Water Resources Engineering

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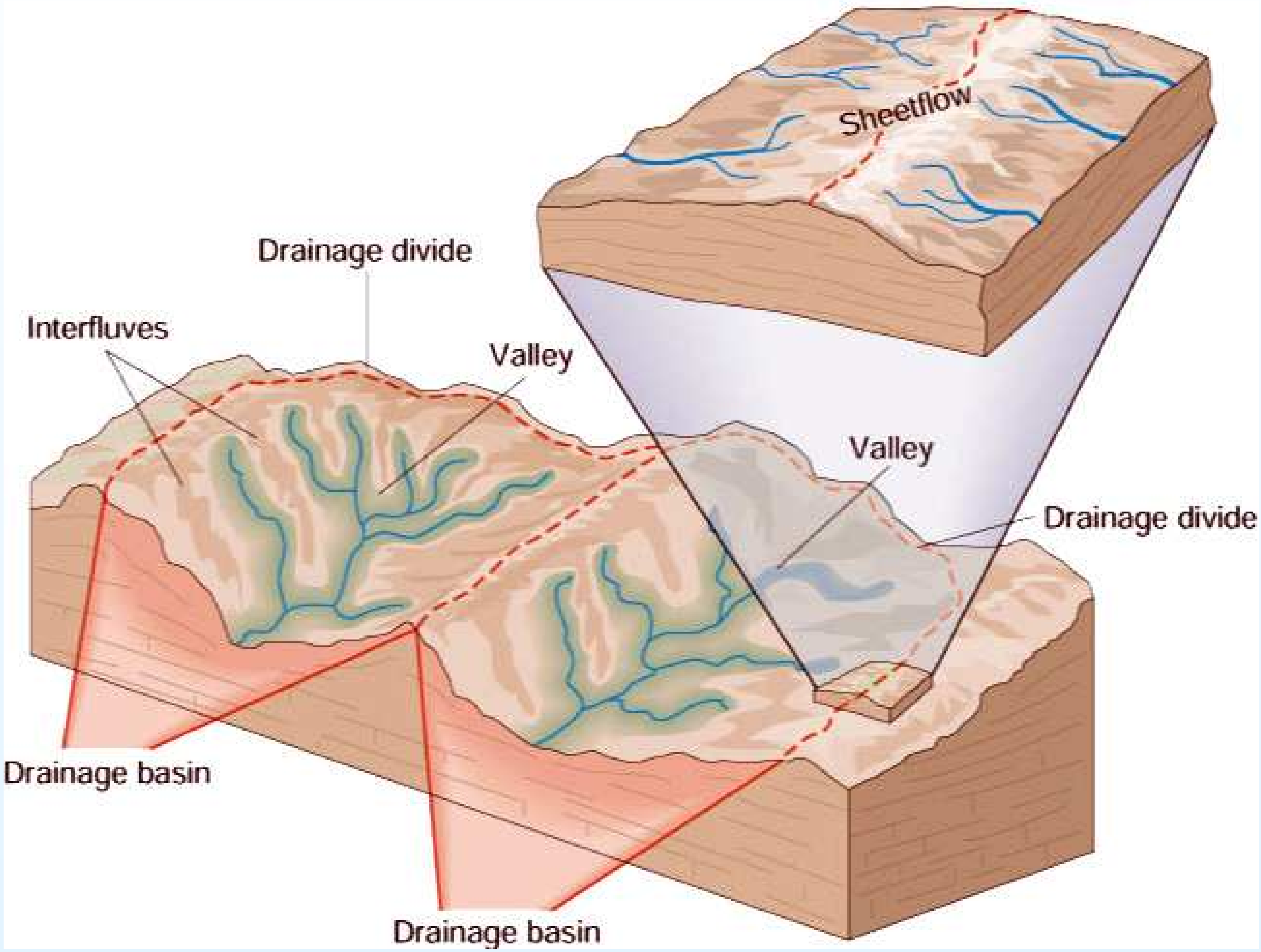
Catchment

