Geomorphic Processes: Landforms and Landscapes
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Lecture - 19
Fluvial Processes and Related Landforms (Part V)

So welcome back, so as I told that in this lecture we will talk on Kosi River which is one of the rivers which have resulted into several floods in the past and also be termed as or called or well known as sorrow of Bihar.

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So if you look at the satellite image this is google earth image which shows the rugged terrain over here and this is the Kathmandu and this area is Nepal and then we have Bihar over here and there are many major streams which are flowing or the bulging into the Indo-Gangetic plain from the Himalayas. So again from the confined to unconfined area this channel is here Ganga and the Kosi which has resulted into right now this is the present day Kosi channel but it has multiple channels which exist over here and these are all old channels.

So if you draw a boundary from here like this it very well goes over here and then narrows down here and this is the alluvial plain of and the alluvial fan associated with the Kosi River. So let us see further what has happened when you have this landform like alluvial fan and then you have alluvial fan with multiple palaeochannels in the fan region.

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So this is a close up of that and the channel in the blue water which you see here it showing is in the flooding state. So this image was been taken during the monsoon season and if you look at the closer view then you have all the tight meanders over here you can see very clearly and then the stream of course they are devoid of water during the dry spell but some water flows through when there is a precipitation higher precipitation.

So you have this streams and this all streams are the palaeochannels. So they are the dried bed but sometimes it also carries the water. So people have occupied this region or this area for the settlement. Because it is one of the best alluvial plain region of the fertile land but if you see the shape here it is the part of the alluvial fan.

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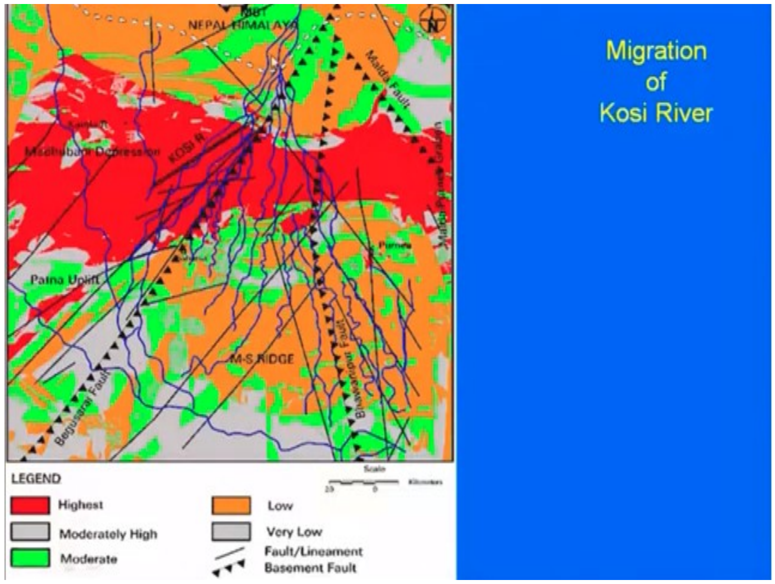

So, Kosi migration which shows that people have talked about or the scientific group that the formation of this fan area is because of the 2 faults at in the basement, so 1 is your Begusarai fault and another is Bhawanipur fault, so these are the 2 faults and in between this is the ridge which has resulted into the formation of this shape. But this is not true to some extent because this type of landforms as we have been discussing will form at the base of the front or where we are having the geomorphic divide which results into the formation of such landforms because of the rivers which are diverging from the steeper slope to the gentler slope.

