blade can be lowered or lightly tilted to ad311st for the level of the graded surface.

Scraper – The machine works similarly to a grader but it has a container to hold the surplus soil after scraper .The container which is filled with soil can also serve the purpose of backfill of hollow ground.

Bulldozers- Heavy machinery equipped with special equipment used for road construction, fill drilling , removal of dirt barriers, grading and modification of land. It is one of the most important machines used in maintenance , where the conduct by sprayed sediments are removed from the channels and the drains by the excavators

The Maintenance

Is to keep the irrigation and drainage network in the best case of operating conditions at the lowest possible from cost and that all drains and streams are subject to consumption and to varying degrees

Type of maintenance

Routing Maintenance : Routine or normal maintenance which include all work necessary to keep the irrigation system ,It is the simplest type maintenance, and is normally done daily

Special Maintenance(Emergency) : This maintenance is related to special cases such as sudden stopping of irrigation and drainage pumping stations or the occurrence of fractures in irrigation channels and requiring quick procedures to be treated so as not to cause stopping of water on the farms or large damage in the network. This maintenance requires give prioritizing by use of maintenance equipment and staff in the project to treatment the damage.