Natural Hazards
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Lecture – 35
Flood and Related Hazards Part IV

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So, welcome back. As we have discussed ah many points in the previous lectures about the drainage, ah we can see this channel shape or ah that the peak discharge and all that in different areas the river basin.

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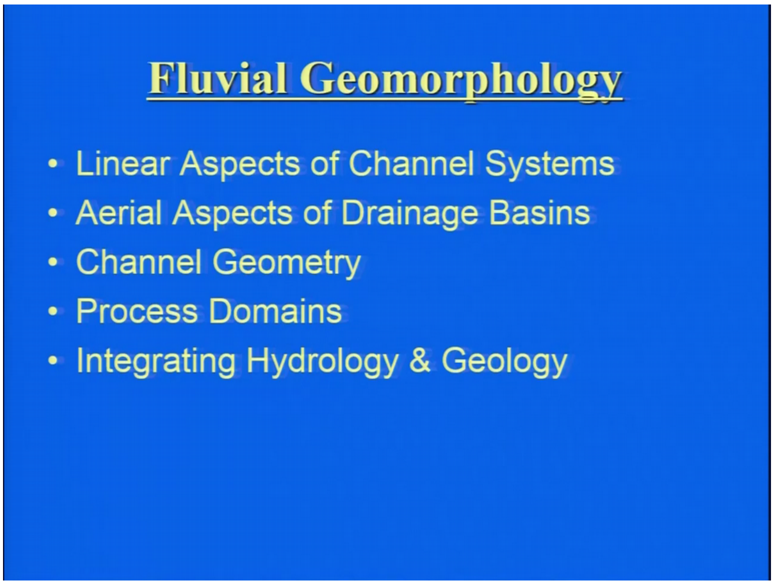

Let us see how this parameters are important in understanding the overall flooding events. So, mainly this is what we do in fluvial geomorphology is that we try to look at the linear aspect of the channel system, aerial aspect of the drainage basin, channel geometry and process domain, integrating hydrology and geology. Few things, we will discuss in this lectures.

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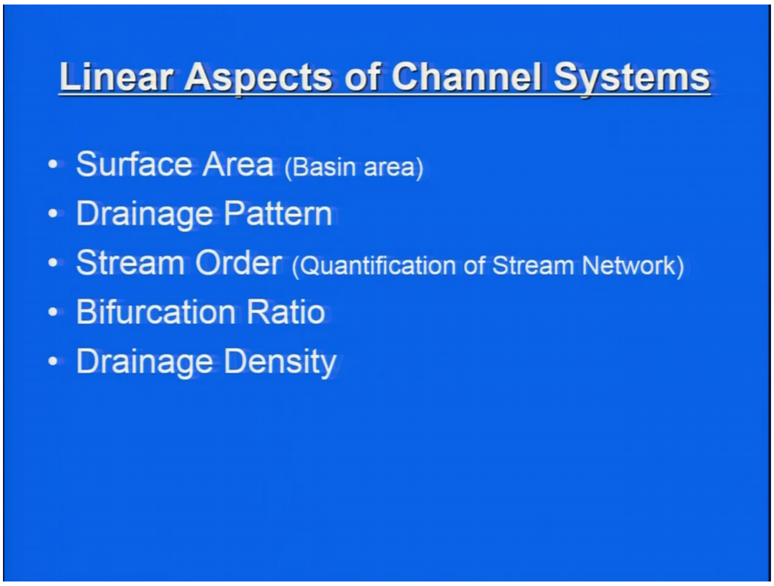

So, coming to the linear aspect of the channel, what we see mainly is try to understand that what is the surface area that is the basin area, what is the drainage pattern, steam order, where we can do the quantification of this stream network, bifurcation ratio, drainage density. So, these all parameters are going to help us in understanding that what will be the flooding conditions in the drainage basin.

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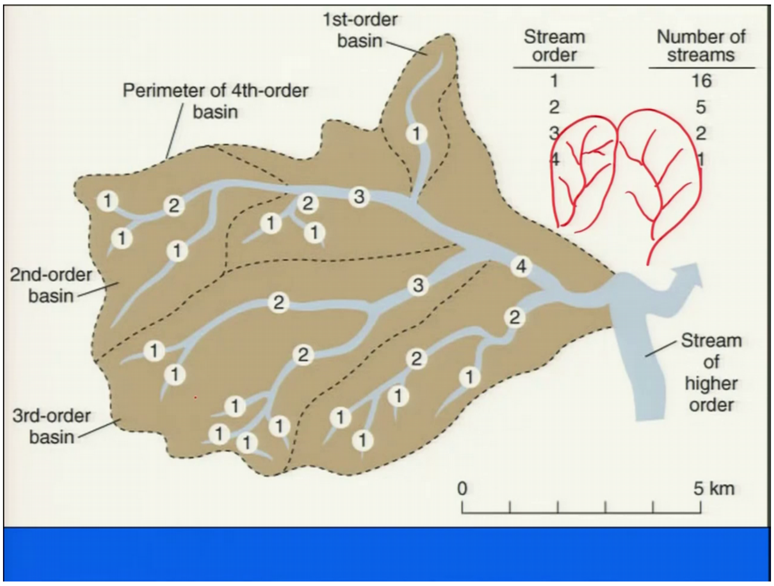

So, usually what we do is that if you if you have the major trunk stream, then we; then the area which is like flowing last time, I was showing you that you have like two sloping surfaces here. So, streams which are flowing here like this and then you have the mains trunk stream and the streams are getting into this here, and then few streams are flowing and maybe I can try to little better.

So, suppose one trunk steam is like that and then you have in the streams or the tributaries which are joining here, another trunk stream is like that and then you have these streams which are joining. So, this will have what we will put as and this is one basin area and this is another basin area. So, ah this is what is it exactly is been shown here. So, you have the main trunk stream, and then you have the tributaries which are joining the main trunk stream.

So, ordering of this stream will also be important, because the ordering will help us in getting the bifurcation ratio of any particular basin. So, we have one is the main basin of the major channel that is in fourth-order, how we are we order this, I will explain and then we are having the sub basins and these are all smaller basins which are feeding the main trunk stream.

So, what is been done as I said the boundary here, we have two smaller streams or the of 1st order with if it the joins here, then this becomes the 2nd order and two 2nd order streams, when joins become the downstream stream will be; will be considered in the third order. And when two-third order stream meets, then it becomes the higher order, so this is what we usually do.