Introduction

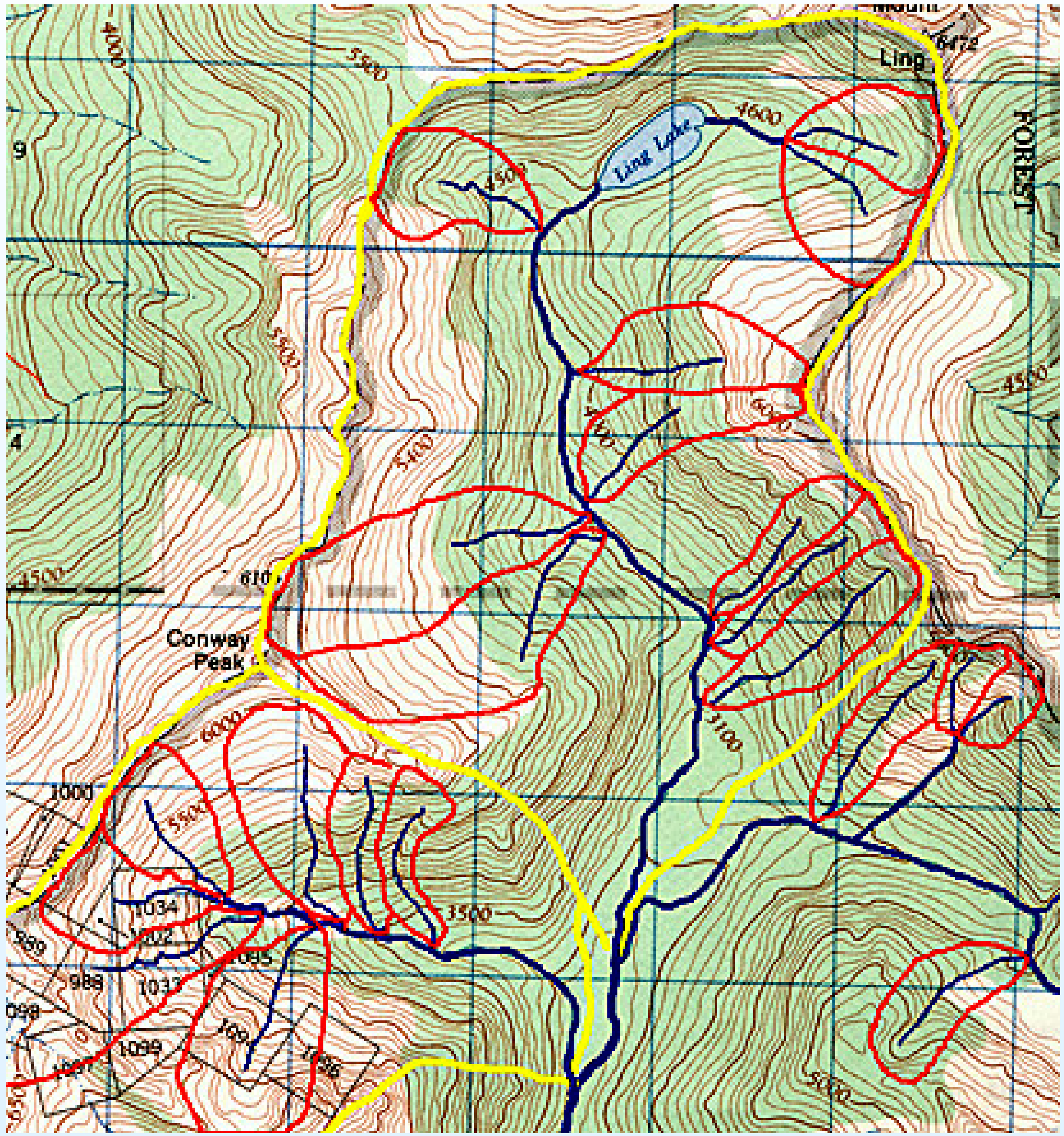
A **catchment** (or drainage basin) is a region of land where water from rain or snowmelt drains downhill into a body of water, such as a river, lake, dam, estuary, wetland, sea or ocean. The catchment includes both the streams and rivers that convey the water, as well as the land surfaces from which water drains into those channels.

The catchment acts like a funnel - collecting all the water within the area covered by the basin and channeling it into a waterway. Each catchment area is separated topographically from adjacent basins by a ridge, hill or mountain, which is known as the catchment boundary.

