Water Resources Engineering

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Lecture No. # 6

In the previous lecture we had seen some alternative ways of expressing the stream flow data. For example we have looked at the hydrograph where we plot the stream discharge verses time. We have looked at a flow duration curve which tells us at what percentage if time a certain discharge will be exceeded or equalled. We have also seen the mass curve which represents the accumulated volume passing through that point in the river verses time. So we briefly introduce the flow duration curve and the mass curve and we said that we can use them to find out the dependable discharge and also to find out the storage requirement to maintain certain demand. So let us look at flow duration curve and the mass curve in detail. We will start with the flow duration curve and then we will move on to the mass curve also we would look at some situations where enough data may not be available and we have to estimate the yield of the stream. For example if you do not have enough data available we can derive a synthetic unit hydrograph and based on that we can find out the runoff for any given precipitation. But there are other empirical or semi empirical relationships which are available to estimate the runoff for any given rainfall. So we would look at some of these techniques also in this lecture. So let us start with the flow duration curve and see how we can obtain the flow duration curve for any stream at a given station.

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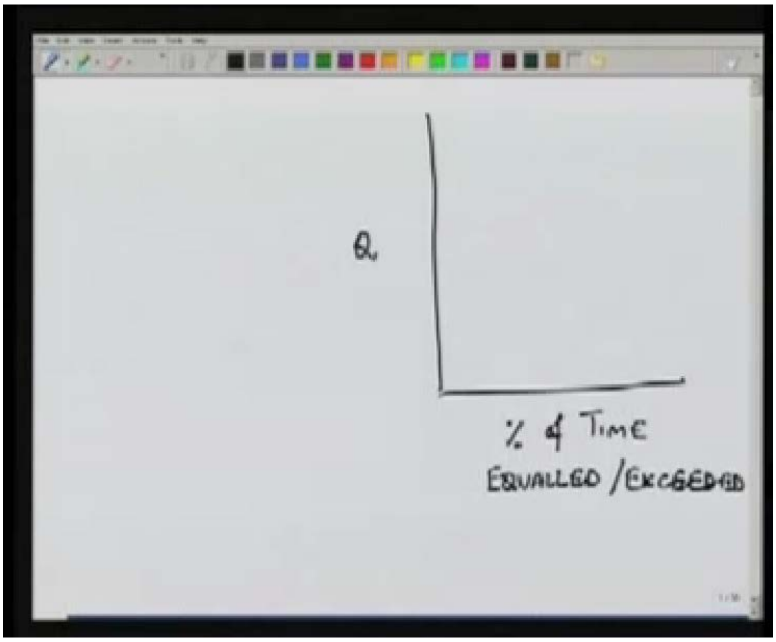

As we saw in the previous lecture, we plot the discharge verses the percentage of time. It is equalled or exceeded. Suppose we have the data for the runoff in the stream over a period of let us say 10 years, 20 years, 30 years. So for a long period, we have the data for discharge in the stream. We can decide on an interval that this may be daily, weekly, monthly or sometimes we taken an interval of 10 days and average discharge over that period can be estimated. If we take daily discharge and we want to find out average daily discharge. We have a 10 year data; we can pick up a certain data. For example first from January and find out the average discharge on that date over this period of 10 years. So that will give us an average daily flow or if we want to go for weekly flow, we say in the first week of the year, we want to find out what the average over all this 10 years. Depending on the our aim for using this data we can go for a small duration which may be daily or we may go for a longer duration which may be monthly.

Typically when we take smaller durations, we get more variation in the data but when you average it over a period of let us say 7 days or 10 days then the variations are averaged out and the data does not show that much variability. Let us take an example of this daily data. So if we have obtained this average daily flow for all 365 days in the year, we have these 365 values of the daily discharges. Now we can arrange them in descending order. So the first value would be highest. Now suppose we assume that it occurs for example on 15th of July. Then we go to second highest and so on and this way we can arrange all the 365 data in the descending order and assign a rank to them. So the first data will have a rank of 1.

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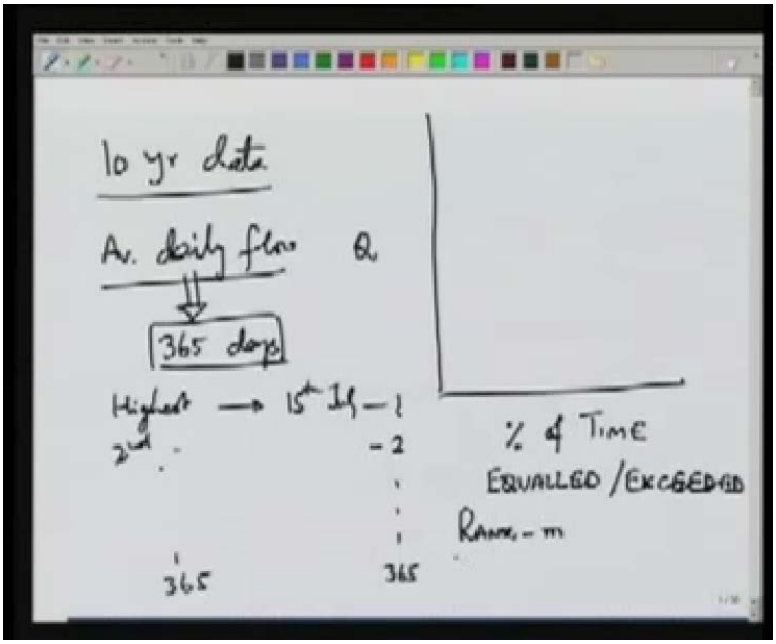

The second data will have a rank of 2 and this way till 365. Now suppose we find out the percentage of time, a particular discharge is equalled or exceeded, we can just take the rank which we denote by let us say m and the total number of points let us say they are N. In this case N would be 365 and the rank for the 15 July discharge will be 1 and the next rank would be 2 and so on.

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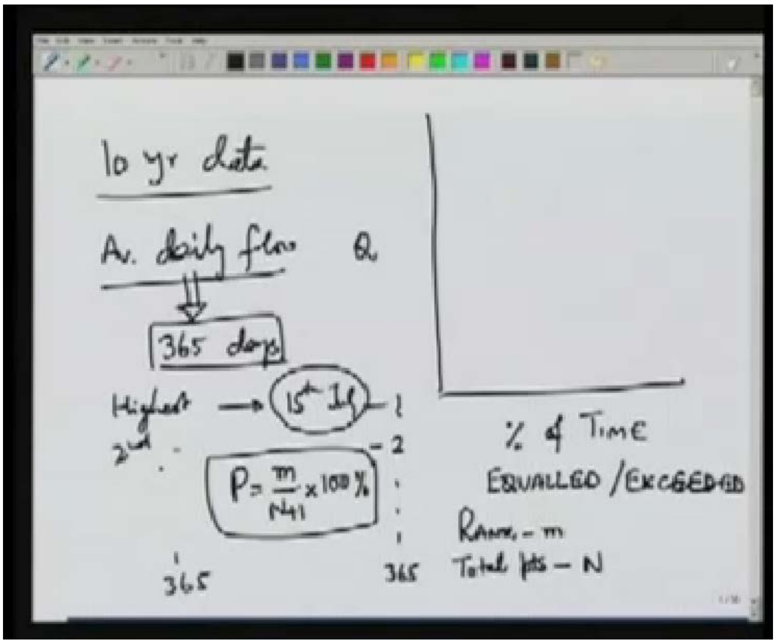

We say that the percent P for any given discharge of time t is equalled or exceeded is given by this plotting position m over N + 1 into 100 percent. So in this way we can find out a certain discharge verses, its percent and get the flow duration curve which would look like this. From this data once we prepare the flow duration curve from this data, we can answer questions like what is the 50 percent dependable discharge or what is the 85 percent dependable discharge and so on.

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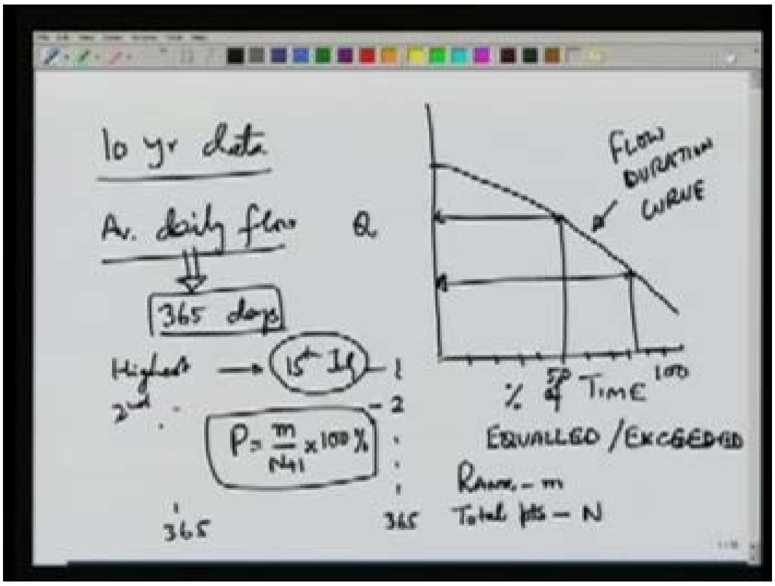

This way we can predict dependability of a certain given discharge. Now let us look at the mass curve and see how we can decide the storage capacity for a given demand. In order to maintain certain demand, we need to store water and then release it during the dry periods and we can also look for a given storage the demand which can be maintained. So let us look at these two questions first.

