Groundwater Hydrology and Management
Professor Pennan Chinnasamy
Centre for Technology Alternatives for Rural Areas
Indian Institute of Technology, Bombay
Week - 8
Lecture 1
Groundwater well type

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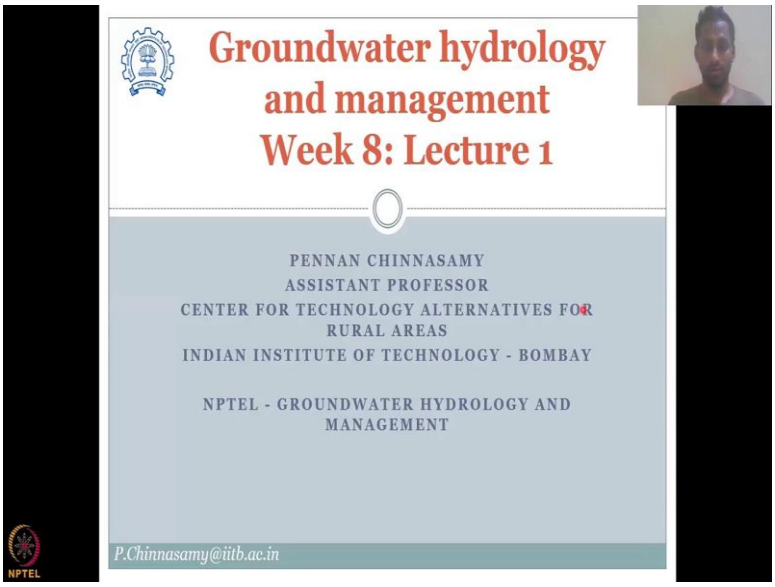

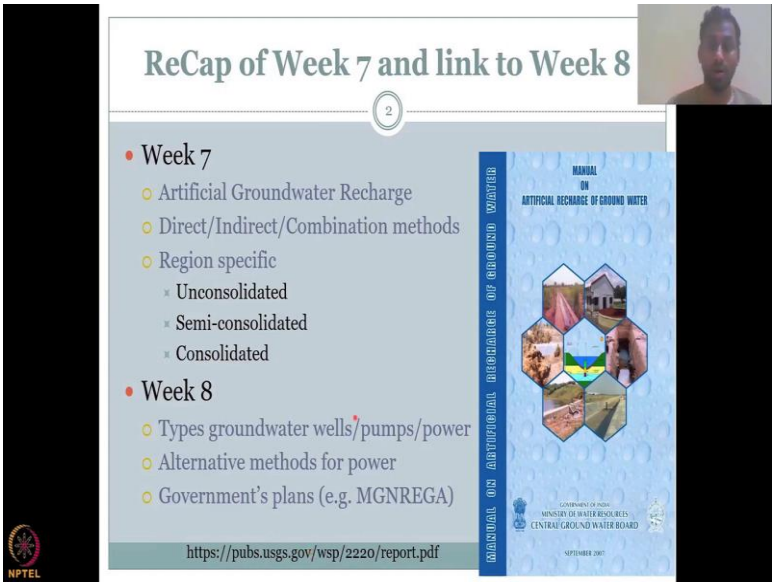

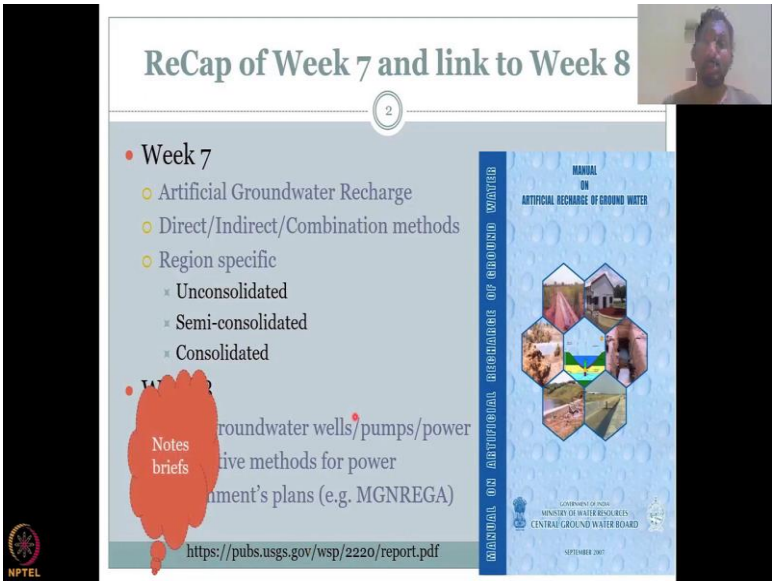

Hello everyone, welcome to NPTEL course on Groundwater Hydrology and Management. This is week 8. And we are at lecture 1. Let us quickly see what we looked at in the previous lectures, especially week 7, where we looked at the manual on artificial recharge of groundwater. Firstly establish the fact that the recharge is not enough for sustainable groundwater use.

