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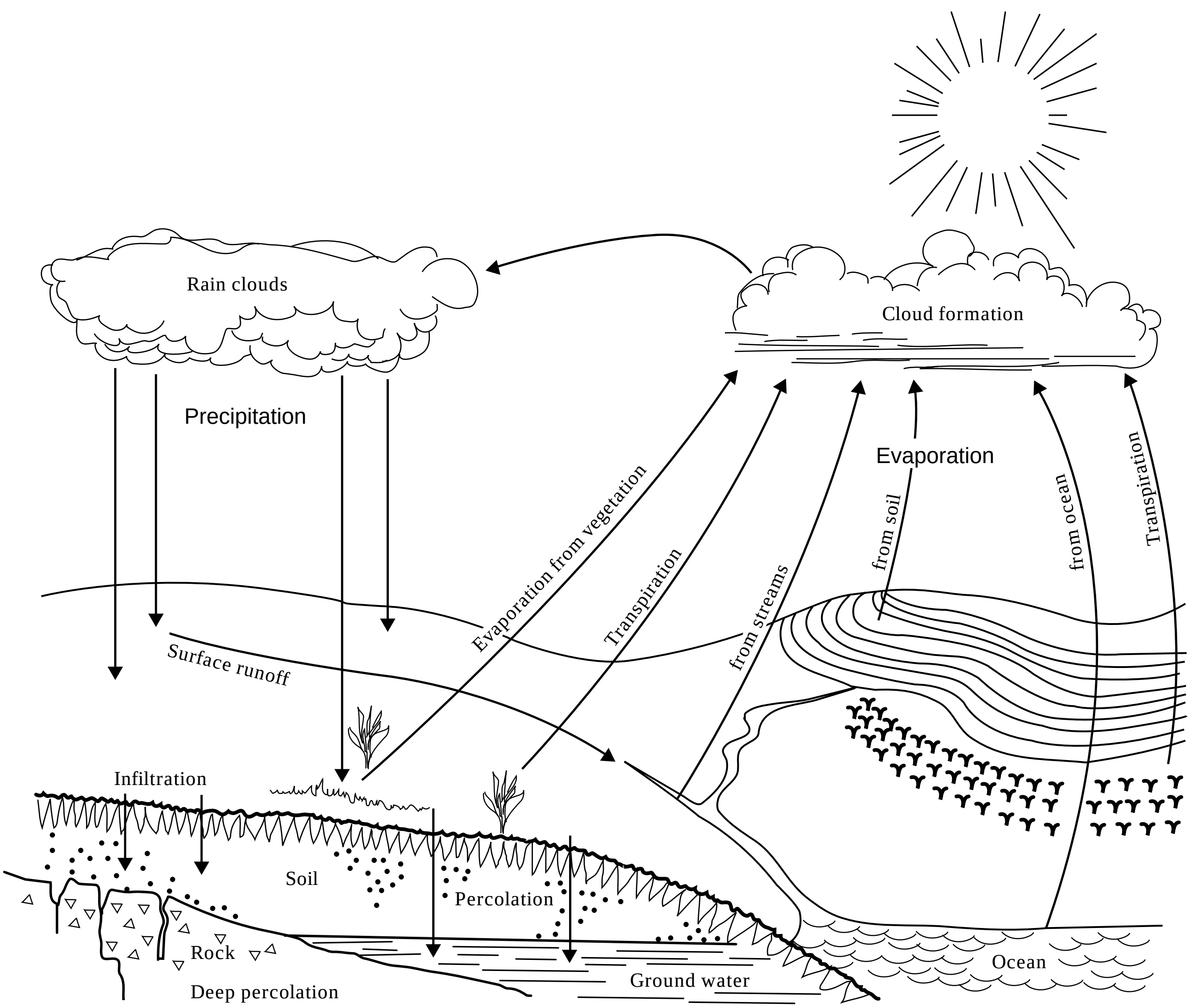
Part 630 Hydrology
National Engineering Handbook

Chapter 6 Stream Reaches and Hydrologic Units



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Chapter 6 Stream Reaches and Hydrologic Units

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630.0600 Introduction

The stream system of a watershed is divided into reaches, and the watershed into hydrologic units, for the convenience of work during study. This chapter gives some details on the selection of reaches for hydrologic or economic studies, presents alternative means for studies of alluvial fans, and briefly describes a hydrologic unit and its use in a study.

630.0601 Reaches

A reach is a length of stream or valley used as a unit of study. It contains a specified feature that is either fairly uniform throughout, such as hydraulic characteristics or flood damages, or that requires special attention in the study, such as a bridge. Reaches are shorter for hydraulic studies than for economic ones, so it is best to consider hydraulic needs first when selecting reaches and then combine the hydraulic reaches into longer ones for the economic study.

