Environmental Remediation of Contaminated Sites
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Lecture – 56
Case Study: Soil Vapor Extraction Part - I

Hello everyone. So again welcome back to latest lecture session. So we have been discussing the relevant aspects with respect to soil vapor extraction, bioremediation and so on and so forth in the previous sessions, right. So now we will look at a few case studies that are relevant to these particular aspects. So today, we are going to obviously look at the particular case study relevant to soil vapor extraction, let us say, right.

Again keep in mind that the choice of the particular site is more or less based upon the availability of data in the public domain. So the site that we are going to look at is the one that I believe, I could find more data that was relatively more presentable and something that would have would throw more insights, let us say, right. So again we will go through with this particular aspect. So again what are we going to look at?

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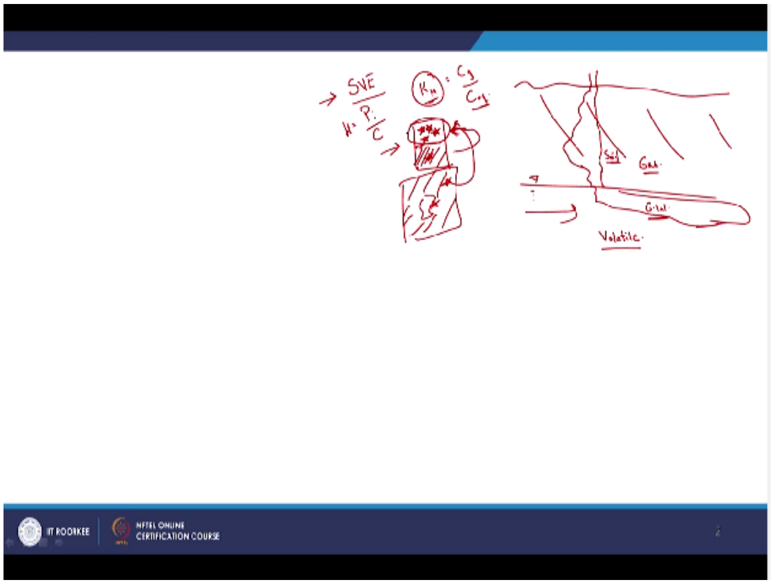

A system that has been remediated by a system or site that has been remediated by soil vapor extraction, right. So just a quick recap of what are the relevant aspects. So you have the relevant subsurface out here. So ground water table out here, let us say. And all this is, let us say, relatively porous soil. So let us say, if you have a spill out here, right and that has reached your particular ground water, let us say, and then the co-plume, right, contaminated plume is being transported in this particular direction, right.

So what are the relevant media that are contaminated. One is the ground water. This is contaminated certainly. And out here, obviously soil or sediments are contaminated, right. And obviously unsaturated zone out in the vadose zone, you will also have the gaseous phase or the gas entrapped within those pores, let us say. And you are going to have considerable mass of the contaminant in that particular gaseous phase.

But which types of contaminants, let us say,? Only those that are relatively volatile, let us say, right. So those compounds that are relatively volatile, these are the types of compounds we are concerned with and also these are the compounds that would be more amenable to be removed by or remediated by soil vapor extraction, let us say. So again the key is that the compound is relatively more volatile.

Thus what does it mean? It wants to stay or would prefer to stay in the gaseous phase. Obviously there is always going to be an equilibrium between the concentration of the relevant contaminant. Let us say, if this is water and this is air. So, let us say, even though most of it would want to be present in the gaseous phase, you will still have some of it present in the aqueous phase, right.

There is always going to be an equilibrium. So if you shift the equilibrium, it is going to, what do we say, shift in such a way or the system is going to travel in such a way such that or move in such a way such that again equilibrium will be reached. For example, if this is the particular case and by, this is the contaminant in the gaseous phase, contaminant in the aqueous phase. So by soil vapor extraction, let us say, I am able to remove this particular, what do we say, contaminated gas.

And now I am going to have fresh or uncontaminated gas in contact with the relevant aqueous phase, let us say. So what is going to happen? The contaminant is going to now change phase from the aqueous phase into the gaseous phase and again new equilibrium is going to be achieved. And how can we understand the relationship here? Typically based on the Henry's constant, let us say, right which will give us an idea about the concentration of the compound in the gaseous phase to concentration of the compound in the aqueous phase, right.

Again as we mentioned, there are different types of, what do we say, Henry's constants depending upon the type of, what do we say, dimensions that particular constant has, let us say, right. As in this can also be expressed in terms of Henry's constant, can be expressed in terms of partial pressure of that particular contaminant, let us say, in the relevant gaseous phase to the concentration of the contaminant in the relevant water or aqueous phase, let us say, right.

Different ways to express the relationship or equilibrium here, right. So that is something to keep in mind. So simultaneously what will also happen, let us see. If I remove this particular contaminated gaseous phase, let us say, right, what is going to happen? The contaminant is going to change phase from the aqueous phase into the gaseous phase, right. So again we know that you also have soil and you have water in contact with that particular soil.

So let us say, if some of the contaminant left from here into the gaseous phase, what is going to happen to the contaminant adsorbed on to the relevant soil, let us say, right. Again there is, you know that there is an equilibrium between the contaminant, between the contaminant adsorbed on to soil and the contaminant in the relevant water or the aqueous solution, right. So you are going to again have a shift in the equilibrium again.

And thus all these aspects, let us say, as in the concentrations of the contaminant in the aqueous phase, the soil, adsorbed on to the soil and in the gaseous phase are at equilibrium. So if you shift one of these variables, let us say, then again you are going to have a change in all the relevant variables here, right. So again that is the relevant aspect obviously.

We are going to try to remove this particular contaminant in the gaseous phase and with time, everything or most of the relevant contaminant you presume will be in the gaseous phase. And by removing this gaseous phase, you will thus capture all the relevant contaminant or most of the contaminant, right. So that is the relevant aspect we need to keep in mind.

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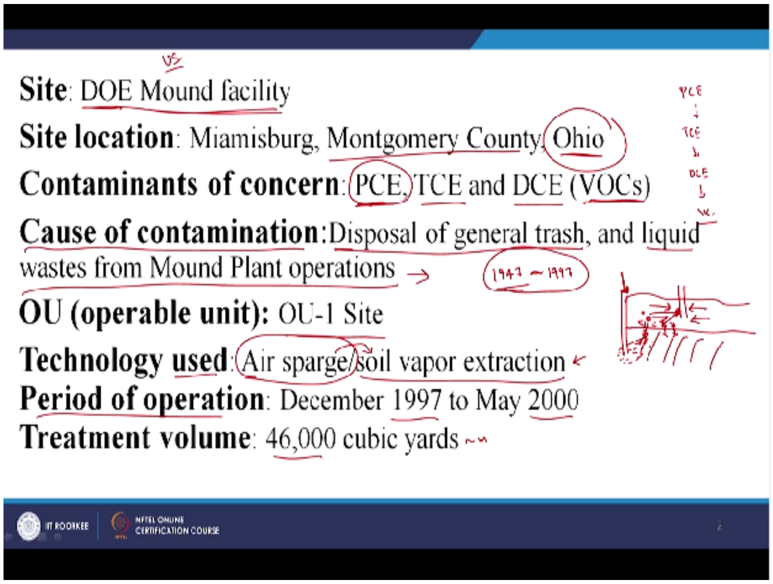

Site: DOE Mound facility

Site location: Miamisburg, Montgomery County, Ohio

Contaminants of concern: PCE, TCE and DCE (VOCs)

Cause of contamination: Disposal of general trash, and liquid wastes from Mound Plant operations

OU (operable unit): OU-1 Site

Technology used: Air sparge/soil vapor extraction

Period of operation: December 1997 to May 2000

Treatment volume: 46,000 cubic yards

US

PCE ↓ TCE ↓ DCE ↓ VC

1947 ~ 1997

So let us move further. So we are looking at Department of Energy Mound facility, let us say, right. Again this is the site in the US. We are going to look at that particular aspect, right. So they are calling it the DOE Mound facility. So if you want to look at the relevant aspects, simple search in the internet, let us say, the relevant title and such. You will be able to excess the relevant documents, let us say.

