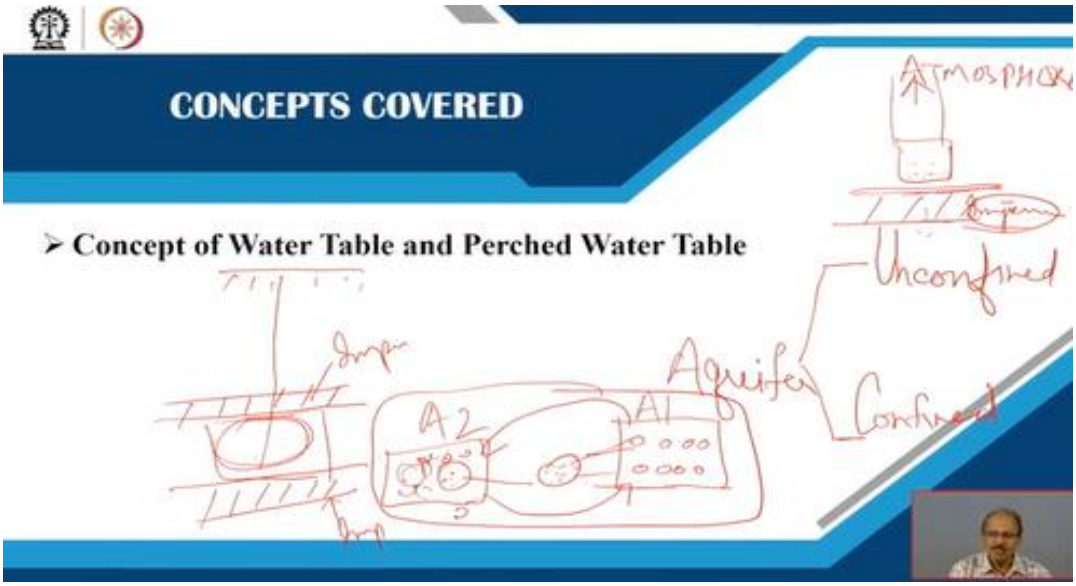
Availability and Management of Groundwater Resources
Prof. Prasoon Kumar Singh
Department of Civil Engineering
Indian Institute of Technology (ISM), Dhanbad

Lecture - 16
Confined and Unconfined Aquifer and their Parameters (Continued)

Welcome you all in the module 4 of the lecture series entitled confined and unconfined aquifers and their parameters. Today we will discuss the part second of this module 4 in which basically the concept related to the water table and perched water table will be discussed.

(Refer Slide Time: 00:45)



So, prior to it we have already discussed about the formations in general which restores the water and which behaves like an aquifer. When the term aquifer is coming it means any soil or rock formations which is having the characteristics of within it some pore spaces sometimes porosity as well as it is having the ability to move the water or to take the water from some other aquifer. To send some volume of water to another aquifer or to receive some volume of water from some other aquifer.

So, if a rock is having this characteristic having the good number of pore spaces are within it so it will store much volume of water it will just store good volume of water also it will store. So, this is storing good volume of water and also it is having some sort of connectivity with some

different trucks which are also having some pore spaces within it. So, in terms of volume number of pores are more so more amount of water is being stored here.

In other point is that these rocks are having good porous behaviour as well as they are also a very permeable, permeable means able to move means it is having availability to transmit the water from one aquifer say if it aquifer one and it is a aquifer two. So, it both the aquifers are a very good amount of pore spaces. So, they can store more volume of water plus they are having the availability to receive the water as well as to send the water to another aquifer.

So, this condition when it is coming with some soil or rock formation then the whole formation is termed as an aquifer. So, this in the previous lecture we have seen that the aquifer which is a rocky formation inside the earth's surface is basically on the basis of occurrence divided into two important types. Primarily it is divided into two important types one is the unconfined aquifer this is the unconfined and the second is the confined aquifer this is the confined aquifer.

We have developed the concept of this much in the previous lecture. What we have seen in the previous lecture also part 1 lecture series we have seen that these unconsolidated formations generally the formations which are remains saturated with water is termed as an aquifer. But when this saturated rock or the aquifer is having some impermeable rock within just down to it any formation say if it is an aquifer and just beneath it or underline to it remains an impermeable formation, this is impermeable formations.

So, what will happen? The water will remain stored in this formation and the upper portion will remain free with the atmosphere. So, it is remaining free with the atmosphere. So, when such condition will develop when any formations rocky formation will hold the water and its upper portion will remain in direct contact with the atmosphere. So, then such type of aquifer is termed as an unconfined aquifer because it is not remaining the water.