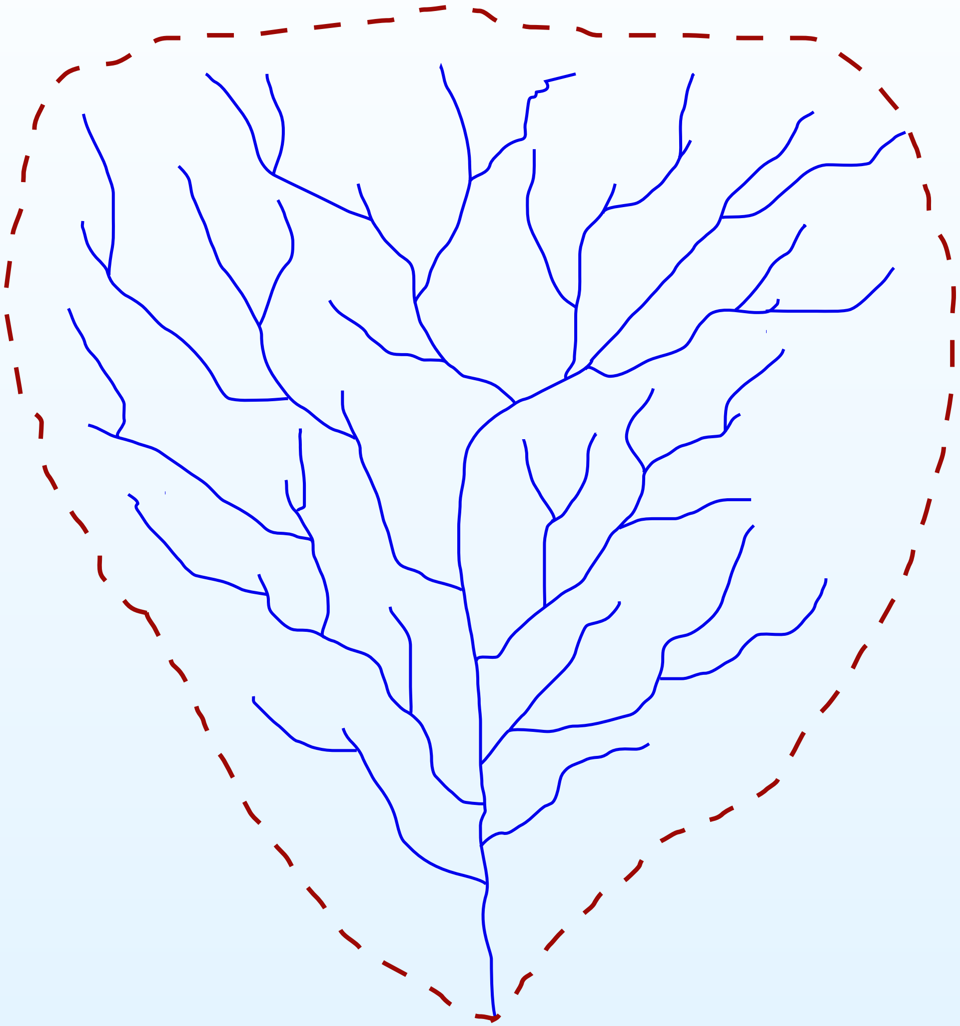
Introduction

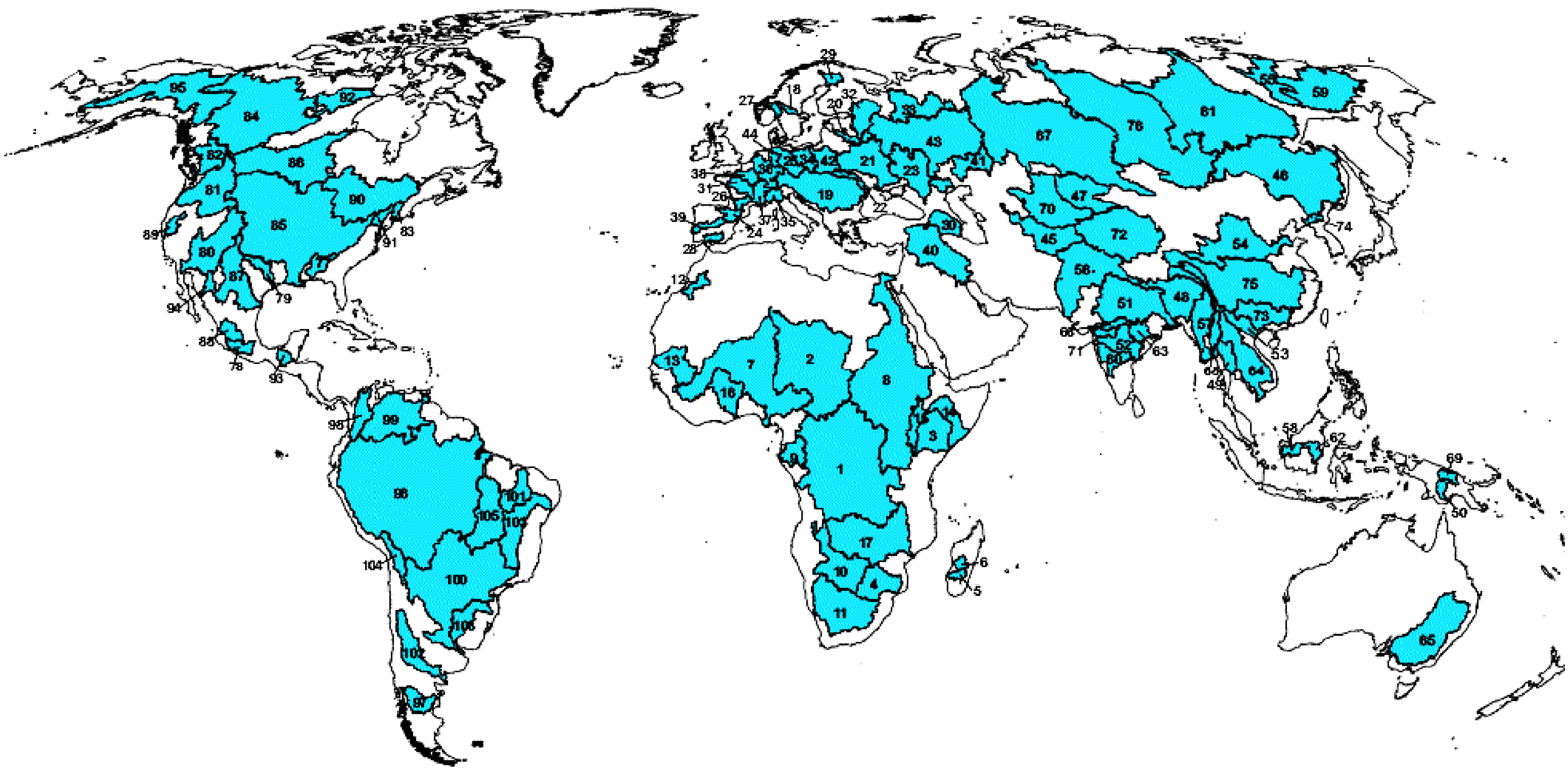


Concept



Map

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Characteristics

Certain characteristics of catchments reflect hydrologic behaviour. These are useful in evaluating the hydrologic response of the basins. These characteristics relate to either the physical catchment or to the channels.

Physical Characteristics

- Catchment Area
- Catchmen Shape
- Ground Slope
- Centroid of the Area

Channel Characteristics

- Channel Order
- Channel Length
- Channel Slope
- Drainage Density

To identify these characteristics, topographic maps and satellite images can be used together with GIS based software.

Catchment Area

Catchment area is defined as the area contained within the vertical projection of the catchment boundary on a horizontal plane. This condition is exhibited on a topographic map. On the map, the boundary is traced beginning with the drainage outlet on the stream and following the boundary around the catchment and back to the outlet.

It is apparent that the boundary of the catchment can only cross the stream at the basin outlet. Catchment area is measured in square kilometers or hectares. Catchment area is highly correlated with several hydrologic parameters. Discharge (runoff) Q from a catchment has been related to the catchment area. One of the simplest relationship is of the form

$$Q = kA^x$$

where k and x are parameters.

Catchment Shape

Numerous symmetrical and irregular forms of catchment areas are encountered in practice. A frequently occurring shape is a pear shape in plan view.

A number of dimensionless parameters have been proposed to quantitatively define the catchment shape. Some of these are

