# CHAPTER DR-04
# DISCHARGE

**CHAPTER DR-04**
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## CHAPTER DR-04
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### DR-04.100 FUNDAMENTALS
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#### DR-04.110 General

The first procedure in the design of a drainage structure is estimating the values for the discharges for a range of Return Intervals, from which the design (or overtopping) discharge and the check discharge are selected. These values are determined for a designated frequency of recurrence from available data and methods. The highest degree of accuracy possible is necessary to provide economical facilities for disposing of storm water without excessive damage to the highway, the installation, the adjacent property or the environment.

Numerous empirical formulas are available for determining the discharge from a given number of acres, but each has a unknown coefficient that may vary as much as one hundred percent. On some surfaces the volume of the runoff may be as much as ninety percent of the volume of the rainfall, where the only loss is through evaporation and transpiration. In other areas, the runoff may only be ten percent of the volume of rainfall. The determination of the quantity of surface runoff from a given amount of precipitation is a complex process.

The Rational Method has been adopted by the Department for discharge from all areas up to 200 acres. This formula, Q=CIA, merely states that a runoff coefficient times the intensity of the precipitation times the number of acres in an area will be the approximate discharge in cubic feet per second. The accuracy of this formula depends entirely upon the user's ability to select the correct percentage to be used as runoff.

The Regional Method is a new method developed by the USGS. This method divides the state into seven regions. Regression equations have been developed for each region based on gage station data, rainfall, flooding, and parameters that are applicable to each particular watershed. These equations shall be used to predict the volume of discharge if the watershed area is between 200 acres and 1000 square miles.

For the areas greater than 1000 square miles, the Floods-in-Kentucky Method outlined in the USGS publication, "Technique for Estimating Magnitude and Frequency of Floods in Kentucky" shall be used to predict the volume of discharge.

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Maximum discharge estimates can be checked by using gauging station records. "Stream Flow in Kentucky" published by the Department of Economic Development, Frankfort, Kentucky, gives the location and maximum discharge for various gaging stations throughout the state.

The HEC-1, TR55, and Slope-Area methods can be used as comparison values to the discharge estimates presented above. The designer must provide justification for the selection of these values over the methods presented above.

The FHWA Method, Talbot's formula, and Dickens' formula have been discarded for more accurate methods of determining discharge. These procedures have been included so the drainage folders from existing projects, which utilized these methods, can be more readily understood when such projects are being investigated or redesigned. Details of these methods, with the necessary nomographs, equations, and charts, are available to the designer on a need-to-know basis. Contact the Central Office Drainage Section, Division of Design in Frankfort for more information.

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**NOTES AND COMMENTS**

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## DR-04.200 HYDROLOGY
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### DR-04.210 General

Hydrology is the science dealing with the occurrence and movement of water upon and beneath the land areas of the earth. It overlaps and includes portions of other sciences such as meteorology and geology. The following discussion of hydrology is included to point out the improbability of developing an absolute formula for discharge determination.

The sequence of events, called the "Hydrologic Cycle," describes the various movements of water as it relates to the earth. These processes of water movement are:

1. Precipitation
2. Infiltration
3. Evaporation, Transpiration, Interception
4. Surface runoff
5. Subsurface runoff and storage

The drainage engineer is concerned primarily with runoff and relationships of rainfall to runoff.

### DR-04.220 Precipitation Losses

1. Total losses constitute the difference between total rainfall and the surface runoff available from that rainfall.

   Precipitation MINUS evaporation, interception, infiltration, transpiration, and ground water storage EQUALS surface runoff.

2. Only total loss is considered in drainage investigations.

   a. Generally, no attempt is made to evaluate separate losses.
   b. Surface runoff is sometimes called "excess rainfall."

### DR-04.230 Surface Runoff

1. Runoff comprises the movement of water overland or through channels.

2. Runoff is characterized by variations in precipitation.

   a. Seasonal fluctuations;
   b. Long-term variations as cycles of droughts and floods over periods of many years.

3. Runoff rate is influenced by:

   a. Topographic features;
   b. Geological formations;
   c. Soil;
   d. Vegetal cover; and
   e. Land usage.

4. Runoff from small drainage areas (less than 10 square miles) is affected by factors of physiography usually differing from those for river basins.

   a. Factors affecting runoff from small areas are:

      (1) Topography;
      (2) Soil type and depth;
      (3) Shape and Slope of area;
      (4) Land usage;
      (5) Vegetal cover;
      (6) Condition and season of crops;
      (7) Method of tillage;
      (8) Antecedent soil moisture;
      (9) Stream patterns; and
      (10) Pondage.

   b. Factors Influencing Runoff In River Basins

      (1) Topography, geology and soil provinces;
      (2) Size and shape of basin;
      (3) Size and shape of tributary watershed;
      (4) General vegetal cover;
      (5) Infiltration losses;
      (6) Depression storage; and
      (7) Channel storage.

5. Foregoing factors may have greater influence on runoff rates and volumes than indicated by rainfall intensity alone.

   a. Frequency of peak runoff is not always the same as recurrence of like rainfall intensities in an area. Peak rate of runoff produced by rainfall of given amounts, distribution, and intensities cannot be expected to occur as often as such rainfall recurrence.

b. When physiographic factors remain the same in any one drainage area, then:

   (1) High intensity, short duration rainfall results in high rate of runoff.
   (2) Low intensity, long duration rainfall results in low rate of runoff, but the total volume of runoff may be higher than (1).

c. Runoff rates (quantity of flow per unit of time) and runoff peaks should be based on actual runoff measurement records (whenever possible) rather than rainfall relationships.

**DR-04.240 The Hydrograph**

The hydrograph is a graphical representation of the discharge from the watershed vs. time. The Division of Design prefers the use of the Rational Method to determine the hydrograph from the peak discharge. This method establishes a runoff coefficient (C), to be used in the determination of the peak runoff, and has a time of concentration variable (Tc), determined by the Kinematic Wave Equation. The procedure for finding these values is described in Section 04.420, along with the rainfall intensity (I).

The lag time of the hydrograph, T1, is the time from when half of the duration of the storm has passed to the time of peak discharge from the watershed, and is equal to:

$$T1 = 0.7\ Tc \quad \text{for large C values } (C = 0.8)$$
$$T1 = 1.0\ Tc \quad \text{for small C values } (C = 0.2)$$

Interpolate lag time for C between 0.2 & 0.8

The time to the peak discharge of the hydrograph, Tp, is equal to:

$$Tp = (Tc/2) + T1$$

The time of the base is equal to 2.5Tp for large C values, and equal to 6.0Tp for small C values. Finally, the routing interval (Tr), is less than or equal to the Time of Concentration.

The hydrograph may be validated by assuring that the volume underneath the hydrograph is equal to or less than the volume of the rainfall over the entire watershed (Intensity X time of duration X area of watershed) in units of acre feet (ac-ft).

Another useful tool is the unit hydrograph, which is defined as "the hydrograph of direct flow resulting from one inch of effective rainfall generated uniformly over the basin area at a uniform rate during a specified period of time."

To figure a unit hydrograph, divide the ordinates of the direct flow hydrograph by the direct flow volume, and plot the results versus the time as a unit graph. The unit hydrograph can be determined from the discharge hydrograph of one particular storm, and used to project the direct flow hydrographs for other intensities of storms. There are also methods to create synthetic unit hydrographs, or convert unit hydrographs to other duration unit hydrographs. They are useful in routing reservoirs and drainage basins, and are not as limited in application as the direct flow hydrograph.

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**NOTES AND COMMENTS**

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**DR-04.300 RETURN PERIOD**
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### DR-04.310 General

A highway drainage structure is designed on the assumption that they will carry discharges at least equal to that resulting from storms that statistics show may be expected to occur once during a designated number of years. This frequency of recurrence of storms of a specific magnitude is called the return period.

### DR-04.320 Applications

The return period for a given storm is an important consideration in the design of highway drainage structures. Structures are designed on the assumption that they may temporarily impound water in the area, provided it is done safely with no serious damage to adjacent property or the highway. Minor development may allow the use of a 25-Year storm. Residences may require the use of a 100-Year storm. Major development may require the use of the 500-Year storm. Value and public safety are the concern. Another possible control is the inundation of the highway. The return period selected for design may vary with the future Average Daily Traffic (ADT). Given below in Table 4-1 are return periods in years to be used shown for various structure types:

TABLE 4-1 Return Interval

| STRUCTURE TYPE | TRAFFIC VOLUME | RETURN INTERAL | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
| Bridge | ADT<400 | | | √ | | | | |
| | 400<ADT<1500 | | | | √ | | | |
| | 1500<ADT | | | | | √ | | |
| Culvert or (Lateral storm sewer in sag) | ADT<400 | | | √ | | | | |
| | 400<ADT<1500 | | | | √ | | | |
| | 1500<ADT | | | | √ | | | |
| | BRIDGE LENGTH | | | | | | | |
| Scour Analysis | <100′ | | | | | | √ | |
| | >100′ | | | | | | | √ |
| Storm Sewer | | | | √ | | | | |
| Ditches | | | | √ | | | | |
| Dt. Linings | | | | √ | | | | |
| Inlets | | | | √ | | | | |
| TYPE OF ANALYSIS | | | | | | | | |
| Risk | | √ | √ | √ | √ | √ | √ | √ |
| No Rise Certification | | | | | | | *√ | |
| Letter of Map Revision | | | | √ | | √ | √ | √ |
| DEVELOPMENT IN FLOODPLAIN | | | | | | | | |
| Barns, Fields, etc. | | | | | √ | | | |
| Residences, Businesses | | | | | | | √ | |
| Nuclear Power Plant | | | | | | | | √ |

* For evaluation of the Floodway as well as the Floodplain

**NOTES AND COMMENTS**

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**DR-04.400 DISCHARGE METHODS**
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### DR-04.410 General

There are three primary methods which shall be used to determine discharges:

1. Rational Method (Q=CIA)
(uses Kinematic Wave Time of Concentration);

2. Regional Method
(see USGS Water-Resources Investigations Report 87-4209, "Regionalization of Peak Discharges for Streams in Kentucky," 1988); and

3. Floods-in-Kentucky Method based on USGS
(see USGS Water-Resources Investigations Report 76-62, "Technique for Estimating Magnitude and Frequency of Floods in Kentucky," 1976).

Use the following guidelines to determine the correct discharge method in designing all drainage structures:

| AREA SIZE | METHOD TO USE |
|---|---|
| 0 to 200 Acres | Rational |
| 201 Acres to 1000 sq. mi. | Regional |
| Over 1000 sq. mi. | Floods-in-Kentucky |
| Downstream of Reservoirs (any size) | Contact Corps of Engineers or Soil Conservation Service, as applicable |
| Community Ordinance | See Flood Insurance Study |
| Over 15% Development | Use Urbanization Technique; (Applicable to Regional and Floods-in-Kentucky methods only) |

### DR-04.420 Rational Method

The Rational Method has been used in Kentucky for several years. It shall be used for determining discharges when the drainage area is 200 acres or less.

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Culvert design discharge and check discharge shall be calculated by the Rational Method for all drainage areas up to 200 acres. The Rational Method is:

$$Q = CIA$$

Where:

- Q = Discharge (cubic feet per second)
- C = Runoff Coefficient
- I = Intensity of Rainfall (inches per hour)
- A = Drainage Area (acres)

RUNOFF COEFFICIENT, C

Only a certain percentage of the total storm water falling on an area will reach the drainage structure. The percent of runoff will be governed by such factors as: rate of evaporation, rate of transpiration, quantity of water soaking into the ground, and quantity of water ponding in the area. The relationship between the rainfall intensity and the peak discharge is called the C-factor. A close estimate of the C-factor for any area may be made by subdividing the area according to the type of cover, as listed in Table 4-2, and applying the recommended C-value to each section. The summation of the products of the C-values and the portion of the total area for each section gives a weighted C-factor for the entire area.

**Table 4-2 Runoff Coefficients (C-factor)**

| | |
|---|---|
| All Water-tight roof surfaces | .75-.95 |
| Bituminous or Concrete pavement | .80-.95 |
| Traffic Bound pavements | .70-.90 |
| Gravel pavements | .35-.70 |
| Impervious soils (heavy) | .40-.65 |
| Impervious soils, with turf | .30-.55 |
| Slightly pervious soils | .15-.40 |
| Slightly pervious soils, with turf | .10-.30 |
| Moderately pervious soils | .05-.20 |
| Moderately pervious soils, with turf | .00-.10 |

**EXAMPLE:** Weighted C-factor

| | |
|---|---|
| Water-tight roof surfaces. . . . . . . . | 10% x 0.85=.085 |
| Traffic-bound pavement . . . . . . . . . | 15% x 0.80=.120 |
| Concrete pavement. . . . . . . . . . . . | 20% x 0.90=.180 |
| Slightly pervious soil, with turf. . . . | 55% x 0.20=.110 |
| Weighted C-factor: | 100% = .495 |

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## INTENSITY, I

The region or area in which a structure is to be located also affects the intensity of rainfall selected for the design calculations in that the magnitude of storms. Their return periods vary, depending upon the characteristics of the area. Statistical methods are often used in the analysis of past records of storm Intensity-storm Duration relationships for the various design return periods to produce Intensity-Duration curves. The state is divided into nine zones of influence. Each zone has its own Intensity-Duration curve. The nine zones of influence are shown on the Theissen Diagram for Kentucky, see Exhibit 04.902.

Kentucky has adopted the Kinematic Wave to determine the time (in minutes) taken for excess runoff to travel from the hydraulically most distant point of the watershed to the point of interest in the watershed. This time is called the "time of concentration" (Tc), or the duration of the storm. The time of concentration is made up of two components of travel time. Travel time is the time it takes water to travel from one location to another in a watershed:

$$Tc = To + Tt$$

Where:

To = Overland Flow travel time in minutes
Tt = Channel Flow travel time in minutes

## OVERLAND FLOW TRAVEL TIME COMPONENT

Overland flow, or sheet flow, is flow over plane surfaces. It usually occurs in the headwater of streams. With this flow, the friction value is an effective roughness coefficient that includes: the raindrop impact; drag over the plane surface; obstacles such as litter; crop ridges and rocks; erosion; and transportation of sediment. These friction values are for very shallow depths of approximately 0.10 ft.

The formula for the overland flow component is:

$$To = \frac{(0.42) \times (L^{0.8}) \times (N^{0.8})}{P_{2,24}^{0.5} \times (S^{0.4})}$$

Where:

| | |
|---|---|
| To= | Overland Flow Travel Time (minutes) |
| L = | Length of Flow (feet) |
| N = | Overland Flow Coefficient (shallow depths) 0.1 for paved, 0.4 for unpaved |
| $P_{2,24}$= | Precipitation (RI = 2 yrs, Duration = 24 hrs) (inches)(See Exhibit 04.939) |
| S= | Average Overland Slope (ft/ft) |

The Overland flow is to be used for flows less than 300 feet in length. The designer shall use an average overland flow length which is obtained in the following manner:

1. Outline the entire drainage area on the drainage area map.
2. Determine the maximum flow path from the point of interest to the drainage divide. This is done by measuring along the longest combination of channels to the drainage area boundary.
3. If the drainage area is large enough, lay out a second boundary inside the drainage area which does not cross itself or cross the longest flow path more than once. This boundary should be 300 feet from and parallel to the drainage area boundary. Where this boundary cannot be located as described above, merely create that portion of the boundary by connecting the beginning points of the channels. This area between the drainage area boundary and this second boundary is known as the Overland Flow Zone.
4. Where the beginnings of channels on the map fall within the overland flow zone, measure the lengths from the beginnings of the channels to the drainage area boundary.
5. Where the beginnings of channels on the map fall below the overland flow zone, the overland flow lengths for these channels is 300 feet.
6. Add up the distances obtained from (4) and (5) above, then divide by the number of channel beginning points involved. This is the value for the average length to use in the overland flow equation.
7. The average overland slope shall be obtained in a similar manner using the average difference in elevations of the points obtained in (4) and (5) above divided by the average overland flow length obtained in (6) above.

## CHANNEL TRAVEL TIME COMPONENT

The length of the channel is the longest flow path in the drainage basin measured from the point of interest to the drainage area boundary minus the average overland flow length. The Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank full elevations. A channel section which is typical of the entire channel length must be used.

Manning's Equation is:

$$V = (1.49/n) * r^{0.67} * s^{0.5}$$

Where:

- V = average velocity (ft/s)
- r = hydraulic radius (ft) = a/wp
- a = cross sectional flow area (sq ft)
- wp = wetted perimeter (ft)
- s = channel slope (ft/ft)
- n = Manning's roughness coefficient

From the above equation, the channel travel time component is:

$$Tt = L / (60 * V)$$

Where:

- Tt = channel travel time, in minutes
- L = channel length, in feet
- V = average velocity, in ft./s.
- 60 = conversion of seconds to minutes

Swale ditches and indeterminate flow paths may require the assumption of r = 0.2 feet for paved and r = 0.4 feet for unpaved areas.

## TIME OF CONCENTRATION

After determining the overland flow and channel flow travel time components, the time of concentration is merely the sum of the components:

$$Tc = To + Tt$$

Where:

- Tc = time of concentration, in minutes
- To = overland flow travel time, in minutes
- Tt = channel flow travel time, in minutes

RAINFALL INTENSITY

See Theissen Diagram (Exhibit 04.902) for the boundaries of the various Zones of Influence to be used with the following Rainfall Intensity Equation:

$$I_{RI}=A_0 * T_C^{A_1+A_2*LOG_e(T_C)}$$

Parameters for the different Zones of Influence are listed below:

CAIRO

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 6.41 | -0.02 | -0.082 |
| 5 | 8.25 | -0.035 | -0.076 |
| 10 | 9.45 | -0.040 | -0.074 |
| 25 | 10.95 | -0.043 | -0.072 |
| 50 | 12.07 | -0.046 | -0.070 |
| 100 | 13.17 | -0.047 | -0.070 |

CINCINNATI

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 7.26 | -0.127 | -0.074 |
| 5 | 7.98 | -0.040 | -0.084 |
| 10 | 8.53 | -0.000 | -0.088 |
| 25 | 9.26 | 0.038 | -0.092 |
| 50 | 9.81 | 0.060 | -0.095 |
| 100 | 10.37 | 0.079 | -0.097 |

EVANSVILLE

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 6.68 | -0.072 | -0.077 |
| 5 | 8.21 | -0.066 | -0.074 |
| 10 | 9.23 | -0.064 | -0.074 |
| 25 | 10.53 | -0.061 | -0.072 |
| 50 | 11.49 | -0.060 | -0.072 |
| 100 | 12.44 | -0.059 | -0.071 |

KNOXVILLE

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 5.50 | 0.036 | -0.095 |
| 5 | 5.68 | 0.152 | -0.106 |
| 10 | 5.90 | 0.204 | -0.111 |
| 25 | 6.24 | 0.254 | -0.116 |
| 50 | 6.52 | 0.283 | -0.119 |
| 100 | 6.81 | 0.307 | -0.122 |

LEXINGTON

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 5.70 | -0.004 | -0.088 |
| 5 | 6.44 | 0.056 | -0.091 |
| 10 | 6.96 | 0.086 | -0.093 |
| 25 | 7.64 | 0.114 | -0.095 |
| 50 | 8.14 | 0.131 | -0.096 |
| 100 | 8.66 | 0.145 | -0.097 |

LOUISVILLE

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 7.29 | -0.135 | -0.071 |
| 5 | 8.53 | -0.084 | -0.076 |
| 10 | 9.37 | -0.059 | -0.079 |
| 25 | 10.47 | -0.037 | -0.081 |
| 50 | 11.28 | -0.025 | -0.082 |
| 100 | 12.11 | -0.014 | -0.084 |

NASHVILLE

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 7.31 | -0.104 | -0.074 |
| 5 | 9.94 | -0.159 | -0.063 |
| 10 | 11.68 | -0.182 | -0.059 |
| 25 | 13.89 | -0.205 | -0.054 |
| 50 | 15.54 | -0.218 | -0.051 |
| 100 | 17.17 | -0.229 | -0.049 |

PARKERSBURG, W. VA.