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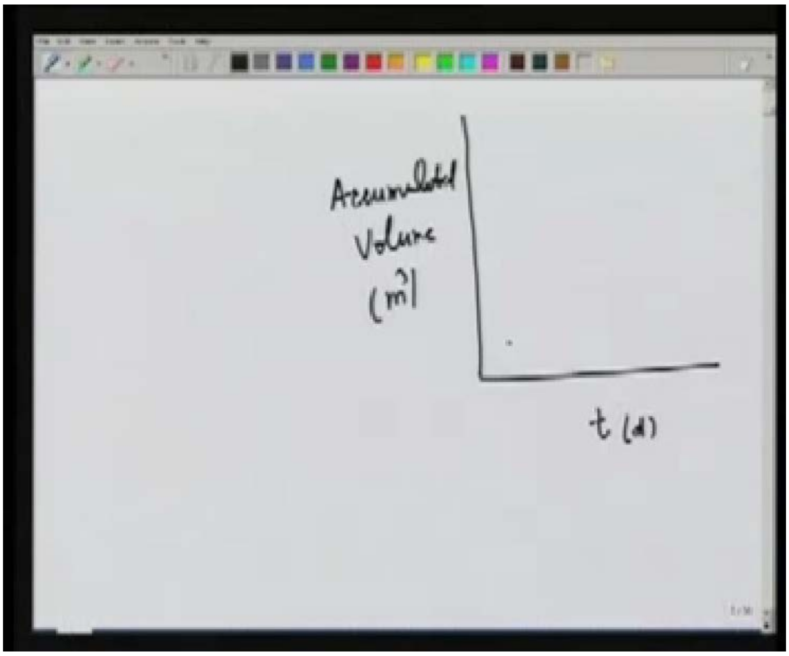

As we have seen a mass curve is a plot of time verses cumulative volume. So a cumulated volume, let us say is in metre cubes. The time may be in days or months. Now the mass curve as we have seen earlier looks like this. When the volume is increasing at a very fast rate, it means the discharge in the stream is high and then we have these dry periods where the mass is increasing at a very slow rate indicating the discharge is very small. So over this period we can see that there are lots of highs and lows or bridges and valleys in the curve in order to find out the maintainable demand. So there are really two kinds of problem which we can solve. One is given demand, find the storage and the second problem would be for a particular storage, suppose our storage capacity is limited then we estimate the number of demands which can be maintained. So given the storage we find maintainable demand. So if our storage capacity is limited or given to us fixed from some other considerations, what demand can we maintain at that point? When we say demand, it also includes the amount of water we have to release down the stream of that point.

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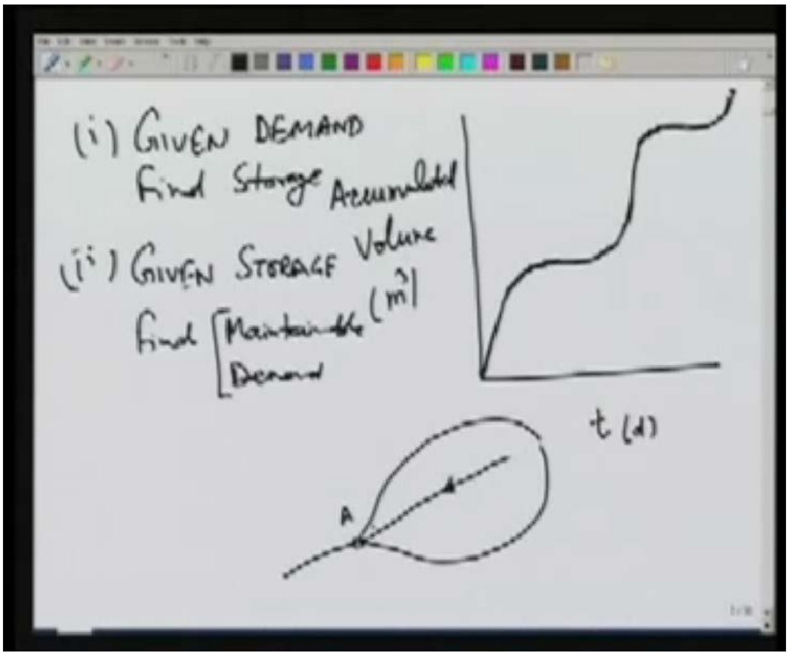

So this is the channel and we are looking at this point A. The hydrograph at A will give us the amount of water which is coming upstream from the up side at point A and the demand would mean whatever demands are existing in the nearby area as well as the amount of water, that needs to be released downstream. So we will include everything in the demand and we have already seen that the maximum demand which we can maintain would be obtained by the average annual yield of the stream. So let us say that the volume is b.

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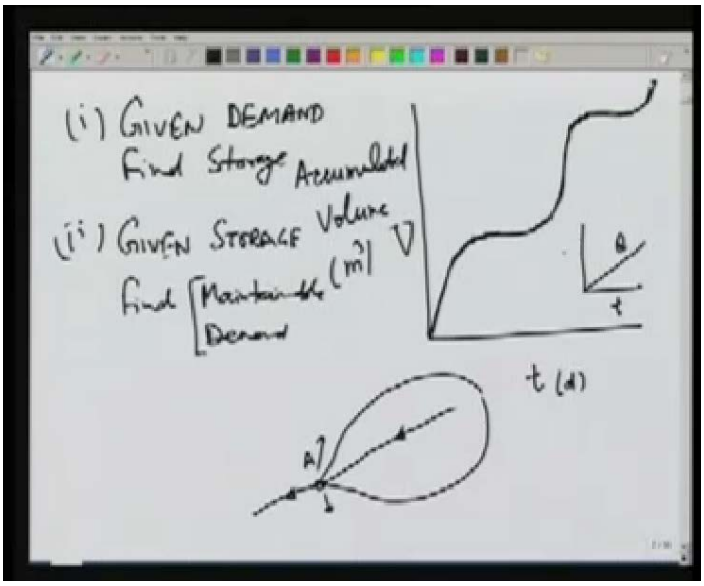

The demand can be plotted on this insert and let us assume the demand which we want is Q, so again this is on the same scale time verses volume, that we are maintaining. Let us first assume that the demand is constant so for maintaining a particular demand Q it means that we are withdrawing from the storage at a constant rate and therefore the curve will be a straight line.

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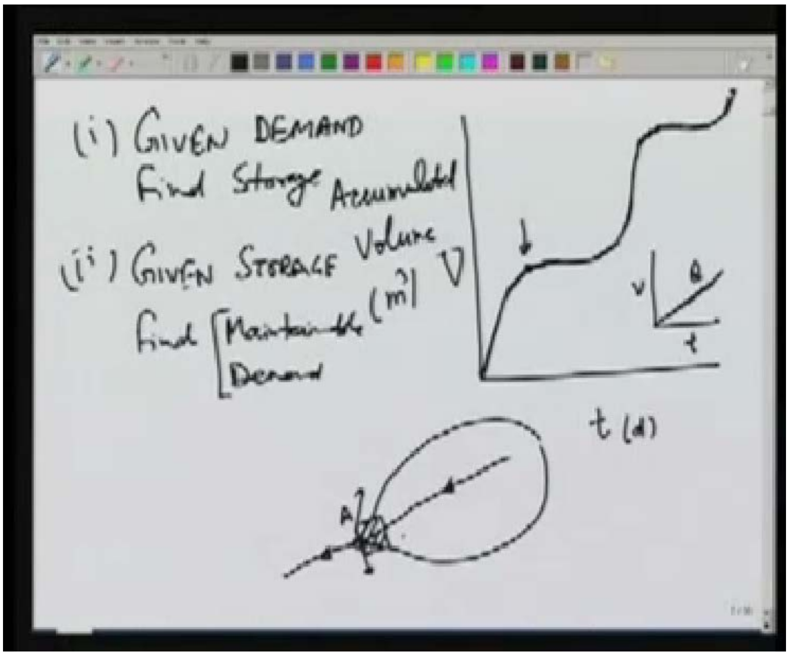

Let us assume that this is the start of the dry period and let us assume that the reservoir is full at this point. We have some reservoir created here. Let us assume we created a reservoir here and it is full at the start of the dry period. Now this is a dry period because after this, the slope is very flat, which means the discharge in the river is very small. Now at this dry period we draw a tangent which is parallel to our demand line. This will include all the demands as we have already seen and this is the tangent at the highest point here or the ridge. Now in order to find out the storage let us look at what is happening here. Our demand is constant at this rate. The supply is small and therefore there is a deficit between the supply and the demand which has to come from storage. So at this point this (Refer Slide Time: 11:54), a deficit which must come from the storage and at this point. Therefore whatever be the maximum difference between these two curves, it will give us the required amount of storage.