In such type of an aquifer is not remaining within any confined situation it is remaining unconfined. Only one underlain bed is there which is impermeable. Since it is impermeable so it is not sending the volume of water down so it can store the water here and the upper part remains

directly free in touch with the atmosphere. So, here in case of unconfined aquifer the water whatever the water groundwater remains within these formations is remaining there with the atmospheric pressure.

In this formation the water remains with the atmospheric pressure. So, because it is in direct contact with the atmosphere and the good example is of such type of aquifer is dug well. You can see in the well we are having the free surface; we can see the level of the water. When just we see inside the well, we are seeing the level of the water and this level of water is the good example of an unconfined aquifer.

Generally unconfined aquifer we are getting at cellular depth, this type of aquifer we are getting at cellular depth. Whereas some deeper aquifers also remain present inside the earth's surface. Some deeper aquifer means the aquifers which are having say aquifer which is remaining at greater depth and it is overline as well as underline both. Here only underline was impermeably this is the impermeable layer in case of unconfined.

But in case of confined aquifer, we are getting the impermeable rocks above and down below this type of rocks we are getting above it also and down. So, it can this formation this soil or rock formation is also storing the water but these water remains under confined condition. It is not remaining in freely with contact with the atmosphere. Since this is also impermeable and this is also impermeable so it is restricting the area of the water content here.

So, this water remains in confined conditions. Now what is the point? The point is that when in the unconfined aquifers we have seen when the since it is remaining in direct contact with the atmosphere so here the water remains with the atmospheric pressure. But here in case of this the water remains with the hydrostatic pressure not with the atmospheric pressure. This is the very important point here the water remains with the hydrostatic pressure in case of confined aquifer.

Whereas in case of unconfined aquifer the water remains with the atmospheric pressure. The point is when you will just puncture this aquifer confined aquifer just puncture by some sort of activities all on a sudden the water will move up to the ground surface. This is the ground surface

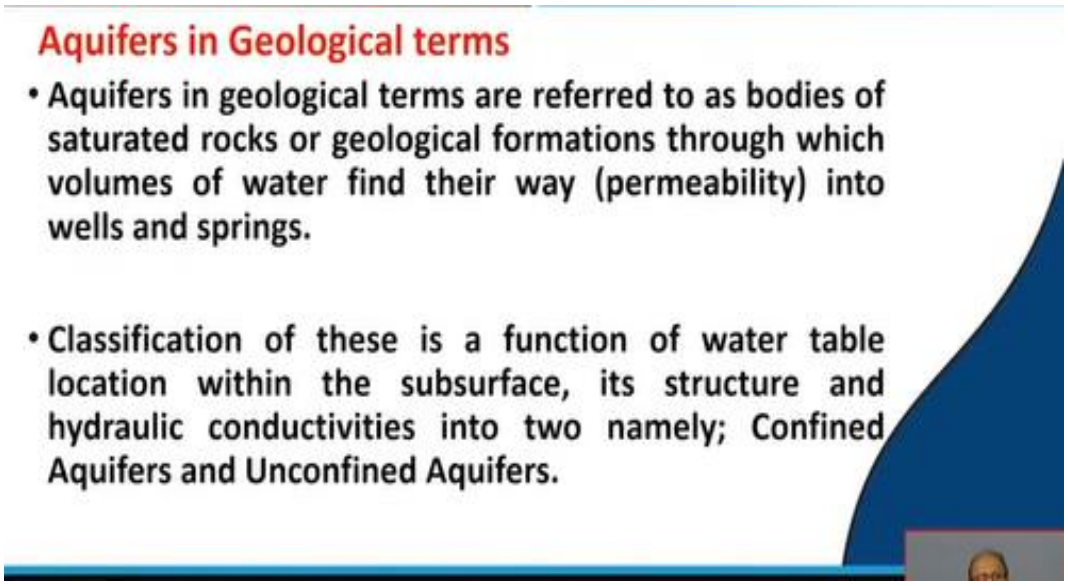
the water will move up which is called as an artesian condition. Since it is with the atmospheric hydrostatic pressure the water comes near to the surface.

Whereas in the unconfined aquifer we can able to see some depth of the water. So, here the level of the water what we are seeing in the case of unconfined aquifer is termed as water table, it is termed as water table. So, this is the upper layer of the water within an unconfined aquifer is termed as water table. So, this is the basic difference between two different types of aquifers. In one case the only the impermeable beds remain just beneath the aquifer.