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 6.32 | -0.42 | -0.091 |
| 5 | 8.08 | -0.040 | -0.089 |
| 10 | 9.25 | -0.040 | -0.088 |
| 25 | 10.72 | -0.039 | -0.087 |
| 50 | 11.82 | -0.038 | -0.087 |
| 100 | 12.91 | -0.038 | -0.086 |

WYTHEVILLE, VA.

| RETURN INTERVAL | $A_O$ | $A_1$ | $A_2$ |
|---|---|---|---|
| 2 | 6.09 | -0.071 | -0.080 |
| 5 | 6.51 | 0.038 | -0.092 |
| 10 | 6.90 | 0.085 | -0.096 |
| 25 | 7.45 | 0.128 | -0.101 |
| 50 | 7.88 | 0.154 | -0.104 |
| 100 | 8.32 | 0.174 | -0.106 |

AREA, A

The area in acres shall be obtained from the various sources listed in Chapter 1.

**DR-04.430 Regional Method**

In 1988 the USGS published a Water Resources Investigations Report using a regression analysis procedure titled "Regionalization of Peak Discharges for Streams in Kentucky." The state is divided into seven hydrologic regions as shown in Exhibit 4.913. Regression equations have been developed to determine the 2, 5, 10, 25, 50, and 100 Year Flood Discharges for each region. Table 4-3 is a breakdown by Hydrologic Region, the regression equation parameters required, and the applicable Highway districts.

**Table 4-3**

| Region No. | Region Name | Regression Parameters | Highway Districts |
|---|---|---|---|
| 1 | North | Ac, Sc | 5,6,7,9 |
| 2 | Upper East | Ac, Bs, Ss | 4,5,6,7,9,10,11,12 |
| 3 | Lower East | Ac, Ss | 7,10,11,12 |
| 4 | Southeast | Ac | 8,11 |
| 5 | East Central | Ac | 3,4,5,7,8 |
| 6 | West Central | Ac, Sc | 2,3,4 |
| 7 | West | Ac, Bs, Ss | 1,2,3 |

DEFINITIONS OF REGRESSION PARAMETERS

**At** = Total drainage area, in square miles

**Ac** = Contributing drainage area, in square miles, excludes any depressions characterized by internal drainage

The Contributing Drainage Area for gaged sites with large total areas are shown in Exhibits 04.914 through 04.930.

For gaged sites with small drainage areas or ungaged areas of any size in Karst Regions or areas outside Karst boundaries where field or topographic map evidence indicates prevalent sink-holes or underground streams, the contributing drainage area shall be determined by the equation:

$$Ac = 0.85\ At$$

**Lc** = Main channel length, in miles, measured along the main stream channel from the gage (or site) to the drainage basin divide extending the main channel upstream by following the longest tributary.

**Ba** = Basin length, in miles, measured on the map as the straight-line distance from the gage (or site) to the point on the drainage divide used to determine the main channel length.

**Sc** = Main channel slope, in ft./mi., determined by the difference in elevation between points located 10% and 85% along the main channel length (**Lc**) divided by 0.75***Lc**.

**Ss** = Main channel sinuosity = **Lc/Ba**

**Bs** = Basin shape index = $\mathbf{Ba}^2/\mathbf{At}$

## REGRESSION EQUATIONS BY REGION

Region 1: $Qr = K\ (Ac^{M})\ (Sc^{N})$

| | K | M | N |
|---|---|---|---|
| Q-2 | 105.3868 | .824 | .224 |
| Q-5 | 81.6864 | .882 | .389 |
| Q-10 | 72.8850 | .910 | .472 |
| Q-25 | 65.2085 | .940 | .560 |
| Q-50 | 60.9915 | .959 | .617 |
| Q-100 | 57.0026 | .978 | .669 |

Region 2: $Qr = K\ (Ac^{M})/[(Bs^{P})\ (Ss^{R})]$

| | K | M | P | R |
|---|---|---|---|---|
| Q-2 | 188.825 | .764 | .174 | .304 |
| Q-5 | 321.632 | .773 | .256 | .522 |
| Q-10 | 427.940 | .776 | .297 | .628 |
| Q-25 | 578.646 | .777 | .330 | .739 |
| Q-50 | 707.520 | .777 | .356 | .803 |
| Q-100 | 845.880 | .777 | .373 | .862 |

Region 3: $Qr = K\ (Ac^{M})/(Ss^{R})$

| | K | M | R |
|---|---|---|---|
| Q-2 | 210.532 | .743 | .111 |
| Q-5 | 372.665 | .730 | .205 |
| Q-10 | 506.385 | .723 | .264 |
| Q-25 | 704.175 | .717 | .338 |
| Q-50 | 871.923 | .714 | .392 |
| Q-100 | 1060.900 | .711 | .447 |

Region 4: $Qr = K\ (Ac^{M})$

| | K | M |
|---|---|---|
| Q-2 | 114.290 | .825 |
| Q-5 | 187.096 | .804 |
| Q-10 | 242.372 | .794 |
| Q-25 | 316.517 | .785 |
| Q-50 | 375.705 | .780 |
| Q-100 | 437.220 | .775 |

Region 5: Qr = K ($Ac^M$)

| | K | M |
|---|---|---|
| Q-2 | 287.260 | .707 |
| Q-5 | 483.804 | .698 |
| Q-10 | 637.098 | .695 |
| Q-25 | 860.360 | .692 |
| Q-50 | 1045.280 | .690 |
| Q-100 | 1241.900 | .689 |

Region 6: Qr = K ($Ac^M$) ($Sc^N$)

| | K | M | N |
|---|---|---|---|
| Q-2 | 55.0605 | .821 | .368 |
| Q-5 | 66.0000 | .839 | .422 |
| Q-10 | 71.1070 | .850 | .454 |
| Q-25 | 75.5067 | .865 | .494 |
| Q-50 | 78.8424 | .873 | .520 |
| Q-100 | 81.3200 | .882 | .545 |

Region 7: Qr = K ($Ac^M$)/[($Bs^P$) ($Ss^R$)]

| | K | M | P | R |
|---|---|---|---|---|
| Q-2 | 642.469 | .659 | .569 | .964 |
| Q-5 | 945.687 | .647 | .523 | .809 |
| Q-10 | 1154.310 | .642 | .501 | .725 |
| Q-25 | 1424.420 | .640 | .482 | .635 |
| Q-50 | 1635.570 | .639 | .472 | .579 |
| Q-100 | 1838.250 | .639 | .466 | .528 |

ESTIMATION OF PEAK DISCHARGES

The procedure to estimate peak discharges at a specific site is dependent upon whether the site is gaged or ungaged and whether the drainage area crosses hydrologic region boundaries.

For Gaged sites:

1. Use the weighted discharges from Exhibits 04.914 through 04.930, for the gaged site. See Exhibit 04.913 for the gage station number.

2. Discharges at gaged sites include the effect of development in the drainage basin. Therefore, discharges at gaged sites should not be adjusted for urbanization.

For Ungaged sites:

1. When the drainage area for a ungaged site is entirely within a single hydrologic region, the regression equations for that region are used.

2. When the drainage area falls in two or more hydrologic regions, determine the percentage of the total area applicable to each region. These percentages will be used as weighted factors after determining the discharges using the regression equations for each applicable hydrologic region as though the entire basin fell in that particular region. The sum of the weighted discharges is the regression estimate for the site.

3. When an ungaged site is located on a stream that does have a gage and the contributing drainage area of the ungaged site is more than 50% and less than 150% of the drainage area of the closest gaged site, use the following weighted regression estimate for the ungaged site:

$$Cu = Cg - 2\left(\frac{|Ag - As|}{Ag}\right)(Cg - 1)$$

Where:

Cu = correction factor for ungaged site
\# Cg = correction factor for gaged site
Ag = contributing drainage area for gage
As = contributing drainage area for site
/Ag - As/ = absolute value of this difference

Weighted Regression Estimate = Cu * Qr

\# [Note: Cg = Qw/Qr (Gage weighted Q / Gage regression Q)]

4. When a ungaged site falls outside the 50% to 150% range mentioned in Step 3, then use the unweighted regression values.

5. Determine if the drainage basin is 15% or more developed. If so, adjust the discharge values obtained in Step 3, or Step 4 above, by the urbanization technique in Section 04.450. See also Exhibit 09.941.

## DR-04.440 Floods-in-Kentucky Method

The "Floods in Kentucky" method was developed by the USGS and presented in a report entitled "Technique for Estimating Magnitude and Frequency of Floods in Kentucky." This method preceded the Regional Method and is similar in nature to the Regional Method in that regression equations are used, but different in that only one set of equations are provided for the entire state. These equations are provided in the following sections.

Flood magnitude and frequency are primary factors in the design of structures in the flood plains of streams. The Floods-in-Kentucky Method can be used to estimate magnitude and frequency of floods for ungaged sites on most streams where flood discharges are not significantly affected by regulation or urbanization.

All flood data for stream gaging stations with 10 or more years of records, not significantly affected by regulations or urbanization, were used in the regression analysis to relate flood frequency at the gaged sites to area parameters. The flood relationships are presented mathematically and apply to all natural flow streams within designated areas in Kentucky.

ESTIMATING TECHNIQUE

Flood magnitudes having recurrence intervals of 2, 5, 10, 25, 50, and 100 years may be computed for ungaged natural flow sites by using the appropriate values for the contributing drainage area and regional factor in equations shown below:

Magnitude of Flood Discharge (cfs)

$$Q\text{-}2 = 187 \times (A^{0.703}) \times (R^{0.965})$$
$$Q\text{-}5 = 318 \times (A^{0.685}) \times (R^{0.991})$$
$$Q\text{-}10 = 412 \times (A^{0.677}) \times (R^{1.006})$$
$$Q\text{-}25 = 540 \times (A^{0.668}) \times (R^{1.025})$$
$$Q\text{-}50 = 638 \times (A^{0.663}) \times (R^{1.040})$$
$$Q\text{-}100 = 740 \times (A^{0.659}) \times (R^{1.051})$$

A = Drainage area, in square miles; the area contributing surface flow to the site. Within areas of Karst geology, some basins may contain closed areas which do not contribute to surface runoff because of sinkholes. The total drainage area of such basins should be adjusted only to reflect contributing drainage by using Exhibit 04.934. Areas outside the limits of the graph should be reduced by 15%.

R = Regional factor, a dimensionless element; geographical factor relating flood peaks to geology and topography. The regions and regional factors are shown on Exhibit 04.932. Exhibit 04.933 gives the results of "R," raised to the appropriate power, for the frequency desired.

If the site is near a gaging station on the same stream, a weighted value of the ratio of the computed flood magnitude to the regression value at the gage site should be used to adjust the regional equations to the ungaged site. This method is not recommended for drainage areas more than twice or less than half the drainage area at the gage site.

The applicable weight to transfer the ratio of computed flood magnitude to the regressive value of the gage site is:

Ks = (Kg-1) [(2*Ag-As)/(Ag)] + 1, for site downstream of gage

Ks = (Kg-1) [(2*As-Ag)/(Ag)] + 1, for site upstream of gage

Where:
Ks = ratio of assigned value to regression value at site
Kg = ratio of assigned value to regression value at gage
As = Drainage area at site
Ag = Drainage area at gage

If the site is located between gages such that the flood magnitude could be adjusted from either gage, make the adjustment from the gage with the longer period record.

Where a stream crosses a regional boundary, a weighted average of the regional factor based on the percent of the drainage area in each region should be used. It is recommended that this method not be used for drainage areas where more than twice the drainage area is in the upstream region.

LIMITATIONS OF THE FLOODS-IN-KENTUCKY METHOD

The previously described procedure is not applicable to sites on main-stem streams or streams downstream from reservoirs.

## CHAPTER DR-04
## DISCHARGE

Exhibit 04.935 lists major streams in Kentucky for which peak discharges are probably affected by more than 10 percent by reservoirs upstream and the agency to contact for flood magnitude and frequency data.

EXAMPLE 1

Assume the discharge is desired for a flood with a recurrence interval of 50-years for a site in the upper Kentucky River Basin (Area 4) having a drainage area of 200 square miles.

The equation to use is:

$Q_{50}$ = 638 $A^{0.663}$ $R^{1.040}$

A = 200 sq. mi.; $(200)^{0.663}$ = 33.54

From Exhibit 04.932, R = 1.271 for Area 4

From Exhibit 04.933, $1.271^{1.040}$ = 1.283

The final equation is:

$Q_{50}$ = 638 33.54 1.283 = 27,500 cfs

EXAMPLE 2

Assume the discharge is desired for a flood with a recurrence interval of 50 years for a site in the Barren River basin having a drainage area of 50 square miles. The site is in the Karst region, therefore, the drainage area must be corrected for non-contributing drainage area by using values from Exhibit 4-934. For a total drainage area of 50 square miles, the graph gives a net drainage area of 42 square miles that is the "A" used in the equation for the 50-year flood.

The equation to use is:

$Q_{50}$ = 638 * $A^{0.663}$ * $R^{1.040}$

A = 42 sq. mi.; $(42)^{0.633}$ = 11.92

From Exhibit 04.932, R = 1.351 for Area 11

From Exhibit 04.933, $1.351^{1.040}$ = 1.367

The final equation is:

$$Q_{50} = 638 * 11.92 * 1.367 = 10,400 \text{ cfs}$$

EXAMPLE 3

The discharge for a flood with a recurrence interval of 50 years is desired for a site on Crab Orchard Creek at State Highway 85. The site has a drainage area of 87 square miles. Crab Orchard Creek crosses from Area 11 to Area 13 at the mouth of Lynn Fork. The drainage area of Crab Orchard Creek, including Lynn Fork, is 25 square miles or 29 percent of the total drainage area at the site. Determine discharge for 50-year flood for Areas 11 and 13 for 87 square miles. The final discharge is a weighted average of discharges based on percent of drainage area in each area.

The equation to use is:

$$Q_{50} = 638 * A^{0.663} * R^{1.040}$$

$$A = 87 \text{ sq. mi.}; (87)^{0.633} = 19.32$$

From Exhibit 04.932, R = 1.351 for Area 11 and R = 0.449 for Area 13

From Exhibit 04.933, $1.351^{1.040} = 1.367_{\text{Area 11}}$ and $0.449^{1.040} = 0.435_{\text{Area 13}}$.

The final equations (for areas in each region) are:

$$Q_{50,\text{ Area 11}} = 638 * 19.32 * 1.367 * 0.29 = 4,900 \text{ cfs}$$

$$Q_{50,\text{Area 13}} = 638 * 19.32 * 0.435 * 0.71 = 3,800 \text{ cfs}$$

$$Q_{50,\text{Final}} = 8,700 \text{ cfs}$$

**DR-04.450 Urbanization Technique**

Determine the Basin Development Factor (BDF) for the watershed basin by dividing the drainage basin, on a quadrangle map, into thirds (upper, middle, and lower). This division should be based on area and time of travel. The lower third includes the outlet of the basin. Within each third, 4 ASPECTS of the drainage system are evaluated and assigned a Code.

# CHAPTER DR-04
# DISCHARGE

<u>ASPECTS</u>

a. Channel Improvements -- if at least 50% of the main drainage channels and principal tributaries have been straightened, enlarged, deepened, or cleared, then Code = 1; otherwise, Code = 0.

b. Channel Linings -- if at least 50% of the length of the main drainage channels and principal tributaries have been lined with an impervious material, such as concrete, then Code = 1; otherwise, Code = 0.

c. Storm Drains, Storm Sewer -- if more than 50% of the secondary tributaries consist of storm drains, then Code = 1; otherwise Code = 0. Note also that if 50% or more of the main drainage channels and principal tributaries are enclosed, then Code = 1 in both "a" and "b" above.

d. Curb and Gutter streets -- if more than 50% of a third is covered by residential, commercial, and/or industrial development; if more than 50% of the streets and highways are constructed with curbs and gutters, then Code = 1, otherwise, Code = 0.

The BDF is the sum of the 4 <u>ASPECT</u> Codes for each third of the drainage basin, with a maximum BDF of 12 and a minimum of 0. The BDF is then used in the following equation:

$$UQr = \frac{K\,(Ac^{M})(Qr^{N})}{(13 - BDF)^{P}}$$

Where:

UQr = Regression discharge adjusted for urbanization
Ac = Contributing drainage area in square miles
BDF = Basin development factor
Qr = Regression estimate of discharge (weighted or unweighted as applicable)
K,M,N,P = Constants, from Table 5-4, for the equation

**Table 5-4 Constants for the Urbanization Equation**

| | K | M | N | P |
|---|---|---|---|---|
| $Q_2$ | 13.20 | .21 | .73 | .43 |
| $Q_5$ | 10.60 | .17 | .78 | .39 |
| $Q_{10}$ | 9.51 | .16 | .79 | .36 |
| $Q_{25}$ | 8.68 | .15 | .80 | .34 |
| $Q_{50}$ | 8.04 | .15 | .81 | .32 |
| $Q_{100}$ | 7.70 | .15 | .82 | .32 |
| $Q_{500}$ | 7.47 | .16 | .82 | .30 |

See Exhibit 4.941 for an example of this procedure.

**DR-04.460 Other Discharge Methods**

As hydrological research has improved, so has the technique for determining discharge volumes from a watershed. New computer programs have eliminated many of the lengthy and tedious calculations, while even simple formulas have been improved upon. As the methods have changed, the Division of Design has attempted to keep accurate, yet understandable methods. The new methods are listed here as references, supplemental material, or for future considerations.

HEC-1 FLOOD HYDROGRAPH PACKAGE

HEC-1 is a computer software system created by the United States Army Corps of Engineers to determine surface runoff responses to precipitation. Refer to the HEC-1 User's Manual for more information.

TR55 METHOD

TR55 was developed by the Soil Conservation Service (SCS) to automate the procedures contained in the Technical Release (TR), including the SCS runoff curve number, runoff volume, peak discharge and detention storage. The program applies in small urban watersheds and provides for hydrological analysis of a watershed of various land uses, using single event storm rainfall frequency data.

The TR55 program is limited to accuracy only for a 24 hour storm, and is approved for use by the Central Office Division of Design in dam design situations, only.

## DR-04.470 Outdated Discharge Methods

As the Division of Design has incorporated new methods for determining discharge into its procedures, it has discarded older, less accurate methods. The methods that were once used are listed here to provide an understanding of old drainage folders. For detailed information about each procedure, contact the Drainage Section.

### FHWA METHOD

The FHWA method was used to overlap the Rational and Floods-in-Kentucky methods and provides a comparison for the transition areas (200 acres to 10 square miles). Since it is the most recent method to be discarded, it is presented in more detail than the other discarded methods.

The FHWA method incorporates the use of three easily obtainable parameters:

1. A, drainage area, in square miles.
2. R, Iso-erodent Factor
3. DH, Elevation difference between crossing and extreme point in the watershed ("H" used in rational intensity)

The state was divided into four zones for which equations were developed. The three above mentioned parameters were obtained and applied in the equation for a particular zone. The equation gives a value for the 10 year peak discharge that is then used to determine values for the 2, 25, 50 and 100 year peak discharges. A procedure for compensating for surface storage was also used. A procedure to compensate for the urbanization of watersheds was not incorporated. This procedure was intended for use only in rural areas.

### SLOPE-AREA METHOD

As the drainage basin increases in size, the channel becomes more defined; and the larger the area, the more likelihood of debris and drift to be left behind, to mark high water. A well defined channel section and a reasonably close hydraulic gradient were used in determining discharge.

Wherever it was possible to measure a channel section, regardless of the size area, this became a part of the drainage survey. Where drainage areas had 10 square miles or more and the stream was not gaged; the slope area method was used in discharge determinations.

To use this method, first determine the energy gradient from a high water profile taken below, through, and above the reach being surveyed. This high water profile will, of necessity, have to be for a high water of recent enough occurrences to have left distinguishable high water marks; and, therefore, may not be the same elevation as the extreme high water mark from records or local information.

If it is difficult to find a reach 200 feet or more in length at the proposed stream crossing, these measurements shall be moved upstream or downstream to a more suitable location. If there is any appreciable difference in the area, an adjustment in the discharge must be made by multiplying the discharge by the two thirds power of the ratio of the drainage area at the site of the proposed structure to the drainage area at the site of the measurements.

The reach should preferably be contracting downstream and several cross-sections of the channel should be obtained within the reach. Then several discharge computations should be made, and if the results are reasonably close, the average may be taken.

TALBOT'S FORMULA

Areas of waterways that were calculated by Talbot's Formula ($ab = CA^{0.75} * 0.25 * r$) were based on an equivalent rainfall intensity of one inch per hour.

