Geoenvironmental Engineering (Environmental Geotechnology):
Landfills, Slurry Ponds & Contaminated Sites
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Lecture - 26
Construction and Operation of Landfills

Good day and welcome to this class in which we will discuss construction and operation of landfills. So, in the last few lectures we covered monitoring of landfills and then we covered costume of landfills right and costume of landfills you were able to work out some geotechnical costs per square meter and also per turn of the wastes right. So, today this is a kind of wrap up that we have now learned most of the things regarding the geotechnical design and we would like to see how those steps of construction and operation of a landfill are executed and what are the stages in which you have to be a little careful of doing this design.

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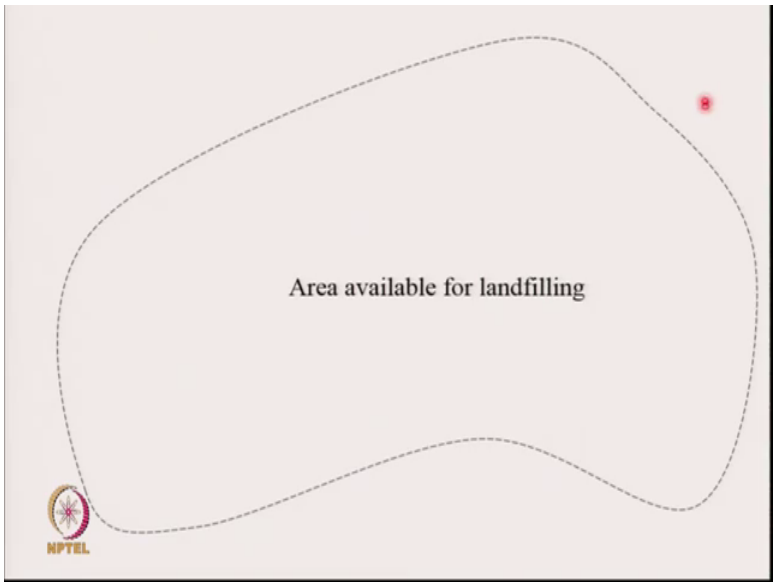

So, let us begin by taking a site and see how we will proceed on that site. So, let us say that this is a site which has been selected and this area is available for land filling. You will be doing a lecture immediately after this is once how to select the site, but let us say this is the site which has been selected and is available to us this is the shape this is the land.

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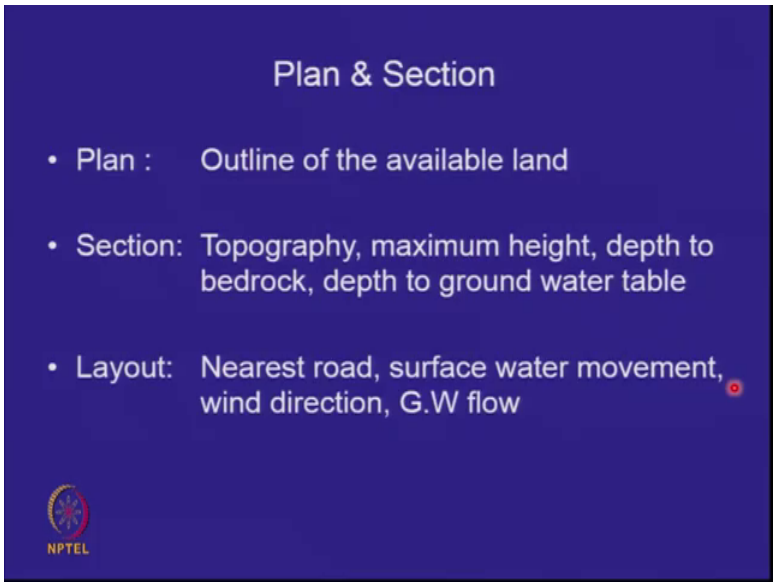

So, the question is my first steps or let me decide the plan and section of the landfill. Now the plan is quite clearly governed by the outline of the available land every land is in square shape your land fill will be square if the land is in circular shape in plan your land fill is likely to be having a circular plan. So, the plan depends on the outline of the available and what are the cross section depend on? The cross section depends on how high we can go and how deep we can go and how deep we can go depends on?