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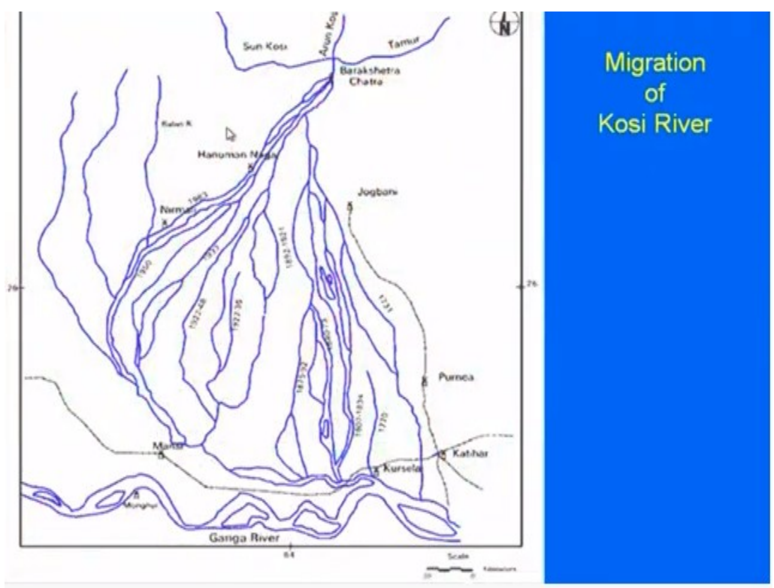

Now this is the history I would request that you carefully look at the years which have been listed here. Because this is an very old figure where you can see that the channel has never remain at the same or float along the same stream or the area in the past it has shifted. Now for example this is the channel since 1950 but in 1922 till 48 the channel remained here. In 1933 the channel flowed through this one and so on and this area it shows 1770.

So you can understand that this whole region the fan area occupied by the multiple channels has been reoccupied again and again in the past and recently also this happened in 2008. There was an breach of the reservoir in the Nepal side and excess of water which was poured into the channel resulted into the reoccupation or the reoccupying of another channel in between here.

So this is an hazard which has been associated always with the Kosi River where anytime if you are having the higher velocity or the water or excess water during the flooding state the channel it will shift the river, river will shift from and reoccupy or occupy you can say to its own paleochannels. So you can figure it out that in the past the river has shifted and occupied its own paleochannels.

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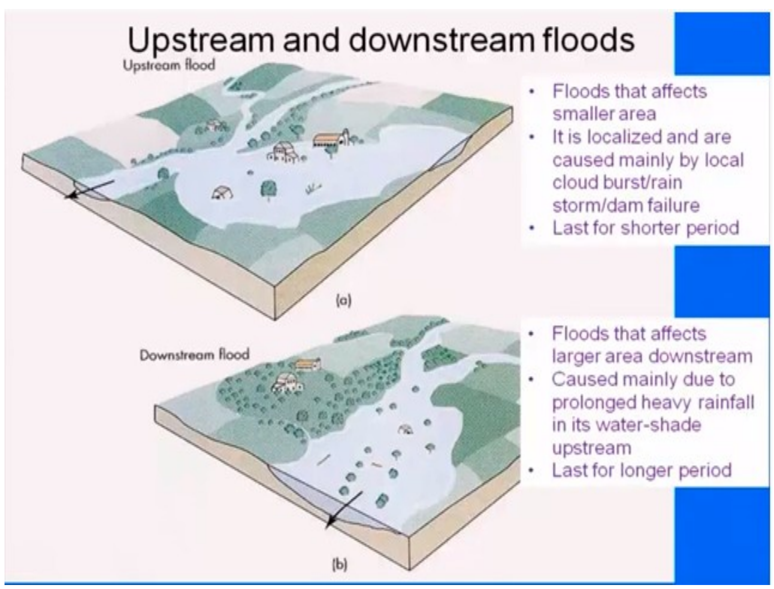

Now very important part related to weighing the floods is the upstream and downstream flood. So if you take is the upstream areas and the downstream flood it will vary in terms of the area it will cover as well as the time it will last. So the flood that affects smaller areas in the upland floods region it will not occupy or cover a larger area it is localized and are caused mainly by local cloud burst.

Because you have channelized flow and mostly this will happen if you are having an very heavy rainfall and if you are having an cloud burst mainly the rainstorm or even you are having the dam failure. If you are having you have constructed the dam. So mainly the upstream floods will affect smaller areas and will last for a very shorter period whereas the floods that affects the larger area that is the downstream flood downstream region for example in the Indo-Gangetic plain as we will talk about.

And the previous area which we are talking about the Kosi the region mostly the channels in that region is very shallow because of more of amount of sediment is poured into the because of erosion in the Himalayas more bed load has been supplied to the channel and the channel cross sectional area has been reducing considerably over the time whereas in the upstream area you have deeper channels.