And thereby, we have to increase the recharge rates, how do you increase recharge rates? By having artificial groundwater recharge, the natural recharge is not adequate for the current use scenario. And that is why we have to engage in artificial recharge mechanisms. Those can be divided into 3 types, the direct, indirect and combination methods. In simple terms, direct recharge is making the water slowly get into the ground and reach as a groundwater by creating increased contact between the water and the surface and our presence time.

Whereas your indirect method is by you pump in one region and because of your extensive pumping, there is charge or movement of water towards the well, you create a cone of depression and you can have indirect recharge. The best methods were found to be a combination of methods, because most of these problems do not have one type of solution. And they should be region specific. For example, it is different in the unconsolidated regions, semi consolidated region and consolidated and based on what and how they use the water.

If there is much use for groundwater then you have to engage in artificial groundwater recharge, otherwise the natural recharge should slowly cater to the groundwater recharge, and there is no need for artificial networks. So, with this, we are coming to week 8, we did see

how water recharges, but it is also important to see how water is extracted from the groundwater aquifer.

The most important mechanism is by pumping because the trees, plants, living organisms, natural discharge all are very small on the planet or even in India, compared to the pumping volume. Same way like the discharge and consumption, springs, etcetera are very small, because natural processes are small, it goes in a way to sustained but when you put technology and take out the groundwater, then you are actually engaging in a faster discharge.

So, for that it is important to understand what are the different types of groundwater discharge axes on wells and how does water being taken out of these wells? Is it pumps? Is it lift irrigation type mechanisms? Or using manual labor, animals, livestock, power, what power do they use? Is it diesel power, solar power etcetera? And what are the alternative methods for power? On the same report, it is important to understand the government's plans for excessively recharging the groundwater.

In the previous week, we will see like, we will have conversions of funds and other things. However, in week 8, we will also see what are the other programs that are used to monitor and augment groundwater. There has been some questions regarding and comments regarding notes and books. So, I am giving you one book which is open source. You can find it on the bottom page, here are the presentation, https://pubs.usgs.gov please use that it has all the basics of groundwater.

The other books and materials are available online or you can purchase it, but please, for your exams and for your test, the questions will only come from my slides, which are based on all these books because I have the book I cannot put the book on the online platform. However, I can share open source documents. So, the one you see down is an open source document, please download this and you can go through all the comments and sections that we have made during the last 8 weeks and also the weeks to come.

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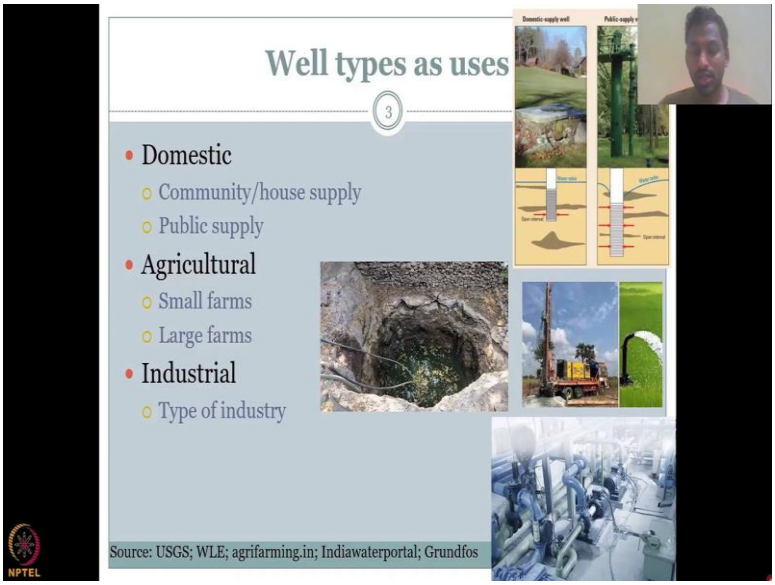

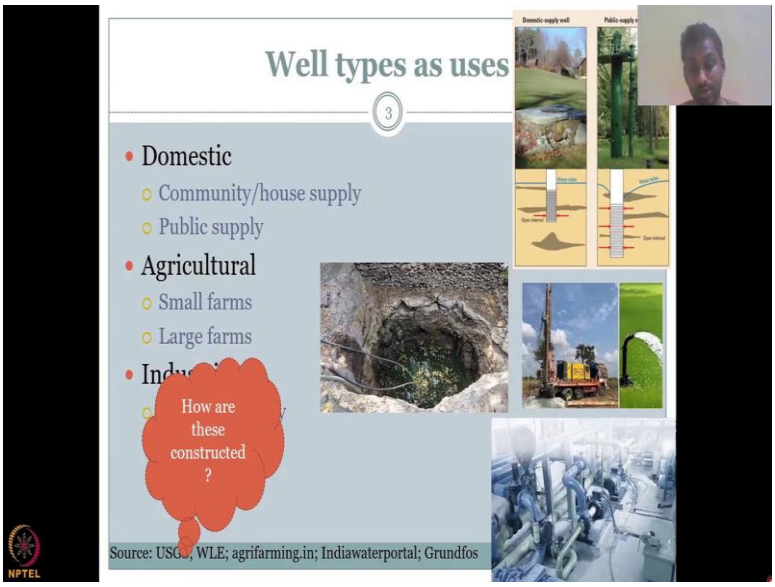

Well types as uses, so the most important is to understand what well types we have. And it is important to understand what are the uses of these wells. So, you could see that well type can be or access point of groundwater can be dependent on the location, the timing or the use, the use is more important because all the others are kind of taken care of by science and technology. For example, when you have a well in the hard rock aquifer and water is not coming you drill deep to get water. Nowadays you can have pumps readily to take the water out.