And this is in Montgomery in Ohio. Let us say Ohio is the state within the US, right. So what are the contaminants of concern? Obviously we are looking at soil vapor extraction. So thus typically we are going to be looking at relatively volatile compounds, let us say. And here we look at most of the industrial solvents again. We looked at these compounds widely, let us say, right, chlorinated solvents.

So perchloro or tetrachloroethylene, TCE trichloro, dichloro and so on. All these are volatile organic compounds, right. The key aspect is that they are volatile. And as we have looked at in multiple cases where we also looked at the similar examples, let us say, or similar compounds, pardon me. We know that PCE can be degraded to TCE, right by natural attenuation, let us say, or remediation.

And then DCE and vinyl chloride and so on and so forth, right. So that is something to keep in mind, let us say, right. So let us move forth. So what was the cause of contamination, let us say. So it was during a period of time, let us say, or major part of the time, let us say, general trash and liquid waste from the Mound Plant operations. And what was this Mound Plant used for, let us say?

So they had, I believe, Monsanto. I think you know that it is I guess now relatively famous for the genetically modified or engineered crops or the seeds and so on, right. Again I believe they were operating, what do we say, or using this facility from around 1947 and also I believe before them another particular, what do we say, company was using that particular site and they dumped their or as you can see or disposed their relevant waste in that particular site now, right.

So that is the relevant aspect. So I believe 2 owners between 1947 to I believe around 1997, let us say, right. So that is the relevant period over which, let us say, contaminant occurred. Again based on the type of products or the type of industry that was using that particular site, let us say, right. So let us move on. And now we are going to look at typically one particular size or not size pardon me, site within the whole, what do we say, area we are going to look at, right.

Otherwise, it is going to get too comprehensive. And again as I mentioned, we are going to look at soil vapor extraction, right. But again in the relevant theoretical aspects, we did talk about or maybe briefly mentioned or discussed the air sparging. So what is this about, let us say. And it is more or less typically used as an enhancement for soil vapor extraction. So we know what soil vapor extraction is about.

So what is this air sparging about. Let us say, you have this particular subsurface and let us say, this is your ground water table, let us say. And by soil vapor extraction, you are trying to remove this particular gaseous phase. But as we know, you also have the contaminant in the aqueous phase here, right. This is the aqueous phase, right.

And so thus, let us say, you can let the system, let us say, reach equilibrium as in when this particular contaminant gas is removed, then there is again going to be an equilibrium between the gaseous phase here and the aqueous phase here, let us say, for the contaminant anyway, right. Or you can also have or you can bubble the air through this particular contaminated water, right. Thus accelerating the change in phase, let us say, of the contaminant from aqueous phase to the gaseous phase, right.

So what are we going to do? We are just going to bubble the air, let us say, or purge air through this particular contaminated water, let us say, right. So you have this uncontaminated air, the bubble, let us say, that is moving through your particular contaminated water now. What is going to happen? Because of again the relationship, let us say, or you know that there is going to be an equilibrium between the gaseous and aqueous phases.

And now you have this uncontaminated gas bubble in contact with your particular relevant contaminated water. So the contaminant is going to change phase from the aqueous phase or the water into the gaseous phase. And this particular gaseous phase, let us say, is now going to reach this particular zone. And then will be removed by your negative pressure that is typically applied during the soil vapor extraction, right.

So that is an enhancement, let us say, to soil vapor extraction. So that is what the people here have used. And the remediation was between 1997 to 2000, let us say. And treated volume is these many cubic yard. 1 yard is typically equal to meter, let us say, 46,000 cubic yards. So you get an idea about the relevant site. So it is not miniscule or very small, it is certainly not a huge site either, right.

So again these are, you can use relatively compact systems and get these aspects done, let us say, right or get the remediation done. So site background, obviously we will look at the relevant location, let us say, and obviously we need to understand the relevant layers. Why is that? Because as we know here we are talking about extracting the gas. So obviously the porosity or the permeability is the considerable aspect out here. So we need to understand what are the different subsurface layers out here, right. So let us go on or move on.

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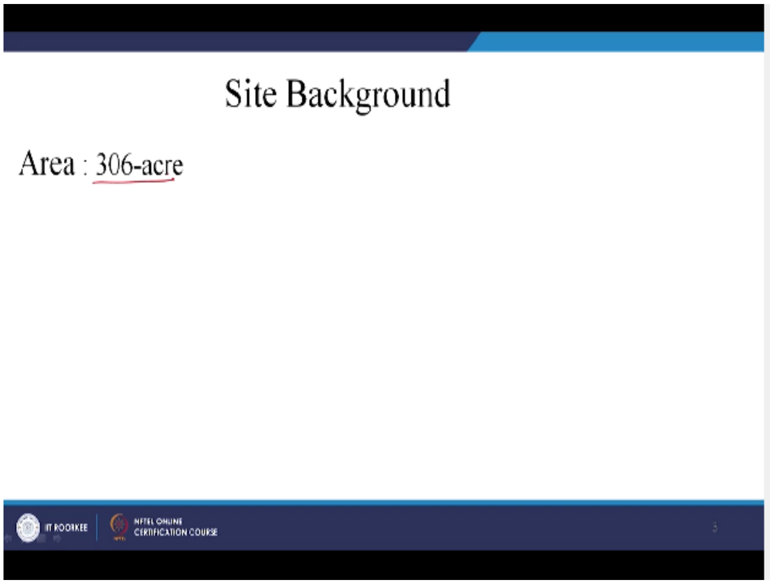

Site Background

Area : 306-acre

So obviously considerable site, let us say.

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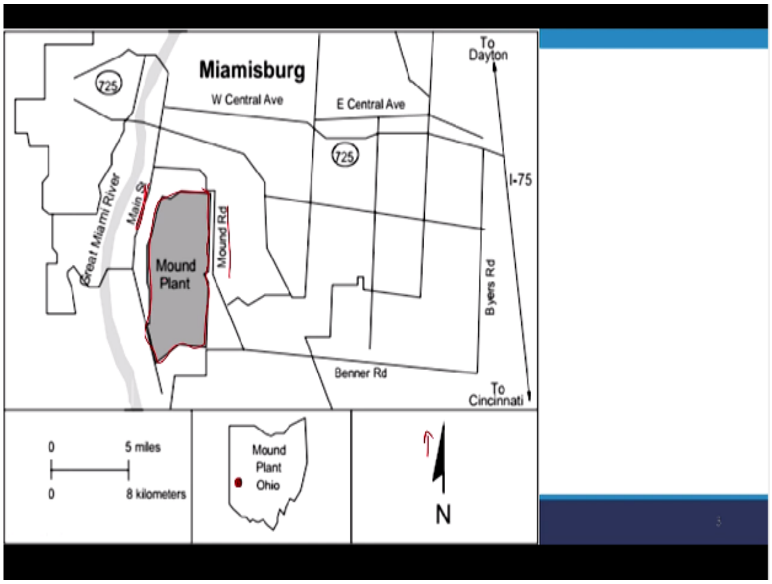

And typically we are looking at this particular plant, Mound Plant. We are going to look at better maps too but you should be able to get an idea about this. So you have Mound Road on one particular side out here, right. So to the east, you have the Mound road and I believe to the west, you have the Main street, right. This is north out here. So again this is, I believe, Ohio and I believe, this is what we have out here, right or hopefully this is Ohio anyway.