So the it will be not easy for the channels which are deep channels in the uplands to come into the flooding state. So this is very important that in the lower regions you will have you will come across shallow or channels in terms of the depth because of the sediment supply in the downstream region. So the downstream region mainly you will have the larger area will be covered because if you are having shallow or channels then the spill over of the water will be very fast.

So it causes mainly due to prolonged heavy rain in the water shade area. So whatever the rain you see in the upstream in the water shade area will affect the low-lying areas in the downstream region. And such floods in the downstream region will last for a longer period. So this is the main difference between the upland floods and the downstream floods. So please keep in mind that the areas even the channel patterns will be different in the upstream area and the downstream area and even this because of the slope the carrying capacity or the bed load will vary and the channel pattern will vary and the flooding state also will vary from place to place.

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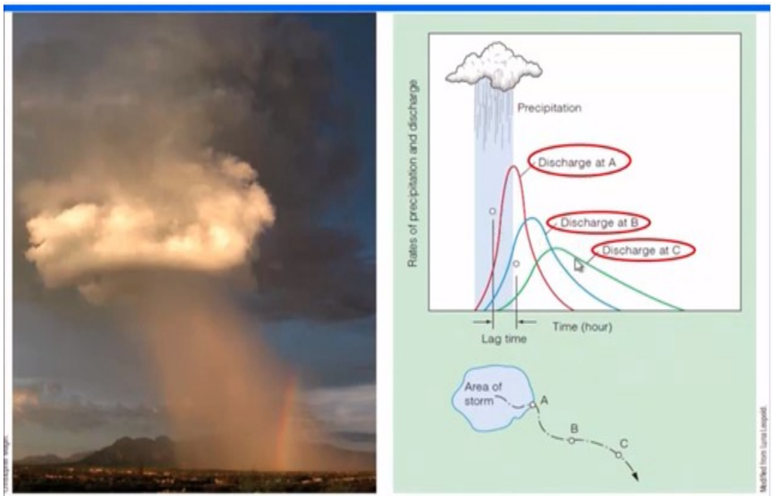

A B

A. Localized afternoon rainfall over Tucson, Arizona. **B.** Storm rainfall entering a stream precedes the flood crest that it causes. The flood hydrograph nearest the rainfall area is highest and narrowest. Farther downstream at location B, the flood hydrograph crests at a lower level but lasts longer. Still farther downstream at C, the flood crests at an even lower level and lasts longer.

Now for example if you take you are having for if you consider the lag time of the flooding state between the rainfall and the channel coming into the flooding state will vary also from place to place. So what you see here is the rain strom in the region and the 3 areas, 1 area is A which is the area of where the rainstorm has occurred and B and C is the area which are located away from the region which will experience the rainstorm.

So in the region where you have the this is what the flood hydrograph shows that the nearest to the area that is in A area which is close to the heavy precipitation the hydrograph is highest and narrowest. So the lag time is very less whereas the area will get into the flooding state very fast. Whereas the farthest downstream location B what you see the hydrograph crust at lower level but last for longer time as compared to what you see in the upstream area very much similar to what we were talking about the upstream flood and downstream flood.

And then further downstream that is your C what do you see the flood crust that is the flood hydrograph crust at even lower portion or the lower side and it last for longer period. So this is the main difference which you will see and this hydrograph understanding of this hydrograph is extremely important if you are sitting in urban settlement. The hydrograph will be the lag will be completely different and mostly what we see in the urban areas, the lag time between the precipitations will be very less and resulting into the flooding state.

So the lag time between the rainfall which is coming on the surface the rainwater and the runoff and resulting into the flooding state will be very short. So this is important 3 states which have been shown. So the closest to the area where these higher precipitation of this rainstorm is experienced, the hydrograph is very pricked very sharp whereas it becomes broader and they it remain for last for a longer time if you move to the areas away from the area of highest of rainfall in case of B and C.

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So this is 1 example of the floods in most in Uttarkashi in 2012 most of the areas which were adjacent to the riverbed got affected and this was mainly because of the erosion of the banks.