So, it is no more constrained to use water from a particular location, the constraint or the important factor is the use, where do you want to use it, how do you want to use. So, that we are understanding or debating today on the 3 main uses which is domestic, domestic as in for

humans use and use community, house supply, how is it a public supply, so there is multiple different types of supplies, one house by itself and one groundwater well, gated community like 5, 6 houses, one groundwater well or for a street or a village, one groundwater well or a city has many wells to cater for the groundwater market.

This is how it looks like as per the USGS diagram, you could see that the first figure is kind of a house slash community supply where you have the well put, what type of well is a different mechanism and others may not look at, what is the use of the well so. So, well is put and it has a screen interval and through which water can go through and then you pump it out as you and how much you pump, water starts to move into the wells and then you get more and more recharge or discharge based on the pump speed. That is the community or individual house.

But when you go to the public, as I said one massive well, which could cater to a lot of houses, you could see that it is much much deeper, much bigger in diameter look at the diameter size and the depth and it pumps at a very high speed rate and that rate makes the water table converge. So, think that it is like a sponge and then you put and then you squeeze all the water out or you pull all the water out then the water table would just go into the well, it converges.

And that convergence causes this cone of depression and more water would come. We did see this phenomena in the previous lecture under induced pumping or indirect pumping. So, the most important take home message here is there are public suppliers which run deep but it is one massive well catering to a lot of people and there is a possibility for groundwater depletion if the recharge is not taken.

The next part is agriculture, the most important groundwater user in terms of volume. So, the different types are within the agricultural sector. There is small farms there is which looks like this like your small farms would have dug wells or a hand manmade wells. This is a very clear example from the villages where you have a well and it is right in between your farm field or a small farm and then there is tube wells or pumps going in which pump the water out.

You see some uneven surface because it is done by hand or blasted by a small bombs and then they remove the debris and those are small farm ponds. Then there are large farms where it is more bore well type where you bring a rig and then you dig a well and then it becomes

from a well out and I could have either the motor within a submersible pump or in most cases a pumps are kept outside and it pumps using solar power or electricity, solar is very hard because the pump has to operate at a high rate. So, mostly it is a diesel or electricity.

Then we come to the other sector which is the most highest consumer after agriculture which is a industrial sector, but it depends on the type of industry. So, we cannot generalize this throughout the planet. We can generalize domestic use, we can generalize agriculture based on the crop type, but it is hard to generalize the industrial demand without knowing what is the industry.

But most importantly it looks like this where a series of pumps are placed like massive massive built pumps and there is a diameter tube which runs under the ground and then pumps the water out. So, same like the public supply well, but this is at a much much higher rate, because it goes to the industry and industries like bottling industries, food industries, car industries, where they have a lot of washing to be done, garment industries. So, all of them take a lot of water, which is sometimes undocumented, you do not have a rate at which they take all industries do not disclose it, because the pump is really, really very high tech pumps.

So, if you look at the costliest types of wells, definitely the costliest would go at the industry, then agriculture, then domestic. If you look at the volume it is agriculture, then industry, then domestic, it will look at number of wells it will be domestic more because it is spread across at a household level or so. So, how are these constructed? Now, we have discussed about what are the different well types based on the uses, but how are these constructed is very, very important to understand.

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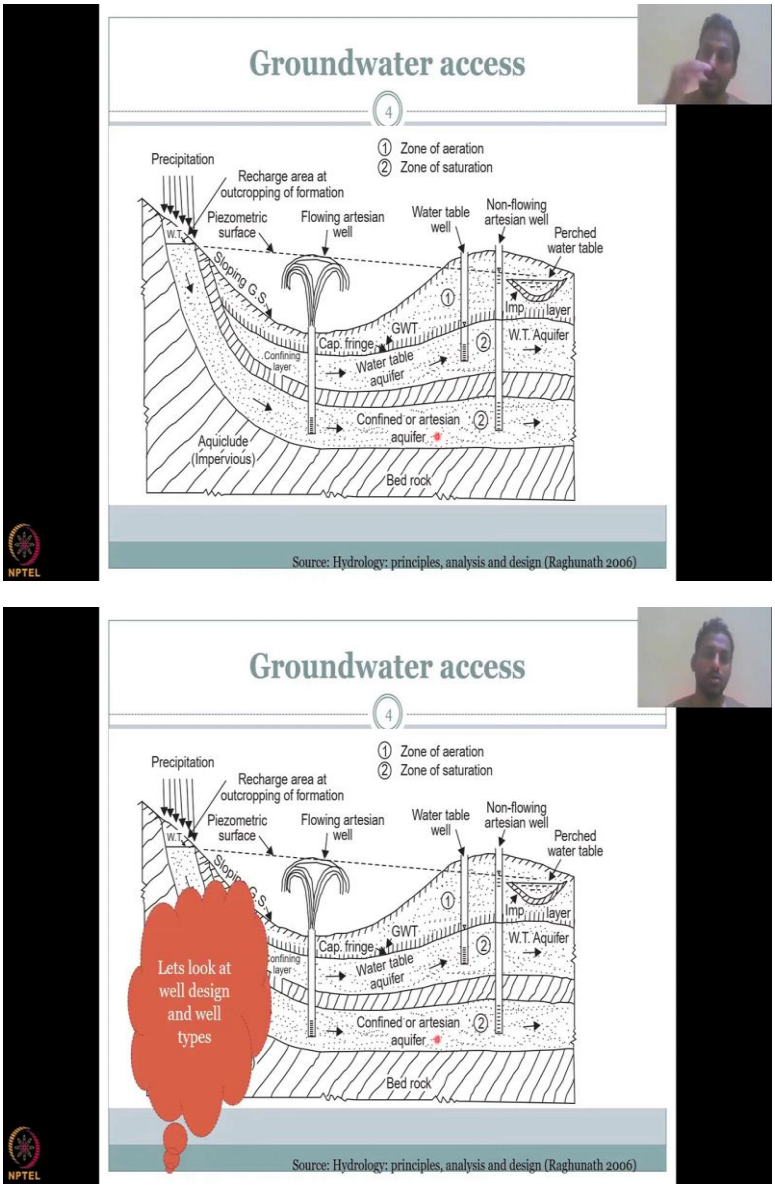