Student: Groundwater.

Groundwater level and or.

Student: Hard rocks.

Hard rock. So, normally we do not excavate in hard rock and if there is no groundwater table and if there is no hard rock typically we do excavation up to 7 meters 8 meters after which it becomes problematic to do open excavations. So, the section will depend on the maximum height to which you can go the maximum height we would like to go to is height which does not create a very huge visual impact and I have said this earlier that 15 meters is a good height which we typically adopt. So, we will know the height of the landfill depending on the depth to bedrock and depth to groundwater table we will have an idea of the depth of the landfill. However what the section will look like will also

depend on the topography is it flat ground is it sloping ground is it low lying area is it a valley. So, that will determine the section of the landfill.

Within the planned outline what will influence your layout of the elements inside the plan where is the gate, where are the roads, where is the ligatured pipe, where is the treatment facility. So, you will need to know then where is the nearest road, how does the surface water move on the site, what is the wind direction and what is the groundwater flow direction. So, typically if you have a site surface water movement direction is most important because water flows from a higher elevation to a lower elevation and if you do not want to start pumpings then you want to make use of gravity flow then you would always be having things flowing from a hard point to a lower point.

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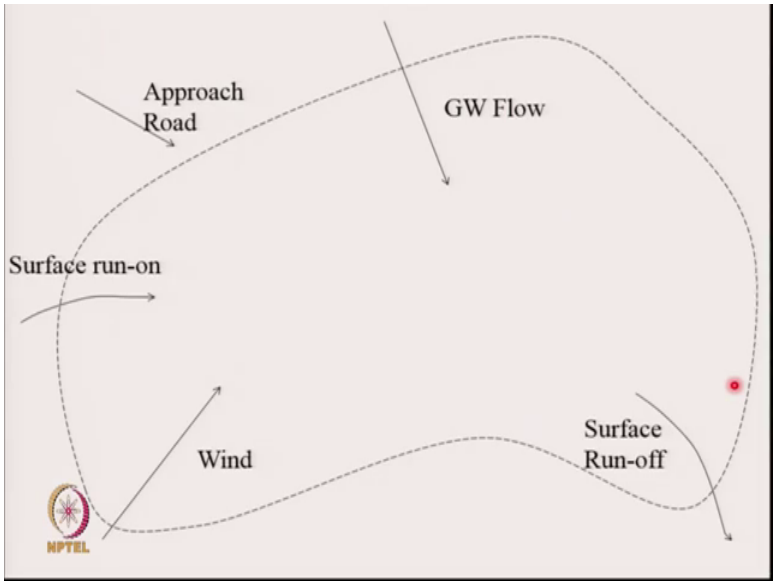

So, if this is the information becomes available after site characterization or after site investigations see this is the land we got and we did our site characterization approach road is from this site, let us say a state highway or a big road is somewhere here. The site is having surface water flow like this it goes from here and gets off here right. So, that tells you that this is higher elevation this is lower elevation the predominant wind direction most of the time is in this direction. So, if I have to locate my office and I do not want to get the bad odor all the time I am going to put my office in the up wend direction. Are you understanding that it will help you to avoid odor and then your

groundwater flow direction is like this is now let us see how we arrive at the landfill plan landfill operation sequence and how do we construct that thing.

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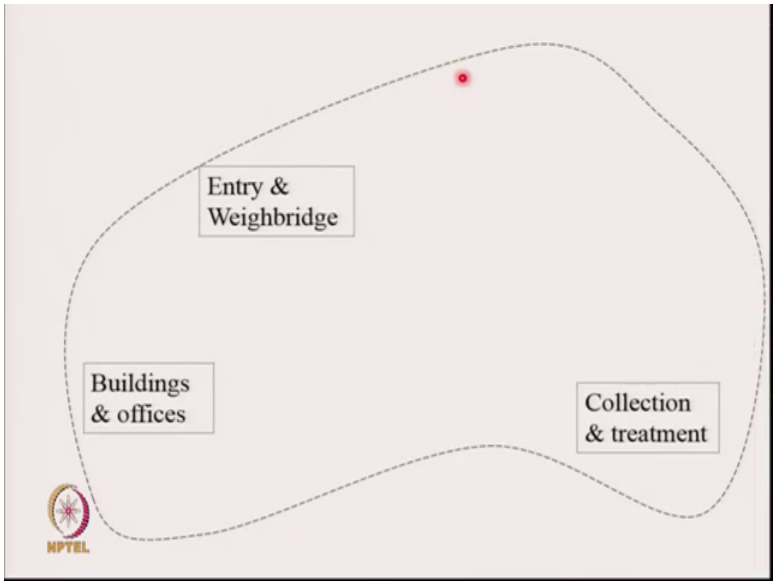