But in another case, we are seeing the impermeable beds remains at the top as well as the bottom of an aquifer. And these impermeable beds are nothing but these are only the rocky formations. So, these are the different arrangement of the rocky formation within the earth's surface. So, different arrangement lies within the earth surface and when we are having a very good arrangement having some arrangement of some good porous rocks at a place with some impermeable behaviour rocks with just below it.

Then it behaves like a very good unconfined aquifer. So, this is the basic difference what we have learned just now that unconfined aquifer is of two types unconfined and unconfined aquifer. Now today as I told you the upper layer of the water body in of any unconfined aquifer is termed as water table. So, today we will discuss a bit more about the concept of water table and perched water table.

(Refer Slide Time: 10:53)

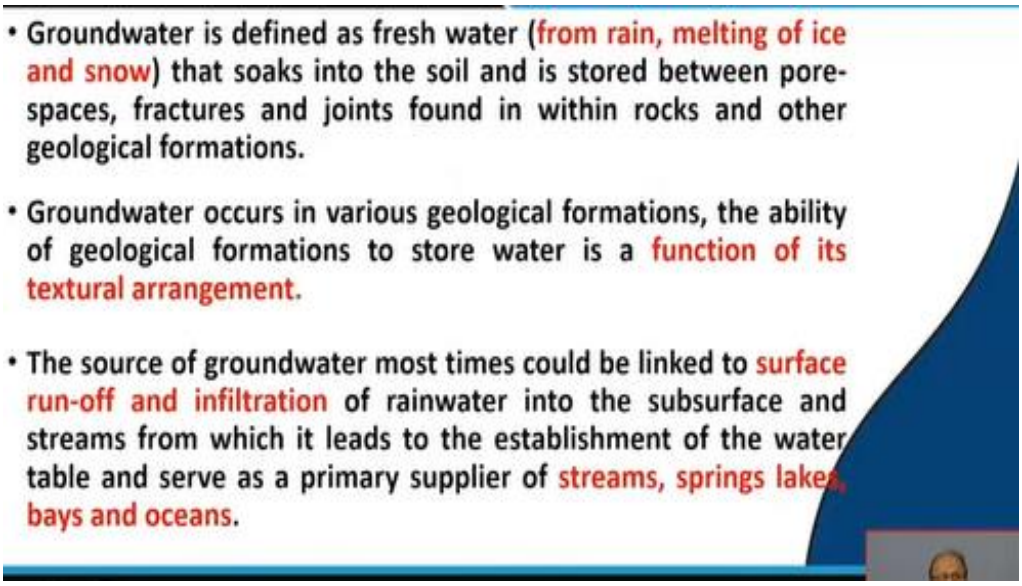


But before do it we have understood this that aquifers in geological terms are referred to as body of saturated rocks. Wherever aquifers we are using we must think about the it is some rock which is having some sort of saturation with water. So, saturated rocks or geological formation through which volume of water find their way because groundwater will have some sort of movement. So, permeability helps in it so into wells and springs.

So, this volume of water find their way to where to either some wells or to some springs through which the water can be extracted out. So, this is the general geological behaviours geological terms of aquifers. Classification of these is a function of water table location within the earth's surface. Wherever the water table is locating that is one of the important factor for its classification.

It is structural hydraulic conductivity into two different types of aquifer as discussed confined aquifers and unconfined aquifers. So, we are getting the two different types of aquifers.

(Refer Slide Time: 12:08)



Now since we are discussing about the availability of the groundwater resources so we should think that the groundwater, the fresh water from freshwater that soaks into the soil. it is being soaked into which into the soil and is stored where stored between pore spaces fractures and joints found within rocks and other geological formations. So, this rain water or melting of ice and snow when it just comes into the contact with the soil soaks the rain water or the melting of snow.

And ice and this water stored between pore spaces or fractures or joints as I discussed in the previous lectures also that the consolidated rocks are not having good number of pores within it. So, why it is storing the water? Because it is having some sort of fracture and joints and lineaments etcetera. Within this fracture, joints, lineaments the consolidated rocks can store more volume of water within it.

So, these are some of the geological formations which are storing the water and groundwater occurs in various geological formation. This also we have discussed in the lecture two the different formations, geological formations. So, the availability of geological formations to store water is because of the function of its textural arrangement. So, somewhere the groundwater is more in some formations in other places ground water is less in other formation.

This is a very important function of a textural arrangement how the rocks formations have to actually arrange at certain location. The source of groundwater most times could be linked to the surface runoff and infiltration of rainwater into the subsurface and streams from which it leads to the establishment of the water table and serve as a primary supplier of steam springs and lakes, bays and ocean.