Before we understand how they are constructed, please just list revisit where the wells are what we are talking about, there is only two types of wells that we are going to talk about, it is either in the unsaturated zone or in the confined aquifers. The unsaturated zone can also have some saturated water table in the unconfined aquifer. So, there is a water table and underneath that the pump or the well that can be placed and water can be extracted.

So, there is either unconfined aquifer or a confined aquifer and within the unconfined there could be a saturated and unsaturated level that can also happen in the confined aquifer after you pump a lot. Once you pump everything out then it becomes unsaturated.

So, let us look at well design and well types based on the network that we are going to see. So, most importantly it is between the two aquifers, what wells are available in the two aquifers and also what speed of discharge is going to come based on the use.

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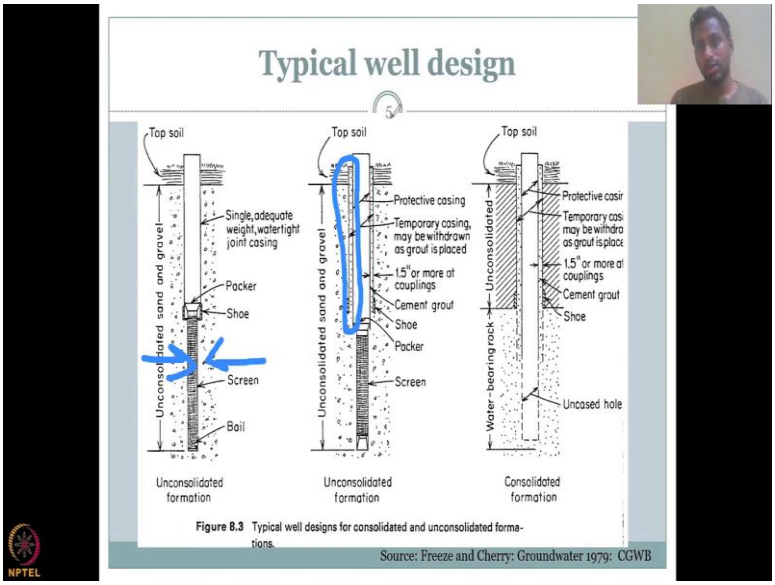

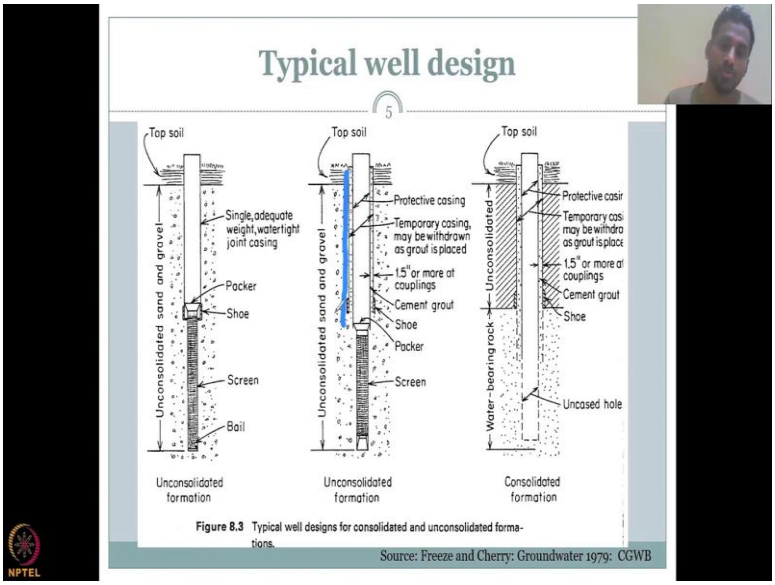

So, the typical well design is given here for the unconsolidated formation and unconsolidated loose formation and then a consolidated formation. So, what is this unconsolidated formation? We look at this in the previous lectures. These are mostly the younger sediments or younger aquifers which are mostly in the unconfined zone. It is in the top layer and it is still not consolidated as a unit or the structures still loose and so there is a lot of movement of water.