The application of the rainfall to Talbot's Formula was revised, making it possible to consider the predicted rainfall for the drainage area for the time of concentration and the desired return period. The method of estimating the value of "C" was revised to eliminate the variation in rainfall as part of the "C" value, as was the case in Talbot's Formula.

DICKEN'S FORMULA

The solution of Dicken's Formula is based on the equation: $Q = BM^{0.75}$. This formula is an empirical solution by which an approximation of the design discharge was made. This method had limitations similar to Talbot's Formula and a degree of accuracy dependent upon the judgment of the engineer in selecting the runoff coefficient "B." It did, however, arrive at an estimated discharge "Q" rather than an estimated size of opening.

Since this method was to be applied to areas of five (5) square miles and greater, revisions were made to accommodate the more recent rainfall data for Kentucky and to put design on a frequency or return period basis.

Since Dicken's Formula was based on the 24-hour rainfall and was recommended to be used for the larger drainage areas, the time of concentration was significant.

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**NOTES AND COMMENTS**

**CHAPTER DR-04**
**DISCHARGE**

**CHAPTER DR-04**
**DISCHARGE**

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## DR-04.900 EXHIBITS
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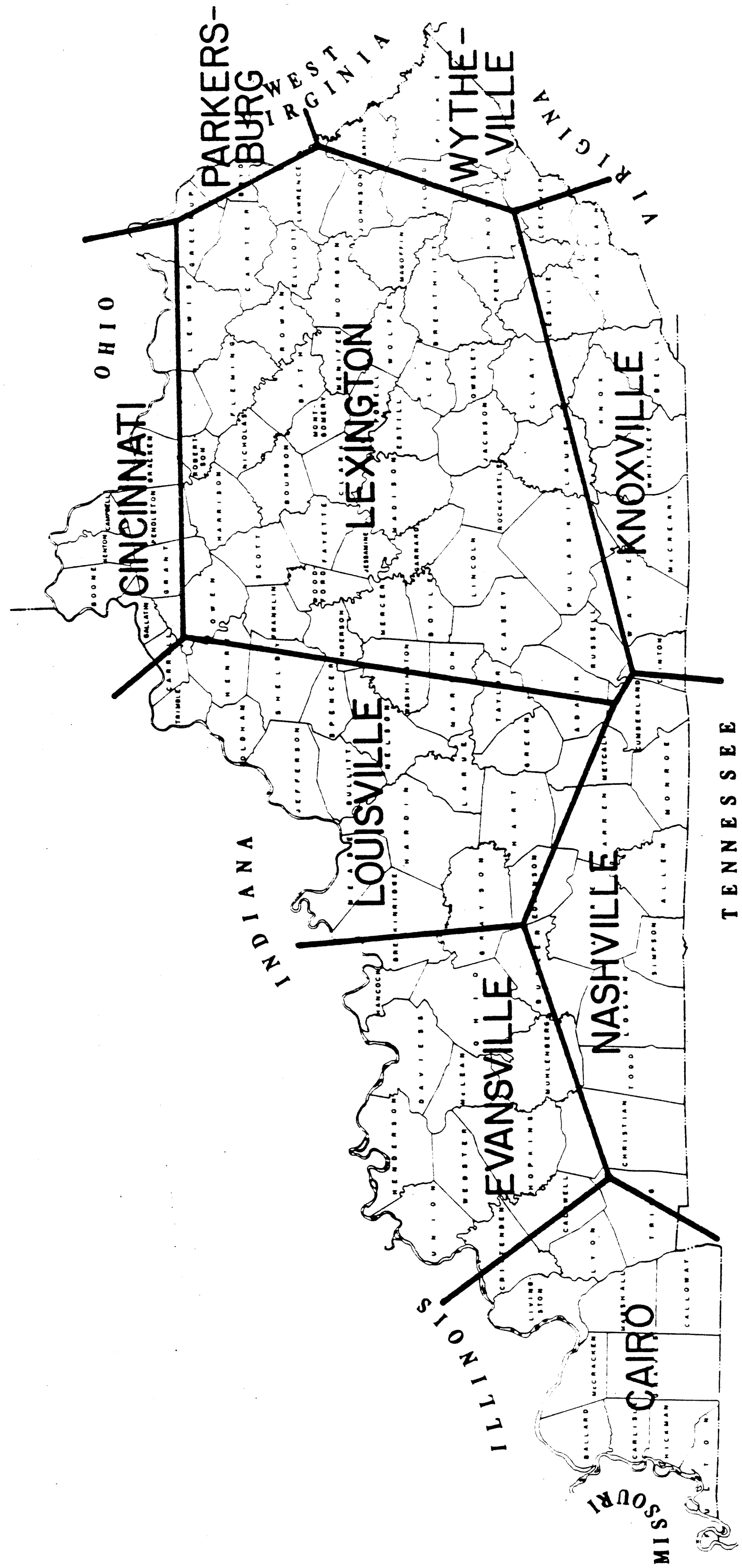
<u>Number</u>

| | |
|---|---|
| 04.902 | The Thiessen Diagram |
| 04.913 | Regional Method Discharge - Hydrologic Region Boundaries and Gaging Stations |
| 04.914 to .930 | Regional Method Discharge - Weighted Discharges at Gage Stations |
| 04.932 | Floods in Kentucky Method - Geographical Areas for Streams in Kentucky |
| 04.933 | Floods in Kentucky Method - R for Geographical Areas |
| 04.934 | Floods in Kentucky Method - Karst Region Coefficients |
| 04.935 | Regulated Streams and Responsible Agencies |
| 04.939 | Engineering Memo No. 2 (4-30-71) |
| 04.940 | Example Overland Flow |
| 04.941 | Urbanization Technique |
| 04.942 | Selection of Stream Headwater |

**CHAPTER DR-04**
**DISCHARGE**



PARKERS-BURG
WEST VIRGINIA
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TENNESSEE
NASHVILLE
EVANSVILLE
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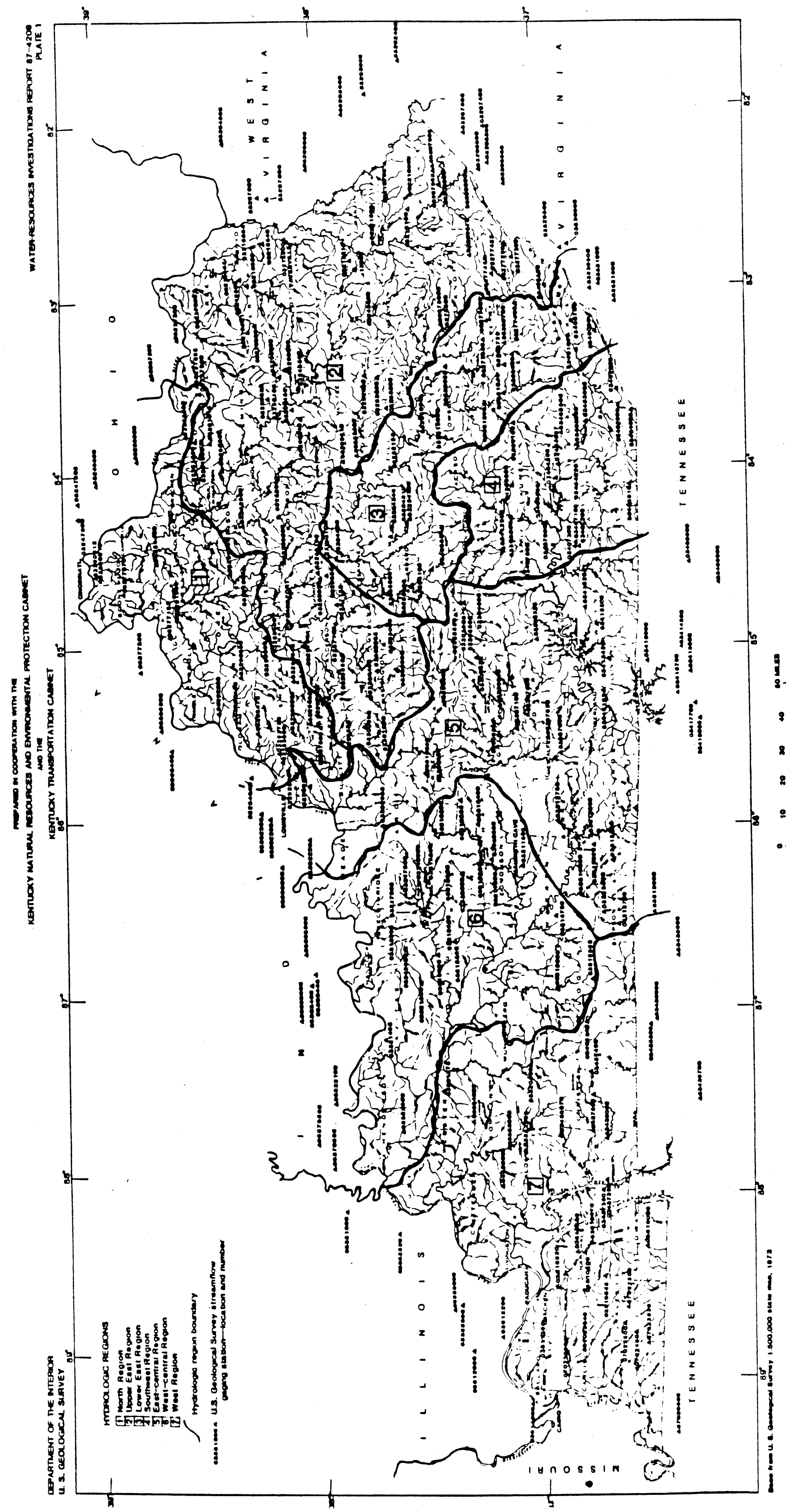
MISSOURI




LOCATIONS OF HYDROLOGIC REGION BOUNDARIES AND STREAMFLOW GAGING STATIONS USED IN THE STUDY

# REGIONAL METHOD : HYDROLOGIC REGION NO. 1
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At (mi²) | Ac (mi²) | Ba (mi) | Lc (mi) | Bs (mi/mi) | Ss (mi/mi) | Sc (ft/mi) | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Weighted Discharge (Qw) and Gage Correction (Cg) — Q in cubic feet per second | | | | | | |
| 03237895 | 0.23 | 0.23 | 1.05 | 1.08 | 4.49 | 1.03 | 209.1 | 87 | 126 | 161 | 213 | 251 | 305 | Qw |
| | | | | | | | | 0.833 | 0.704 | 0.676 | 0.653 | 0.623 | 0.631 | Cg |
| 03237900 | 22.40 | 22.40 | 4.77 | 5.77 | 1.02 | 1.21 | 32.4 | 3910 | 5780 | 6970 | 8540 | 9740 | 11000 | |
| | | | | | | | | 1.321 | 1.180 | 1.094 | 1.006 | 0.946 | 0.902 | |
| 03238030 | 1.90 | 1.90 | 1.60 | 2.28 | 1.35 | 1.43 | 53.1 | 318 | 513 | 676 | 902 | 1080 | 1280 | |
| | | | | | | | | 0.733 | 0.760 | 0.793 | 0.820 | 0.824 | 0.842 | |
| 03254400 | 13.60 | 13.60 | 4.59 | 5.71 | 1.55 | 1.24 | 28.3 | 2680 | 4990 | 6870 | 9800 | 12600 | 15500 | |
| | | | | | | | | 1.403 | 1.663 | 1.813 | 1.992 | 2.150 | 2.266 | |
| 03260010 | 0.68 | 0.68 | 0.97 | 1.32 | 1.38 | 1.36 | 81.1 | 210 | 371 | 488 | 647 | 778 | 904 | |
| | | | | | | | | 1.024 | 1.156 | 1.193 | 1.216 | 1.225 | 1.222 | |
| 03260012 | 1.62 | 1.62 | 1.77 | 2.22 | 1.93 | 1.25 | 138.1 | 279 | 581 | 875 | 1340 | 1740 | 2220 | |
| | | | | | | | | 0.592 | 0.684 | 0.754 | 0.827 | 0.857 | 0.899 | |
| 03277070 | 1.54 | 1.54 | 0.99 | 1.40 | 0.64 | 1.41 | 52.7 | 262 | 411 | 530 | 702 | 846 | 1010 | |
| | | | | | | | | 0.720 | 0.735 | 0.755 | 0.779 | 0.791 | 0.821 | |
| 03277185 | 0.68 | 0.68 | 1.24 | 1.72 | 2.26 | 1.39 | 206.0 | 252 | 429 | 560 | 743 | 884 | 1050 | |
| | | | | | | | | 1.000 | 0.929 | 0.882 | 0.828 | 0.782 | 0.761 | |
| 03290000 | 5.63 | 5.63 | 3.01 | 3.40 | 1.61 | 1.13 | 39.8 | 1940 | 3110 | 3960 | 5150 | 6180 | 7210 | |
| | | | | | | | | 1.950 | 1.981 | 1.980 | 1.981 | 1.987 | 1.986 | |
| 03290580 | 5.62 | 4.87 | 3.29 | 3.69 | 1.93 | 1.12 | 37.2 | 483 | 809 | 1110 | 1530 | 1850 | 2240 | |
| | | | | | | | | 0.555 | 0.599 | 0.653 | 0.699 | 0.714 | 0.744 | |
| 03291000 | 42.90 | 42.90 | 8.27 | 16.00 | 1.59 | 1.93 | 9.0 | 4270 | 5790 | 6810 | 8170 | 9210 | 10200 | |
| | | | | | | | | 1.124 | 1.095 | 1.083 | 1.069 | 1.059 | 1.042 | |
| 03291050 | 0.58 | 0.58 | 1.19 | 1.21 | 2.44 | 1.02 | 73.9 | 206 | 297 | 361 | 450 | 524 | 599 | |
| | | | | | | | | 1.170 | 1.104 | 1.068 | 1.034 | 1.017 | 1.007 | |
| 03291500 | 437.00 | 437.00 | 30.80 | 80.80 | 2.17 | 2.62 | 3.5 | 21600 | 29700 | 35000 | 41900 | 47100 | 52200 | |
| | | | | | | | | 1.038 | 1.049 | 1.054 | 1.053 | 1.049 | 1.038 | |
| 03292200 | 0.87 | 0.87 | 1.96 | 2.06 | 4.42 | 1.05 | 139.0 | 420 | 602 | 725 | 905 | 1050 | 1220 | |
| | | | | | | | | 1.484 | 1.221 | 1.100 | 0.998 | 0.938 | 0.904 | |
| 03292460 | 24.10 | 24.10 | 6.77 | 9.66 | 1.90 | 1.43 | 11.7 | 3370 | 4350 | 4900 | 5590 | 6100 | 6600 | |
| | | | | | | | | 1.343 | 1.236 | 1.161 | 1.085 | 1.036 | 0.992 | |
| 03292472 | 0.97 | 0.97 | 1.54 | 1.83 | 2.44 | 1.19 | 109.0 | 307 | 462 | 560 | 680 | 763 | 849 | |
| | | | | | | | | 1.048 | 0.937 | 0.863 | 0.775 | 0.713 | 0.663 | |
| 03292500 | 17.20 | 17.20 | 7.00 | 8.90 | 2.85 | 1.27 | 19.4 | 1210 | 2130 | 2850 | 3860 | 4650 | 5510 | |
| | | | | | | | | 0.568 | 0.670 | 0.725 | 0.775 | 0.799 | 0.822 | |
| 03292785 | 6.59 | 6.51 | 3.95 | 5.34 | 2.37 | 1.35 | 24.0 | 780 | 1300 | 1690 | 2200 | 2580 | 2980 | |
| | | | | | | | | 0.780 | 0.884 | 0.939 | 0.978 | 0.989 | 1.000 | |
| 03293000 | 18.90 | 18.40 | 5.73 | 9.60 | 1.74 | 1.68 | 20.0 | 1430 | 2160 | 2750 | 3600 | 4260 | 5040 | |
| | | | | | | | | 0.633 | 0.633 | 0.650 | 0.669 | 0.676 | 0.693 | |
| 03294000 | 189.00 | 189.00 | 16.20 | 25.10 | 1.38 | 1.55 | 5.5 | 6670 | 10300 | 13200 | 17000 | 20100 | 23500 | |
| | | | | | | | | 0.575 | 0.640 | 0.688 | 0.726 | 0.756 | 0.783 | |
| 03295845 | 1.36 | 1.36 | 1.76 | 1.80 | 2.28 | 1.03 | 75.1 | 294 | 621 | 908 | 1350 | 1770 | 2190 | |
| | | | | | | | | 0.826 | 1.080 | 1.225 | 1.380 | 1.500 | 1.587 | |
| 03296500 * | 19.10 | 19.10 | 8.82 | 9.94 | 4.07 | 1.13 | 14.8 | 2820 | 4110 | 4900 | 5900 | 6650 | 7350 | |
| | | | | | | | | 1.294 | 1.309 | 1.289 | 1.253 | 1.225 | 1.189 | |
| 03297000 | 5.15 | 5.15 | 3.85 | 4.40 | 2.88 | 1.14 | 52.1 | 1410 | 2310 | 3000 | 3990 | 4860 | 5770 | |
| | | | | | | | | 1.436 | 1.435 | 1.435 | 1.435 | 1.442 | 1.446 | |

* = Gage on Regulated Stream

## REGIONAL METHOD : HYDROLOGIC REGION NO. 1 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
| | mi² | mi² | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03297500 | 31.80 | 31.80 | 11.80 | 14.90 | 4.36 | 1.26 | 15.0 | 5700 | 8320 | 9830 | 11700 | 13200 | 14400 | Qw |
| | | | | | | | | 1.712 | 1.681 | 1.614 | 1.525 | 1.477 | 1.398 | Cg |
| 03298000 | 138.00 | 138.00 | 18.20 | 34.70 | 2.40 | 1.91 | 5.5 | 9500 | 13600 | 16700 | 21100 | 24700 | 28600 | |
| | | | | | | | | 1.065 | 1.115 | 1.160 | 1.213 | 1.254 | 1.294 | |
| 03298535 | 0.68 | 0.68 | 1.51 | 1.60 | 3.35 | 1.06 | 130.5 | 156 | 313 | 463 | 699 | 917 | 1170 | |
| | | | | | | | | 0.684 | 0.809 | 0.904 | 1.007 | 1.078 | 1.147 | |