So, as I said if the road is here you would prefer the weighbridge and the entry gate to be here closest to the road of course, if there is some other consideration that the weighbridge has to be here then you will have to make a road either internally or externally, externally this land will not be available to you. So, then you might have to come in here and go along the boundary and come to this point if for some reason you want to put the weighbridge here, but normally you take the entry from the site which is closest to the road.

As I said the buildings and offices you might want to put here because the wind direction was in that and all ligatured and surface water drains are going to run like that under gravity. So, your collection systems will be here right your collection systems will be here.

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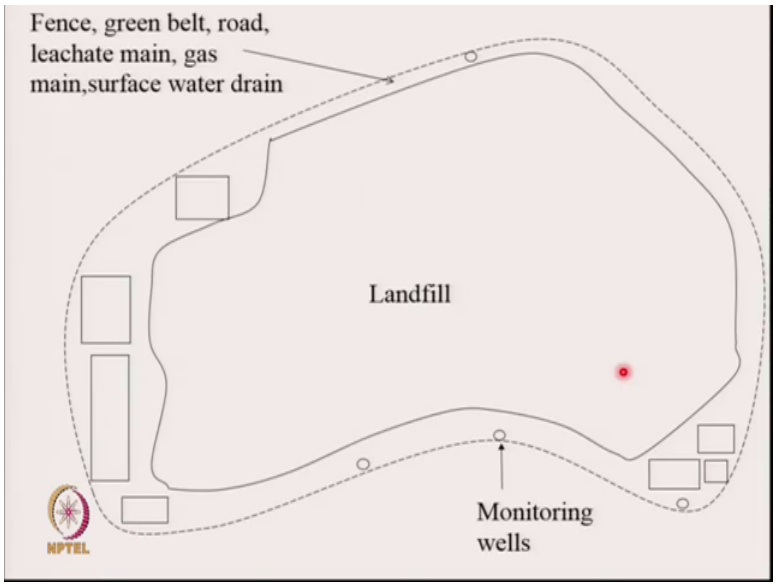

So, between what I have already thought you that 80 percent or more is the landfill area. So, the shape of the land fill has now I merge like this agreed and this shape is primarily governed by the outline and where are I am going to put the facility. So, entry and weighbridge office buildings laboratories treatment facilities and since the ground water flow direction is in this way I am putting and up string monitoring well and three down monitoring string wells here. Any questions so far about what we have decided in the design, no great.

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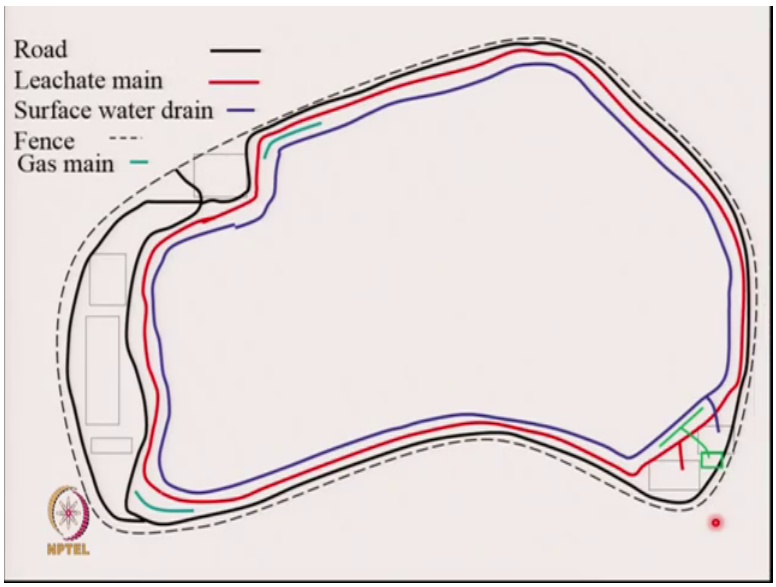