So, in the later coming lectures we will discuss in greater detail about the surface runoff. Two things happen when the rain falls two things can happen. Based on the our information's with the hydrological cycles we are at present knowing that precipitation, evaporation, transpiration, surface runoff and the groundwater runoff they are few important parameters of the hydrological cycles which plays cyclically and it is very difficult to find its start and end.

That is why it is coming into the cyclic nature hydrological cycle. So, in this hydrological cycle we are seeing that one of the components is the run off. So, this means the volume of rain water which is coming down to the surface first it will try to just infiltrate down. Why it will try to go in inside the surface? Because the soil layer beneath the surface remains dry it is not having water body within it so it is perfectly dry situation.

So, if it is in perfectly dry situation so first drop of rain water will try to infiltrate down. This first drop of rain water will try to infiltrate down. As soon as it will move inside the first layer of the soil within the surface again it will try to send the top layer of water which just entered to the infiltration to the just beneath the different layers. So, point is that during the during the dry season when the rain water falls on the earth's surface.

It just comes down the term is infiltrate down and then percolates down and then moves towards the cavity and ultimately reaches to aquifer. But what will happen? See after five minutes of rain what will happen? Whether the same volume of water which has started to infiltrate down will remain there, never. Why? The point is that what is happening? When the first layer of the drop will fall when water drop will fall it will saturate the area.

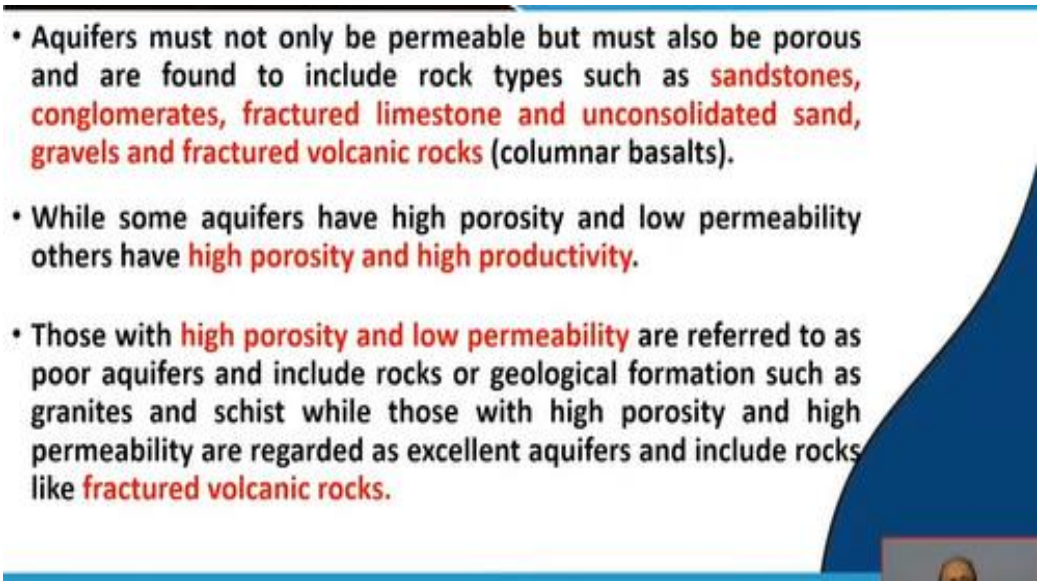
Saturate the area means what the total area which were earlier dried has become wet. Once it will become wet then the further it will not allow to send or infiltrate down and percolate down, never it will never allow. Then what will happen? The rain water with raining is going on so rain water will never comes down rather it will follow the topography, topography means surficial features whatever we are seeing from the top of the surface, surface shape feature.

So, it will follow the top surficial features and then what will happen? It will ultimately join to some river or water bodies at the just near to the point or at some distance. But ultimately it will meet to some river body. The point is what has happened? We have seen that during the rain when the rain has started the drops were able to move inside the surface, but after few minutes of rain now the drops are not entering into the surface rather the drops are accumulating.

And just flowing through the topography of the area and this volume of water are being wasted water. This volume of water is the rain water which is being wasted is termed as the runoff. So, runoff it is a surface runoff is through the surface of the earth. So, this high volume of water are being wasted from the area, once it will the area has become saturated from the water. So, this is runoff and this runoff and infiltration.

Basically, decides the area from where we can get good amount of good volume of water. So, this is very important, we will discuss in greater detail in the coming lectures.