* = Gage on Regulated Stream

## REGIONAL METHOD : HYDROLOGIC REGION NO. 2
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At mi² | Ac mi² | Ba mi | Lc mi | Bs mi/mi | Ss mi/mi | Sc ft/mi | Weighted Discharge (Qw) and Gage Correction (Cg) Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q in cubic feet per second | | | | | | |
| 03207400 | 19.80 | 19.80 | 4.73 | 6.30 | 1.13 | 1.33 | 119.0 | 898 | 2070 | 3180 | 4940 | 6500 | 8300 | Qw |
| | | | | | | | | 0.541 | 0.767 | 0.911 | 1.081 | 1.188 | 1.293 | Cg |
| 03207500 | 235.00 | 235.00 | 21.30 | 23.50 | 1.93 | 1.10 | 36.6 | 10700 | 17100 | 21600 | 27200 | 31700 | 36000 | |
| | | | | | | | | 1.009 | 0.972 | 0.947 | 0.904 | 0.881 | 0.851 | |
| 03207962 | 0.82 | 0.82 | 1.16 | 1.46 | 1.64 | 1.26 | 509.9 | 67 | 142 | 209 | 313 | 402 | 498 | |
| | | | | | | | | 0.481 | 0.660 | 0.766 | 0.884 | 0.955 | 1.010 | |
| 03207965 | 6.20 | 6.20 | 5.02 | 5.39 | 4.06 | 1.07 | 128.6 | 799 | 1080 | 1270 | 1550 | 1770 | 2020 | |
| | | | | | | | | 1.368 | 1.216 | 1.144 | 1.084 | 1.060 | 1.036 | |
| 03208000 * | 392.00 | 392.00 | 39.50 | 52.70 | 3.98 | 1.33 | 16.9 | 12200 | 17800 | 21600 | 26600 | 30400 | 34300 | |
| | | | | | | | | 0.938 | 0.904 | 0.889 | 0.869 | 0.856 | 0.841 | |
| 03208500 | 286.00 | 286.00 | 17.00 | 23.50 | 1.01 | 1.38 | 19.3 | 14000 | 24400 | 31900 | 42000 | 49800 | 57800 | |
| | | | | | | | | 1.085 | 1.135 | 1.139 | 1.144 | 1.132 | 1.118 | |
| 03208950 | 66.50 | 66.50 | 13.80 | 17.00 | 2.87 | 1.23 | 42.5 | 2820 | 5450 | 7740 | 11200 | 14100 | 17500 | |
| | | | | | | | | 0.773 | 0.963 | 1.087 | 1.227 | 1.318 | 1.400 | |
| 03209000 * | 221.00 | 221.00 | 25.80 | 41.30 | 3.02 | 1.60 | 10.2 | 10000 | 15300 | 19000 | 23800 | 27400 | 31200 | |
| | | | | | | | | 1.196 | 1.244 | 1.258 | 1.266 | 1.263 | 1.258 | |
| 03209300 * | 554.00 | 554.00 | 26.20 | 40.30 | 1.24 | 1.54 | 21.2 | 22600 | 34900 | 44000 | 56300 | 66200 | 77000 | |
| | | | | | | | | 1.136 | 1.084 | 1.068 | 1.060 | 1.054 | 1.055 | |
| 03209575 | 3.17 | 3.17 | 1.47 | 2.59 | 0.68 | 1.76 | 180.9 | 308 | 488 | 639 | 866 | 1070 | 1270 | |
| | | | | | | | | 0.749 | 0.757 | 0.778 | 0.817 | 0.849 | 0.864 | |
| 03210000 | 56.30 | 56.30 | 13.20 | 21.50 | 3.09 | 1.63 | 24.3 | 2720 | 4300 | 5370 | 6720 | 7730 | 8740 | |
| | | | | | | | | 0.935 | 1.190 | 1.047 | 1.057 | 1.056 | 1.047 | |
| 03210160 | 3.74 | 3.74 | 2.41 | 3.07 | 1.55 | 1.27 | 101.9 | 504 | 681 | 810 | 998 | 1170 | 1340 | |
| | | | | | | | | 1.130 | 0.969 | 0.904 | 0.860 | 0.842 | 0.827 | |
| 03211500 * | 206.00 | 206.00 | 32.40 | 55.10 | 5.10 | 1.70 | 6.4 | 4370 | 6620 | 8270 | 10600 | 12500 | 14200 | |
| | | | | | | | | 0.615 | 0.670 | 0.701 | 0.741 | 0.772 | 0.776 | |
| 03212000 | 103.00 | 103.00 | 14.60 | 21.00 | 2.07 | 1.44 | 8.3 | 5270 | 9090 | 11800 | 15300 | 17900 | 20600 | |
| | | | | | | | | 1.025 | 1.143 | 1.181 | 1.205 | 1.201 | 1.191 | |
| 03212515 | 2.10 | 2.10 | 1.26 | 2.19 | 0.76 | 1.74 | 91.2 | 186 | 317 | 425 | 587 | 729 | 868 | |
| | | | | | | | | 0.628 | 0.689 | 0.729 | 0.783 | 0.817 | 0.835 | |
| 03215500 | 217.00 | 217.00 | 20.00 | 40.10 | 1.83 | 2.01 | 3.5 | 6000 | 9200 | 11600 | 14900 | 17600 | 20400 | |
| | | | | | | | | 0.715 | 0.748 | 0.773 | 0.805 | 0.826 | 0.843 | |
| 03216500 * | 400.00 | 400.00 | 26.50 | 47.20 | 1.76 | 1.78 | 3.7 | 10200 | 14500 | 17600 | 22000 | 25700 | 29400 | |
| | | | | | | | | 0.729 | 0.684 | 0.669 | 0.669 | 0.671 | 0.671 | |
| 03216505 | 0.51 | 0.51 | 0.96 | 1.02 | 1.81 | 1.06 | 169.4 | 48 | 86 | 118 | 171 | 218 | 264 | |
| | | | | | | | | 0.472 | 0.538 | 0.578 | 0.636 | 0.675 | 0.691 | |
| 03216540 | 12.20 | 12.20 | 6.16 | 8.73 | 3.11 | 1.42 | 18.3 | 832 | 1110 | 1330 | 1640 | 1920 | 2190 | |
| | | | | | | | | 0.882 | 0.799 | 0.778 | 0.763 | 0.771 | 0.766 | |
| 03216563 | 0.94 | 0.94 | 1.50 | 1.57 | 2.39 | 1.05 | 85.0 | 191 | 268 | 322 | 397 | 459 | 526 | |
| | | | | | | | | 1.248 | 1.117 | 1.056 | 0.995 | 0.964 | 0.939 | |
| 03216564 | 1.61 | 1.61 | 2.26 | 2.43 | 3.17 | 1.08 | 74.0 | 323 | 443 | 521 | 620 | 694 | 771 | |
| | | | | | | | | 1.482 | 1.330 | 1.243 | 1.144 | 1.084 | 1.031 | |
| 03216800 | 59.60 | 59.60 | 9.09 | 12.00 | 1.39 | 1.32 | 17.8 | 4780 | 7200 | 8790 | 10800 | 12300 | 13800 | |
| | | | | | | | | 1.282 | 1.192 | 1.133 | 1.069 | 1.017 | 0.979 | |

* = Gage on Regulated Stream

## REGIONAL METHOD : HYDROLOGIC REGION NO. 2 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
| | $mi^2$ | $mi^2$ | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03216901 | 1.11 | 1.11 | 1.66 | 1.87 | 2.48 | 1.13 | 103.8 | 188 | 262 | 319 | 399 | 468 | 541 | Qw |
| | | | | | | | | 1.112 | 1.008 | 0.973 | 0.939 | 0.929 | 0.917 | Cg |
| 03217000 | 242.00 | 242.00 | 28.60 | 61.20 | 3.38 | 2.14 | 4.6 | 7220 | 11200 | 14100 | 18100 | 21300 | 24600 | |
| | | | | | | | | 0.898 | 1.018 | 1.076 | 1.153 | 1.203 | 1.242 | |
| 03248500 | 140.00 | 140.00 | 20.20 | 36.40 | 2.91 | 1.80 | 4.7 | 4290 | 6870 | 8710 | 11100 | 13100 | 15000 | |
| | | | | | | | | 0.750 | 0.837 | 0.876 | 0.910 | 0.936 | 0.943 | |
| 03249500 * | 827.00 | 827.00 | 54.80 | 81.00 | 3.63 | 1.48 | 3.3 | 12000 | 17300 | 20900 | 26200 | 30800 | 34800 | |
| | | | | | | | | 0.529 | 0.509 | 0.500 | 0.501 | 0.511 | 0.504 | |
| 03250000 | 47.50 | 47.50 | 8.16 | 9.70 | 1.40 | 1.19 | 29.4 | 6130 | 9670 | 12300 | 15500 | 17900 | 20600 | |
| | | | | | | | | 1.898 | 1.811 | 1.775 | 1.696 | 1.627 | 1.597 | |
| 03250080 | 0.19 | 0.19 | 0.72 | 0.80 | 2.73 | 1.11 | 164.4 | 39 | 63 | 81 | 105 | 124 | 145 | |
| | | | | | | | | 0.884 | 0.957 | 0.983 | 0.991 | 0.992 | 0.993 | |
| 03250100 | 84.70 | 84.70 | 11.80 | 18.50 | 1.64 | 1.57 | 15.8 | 5930 | 7410 | 8390 | 9740 | 10900 | 12100 | |
| | | | | | | | | 1.321 | 1.069 | 0.964 | 0.878 | 0.838 | 0.807 | |
| 03250150 | 2.43 | 2.43 | 2.13 | 2.76 | 1.87 | 1.30 | 45.5 | 384 | 605 | 767 | 987 | 1160 | 1350 | |
| | | | | | | | | 1.243 | 1.271 | 1.278 | 1.275 | 1.265 | 1.262 | |
| 03250243 | 0.70 | 0.70 | 1.16 | 1.23 | 1.92 | 1.06 | 81.0 | 184 | 245 | 287 | 347 | 398 | 454 | |
| | | | | | | | | 1.460 | 1.219 | 1.117 | 1.027 | 0.983 | 0.950 | |
| 03250320 | 4.01 | 4.01 | 2.10 | 3.05 | 1.10 | 1.45 | 95.7 | 889 | 1330 | 1620 | 1970 | 2220 | 2530 | |
| | | | | | | | | 1.852 | 1.757 | 1.679 | 1.576 | 1.490 | 1.454 | |
| 03250620 | 0.33 | 0.33 | 0.91 | 1.03 | 2.51 | 1.13 | 130.1 | 83 | 122 | 148 | 184 | 211 | 241 | |
| | | | | | | | | 1.241 | 1.208 | 1.165 | 1.115 | 1.082 | 1.057 | |
| 03251000 | 119.00 | 119.00 | 18.00 | 34.30 | 2.71 | 1.91 | 2.7 | 5690 | 7570 | 8840 | 10500 | 11800 | 13100 | |
| | | | | | | | | 1.131 | 1.057 | 1.024 | 0.991 | 0.975 | 0.956 | |
| 03251008 | 0.96 | 0.93 | 0.53 | 0.65 | 0.29 | 1.23 | 123.3 | 105 | 233 | 350 | 535 | 704 | 874 | |
| | | | | | | | | 0.505 | 0.621 | 0.685 | 0.759 | 0.801 | 0.825 | |
| 03251015 | 0.45 | 0.45 | 1.69 | 1.76 | 6.35 | 1.04 | 81.2 | 86 | 126 | 155 | 195 | 226 | 260 | |
| | | | | | | | | 1.161 | 1.189 | 1.202 | 1.184 | 1.183 | 1.182 | |
| 03252000 | 239.00 | 239.00 | 18.30 | 56.20 | 1.40 | 3.07 | 2.4 | 8240 | 11300 | 13200 | 15600 | 17300 | 19200 | |
| | | | | | | | | 0.990 | 1.000 | 0.985 | 0.981 | 0.966 | 0.960 | |
| 03252500 | 621.00 | 615.00 | 31.40 | 85.90 | 1.59 | 2.73 | 2.4 | 17700 | 23800 | 27300 | 31100 | 33800 | 36300 | |
| | | | | | | | | 1.017 | 0.983 | 0.945 | 0.899 | 0.860 | 0.827 | |
| 03277290 | 3.03 | 3.03 | 2.81 | 3.69 | 2.61 | 1.31 | 276.1 | 199 | 373 | 518 | 736 | 915 | 1110 | |
| | | | | | | | | 0.578 | 0.724 | 0.809 | 0.903 | 0.957 | 1.000 | |
| 03277300 | 66.40 | 66.40 | 12.70 | 17.20 | 2.43 | 1.35 | 19.5 | 2120 | 3700 | 4990 | 6920 | 8550 | 10300 | |
| | | | | | | | | 0.582 | 0.660 | 0.710 | 0.771 | 0.814 | 0.844 | |
| 03277437 | 0.69 | 0.69 | 1.03 | 1.34 | 1.54 | 1.30 | 366.0 | 102 | 163 | 212 | 285 | 347 | 414 | |
| | | | | | | | | 0.836 | 0.862 | 0.887 | 0.922 | 0.943 | 0.963 | |
| 03277450 * | 60.60 | 60.60 | 12.70 | 19.80 | 2.66 | 1.56 | 17.1 | 3150 | 4280 | 5110 | 6280 | 7260 | 8250 | |
| | | | | | | | | 0.984 | 0.903 | 0.875 | 0.859 | 0.857 | 0.850 | |
| 03278000 | 2.21 | 2.21 | 2.37 | 2.60 | 2.54 | 1.10 | 125.0 | 246 | 387 | 489 | 629 | 742 | 858 | |
| | | | | | | | | 0.860 | 0.868 | 0.865 | 0.856 | 0.851 | 0.841 | |
| 03278500 | 177.00 | 177.00 | 19.60 | 35.70 | 2.17 | 1.82 | 8.8 | 9160 | 14900 | 18600 | 23200 | 26300 | 29600 | |
| | | | | | | | | 1.276 | 1.406 | 1.442 | 1.450 | 1.422 | 1.403 | |

* = Gage on Regulated Stream

# REGIONAL METHOD : HYDROLOGIC REGION NO. 2 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At (mi$^2$) | Ac (mi$^2$) | Ba (mi) | Lc (mi) | Bs (mi/mi) | Ss (mi/mi) | Sc (ft/mi) | Weighted Discharge (Qw) and Gage Correction (Cg) Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q in cubic feet per second | | | | | | |
| 03282500 | 65.80 | 65.80 | 16.00 | 18.70 | 3.89 | 1.17 | 9.9 | 2430 | 3940 | 5110 | 6800 | 8190 | 9660 | Qw |
| | | | | | | | | 0.696 | 0.734 | 0.767 | 0.800 | 0.823 | 0.840 | Cg |
| 03283000 | 24.00 | 24.00 | 6.26 | 7.40 | 1.63 | 1.18 | 23.6 | 2080 | 3640 | 4810 | 6370 | 7590 | 8900 | |
| | | | | | | | | 1.112 | 1.197 | 1.230 | 1.242 | 1.238 | 1.234 | |
| 03283305 | 0.58 | 0.58 | 0.77 | 1.09 | 1.02 | 1.42 | 160.0 | 139 | 177 | 205 | 249 | 290 | 331 | |
| | | | | | | | | 1.241 | 1.011 | 0.919 | 0.856 | 0.833 | 0.813 | |
| 03283500 | 362.00 | 362.00 | 38.90 | 68.90 | 4.18 | 1.77 | 6.0 | 8810 | 14000 | 17600 | 22300 | 25700 | 29200 | |
| | | | | | | | | 0.787 | 0.892 | 0.931 | 0.970 | 0.985 | 0.990 | |
| 03283610 | 0.33 | 0.33 | 0.85 | 1.01 | 2.19 | 1.19 | 105.0 | 54 | 88 | 112 | 146 | 174 | 202 | |
| | | | | | | | | 0.802 | 0.856 | 0.875 | 0.880 | 0.883 | 0.878 | |
| 03287128 | 1.26 | 1.26 | 1.83 | 2.05 | 2.66 | 1.12 | 58.0 | 154 | 279 | 382 | 530 | 649 | 786 | |
| | | | | | | | | 0.837 | 0.986 | 1.073 | 1.150 | 1.191 | 1.232 | |
| 03287160 | 0.81 | 0.81 | 0.85 | 1.34 | 0.89 | 1.58 | 60.5 | 172 | 245 | 295 | 359 | 410 | 461 | |
| | | | | | | | | 1.203 | 1.104 | 1.046 | 0.986 | 0.945 | 0.911 | |
| 03287534 | 4.47 | 4.47 | 4.01 | 5.53 | 3.60 | 1.38 | 12.1 | 529 | 666 | 760 | 893 | 1010 | 1120 | |
| | | | | | | | | 1.227 | 1.067 | 0.996 | 0.934 | 0.910 | 0.882 | |
| 03288000 | 119.00 | 111.00 | 17.60 | 31.40 | 2.60 | 1.78 | 3.8 | 4190 | 5730 | 6760 | 8140 | 9260 | 10300 | |
| | | | | | | | | 0.855 | 0.807 | 0.782 | 0.761 | 0.753 | 0.736 | |
| 03288500 | 2.53 | 1.93 | 2.35 | 2.70 | 2.18 | 1.15 | 38.5 | 124 | 228 | 316 | 452 | 570 | 694 | |
| | | | | | | | | 0.475 | 0.559 | 0.611 | 0.673 | 0.714 | 0.742 | |
| 03289000 | 24.00 | 21.00 | 5.73 | 9.60 | 1.37 | 1.68 | 16.5 | 931 | 1430 | 1810 | 2350 | 2810 | 3250 | |
| | | | | | | | | 0.593 | 0.598 | 0.605 | 0.620 | 0.631 | 0.632 | |
| 03289190 | 5.30 | 5.30 | 3.80 | 4.55 | 2.72 | 1.20 | 28.9 | 923 | 1290 | 1510 | 1760 | 1930 | 2150 | |
| | | | | | | | | 1.719 | 1.567 | 1.466 | 1.323 | 1.237 | 1.181 | |
| 03289500 | 473.00 | 403.00 | 32.70 | 78.20 | 2.26 | 2.39 | 3.6 | 12200 | 17400 | 20600 | 24200 | 26800 | 29200 | |
| | | | | | | | | 0.992 | 1.018 | 1.010 | 0.988 | 0.964 | 0.939 | |
| 03295000 | 41.40 | 39.70 | 10.60 | 18.70 | 2.71 | 1.76 | 8.5 | 3080 | 4750 | 5920 | 7460 | 8610 | 9850 | |
| | | | | | | | | 1.381 | 1.489 | 1.530 | 1.564 | 1.568 | 1.579 | |
| 03295500 | 196.00 | 192.00 | 19.70 | 25.30 | 1.97 | 1.29 | 3.7 | 8960 | 12200 | 14300 | 17000 | 19100 | 21200 | |
| | | | | | | | | 1.037 | 0.884 | 0.813 | 0.746 | 0.707 | 0.675 | |
| 03300000 | 85.90 | 85.90 | 9.74 | 26.20 | 1.10 | 2.69 | 5.8 | 5120 | 7050 | 8360 | 10000 | 11200 | 12600 | |
| | | | | | | | | 1.240 | 1.205 | 1.184 | 1.167 | 1.142 | 1.135 | |
| 03300065 | 1.71 | 1.71 | 1.75 | 1.94 | 1.79 | 1.11 | 75.6 | 477 | 782 | 967 | 1170 | 1300 | 1460 | |
| | | | | | | | | 1.916 | 1.965 | 1.846 | 1.746 | 1.621 | 1.545 | |
| 03300400 | 436.00 | 436.00 | 16.70 | 29.90 | 0.64 | 1.79 | 3.8 | 17500 | 25500 | 31300 | 39600 | 46800 | 53800 | |
| | | | | | | | | 0.983 | 0.870 | 0.828 | 0.808 | 0.800 | 0.790 | |
| 03300990 | 0.32 | 0.32 | 0.81 | 0.98 | 2.05 | 1.21 | 106.0 | 51 | 78 | 96 | 122 | 143 | 163 | |
| | | | | | | | | 0.766 | 0.764 | 0.762 | 0.748 | 0.737 | 0.718 | |
| 03301000 | 669.00 | 669.00 | 34.70 | 92.60 | 1.80 | 2.67 | 3.7 | 20200 | 27500 | 31900 | 36900 | 40500 | 43900 | |
| | | | | | | | | 1.110 | 1.083 | 1.056 | 1.022 | 0.990 | 0.961 | |
| 03400500 | 82.30 | 82.30 | 16.50 | 25.80 | 3.31 | 1.56 | 28.1 | 3630 | 5890 | 7500 | 9630 | 11300 | 13000 | |
| | | | | | | | | 0.933 | 1.037 | 1.082 | 1.117 | 1.138 | 1.150 | |
| 03529500 | 112.00 | 112.00 | 13.20 | 23.40 | 1.56 | 1.77 | 41.2 | 5070 | 8030 | 10400 | 13800 | 16700 | 20000 | |
| | | | | | | | | 0.937 | 0.982 | 1.020 | 1.078 | 1.121 | 1.170 | |
| 03530000 | 40.00 | 40.00 | 10.50 | 14.60 | 2.74 | 1.40 | 156.0 | 2350 | 3530 | 4410 | 5650 | 6640 | 7710 | |
| | | | | | | | | 0.979 | 0.975 | 0.980 | 0.991 | 1.000 | 1.007 | |