Now, the other major thing is, the other major picture we should come into your head is this; that means, the actual landfill there will be a road. So, there is a road, there is a fencing all around. So, first let us say that the dotted line which is the boundary becomes your fence normally you do not have a wall you have a fence then there will be a peripheral road you should be able to access any part of your land fill at any time on the peripheral road you have a fire here your fire tender has to go here you have some injury accident you should be able to go.

Then you have collecting Leachate and the Leachate has to go to the Leachate treated facility here, now there will be pumps and sumps inside the land fill that will merge, but there has to be a Leachate header pipe, big pipe in which all the Leachate is coming and whatever Leachate comes out here for example, it may travel like this whatever Leachate comes out here it may travel like this. So, the red line is the Leachate header pipe and or the Leachate main pipe and it goes to the Leachate treatment tank or a Leachate storage tank.

Similarly, you need of surface water drain; that means, what falls on your cover is not going to be Leachate you do not want to treat it. So, you should collect it separately. The problem is that your Leachate and the surface water if they mix then the quantity of Leachate becomes very large. So, there will be a similarly similar to a road there will be a surface water drain all around the land fill and it will go to a surface water holding area. And also shown is a green pipe here it should be all around that is the gas main it should be all around I have just shown it in small bits in pieces all the gas which is pumped out it can go to a flaring unit and therefore this is what the Leachate gas and surface water collection system looks like.

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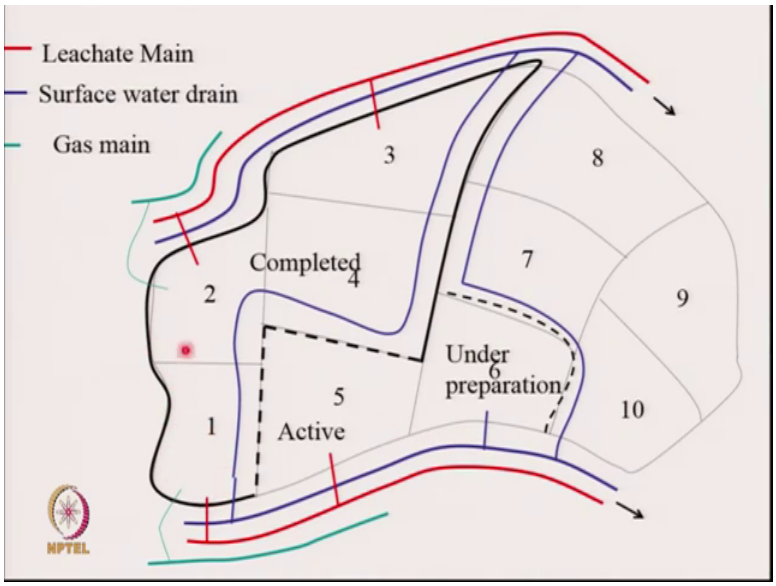

Next step, now, that you have got your outline of your land fill area you have to decide your phases and phases have to be decided in plan and have to be decided in section here is a land fill which is going to operate for 10 years. So, 10 phases have been mark first you will fill this first, second, third, fourth, fifth, sixth, seventh, eighth, ninth and tenth and after that you will not be able to fill anymore. If it is above ground if it is below ground, so if I have a land fill area if it is above ground section, it will look like this and if it is a combination of a below ground and above ground land fill it will look like.

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Irrespective to that if this is the first phase the first phase will be there or the first phase will be here I will be taking the face to the top because after every year you have to close then I will move in the direction that he wanted. So, here we are said that our phases are like this, so one and two. So, that will be phase 1 and then the there will be a phase behind that phase 2.

I would like to now put my Leachate collection walls. So, where let us say in place one where will you put your Leachate collection? Is it at the center of the phase is it at the side of the phase.