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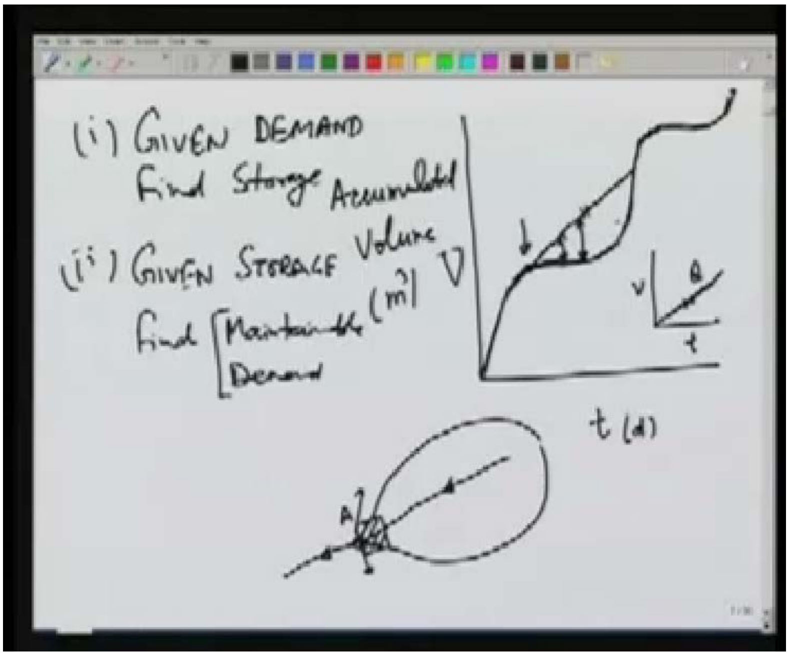

In this case to find out the maximum difference we take a tangent which is again parallel to the demand line and the difference between these two lines is the required storage is S. So if we have this storage, we start with a full reservoir at this point and by the time we reach here, the reservoir becomes empty because we have utilised all the storage S. But after this point as you can see from this figure, the supply is more than the demand and therefore the reservoir starts filling again. Now we can do the same thing on the second curve. We can draw a line tangent at the ridge and find out the storage requirement for this part of the curve.

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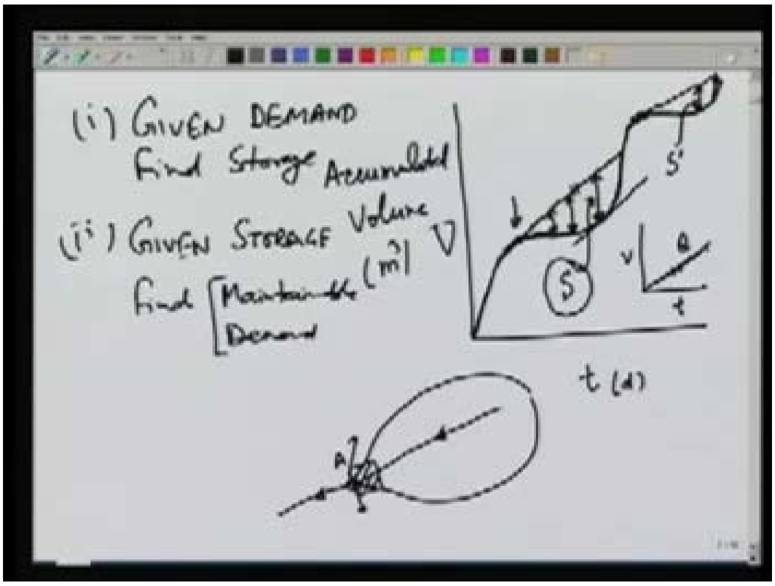

Let us call it S prime. Now we can do it throughout the mass curve and find out all these ordinates and whatever is the maximum ordinate, we choose that as the storage capacity. If we have this 2 year data in this case, S is more the S prime, this S will be our required storage which will be able to maintain this demand Q. If you look at the reservoir filling and emptying, pattern reservoir is full at this point, empty here and it will again become full at this point. After this there is some water entering the reservoir which may also fill but at this point again, the reservoirs is full so our assumption that at the start of a dry season, the reservoirs is full is valued throughout this curve.

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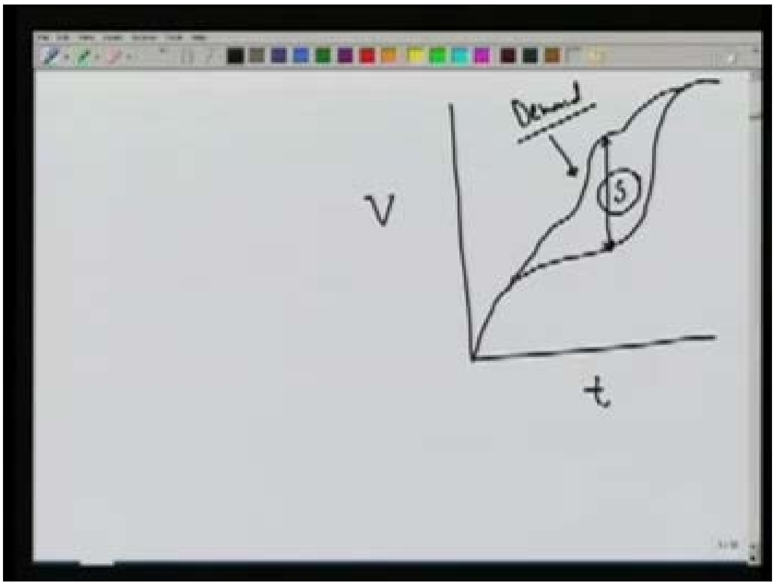

Now let us look at what happens if the demand is variable. Accumulated volume V verses time t. So we again have this mass curve and then we can plot the demand curve on this. This is variable, so it may look like this and again the philosophy is the same. Let us take the maximum difference between these two curves. In this case we cannot use the same method which we had used earlier because now we cannot draw a parallel line at the point. We have to estimate the maximum ordinate. For example in this case, this S may be the maximum ordinate. So for a variable demand we have to compute the maximum ordinate and would the required storage S.

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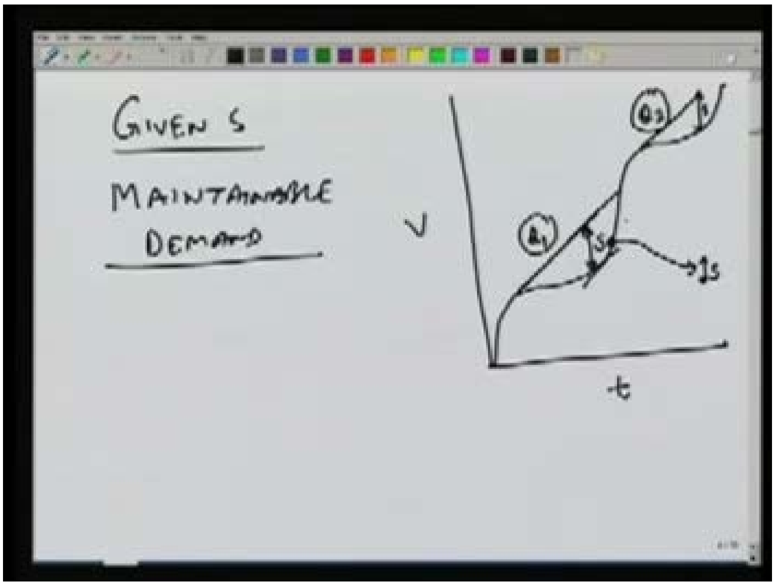

Now let us assume the other problem in which for a given storage, we find out Q which we can supply from the river at that point.