(Refer Slide Time: 18:56)



Now aquifer must not only be permeable. If the aquifer one day in some lectures I have told you the good aquifer is that the aquifer which is porous as well as permeable then only it is said as good aquifer. If aquifers is it is not necessary that aquifer is a very good permeable it is a very good porous rock but it not having the ability to transmit then it is not for a good aquifer. So, aquifer must not only be permeable but must also be porous.

And are found to include rock types in which we are getting rocks getting sandstones, conglomerates, fractured limestone, unconsolidated sand, gravels and fractured volcanic rocks. So, in this generally we are meeting the points while some aquifers have high porosity and low permeability. Some aquifers you will see high porosity is there but permeability is very low means it can store more amount of water but it will not allow more volume of water to move somewhere else.

On other aquifers have high porosity and high productivity. So, those with high porosity and low permeability are referred to as pure aquifers I have told you, porosity is high but permeability is low. One point is that very good porosity very good permeability very good, but whether very good porosity and low permeability is good or not? No, it is a poor aquifer. Why? Because the; aquifer must have availability to take the water and to send the water.

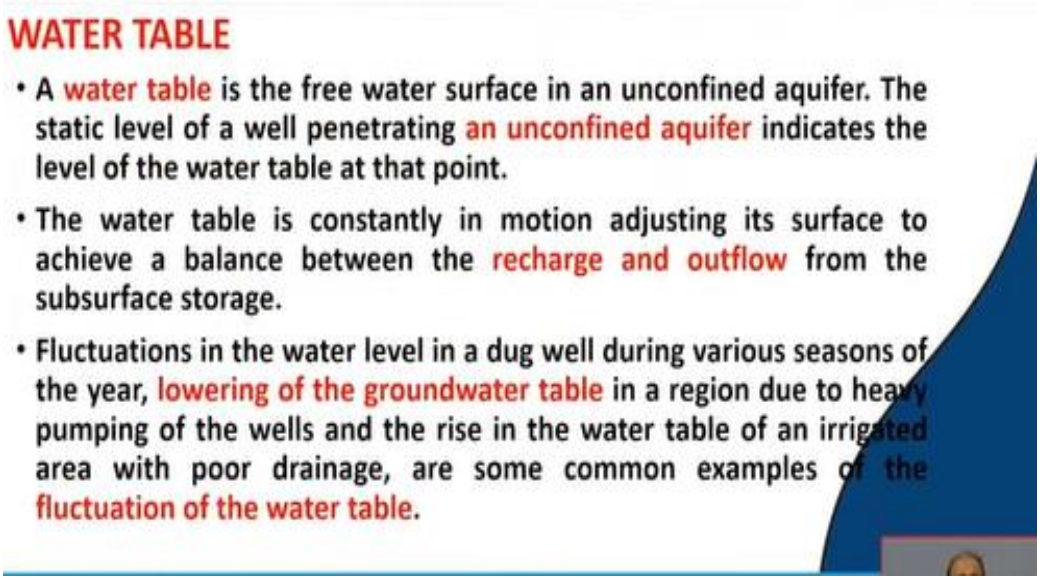
Why I am telling inside the earth's surface also we are having different rock formation at different alignment different height, different depth, different extent of the aquifer inside the earth's surface say porous. It will have good volume of water that is good. But if it is having the low permeability then whenever some extraction will be done, it may give water for a certain duration. But after that what will happen? Whether, it will give more, no never.

Why? Because it is low permeable, it is not having ability neither to receive nor to send. Then what is happening? It is not a very good aquifer. Although it is a highly porous rock formation but it is having the low permeable nature. So, it is poor aquifer. So, some of the rock formations are geological formations such as granites these are having high porosity but very low permeability.

While those with high porosity and high permeability is regarded as excellent aquifer. And the example is your fractured volcanic rocks. Fractured volcanic rocks these are having high porosity also and high permeability also. So, these are some of the points down the concept we should keep in mind as we are moving because our target is to find out how much water is available at a particular area and then what are the different parameters through which we can conserve the water in those areas.

The title of the subject is availability and management of groundwater resources. So, for knowing about the availability of the groundwater inside earth’s surface we are discussing the different aspects of the groundwater study in the present lecture.

(Refer Slide Time: 22:50)



Now water table as discussed, a water table in the free water surface in an unconfined aquifer. Wherever the water table term is come it will be related with the unconfined aquifer. The water table is constantly in motion it is adjusting its surface to achieve balance between the recharge and outflow from the sub surface to raise since it is remaining within certain rock formation aquifer. So, the fluctuation of the water table is on the basis of the recharge.