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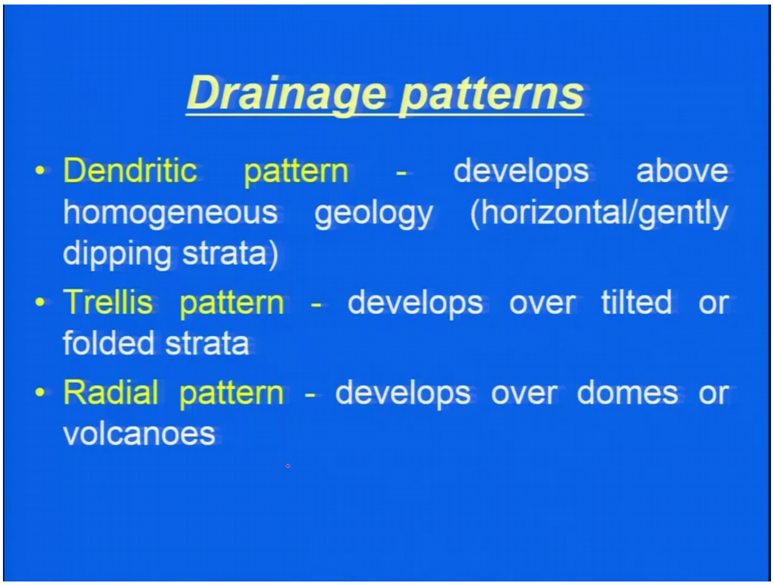

So and then coming to the drainage pattern and which is again an important part, because this will help us in identifying the subsurface geology. So, for example if you are having the drain dendritic patterns, we will come to that how it looks like ok. Then what straight away we can identify that, it shows homogeneous geology, horizontal or gently dipping strata's in such regions usually, we will be able to find the dendritic pattern.

So, one what we were discussing earlier was straight channel, meandering channel and the braided channel here. But, here what we look, we are looking at is the drainage pattern, so you need to be careful in distinguishing or putting the terminologies. So, trellis pattern, develops over tilted or folded strata. A radial patterns, develops over domes and volcanoes. So, along with the geology, one can also identify the landforms on which the drainage of the drainage is are developed.

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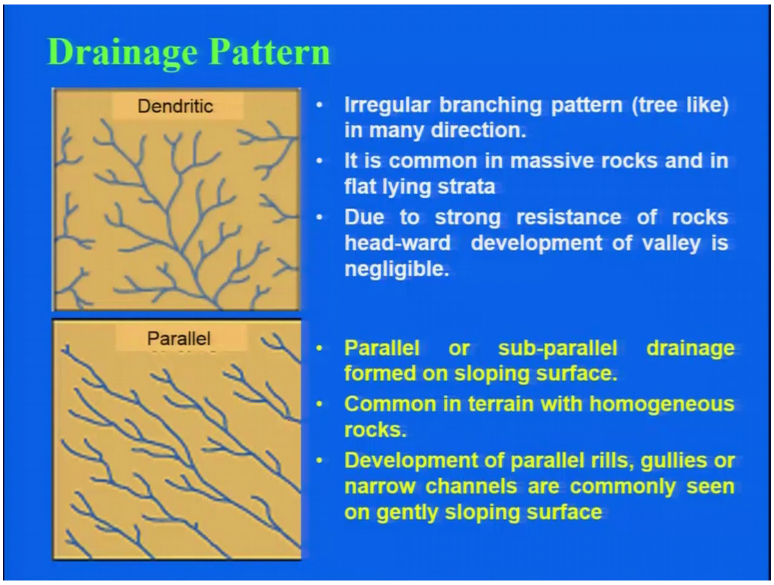

So, drainage pattern dendritic mainly is in typical irregular branching pattern and it looks like an tree. So, you have a tree pattern and the streams are rolling in many direction. It is common in massive rocks and flat line strata or slightly inclined strata and due to the with its developed due to the strong resistance of the rock head-ward development of the valley is negligible.

So, in most some cases, we will find that ok. Then parallel streams or the sub-parallel streams are commonly seen over a sloping surface. So, you can also judge based on such pattern that in which direction, the the will slope is. Common in terrain with homogeneous rocks. Developed development of parallel rills or gullies or narrow channels are commonly seen on gently sloping surfaces.

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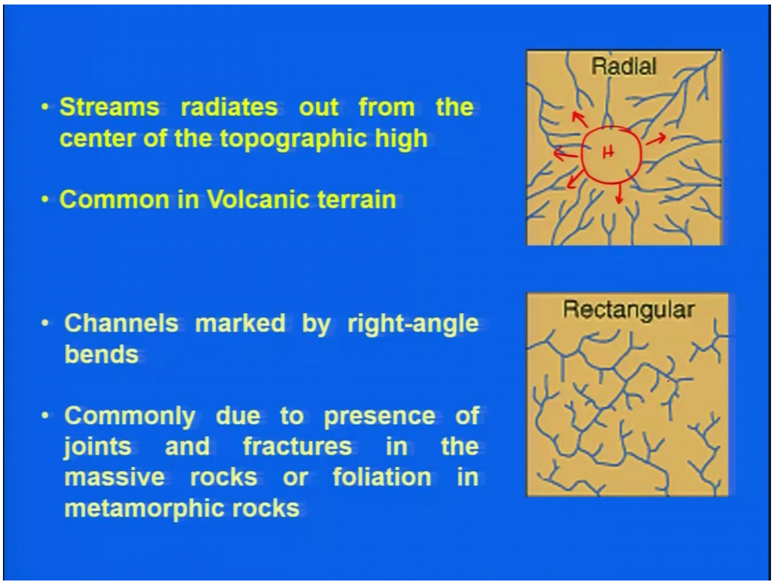

Then coming to the radial, as I told that it will also help us in identifying the land form, either it is in dome or it is so this portion is the central portion is elevated, so higher and this one will be sloping in this direction. So, away from the center and that will give you a typical radial pattern.

Then we have rectangular channels which are mostly seen, where you have the jointed and fracture and terrain and it will typically show that if they intersect or bends at the right angle. So, when in most of the massive rocks or fractured rocks or foliated metamorphic rocks, you will be able to see a typical rectangular pattern drainage pattern.