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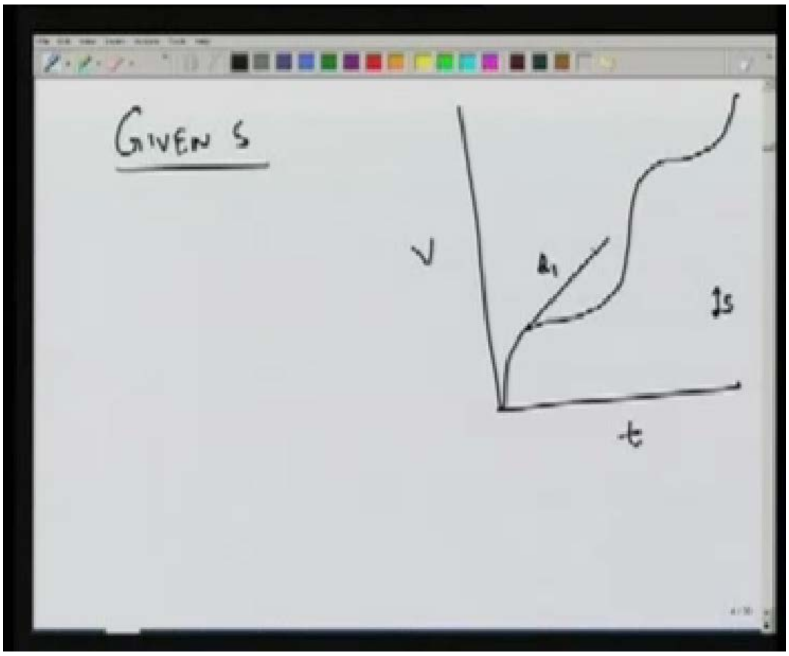

Let us have a similar mass curve and the storage is given, which is what I am showing here as S. For this, S value is given to us and we want to find out the demand which we can maintain at the point at the outlet point A. Draw lines, let the rigid at some point be Q_1 such that our demand here is met by a storage of S. This S is known to us. This will give us an idea about what the Q is, which we can maintain for this S. Similarly from here if we have certain S, we will get to have an idea of what Q can be maintained.

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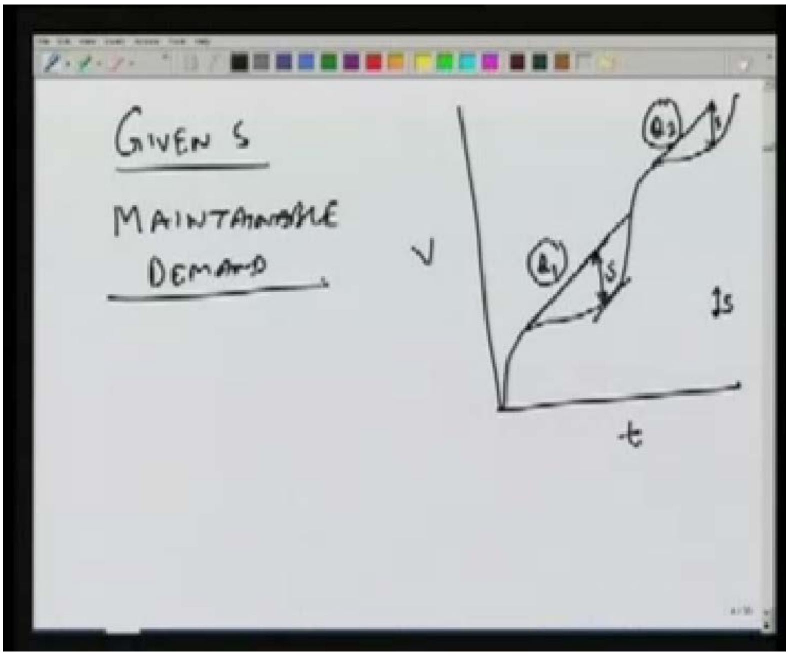

Let us call it Q_2 and so on. So we have to find out all these values, Q_1, Q_2, and Q_3 and so on and choose the smallest Q that will be our maintainable demand. The smallest of this Q_1, Q_2, and Q_3 etc will be the maintainable demand. The procedure of finding out this Q_1 involves little bit of trial because the point at which we are drawing the tangent is not fixed and we have to adjust the Q_1 line so that this storage available is effectively equal to the given storage S. But the way we do it is for all the valleys and find the minimum of the Q's that will be the maintainable demand. Now in some cases we may not have enough data or sometimes we may want to extrapolate the values for some other conditions. For example in extreme conditions, the data may not be available in which case we have to come up with some either empirical or semi empirical relationships. So we would look at these methodologies to estimate the yield of the stream at a point.

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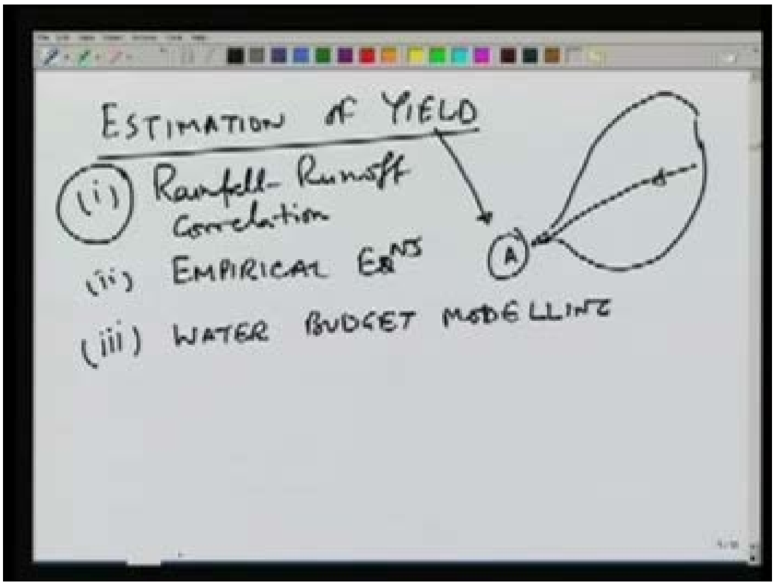

So estimation of yield typically represents the annual flow in the stream at a particular point. so if we have this catchment area of the stream at the point A, what yield generally refers is although it can be over any period, it generally refers to annual flow at the point A from the stream. If we have data as we have seen earlier, we can find out yield from the mass curve but sometimes we may not have data. In that case we either use some synthetic hydrograph to obtain the yield or there are some methodologies which can be used which may be written as rainfall runoff correlation. We can also use some empirical equations or if data is available and of a very good quality, sometimes people have used water budget modelling to estimate the runoff, given the catchment property. So if we know the rainfall over the catchment, we can estimate the evapotranspiration and infiltration. So we can estimate the entire abstraction estimate and do a water budget modelling to find out the runoff. So we would look at these three different methods in detail, let us start with this rainfall runoff correlation. As we know rain fall or precipitation is the driving force behind runoff, so naturally the runoff will depend on the rainfall but the relationship is not very clear because sometimes there are some other factors which affect the runoff. So for the same rainfall, we may have a different runoff depending on the existence.

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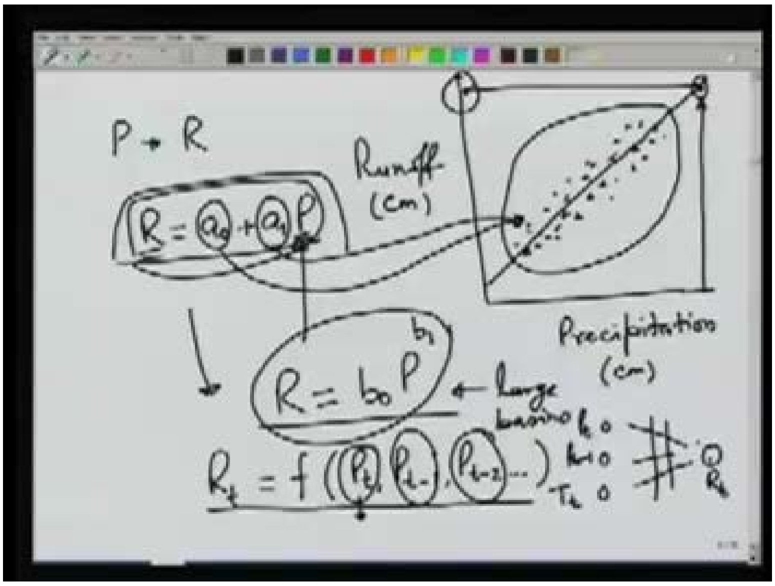

Now you plot the record of the rainfall and runoff. If we have the precipitation let us say in cms or mms and the runoff can also be converted into cm units over the whole catchment area.