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Another example of the cloudburst was the Kedarnath tragedy in 2013 which killed more than 1000 people. So this is the area before and this is after which shows that the cloudburst resulted into the increase in or added more water into the stream. So in the upstream it was lot of water which has been flowed and resulted into the increase in carrying capacity and what we see here is the debris material of mostly the comprising of pebbles and boulders.

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So this was the condition that they mainly the debris flow which you see here comprising large huge boulders.

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And flood in Uttarkashi in 2013 again so what you see here is you can easily identify the landforms. So this is an typical of Gray channel so this is an erosional side and this side is the deposition but right now the channel is in flooding state so most of the erosion is taking place along the banks here.

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So the next slide if you see here this is the outer side of the channel which is eroding and you can see the hanging houses on the cliff here. So the erosion of course it will the water is not in the upstream is not getting into the flooding state but the flow is so high. So the velocity is high and the carrying capacity increases it increases the erosion. So the outer side or the banks adjacent to the channel are getting eroded.

And there is an caving effect which is resulting into the collapse of the banks and this houses which are sitting along the banks were collapsed. Most of the houses you must have watched on television that they slided down into the river because of the undercutting of the banks.

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So this is an example of same one. So lot of the houses were collapsed because of the erosion of the banks.

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So and this is from Rishikesh the tall statue of Shivas which is sitting the height of the statue is 15 feet and it sits almost 10 feet above the riverbed. So, 10 feet above the riverbed so this one is 10 feet and this is another 15 feet switch above the riverbed and this one.

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And this was bank full flow if you see was this was in this condition and finally what happened was that this statue was been eroded and carried away into the water.

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So, drainage basin evolution, morphometry and drainage pattern. So this is another important aspect of the fluvial system which we will discuss in coming slides mostly we will also try to understand that how the basin the drainage basin is formed and what are the different drainage pattern. So in the previous lectures we discussed about mostly the channel pattern and channel landforms.

Here we will talk about the channel during drainage pattern and drainage pattern will vary from place to place depending upon the subsurface lithology or the subsurface material. If you are having a rocky terrain, then the drainage pattern will be different. If you are having the drainage developed on the loose material, then the pattern will be different and how the basin is evolved that we will talk about.

So, some of the parameters which usually we take into consideration for example the drainage basin area and the morphometry or the drainage pattern, these parameters help us in the evolution of the flood hazard.

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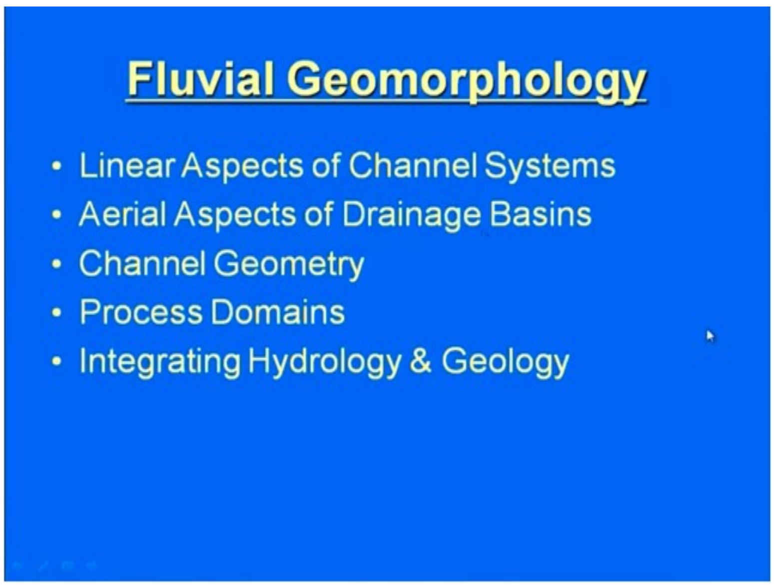

So fluvial geomorphology, in this we will talk about the linear aspect of channel system, aerial aspect of drainage basin, channel geometry, process domain, integrating hydrology and geology. So this plays an important role in terms of the deformation of the drainage pattern on the surface. Because the geology that is the material which exists subsurface plays an important role in developing the or in the evolution of the drainage basin and drainage pattern.