* = Gage on Regulated Stream

# REGIONAL METHOD : HYDROLOGIC REGION NO. 3
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mi² | mi² | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03277400 | 40.9 | 40.9 | 6.89 | 13.5 | 1.16 | 1.96 | 51.2 | 2660 | 4620 | 6100 | 8130 | 9730 | 11400 | Qw |
| | | | | | | | | 0.861 | 0.947 | 0.984 | 1.014 | 1.026 | 1.036 | Cg |
| 03277500 * | 466.00 | 466.00 | 27.20 | 61.60 | 1.59 | 2.26 | 7.4 | 18900 | 27800 | 33400 | 40400 | 45300 | 50300 | |
| | | | | | | | | 1.196 | 1.198 | 1.180 | 1.154 | 1.124 | 1.098 | |
| 03277630 | 1.32 | 1.32 | 1.60 | 2.33 | 1.94 | 1.46 | 188.4 | 246 | 403 | 531 | 715 | 875 | 1040 | |
| | | | | | | | | 0.988 | 0.953 | 0.948 | 0.945 | 0.953 | 0.954 | |
| 03280600 | 202.00 | 202.00 | 17.10 | 27.20 | 1.45 | 1.59 | 24.5 | 12100 | 20800 | 27600 | 37300 | 44500 | 52400 | |
| | | | | | | | | 1.175 | 1.276 | 1.327 | 1.376 | 1.382 | 1.397 | |
| 03280700 | 61.30 | 61.30 | 13.10 | 18.40 | 2.80 | 1.40 | 44.6 | 4400 | 7380 | 9640 | 12800 | 15400 | 18100 | |
| | | | | | | | | 1.016 | 1.051 | 1.063 | 1.067 | 1.069 | 1.065 | |
| 03280728 | 1.84 | 1.84 | 1.39 | 1.88 | 1.05 | 1.35 | 202.7 | 293 | 494 | 662 | 909 | 1130 | 1360 | |
| | | | | | | | | 0.913 | 0.903 | 0.912 | 0.924 | 0.942 | 0.951 | |
| 03280935 | 1.57 | 1.57 | 2.39 | 2.73 | 3.64 | 1.14 | 129.4 | 213 | 423 | 610 | 898 | 1150 | 1440 | |
| | | | | | | | | 0.732 | 0.838 | 0.901 | 0.966 | 1.009 | 1.044 | |
| 03281000 * | 537.00 | 537.00 | 50.40 | 95.00 | 4.73 | 1.88 | 4.7 | 15000 | 24200 | 31500 | 41900 | 51100 | 60600 | |
| | | | | | | | | 0.714 | 0.752 | 0.782 | 0.814 | 0.845 | 0.869 | |
| 03281040 | 155.00 | 155.00 | 17.70 | 29.30 | 2.02 | 1.66 | 16.4 | 10700 | 15100 | 18200 | 22600 | 26100 | 29900 | |
| | | | | | | | | 1.265 | 1.127 | 1.071 | 1.023 | 0.996 | 0.980 | |
| 03281200 | 486.00 | 486.00 | 27.60 | 45.50 | 1.57 | 1.65 | 7.6 | 20600 | 31100 | 38400 | 48000 | 55500 | 63200 | |
| | | | | | | | | 1.062 | 1.054 | 1.046 | 1.028 | 1.013 | 1.002 | |
| 03281500 | 722.00 | 722.00 | 36.20 | 77.00 | 1.82 | 2.13 | 5.1 | 24400 | 37800 | 47200 | 59700 | 69400 | 79200 | |
| | | | | | | | | 0.942 | 0.980 | 0.994 | 0.998 | 0.999 | 1.000 | |
| 03282198 | 0.59 | 0.59 | 1.06 | 1.19 | 1.90 | 1.12 | 149.0 | 146 | 255 | 340 | 463 | 565 | 678 | |
| | | | | | | | | 1.035 | 1.028 | 1.015 | 0.998 | 0.988 | 0.980 | |
| 03284300 | 28.60 | 28.60 | 8.98 | 13.70 | 2.82 | 1.52 | 22.2 | 2890 | 4850 | 6210 | 8020 | 9310 | 10700 | |
| | | | | | | | | 1.189 | 1.639 | 1.213 | 1.186 | 1.148 | 1.122 | |
| 03284310 | 53.40 | 53.30 | 9.45 | 16.00 | 1.67 | 1.69 | 11.0 | 3630 | 5940 | 7710 | 10200 | 12300 | 14400 | |
| | | | | | | | | 0.950 | 0.974 | 0.988 | 1.000 | 1.017 | 1.014 | |
| 03284340 | 1.83 | 1.83 | 1.91 | 2.37 | 1.99 | 1.24 | 61.9 | 307 | 527 | 706 | 967 | 1190 | 1440 | |
| | | | | | | | | 0.950 | 0.950 | 0.954 | 0.957 | 0.967 | 0.973 | |
| 03284550 | 11.00 | 10.90 | 4.60 | 5.58 | 1.92 | 1.21 | 19.1 | 1240 | 2130 | 2840 | 3880 | 4710 | 5630 | |
| | | | | | | | | 1.016 | 1.039 | 1.052 | 1.060 | 1.058 | 1.060 | |
| 03285000 | 318.00 | 318.00 | 24.60 | 50.50 | 1.90 | 2.05 | 4.1 | 13300 | 19600 | 24200 | 30600 | 35900 | 41400 | |
| | | | | | | | | 0.943 | 0.907 | 0.896 | 0.890 | 0.891 | 0.896 | |
| 03285100 | 0.13 | 0.13 | 0.54 | 0.56 | 2.24 | 1.04 | 143.4 | 46 | 73 | 96 | 130 | 164 | 201 | |
| | | | | | | | | 0.996 | 0.873 | 0.835 | 0.807 | 0.820 | 0.824 | |
| 03285500 | 395.00 | 379.00 | 31.90 | 78.90 | 2.58 | 2.47 | 5.3 | 17600 | 24100 | 28700 | 34800 | 39900 | 45100 | |
| | | | | | | | | 1.121 | 1.021 | 0.983 | 0.951 | 0.941 | 0.936 | |
| 03400700 | 82.40 | 82.40 | 18.30 | 24.40 | 4.06 | 1.33 | 38.8 | 5740 | 9610 | 12500 | 16800 | 20100 | 23700 | |
| | | | | | | | | 1.059 | 1.092 | 1.096 | 1.113 | 1.104 | 1.102 | |
| 03400800 * | 55.80 | 58.80 | 10.20 | 19.00 | 1.88 | 1.86 | 33.0 | 3700 | 6250 | 8180 | 10900 | 12900 | 15200 | |
| | | | | | | | | 0.941 | 1.005 | 1.034 | 1.058 | 1.066 | 1.078 | |
| 03401000 * | 374.00 | 374.00 | 38.40 | 51.30 | 3.94 | 1.34 | 13.0 | 17000 | 26900 | 34200 | 44200 | 52300 | 60900 | |
| | | | | | | | | 1.018 | 1.011 | 1.006 | 0.989 | 0.978 | 0.968 | |

* = Gage on Regulated Stream

# REGIONAL METHOD : HYDROLOGIC REGION NO. 3 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
| | mi² | mi² | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03405854 | 1.91 | 1.91 | 1.89 | 2.24 | 1.87 | 1.19 | 102.9 | 454 | 818 | 1080 | 1450 | 1690 | 1980 | Qw |
| | | | | | | | | 1.356 | 1.415 | 1.399 | 1.368 | 1.310 | 1.269 | Cg |
| 03530500 | 70.0 | 70.0 | 11.8 | 16.5 | 1.99 | 1.40 | 59.4 | 4290 | 6900 | 9060 | 12300 | 15300 | 18500 | |
| | | | | | | | | 0.861 | 0.825 | 0.824 | 0.820 | 0.832 | 0.837 | |
| 03531000 | 290.0 | 290.0 | 26.0 | 45.9 | 2.34 | 1.76 | 21.5 | 13300 | 19600 | 24500 | 31400 | 37200 | 43200 | |
| | | | | | | | | 0.993 | 0.942 | 0.932 | 0.926 | 0.930 | 0.933 | |
| 03531500 | 319.0 | 319.0 | 33.1 | 58.9 | 3.44 | 1.78 | 16.8 | 12200 | 19200 | 24700 | 32500 | 39200 | 46500 | |
| | | | | | | | | 0.847 | 0.861 | 0.879 | 0.898 | 0.918 | 0.941 | |

* = Gage on Regulated Stream

# REGIONAL METHOD : HYDROLOGIC REGION NO. 4
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At (mi²) | Ac (mi²) | Ba (mi) | Lc (mi) | Bs (mi/mi) | Ss (mi/mi) | Sc (ft/mi) | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Weighted Discharge (Qw) and Gage Correction (Cg); Q in cubic feet per second | | | | | | |
| 03281100 | 163.00 | 163.00 | 16.00 | 24.40 | 1.57 | 1.53 | 13.7 | 8610 | 12100 | 14500 | 17700 | 20200 | 22700 | Qw |
| | | | | | | | | 1.130 | 1.071 | 1.051 | 1.029 | 1.015 | 1.004 | Cg |
| 03401500 | 35.30 | 35.30 | 9.49 | 9.90 | 2.55 | 1.04 | 127.1 | 3070 | 4510 | 5530 | 6940 | 8090 | 9310 | |
| | | | | | | | | 1.421 | 1.367 | 1.349 | 1.340 | 1.339 | 1.345 | |
| 03402000 | 60.60 | 60.60 | 9.53 | 12.70 | 1.50 | 1.33 | 74.4 | 3800 | 5680 | 7090 | 9070 | 10700 | 12400 | |
| | | | | | | | | 1.126 | 1.114 | 1.125 | 1.145 | 1.162 | 1.181 | |
| 03402020 | 2.96 | 2.96 | 4.13 | 5.87 | 5.76 | 1.42 | 342.6 | 496 | 645 | 736 | 864 | 967 | 1070 | |
| | | | | | | | | 1.778 | 1.433 | 1.332 | 1.166 | 1.106 | 1.059 | |
| 03403000 * | 809.00 | 809.00 | 60.60 | 94.90 | 4.54 | 1.57 | 8.2 | 27900 | 40300 | 48900 | 60300 | 69200 | 78500 | |
| | | | | | | | | 1.109 | 0.983 | 0.970 | 0.953 | 0.939 | 0.932 | |
| 03403500 * | 960.00 | 960.00 | 66.00 | 106.90 | 4.53 | 1.62 | 7.4 | 26800 | 37800 | 45700 | 56000 | 64500 | 73000 | |
| | | | | | | | | 0.843 | 0.809 | 0.802 | 0.787 | 0.781 | 0.777 | |
| 03403538 | 11.50 | 11.50 | 3.32 | 5.99 | 0.96 | 1.80 | 23.1 | 792 | 1440 | 1900 | 2510 | 2990 | 3490 | |
| | | | | | | | | 0.926 | 1.075 | 1.131 | 1.167 | 1.187 | 1.203 | |
| 03403910 | 331.00 | 331.00 | 19.20 | 27.70 | 1.11 | 1.44 | 15.4 | 11900 | 18400 | 22800 | 28600 | 33000 | 37400 | |
| | | | | | | | | 0.864 | 0.920 | 0.942 | 0.953 | 0.954 | 0.954 | |
| 03404820 | 140.00 | 140.00 | 14.20 | 30.80 | 1.44 | 2.17 | 3.7 | 6160 | 9930 | 12600 | 16200 | 19100 | 22000 | |
| | | | | | | | | 0.917 | 0.994 | 1.033 | 1.059 | 1.079 | 1.095 | |
| 03404867 | 0.31 | 0.31 | 1.00 | 1.22 | 3.23 | 1.22 | 98.3 | 37 | 58 | 75 | 98 | 115 | 134 | |
| | | | | | | | | 0.834 | 0.786 | 0.779 | 0.774 | 0.767 | 0.761 | |
| 03404900 | 53.80 | 53.80 | 7.08 | 10.00 | 0.93 | 1.41 | 10.3 | 2470 | 3940 | 5070 | 6650 | 7920 | 9280 | |
| | | | | | | | | 0.810 | 0.851 | 0.885 | 0.921 | 0.943 | 0.968 | |
| 03405000 | 201.00 | 201.00 | 16.90 | 28.40 | 1.42 | 1.68 | 5.8 | 6820 | 10700 | 13600 | 17400 | 20400 | 23500 | |
| | | | | | | | | 0.753 | 0.799 | 0.834 | 0.857 | 0.868 | 0.883 | |
| 03406000 | 3.89 | 3.89 | 1.99 | 2.60 | 1.02 | 1.31 | 49.2 | 307 | 480 | 597 | 742 | 849 | 957 | |
| | | | | | | | | 0.877 | 0.857 | 0.838 | 0.808 | 0.786 | 0.766 | |
| 03406500 | 604.00 | 604.00 | 24.80 | 57.30 | 1.02 | 2.31 | 3.6 | 21900 | 31900 | 38500 | 46700 | 52900 | 59000 | |
| | | | | | | | | 0.978 | 0.979 | 0.975 | 0.957 | 0.941 | 0.928 | |
| 03407000 | 745.00 | 745.00 | 37.40 | 74.70 | 1.88 | 2.00 | 3.6 | 24100 | 35000 | 42300 | 51800 | 58900 | 66000 | |
| | | | | | | | | 0.903 | 0.914 | 0.916 | 0.912 | 0.903 | 0.898 | |
| 03407100 | 0.67 | 0.67 | 1.07 | 1.31 | 1.71 | 1.22 | 206.0 | 83 | 157 | 216 | 300 | 369 | 444 | |
| | | | | | | | | 1.015 | 1.154 | 1.227 | 1.299 | 1.347 | 1.388 | |
| 03407200 | 0.26 | 0.26 | 0.83 | 1.00 | 2.65 | 1.20 | 186.7 | 41 | 66 | 84 | 109 | 130 | 152 | |
| | | | | | | | | 1.077 | 1.027 | 1.011 | 0.991 | 0.992 | 0.987 | |
| 03407300 | 0.85 | 0.85 | 1.00 | 1.55 | 1.18 | 1.55 | 223.7 | 58 | 115 | 161 | 221 | 268 | 316 | |
| | | | | | | | | 0.577 | 0.697 | 0.756 | 0.795 | 0.812 | 0.821 | |
| 03407500 | 165.00 | 165.00 | 19.50 | 30.00 | 2.30 | 1.54 | 10.1 | 9050 | 13700 | 16800 | 20700 | 23600 | 26600 | |
| | | | | | | | | 1.175 | 1.202 | 1.209 | 1.190 | 1.174 | 1.162 | |
| 03412500 | 31.30 | 31.30 | 9.55 | 12.20 | 2.91 | 1.28 | 21.3 | 2060 | 2770 | 3240 | 3840 | 4290 | 4750 | |
| | | | | | | | | 1.056 | 0.923 | 0.869 | 0.814 | 0.780 | 0.754 | |

* = Gage on Regulated Stream

# REGIONAL METHOD : HYDROLOGIC REGION NO. 5
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At mi² | Ac mi² | Ba mi | Lc mi | Bs mi/mi | Ss mi/mi | Sc ft/mi | | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Weighted Discharge (Qw) and Gage Correction (Cg); Q in cubic feet per second | | | | | |
| 03299000 | 239.00 | 239.00 | 25.70 | 38.60 | 2.76 | 1.50 | 9.1 | Qw | 14500 | 22200 | 27900 | 35600 | 41800 | 48400 |
| | | | | | | | | Cg | 1.051 | 1.005 | 0.972 | 0.937 | 0.919 | 0.890 |
| 03302000 | 64.00 | 64.00 | 12.70 | 15.20 | 2.52 | 1.20 | 11.7 | | 2850 | 4190 | 5280 | 6610 | 7870 | 9310 |
| | | | | | | | | | 0.523 | 0.475 | 0.459 | 0.432 | 0.430 | 0.425 |
| 03302085 | 0.90 | 0.85 | 1.57 | 2.00 | 2.74 | 1.27 | 60.5 | | 190 | 301 | 391 | 497 | 602 | 724 |
| | | | | | | | | | 0.739 | 0.697 | 0.686 | 0.646 | 0.647 | 0.646 |
| 03304500 | 2.14 | 2.14 | 1.76 | 2.10 | 1.45 | 1.19 | 150.0 | | 382 | 744 | 1040 | 1450 | 1790 | 2140 |
| | | | | | | | | | 0.775 | 0.904 | 0.963 | 0.993 | 1.017 | 1.014 |
| 03305000 | 22.40 | 22.40 | 5.32 | 8.30 | 1.26 | 1.56 | 32.1 | | 3900 | 7900 | 11100 | 15900 | 19800 | 23800 |
| | | | | | | | | | 1.506 | 1.863 | 2.004 | 2.152 | 2.227 | 2.245 |
| 03305500 | 36.30 | 36.30 | 6.56 | 9.10 | 1.19 | 1.39 | 28.4 | | 5190 | 9290 | 12300 | 16700 | 20000 | 23600 |
| | | | | | | | | | 1.442 | 1.564 | 1.589 | 1.621 | 1.613 | 1.595 |
| 03305559 | 0.88 | 0.88 | 1.85 | 1.95 | 3.89 | 1.05 | 104.9 | | 358 | 525 | 634 | 784 | 902 | 1030 |
| | | | | | | | | | 1.361 | 1.185 | 1.086 | 0.996 | 0.947 | 0.904 |
| 03305725 | 1.37 | 1.37 | 1.33 | 1.84 | 1.29 | 1.38 | 82.9 | | 415 | 820 | 1170 | 1780 | 2280 | 2880 |
| | | | | | | | | | 1.153 | 1.360 | 1.474 | 1.664 | 1.767 | 1.858 |
| 03305835 | 0.71 | 0.71 | 1.49 | 1.71 | 3.13 | 1.15 | 154.2 | | 247 | 356 | 439 | 553 | 654 | 770 |
| | | | | | | | | | 1.093 | 0.934 | 0.873 | 0.814 | 0.797 | 0.780 |
| 03306000 * | 682.00 | 682.00 | 40.50 | 79.10 | 2.41 | 1.95 | 3.9 | | 19300 | 30700 | 41600 | 55200 | 68500 | 84000 |
| | | | | | | | | | 0.666 | 0.667 | 0.699 | 0.702 | 0.730 | 0.754 |
| 03306500 * | 736.00 | 729.00 | 45.80 | 103.00 | 2.85 | 2.24 | 3.5 | | 18400 | 28100 | 36100 | 46400 | 56200 | 67100 |
| | | | | | | | | | 0.605 | 0.583 | 0.579 | 0.564 | 0.572 | 0.575 |
| 03307000 | 188.00 | 173.00 | 18.70 | 28.40 | 1.86 | 1.52 | 9.4 | | 8730 | 15100 | 20400 | 28700 | 36000 | 44500 |
| | | | | | | | | | 0.794 | .0853 | 0.891 | 0.944 | 0.989 | 1.030 |
| 03307100 | 265.00 | 246.00 | 23.10 | 58.70 | 2.01 | 2.54 | 5.1 | | 11900 | 22000 | 31100 | 45900 | 59100 | 74700 |
| | | | | | | | | | 0.844 | 0.973 | 1.061 | 1.183 | 1.274 | 1.346 |
| 03307500 | 18.30 | 18.30 | 6.17 | 9.00 | 2.08 | 1.46 | 16.4 | | 1820 | 2720 | 3480 | 4550 | 5510 | 6620 |
| | | | | | | | | | 0.809 | 0.739 | 0.723 | 0.708 | 0.713 | 0.715 |
| 03307670 | 2.53 | 2.34 | 2.50 | 3.03 | 2.47 | 1.21 | 78.7 | | 983 | 1460 | 1760 | 2240 | 2570 | 2930 |
| | | | | | | | | | 1.872 | 1.667 | 1.530 | 1.445 | 1.374 | 1.302 |
| 03309500 | 5.34 | 5.34 | 4.19 | 4.90 | 3.29 | 1.17 | 24.0 | | 873 | 1510 | 2000 | 2700 | 3280 | 3910 |
| | | | | | | | | | 0.928 | 0.968 | 0.980 | 0.985 | 0.994 | 0.987 |
| 03310000 | 36.4 | 35.6 | 8.57 | 10.7 | 2.02 | 1.25 | 20.0 | | 4230 | 6730 | 8410 | 10600 | 12100 | 13700 |
| | | | | | | | | | 1.175 | 1.148 | 1.101 | 1.039 | 0.992 | 0.932 |
| 03312500 | 531.00 | 514.00 | 23.90 | 65.80 | 1.08 | 2.75 | 4.3 | | 19600 | 33700 | 45300 | 62200 | 76600 | 92700 |
| | | | | | | | | | 0.824 | 0.892 | 0.926 | 0.963 | 0.992 | 1.005 |
| 03312795 | 0.89 | 0.89 | 0.77 | 0.86 | 0.67 | 1.12 | 186.1 | | 181 | 283 | 378 | 495 | 615 | 753 |
| | | | | | | | | | 0.683 | 0.634 | 0.643 | 0.624 | 0.641 | 0.655 |
| 03313020 | 0.24 | 0.24 | 0.62 | 0.66 | 1.60 | 1.06 | 121.6 | | 88 | 142 | 185 | 241 | 292 | 351 |
| | | | | | | | | | 0.835 | 0.793 | 0.781 | 0.753 | 0.752 | 0.750 |
| 03313500 | 7.47 | 7.47 | 4.27 | 4.80 | 2.44 | 1.12 | 47.2 | | 1430 | 2080 | 2580 | 3310 | 3920 | 4600 |
| | | | | | | | | | 1.202 | 1.056 | 1.000 | 0.957 | 0.940 | 0.920 |
| 03313600 | 0.95 | 0.95 | -- | -- | -- | -- | 73.9 | | 220 | 419 | 591 | 849 | 1070 | 1320 |
| | | | | | | | | | 0.791 | 0.897 | 0.959 | 1.023 | 1.070 | 1.091 |

