River Basin Hydrology: Characteristics of river basins

Basin Hydrology

Drainage basins are the principal hydrologic unit considered in fluvial geomorphology. A drainage basin is the source for water and sediment that moves from higher elevation through the river system to lower elevations as they reshape the channel forms.

A drainage basin is a most natural hydrologic unit. Guided by topography, a drainage divide separates the water that flows into and away from a catchment. A basin integrates the disparate hydrologic activities occurring spatially within its domain. Streamflow characteristics are a manifestation of the combined results of various hydrologic processes occurring in a basin. Basin water balance investigation yields information on how much water is gained and lost in quantitative terms.

The fluvial system:

Inputs, outputs and stores

The basic unit of the fluvial system is the drainage basin. Fluvial systems are open systems, which means that energy and materials are exchanged with the surrounding environment. In closed systems, only energy is exchanged with the surrounding environment.

Inputs

The main inputs to the system are water and sediment derived from the breakdown of the underlying rocks. Additional inputs include biological material and solutes derived from atmospheric inputs, rock weathering and the breakdown of organic material. Most of the energy required to drive the system is provided by the atmospheric processes that lift and condense the water that falls as precipitation over the drainage basin. The pull of gravity then moves this water downslope, creating a flow of energy through the system. This energy is expended in moving water and sediment to river channels and through the channel network.

Outputs

Water and sediment move through the system to the drainage basin outlet, where material is discharged to the ocean. Not all rivers reach the ocean; some flow into inland lakes and seas, while others, such as the Okavango River in Botswana, dry up before reaching the ocean. This reflects another important output from fluvial systems: the loss of water by evaporation to the atmosphere.

Most of the available energy is used in overcoming the considerable frictional forces involved in moving water and sediment from hillslopes into channels and through the channel network. Much of this energy is lost to the atmosphere in the form of heat.

Stores

A certain amount of material is stored along the way. For example, water is stored for varying lengths of time in lakes and reservoirs, and below the ground in the soil and aquifers. Sediment is stored when it is deposited in channels, lake basins, deltas, alluvial fans and on floodplains. This material may be released from storage at a later stage, perhaps when a channel migrates across its floodplain, eroding into formerly deposited sediments which are then carried downstream. Ferguson (1981) describes the channel as ‘a jerky conveyor belt’, since sediment is transferred intermittently seawards.

Morphological (form) systems

Landforms such as channels, hillslopes and floodplains form a morphological system, also referred to as a form system. The form of each component of a morphological system is related to the form of the other components in the system. For example, if the streams in the headwaters of a drainage basin are closely spaced, the hillslopes dividing them are steeper than they would be if the streams were further apart from each other. Relationships such as this can be quantified statistically.

Cascading (process) systems

The components of the morphological system are linked by a cascading system, which refers to the flow of water and sediment through the morphological system. Cascading systems are also called process systems or flow systems. These flows follow interconnected pathways from hillslopes to channels and through the channel network.

Process–response systems

The two systems interact as a process–response system. This describes the adjustments between the processes of the cascading system and the forms of the morphological system. There is a two-way feedback between process and form. In other words, processes shape forms and forms influence the way in which processes operate (rates and intensity). This can be seen where a steep section of channel causes high flow velocities and increased rates of erosion. Over time erosion is focused at this steep section and the channel slope is reduced. Velocity decreases as a result, reducing rates of erosion. In order to examine the components of the fluvial system in more detail, it can be divided into sub-systems, each operating as a system within the integrated whole. One way of doing this is to consider the system in terms of three zones, each of which is a process−response system with its own inputs and outputs (Figure 2.1). Within each zone certain processes dominate. The sediment production zone in the headwater regions is where most of the sediment originates, being supplied to the channel network from the bordering hillslopes by processes of erosion and the mass movement of weathered rock material. This sediment is then moved through the channel network in the sediment transfer zone, where the links between the channel and bordering hillslopes, and hence sediment production, are not so strong. As the river approaches the ocean, its gradient declines and the energy available for sediment transport is greatly reduced in the sediment deposition zone. It is primarily the finest sediment that reaches the ocean, as coarser sediment tends to be deposited further upstream. In fact, only a certainproportion of all the sediment that is produced within a drainage basin actually reaches the basin outlet.