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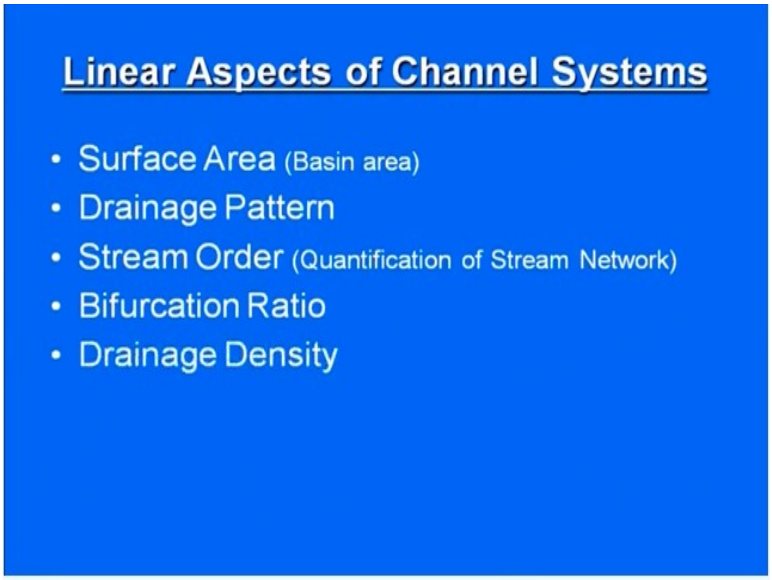

So linear aspect of channel system, surface area that is what we were going to talk about the basin area, drainage pattern, then stream order this quantification again helps in evaluation of the floods mainly the stream order, bifurcation ratio, drainage density, etc.

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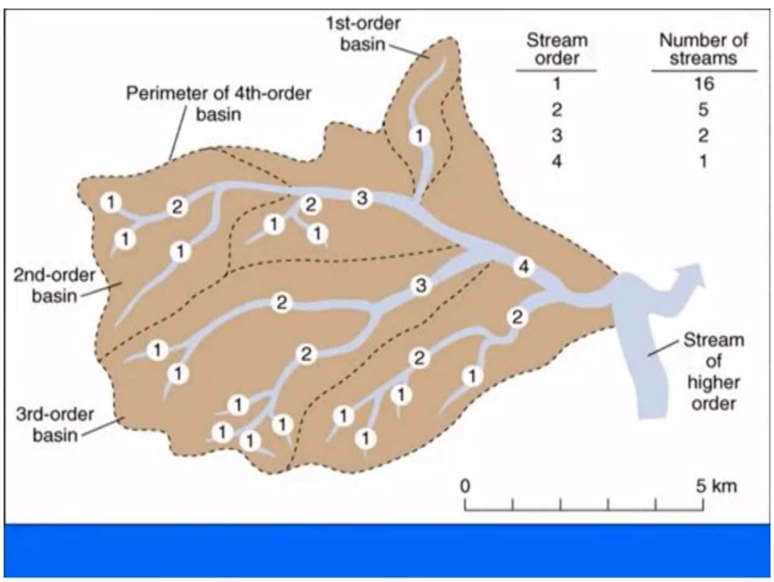

Now coming to one by one to this portion we can quickly look at the trunk stream and the tributaries. So we can have the area of the drainage basin which has been shown for here or you can say the perimeter of the basin and what we have within the basin of this basin that is the fourth order because the order has been given which is showed here that 2 smaller stream at the location of the source or the origin when it joins.

It result into the formation of or this will be termed as second order and 1 second order and 1 first order joins, it will result into the third order and third order and the second order joins or 2 third order joins, it will result into the formation of fourth order. So on what we see is the higher order. So if 2 fourth order streams joins then it will become fifth order. So right now this is the highest order stream which we have and this stream will be of higher order stream of higher order.

This will be either we can say the fifth order stream which is where because the fourth order stream goes and join this stream so this will become higher order stream. So we have first order, we have second order, third order, fourth order. So this basin in particularly is the fourth order basin and within the fourth order basin we have sub basins where we can say that this basin because the highest order is this and second order basin whereas this basin is the third order basin.