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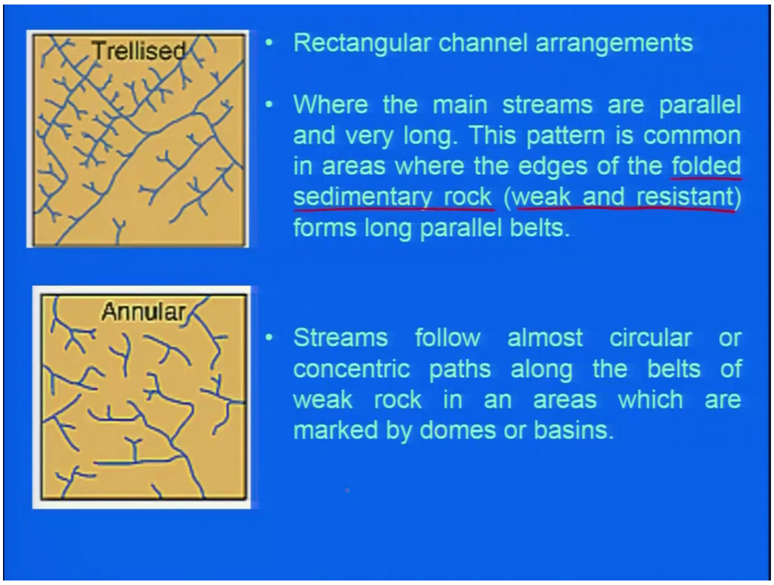

Trellised, so you have an again an rectangular channel arrangements, where the main stream are parallel and very long. So, main stream will be parallel and made a very long and this pattern is commonly in the area, where you are having the folded terrains or you are having an alternate of weak and the resistive rocks. So, you will be will be able to see in folded sedimentary rock rocky terrain where you have the weak and resistive rock forms long parallel belts so it is being seen here. Annular stream follow almost circular or concentric path along the belt of weak rocks in an area, which are marked by domes and basins.

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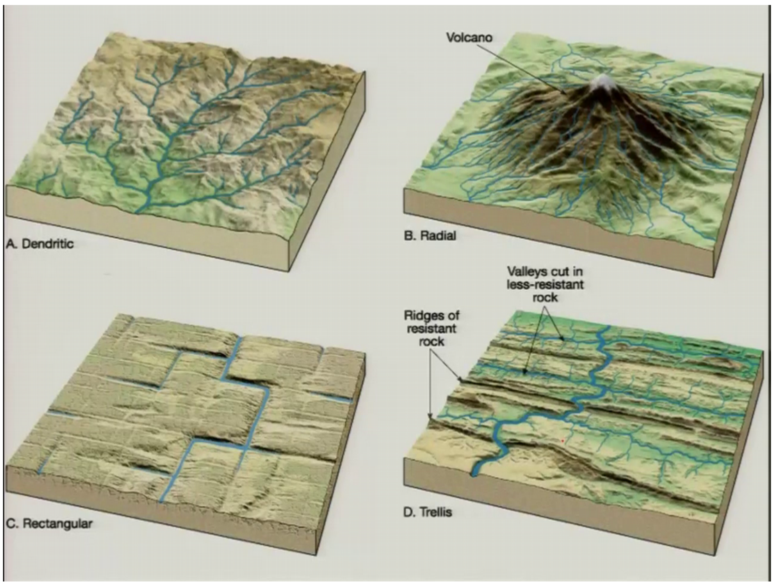

These are typical of different type of drainages and these are the most common one. So, you have dendritic drainage typical tree shape and then you have radial. So, either you have an elevated portion or the domal areas or you are having the volcanic cones, then you will see a radial pattern. In the area, where you are having well developed fractures and joints, then you have rectangular pattern and trellised mostly in the areas, where you are having folded sedimentary rock succession and with softer and or weaker and resistive rocks alternative succession of that if you have, so then you will see and trellised pattern there.

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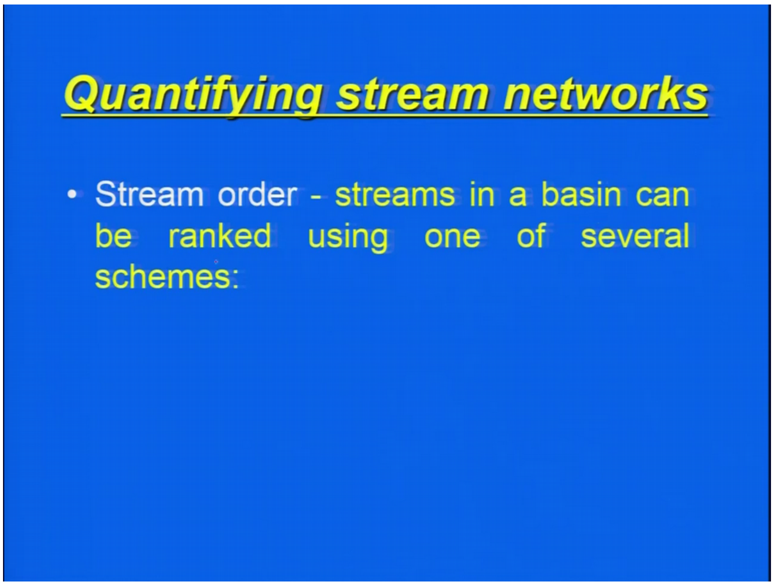

Quantifying stream network. Stream in a basin can be ranked using one or several schemes, so we are talking about the flood intensity.