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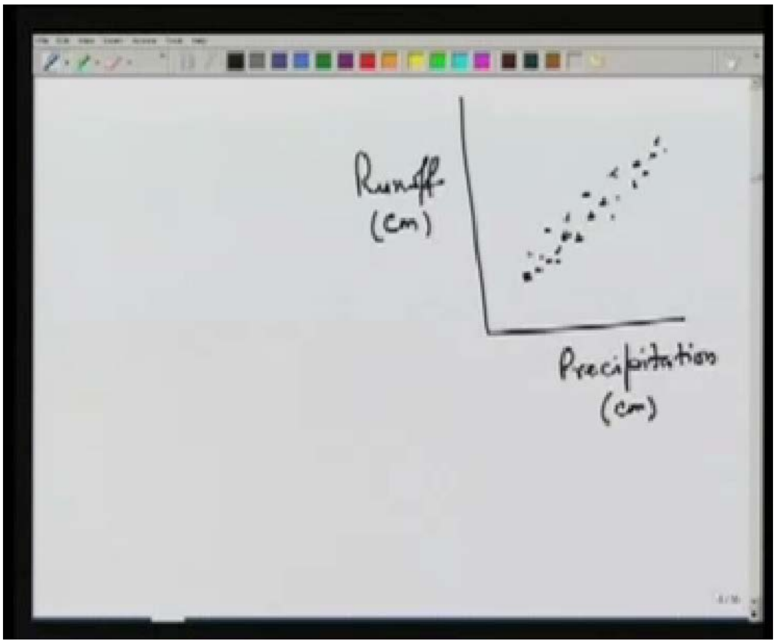

Let us say the runoff also has units of cm. If you have data for example a yearly amount of precipitation in a catchment and the yearly runoff, we can plot it on the curve and for a number of years if you plot the data it is seen that there is a definite trend. It may not be a much defined relationship but there is a trend between the precipitation and the runoff. So based on this observed trend, we use rainfall, runoff correlations or typically we write PR correlations, P for precipitation and R for runoff. So precipitation verses runoff correlations can be obtained for any given catchment if we have this data available for a large number of years. So over duration if we have the data available, we can plot them and typically a straight line is fitted. Suppose we have lot of data, we can use a lot of techniques that are available for fitting a straight line for data. So we will not go over those techniques but once you fit the straight line you have a relationship like this which relates the runoff with the precipitation on the area. Even if there is no precipitation there may be some base flow so that is why for 0 precipitations also you may have a fixed or a finite amount of runoff.

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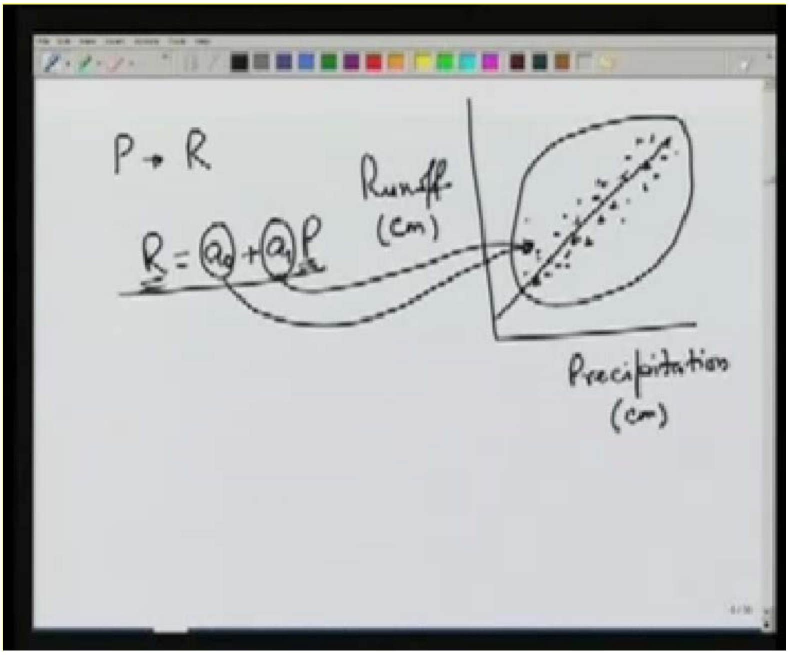

a_0 and a_1 would be obtained from the data. So once you develop this relationship for example we want to estimate the runoff for a precipitation which has not been measured in the field but which is accepted to be the maximum precipitation which can occur over the area.

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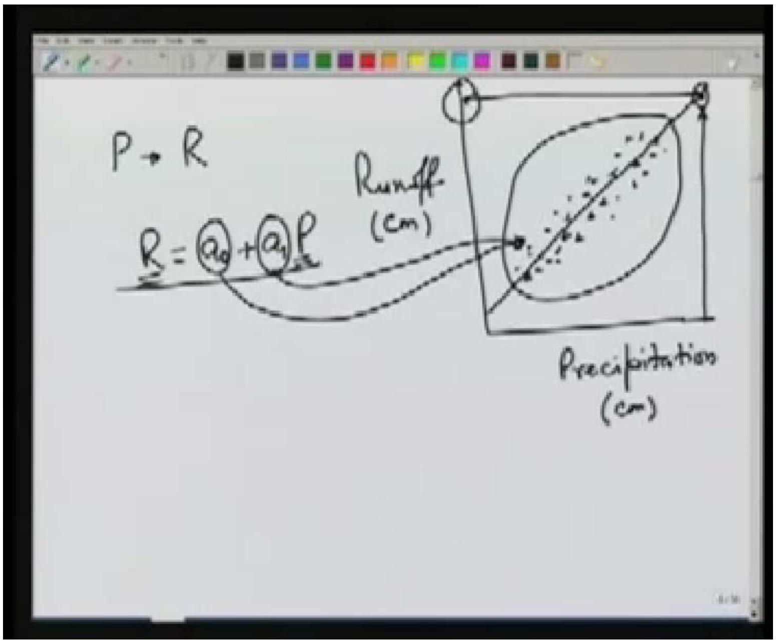

For that we can find out the probable runoff even though we do not have data for that point because rainfall has not occurred. Based on the existing trend we can extrapolate the value of the runoff to estimate the maximum flood likely in the river if extreme rain fall occurs. So that is the advantage of having the relationship like this. The precipitation data is available for a very long duration compared to runoff and also runoff data for very high discharge. Discharges at a very high stage in the river are not very reliable. Therefore R verses P relationships are very useful since P is known for a longer duration and P is also more reliable compared to R for high values of runoff. This is not the only possible correlation.

There are sometimes people who use a power law in which you relate R with some power of t. For larger basins a power law is found to be better than the linear relationship. Some other options are that instead of relating it with rainfall of that time, for example that year for that particular month, you relate the runoff with precipitation for that time and also a few pervious times. For example if in a year there is some rainfall, the runoff will also depend on what is the rainfall in the previous year is because if the rainfall in the previous year is more, then the ground is likely to be better. Therefore there will be more runoff. Also the ground water level is likely to be higher and therefore there will be more base flow.

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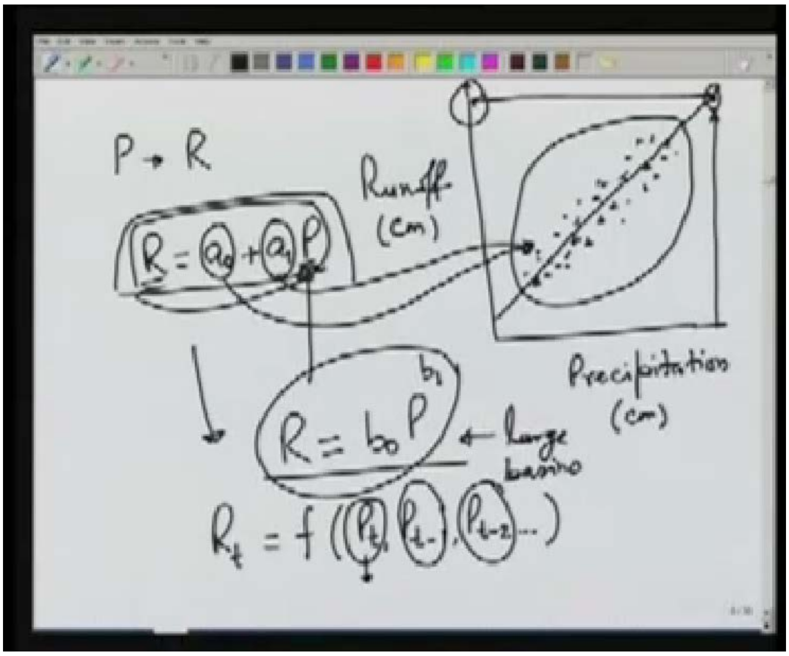

Not only the precipitation in that time period for example in that year but precipitation in the previous year or year before that may influence the runoff and therefore sometimes people have tried to develop a correlation like this. Also sometimes we do not have a well defined straight line or power law relationship and we really do not want to find out the relationship. We just want to find the runoff for any given precipitation event. In that case artificial intelligences models like an ANN, Artificial Numeral Network have been used in which the input values are put here as Pt, Pt – 1, may be the temperature also and all these input result in one output which is the runoff at time t and in between we have these various layers of neurons which convert this input into this output Rt. But models are little more advanced we will not discuss them here in this course. The second method of estimating the yield is based on empirical equations.