So anyhow, we have this particular Mound Plant out here. And I believe we have sections of this particular plant, let us say. Again this plant or various places within this particular locality, let us say, were used for different chemical operations. And some of the relevant waste were dumped in the particular area or location.

And that more or less, what do we say, transformed into or contaminated the relevant site, let us say. And after few years, they maintained the sanitary landfill but by then again there was already considerable, what do we say, contamination of the relevant site, right. So let us look at this particular site further.

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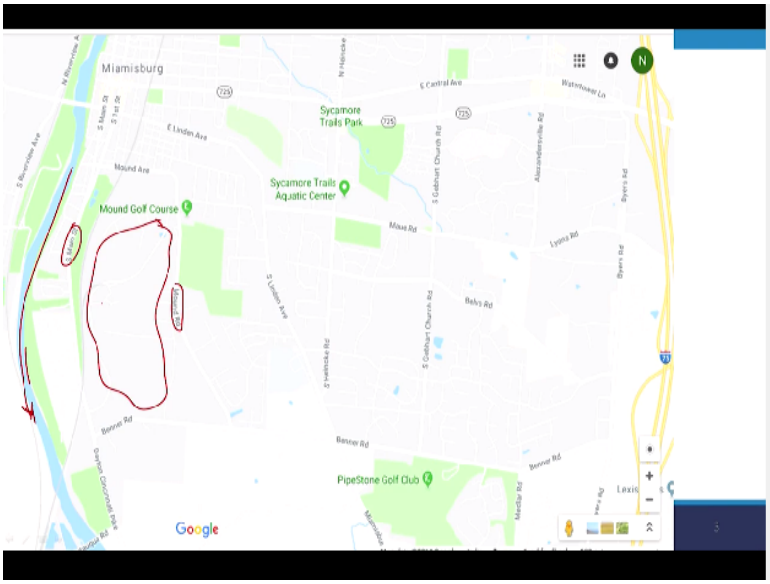

So as I mentioned, we had Mound road to the east and Main street to the west and so our site is somewhere out here. So from here, you can understand that it is within, near a particular canal, right. So if, let us say, the relevant contaminant reaches the relevant canal, right or the surface water body depending upon whether it is lined or unlined or such, let us say. The contaminant can then be transported over a wider area or distance, thus affecting a greater population, let us say, right. So again we look at this in a bit more detail, right.

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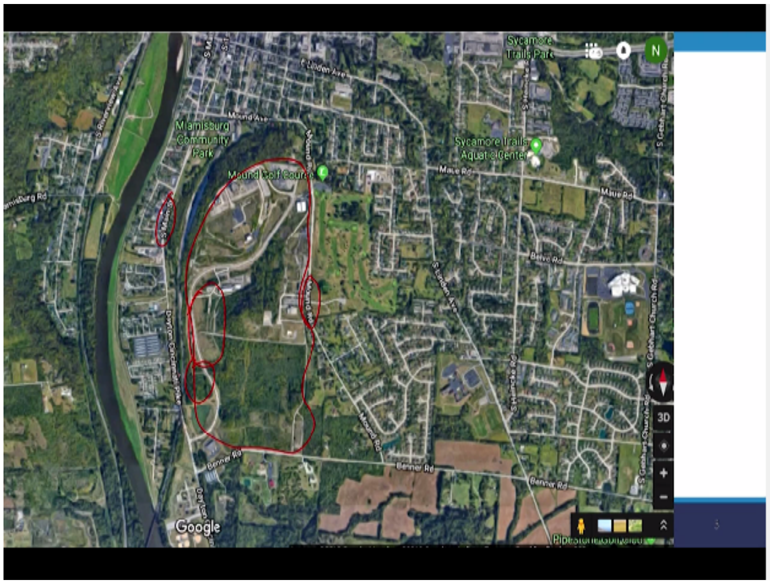

So we have this particular aspect out here. Again Mound road out here and Main street out here. So this is our particular contaminated site, let us say, right. As you see, there are different aspects out here. Some undeveloped plan out here, right. and also some developed area here that was used by various industries. And I believe this is where we have the relevant contamination, let us say, and also out here, let us say. But we will look at this, right.

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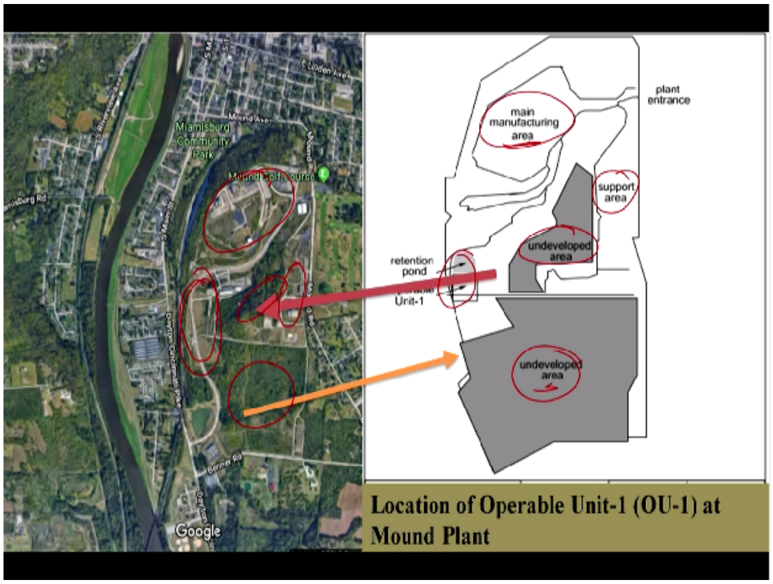

Location of Operable Unit-1 (OU-1) at Mound Plant

So let us go forth. And obviously we have some undeveloped area out here, 2 sections right, undeveloped area out here. And again another undeveloped area out here, right. So as you can see, the main manufacturing area seems to be to the north. This is the main manufacturing area. They were using some support area out here, that is what you can see out here, right.

And the retention pond and this particular relevant units, let us say, the operable unit which we are going to look at is as I mentioned earlier, somewhere out here, let us say, right. So this is more or less the typical and not the typical, the place where the dumping took place and then later they end up putting a landfill, I believe a sanitary landfill. But still you have considerable contamination out there, right. So that is what you see out here, right.