So this basin is the third order basin and this is second order basin. Similarly, this is also second order basin and this count is important because this will give you the bifurcation ratio between the first order and the next higher order. So one first order 16 streams are there, second order 5 streams, third order 2 streams and fourth order is 1 stream. So the bifurcation between the ratio between this streams will help us in calculating the ratio will help us in calculating the bifurcation ratio. So these are the main parameters which will help us in talking about the drainage density also.

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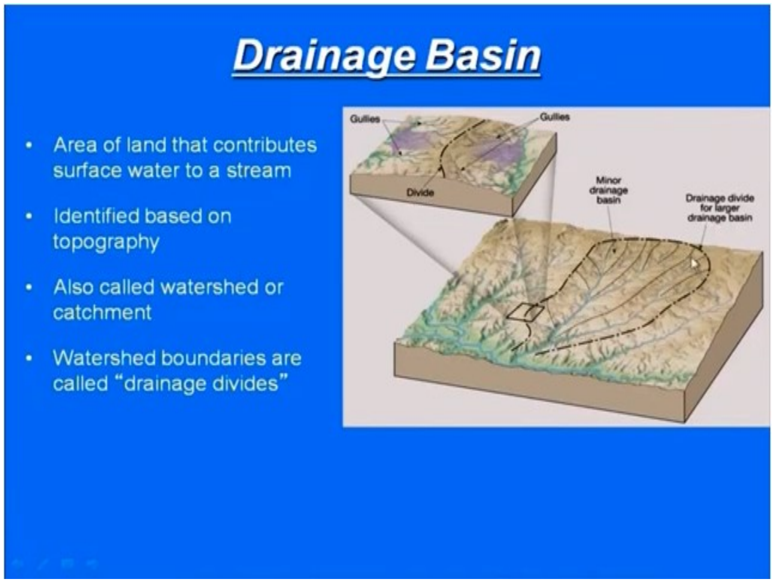

So the drainage basin basically area of land that contributes surface water to a stream, identified based on the topographic break, also called watershed or catchment area, watershed boundaries are called drainage divides. So this is what we also discussed in the beginning that you are having the boundary between the drainages which are flowing on either side. So this drainage is flowing in this direction whereas this drainage is flowing in another opposite direction and contributing to respective basins.

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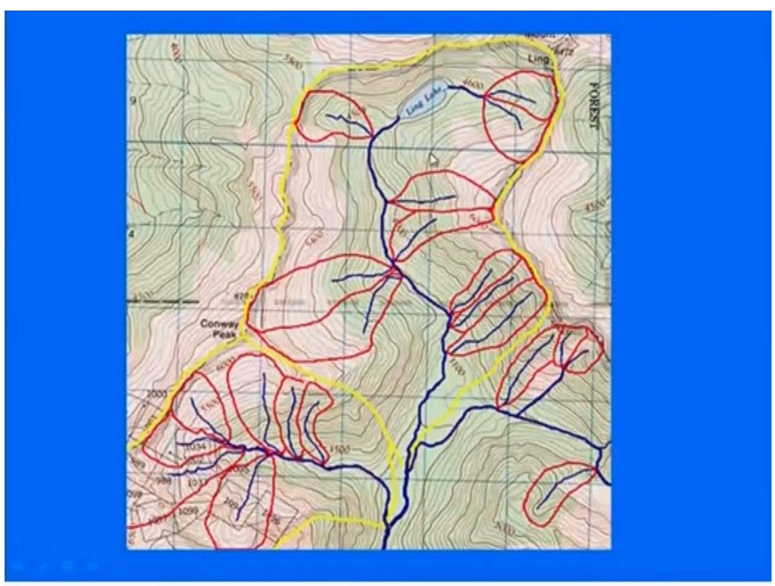

So the divide in between this 2 are termed as the drainage basin and we have the transtream which has been showed here by blue whereas the smaller sub basins are been shown here. So this is the main divide between the 2 basin. So the next basin is this one here which has been seen and this one is the final major basin. So this trunk stream is going and meeting the higher order stream here.