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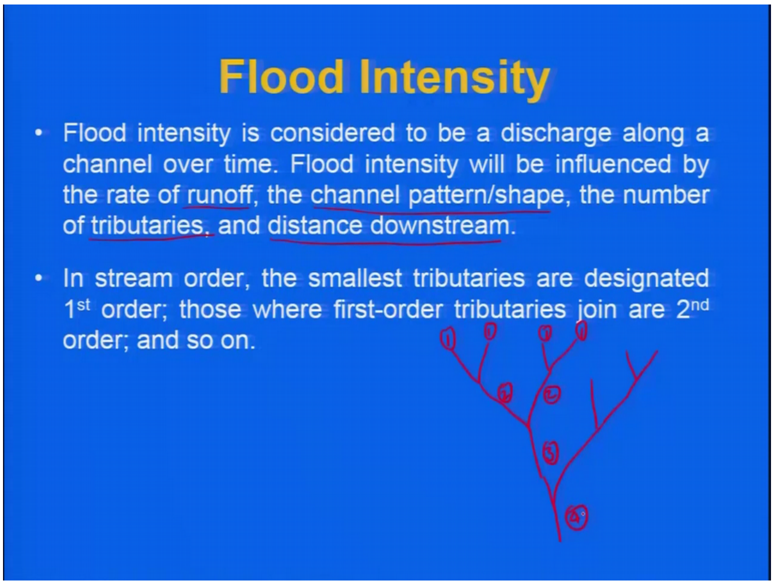

So, the flood intensity is considered to be a discharge along channel over time. And this will be influenced one by they run off, the channel pattern in shape and the number of tributaries and then distance downstream at an point of interest.

So, the stream model usually what we do is I was explaining in the previous ah slide that the smallest tributaries are designated has 1st order and then further if two 1st order joints, then you have 2nd order. So, for example, at the time of the origin or the up planed areas, so this will be the 1st order stream and then if you are having the other one joining here, then this will become 2nd order, this will be 1st order, this will be 1st order first and this will be second and two 2nd order will become 3rd order and similarly, if you are having the 2nd order stream two 2nd order joint two 3rd order joining, the main stream then that will become the 4th order stream and so on. So, this will play an important role, when we are talking about the bifurcation ratios and the drainage density and all that. So, drain density, mainly we will see consider the overall area of the basin and the length of the streams the all streams.

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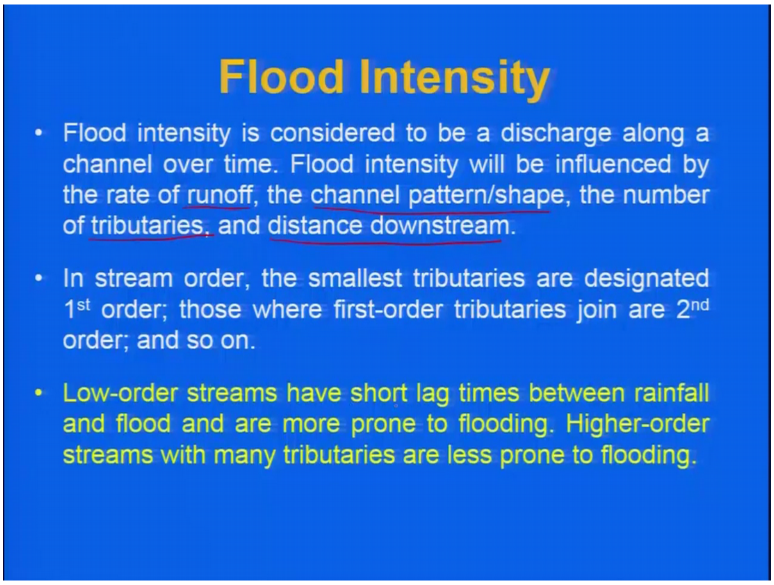

So, low-order streams have shorter lag, this is; this is important for us. So, if you are having more number of lower-order streams, then the then you are you will be able to see at the; at the peak discharge or the hydrograph will be very sharp or it will be where the flooding conditions, where be very quick between the rainfall and the flood events.

So, lower order streams have shorter lag times between rainfall and flood and are more prone to flooding. Higher-order streams with many tributaries are less prone to so this you please remember and it is the lower-order stream, short lag and prone to flooding. Higher-order with many tributaries, less prone to flooding.

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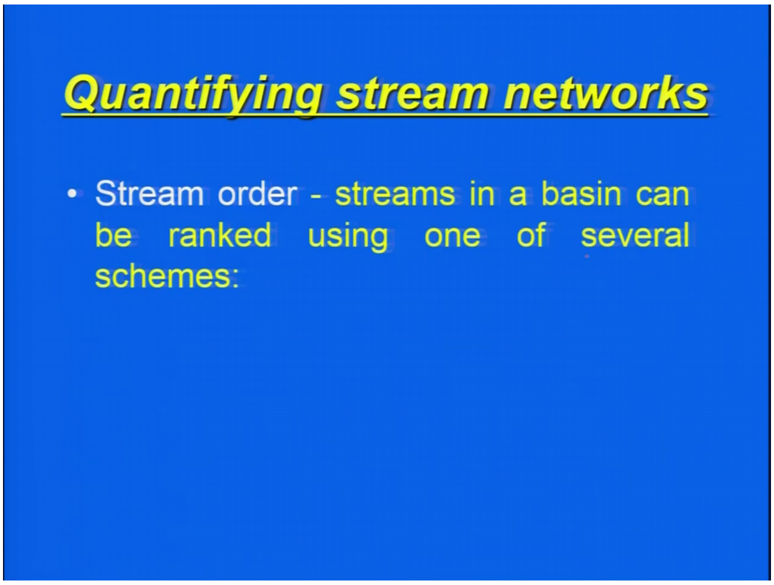

So, the quantifying stream network, stream order what we take is streams in the basin can be ranked using one of the several methods. So, this what we have already discussed, so I will move ahead.

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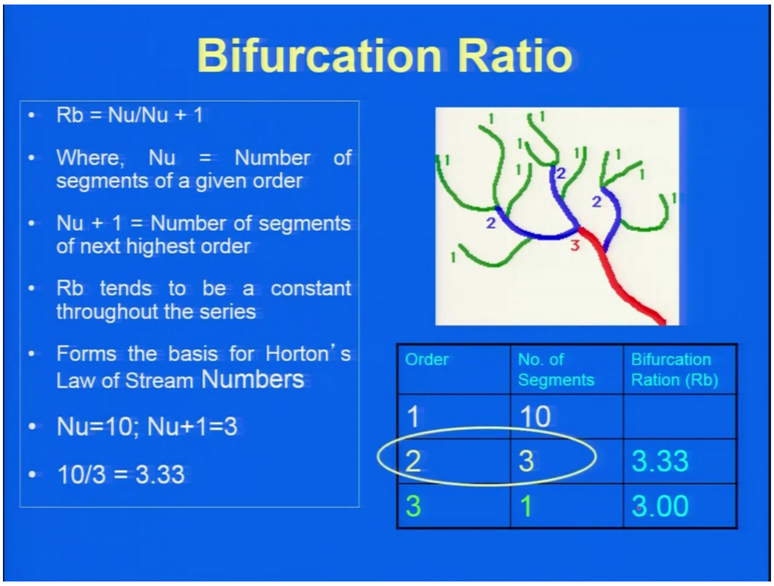

So, if you are having the more the streams or the drainage which are which has been shown here, so you have two smaller streams joining making it 2nd order to 2nd order making it 3rd order. So, what you can do is you can easily calculate the bifurcation ratio is which is been given as Nu by Nu plus 1. So, higher order stream the next higher order stream, so where Nu is the number of segments of a given order and then Nu plus 1 is your number of segments of the next higher order.