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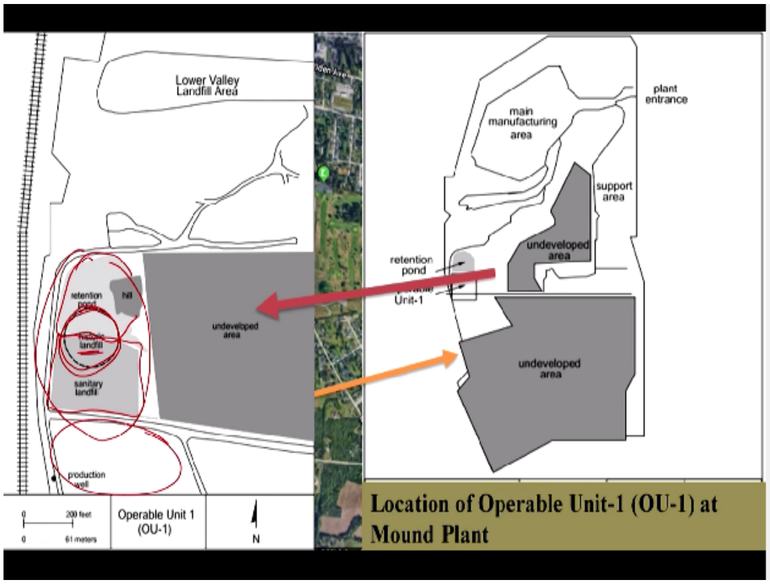

Location of Operable Unit-1 (OU-1) at Mound Plant

So let us look at this particular aspect in a bit more detail. So you have this undeveloped area and looks like you have a minor hill or mound here. So earlier they were dumping in this particular area, historic landfill, let us say. Though it is not a landfill, I believe it was a dump. And then they constructed this sanitary landfill, right.

This will be clear in the reference electrode section and then sanitary landfill as in they had some impermeable layer beneath it and then transported or put the waste in this particular landfill. And now they are again maintaining a retention pond, let us say, for various purposes, right. So we are going to more or less look at this particular contaminated area, let us say, right. This particular contaminated area, right.

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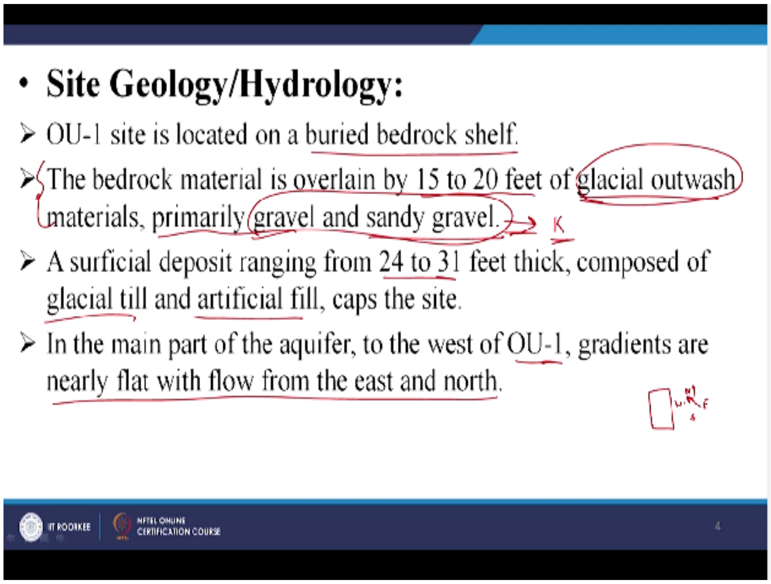

- **Site Geology/Hydrology:**
  - ➢ OU-1 site is located on a buried bedrock shelf.
  - ➢ The bedrock material is overlain by 15 to 20 feet of glacial outwash materials, primarily gravel and sandy gravel. → K
  - ➢ A surficial deposit ranging from 24 to 31 feet thick, composed of glacial till and artificial fill, caps the site.
  - ➢ In the main part of the aquifer, to the west of OU-1, gradients are nearly flat with flow from the east and north.

So let us look at the site characteristics and so on, right. So it is located on buried bedrock shelf, right. So that is something to keep in mind, okay. And it is overlain by 15 to 20 feet of glacial outwash, primarily gravel and sandy gravel. Again glacial outwash as in I believe, you can check this up, I guess. So if you have relevant mountains or any such glaciers, let us say, and you have surface water flowing through, you maybe, this is not the right term.

But I guess due to erosion or such, you will have transport of the relevant sediments and deposition, let us say, downstream and that is what you see out here, I believe. This is what they refer to a glacial outwash. So as expected, let us say, typically it is gravel and sandy gravel. And the key aspect to understand is that, this particular type of soil obviously will have higher hydraulic conductivity, let us say, right. The hydraulic conductivity will be typically high, let us say, that is something to keep in mind.

So above that, let us say, it seems you have around 25 to 30 feet thick glacial till and artificial till above this particular layer, let us say. Again we are going to look at the relevant figure but keep in mind that we have considerable, what do we say, zone of, what is this now, highly permeable or zone with high hydraulic conductivity, let us say, right. So that is something to keep in mind and the main part of the aquifer to the west of this OU-1, gradients are nearly flat with flow from east to the north. Again we are going to look at this particular case.

If you look at it, the site is somewhere out here. So north, east, west and south. So east to the north, I guess, right. So that is how, I believe, the relevant terrain is, okay.

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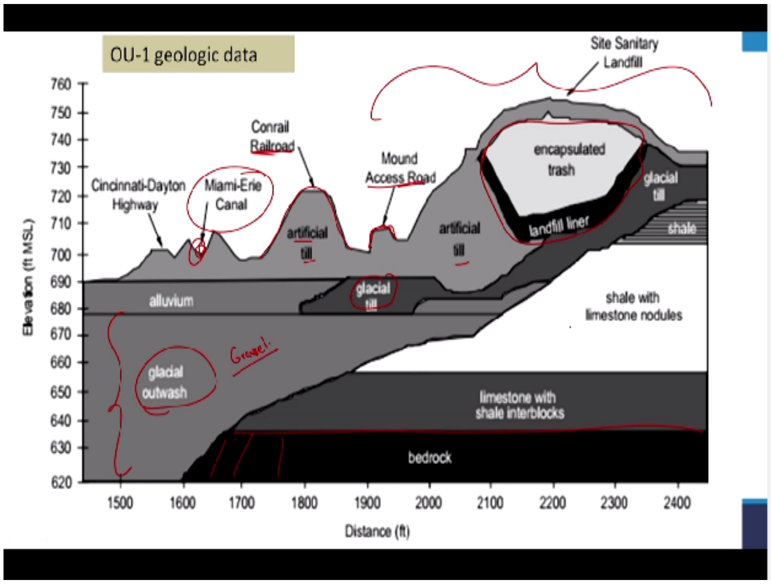

OU-1 geologic data

This is what we have out here. So this is the bedrock, right that was referred to earlier, yes. And as you can see here, what do you see here? You see this sanitary landfill, right. Again earlier it was just a dump and now they constructed this sanitary landfill with relevant liner and so on. You see that we have a very generic diagram out here, right. This is what we see out here and we have the contaminated zone, more or less, out here, let us say, in this particular area, let us say, right.

Again you have an impermeable layer typically here, a bedrock here and here a canal somewhere out here, we have the relevant canal, right. So here you have the canal. This is obviously the side view, right. And here you have a railroad, right. And thus artificial fill out here, right. Another road here, right. And that is another artificial till. So you have this artificial till or fillings out here, right.

Beneath that again as they were mentioning, let us say, they have the glacial till and artificial till and beneath that they have this glacial outwash which has mostly or which mostly consists of gravel, let us say, right. So you have gravel out here, few, what do we say, tens of feet thick. And similarly over that, you have glacial fill and artificial fill. And out here, you have the relevant sanitary landfill out here, right. So this is the generic diagram out here.