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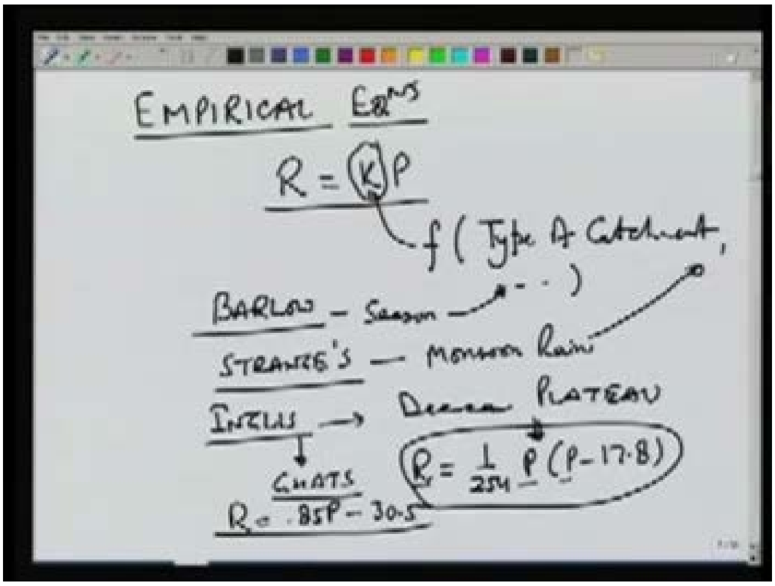

They are nothing but equations of similar kind for example R = KP but this constant K is an empirical constant which is not really based on analysis of observed values but is based on analysis of similar catchment areas. We can say that this K's value were dependent on the type of catchment area. So the K is typically is a function of type of catchment and some other parametres and different investigators have related K with different parameters. For example there is a Barlow equation where he says that K would be a function of type of catchment as well as the season. So K will be a function of the season then there is a Strange's empirical equation which relates K with the amount of monsoon rain.

There would be a number of empirical relationships like this but they will be useful only in catchments which are similar to the catchments for which the relationships have been derived. There are some regional relationships also which has been derived. For example Inglas for Deccan plateau has derived a relationship in which the runoff is given in cm and P also in cm. So everything is based on observed values and for a given region you can use this kind of equation. For example for the Ghats a similar relationship has been obtained as R = .85P – 30.5. So these kinds of relationships are available but for a very limited area. In that area we can use these but not everywhere. These are for annual runoffs and annual precipitation but there is an equation by Khosla which computes the monthly values of rainfall and runoff.

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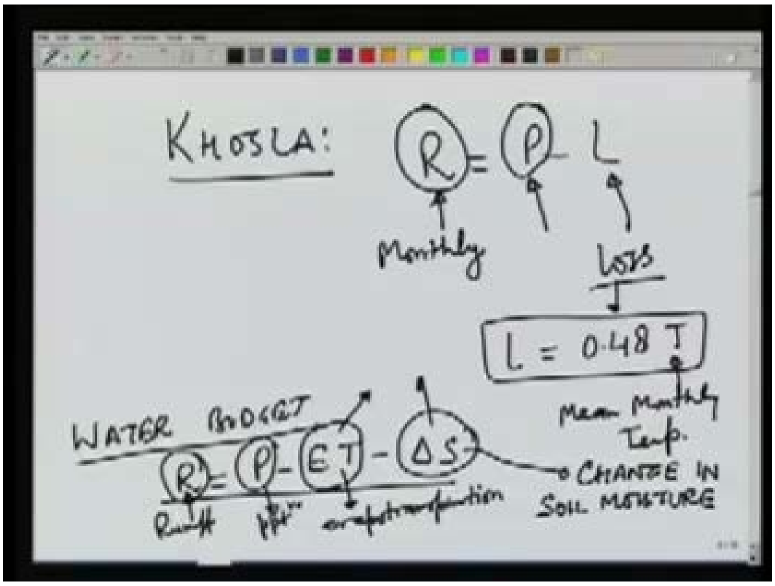

The Khosla empirical equation is given by R = P – L. Again R is now monthly, so we find out a precipitation in a month which we can obtain from the rain gauge. L is the loss and this loss typically depends on the mean monthly temperature at that area. Khosla has given the relationship which says that RL = 0.48 T where T is the mean monthly temperature. Mean monthly temperature of the area will be known to us from the atmosphere or from meteorological records. We can find the losses from here. The Precipitation will also be known to us so. We can find out the monthly value of runoff and then we add this for the entire year to get the annual yield. The Water Budget model is quiet a straight forward method mathematically but we will need computers to implement this model because there are lot of computations involved and a lot of data has to be collected which can be used to obtain the abstractions from the precipitations.

The equation which is used in water budget models is a simple mass balance equation that says that the runoff is nothing but precipitation minus the abstractions. The abstractions are evapotranspiration and delta S is the change in soil moisture. So what the model says is that out of total precipitation some part goes into evapotranspiration and some part goes to increase the soil moisture. So it infiltrates into the ground and therefore the soil moisture is increased. Now if delta S is negative then of course it means that the there is decrease in soil moisture and therefore precipitation minus delta S would be the runoff which would be very higher than what it would be for delta S which is positive. But for this model we need to estimate evapotranspiration. We have seen in other lectures that evapotranspiration can be obtained from the atmospheric conditions like wind, velocity, temperature and so on. All those factors have to be put in here to obtain the evapotranspiration and we can do this water budget modelling over a daily, weekly or monthly time interval. Delta S has to be estimated based on the crop pattern. The crop water requirement or soil moisture data is directly available and we can utilize that.

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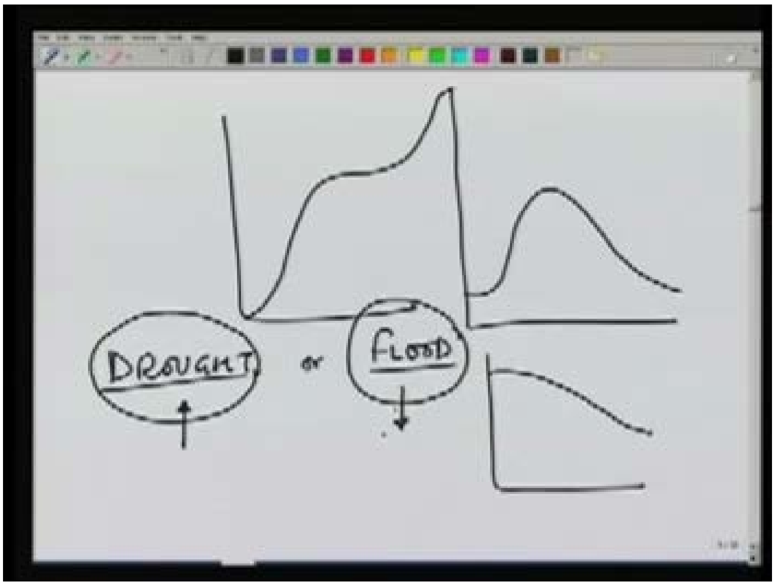

Next thing which we would like to look at is, once we have an idea about the stream flow, either hydrograph or a flow duration curve or a mass curve, how do we obtain the extreme conditions? Our interest as a water resource engineer is in the extreme conditions of either very small flow or very large flow. So we are interested in these conditions of drought or flood. So if the flow in the river is at an average rate and our demand is also an average rate, we do not have to worry about these things. But in extreme cases when there is a drought, it means lack of water. Now this drought may be defined in various ways. We will look at the different ways. But drought in general indicates a lack of water and similarly the flood indicates a lot more water than the desired and both of these are not good for a water resource engineer point of view.

We need to control them. So if there is a drought condition, we must be able to find out the deficit and we should be able to account for it. We should be able to carry water from some other place to that place where there is drought. Similarly for flood, we need to be able to device flood control measures. We can store water out of that flood or we can have some other measures of stream so that the entire water is not coming at the same time. There is some delay and therefore the flood peak is reduced. So drought and floods are two characteristics we should look at in detail now. When we say drought, the general understanding of this term is that there is lack of water. There is not enough water to satisfy our demands. But the demands are also different from different point of view. A drought occurs for a person who uses that water for drinking purposes or other household purposes. Drought means that he is not getting enough water. But if you look at it from let us say agriculture point of view, then a drought means that the plants are not able to get enough water. So a drought can be defined based on our point of view and the definitions.