So, what this well would have is from the topsoil from the ground, well is there and the well would have passed through the unconsolidated sand and gravel basically the aquifer and it has a base under the base is like a stop, but from a particular depth there is screening. So, it is like a tube and inside the tube there is screening where water can come. Not all the well is screened which means water cannot come on the top, but it can only come in the bottom region here.

So, water can come here, but not on the top. So, this is mostly in a normal setting where the well is there is no casing here still some wall some water can come through these walls into the well, but mostly it is coming from the screened interval. So, that is where most of the water comes in. Then we go to the unconsolidated formation with more loose, sand and gravel, what happens if you have a well and there is a loose material outside? Slowly when you pump and there is activity in the well, the solid particles can fall in this is not good for the well.

Because you have a pump on the bottom or you can have a pipe at the end of the well which you pump up the water. And now it all the sediments and debris filling into the well you will lose the well, see idea is you dig and take out the debris, rocks, sand and then you create a well. Now if all of them go back in you lose the well, so, to increase this productivity of the well in some locations they make a screen. So, you could see here like a productive casing. So, on the outside of the well there is a case.

So, it can be along the diameter of the well, like the perimeter of the well there is a casing which actually prevents the sediment and movement of the material to fall into the well. So, the that you need to be very careful in understanding that not every type requires it. It is very expensive.

It costs a lot to put all these because throughout the depth or you have to put a casing and it is not needed in every aquifer system only those aquifer systems where you know that solid particles can move in and fill in the well. Still the screening is the same you have a screening at the bottom where you wanted water. The only thing here which is more important is you have a casing, the protective case.

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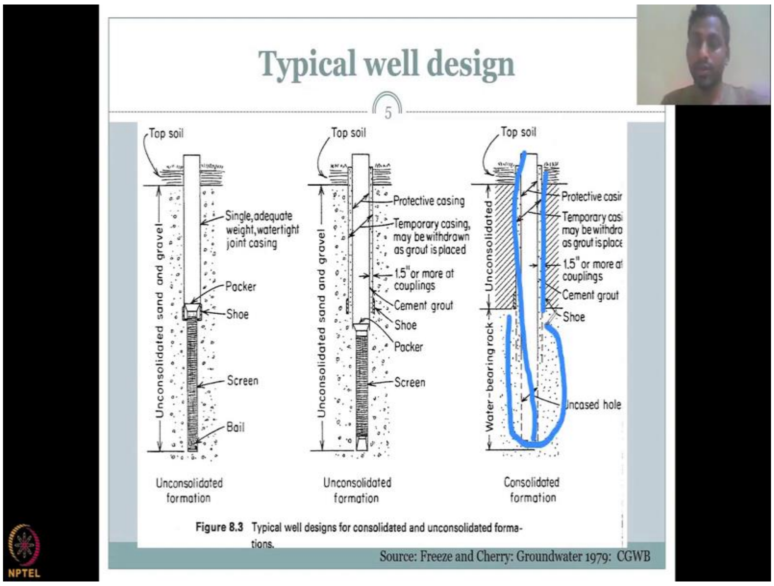