- Form Factor A/L^2
- Shape Factor L^2/A
- Elongation Ratio $1.128A^{0.5}/L$ etc.

A = catchment area, L = length of the catchment and P = perimeter.

Catchment Slope

Slope of a catchment has a profound effect on the velocity of overland flow, erosion potential and local wind system. Basin slope is defined as

$$S = h/L$$

where h is the fall and L is the horizontal length over which the fall occurs.

Because ground slope varies greatly from point to point within the catchment, the above simple equation needs suitable modifications. One method, suggested by Horton, is to divide the catchment area into a grid system on the topographic map. The average horizontal slope S_H and vertical slope S_V are obtained for each grid, from the contour intervals. Finally, the average slope for the catchment is obtained as

$$S = \frac{S_V + S_H}{2}$$

Centroid

The centroid of a catchment area is simply the location of the point within the area that represents the weighted center of the basin. It is the first moment of the area about the origin.

The centroid of a catchment can be determined by using the method of moments and representing the catchment by a grid system. Because the centroid is the first moment of inetrtia, it coordinates $(\bar{x}, \bar{y})$ can be computed as

$$\bar{x} = \frac{1}{A}\sum_{i=1}^{N} x_i a_i \qquad \bar{y} = \frac{1}{A}\sum_{i=1}^{M} y_i a_i$$

where x_i is the distance between the y-axis and the center of the i-th grid square, a_i is the area of the grid square, y_i is the distance between the x-axis and the center of the i-th grid square. M and N are the total number of grids in x- and y-directions, respectively.