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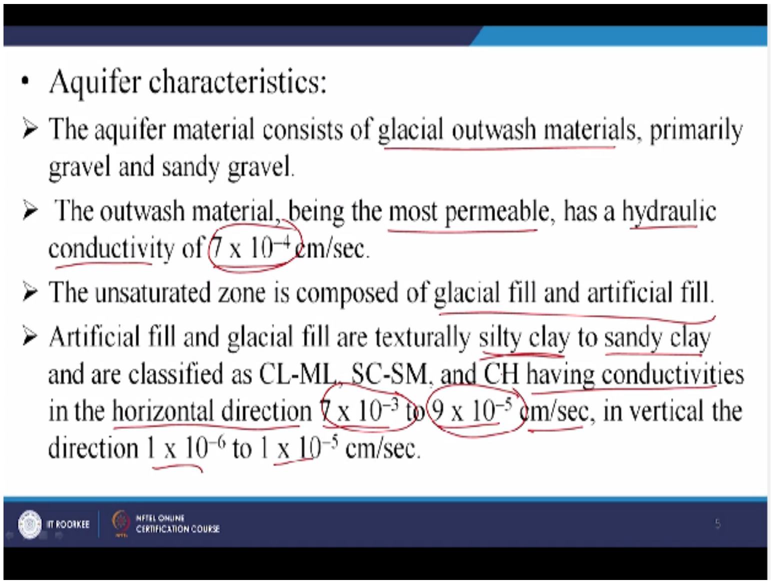

- Aquifer characteristics:
  - ➢ The aquifer material consists of glacial outwash materials, primarily gravel and sandy gravel.
  - ➢ The outwash material, being the most permeable, has a hydraulic conductivity of 7×10^{-4} cm/sec.
  - ➢ The unsaturated zone is composed of glacial fill and artificial fill.
  - ➢ Artificial fill and glacial fill are texturally silty clay to sandy clay and are classified as CL-ML, SC-SM, and CH having conductivities in the horizontal direction 7×10^{-3} to 9×10^{-5} cm/sec, in vertical the direction 1×10^{-6} to 1×10^{-5} cm/sec.

So, right obviously aquifer characteristics. So glacial outwash materials, primarily gravel and sandy gravel, right. Again something we discussed. So it is relatively permeable or considerably permeable if I may say so. And thus has a relatively high hydraulic conductivity of 7*10 power -4 cm/sec, let us say, right and then the unsaturated zone, let us say, has glacial fill and artificial fill and I guess it varies as in it as in the hydraulic conductivities vary.

So in the horizontal direction, we have it ranging from high of around 10 power -3 to a low of 10 power -5 cm/sec. And in the vertical direction, obviously relatively less, let us say, right. And what is it typically made of? Either silty clay or sandy clay. Obviously it is a relevant mixture, let us say, right. This is an artificial till and the glacial till, let us say, right or the fill, pardon me, right. So these are the aspects that we have, again relatively higher hydraulic conductivities, let us say, relatively again, right. So that is something to keep in mind, right. So let us move forth.

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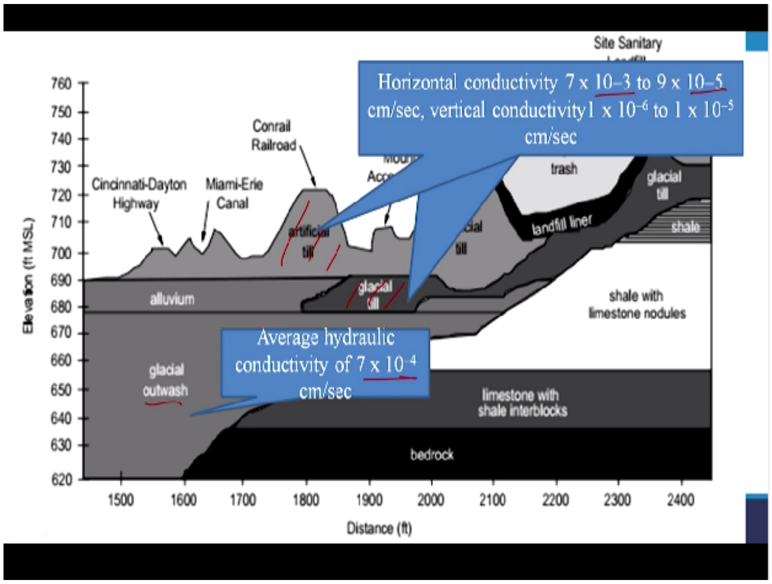

Horizontal conductivity 7 x 10–3 to 9 x 10–5 cm/sec, vertical conductivity1 x 10^{-6} to 1 x 10^{-5} cm/sec

Average hydraulic conductivity of 7 x 10^{-4} cm/sec

I believe, here we have a better representation of the relevant sites. So here for the glacial till or the artificial till, horizontal hydraulic conductivity, either 10 power -3 to 10 power -5 cm/sec. And vertical, 2 orders of magnitude lower, I guess, right. So here we have the glacial outwash of gravel, let us say, right. And again relatively higher hydraulic conductivity now, right.

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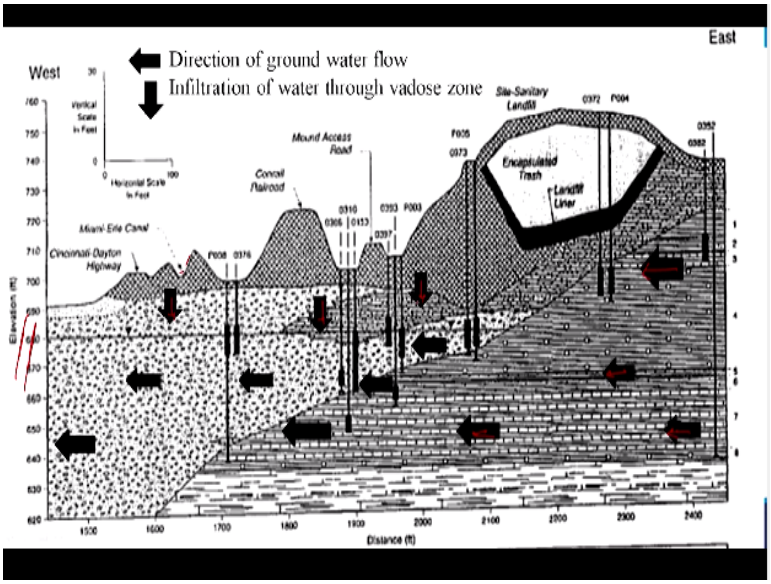

So let us move on and this is the diagram obviously based on the relevant gradients, let us say or the piezometric readings, let us say that they were able to come up with for the direction of the ground water, right. So let us look at what we have out here, right. So obviously ground water flow is in this particular direction, let us say, right. And why is that obviously? Typically, you have a canal or surface body, water body out here, right.

But again I believe you have some river or such or water body out here too, right. Again typically as you see the water is flowing from the east to the west or either east to the north and then north-west, let us say, right. So let us say move on. So direction of ground flow of water or ground water flow that is what you see here. And again infiltration of water through the vadose zone, let us say, right. So that is something to obviously keep in mind, right.