Student: (Refer Time: 10:27).

Why do the side why not to the centre? We take all the Leachate to the side we do not keep Leachate at the center of a landfill I will not be taking all my Leachate here I will be taking all my Leachate if I to start collecting the Leachate from the first phase. So, both I make a well here in this Leachate has to travel all the way across. So, typically you will have Leachate well for one annual phase typically. And I have said this earlier that if you think that you can take Leachate from one end to the other, suppose this is 400 meters long path and you have a 2 percent slope then you have a 8 meters elevation difference between the two sides. So, normally it is not done like that you have an accordion arrangement and each phase may have its own low lying area.

So, in now deciding that the Leachate of phase one will not go somewhere far off and well will be there in phase one where will you places it or a Leachate collection point will be there where will you place it. I can say all right this is my Leachate floor I will make it like this and I will take the Leachate to a edge. So, it will be had an edge, but it can be any place one two three, so these are three locations one can think of right and water will have to flow if Leachate will have to flow the middle one appears most appealing why because the amount of cut that you will have to do is less because the distance is the Leachate will have to travel is low.

So and why do you keep driving into the site? Because if everything is coming out to the side the and if you are using a sites low price, the height of the sites low price or the height of the well even if you are using a vertical well it is going to be less than if it is at the center. So, take everything to the sides as far as possible and the side slopes either can rest on the regional ground, but even if your doing a vertical well the height will be

less. So, Leachate comes to the side. So, our thought processes that we can put the Leachate wills I am only going to discuss one and two somewhere here and somewhere here right. So, let us look at what it says. So, you have looked at 1 2 3 and 4. So, what is you have done that I suggested 1 here, 2 here, 3 here, 4 here. So, all the Leachate will come here. Please remember the Leachate of 2 will go here the Leachate of 3 will go there and the Leachate of 4 will go there. So, this will be a kind of a range the high point.

There is often an attempt to economies on the number of wells there is a often an attempt to economies in the number of wells and an alternative range where you can reduce the number wells is this. Here I put a well here all the Leachate from here will come here and all the Leachate from here will also come here the distance should travel now is a little more. So, this also travel is more, but there is only one well instead of two. So, it is one phase is sloping like this the other phase is sloping like this and the well is at the center.

So, when phase 1 is being filled up all the Leachate tends to flow where you have to put a small berm here. So, that the Leachate does not cross over into the next area. When you start feeling the second area this is already filled you can remove the berm and you can slope this way and collect it. So, basically this well is for 1 and 2. Similarly for 3 and 4 this Leachate can travel like this and this Leachate can travel like this. So, this is the way you can economies on your wells, but they all go to the sites the wells are mostly on the sites this is not to say that this is not in the center seven is not touching any side. So, maybe there will be a well somewhere in the middle.

Then let us look at the gas wells where will the gas wells be and the gas wells to be side of the gas wells are in a above towards the center.

Student: (Refer Time: 14:49).

Why?

Student: (Refer Time: 14:53).

So, let it rise, it can rise in the side also.

Student: (Refer Time: 14:56).

Density, [FL] I do not know of the wells are at the centre because you could know the wells in the depth maximum depth of waste. So, if you put a well at in the side if you would put a well here I do not even need a well here I do not like to put a well here, but this is the maximum highest. So, you tend to put the wells two-thirds of the depth of the waste where the waste is maximum. So, your wells are gas wells would be at spacing of 50 to 75 meters towards the center. So, the starting phase is which are on the sides may not have many wells, may not have many wells you may have a gas collection parameter trench you will have the gas collection layer under the cover they will work as gas collection wells may be used at slightly different locations.

So, just to get a feeling of what we done that is wells may be. See the landfill high is increasing like this then decreasing like that this is the area where most of the wells are going to be. So, you do see that one and two only have a single well 3 also has, but the 4 and 7 will have many more wells at spacing the 50 to 75 meters of course, this is all depend on the dimensions, but I just want you to get the clear picture that the Leachate wells are towards the side and the gas wells are towards the center agreed.