* = Gage on Regulated Stream

## REGIONAL METHOD : HYDROLOGIC REGION NO. 5 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mi² | mi² | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03313700 | 110.00 | 91.00 | 17.00 | 22.80 | 2.63 | 1.34 | 9.1 | 7540 | 11800 | 15000 | 19700 | 23400 | 27600 | Qw |
| | | | | | | | | 1.079 | 1.044 | 1.020 | 1.010 | 1.000 | 0.986 | Cg |
| 03313800 | 21.60 | 7.80 | 7.23 | 9.20 | 2.42 | 1.27 | 19.5 | 2010 | 3600 | 4830 | 6730 | 8220 | 9790 | |
| | | | | | | | | 1.634 | 1.770 | 1.816 | 1.890 | 1.916 | 1.901 | |
| 03314000 | 478.00 | 358.00 | 28.30 | 41.70 | 1.68 | 1.47 | 6.6 | 16400 | 27600 | 37100 | 51800 | 64800 | 79800 | |
| | | | | | | | | 0.891 | 0.942 | 0.976 | 1.030 | 1.078 | 1.110 | |
| 03408500 | 382.00 | 382.00 | 23.90 | 46.20 | 1.49 | 1.94 | 7.1 | 24100 | 34300 | 41700 | 51600 | 59400 | 68000 | |
| | | | | | | | | 1.249 | 1.117 | 1.048 | 0.981 | 0.944 | 0.904 | |
| 03409000 | 13.50 | 13.50 | 4.54 | 5.70 | 1.53 | 1.26 | 54.5 | 1960 | 2830 | 3460 | 4280 | 4970 | 5730 | |
| | | | | | | | | 1.083 | 0.950 | 0.889 | 0.821 | 0.793 | 0.763 | |
| 03413200 | 43.40 | 43.40 | 10.60 | 17.50 | 2.59 | 1.65 | 20.2 | 3560 | 5900 | 7700 | 10100 | 12100 | 14400 | |
| | | | | | | | | 0.860 | 0.877 | 0.878 | 0.863 | 0.864 | 0.857 | |
| 03413202 | 0.57 | 0.57 | 0.87 | 1.10 | 1.33 | 1.26 | 333.3 | 159 | 309 | 443 | 657 | 845 | 1060 | |
| | | | | | | | | 0.820 | 0.945 | 1.025 | 1.127 | 1.197 | 1.249 | |
| 03413425 | 0.76 | 0.76 | 1.09 | 1.16 | 1.56 | 1.06 | 189.7 | 179 | 245 | 307 | 378 | 462 | 561 | |
| | | | | | | | | 0.755 | 0.613 | 0.583 | 0.532 | 0.537 | 0.545 | |
| 03414102 | 3.52 | 3.52 | 2.44 | 3.13 | 1.69 | 1.28 | 49.4 | 618 | 1090 | 1460 | 1990 | 2420 | 2900 | |
| | | | | | | | | 0.882 | 0.932 | 0.954 | 0.971 | 0.976 | 0.976 | |
| 03414500 | 202.00 | 196.00 | 26.80 | 37.60 | 3.56 | 1.40 | 37.0 | 16100 | 24300 | 30000 | 37500 | 43000 | 48800 | |
| | | | | | | | | 1.342 | 1.259 | 1.200 | 1.130 | 1.083 | 1.027 | |
| 03415000 | 115.00 | 81.00 | 17.00 | 20.50 | 2.50 | 1.21 | 33.6 | 6700 | 10000 | 12200 | 14900 | 17000 | 19300 | |
| | | | | | | | | 1.040 | 0.962 | 0.904 | 0.838 | 0.787 | 0.748 | |
| 03415700 | 7.98 | 4.77 | 3.35 | 4.40 | 1.41 | 1.31 | 68.5 | 742 | 1160 | 1440 | 1790 | 2080 | 2380 | |
| | | | | | | | | 0.855 | 0.806 | 0.762 | 0.705 | 0.680 | 0.649 | |
| 03416000 | 106.00 | 106.00 | 15.60 | 23.40 | 2.29 | 1.50 | 12.3 | 7000 | 10100 | 12300 | 15000 | 17200 | 19600 | |
| | | | | | | | | 0.899 | 0.808 | 0.755 | 0.691 | 0.662 | 0.630 | |
| 03417700 | 0.49 | 0.49 | -- | 0.90 | -- | -- | 161.4 | 137 | 247 | 337 | 464 | 571 | 689 | |
| | | | | | | | | 0.787 | 0.840 | 0.866 | 0.884 | 0.898 | 0.901 | |
| 03418000 | 78.70 | 51.60 | 10.50 | 20.10 | 1.39 | 1.92 | 14.6 | 3460 | 5560 | 7110 | 9080 | 10700 | 12400 | |
| | | | | | | | | 0.739 | 0.733 | 0.719 | 0.688 | 0.677 | 0.656 | |

# REGIONAL METHOD : HYDROLOGIC REGION NO. 6
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
| | $mi^2$ | $mi^2$ | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03310300 | 357.00 | 237.00 | 23.80 | 46.30 | 1.59 | 1.95 | 4.2 | 8310 | 12900 | 16600 | 21600 | 25900 | 30800 | Qw |
| | | | | | | | | 0.639 | 0.626 | 0.626 | 0.617 | 0.621 | 0.621 | Cg |
| 03310385 | 0.56 | 0.56 | 0.65 | 0.85 | 0.75 | 1.31 | 117.2 | 202 | 346 | 444 | 570 | 664 | 758 | |
| | | | | | | | | 1.020 | 1.142 | 1.175 | 1.185 | 1.173 | 1.159 | |
| 03310400 | 85.40 | 54.40 | 15.20 | 27.20 | 2.71 | 1.79 | 8.0 | 1800 | 3270 | 4450 | 6090 | 7420 | 8810 | |
| | | | | | | | | 0.571 | 0.720 | 0.815 | 0.912 | 0.976 | 1.028 | |
| 03310500 | 600.00 | 378.00 | 31.30 | 91.40 | 1.63 | 2.92 | 2.6 | 9700 | 13900 | 17100 | 20900 | 24200 | 27900 | |
| | | | | | | | | 0.651 | 0.607 | 0.592 | 0.560 | 0.551 | 0.541 | |
| 03310880 | 0.31 | 0.31 | 0.74 | 0.79 | 1.77 | 1.07 | 309.9 | 117 | 192 | 259 | 352 | 435 | 523 | |
| | | | | | | | | 0.672 | 0.691 | 0.730 | 0.755 | 0.777 | 0.794 | |
| 03311000 * | 703.00 | 480.00 | 38.90 | 75.50 | 2.15 | 1.94 | 3.2 | 10900 | 16100 | 20200 | 25300 | 29700 | 34800 | |
| | | | | | | | | 0.619 | 0.603 | 0.601 | 0.587 | 0.588 | 0.589 | |
| 03311600 | 10.90 | 10.90 | 4.80 | 6.71 | 2.11 | 1.40 | 23.9 | 1600 | 2700 | 3470 | 4530 | 5320 | 6150 | |
| | | | | | | | | 1.270 | 1.444 | 1.515 | 1.584 | 1.612 | 1.631 | |
| 03312000 | 30.80 | 30.80 | 5.40 | 7.70 | 0.95 | 1.43 | 26.8 | 4620 | 6120 | 7010 | 8100 | 8900 | 9690 | |
| | | | | | | | | 1.500 | 1.305 | 1.202 | 1.090 | 1.025 | 0.969 | |
| 03314750 | 0.50 | 0.50 | 0.82 | 1.09 | 1.34 | 1.33 | 226.7 | 136 | 202 | 258 | 341 | 412 | 493 | |
| | | | | | | | | 0.591 | 0.555 | 0.557 | 0.565 | 0.571 | 0.581 | |
| 03315885 | 0.25 | 0.22 | 0.64 | 0.73 | 1.64 | 1.14 | 91.0 | 59 | 88 | 114 | 148 | 177 | 207 | |
| | | | | | | | | 0.700 | 0.710 | 0.750 | 0.783 | 0.808 | 0.828 | |
| 03316000 | 90.50 | 80.80 | 13.40 | 24.40 | 1.99 | 1.82 | 7.1 | 5180 | 7250 | 8620 | 10400 | 11700 | 13100 | |
| | | | | | | | | 1.242 | 1.206 | 1.191 | 1.171 | 1.158 | 1.149 | |
| 03317000 | 225.00 | 158.00 | 16.90 | 39.80 | 1.26 | 2.36 | 4.9 | 8830 | 11800 | 13400 | 15200 | 16500 | 17700 | |
| | | | | | | | | 1.399 | 1.307 | 1.241 | 1.152 | 1.100 | 1.054 | |
| 03317500 | 42.00 | 22.60 | 7.46 | 11.30 | 1.33 | 1.51 | 15.3 | 2030 | 2880 | 3420 | 4070 | 4560 | 5040 | |
| | | | | | | | | 1.041 | 1.007 | 0.983 | 0.942 | 0.919 | 0.895 | |
| 03317965 | 0.38 | 0.38 | 0.73 | 1.02 | 1.40 | 1.40 | 222.7 | 220 | 321 | 390 | 487 | 566 | 651 | |
| | | | | | | | | 1.209 | 1.118 | 1.071 | 1.032 | 1.005 | 0.988 | |
| 03318000 | 454.00 | 344.00 | 27.90 | 49.20 | 1.71 | 1.76 | 3.4 | 8840 | 12500 | 14700 | 17300 | 19200 | 21200 | |
| | | | | | | | | 0.842 | 0.839 | 0.826 | 0.801 | 0.787 | 0.774 | |
| 03318200 | 20.10 | 20.10 | 5.63 | 6.30 | 1.58 | 1.12 | 31.3 | 2910 | 4410 | 5480 | 6950 | 8120 | 9360 | |
| | | | | | | | | 1.265 | 1.260 | 1.260 | 1.252 | 1.253 | 1.250 | |
| 03318500 | 504.00 | 394.00 | 26.90 | 73.30 | 1.43 | 2.73 | 2.4 | 9200 | 12300 | 14200 | 16600 | 18400 | 20300 | |
| | | | | | | | | 0.893 | 0.848 | 0.830 | 0.806 | 0.797 | 0.790 | |
| 03318505 | 0.22 | 0.22 | 0.76 | 0.82 | 2.63 | 1.08 | 246.0 | 139 | 216 | 263 | 323 | 370 | 418 | |
| | | | | | | | | 1.149 | 1.143 | 1.100 | 1.045 | 1.005 | 0.972 | |
| 03318800 | 124.00 | 124.00 | 19.30 | 29.60 | 3.00 | 1.53 | 3.0 | 5410 | 7680 | 9190 | 11100 | 12600 | 14000 | |
| | | | | | | | | 1.252 | 1.282 | 1.304 | 1.321 | 1.343 | 1.346 | |
| 03319000 | 757.00 | 637.00 | 40.20 | 74.50 | 2.13 | 1.85 | 2.9 | 10800 | 15400 | 18700 | 22700 | 25700 | 28800 | |
| | | | | | | | | 0.663 | 0.661 | 0.670 | 0.668 | 0.668 | 0.667 | |
| 03319520 | 0.26 | 0.26 | 0.89 | 0.93 | 3.05 | 1.04 | 121.6 | 106 | 157 | 189 | 231 | 263 | 297 | |
| | | | | | | | | 0.991 | 0.969 | 0.945 | 0.917 | 0.892 | 0.876 | |
| 03321350 | 58.20 | 58.20 | 14.50 | 19.50 | 3.61 | 1.34 | 7.5 | 2710 | 3430 | 3980 | 4660 | 5230 | 5830 | |
| | | | | | | | | 0.834 | 0.734 | 0.709 | 0.678 | 0.671 | 0.664 | |

* = Gage on Regulated Stream

# REGIONAL METHOD : HYDROLOGIC REGION NO. 6 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

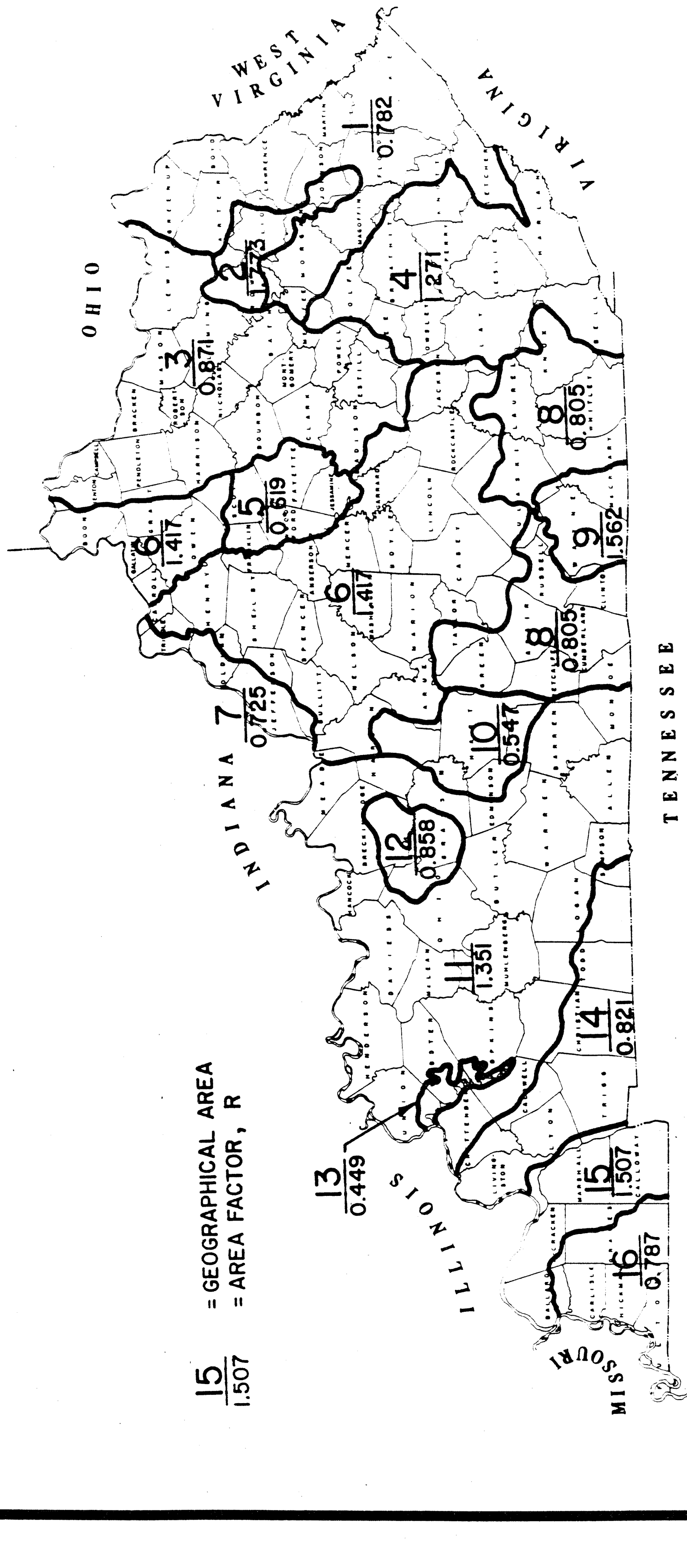
| Gage No. | At ($mi^2$) | Ac ($mi^2$) | Ba (mi) | Lc (mi) | Bs (mi/mi) | Ss (mi/mi) | Sc (ft/mi) | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Weighted Discharge (Qw) and Gage Correction (Cg) — Q in cubic feet per second | | | | | | |
| 03321465 | 0.29 | 0.29 | 0.67 | 0.75 | 1.55 | 1.12 | 62.1 | 106 | 158 | 194 | 241 | 278 | 315 | Qw |
| | | | | | | | | 1.164 | 1.188 | 1.198 | 1.211 | 1.214 | 1.216 | Cg |
| 03322360 | 14.30 | 14.30 | 5.73 | 5.91 | 2.30 | 1.03 | 13.5 | 2140 | 2490 | 2660 | 2890 | 3070 | 3260 | |
| | | | | | | | | 1.672 | 1.346 | 1.193 | 1.059 | 0.984 | 0.929 | |