So, for example if you are having Nu is 10 here that is this one 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and the next higher order is only 3 that is 2, then you will have the bifurcation ratio 3.33. So, usually what is been under we understand is the, if you are having high bifurcation ratio, then you will have high discharge and if you are having low bifurcation ratio, then you will have low discharge, but again it will depend on the shape of the basin. So, this is just the correlation given between the first that is a lower order and the ratio between the next higher order, so what we see over here.

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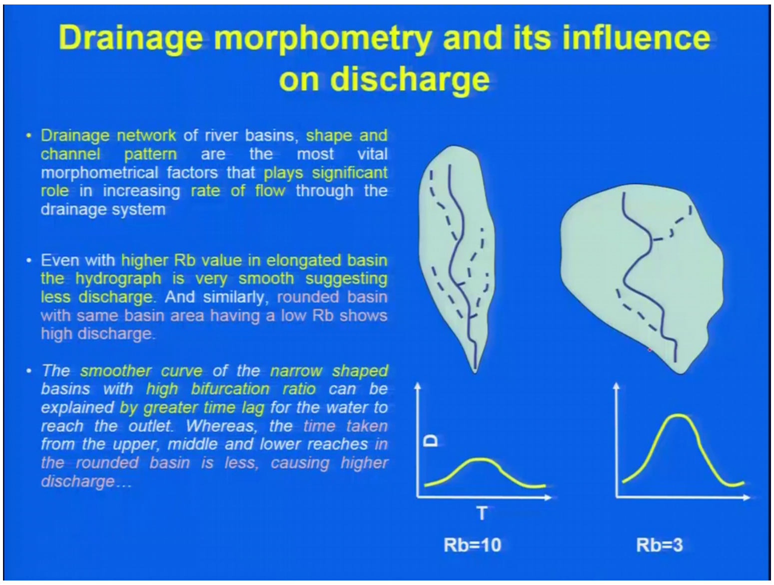

So, drainage morphometry and its influence on discharge. So, the it is extremely important for us to understand the peak discharge of any particular drainage basin or the stream, because it is considerably important for example, in deciding upon the size of the culverts, bridges or cosways, during highway construction. And so this is this part plays an very important role, when we are talking about the flooding conditions.

So, drainage network of river basin, shape and channel pattern are most vital morphometrical factors that plays significant role in increasing rate of flow through the drainage system. Even with higher Rb values and an elongated basin that what I was talking about that even though we consider that the high bifurcation ratio, we will show us not they will be in high discharge and low bifurcation ratio low discharge, but eventually it will depend upon the shape of the basin.

So, in a the basin, where the higher bifurcation value and the elongated base in the hydrograph is very smooth. Whereas, we should what we should have expected is that, because it is having higher bifurcation ratio, the hydrograph would have been slightly picked up or maybe an sharper one, but it is quite smooth as compared to the rounded basin.

So, if you take an example here. So, one is we are having the elongated basin, where the bifurcation ratio is higher. So, in this case, we should have expected that there will be high discharge. And then another one with a similar area, this is just the sketch to explain you. So, what we see here is the rounded basin the next one here a with the same basin area having low Rb value bifurcation ratio shows high discharge which is completely opposite, what we learn ok.

So, you have the hydrograph that is a discharge versus time. So, in terms of the elongated basin, even though it is having higher bifurcation ratio, the hydrograph is quite smooth. Whereas, in this case the hydrograph is different and very quickly, the basin enters into the or the stream enters into the flooding state.

So, the reason here is that the smoother curve of the narrow shaped that is this one elongated basin with high bifurcation ratio can be explained by greater lag time. So, the lag time then that is the time to reach this point the water to reach this point through the streams is the takes more time for the water to end and reach the outlet, this is an outlet here, the major trunk steam whereas, the time taken from the upper, middle and lower reaches in the rounded basin is less, causing higher discharge. So, along with the bifurcation ratio one has to take into consideration the shape of the basin.

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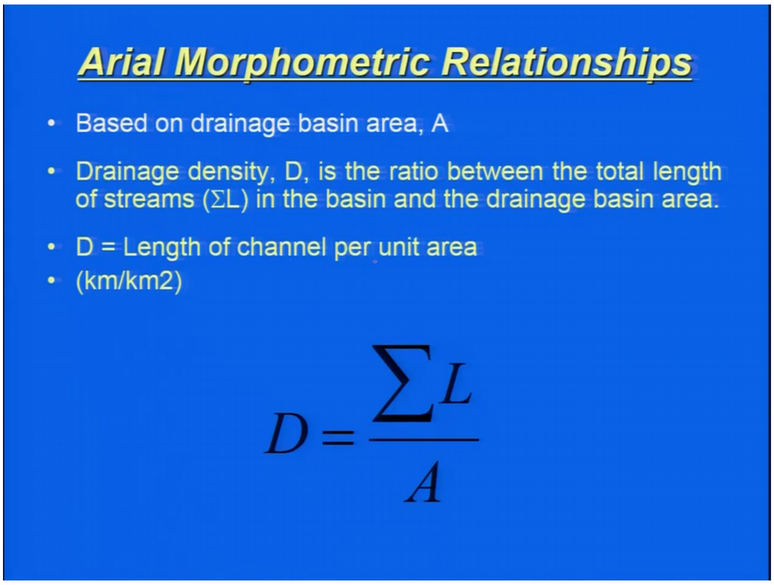

Then we have the another important parameter that is your drainage density and the drainage density is basically given is an ratio between the total length of streams in the basin and the drainage basin area. So, D is the length of the channel per unit area that is in kilometer per kilometer square. So, it is been given as D is equal to some of the length of all the channels within the basin up on the length of the channel per unit area.