Now, let us say I am in the fifth year, first year is over I have capped it, second year is over I have capped it, third year is over I have capped it and fourth year is over, this is being cap capped. Fifth is waste is coming and sixth is under preparation because next year the waste will come here right. So, now, I have to manage everything I have to manage the Leachate which is coming out of 1 2 3 4 it will have its own wells, I have to manage the surface water which falls on this; that means, it has to run off into some drains, so there has to be a surface water drain. If all this water falls into the active phase it will make more Leachate we do not wanted to make and in any case remember this is the this land is net is not been touched this may be still scrubbed land you do not going to clear up the own I do not know the money for doing that I do each excavations every year at time.

Next year while this is active this is been prepared still this is untouched. So, what I wanted to see is this, I have completed these so the Leachate will be going from these to the Leachate main and the gas will be going from here to the gas main from here as well as from here into the gas main. And you may have laid the full Leachate main to the facilities or you want to say some cost is I do not know what. So, you may have only put

part of the Leachate main going to the facility directly and you will be relocated as you go forward let us look at what happens to the road.

There is a road which has to be made all around it and owner how is got a lot of cash flow is in cash flow can put a boundary fence and a boundary road all along well suppose the site is 800 meters or by 1500 meters. So, you would have 4.6 kilo meters 800 into 1500 4 perimeter will be 4.6, will have 4.6 kilometers of road if you have the money to invest in 4.6 kilo meters fine what he will says I will make a cycle track. So, that my guard can go every day, but I will only make the road as this progress is forward or he will make a [FL] road or something like that. So, these things have to move forward step by step. So, that the expenditure is deferred step by step.

So, here in this diagram it is shown that the mains have already been put and your road maker go like this and your trucks have to come in deposit the way so it may come here and there will be around here and there may be a road here. So, in the trucks will come and deposited in the active the road required here is to prepare this and then they all might meet up and go back. So, the whole thing may not be developed. Also remember that the surface water drain very important very very very important what is falling on this must going to the surface water drain right and the surface water drain is also at the covered at the top; that means, no rain water falling here should go into the under preparation area should going to the activity area.

So, remember this is higher it has to be slop backwards, but still you need an intercepted drain here. So, that in case of a lot of rain water collection to this and that runs of down, I only want the for rain falling on this area to be creating. The Leachate whatever falls on this is also surface water whatever falls on this is also surface water surface water surface water surface water. So, you have to collect it in this drain and bring it to the surface do not allow this to mix with this they will have to be berm here. Leachate will be formed here we talked about a well I think we had said 1 and 2 we will have well here, 3 and 4 will have a well here 5 and 6 will have a well here right. So, the well will be stalled and the Leachate will be coming, but there will be a berm whatever falls into this area will become a surface water and it going to the surface water drain and whatever falls onto this area will also become surface water and it will going to the surface water drain.

So, in this way we will gradually progress year by year. So, if you do incremental development your expenditure is incremental year by year your income is incremental; that means, your cash flow is better because if there is a waste stepping fee then as you put the waste you are getting income also that income can be put into this if you get a say I will develop the whole thing sure you can, but two three things here - you will have to make a lot more investment when you make a lot more investment then, if you do not have money you will have bought from bank you will have to pay the interest back to the bank.

So, if you pay interest on a lot more investment what did you do because income is not coming for the income will come only from the ways which is coming daily if you have done half thing investment then this income could have of set the interest and also given you an operators profit. So, do not do too much capital investment to begin with do, the work incrementally forward, but minimum things you have to put a fencing you have to have a peripheral reach. So, that you can go and check that everything is working and you will have your some of your treatment sell it is at that time you should get those barely, any questions.

