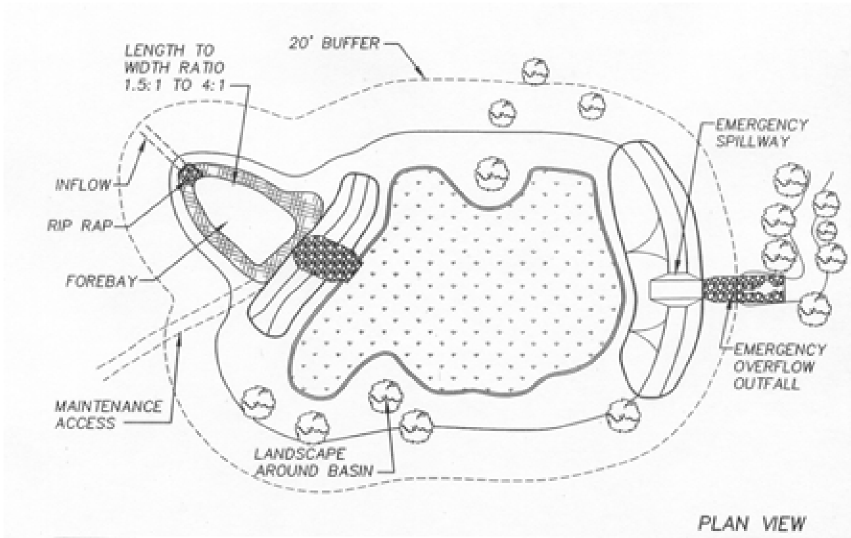

5 PEAK DISCHARGE RATE - RATIONAL METHOD

The Rational Method shall be used only in cases where the tributary area is 40 acres or less.

The Rational Method is a standard method for calculating the peak runoff rate for a parcel. The results of its use are very sensitive to the coefficients selected. As a result the method is best suited for use on small parcels where the additional time that may be required to use another method may not be justified. Larger parcels should utilize more accurate methods.

5.1 The Rational Method is based on three assumptions:

5.1.1 The peak runoff at any design location is a function of the average rainfall intensity during the time of concentration to that location.

5.1.2 The frequency of peak discharge is the same as the frequency of the average rainfall intensity.

5.1.3 The Time of Concentration is the time required for the runoff from the most remote part of the drainage area to become established and flow to the point under design.

5.2 The Rational Method is an empirical method based on the following equation: $Q = C \bullet i \bullet A$

C - Runoff coefficient, is a constant (dimensionless) which represent the fraction of rainfall which will result in the peak runoff rate from the land into a storm drainage system.

A - Area (acres) of the sub-basin upstream from the point of design, and must include upstream tributary areas not part of the development.

i - Rainfall intensity (in/hr) of the storm which represents the duration and frequency of rainfall which will create the maximum peak runoff. Typically, the intensity over the time of concentration for the sub-basin will result in the peak flow for a particular return period.

The Rational Method formula is an empirical equation where the units as assigned are not consistent.

5.3 Procedure For Determining Peak Discharge

5.3.1 Delineate and determine the drainage area, (A), in acres, of the watershed upstream of the point of the storm drainage system in question. If the watershed drainage area is less then 1 acre or greater than 40 acres this method should not be used. The upstream area must be considered completely developed.

5.3.2 Identify the primary drainage channel(s) of the sub-basin area.

5.3.3 Identify any sub-channels and flow paths flowing into the main channel from available topographical maps. Using the sub-channels and contours divide the drainage area sub-basin into sub-basins.

5.3.4 Determine the land uses and zoning classifications for the entire drainage area and the respective percentages of each classification or land use within the drainage area.

5.3.6 Determine the appropriate Runoff Coefficient, "C, for each land use in the drainage area from Table 6.

5.3.7 Determine the overland time flow, t_o, from the following equation:

$$t_o = \left[\frac{2 \bullet L \bullet n}{3 \bullet \sqrt{S}}\right]^{(1/2.14)}$$

L - Distance of the overland flow path with the longest overland flow time for that sub-basin. The path follows a direction parallel to the slope of the sub-basin. Several flow times will have to be calculated for various paths to determine which path actually has the maximum flow time.
n - Friction coefficient (Manning's n) can be taken from Table 7.
S - Slope is the difference in elevation between the extreme edge of the flow path to the point of entry into the defined channel divided by the length of the flow path.

TABLE 6
Runoff Coefficients
Rational Method

Type of Land Use	2-year Storm	10-year Storm	25-year Storm	100-year Storm
Residential 1-2	0.29	0.43	0.45	0.47
Multi-family residential	0.35	0.46	0.47	0.47
Mobile home	0.37	0.53	0.55	0.56
CBD/Shopping	0.43	0.57	0.58	0.58
Comm/Business	0.39	0.51	0.51	0.52
Industrial	0.45	0.58	0.59	0.60
Industrial Park	0.37	0.53	0.55	0.56
Forest	0.1	0.24	0.27	0.32
Agriculture	0.16	0.3	0.33	0.37
Water	1.0	1.0	1.0	1.0
Extractive	0.12	0.27	0.3	0.34
Airport	0.22	0.31	0.32	0.34
Rural Residential	0.15	0.3	0.33	0.37

TABLE 7
Manning's n
Overland Flow

Ground cover	Manning’s n
Smooth asphalt or concrete	0.012
Rough asphalt or concrete	0.014
Packed clay	0.03
Light turf	0.2
Dense turf	0.35
Dense shrubbery	0.5

5.3.8 Determine the stream (channel) flow time, t_s, if stream flow is achieved within the sub-basin.

$$t_s = L \div V$$

and

$$V = 1.49 \bullet R^{2/3} \bullet s^{1/2} \div n$$

Where:

L = Channel Length (ft)
V = Velocity (ft/s)
R = Hydraulic Radius (ft)
s = Channel Slope (ft/ft)
n = Composite Manning's n for channel

For an open channel the hydraulic radius can be approximated as:

R = 0.6 for small streams (less than 100 Ac drained)
R = 1.5 for medium streams (100 Ac to 1 sq. mile)
R = 2.5 for large streams (more than 1 sq. mile)

For flow in a closed conduit (storm sewer) the conduit can be assumed to be flowing full and $R = A \div P$, where A is the flow area and P is the wetted perimeter.