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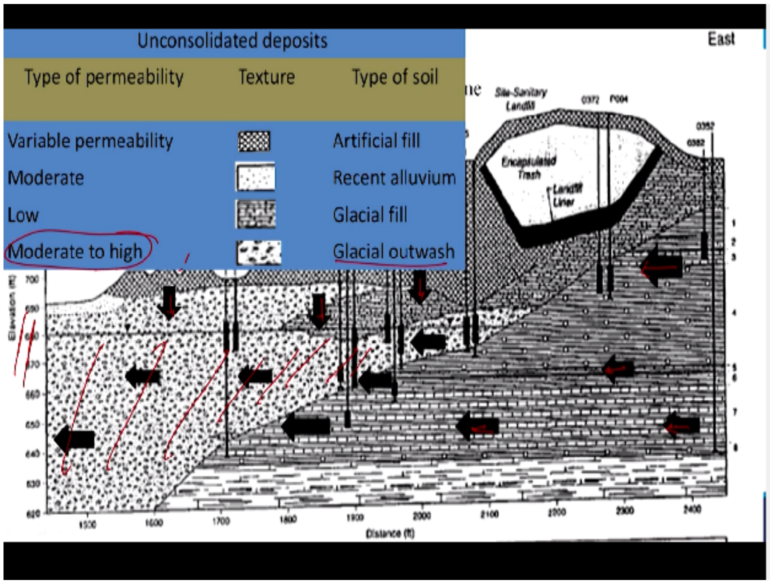

Unconsolidated deposits		
Type of permeability	Texture	Type of soil
Variable permeability	▩	Artificial fill
Moderate	░	Recent alluvium
Low	▒	Glacial fill
Moderate to high	▚	Glacial outwash

And different fills and such but we have an idea about this. So I am going to skip these aspects. But maybe highlight one particular aspect as in where it is relatively moderate to high, right. Moderate to high, where is that? For the glacial outwash which is in this particular region, let us say, right. So that is something to keep in mind, right.

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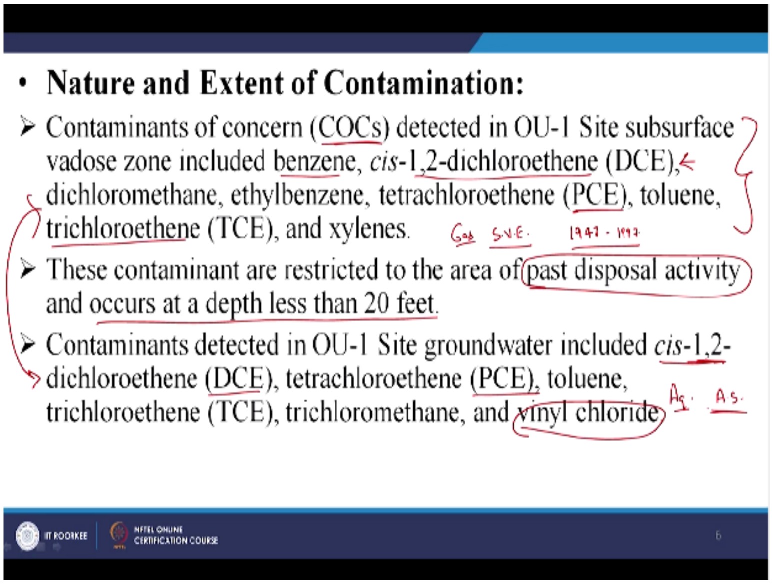

- **Nature and Extent of Contamination:**
  - Contaminants of concern (COCs) detected in OU-1 Site subsurface vadose zone included benzene, *cis*-1,2-dichloroethene (DCE), dichloromethane, ethylbenzene, tetrachloroethene (PCE), toluene, trichloroethene (TCE), and xylenes. Gas S.V.E. 1947 - 1997
  - These contaminant are restricted to the area of past disposal activity and occurs at a depth less than 20 feet.
  - Contaminants detected in OU-1 Site groundwater included *cis*-1,2-dichloroethene (DCE), tetrachloroethene (PCE), toluene, trichloroethene (TCE), trichloromethane, and vinyl chloride As. A.S.

So nature and extent of contamination. So what were the different contaminants of concern, let us say that is the term used by in the US, let us say, right typically. What are the contaminants that they were concerned with? So typically they were concerned with benzene and 1,2 DCE, let us say, right, dichloromethane, ethylbenzene, tetrachloroethene, toluene, tetrachloroethene and xylenes, let us say.

Typically, volatile compounds, let us say, or at least almost all of these are volatile organic compounds, let us say, with various degrees of volatility. As in some are relatively more volatile or would want to strongly stay in the gaseous phase compared to some of the other compounds. But you get the general picture out here. And obviously once you have, let us say, tetrachloroethylene, let us say, you are going to have the relevant by-products too depending upon the extent or the time from, let us say, contamination, let us say.

And as we know, the relevant time period was between 1947 to 1997. So thus you would expect some, what do we say, remediation or bioremediation to have occurred, let us say. And the by-products would have formed. And what are the typical by-products as we know? Trichloroethylene, let us say, or 1,2 DCE, right and so on, right. So that is something to keep in mind.

But typically looks like they were restricted to the area of past disposal activity, right. That is something to keep in mind. And luckily for them, they occurred at depth less than 20 feet, let us say, right. These are not DNAPL typically, right. And again that maybe is probably one of the reasons why it has not permeated through to a greater depth. But again the greater the depth, the slightly more complex but still soil vapor extraction can work well out there too, right.

So again typically to depth less than 20 feet, right. So contaminants were detected in also the ground water. And what were they detected? Or what were the contaminants typically detected? 1,2 DCE, PCE and obviously most of these compounds, they detected out here. But here you have vinyl chloride additionally and maybe not the relevant, some of the relevant compounds that we looked at earlier.

Obviously right, you have some compounds in the gaseous phase and obviously you are going to thus detect the relevant compounds or the similar compounds or same compounds rather in the aqueous phase too, right. Why is that? There is always an equilibrium between the compound and the gaseous phase and the aqueous phase, right. That is what you observe out here.

So again the key aspect is to understand that both the gaseous phase and the aqueous phase are contaminated and thus you need to have soil vapor extraction and to maybe enhance that, you are also going to have air sparging, let us say, right. So that is something that we are going to look at, let us say, right. So let us move on out here.

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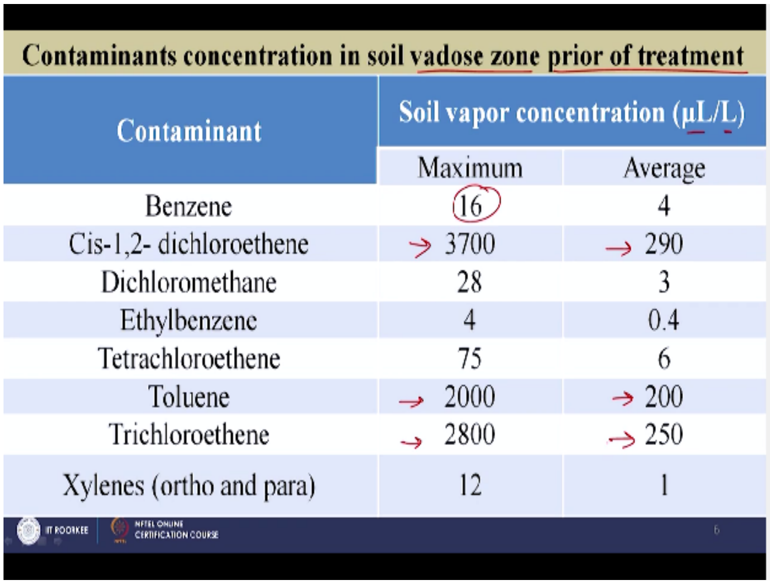

Contaminants concentration in soil vadose zone prior of treatment

Contaminant	Soil vapor concentration (µL/L)	
	Maximum	Average
Benzene	16	4
Cis-1,2- dichloroethene	→ 3700	→ 290
Dichloromethane	28	3
Ethylbenzene	4	0.4
Tetrachloroethene	75	6
Toluene	→ 2000	→ 200
Trichloroethene	→ 2800	→ 250
Xylenes (ortho and para)	12	1

And let us look at the relevant values, right. Contaminants concentration in the soil vadose zone, let us say. And this is prior to treatment obviously, right. So they are giving it in volume per volume units, let us say, right. So that is something to keep in mind here, right. Benzene is 16. What are the major concentrations, let us say, or major compounds, let us say? From the point of view of the maximum, 1,2 DCE; toluene, right and TCE, let us say.