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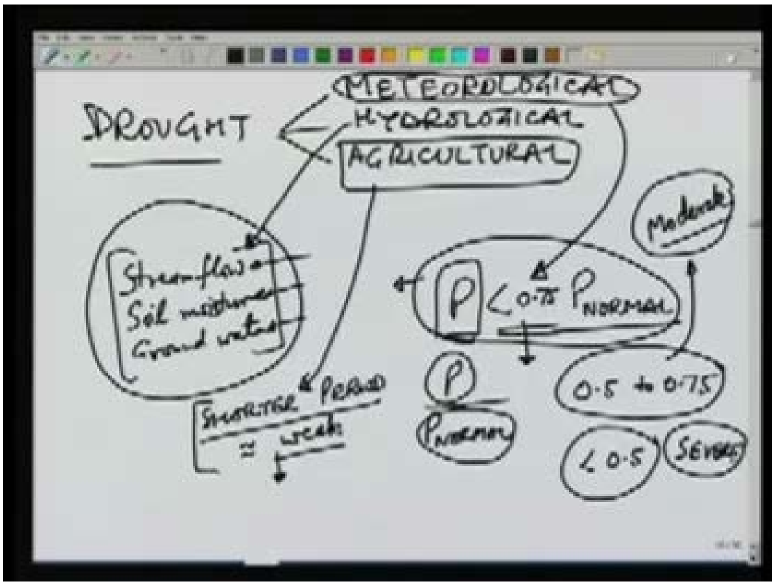

It varies from one point of view to the other and therefore we talk about a meteorological drought or hydrological drought or an agricultural drought. So as the name implies meteorological drought means lack of rain. If we have some precipitation P and there is some normal precipitation in the area let us call it P normal. If P is smaller than P normal then naturally we have less than average conditions. But just that P bit less than P normal would not really be defined as drought.

So there is a limit when we say P is less than 75 percent of the normal rainfall. Then meteorologically speaking, there is a drought. So any annual rainfall over the catchment which is less than 75 percent of normal would be classified as a drought and again less than 0.75. There is a wide range of precipitation below this range. Again it can be classified as severe drought or a moderate drought depending on what the actual values of P compared to P normal. So there is this ratio of P over P normal. It can be, let us say 0.5 to 0.75 or we can say that it may even be less than 0.5. So, 0.5 would be a severe drought indicating that the rainfall in that particular year is less than half of what is normally expected. On that area, this up to a 25 percent deficiency or up to this 75 percent of rainfall. So 50 to 75 percent can be called as a moderate drought. So meteorologically speaking, the drought only depends on the rainfall and the ratio of the actual rainfall to the normal on that area will define whether the drought is severe or moderate.

Now just because the rainfall is less than normal, it does not mean that let us say stream flow will also be less than normal because there may be a stream flow which is contributed by the base flow or the ground water discharge and that may happen even if it is smaller than normal rainfall. Only meteorological drought flow does not indicate drought in terms of hydrological variables. Therefore hydrological drought is defined based on stream flow being less than normal or we can use some other parameters, for example soil wetness, soil moisture or we can have ground water. So a hydrological drought will indicate a lack of stream flow or soil moisture or ground water compared to their usual values, so this encompasses a lot more variables than just the precipitation. Although typically precipitation is what is deriving these values, therefore meteorological drought typically implies hydrological drought also, but not always. The agricultural drought is over a very short period, about a week or so because when we say agricultural drought, it means that the plants are not able to get enough water to sustain and they can die even within a short period of a week. So even if annually let us say we have an annual drought in which annual precipitation is less than 75 percent of normal, but suppose this precipitation occurs when the plants need water then, they will not die. So depending on the temporal distribution of this precipitation, the plants may be able to survive or if sometimes even when there is normal precipitation, the plants may die because they do not get water when they need. So for agriculture drought we have to take a very short interval, for example, a week. During that one week's time, it is seen whether the requirements of the plants are being met or not. If they are not being met then we say that this is an agricultural drought.

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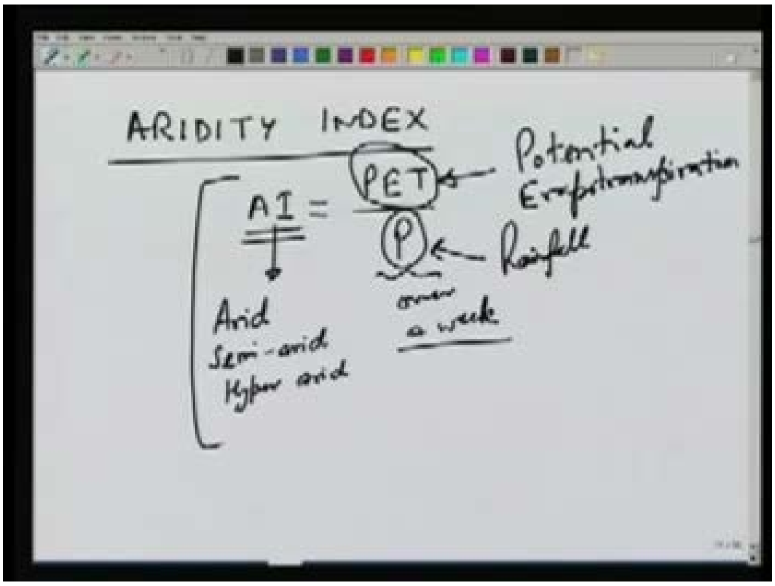

What we do for agricultural drought is define a term which is known as Aridity index. An aridity index is typically defined on the basis of the potential evapotranspiration because potential evapotranspiration represents the requirements of the plants also and therefore we use the PET or the potential evapotranspiration. If water is available in abundance then this would be the rate of evapotranspiration and we divide it by the rainfall. Based on this aridity index, we can classify the areas as arid, semi arid, hyper arid and so on. So this aridity index takes care of the amount of rainfall verses the requirement of the plants for that week. So over a week, we can say that during that time the area can be classified as arid, if the requirements of PET are not met by P.

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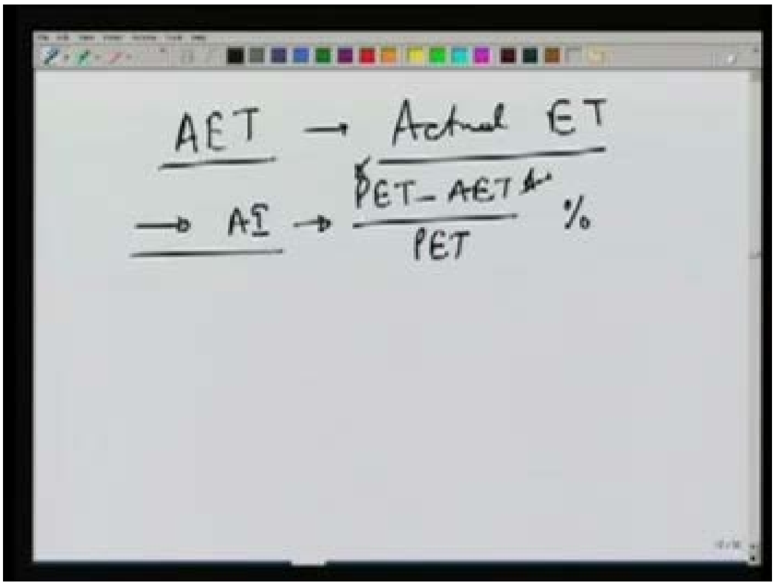

The other term which is used sometimes, is the actual evapotranspiration. Sometimes the aridity index is also defined on the basis of the ratio of actual and the potential evapotranspiration. If PET is the potential evapotranspiration and AET is the actual evapotranspiration, then the deficit has a percent of PET. This is an alternative definition of the aridity index. In fact there are 5 or 6 different kinds of definitions. For aridity index, we will just go over these two and we will not discuss the other definitions here. This is about the drought which is of three kinds. It can be specified based on these indexes.

The floods for a water resources engineer are more relevant than the drought periods although droughts are also significant for the floods. We have to find out really or extrapolate the values which we have not even seen. Sometimes we may have to estimate what is 100 year flood, what is a 1000 year flood because floods will damage the structure.