Reaches are physically defined at each end by cross sections that usually extend across the valley and include the channel section as well as a significant portion of the flood plain. The section should include enough of the flood plain to extend beyond whatever flood limits the engineer expects to occur in the study. A cross section is either straight and at a right angle to the major path of flow in the valley, or it is a connected series of segments that are at right angles to flows in their vicinity. The *head* and *foot* of a reach are the upstream and downstream ends respectively. *Right bank* and *left bank* are designated looking downstream. For reference, reaches and cross sections are numbered in any simple and consistent way, such as the ones in figure 6–1 and table 6–1. However, if a computer program is used, the numbering must follow the system specified in the program.

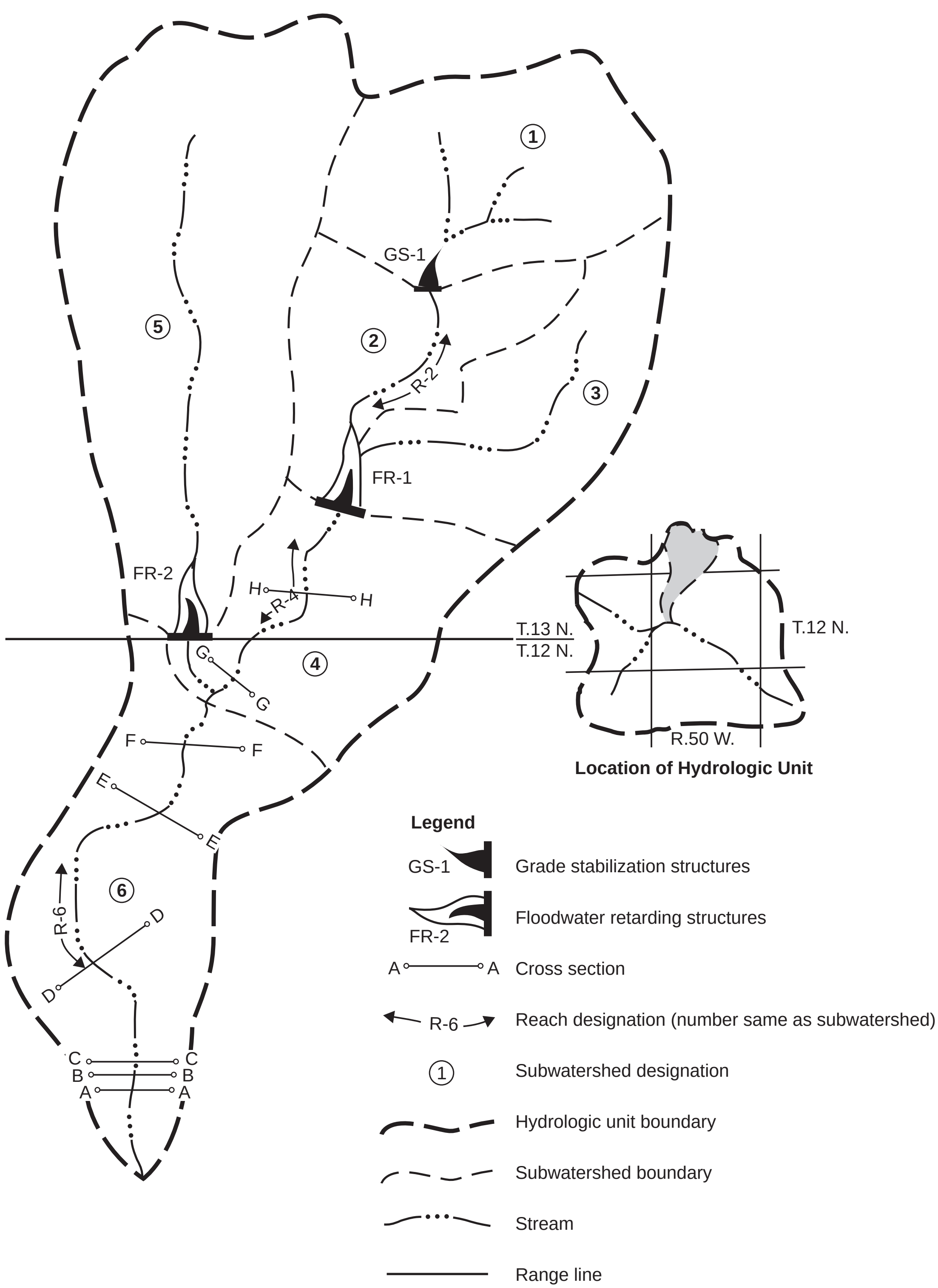
The purpose of a reach determines which relationships of the reach must be developed from field surveys. For a hydrologic study the required relationships include those of stage and discharge (NEH, part 630, chapter 14), stage and end-area (NEH, part 630, chapters 14 and 17), and, if manual flood routings will be made, discharge and velocity (NEH, part 630, chapter 14). For an economic study the relationships are stage and discharge (NEH, part 630, chapter 14), stage and area-inundated (NEH, part 630, chapter 13), and stage and damage (National Resource Economics Handbook, Part 611, Water Resources (Floodwater)).