And similarly though average also is relatively high for those compounds. But obviously different compounds have different toxicities and we need to look at those relevant aspects. As in I cannot just, let us say, look at the compound, let us say, that has the maximum concentration and try to look at that. I need to look at the relevant risks associated with exposure to such particular compounds at such particular concentrations.

And based on that, let us say, I will go forth and look at the relevant remediations, let us say, right. Again here we are going to look at soil vapor extraction. So almost all of these are very volatile compounds and all these compounds are going to be removed, let us say, right. And that is what we have out here. Let us look at what else we have.

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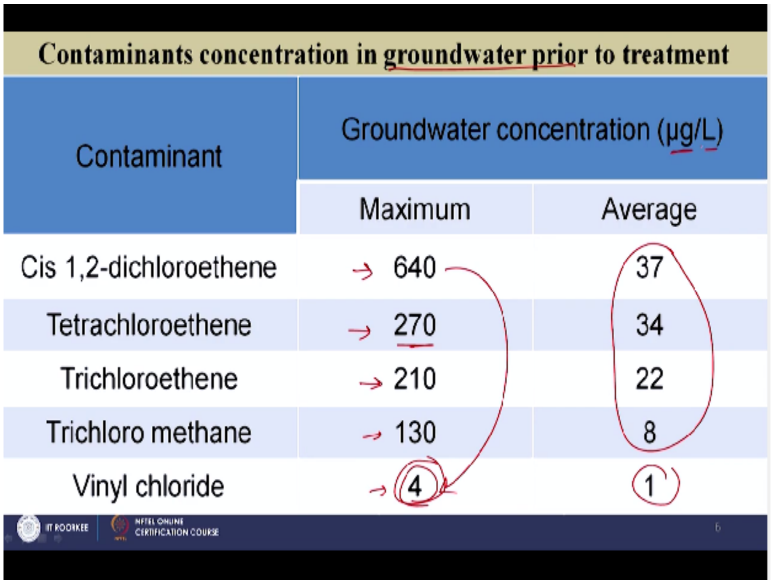

Contaminants concentration in groundwater prior to treatment

Contaminant	Groundwater concentration (µg/L)	
	Maximum	Average
Cis 1,2-dichloroethene	640	37
Tetrachloroethene	270	34
Trichloroethene	210	22
Trichloro methane	130	8
Vinyl chloride	4	1

And again in the ground water now. Earlier in vadose zone and now in the ground water. So ground water again I believe we have 1,2 DCE, tetra PCE. I believe we did not have a lot of PCE in the relevant, what do we say, gaseous phase but in the aqueous phase, we do have some. Anyway, trichloro, tetrachloro and vinyl chloride. I guess vinyl chloride; you end up with vinyl chloride from degradation of 1,2 DCE.

Maybe the relevant compound was too toxic, let us say, for the relevant microbes out there or the kinetics was too low for some reason, let us say. The degradation of 1,2 DCE to vinyl chloride did not take place. That is something to keep in mind. But again obviously what do you see here? The average concentration is relatively less. But here its units are also different. So we cannot make like for like comparisons, let us say.

But typically the concentrations of volatile compounds will be higher in the gaseous phase compared to the aqueous phase, let us say, right. So let us move on.

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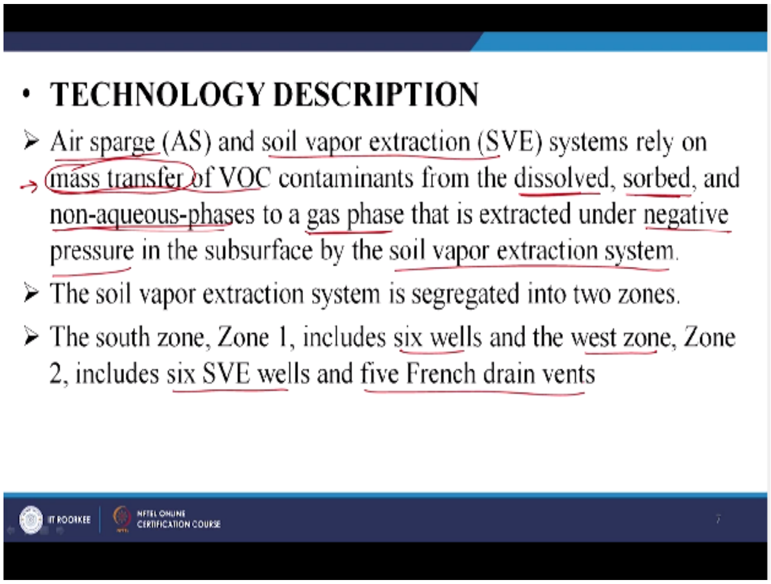

- **TECHNOLOGY DESCRIPTION**
  - Air sparge (AS) and soil vapor extraction (SVE) systems rely on mass transfer of VOC contaminants from the dissolved, sorbed, and non-aqueous-phases to a gas phase that is extracted under negative pressure in the subsurface by the soil vapor extraction system.
  - The soil vapor extraction system is segregated into two zones.
  - The south zone, Zone 1, includes six wells and the west zone, Zone 2, includes six SVE wells and five French drain vents

So technology obviously air sparging, right and soil vapor extraction. This is something that we have already looked at. So we are looking at transfer of the mass. Again the major aspect here maybe compared to other relevant methods is that, we are not, what do we say, degrading the compound. We are only changing the phase or removing the contaminant from the relevant soil or the ground water, let us say, or the air now, right.

We are not degrading it. So once you pump this air out, you again have to look at treating that particular contaminant, let us say, right. So that is something to keep in mind. As in we are only looking at mass transfer, let us say. It is not degradation, let us say. From the dissolved, sorbed and even if there is any NAPL to a gaseous phase and then under negative pressure, let us say, right, due to the soil vapor extraction system, you are going to be able to remove that, let us say, again right.

So what is the key? It is the mass transfer and here, they are looking at dissolved, adsorbed NAPL phase and also gaseous phase and everything you are trying to transform into the gaseous phase, right. So let us move on. They are looking at 2 particular zones. South zone, right and also west zone, let us say, right. And they are looking at 6 wells and again 6 SVE wells and 5 French drain vents, let us say, okay.