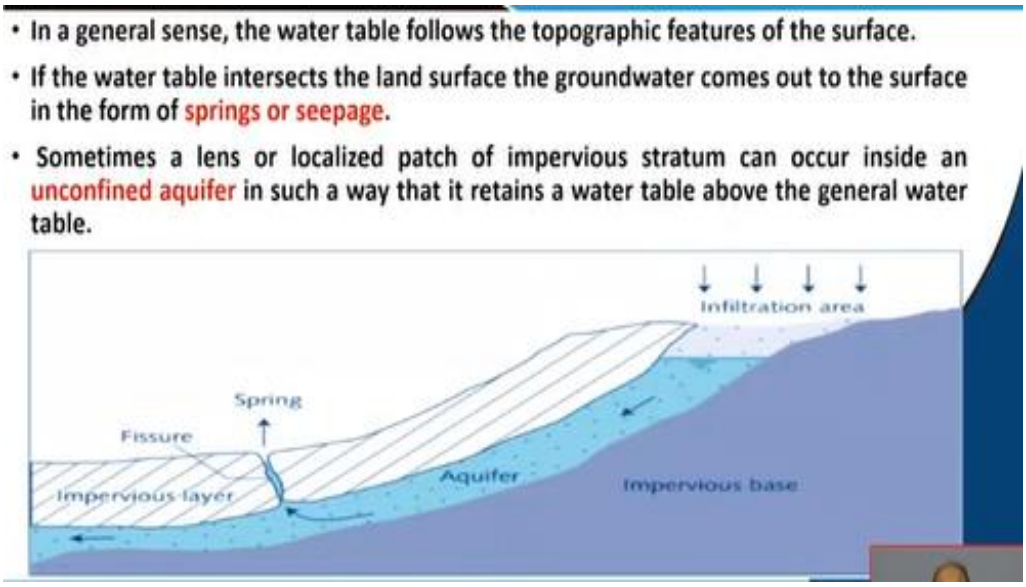
Recharge means after extraction if what is the level of the water. Suppose it is a well and in this well you have this is the level of the water this is the water table. But as soon as you will extract more water from this well so then the level of the water will go down, it will go down. So, the same here also it is water table here also it will be water table. Since, you have extracted the water from this well so level of the water is going down.

Now after few minutes or few hours or few minutes we can see that the earlier the level was here from where you have just started the pumping. So, after few hours you can see that the level has reached at the same point from where you have started the extraction. So, what it gives? It gives the idea that this aquifer because it is also an aquifer is having very good recharging capacity, it is having very good recharge in nature. It is having the availability to receive good amount of water.

Because once you have restructured the water so the level has gone down. But after overnight just in the morning again you are seeing that the level of the water has rest at the same place where we have measured day before yesterday or yesterday. So, this depicts that this area or this aquifer or this formation is a very good formation with respect to the porosity as well as permeability.

So, we are generally we are finding the water availability in the area with respect to the fluctuation of the water table. We can able to find out how much water remains present in certain areas, this can be find out after knowing the details about the water table depth from some instruments. So, this we will discuss.

(Refer Slide Time: 25:28)



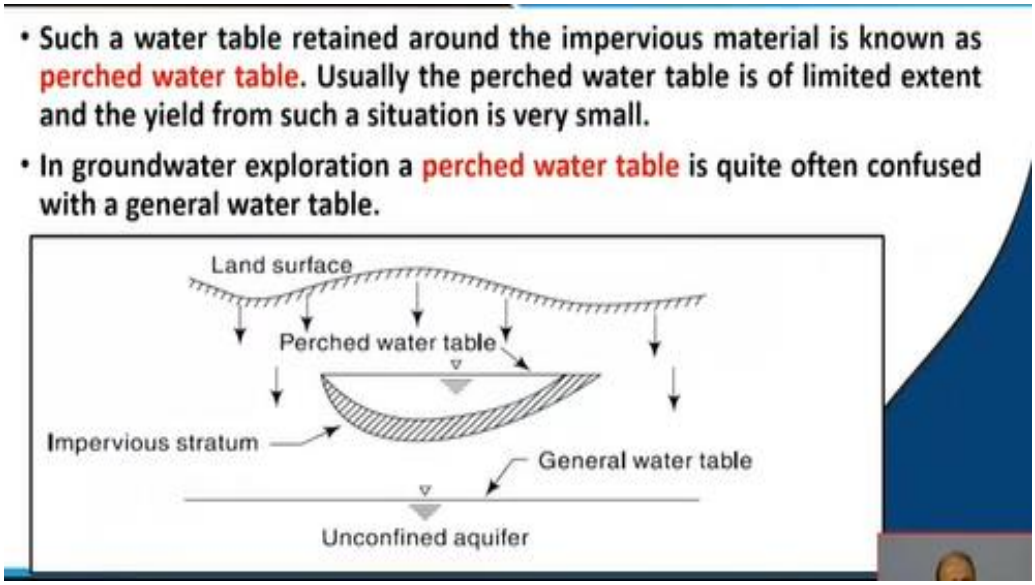
Now in general sense the water table follows the topographic features of the surface. This is very correct because a well is at the hill and at the well is at the plane. So, the depth of the water table will vary. So, what will happen? In general sense it follows the topographic features of the surface. If the water table intersects the land surface, then what is happening? The groundwater comes out to the surface and this behaves like the way we are seeing in the example we can see the springs.