So this will have another basin or this will form a sub basin of this major river. So this is what has been shown here. So the yellow one is the major basin and you have within that you have the trunk stream shown by blue and then we have the smaller sub basins here.

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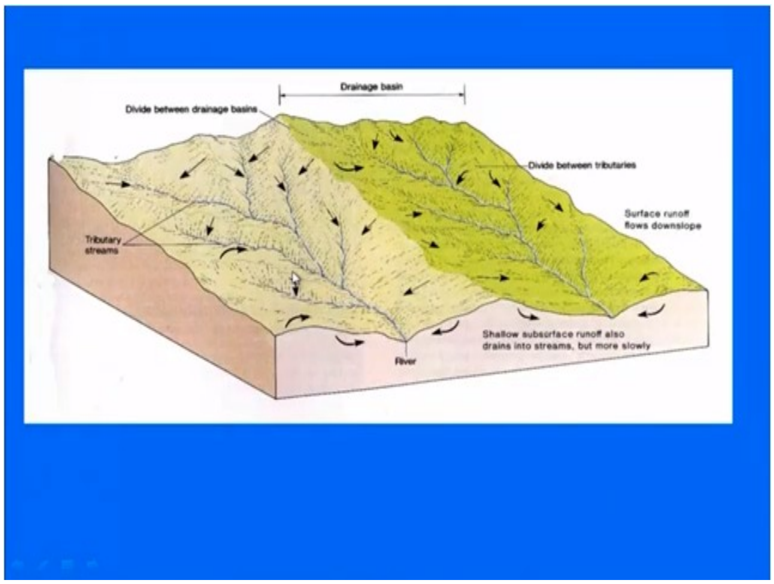

This is another one figure which shows the drainages flowing in different direction by arrow black arrows here and this portion is in sharp contact between or the boundary between the this the 2 basins. one is this one and another was this one which is flowing in opposite direction. So this is a clear-cut drainage divide had different drainage basin.

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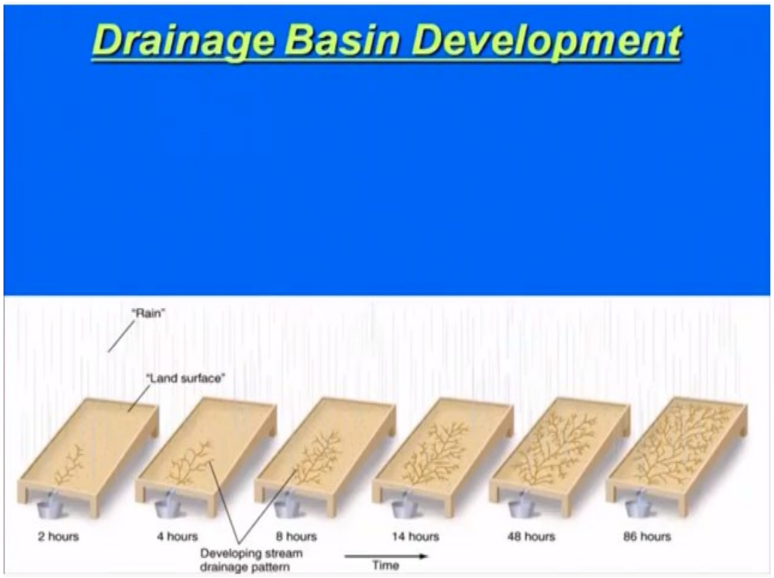

Now the formation of or the evolution of the drainage usually what has been seen is that it will grow towards the headwater or it grows upstream because this smaller streams keep joining and it will keep the resulting into the extension of the basin. So once formed that is in drainage basin the channel erode headward and it lengthen. So slowly what will happen? The precipitation is same here.

But this slowly what you see is that this is the experiment which was been conducted 2 hours and which lasted up to 86 hours where along the slope you have the formation of small streams here. So it will keep on eroding headward and the resulting into the lengthening of the main channel by adding small bow of the addition of the smaller stream. So, channel network form by bifurcation of the headward eroding channels.

So I will stop here and we will continue in the next lecture talking about the formation of the development of the basins and further we will talk about the bifurcation ratios and all other. Thank you so much.