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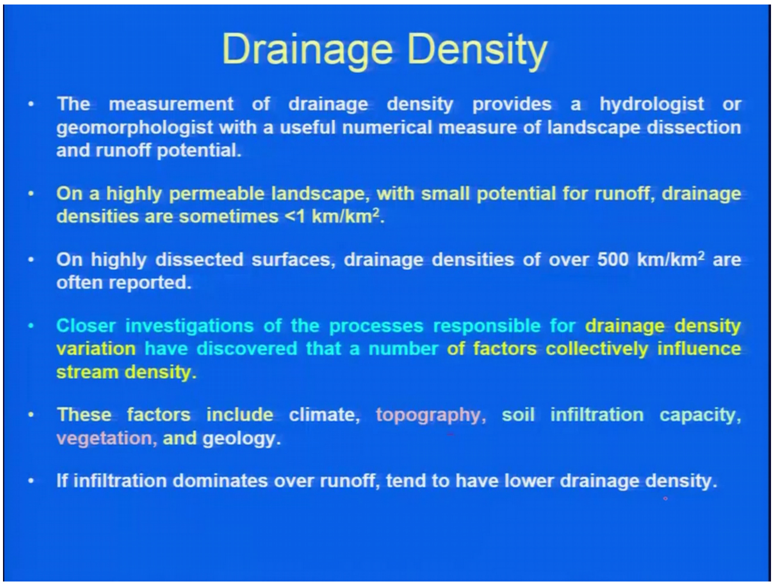

Now, this plays an important role, because the measurement of drainage density provides any hydrologist or gemologist a very useful numerical measure of the landscape dissection and runoff potential. So, in flood this also plays an important role, but this will be governed by the geology or the lithology of the area.

So, on highly permeable landscape, with small potential where the potential will be very less of runoff, because it is permeable so the percolation will be very fast, the drainage densities are sometime less than 1 kilometer by 1 kilometer square. On highly dissected surfaces, drainage density is of over 500 kilometers per kilometer squares are often reported. So, you will have higher values there.

So, closer investigations of the processes responsible for the drainage density variations have discovered that number of factors collecting in collective influence, influences the drainage density. So, one is those factors are climate, topography, soil infiltration capacity, vegetation and geology. Some factors we also discussed in the landslide, whereas here also because they are all related to the topography and the precipitation, they are similar and the factors are responsible for putting the channel in flooding state. So, if the infiltration dominates over runoff, tends to have lower drainage density.

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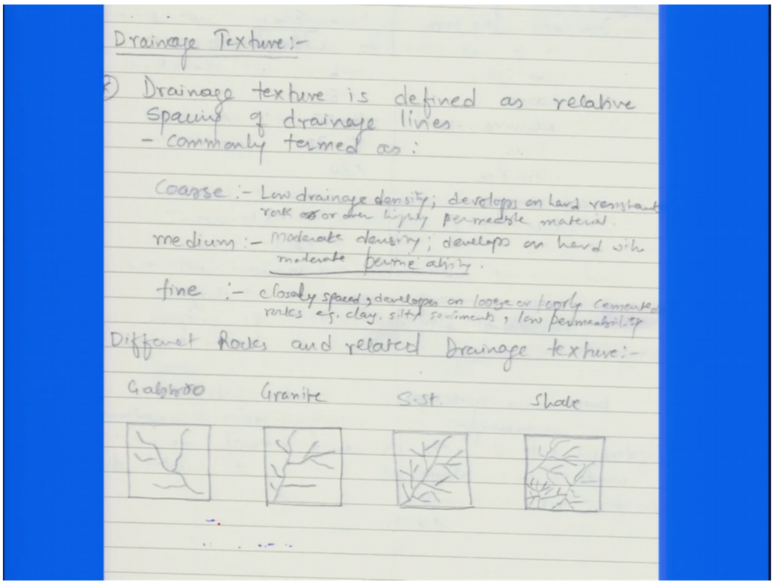

So, if you look at the drainage texture ok, I will considering the different type of rocks, either this is; this is basically the igneous rocks, gabbro, granite, sandstone sedimentary rock and shale, so the drainage texture varies from coarse to fine.

So, the drainage texture is defined as relative space spacing of the drainage lines that is these small tributaries or the main one commonly termed as coarser. If you have low drainage density, which develops on hard resistive rocks or over highly permeable material, so you will have very few drainages which are available so we term this as an coarse drainage, if you have medium and moderate density, it develops on hard rocks with moderate permeability. Fine grain closely spaced, we are having develops over on loose or poorly cemented rocks example clay, silty cells or you are having low permeability in it. So, different type of rocks and related drainage textures are being shown here. So, we are having coarser and then we are getting into the finer texture. So, this can also help in understanding the discharge also.

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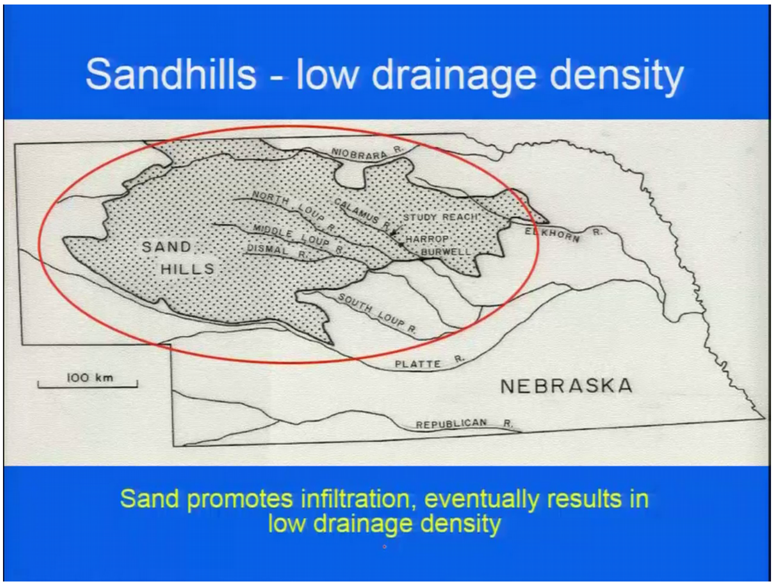

So, for example if you take this basin which is been shown here, so this portion is mostly sandy area. So, sandy is sand is more porous, so the area does not allow much of the runoff, because it is percolated down and you have the less amount of water which is been seen in the channel, whereas in this a region which is as different within less porosity will have more drainage net the net density. So, sand promotes infiltration, eventually result into the low drainage density.