The springs are just on the surface of the earth what happened? Here the water table just touches the surface of the earth. So, then the springs are coming out spring water we have seen few

springs and some hilly regions. Now sometimes this lens or localized part of impervious stratum can occur inside an unconfined aquifer. So, this also happens sometimes some your patch of impervious stratum can occur in unconfined aquifer.

Unconfined aquifer we have seen that there are some impermeable bed remains and the upper layer in touch with the atmosphere so this is an unconfined aquifer. So, here sometimes we are getting some of the impervious layer. So, what is happening in such a way that it retains the water to above the general water table. So, here what is happening?

(Refer Slide Time: 27:06)



This specific just we can see here this is a unconfined aquifer because we have seen some localized patch of impervious nature here impervious stratum has come for a certain area for means it will have volume of water but not in a greater context. So, here this is called as perched water table not the original water table what we have discussed. I know the water table remains with the unconfined aquifer in general and it is remained, it is just the upper layer of the water in any unconfined aquifer and it remains in contact with the atmosphere.

But sometimes what is happening? Some impervious body just enter into the unconfined aquifer situation then it behaves like in impermeable this is the impervious stratum so it will also store water here. So, here the upper layer of this stored water because of the impervious stratum which

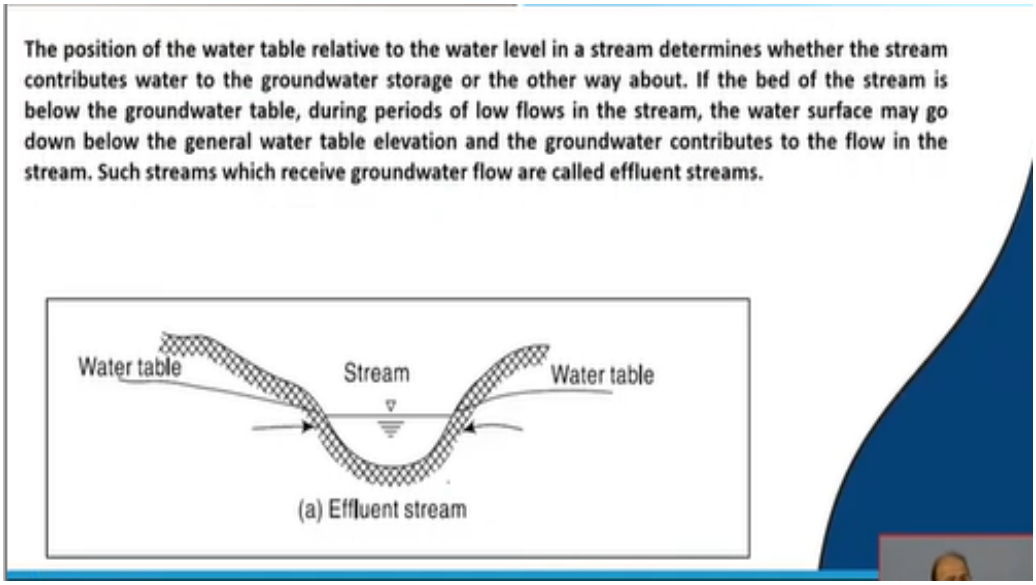
has come all on a sudden within an unconfined aquifer is not termed as water table but rather it is termed as perched water table.

So, usually the perched water table is of limited extent it is not a very regionally great extent it is a very limited extent and the yield from this type of small aquifer which is termed as perched aquifer is very low very small already very little. Because it all of a sudden it has developed within some unconfined aquifer situation. So, this type of aquifer is termed as first aquifer we have read only unconfined and confined.