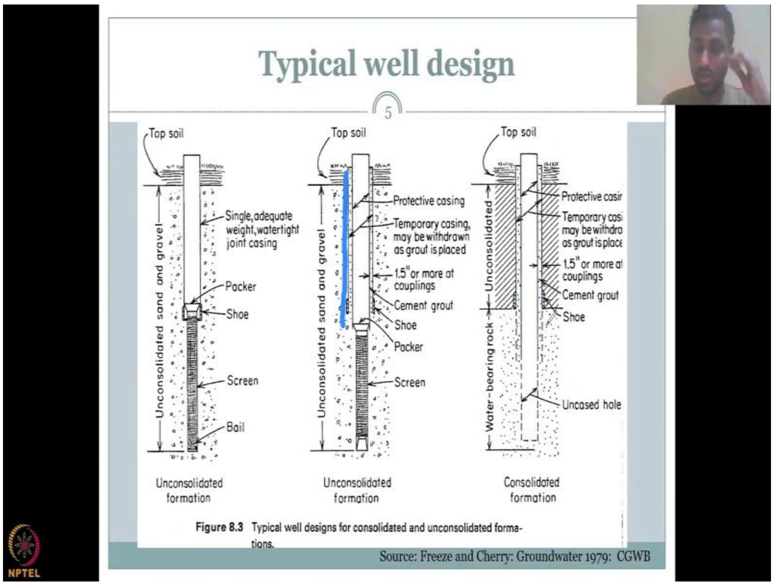

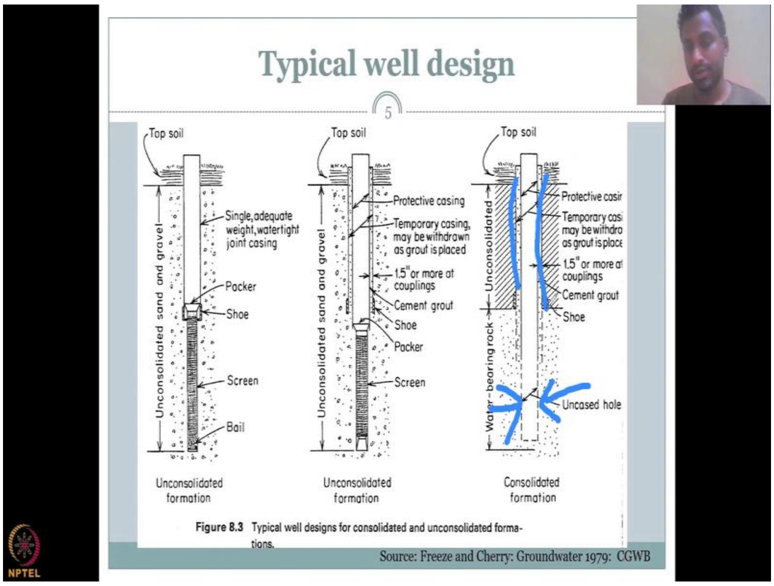

Moving on we have the unconsolidated on the top and the deep aquifer at the bottom. So, this is the consolidated formation. More importantly it is the confined aquifers. And you could see that there is a small boundary between these two and you are not interested in the top water. This can happen in a lot of these polluted regions especially like for example near the Ganges belt, you could see that if the Ganga River is polluted, people are afraid that the Ganga River can pollute the underground wells.

So, what they do is the underground well is not open in the top part, but only the bottom where the water is really, really good. They open the well and from there they take the water, so here if you could see the well is dug, drill is put and then they take out the material, then they put a casing on the top so that water does not move into the well from the top aquifer and the bottom aquifer or the consolidated aquifer is only open. There is nothing there just you drill it and then you take the debris out, the rocks the unwanted things out and you have water coming into this channel.

Now water comes into the well and there is no screening it is just an empty vacuum. Not a vacuum but an empty space. So, water can move in and stored. Once the water stores you can take it out and use it. The other factor to be considered here is this is much, much deeper. There is a possibility to have your screening and also your casing cost. The casing cost is on this side. And it is very deep. These wells are much, much deeper than the other wells.

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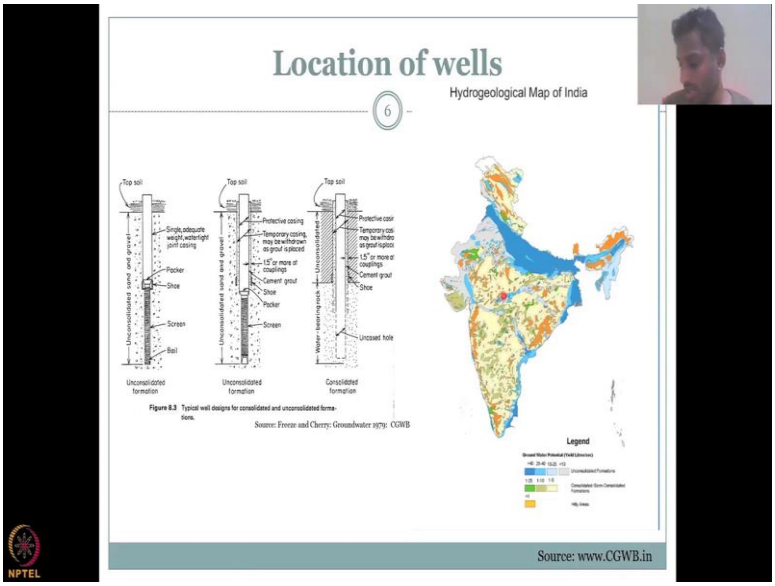

Let us see where they are placed in India at least. First is the unconsolidated formation with not that much loose sand, you do not need the casing. So, how you do is you let us do a hand

digging. For example, you dig or use a machinery through JCP and dig the well. You remove all the derby, and then you make sure that the well is like a cylinder which goes down, you drill it down, I will show you the next lecture on how these wells are dug.

So, what happens here is there is no casing, you know that the alluvial aquifers are okay, the water can seep in because once you put a casing there is no water coming in from that part, please understand, you are protecting your well but you are also compromising on the water. Here we do not put the casing, so water can still come into these place, into these casings as the casing is open.

Here they have the casing open at the bottom screen. So, the screen is where the water can move and you can take the water out. In this protective casing setup, the walls are stabilized, more stabilized of the well by using these casings and here in the last one you have a casing so that you can only tap on the DPAC for groundwater. So, where does the first one come? The first one comes along the unconsolidated formations, but most importantly the light blue colors where you have movement restricted which means the soil and sand down move that much it is still intact in most locations.

It is kind of older compared to the newer alluvium but then when you come to the in between the second type, these are more found along the Ganges, but the dark blue regions where new sediments are keep on coming and along with this water movement there is some sediment that can move into the well.

So, needs to be carefully understood that aspect regarding the wells and the last part as you would know this is the most dominant type of wells across India because these are the consolidated formations, the light yellowish, light orange colors have these wells where you have a screening on the top unconfined part or the unconsolidated formation you have as casing so that water does not come in.