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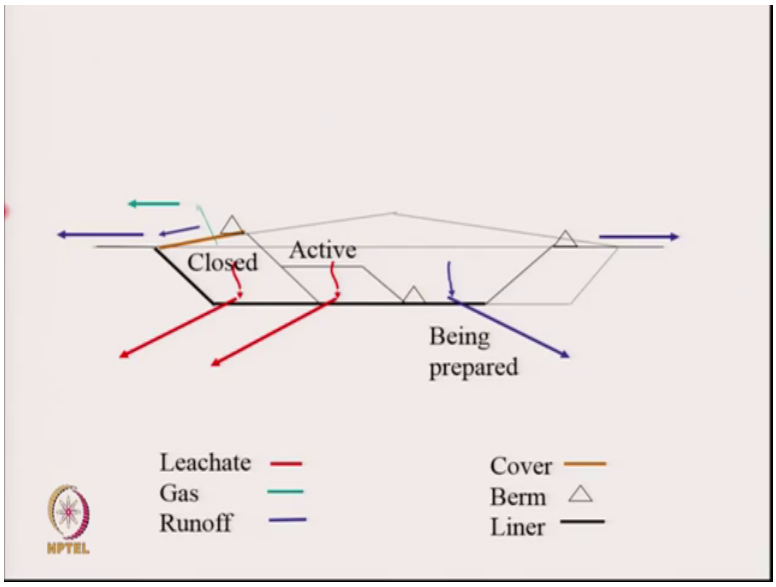

Then if I look at this and if suppose this is going to be my completed land form it is a below ground and above ground of primarily below ground landfill remember again I am going to say this. What; this is the phase which is close the brown is the cover has been

placed whatever falls on this goes as surface one of so the blue line is surface run off it goes to the surface runoff plane. Whatever is coming out from inside the ways which is either squeezed or some parcel inflow will go to the Leachate main. The active one will create the maximum Leachate because when the rain will fall over this it will create on the top you need a berm here. So, that this water does not come and you needed little surface plane here also. So, that the water does not come in any case. This I have seen in the so many sites that in a very heavy downpour that is the tendency for (Refer Time: 23:03) values is to be formed a water to start falling into the active area this has to be very carefully planned so that the surface water remains surface water.

Even when you have dug this up this is being prepared this is active again the tendency say [FL] yeah well [FL] there is a low line low line point unless you put a berm and unless you because system here and a pump and pipe to take a when the surface water it do not get mix to this that is not a great thing to do. Today if I just talk to the (Refer Time: 23:41) landfill people the rate of treating a liter of water I think the rupees 4 or something for that. So, it is an expensive thing to do to treat so much Leachate once it is generated. So, keep it out, keep it out have the slop this way the surface runoff rap the slope this way the surface runoff only here you will get Leachate this Leachate we call I as close relative much lesser than this Leachate because this is the active agreed.

What does it look like when the whole land fill is finished, now everything is fill it well right you have here entrance and weighbridge here you have your fencing, you have your road, you have your buildings, the office, the laboratory, the based inspection facility the garage the equipment everything here. This is the top of the landfill and the top there will be a road and there will be a surface water drain so that whatever falls on this goes into the blue surface water drain this surface water drain is connected to this drain and then this is connected to the lower drain.

So, remember that is your base surface water drain and whatever comes into this drain goes into a surface water collection tank, is a lot of muddy water is coming out you can a allow the muddy water to sell. Whatever falls on the top surface goes to this drain comes to this drain and then eventually comes down and this is a berm an intermediate berm right, this is the surface water drain and a road on the berm and whatever falls on this slope is collected in this and then comes down here whatever falls on this slope comes to this drain. And the road is here you can travel up this road and come to the first level

berm and you can travel up this road the berm is at particular level then you can travel up this and come to the top. So, you have access for everything and remember this is dotted with gas wells and there is vegetation and this is the entire area how it is developed.

I would like to now focus on this small area between the fence and the base of the landfill. So, once you have said that this is my boundary and this is my landfill what is critical in this area, what is critical in this area? Any doubts anybody you have a issue? I hope it is visible from that far. So, if I have a fence then normally there will be requirement of a green belt you do not want to see the landfill. So, if you have a 15 meter high landfill you will like to have tall trees.

So, there will be a green belt minimum of say distance prescribed in the rules. So, you can have the visual impact reduced you think you are there a lot of trees, but behind the tree is the mount there is a green belt and then there is a road right and then there are those three pipes that we are talking about there are three pipes the surface water drain, the Leachate main and the gas main.