Table 6–1 Reach and cross-section data

Reach number 1/	Cross section number	Cross section stationing	Length of reach 2/ (feet)	Travel time 3/ (hours)	Accumulated drainage area (square miles)	Runoff curve number 4/ present	future
4			7,500	0.60		80	78
	FR–1	2231+00			3.6 5/		
	HH	2192+00			4.0 6/		
	GG	2160+00			4.4 7/		
6			15,600	1.50		80	78
	FF	2138+00			7.5 5/		
	EE	2100+00			8.0		
	DD	2054+00			8.4		
	CC	2016+00			8.8		
	BB	2014+00			8.8		
	AA	2012+00			8.9 7/		

1/ Reach number is same as subwatershed number.
2/ Channel length of reach.
3/ Travel time of a 2-year frequency flow through the reach.
4/ Runoff curve numbers for the total area above the foot of the reach. They were obtained by weighting (NEH, part 630, chapter 10).
5/ Drainage area at the head of the reach.
6/ The drainage area at this cross section was estimated.
7/ Use drainage area at the foot of the reach if the cross section is located at or near the lower boundary crossing of the stream.

Figure 6–1 Hydrologic unit having detail for use as a sample watershed



(a) Location

The head or foot of a reach is at or near one of the following places on a stream:

- Boundary of an agricultural area having flood damages.
- Boundary where agricultural damages change significantly.
- Boundary of an urban area or any other area of high potential flood damage for which levees or other local protective works may be proposed.
- Junction of a major tributary and the main stream.
- Station where streamflow is gaged.
- Installation controlling streamflow, such as a weir or a culvert in a high road fill.
- Installation restricting streamflow, such as a bridge.
- Site proposed for a floodwater-retarding or other structure.
- Section where shape or hydraulic characteristics of the channel or valley change greatly.
- Section where channel control creates large storage upstream.
- Major political boundaries.
- Point of diversion.

In selecting reaches the method of computing water-surface profiles may specify a maximum permissible length of reach. Some hydraulic models have a built-in routine for transposing or interspersing auxiliary cross sections to avoid stopping the program when an excessive length of reach is encountered in the data. Even these programs have limitations that must be observed.

Locations for reaches are selected by the hydrologist and others in the evaluation or planning team. Tentative locations are made during the preliminary investigation of a watershed (NEH, part 630, chapter 3) and shown on a base map or aerial photograph. Low-altitude aerial reconnaissance may be necessary for locating reaches in watersheds without access roads or where timber, brush, or cultivated crops obstruct vision at the ground level. If flood damage studies will be made, flood plain areas with potentially high damage are also located and shown. The map or photograph is later used for identifying the reaches that need most attention in the studies. Once the relative importance of the reaches is known, the hydrologist selects the locations of cross sections and determines the intensities of work to be done by the field survey crew.

(b) Measurement

The measurements made during a field survey generally are those necessary to define the changes in ground elevation in the line of a cross section and the horizontal distances between sections. These include definition of the flood plain and channel cross section shape with distance and elevation measurements along a line perpendicular to the channel flow paths. Manning's *n* must be estimated for hydraulic computations (NEH, part 630, chapter 14) for each reach. The value of *n* must represent roughness conditions for the full length of the reach. If a cross section is divided into segments, the *n* for each segment applies to a strip through the reach between adjacent cross sections.

(c) Length

The length of a reach is the distance between cross sections at the head and foot, measured along the sinuous path of flow in the channel or valley. The channel is nearly always longer than the valley so that two lengths may be applied in a study:

- The channel length when the flow is low (within banks of the channel).
- The valley length when the flow is over the flood plain.

This means that as a flood rises the reach becomes shorter, a change that may be taken into account when computing water-surface profiles (NEH, part 630, chapter 14) and flood damages (NEH, part 630, chapter 13). Reach lengths are generally determined using an aerial photograph or a detailed topographic map because the paths of flow are often complex and not easy to determine in the field.