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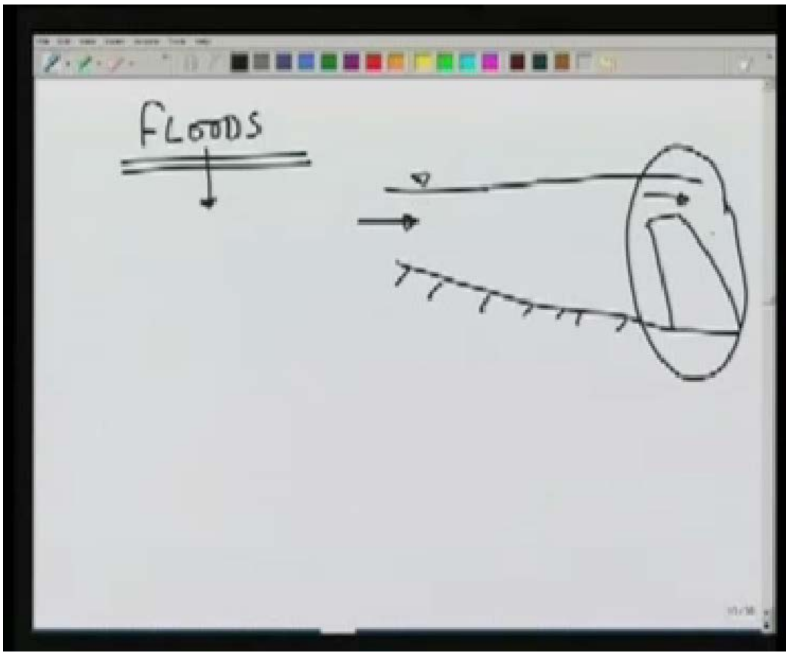

If we have a river and we have a dam here, there is a certain amount of flood which the dam can safely pass. The flood comes in because more than that there is a danger that this water level goes very high and the structural failure of the dam may occur. So to avoid this we need to know the flood accepted in the channel. There are lots of methods to estimate the maximum flood in the river.

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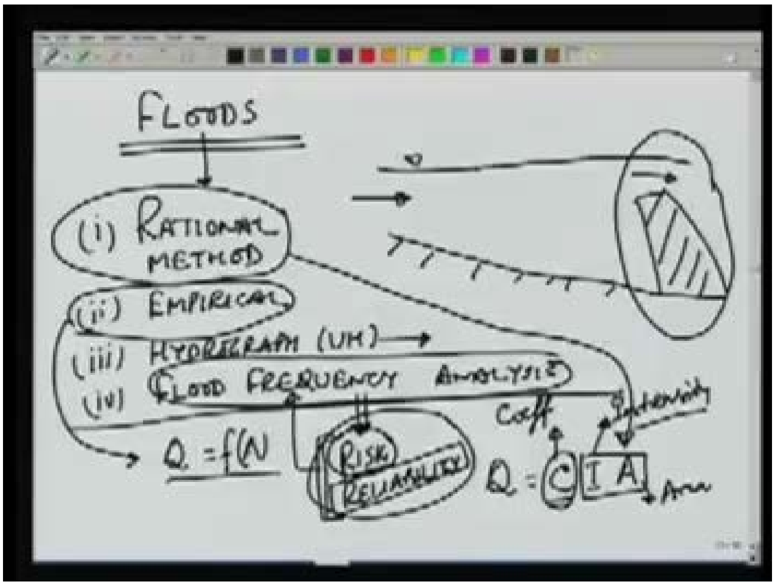

We will look at a few of them. For instance, rational method or we can have some empirical methods. We have already seen and discussed in detail the hydrograph theory. We use the hydrograph rather the unit hydrograph method to estimate the maximum flood or sometimes we use what is known as a flood frequency analysis. These methods are used to estimate the maximum flood likely to occur in the river at a particular point. In the rational method we estimate the maximum flood as a coefficient C and intensity I and the catchment area A. This runoff coefficient C varies widely from area to area and there are values given for this. I is the intensity of rainfall occurring over the catchment. So if you look at this equation, I into A give you the volume of runoff. If there is no loss, I is the intensity, A is the catchment area. AI is the volume of the precipitation occurring over the area and therefore this C value is really a loss coefficient or 1 – a loss coefficient which gives you the runoff for a total amount of precipitation. It is similar to the rainfall runoff relationship which we looked at, earlier, R = K into P, but this runoff coefficient depends on the type of area. For example if the area is very impermeable paved area is a lot C will be very high. If the area is very pervious then a lot of water will go as infiltration and C will be smaller. Tables of C are given for different kinds of areas and we can look at that table little later on. In the empirical equations, the flood is given as some function of the catchment area. So there is no intensity but the area in some function of the catchment area, some of the relationship which has been used is like area to the power 3/4 or area to the power 2/3 and so on.

These are again derived for a particular location and they would be applicable only for similar catchments. We had already looked at hydrograph method in detail. We will not discuss it again and flood frequency analysis is similar to what we did in the flow duration curve that we take the values of annual floods, arrange them in order and based on that we can decide how frequent the particular flood is. We can find out a 100 year flood or 50 year flood depending on the importance of the structure. For example if there is a dam, its failure may be catastrophic. It may include a lot of loss of life or property downstream of the dam. Therefore when we design a dam we should take the one that has a very high of, what is known as return period. When we say a 1000 year flood, it typically means the flood which is expected only once in 1000 years and therefore for the structures which are very critical, for ones which involve a loss of human life, it is generally an accepted practice to take a very high return flow for example 100-1000 years.

But for some structures for example there is a culvert in the road and if we want to design that we do not need to take very large flood or a very high return period. We may be able to do it once in 20 years or once in 50 year flood, because if the flood is exceeded it will only lead to submergence of the culvert. Traffic maybe affected for a few days or a few hours. But it is not so critical that we take a very high flood because when we take a very high flood for design, it will increase the cost of the structure, because we have to pass that amount of flood through the culvert and the utility probably will not be that high. We may be able to live with that in convenience for a few hours or a few days. But there will be a lot of saving in the cost. So these aspects come into picture and therefore flood frequency analysis becomes very important .It also gives us an idea about the risks involved in the design. So we would look at it a little later. We would look at the risks and reliability.

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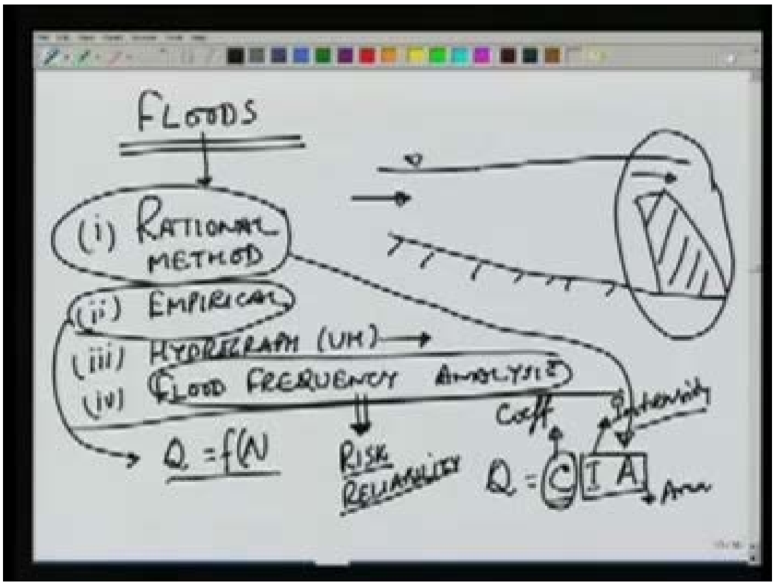

So what is the probability of failure of a structure, within the next 10 years or next 50 years? What design flood is required to be taken for its design? How to find out what is a 100 year flood, because we may not have data available to us for a 100 year period. So we have to have some extrapolation to find out the flood which occurs, maybe once in 1000 years. Every flood will have some risk attached with it. So if we take a 100 year flood, there is a risk that it may come, next year or in 5-10 years. We can find that out by doing this frequency analysis and risk analysis, we can find out the chances of failure of a structure within the next 5 years or 10 years or whatever the useful life of this structure is. We can find out how reliable the structure would be, so all these concepts can be defined and we can analyse the flood frequency to define these concepts.

This drought and flood will be dealt with a little later. To summarise today's lecture, we have looked at alternative ways of presenting the stream flow information, the hydrograph information. We had discussed it in details earlier. We looked at the flow duration curve which represents the dependability of flow; the percentage of the time, that particular flow will be available or what we can say will be equalled or exceeded. The flow duration curves give us an idea about what discharge will be available, for what percentage of time, so we can find out an 85 percent dependable flow or 50 percent dependable flow and so on. The mass curve is another way of representing the stream flow which plots the accumulated volume of water passing through that point verses time. The mass curve is helpful in finding out the storage requirement. So if we have certain demand which we have to satisfy, we can find out the required storage from the mass curve or for a given storage we can also find out the demand which can be maintained.

After looking at the stream flow record presentation in different formats, we looked at the extreme conditions of very small flow which is drought or very large flow which is flood. Droughts were classified based on the view with which we look at the data, as meteorological, hydrological or agricultural drought. For the floods, we looked at various methods of finding out the floods. We introduced them but we will look at more details a little later. We also looked at the various drawbacks or advantages of different approaches. We shall discuss them in detail a little later.