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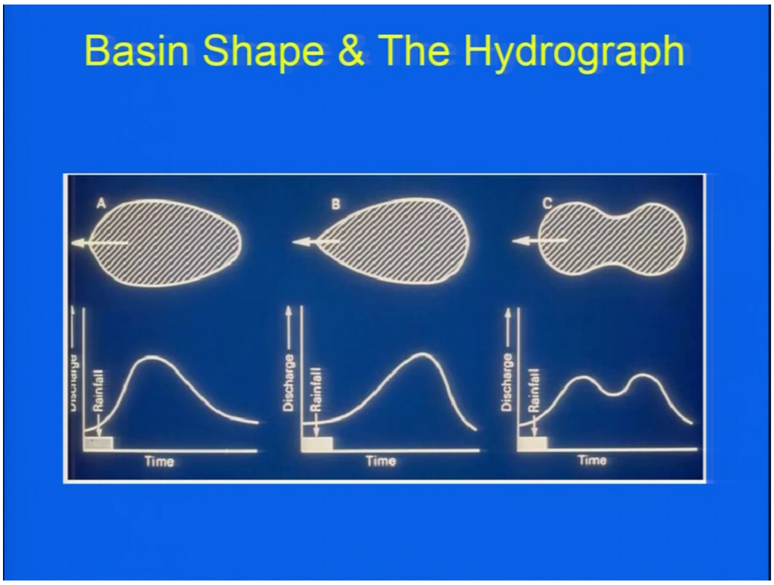

Basin shape as we were talking about the can also be connected with this one, but where exactly you are you are located either you are located in the upstream area or you are located in the middle part of the basin or in the downstream area accordingly, the hydrograph will change that is the time lag between the other the rain and the flood ok. So, if you have different basin shape, you may expect a different ah peaks or the hydrographs with respect to the time and they discharge.

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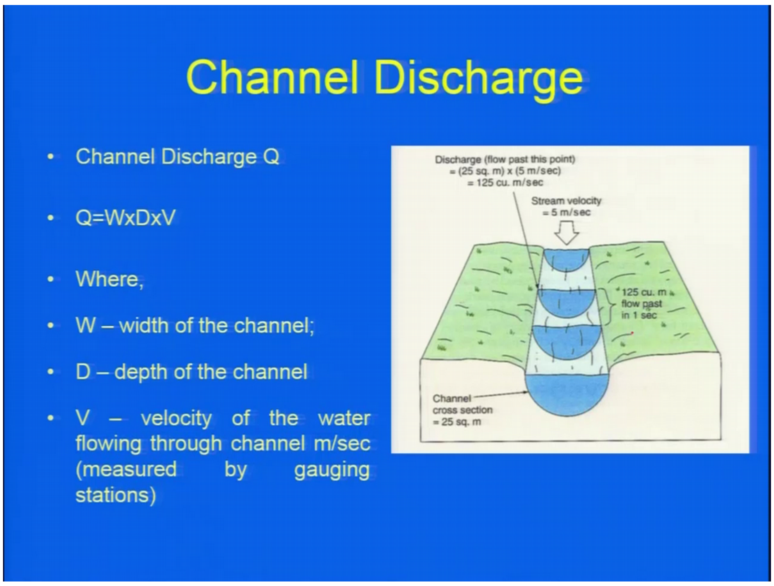

So, as I told that peak discharge of any channel is important. So, this is the basically very simple exercise one can do it, to identify the cross sectional area. So, if you are having the channel cross section is around 25 square meter and then stream velocity is 5 meter per second, then you can have the discharge at that particular given point around 125 cubic meter per second. So, if the cross sectional area varies, then you will have or and then if you keep the velocity ah same, then you may have the flooding conditions in the nearby areas.

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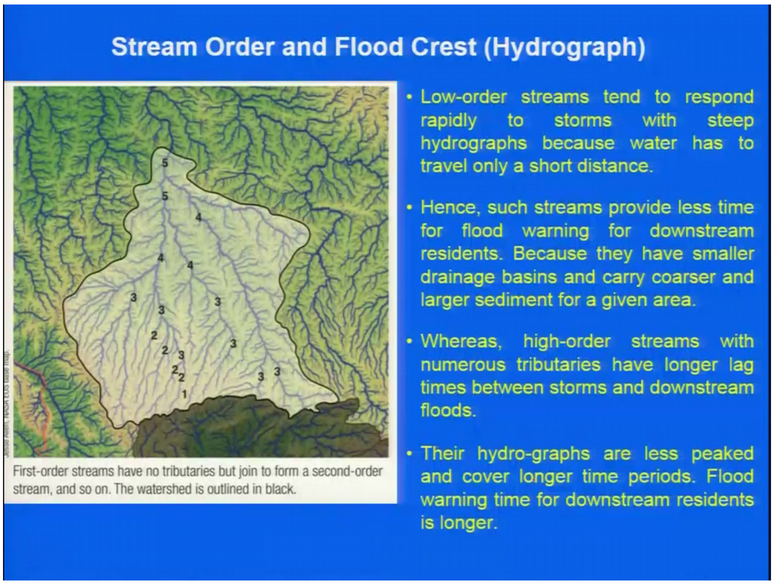

Stream order is important as I was discussing that lower order stream tends to respond a rapidly to the heavy rainfall or storm with steep hydrograph, because water has to travel only a very short distance. So, the smaller streams more number of smaller streams will result into very quick flooding state to the main in the main stream.

Hence, such streams provide less time for flood warnings from diff form for the downstream residents, because they have smaller drainage basin and the caring it carries coarser and largest sediments from a given area. Whereas, higher order streams with numerous tributaries have longer lag times between the storm that is rainfall and you are having downstream flooding. Their hydro-graphs are less peaked and cover longer time lag there is a time period or and it remains for a longer period. So, flood warnings warning can be issued to in such situations, because you will have the longer time gap between the rainfall and the flood.