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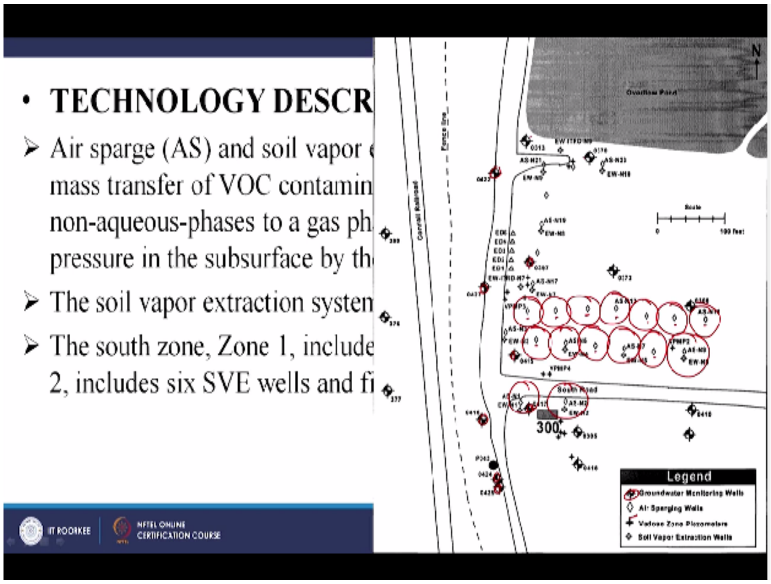

- TECHNOLOGY DESCR
  - Air sparge (AS) and soil vapor
    mass transfer of VOC contamin
    non-aqueous-phases to a gas ph
    pressure in the subsurface by th
  - The soil vapor extraction systen
  - The south zone, Zone 1, include
    2, includes six SVE wells and fi

So let us move on and look at these relevant aspects, right. So you have ground water monitoring wells, right. So obviously they have lot of ground water monitoring wells, yes. So that is what you see out here and air sparging wells, right. Obviously we also looked at a particular example in our particular case. And I believe there we chose some case where we had one particular, what do we say, extraction well and based on, let us say, the radius of influence which we deemed it to be the case when, let us say, the pressure drop or the pressure was 1 inch of water, right.

And based on that, we looked at the radius of influence and put one particular well in. So similarly they would have looked at their particular case and the radius of influence might be something out here or something like this, let us say, right. So you can now estimate, let us say, obviously this is very rough estimate based on their flow rates or such. Zones where or which are going to be removed or where they give greater priority and so on and so forth, let us say, right. So that is something to keep in mind.

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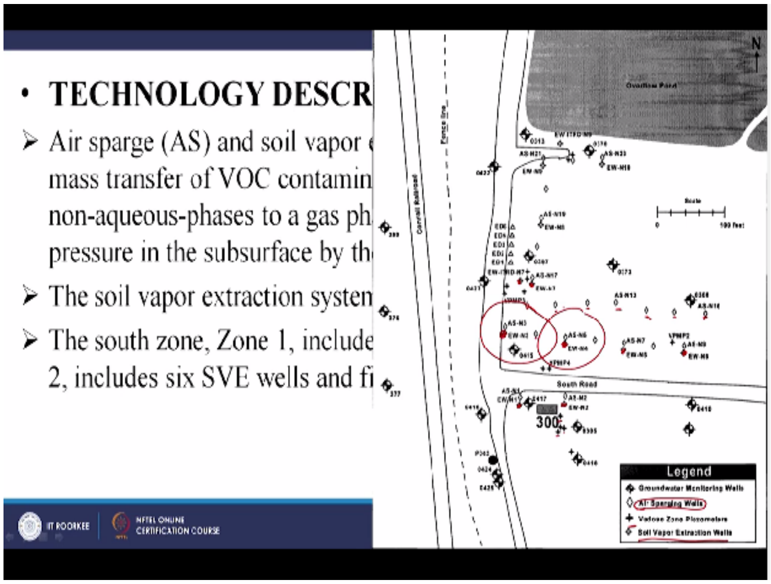

- **TECHNOLOGY DESCR**
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And vadose zone, piezometers, right. Vadose zone for the unsaturated zone. Piezometers in that particular case and next the extraction wells, okay. These are the air sparging wells where they pump the air in pardon me. So they are pumping air in through these particular wells into the ground water. And they have the soil vapor extraction wells out here and we do not have them as closely spaced as you can see they have them here. Here, here and here, right.

And also some in this particular south zone, right. So obviously the location will depend upon, what are the relevant aspects, let us say? Where the contaminant is and so on and so forth and the relevant transport and such and also the soil characteristics, right. Again radius of influence, let us say. So that is something to keep in mind as we looked at earlier, let us say, right. So let us look at one particular slide in the relevant aspect.

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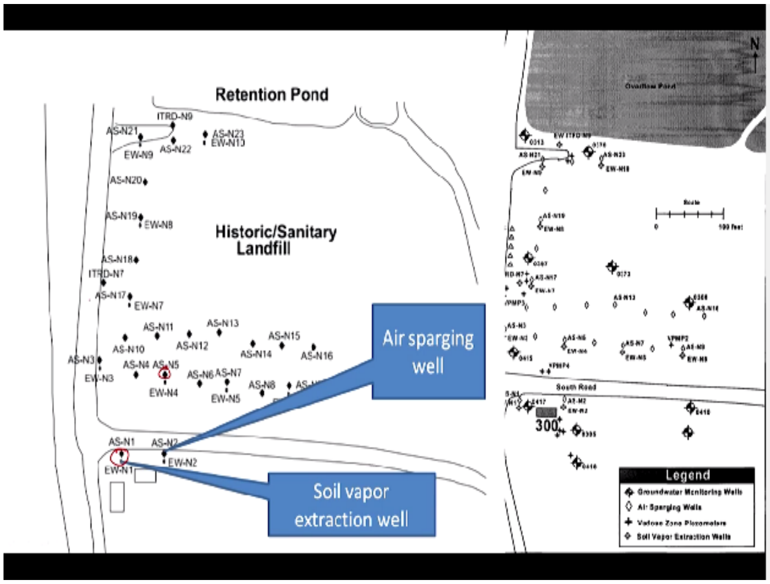

So here, let us say, we have 2 aspects. One is obviously the air sparging well and typically they have had, let us say, the soil vapor extraction well right near it, let us say, right. So you have, what do we say, an air sparging well where you pump air into the relevant water and also very close by you also have the extraction well, let us say, where you are going to pump the gaseous phase or the gas out, let us say, or the air out, right. So that is something to keep in mind. And here you have a relatively better picture probably.

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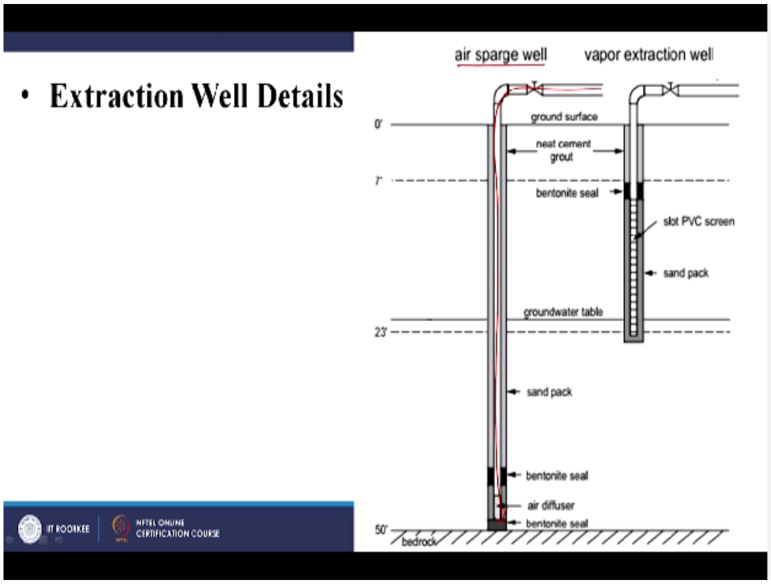

- **Extraction Well Details**

So extraction wells, let us say, right. So let us look at this particular aspect. So obviously what you need? You need an air sparging well where you pump air in, right. And then you are also going to try to extraction the relevant, what do we say, gas. Generic aspects but we are going to discuss this in the next class because I believe I am almost out of time. So we look at these aspects and maybe some of the relevant data in the next session and I guess that is it from me for today and thank you.