



Figure 1.—Average streamflow per square mile.

INTRODUCTION

Section 404 of the Federal Water Pollution Control Act (Public Law 91-500) establishes a permit program for regulation for the discharge of dredged or fill material into navigable waters at specified disposal sites. This program is administered by the U.S. Army Corps of Engineers. Permits are required for discharges of dredged or fill material downstream from the "headwaters" of a stream. The term "headwaters" is defined as the point on a freewater (contidal) stream above which the average flow is less than 5 ft<sup>3</sup>/s. Permits may also be required in the headwaters if the District Engineer determines that regulation of these waters is necessary to protect water quality.

This report was prepared by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers, Mobile District. The purpose is to update a previous report detailing headwater estimating methods by Hartley and others (1961). Data for the 1951-70 period were used in Hartley's investigation; whereas, data for 1951-80 were used for this study. Preparation and interpretation of data were accomplished by four districts of the U.S. Geological Survey (Alabama, Georgia, Florida, and Mississippi) and compilation was by the Alabama District. Maps of the Mobile District area showing (1) lines of equal average streamflow, and (2) lines of equal drainage areas required to produce an average flow of 5 ft<sup>3</sup>/s are contained in this report. These maps are for use by the Corps of Engineers in their permitting program.

Units of Measurements

Unit	Conversion factor	Metric units
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi <sup>2</sup> )	2.590	square kilometer (km <sup>2</sup> )
cubic foot per second (ft <sup>3</sup> /s)	0.02832	cubic meter per second (m <sup>3</sup> /s)
cubic foot per second per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ]	0.01093	cubic meter per second per square kilometer [(m <sup>3</sup> /s)/km <sup>2</sup> ]

AVERAGE FLOW MAP

The average flow map was prepared to estimate areas of equal average flow per square mile. This map then was used to estimate and delineate lines of equal drainage area required to produce an average flow of 5 ft<sup>3</sup>/s which are shown in the headwaters limit map.

Data Base

Streamflow data used in this report were derived from two sources. The primary source was continuous streamflow records collected in or adjacent to the Mobile District before September 30, 1980. These records, particularly the longer ones for small drainage areas, form the statistical framework supporting the computations of average flow.

Supplementing the continuous gaging station records are data obtained at partial-record stations on selected streams in the area. At each partial-record station a number of discharge measurements were made during periods of base flow.

The interest is primarily in natural flow from relatively small drainage areas; therefore, no record for gaging stations having a drainage area greater than 500 mi<sup>2</sup> or any station where streamflow was subject to significant regulation, diversion, or consumptive use, was used. Any stream had more than one gaging station or streamflow from the intervening drainage area between gages was separated and used. This allowed streamflow characteristics of additional small areas to be utilized.

Streamflow data at 307 stations in the Mobile District and 49 stations in adjacent areas were used. The records for these 356 stations provide adequate geographic coverage of average flow conditions in the area.

Base Period

The 30-year period 1951-80 was selected for the average streamflow base period. Average flow was computed from, or adjusted to represent, this common period of years for all streams to make direct comparison between streams possible.

Gaging stations having continuous record for the base period (1951-80) were used as the index stations for correlation with other station records to estimate average flow for the base period for all stations. Graphic correlations were used to estimate the average flow values for stations where records were not available for the base period.

Lines of Equal Average Flow

The drainage area for each station was delineated on a base map. Average flow, in cubic feet per second per square mile, was indicated on the map at each basin or subbasin centroid.

Lines of equal average flow were drawn on the average flow map (fig. 1) using the value of average flow in cubic feet per second per square mile at the centroid of each basin. Basin delineations, station location and basin centroids are not shown to avoid confusion.

HEADWATERS LIMIT MAP

Computation Method

Lines of equal drainage area required to produce an average flow of 5 ft<sup>3</sup>/s were delineated (fig. 2) using the map of equal average flow. Minimum drainage required to produce 5 ft<sup>3</sup>/s ranged from 1.6 to 6.0 mi<sup>2</sup>.

Use of Map

A method of estimating the drainage area required to produce an average streamflow of 5 ft<sup>3</sup>/s at a selected point on a stream can be used as follows:

- Step 1. Plot the selected point on the stream on the headwater limit map (fig. 2).
- Step 2. Delineate the drainage area above the selected point on the stream on the headwater limit map.
- Step 3. Determine the drainage area above the selected point on the stream from topographic maps. Drainage areas larger than 6 mi<sup>2</sup> will be greater than the headwater limits, and computation of headwater limit will not be required because the average flow will be greater than 5 ft<sup>3</sup>/s.

EXPLANATION:

1.0 Line of equal streamflow in cubic feet per second per square mile for 1950-80.

- Step 4. Determine and plot the centroid of the drainage area delineated in step 2 on the headwater limit map. The location of the centroid will not necessarily be on the stream.
- Step 5. From the plotted drainage area centroid on the headwater limit map (step 4), read the value of drainage area required to produce 5 ft<sup>3</sup>/s.

If the drainage area computed in step 3 is less than the value of drainage area selected from the headwater limit map in step 5, the average streamflow of the stream will be less than 5 ft<sup>3</sup>/s. Conversely, if the drainage area of the selected site is larger, the flow will be greater than 5 ft<sup>3</sup>/s.

SELECTED REFERENCES

- Hartley, C. H., and Moss, R. E., 1972, Low-flow characteristics estimated by correlation of base-flow measurements: U.S. Geological Survey Water-Supply Paper 1542-B, 55 p.
- Hartley, J. R., Shell, J. B., Carter, R. F., and Summitt, R. P., 1961, A method of estimating average streamflow and headwater limits in U.S. Army Corps of Engineers Mobile District, Alabama and adjacent states: U.S. Geological Survey, Water Resources Investigations Report 81-59, 2 sheets.
- Riggs, R. C., 1968, Some statistical tools in hydrology: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 4, Chapter A1, p. 39.