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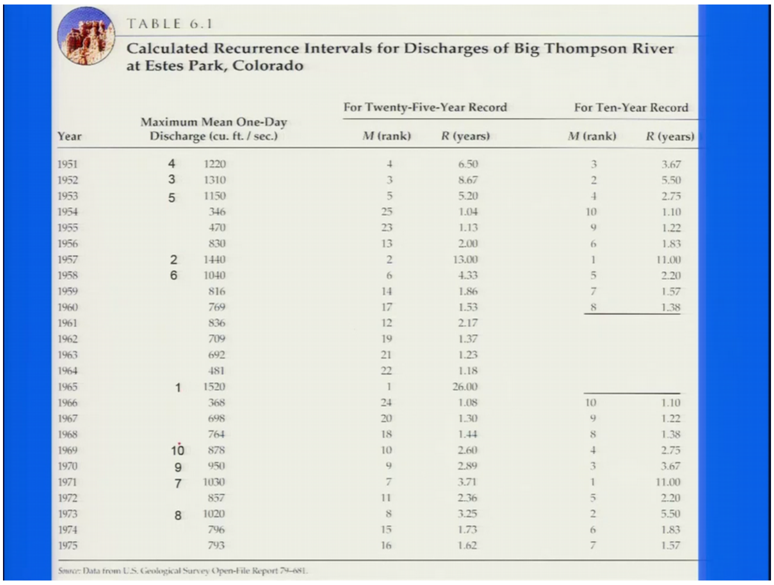

TABLE 6.1

Calculated Recurrence Intervals for Discharges of Big Thompson River at Estes Park, Colorado

Year		Maximum Mean One-Day Discharge (cu. ft. / sec.)	For Twenty-Five-Year Record M (rank)	For Twenty-Five-Year Record R (years)	For Ten-Year Record M (rank)	For Ten-Year Record R (years)
1951	4	1220	4	6.50	3	3.67
1952	3	1310	3	8.67	2	5.50
1953	5	1150	5	5.20	4	2.75
1954		346	25	1.04	10	1.10
1955		470	23	1.13	9	1.22
1956		830	13	2.00	6	1.83
1957	2	1440	2	13.00	1	11.00
1958	6	1040	6	4.33	5	2.20
1959		816	14	1.86	7	1.57
1960		769	17	1.53	8	1.38
1961		836	12	2.17		
1962		709	19	1.37		
1963		692	21	1.23		
1964		481	22	1.18		
1965	1	1520	1	26.00		
1966		368	24	1.08	10	1.10
1967		698	20	1.30	9	1.22
1968		764	18	1.44	8	1.38
1969	10	878	10	2.60	4	2.75
1970	9	950	9	2.89	3	3.67
1971	7	1030	7	3.71	1	11.00
1972		857	11	2.36	5	2.20
1973	8	1020	8	3.25	2	5.50
1974		796	15	1.73	6	1.83
1975		793	16	1.62	7	1.57

Source: Data from U.S. Geological Survey Open-File Report 79-681.

Now, there are ways to understand and identify that the recurrence time or the recurrence interval of the flood events, if you are having good record of that particular region, now what is been shown here, this is from Colorado and from the big Thompson River. The data is almost from 1951 to 1975 and here it gives the peak or maximum mean discharge in one day and accordingly they this has been ranked ok. So, ranking is been done like first the maximum discharge in the record, then second so this ordering has been done based on the or the maximum discharge. So, how to calculate this recurrence, we will see in the next slide ok.

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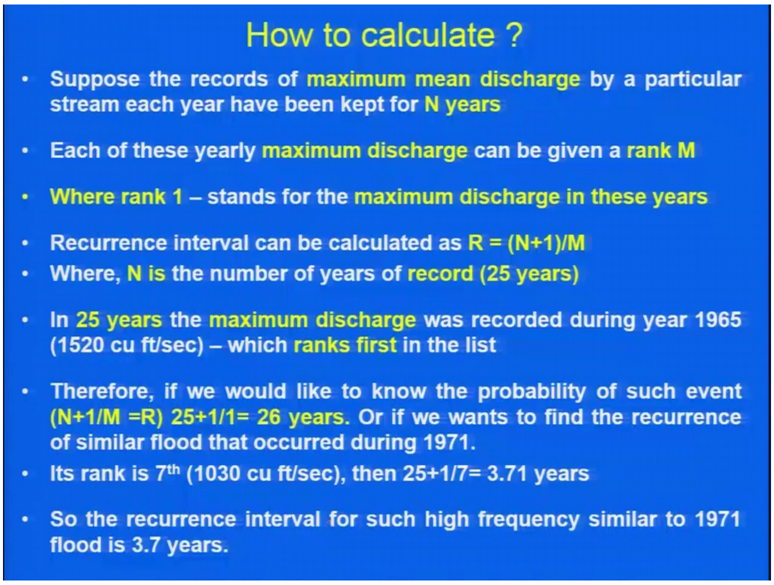

So, for example 10 such cases have been ranked from 1 to 10, so how to calculate is not very difficult. Suppose, the record of maximum mean discharge by a particular stream each year have been kept for N years. Each of this yearly maximum discharge can be given a rank, which is which we were showing rank 1 which stands for the maximum discharge in this years and the recurrence interval as R equal to N plus 1 by M. So, where N is the number of years of records, like say 25 years record is there with us. So, in 25 years the maximum discharge was recorded during 1956, then you take the previous example, and the discharge was 1520 cubic feet per second which ranks first.

So, in this case the similar type of flood can be expected. If we would like to know the probability, then it will be 25 plus 1 by 1 that means, every 26 years, you will have the similar flooding event or if you want to find out the recurrence interval similar flood that occur during 1971, then we can have because it was been rank 7th and the peak or the maximum discharge was a 100 1030 and then we can have the recurrence interval be around 3.7 years or around 4 years. But, most important part he is not whether the conditions remain same or there was an alteration or some changes were being made in the drainage basin by humans, so that may have the difference scenario, what we see here could be affected.

So, thank you so much, we will continue in the next lecture talking more on the recurrence as well as few points, we will discuss that how the urbanization and if you are they is getting affected without when we do not consider the landforms and do not having the understanding of the peak flood discharge or the maximum discharge of that particular channel.

Thank you so much.