# REGIONAL METHOD : HYDROLOGIC REGION NO. 7
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

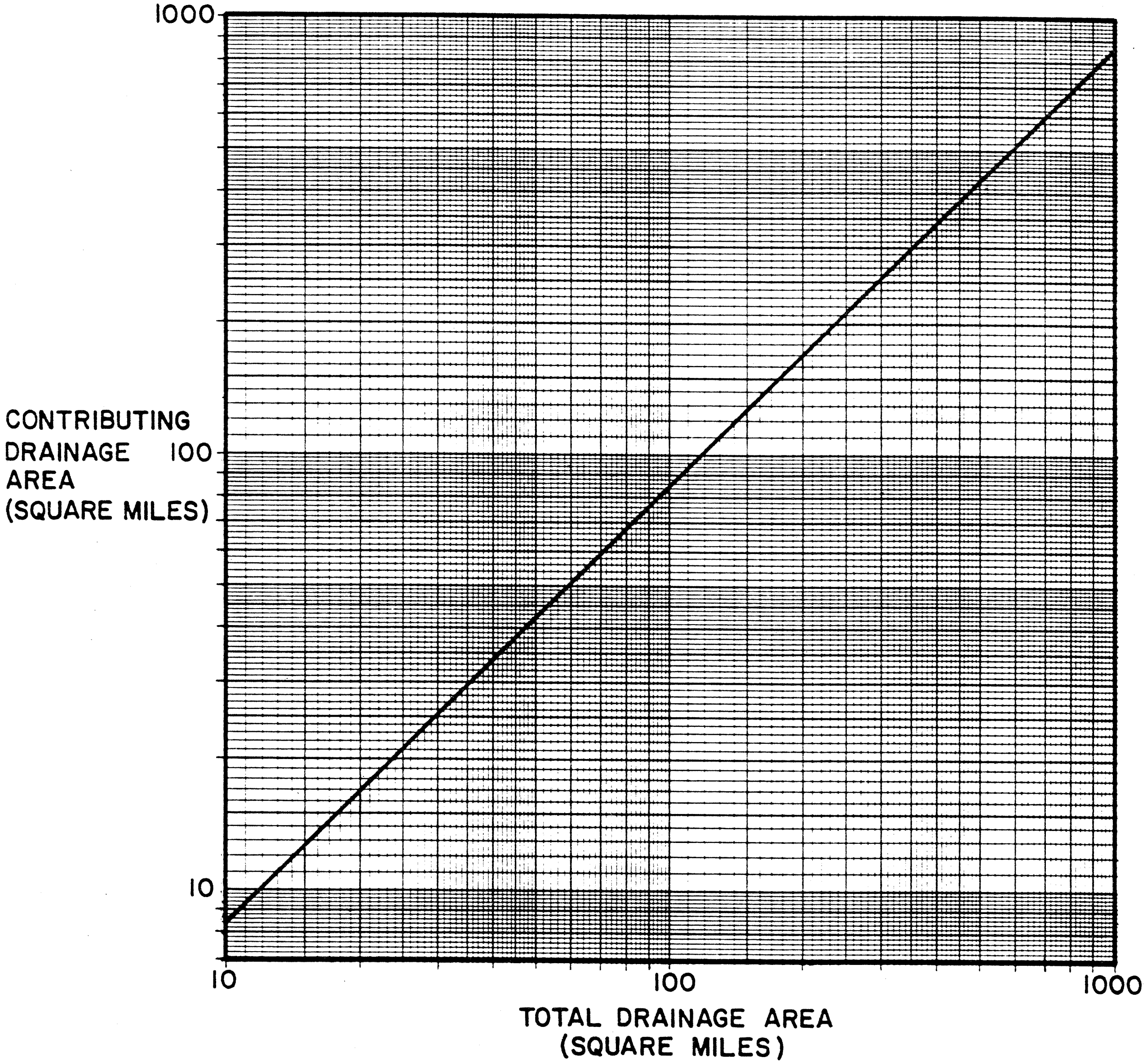
| Gage No. | At | Ac | Ba | Lc | Bs | Ss | Sc | Weighted Discharge (Qw) and Gage Correction (Cg) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
| | mi² | mi² | mi | mi | mi/mi | mi/mi | ft/mi | Q in cubic feet per second | | | | | | |
| 03320500 | 194.00 | 194.00 | 18.90 | 40.30 | 1.84 | 2.13 | 4.6 | 7280 | 12300 | 16200 | 21800 | 26300 | 31200 | Qw |
| | | | | | | | | 1.033 | 1.088 | 1.125 | 1.141 | 1.154 | 1.160 | Cg |
| 03321275 | 0.95 | 0.95 | 1.45 | 1.49 | 2.21 | 1.03 | 51.8 | 419 | 616 | 749 | 922 | 1060 | 1190 | |
| | | | | | | | | 1.088 | 1.042 | 1.022 | 1.001 | 0.991 | 0.983 | |
| 03382975 | 0.91 | 0.91 | 0.91 | 1.36 | 0.91 | 1.49 | 10.7 | 371 | 672 | 890 | 1180 | 1400 | 1620 | |
| | | | | | | | | 0.857 | 0.994 | 1.050 | 1.093 | 1.102 | 1.110 | |
| 03383000 | 255.00 | 246.00 | 25.60 | 53.30 | 2.56 | 2.08 | 2.0 | 3990 | 6290 | 8150 | 10800 | 13200 | 15700 | |
| | | | | | | | | 0.572 | 0.562 | 0.566 | 0.563 | 0.574 | 0.579 | |
| 03383605 | 2.52 | 2.52 | 1.92 | 2.51 | 1.46 | 1.31 | 111.5 | 1190 | 1610 | 1870 | 2190 | 2430 | 2670 | |
| | | | | | | | | 1.619 | 1.412 | 1.317 | 1.217 | 1.152 | 1.108 | |
| 03384000 | 2.10 | 2.10 | 1.79 | 2.20 | 1.53 | 1.23 | 28.8 | 604 | 865 | 1030 | 1240 | 1400 | 1560 | |
| | | | | | | | | 0.893 | 0.832 | 0.798 | 0.761 | 0.737 | 0.716 | |
| 03435140 | 20.80 | 20.80 | 4.41 | 7.37 | 0.94 | 1.67 | 13.8 | 3270 | 5120 | 6470 | 8350 | 9860 | 11400 | |
| | | | | | | | | 1.086 | 1.117 | 1.125 | 1.131 | 1.135 | 1.129 | |
| 03435500 | 706.00 | 309.00 | 33.90 | 66.90 | 1.63 | 1.97 | 4.4 | 14000 | 21000 | 26000 | 33000 | 38500 | 44300 | |
| | | | | | | | | 1.261 | 1.214 | 1.193 | 1.154 | 1.129 | 1.110 | |
| 03435600 | 3.50 | 3.50 | 2.96 | 3.52 | 2.50 | 1.19 | 51.7 | 611 | 1050 | 1390 | 1860 | 2240 | 2630 | |
| | | | | | | | | 0.829 | 0.921 | 0.972 | 1.022 | 1.052 | 1.078 | |
| 03436000 | 186.00 | 165.00 | 22.70 | 36.30 | 2.77 | 1.60 | 6.6 | 7030 | 10900 | 13800 | 18100 | 21600 | 25400 | |
| | | | | | | | | 1.060 | 1.058 | 1.062 | 1.071 | 1.075 | 1.090 | |
| 03436700 | 124.00 | 124.00 | 18.40 | 25.70 | 2.72 | 1.40 | 12.3 | 5850 | 9170 | 11600 | 14700 | 17200 | 19800 | |
| | | | | | | | | 0.927 | 0.949 | 0.959 | 0.948 | 0.945 | 0.943 | |
| 03437380 | 0.83 | 0.83 | 1.57 | 1.77 | 2.97 | 1.13 | 76.0 | 240 | 374 | 471 | 598 | 701 | 804 | |
| | | | | | | | | 0.879 | 0.868 | 0.869 | 0.865 | 0.868 | 0.871 | |
| 03437390 | 0.39 | 0.39 | 0.64 | 0.85 | 1.05 | 1.33 | 140.7 | 210 | 323 | 409 | 526 | 623 | 724 | |
| | | | | | | | | 0.820 | 0.810 | 0.820 | 0.830 | 0.842 | 0.854 | |
| 03437490 | 2.62 | 1.41 | 2.82 | 3.39 | 3.04 | 1.20 | 27.1 | 137 | 287 | 412 | 592 | 741 | 901 | |
| | | | | | | | | 0.382 | 0.504 | 0.573 | 0.642 | 0.686 | 0.727 | |
| 03437500 | 46.50 | 35.30 | 11.10 | 17.40 | 2.65 | 1.57 | 7.1 | 2760 | 4370 | 5600 | 7330 | 8730 | 10200 | |
| | | | | | | | | 1.100 | 1.104 | 1.116 | 1.123 | 1.129 | 1.135 | |
| 03438000 | 244.00 | 150.00 | 25.70 | 48.00 | 2.71 | 1.87 | 3.6 | 6630 | 10200 | 12800 | 16700 | 19800 | 23100 | |
| | | | | | | | | 1.221 | 1.176 | 1.153 | 1.144 | 1.138 | 1.132 | |
| 03438070 | 30.50 | 30.50 | 5.52 | 6.70 | 1.00 | 1.21 | 20.0 | 3740 | 5050 | 6040 | 7410 | 8550 | 9820 | |
| | | | | | | | | 0.736 | 0.683 | 0.673 | 0.662 | 0.663 | 0.664 | |
| 03610000 | 89.70 | 89.70 | 9.76 | 13.20 | 1.06 | 1.35 | 8.6 | 6070 | 10800 | 14800 | 20800 | 25900 | 31800 | |
| | | | | | | | | 0.675 | 0.818 | 0.919 | 1.030 | 1.102 | 1.178 | |
| 03610470 | 0.96 | 0.96 | 1.39 | 1.66 | 2.01 | 1.19 | 57.7 | 417 | 612 | 739 | 903 | 1030 | 1150 | |
| | | | | | | | | 1.178 | 1.105 | 1.065 | 1.024 | 1.000 | 0.975 | |
| 03610500 | 227.00 | 227.00 | 31.20 | 37.50 | 4.29 | 1.20 | 6.2 | 9860 | 16600 | 21600 | 28400 | 33600 | 39000 | |
| | | | | | | | | 1.174 | 1.307 | 1.367 | 1.406 | 1.424 | 1.439 | |
| 03610503 | 0.82 | 0.82 | 1.09 | 1.21 | 1.45 | 1.11 | 52.9 | 647 | 922 | 1090 | 1280 | 1420 | 1550 | |
| | | | | | | | | 1.567 | 1.463 | 1.399 | 1.307 | 1.257 | 1.202 | |

# REGIONAL METHOD : HYDROLOGIC REGION NO. 7 (cont.)
## GAGE STATIONS, BASIN CHARACTERISTICS, AND DISCHARGES

| Gage No. | At mi² | Ac mi² | Ba mi | Lc mi | Bs mi/mi | Ss mi/mi | Sc ft/mi | Q_2 | Q_5 | Q_10 | Q_25 | Q_50 | Q_100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Weighted Discharge (Qw) and Gage Correction (Cg) — Q in cubic feet per second | | | | | | |
| 03610545 | 68.70 | 68.70 | 12.90 | 13.80 | 2.42 | 1.07 | 11.6 | 5340 | 7880 | 9530 | 11600 | 13200 | 14800 | Qw |
| | | | | | | | | 0.904 | 0.906 | 0.899 | 0.872 | 0.857 | 0.846 | Cg |
| 03610820 | 0.13 | 0.13 | 0.56 | 0.62 | 2.41 | 1.11 | 75.2 | 84 | 149 | 202 | 277 | 337 | 401 | |
| | | | | | | | | 0.904 | 1.014 | 1.092 | 1.174 | 1.225 | 1.277 | |
| 03611260 | 14.60 | 14.60 | 5.47 | 6.13 | 2.05 | 1.12 | 17.8 | 2250 | 3570 | 4470 | 5650 | 6530 | 7420 | |
| | | | | | | | | 1.004 | 1.063 | 1.082 | 1.087 | 1.083 | 1.078 | |
| 07022500 | 1.72 | 1.72 | 1.87 | 2.10 | 2.03 | 1.12 | 28.1 | 704 | 1090 | 1360 | 1730 | 2010 | 2300 | |
| | | | | | | | | 1.282 | 1.291 | 1.295 | 1.301 | 1.305 | 1.307 | |
| 07023000 | 212.00 | 212.00 | 34.30 | 41.80 | 5.55 | 1.22 | 5.3 | 6850 | 9910 | 12100 | 15200 | 17700 | 20400 | |
| | | | | | | | | 1.001 | 0.944 | 0.917 | 0.899 | 0.894 | 0.891 | |
| 07023040 | 0.53 | 0.53 | 0.94 | 1.02 | 1.67 | 1.09 | 58.6 | 143 | 236 | 301 | 384 | 448 | 512 | |
| | | | | | | | | 0.490 | 0.526 | 0.539 | 0.547 | 0.550 | 0.553 | |
| 07023500 | 36.80 | 36.80 | 11.10 | 13.90 | 3.33 | 1.25 | 10.9 | 3790 | 4980 | 5720 | 6650 | 7350 | 8050 | |
| | | | | | | | | 1.089 | 0.960 | 0.899 | 0.833 | 0.795 | 0.767 | |
| 07023935 | 0.23 | 0.23 | 0.63 | 0.95 | 1.73 | 1.51 | 59.3 | 120 | 171 | 208 | 256 | 295 | 337 | |
| | | | | | | | | 1.000 | 0.868 | 0.822 | 0.780 | 0.760 | 0.751 | |
| 07024000 | 68.70 | 68.70 | 15.10 | 18.20 | 3.32 | 1.21 | 8.0 | 3370 | 4990 | 6090 | 7490 | 8570 | 9670 | |
| | | | | | | | | 0.764 | 0.745 | 0.732 | 0.707 | 0.691 | 0.681 | |
| 07026500 | 110.00 | 110.00 | 16.80 | 24.30 | 2.56 | 1.45 | 3.7 | 5600 | 9110 | 11800 | 15600 | 18600 | 21800 | |
| | | | | | | | | 0.959 | 1.014 | 1.054 | 1.076 | 1.094 | 1.107 | |


WEST VIRGINIA
VIRGINIA
OHIO
INDIANA
ILLINOIS
MISSOURI
TENNESSEE
1 / 0.782
2 / 1.773
3 / 0.871
4 / 1.271
5 / 0.619
6 / 1.417
6 / 1.417
7 / 0.725
8 / 0.805
8 / 0.805
9 / 1.562
10 / 0.547
11 / 1.351
12 / 0.858
13 / 0.449
14 / 0.821
15 / 1.507
16 / 0.787
15 = GEOGRAPHICAL AREA
1.507 = AREA FACTOR, R

| | Frequency, in years | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 50 | 100 |
| R \ b | 0.965 | 0.991 | 1.006 | 1.025 | 1.040 | 1.051 |
| 0.449 | .462 | .452 | .447 | .440 | .435 | .431 |
| .547 | .559 | .550 | .545 | .539 | .534 | .530 |
| .619 | .629 | .622 | .617 | .612 | .607 | .604 |
| .725 | .733 | .727 | .724 | .719 | .716 | .713 |
| .782 | .789 | .784 | .781 | .777 | .774 | .772 |
| .787 | .794 | .789 | .786 | .782 | .779 | .777 |
| .805 | .811 | .807 | .804 | .801 | .798 | .796 |
| .821 | .827 | .822 | .820 | .817 | .815 | .813 |
| .858 | .863 | .859 | .857 | .855 | .853 | .851 |
| .871 | .875 | .872 | .870 | .868 | .866 | .865 |
| 1.271 | 1.260 | 1.268 | 1.273 | 1.279 | 1.283 | 1.287 |
| 1.351 | 1.337 | 1.347 | 1.353 | 1.361 | 1.367 | 1.372 |
| 1.417 | 1.400 | 1.413 | 1.420 | 1.429 | 1.437 | 1.442 |
| 1.507 | 1.486 | 1.501 | 1.511 | 1.523 | 1.532 | 1.539 |
| 1.562 | 1.538 | 1.556 | 1.566 | 1.580 | 1.590 | 1.598 |
| 1.773 | 1.738 | 1.764 | 1.779 | 1.799 | 1.814 | 1.826 |


1000
CONTRIBUTING
DRAINAGE
AREA
(SQUARE MILES)
100
10
10
100
1000
TOTAL DRAINAGE AREA
(SQUARE MILES)

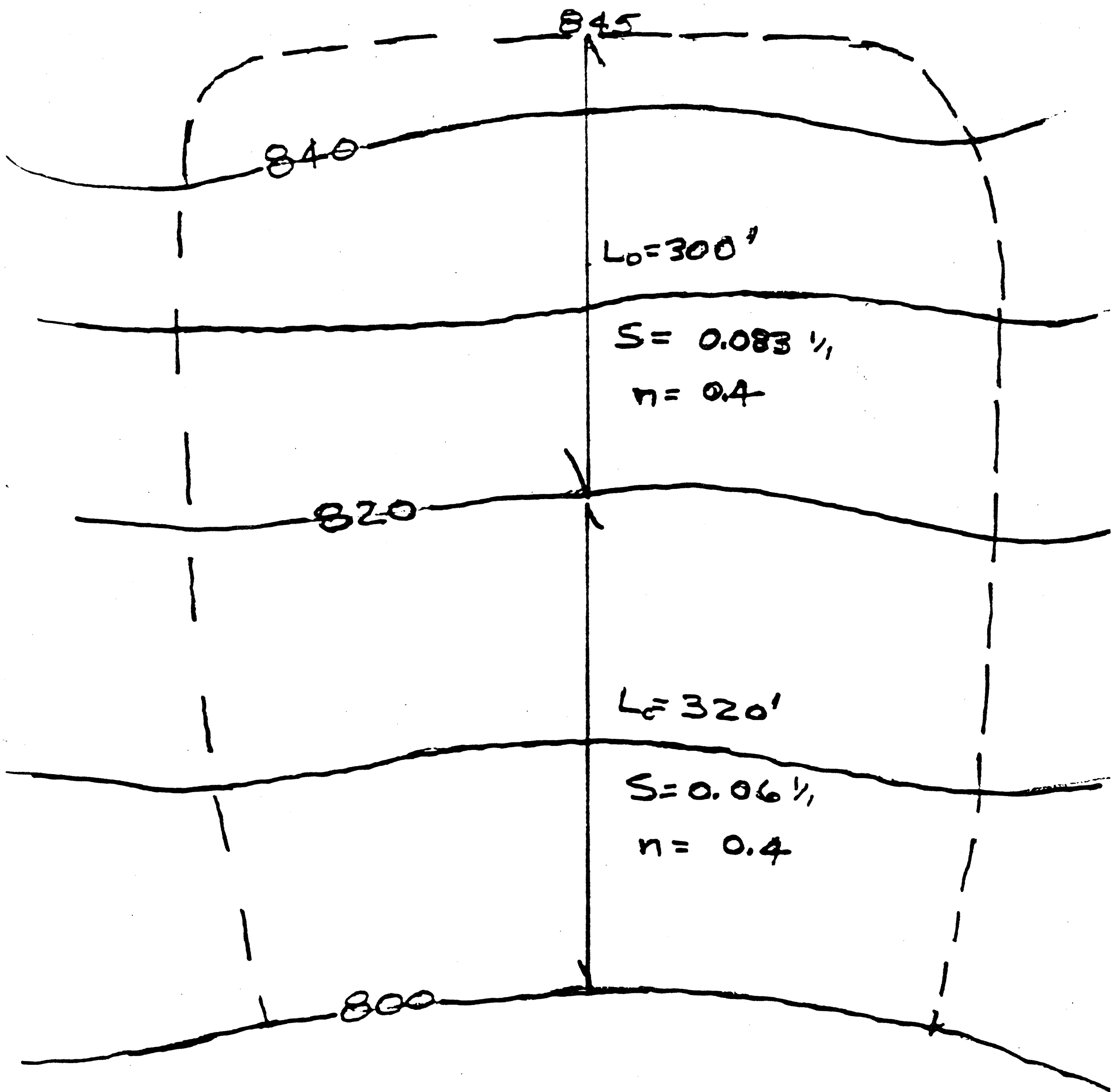
| Stream Name | Agency to contact for flood magnitude and frequency |
|---|---|
| 1. Levisa Fork below Fishtrap Lake near Millard, Ky. | U. S. Corps of Engineers Huntington, West Virginia |
| 2. Russell Fork downstream Va.-Kentucky State Line | " |
| 3. Johns Creek below Dewey Lake near Van Lear, Kentucky | " |
| 4. Big Sandy River downstream from Louisa, Kentucky | " |
| 5. Little Sandy River below Grayson Lake near Leon, Kentucky | " |
| 6. Licking River below Cave Run Lake near Farmers, KY. | U. S. Corps of Engineers Louisville, Kentucky |
| 7. Middle Fork Kentucky River below Buckhorn Lake at Buckhorn, KY. | " |
| 8. North Fork Kentucky River below Middle Fork Kentucky River | " |
| 9. Dix River below Herrington Lake near Burgin, Kentucky | ------ |
| 10. Green River below Green River Lake near Campbellsville, Ky. | U. S. Corps of Engineers Louisville, Kentucky |
| 11. Nolin River below Nolin River Lake near Kyrock, Kentucky | " |
| 12. Barren River below Barren River near Finney, Kentucky | " |
| 13. Rough River below Rough River Lake near Falls of Rough, Kentucky | " |
| 14. Cumberland River below Cumberland Lake near Jamestown, Kentucky | U. S. Corps of Engineers Nashville, Tennessee |
| 15. Cumberland River below Barkley Lake near Grand Rivers, KY. | " |
| 16. Tennessee River below Kentucky Lake at Gilbertsville, Ky. | Tennessee Valley Authority, Knoxville, Tennessee |
| 17. Ohio River below mouth of Cumberland River | U. S. Corps of Engineers Louisville, Kentucky |

| County | Number | P2,24 | P25,6 | P50,6 | P100,6 | PMP,6 |
|---|---|---|---|---|---|---|
| Adair | 001 | 3.3 | 3.8 | 4.4 | 4.6 | 28.7 |
| Allen | 002 | 3.4 | 3.9 | 4.5 | 4.7 | 28.9 |
| Anderson | 003 | 3.1 | 3.7 | 4.2 | 4.4 | 28.1 |
| Ballard | 004 | 3.6 | 4.2 | 4.7 | 5.1 | 28.7 |
| Barren | 005 | 3.3 | 3.9 | 4.4 | 4.7 | 28.8 |
| Bath | 006 | 3.0 | 3.6 | 4.0 | 4.3 | 28.0 |
| Bell | 007 | 3.1 | 3.9 | 4.4 | 4.7 | 28.9 |
| Boone | 008 | 3.0 | 3.5 | 4.0 | 4.2 | 27.5 |
| Bourbon | 009 | 3.0 | 3.6 | 4.0 | 4.3 | 28.0 |
| Boyd | 010 | 2.7 | 3.6 | 3.8 | 4.2 | 27.9 |
| Boyle | 011 | 3.2 | 3.7 | 4.2 | 4.5 | 28.4 |
| Bracken | 012 | 3.0 | 3.5 | 3.9 | 4.2 | 27.7 |
| Breathitt | 013 | 3.0 | 3.7 | 4.0 | 4.5 | 28.4 |
| Breckinridge | 014 | 3.3 | 3.8 | 4.3 | 4.6 | 28.3 |
| Bullitt | 015 | 3.2 | 3.7 | 4.2 | 4.5 | 28.2 |
| Butler | 016 | 3.4 | 3.9 | 4.4 | 4.7 | 28.7 |
| Caldwell | 017 | 3.4 | 4.0 | 4.5 | 4.9 | 28.7 |
| Calloway | 018 | 3.5 | 4.1 | 4.7 | 5.0 | 29.0 |
| Campbell | 019 | 3.0 | 3.5 | 3.9 | 4.2 | 27.5 |
| Carlisle | 020 | 3.6 | 4.2 | 4.7 | 5.1 | 28.9 |
| Carroll | 021 | 3.1 | 3.6 | 4.0 | 4.3 | 27.7 |
| Carter | 022 | 2.8 | 3.6 | 3.9 | 4.2 | 27.9 |
| Casey | 023 | 3.2 | 3.8 | 4.3 | 4.5 | 28.6 |
| Christian | 024 | 3.4 | 4.0 | 4.6 | 4.9 | 28.9 |
| Clark | 025 | 3.0 | 3.7 | 4.1 | 4.3 | 28.1 |
| Clay | 026 | 3.0 | 3.8 | 4.2 | 4.6 | 28.6 |
| Clinton | 027 | 3.3 | 3.9 | 4.4 | 4.7 | 28.9 |
| Crittenden | 028 | 3.5 | 4.0 | 4.5 | 4.9 | 28.6 |
| Cumberland | 029 | 3.3 | 3.9 | 4.4 | 4.7 | 28.9 |
| Daviess | 030 | 3.3 | 3.9 | 4.4 | 4.7 | 28.3 |
| Edmonson | 031 | 3.3 | 3.9 | 4.4 | 4.7 | 28.7 |
| Elliott | 032 | 2.8 | 3.6 | 3.9 | 4.3 | 28.0 |
| Estill | 033 | 3.0 | 3.7 | 4.1 | 4.4 | 28.3 |
| Fayette | 034 | 3.1 | 3.7 | 4.1 | 4.4 | 28.1 |
| Fleming | 035 | 2.9 | 3.6 | 3.9 | 4.2 | 27.9 |
| Floyd | 036 | 2.9 | 3.8 | 3.9 | 4.5 | 28.4 |
| Franklin | 037 | 3.1 | 3.6 | 4.1 | 4.4 | 28.0 |
| Fulton | 038 | 3.7 | 4.2 | 4.8 | 5.1 | 29.0 |
| Gallatin | 039 | 3.1 | 3.5 | 4.0 | 4.3 | 27.7 |
| Garrard | 040 | 3.1 | 3.7 | 4.2 | 4.4 | 28.3 |