But the water is taken from the deep deep aquifers and the deep aquifers are consolidated formations. They have rigid form consolidated formations and that enables the water to be stored in small pockets which they extract using these wells.

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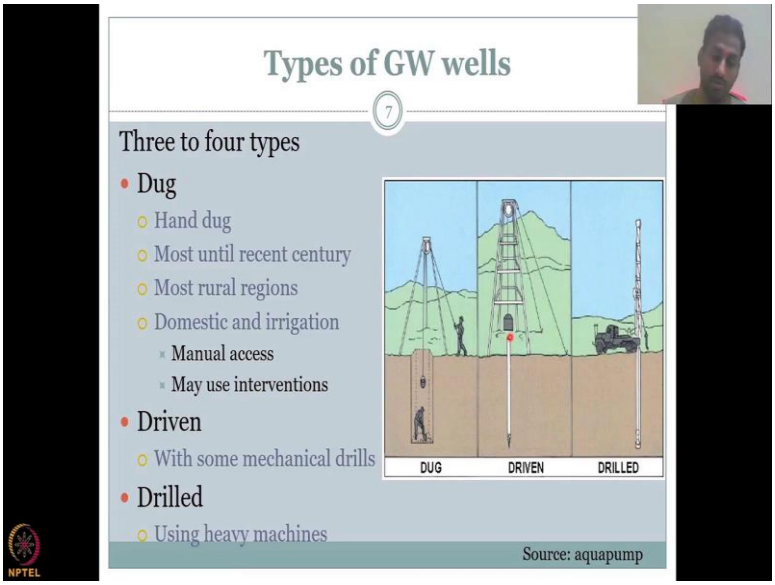

So, how many ways are there? There are only 3 to 4 types of wells depending on who you talk to all the wells are done. So, in the previous slides, you saw the type of well based on the use, which is domestic agriculture and irrigation and then you have a industrial wells, then we looked at in the previous slide the type of well that can fit into a particular geologic situation not everywhere you can put your agricultural wells, it has to be dependent on the consolidated or unconsolidated formation and that is what we mentioned in the previous slide. So, based on the geology formation, you are restricted to only put certain kind of beds.

And the last is how they are constructed based on that a name is given. So, the first one is as you would know it is the well, again the depending on which book you refer, and which notes you take. They can be 3 to 4 types. I would just go through the 3 types because that is the most common in India. And we have the first type is the dug wells, you could see people digging in to the ground and taking the debris out and making the dug wells.

There is a pully system to help the partner to take rocks and sand from the well. The dug wells are mostly dug by hand or manual labor they hand means they use tools of course, it is not like digging in with the hand and it is the most used wells until the recent century because in the recent seventh century there is more mechanizations happening, how people can bring in these big big machines to take water is still available because you cannot have that every time but you know still these bore wells are coming in most Indian regions.

So, this is the most until the recent century the dug wells because dug wells are slowly being replaced as I said, with deep bore wells or driven wells, drilled wells. These wells have been

catered to most of the rural regions in India, still, I could see the wells in my native place in the villages, they are kept intact by most of the people, but when the water is gone, then they leave the well and go. So, there is not much you can do with a well, which is not recharging. Of the type of access for domestic and irrigation wells, mostly it is manual access, and you may use interventions.

The interventions could be something like a pump, with a tandem pipes, so, one pump to one pipe and another pipe. And other interventions also are available. For example, I have seen wells being taken out, the water being taken out using bullock carts, the bullock carts would go on around, and that would turn a gear and the water comes up. And then people can walk on a slide, they walk up the bucket would go down. And then when they come down, the bucket comes up and with this the water. So, the multiple interventions they use for accessing dug wells, there is not one important point.

Then we have the driven wells, the driven wells are you drive a instrument inside the ground, it pierces inside the ground, and then you take the debris out and make a well. Most of the time here, you also do not take the debris out because it is such a small diameter compared to the dug well diameter, you just have the drive point, this is called the drive point. And then you have a weight which goes up and down.

So, it is like hitting the well into the ground. Here it is like using a hammer I have done in my fields. Because these kinds of machinery weight falling onto a well is not available in the forest. So, I used to carry all these hammers, so basically you are hitting a well into the ground. I will explain each and every well in the next class. So, for now we will just discuss the 3 types of major types of wells which is dug, driven, you drive the well into the ground and the drilled.

In the drilled one, you use heavy machineries, especially the bore loggers, which come in trucks behind the truck back and then they just really within a couple of minutes they will put down the tube and then get water for you. Is it sustainable? So, of these wells the most sustainable is the dug wells because you are not using any big machinery and are not using the all the big big water from the deep aquifer. And it is a cautious decision because the access is also mostly by hand for domestic use, I am saying it is really good water for domestic use. However, the other methods have also taken up.