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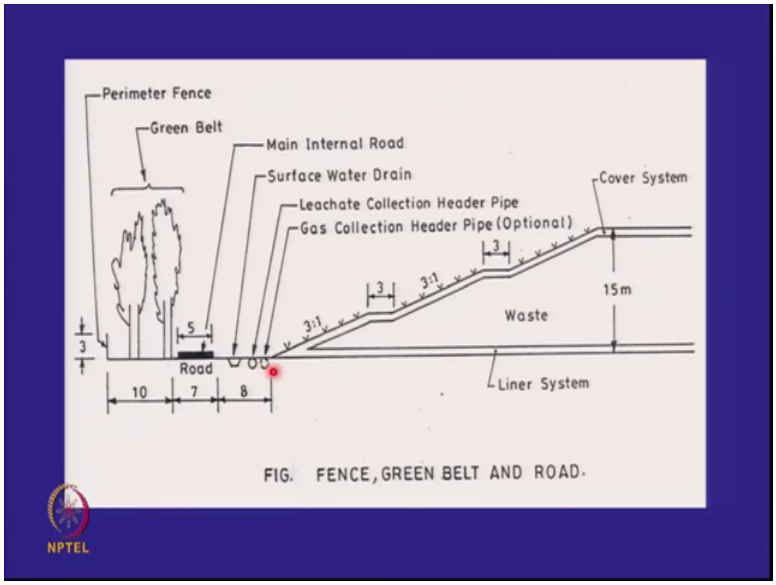

That is your fence, that is your green belt typically it may be 10 meters wide you may have a road of that you have to basically decide how wide the road is weather is one vehicle is going around in coming back or there two vehicles are going in both the directions. So, it will all depend with the two trucks have to pass each other one times to keep the road one vehicle and have certain ways in which these vehicles can pass

because making a double vehicle double width vehicle road is more expensive. So, one tries to give the road and here you can see is the surface water drain and the Leachate header pipe here also the gas header pipe is shown underground, but the important thing is you must be clear that the surface water which runs down this will go in to this drain and the Leachate which comes out will go into the Leachate collection pipe.

So, here what they have done is kept up pipe, if both are opened drains then they would have to cross each other for the surface water to go from one drain to the other either ways suppose both are open Leachate drain is also open and surface water drain. So, when one is carried to other side it would have to cross over which is difficult, but they never buried pipe there is no issue you can put the jio member in top of this and the surface water will reach here. So, in this way this criticality is very very important and you maintain this, the good thing about open drains is they can be maintained the good thing about pipes is they are closed non maintainable and that you sending some pipe cleaning devices, but if you give the Leachate pipe open there is the issue about overhead in smell. So, it is better to keep the Leachate in a closed pipe and the gas in a pipe. So, that is the way you finish of your landfill.

So, we have done this today this is the quick rap up what we have done so far that how do we evolve the plan, how do we evolve the section in the plan where do we place the buildings and where do we place the various infrastructure facilities and how do we do the phrases, in the phases where do we put the wells in the phases where do we put the wells and where do you put your Leachate wells and where do you put your gas wells, how do you manage the land fill when you are at an intermediate stage.

So, if you go to a well designed landfill this is what you will see green vegetation on the closed part, the intermediate cover will have soil on it and if you are conscious about it that monsoon should not affected some people will also have a temporary tarpaulin or a temporary cover on the intermediate cover. And you will see the landfill rising up in the active phase and you will find some machineries working in another phase which is under development that the excursion is staying place the clay liner is lading and after that jio member being led. And all the area or after that is still the original scrub land or the original scrub land the trees and in that you have your surface water drainage systems you do not want any water to come into the landfill.

So, that is a typically a good design, but as seen many landfills in which already read the line for 5 years they why because they got some funding from the government. So, it is a block funding under gnnurm I have seen people 5 year phases, do the drainers and everything ready only a little bit of landfill is used and in the other portions you are getting the sand is clogging up because this is the Leachate collection layer, erosion on the side somewhere something is getting exposed for 5 because you know you put some something over 5 years on the slope and you do not do stone pitching on it, slopes are going to be very prone to erosion all the time as we know it, so that sometimes causes trouble. So, as you move forward you have to repair those things and then use the landfills. Any questions? We will stop here.

Thank you.