| County | Number | P2,24 | P25,6 | P50,6 | P100,6 | PMP,6 |
|---|---|---|---|---|---|---|
| Grant | 041 | 3.1 | 3.5 | 4.0 | 4.3 | 27.7 |
| Graves | 042 | 3.6 | 4.1 | 4.7 | 5.0 | 28.9 |
| Grayson | 043 | 3.3 | 3.9 | 4.4 | 4.7 | 28.5 |
| Green | 044 | 3.3 | 3.8 | 4.3 | 4.6 | 28.6 |
| Greenup | 045 | 2.8 | 3.5 | 3.8 | 4.1 | 27.7 |
| Hancock | 046 | 3.3 | 3.9 | 4.3 | 4.7 | 28.2 |
| Hardin | 047 | 3.2 | 3.8 | 4.3 | 4.6 | 28.3 |
| Harlan | 048 | 3.0 | 3.8 | 4.3 | 4.7 | 28.8 |
| Harrison | 049 | 3.0 | 3.6 | 4.0 | 4.3 | 27.9 |
| Hart | 050 | 3.3 | 3.9 | 4.4 | 4.6 | 28.6 |
| Henderson | 051 | 3.4 | 4.0 | 4.4 | 4.8 | 28.3 |
| Henry | 052 | 3.1 | 3.6 | 4.1 | 4.4 | 27.9 |
| Hickman | 053 | 3.6 | 4.2 | 4.7 | 5.1 | 29.0 |
| Hopkins | 054 | 3.4 | 4.0 | 4.5 | 4.8 | 28.6 |
| Jackson | 055 | 3.1 | 3.8 | 4.2 | 4.5 | 28.5 |
| Jefferson | 056 | 3.2 | 3.7 | 4.2 | 4.5 | 28.0 |
| Jessamine | 057 | 3.1 | 3.7 | 4.1 | 4.4 | 28.2 |
| Johnson | 058 | 2.8 | 3.7 | 3.9 | 4.4 | 28.2 |
| Kenton | 059 | 3.0 | 3.5 | 3.9 | 4.2 | 27.5 |
| Knott | 060 | 2.9 | 3.8 | 4.0 | 4.5 | 28.5 |
| Knox | 061 | 3.1 | 3.8 | 4.4 | 4.7 | 28.8 |
| Larue | 062 | 3.2 | 3.8 | 4.3 | 4.6 | 28.4 |
| Laurel | 063 | 3.1 | 3.8 | 4.3 | 4.6 | 28.7 |
| Lawrence | 064 | 2.8 | 3.6 | 3.9 | 4.3 | 28.1 |
| Lee | 065 | 3.0 | 3.7 | 4.1 | 4.4 | 28.4 |
| Leslie | 066 | 3.0 | 3.8 | 4.2 | 4.6 | 28.7 |
| Letcher | 067 | 2.9 | 3.8 | 4.1 | 4.6 | 28.6 |
| Lewis | 068 | 2.8 | 3.5 | 3.9 | 4.2 | 27.8 |
| Lincoln | 069 | 3.2 | 3.8 | 4.3 | 4.5 | 28.5 |
| Livingston | 070 | 3.5 | 4.1 | 4.6 | 5.0 | 28.6 |
| Logan | 071 | 3.4 | 4.0 | 4.5 | 4.8 | 28.9 |
| Lyon | 072 | 3.5 | 4.1 | 4.6 | 4.9 | 28.8 |
| McCracken | 073 | 3.6 | 4.1 | 4.6 | 5.0 | 28.7 |
| McCreary | 074 | 3.2 | 3.9 | 4.4 | 4.7 | 28.9 |
| McLean | 075 | 3.4 | 3.9 | 4.4 | 4.8 | 28.5 |
| Madison | 076 | 3.1 | 3.7 | 4.2 | 4.4 | 28.3 |
| Magoffin | 077 | 2.9 | 3.7 | 4.0 | 4.4 | 28.3 |
| Marion | 078 | 3.2 | 3.8 | 4.3 | 4.5 | 28.4 |
| Marshall | 079 | 3.5 | 4.1 | 4.6 | 5.0 | 28.8 |
| Martin | 080 | 2.8 | 3.7 | 3.9 | 4.4 | 28.2 |

| County | Number | P2,24 | P25,6 | P50,6 | P100,6 | RVP,6 |
|---|---|---|---|---|---|---|
| Mason | 081 | 2.9 | 3.5 | 3.9 | 4.2 | 27.7 |
| Meade | 082 | 3.2 | 3.8 | 4.3 | 4.6 | 28.2 |
| Menifee | 083 | 2.9 | 3.7 | 4.0 | 4.3 | 28.2 |
| Mercer | 084 | 3.2 | 3.7 | 4.2 | 4.4 | 28.3 |
| Metcalfe | 085 | 3.3 | 3.9 | 4.4 | 4.7 | 28.8 |
| Monroe | 086 | 3.4 | 3.9 | 4.5 | 4.7 | 28.9 |
| Montgomery | 087 | 3.0 | 3.6 | 4.0 | 4.3 | 28.1 |
| Morgan | 088 | 2.9 | 3.7 | 4.0 | 4.3 | 28.2 |
| Muhlenberg | 089 | 3.4 | 4.0 | 4.5 | 4.8 | 28.6 |
| Nelson | 090 | 3.2 | 3.8 | 4.2 | 4.5 | 28.3 |
| Nicholas | 091 | 3.0 | 3.6 | 4.0 | 4.3 | 27.9 |
| Ohio | 092 | 3.3 | 3.9 | 4.4 | 4.7 | 28.5 |
| Oldham | 093 | 3.2 | 3.6 | 4.1 | 4.4 | 27.9 |
| Owen | 094 | 3.1 | 3.6 | 4.0 | 4.3 | 27.8 |
| Owsley | 095 | 3.0 | 3.7 | 4.1 | 4.5 | 28.5 |
| Pendleton | 096 | 3.0 | 3.5 | 4.0 | 4.2 | 27.7 |
| Perry | 097 | 3.0 | 3.8 | 4.1 | 4.6 | 28.6 |
| Pike | 098 | 2.9 | 3.8 | 4.0 | 4.5 | 28.4 |
| Powell | 099 | 3.0 | 3.7 | 4.1 | 4.4 | 28.2 |
| Pulaski | 100 | 3.2 | 3.8 | 4.3 | 4.6 | 28.7 |
| Robertson | 101 | 3.0 | 3.5 | 4.0 | 4.2 | 27.8 |
| Rockcastle | 102 | 3.1 | 3.8 | 4.2 | 4.5 | 28.5 |
| Rowan | 103 | 2.9 | 3.6 | 3.9 | 4.3 | 28.0 |
| Russell | 104 | 3.3 | 3.9 | 4.4 | 4.6 | 28.8 |
| Scott | 105 | 3.1 | 3.6 | 4.1 | 4.3 | 27.9 |
| Shelby | 106 | 3.2 | 3.7 | 4.1 | 4.4 | 28.0 |
| Simpson | 107 | 3.4 | 4.0 | 4.5 | 4.8 | 28.9 |
| Spencer | 108 | 3.2 | 3.7 | 4.2 | 4.4 | 28.1 |
| Taylor | 109 | 3.2 | 3.8 | 4.3 | 4.5 | 28.5 |
| Todd | 110 | 3.4 | 4.0 | 4.6 | 4.8 | 28.9 |
| Trigg | 111 | 3.5 | 4.1 | 4.6 | 4.9 | 28.9 |
| Trimble | 112 | 3.1 | 3.6 | 4.1 | 4.4 | 27.8 |
| Union | 113 | 3.4 | 4.0 | 4.5 | 4.8 | 28.4 |
| Warren | 114 | 3.4 | 3.9 | 4.5 | 4.7 | 28.8 |
| Washington | 115 | 3.2 | 3.7 | 4.2 | 4.5 | 28.3 |
| Wayne | 116 | 3.3 | 3.9 | 4.4 | 4.7 | 28.9 |
| Webster | 117 | 3.4 | 4.0 | 4.5 | 4.8 | 28.5 |
| Whitley | 118 | 3.2 | 3.9 | 4.4 | 4.7 | 28.9 |
| Wolfe | 119 | 2.9 | 3.7 | 4.0 | 4.4 | 28.3 |
| Woodford | 120 | 3.1 | 3.7 | 4.1 | 4.4 | 28.1 |

1/1/93 RAINFALL DATA EM#2 DR-04.939.4




Lo = 300',N = 0.4,P2,24 = 3.1,S = 0.083ft/ft

Lc = 320',N = 0.4, r = 0.4',

To = 30 minutes

Tt = 10 minutes

Tc = 40 minutes

**URBANIZATION TECHNIQUE : TC 61-D20** **(Rev. 1-93)** **Page 1 of 1**

County LOGAN Route US 68 Item No. 3-999.00

UPN SSP 071 0068 000-005 FPN Station 61+50

Equation --

$$UQ_{RI} = C \times A^{a} \times (13 - BDF)^{-b} \times RQ_{RI}{}^{c}$$

Where --

| | | |
|---|---|---|
| UQ | = | Runoff (cfs) for Urbanized Watershed |
| RI | = | Return Interval (yrs) |
| A | = | Drainage Area ($mi^2$) |
| BDF | = | Basin Development Factor ( 1 or 0 for each of 12 components in table below) |
| RQ | = | Runoff (cfs) from Regional Method Discharges |
| C, a, b, c | = | Constants for Equations below. |

BASIN DEVELOPMENT FACTOR : BDF

| Portion of Drainage Area | Channel 1 - 2 Improvement | Channel Lining 1- 2 | Storm Sewers 1 - 2 | Curb & Gutter Streets 2 |
|---|---|---|---|---|
| Upper Third | 1 | 0 | 0 | 0 |
| Middle Third | 0 | 0 | 0 | 0 |
| Lower Third | 0 | 0 | 0 | 0 |

13 − 1 = 12
Σ above 1's and 0's BDF

NOTES : 1. Assign a "1" to these components when Storm Sewers are ≥ 50% .
2. Assign a "1" to these components when Curb & Gutter Streets are ≥ 50%.

EQUATIONS

$UQ_{2} = 13.20 \times 72^{0.21} \times 12^{-0.43} \times 5908^{0.73} = 6{,}305$ cfs

$UQ_{5} = 10.60 \times \_\_\_^{0.17} \times \_\_\_^{-0.39} \times \_\_\_^{0.78} = \_\_\_$ cfs

$UQ_{10} = 9.51 \times 72^{0.16} \times 12^{-0.36} \times 12{,}447^{0.79} = 13{,}242$ cfs

$UQ_{25} = 8.68 \times \_\_\_^{0.15} \times \_\_\_^{-0.34} \times \_\_\_^{0.80} = \_\_\_$ cfs

$UQ_{50} = 8.04 \times \_\_\_^{0.15} \times \_\_\_^{-0.32} \times \_\_\_^{0.81} = \_\_\_$ cfs

$UQ_{100} = 7.70 \times 72^{0.15} \times 12^{-0.32} \times 23{,}648^{0.82} = 25{,}484$ cfs

$UQ_{500} = 7.47 \times \_\_\_^{0.16} \times \_\_\_^{0.30} \times \_\_\_^{0.82} = \_\_\_$ cfs

The most significant index of urbanization that resulted from this study is a basin development factor (BDF), which provides a measure of the efficiency of the drainage system. This parameter, which proved to be highly significant in the regression equations, can be easily determined from drainage maps and field inspections of the drainage basin. The basin is first divided into thirds as described earlier in this report. Then, within each third, four aspects of the drainage system are evaluated and each assigned a code as follows:

1. Channel improvements.—If channel improvements such as straightening, enlarging, deepening, and clearing are prevalent for the main drainage channels and principal tributaries (those that drain directly into the main channel), then a code of 1 is assigned. Any or all of these improvements would qualify for a code of 1. To be considered prevalent, at least 50 percent of the main drainage channels and principal tributaries must be improved to some degree over natural conditions. If channel improvements are not prevalent, then a code of zero is assigned.
2. Channel linings.—If more than 50 percent of the length of the main drainage channels and principal tributaries has been lined with an impervious material, such as concrete, then a code of 1 is assigned to this aspect. If less than 50 percent of these channels is lined, then a code of zero is assigned. The presence of channel linings would obviously indicate the presence of channel improvements as well. Therefore, this is an added factor and indicates a more highly developed drainage system.
3. Storm drains, or storm sewers.—Storm drains are defined as enclosed drainage structures (usually pipes), frequently used on the secondary tributaries where the drainage is received directly from streets or parking lots. Many of these drains empty into open channels; however, in some basins they empty into channels enclosed as box or pipe culverts. When more than 50 percent of the secondary tributaries within a subarea (third) consists of storm drains, then a code of 1 is assigned to this aspect; if less than 50 percent of the secondary tributaries consists of storm drains, then a code of zero is assigned. It should be noted that if 50 percent or more of the main drainage channels and principal tributaries are enclosed, then the aspects of channel improvements and channel linings would also be assigned a code of 1.
4. Curb-and-gutter streets.—If more than 50 percent of a subarea (third) is urbanized (covered by residential, commercial, and/or industrial development), and if more than 50 percent of the streets and highways in the subarea are constructed with curbs and gutters, then a code of 1 would be assigned to this aspect. Otherwise, it would receive a code of zero. Drainage from curb-and-gutter streets frequently empties into storm drains.

The above guidelines for determining the various drainage-system codes are not intended to be precise measurements. A certain amount of subjectivity will necessarily be involved. Field checking should be performed to obtain the best estimate. The basin development factor (BDF) is the sum of the assigned codes; therefore, with three subareas (thirds) per basin, and four drainage aspects to which codes are assigned in each subarea, the maximum value for a fully developed drainage system would be 12. Conversely, if the drainage system were totally undeveloped, then a BDF of zero would result. Such a condition does not necessarily mean that the basin is unaffected by urbanization. In fact, a basin could be partially urbanized, have some impervious area, have some improvement of secondary tributaries, and still have an assigned BDF of zero.

The BDF is a fairly easy index to estimate for an existing urban basin. The 50-percent guideline will usually not be difficult to evaluate because many urban areas tend to use the same design criteria, and therefore have similar drainage aspects, throughout. Also, the BDF is convenient for projecting future development. Obviously, full development and maximum urban effects on peaks would occur when BDF = 12. Projections of full development or intermediate stages of development can usually be obtained from city engineers.

some basins were divided into upper, middle, and lower thirds on a drainage map with the drainage divide delineated. Each third contains approximately one-third of the contributing drainage area and drains the upper, middle, or lower reaches of the basin. Because travel time or flow time was considered in drawing the lines separating the basin thirds distances along main streams and tributaries were marked to help locate the boundaries of the thirds. This drawing of the boundaries means not that all thirds of the basin have equal travel distances but that within each third the travel distances of two or more streams are about equal. Since precise definition of the lines dividing the basin into thirds was not considered necessary for the variables that utilize this concept, the lines can generally be drawn on the drainage map by eye, without precise measurements. Figure 2 shows schematics of three typical basin shapes and their division into thirds. Complex basin shapes and drainage patterns are sometimes encountered; they require more judgment in subdividing.

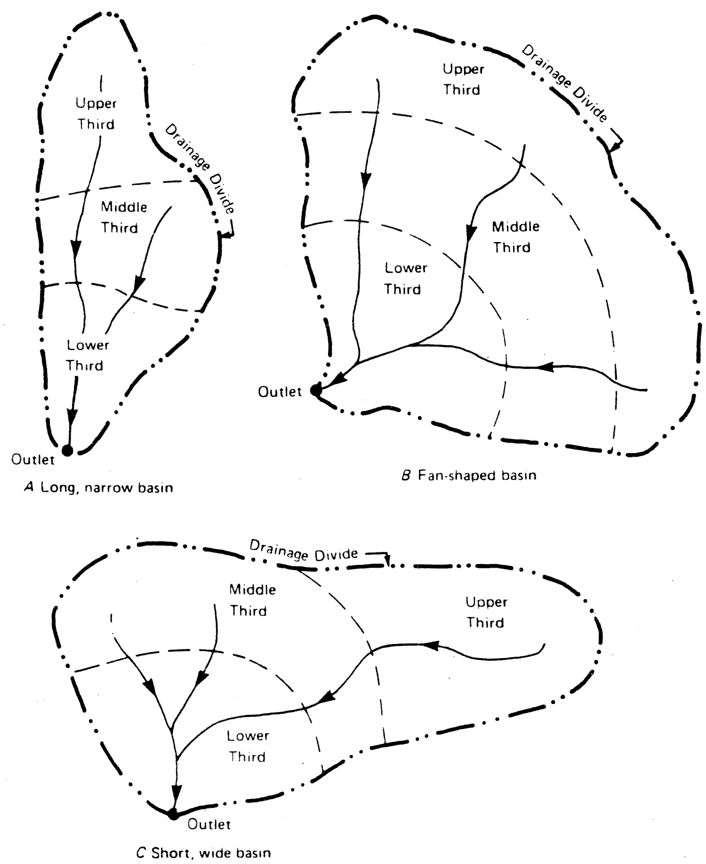



**Figure 2.** Schematic of typical drainage basin shapes and subdivision into basin thirds. Note that stream-channel distances within any given third of a basin in the examples are approximately equal, but between basin thirds the distances are not equal, to compensate for relative basin width of the thirds.

**SELECTION OF STREAM HEADWATER : DR-04.942 (Rev. 1-93) Page 1 of 1**

County PIKE Route US 119 Item No. 12-309.00

UPN FSP 098 0119 012-015 FPN Station 569+50

The HEADWATER point on a stream is located at the site where the normal flow is 5 cubic feet per second (cfs).

Use the following equation —

$$Q_a = 0.290\ A^{1.01}\ E^{0.25}\ I^{1.27}$$

Where :

$Q_a$ = the mean annual discharge or the normal flow in cfs.

A = the drainage area in square miles

E = the mean elevation of the basin in thousands of feet. This is determined by laying a grid on the quad sheet and locating the elevation of five to ten uniformly spaced points. The average of these elevations divided by 1000 is E.

I = the maximum 24-hour 2-year rainfall

1. Determine A for site from USGS quadrangle sheets.
2. Determine E for the watershed.
3. Determine I from Exhibit DR-04.939.
4. Solve the above equation for $Q_a$.
5. If $Q_a \geq 5$ cfs, site is below the Headwaters for the stream.

A = 0.6 mi²

E = 1.3 ft.

I = 2.9 in.

$Q_a$ = 0.71 cfs