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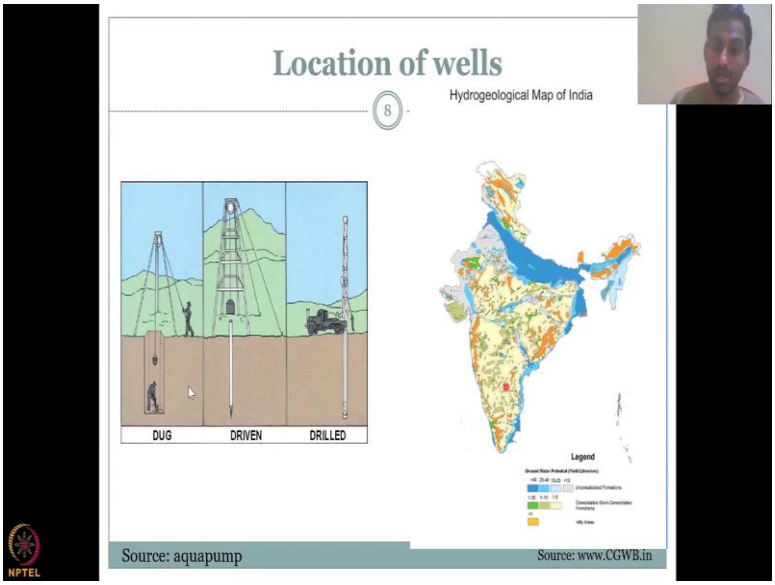

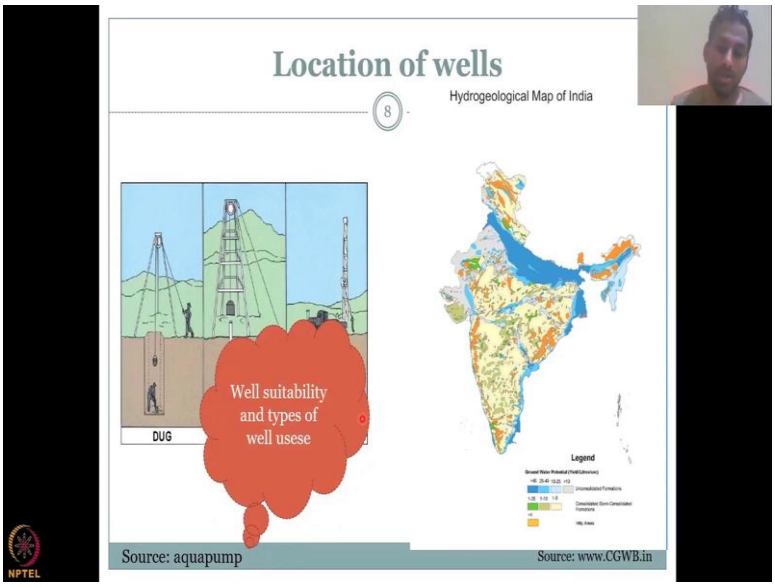

So, the location wise, it is also important to understand where these types of well formations I would say or well constructions happen and mostly the dug wells happen along the shallow aquifers and the shallow aquifers mostly are present in the unconsolidated formations, so along these blue line areas. And also in most of the Indian regions with shallow aquifer or they say shallow is enough. Then they would use dug wells. The driven wells are used across India however, not much difference between the driven and drilled, if you can afford the bore logger.

And so, for that simple fact, these bore loggers bore well service people have been putting these drilled wells instead of the driven wells. And they have been successful to put many, many wells in India. The water recharge is not a successful event, but the water they are

getting through these drill is the maximum in India compared to dug and driven wells. Initially it was dug wells, which were really good, but now it is driven and the drill wells which are accessing deep groundwater aquifer and of that the most important is the drilled wells.

We will in the next class see how these wells are dug, each type and what are the precautions that need to be taken. So, the well suitability and types of well uses we have discussed in this today's lecture.

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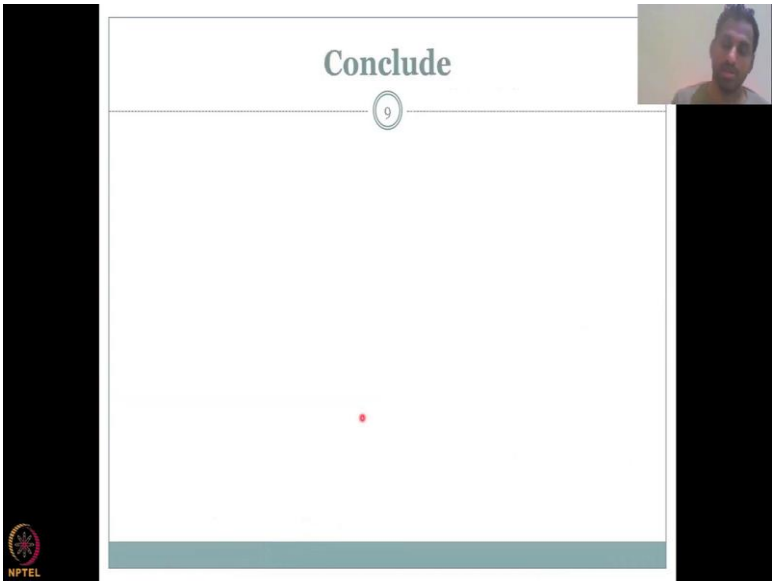

In the next lecture, we will discuss actually how that is being done across the world. I will conclude today's lecture. Thank you.