Catchment Length

Length of the catchment is defined as the longest dimension of the catchment parallel to its principal drainage channel. Hydrology is concerned with flow in the drainage channels and, therefore, specifically requires that such measurements are made along the drainage system to a given point.

In a similar vein, basin width can be measured in a direction approximately perpendicular to the length measurement.

The relationship between the length L_b and the area A of a catchment can be approximately represented as

$$L_b = 1.312A^{0.68}$$

where L_b is in km and A in km^2.

Channel Order

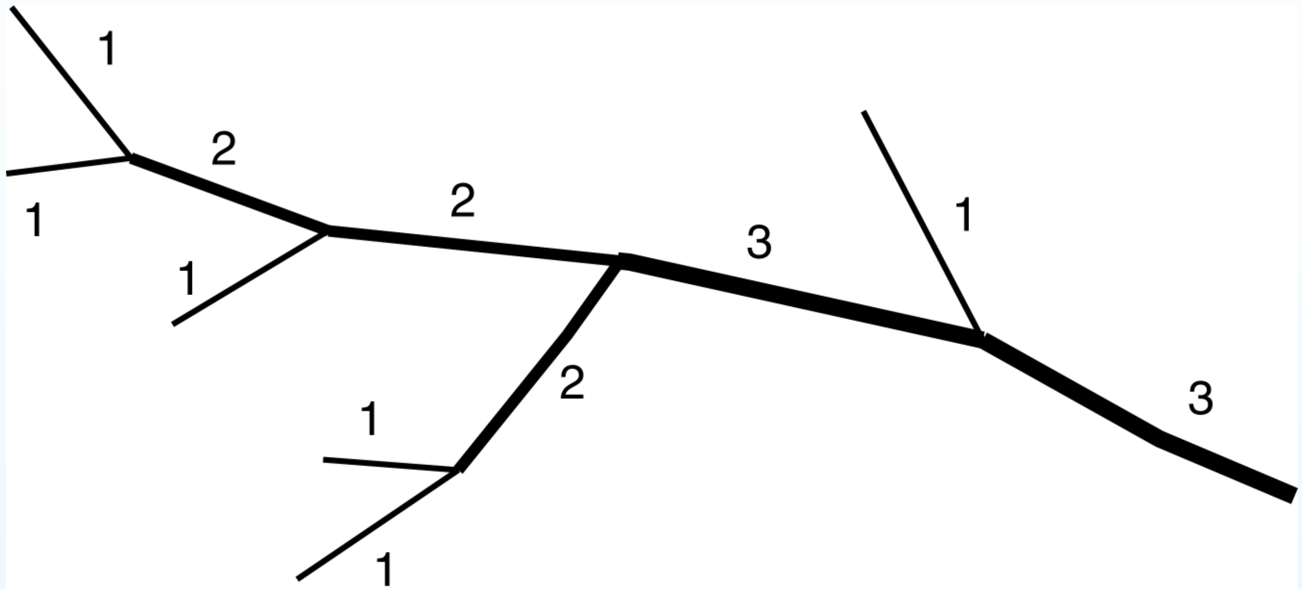
Catchment areas may be characterized in terms of channel ordering. The order of the catchment is the order of its highest-order channel.
An inspection of the channel network of a catchment reveals that as one traces the flow from one of the uppermost channel in the catchment toward the outlet, the uppermost channel joins another channel, which in turn joins another channel and so on.

The **first order** channels are defined as those having no tributaries. these are the streams whose flow is dependent entirely on surface overland flow to them.

The junction of two first order channels form a **second order** channel. A second order channel receives flow from the two first-order channels that form it, and from overland flow from ground surface. It might receive flow from another first-order channel that flows directly into it. Thus a second order channel must carry much more flow of water than a first order channel.

A **third order** channel is formed by the junction of two second order channels.

Channel Order



When two **first order** channels join together, they form a **second order** stream. When **two second** order channels come together, they form a **third order** stream. Channels of lower order joining a higher order channel *do not change* the order of the higher channel. Thus, if a first order channel joins a second order channel, it remains a second order channel. It is not until a second order channel combines with another second order channel that it becomes a third order channel.

Catchment Order

The order of a catchment is defined by the highest channel order inside the catchment, i.e., the order of the channel at the outlet.

Catchment of the **Amazon River** is having the highest order, 12. The **Ohio River** is an "8" and the **Mississippi River** is a "10." 80 percent of the streams and rivers on the planet are first or second order.

Exercise

Identify the catchment order.