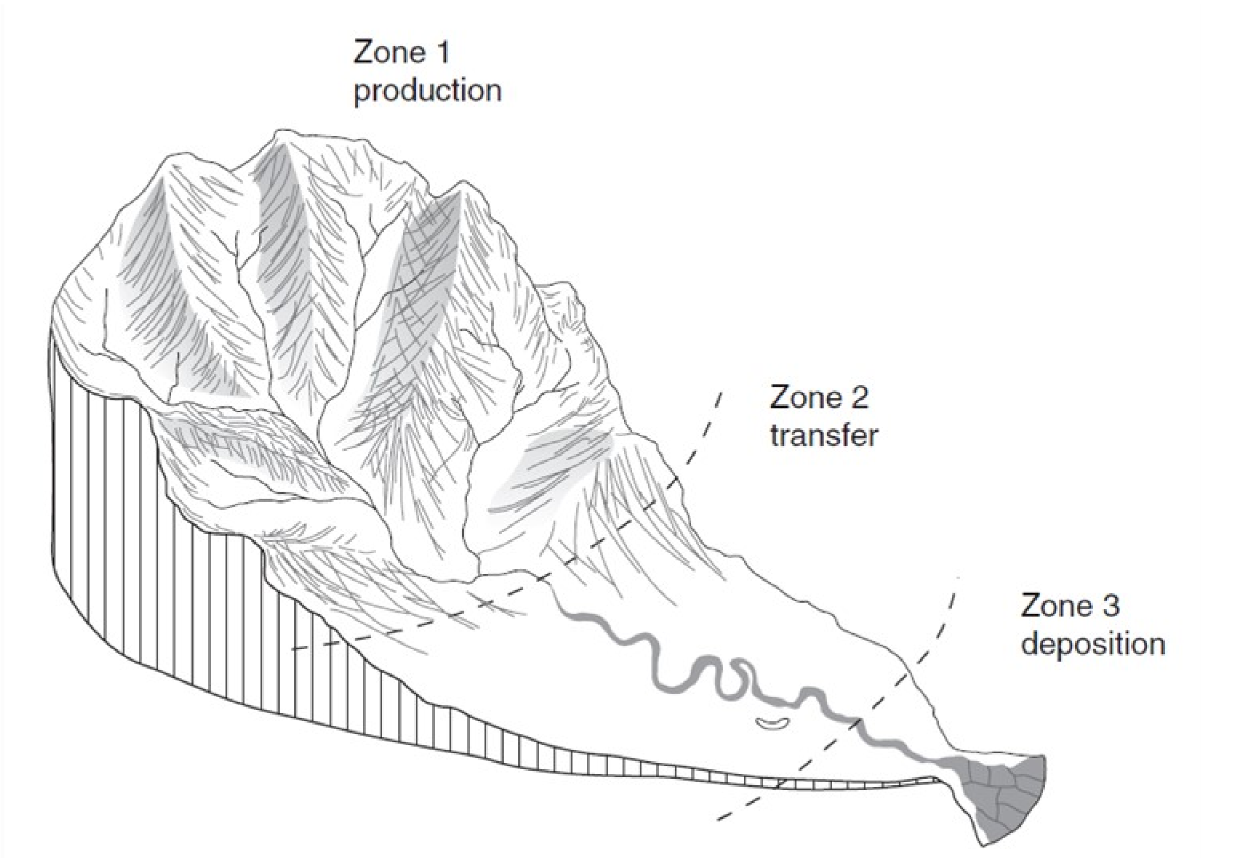

Fig. 1 The fluvial system can be subdivided into three zones on the basis of the dominant processes operating within each zone. These are the sediment production zone, sediment transfer zone and sediment deposition zone. Adapted from Schumm (1977).

Reference: Charlton Ro (2007). FUNDAMENTALS OF FLUVIAL GEOMORPHOLOGY