Now we are knowing about the third name that is the perched aquifer, perched aquifer is an aquifer of a very limited extent within an unconfined aquifer when it is having some impermeable layer just beneath it, it will have small storage of water and also through it very poor yield remains very limited. So, this is called as perched water table. In groundwater exploration a perched water table is quite confused with the general water table.

Whenever the groundwater explosions are being done it is very difficult to know whether it is a water table or groundwater table.

(Refer Slide Time: 29:35)



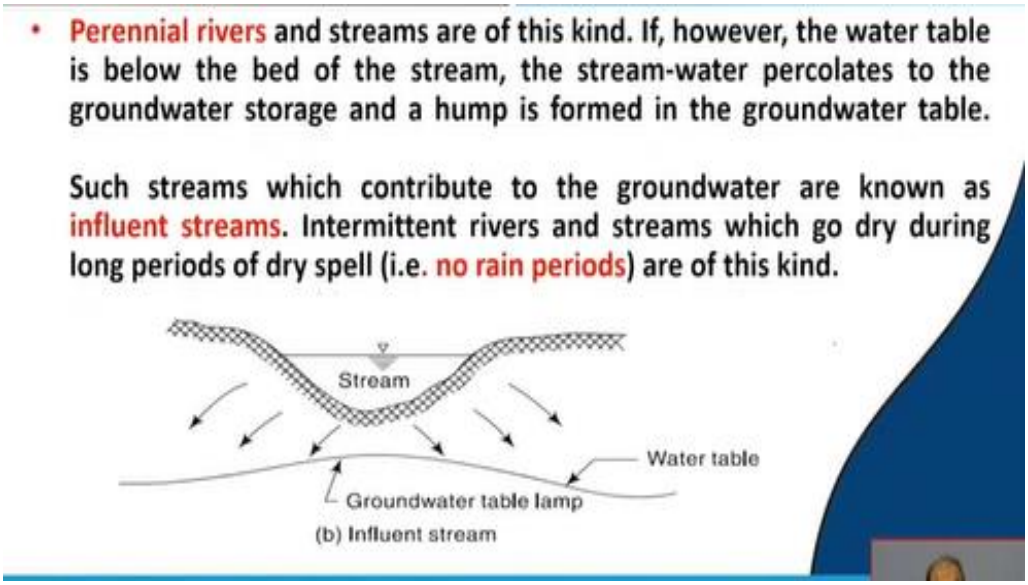
So, what is happening? The position of the water table relative to the water level in a stream determines whether the stream contributes water to the groundwater storage or the other way

about if the bed of stream is below the groundwater table. Say if this is the bed of the stream which is below the groundwater table then whatever during the periods of low flows in the stream the water surface may go down.

The water surface in the stream; suppose this is the stream and, in the stream, also we are having some rocks. So, when if the bed of the stream this rock beds are lying within it also above it the water flows. So, if the bed of the stream is below the water table during periods of low flow in the stream the water surface may go down below the general water table elevation and the groundwater contributes to the flow.

This groundwater which remains inside the earth it contributes to the flow in the stream, such stream which receives groundwater flows are called effluent streams. If any stream is receiving groundwater from inside in it then such type of streams which is receiving the ground water then it is called as effluent streams.

(Refer Slide Time: 31:02)



Now perennial rivers and streams are of this kind. Perennial rivers that is why sometimes we; are meeting with a river which is having water throughout the year. So, from where the water is coming? Because the groundwater which is remaining inside the is just sending water to the bed of the river and that is why throughout the years the water remains there and it is a very good example, perennial rivers and streams are a very good example of effluent river.

But some streams are also which contribute to the ground water are known as influent streams when the river water are being sent to the nearby aquifer underline aquifers. So, what is happening? River water, stream water is entering into the ground water in entering with the aquifer and making the groundwater, in such case the streams are called as influent stream. So, influent streams.

So, these intermittent rivers and streams which go dry during the long period of dry space of this kind. So, we have seen many streams during the summer season they becomes dry they are the good example of influent streams. Because in these streams there are lesser chance to have the groundwater and wherever we are also seeing some streams which is having a very good ability to store water throughout the year means it some connection from the inside.

And the inside aquifer means the groundwater sends water to the streams and that is why throughout the year the water remains within that in streams which is called as effluent streams. So, this is the basic difference between effluent streams and influent streams. So, with this concept we should know we will the next some of the important parameters of the aquifers and then we will learn about the different characteristics. Thank you very much.