(d) Profile

Elevations of cross sections are related to a common datum if profiles of the valley or channel are needed for computation of water-surface profiles by the standard step method.

(e) Hydraulic roughness

Estimates of hydraulic roughness (Manning's *n*) are made by the procedure given in NEH-5, Supplement B, or an equivalent procedure. Publications such as Barnes, Jr., H.H., Roughness characteristics of natural channels, U.S. Geological Survey Water Supply Paper 1849, 1967; Arcement, G.J., and Schneider, V.R., Guide for selecting Manning's roughness coefficients for natural channels and flood plains, U.S. Geological Survey Water Supply Paper 2339, 1989; and Fasken, G., Guide for selecting roughness coefficient "n" values for channels, 1963, give more information on Manning's *n* and its variations in natural channels.

(f) Reach data for a computer program

If water-surface profile or similar computations will be made by an electronic computer, the computer program description should be examined for limitations on the input data, such as length of reach and number of elements in a cross section. These limitations must be kept in mind when working instructions are given to the survey crew. Typical limitations are given in NEH part 630, chapter 31.

630.0602 Alluvial fans

Alluvial fans, also called debris slopes or debris fans, are sediment deposits formed where the grade of a mountain stream is abruptly reduced as the stream enters an area of gentler slope, such as the valley of another stream. Large fans may be inhabited or have agricultural use. The paths of flood flows shift from one side to another of a fan so that reaches are useless and a special method for project evaluation must be adopted. In this method the floodwater damages on alluvial fans are related to actual or estimated runoff volumes that are referenced to an upstream cross section above the fan, such as a stream gage or other control section. The evaluation of flood damages follows this order:

1. Information about the monetary value of damages for each known flood on the fan is obtained by interviews or from historical sources.
2. The volume of flood runoff for each flood is determined from streamflow records or estimated by use of rainfall and watershed data and the methods shown in NEH, part 630, chapter 10.
3. The relation between flood runoffs and damages is developed (National Resource Economics Handbook, Part 611, Water Resources (Floodwater)).
4. The frequencies of flood-runoff amounts are estimated (NEH, part 630, chapter 18).
5. A damage-frequency curve is developed (National Resource Economics Handbook, Part 611, Water Resources (Floodwater)).
6. The average annual damage is determined (National Resource Economics Handbook, Part 611, Water Resources (Floodwater)).
7. The effects of a proposed upstream project on the amounts of runoff are determined. The amounts (and therefore the flood damages) decrease when changes in land use and treatment decrease the runoff curve number (NEH, part 630, chapter 10) or when storage structures or upstream channel storage increases reduce flood flows (NEH, part 630, chapter 17).
8. The runoff-damage relation of step 3 is used with the reduced runoffs of step 7 to estimate damages still remaining.
9. A modified damage-frequency curve is developed and plotted on the graph used in step 5.

10. The difference between present and future damage-frequency curves is obtained as shown in National Resource Economics Handbook, Part 611, Water Resources (Floodwater) to estimate the project benefits.

630.0603 Hydrologic units

When a large watershed or a river basin is studied, the watershed or basin should be divided into subareas or subwatersheds, called hydrologic units (HU), and the study made in terms of these units.

An HU may also be used as a sample watershed; that is, project costs and benefits within a selected HU are evaluated in detail and afterward applied to other similar HU's for which no internal evaluation is made. The data in the sample evaluation reach or HU can be expressed as units per mile of reach or per square mile of HU. Transfer of evaluation to another similar reach or HU can then be accomplished by simply multiplying the unit values by stream miles or square miles for the HU of interest. The small watershed in figure 6–1 has enough detail for a sample watershed.

Each HU is the drainage area of a minor tributary flowing into the main stream or a major tributary. Areas between minor tributaries are combined and also used as HU's. Cross sections and reaches are needed only when an HU is a sample watershed. Storms in the historical or frequency series (NEH, part 630, chapter 18) are developed on an HU basis, as are runoff curve numbers and hydrographs. Hydrographs for present, and with future land use and treatment conditions, are developed for an entire HU with reference to its outlet (NEH, part 630, chapter 16).

If an HU contains structural measures that affect the peak flow rate and/or timing of a hydrograph, the changes are determined by methods of routing (NEH, part 630, chapter 17) and the modified hydrograph, like the others, is referenced to the HU outlet. The watershed or basin flood routing is carried out on the major tributaries and main stream, with the HU's supplying the starting and local inflow hydrographs.

630.0604 References

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