5.3.9 Determine the pipe flow time;

$$t_p = L \div V$$

Where L is the pipe length, and V is the average pipe velocity.

5.3.10 The time of concentration, tc, is the sum of the overland flow time, the stream flow time, and the pipe flow time.

$$t_c = t_o + t_s + t_p$$

5.3.11 The time of concentration indicates the duration of a storm that will cause the maximum peak runoff rate to be reached. Using the return period from step 5 and the time of concentration as duration, the average intensity of the storm can be found using Figure 2.

5.3.12 The Peak Runoff Rate, Q, is then calculated using:

$$Q = C \bullet i \bullet A$$

Where:

Q = Peak Runoff Rate (cfs)
C = Composite Runoff Coefficient
i = Average Rainfall Intensity (in/hr)
A = Drainage Area (acres)

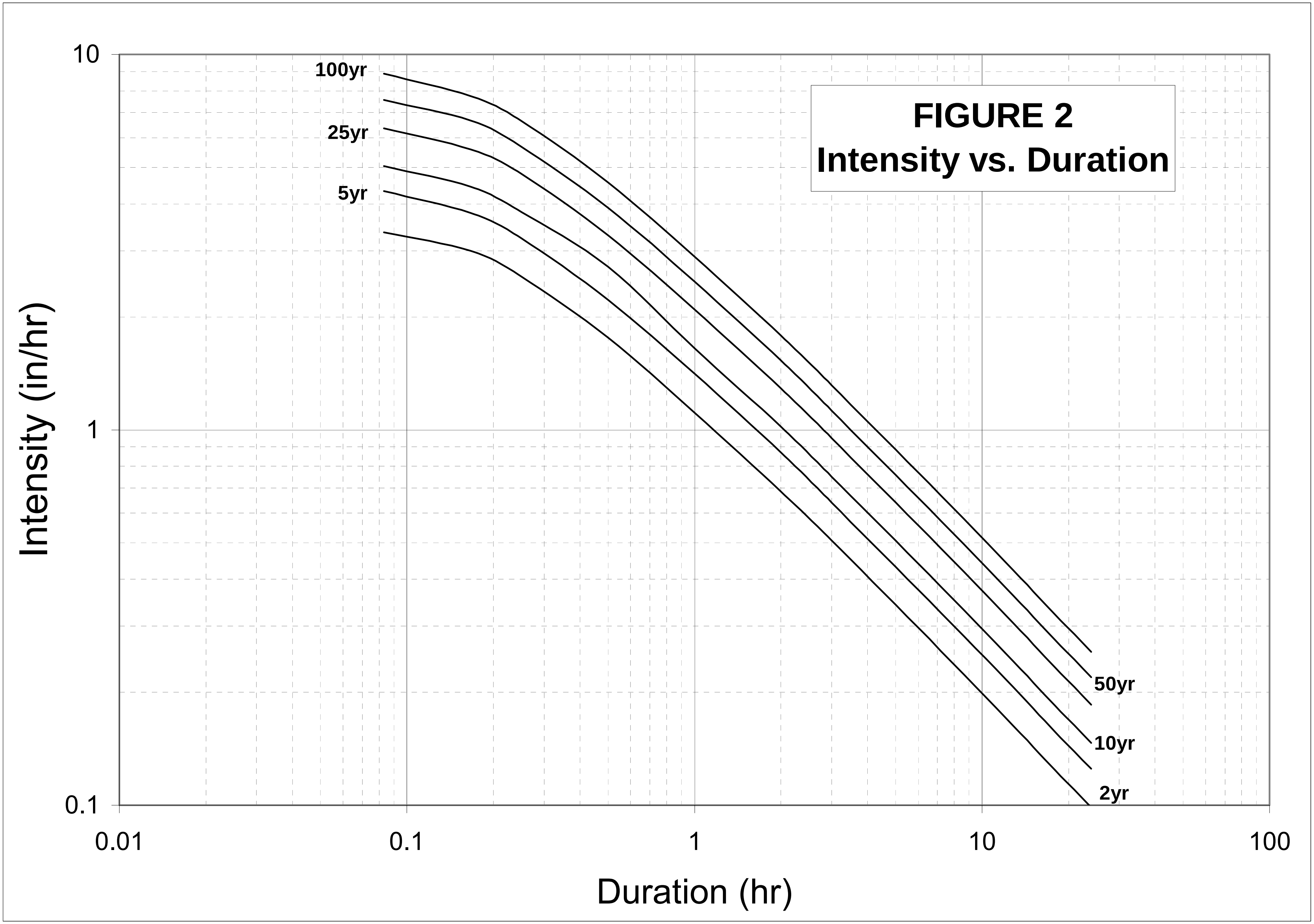

FIGURE 2
Intensity vs. Duration
10
1
0.1
0.01
0.1
1
10
100
Intensity (in/hr)
Duration (hr)
100yr
25yr
5yr
50yr
10yr
2yr