- Please submit Drainage Letter with engineer stamp and signature as well as developer's signature for subsequent submittal.
- Please make sure to address comments.

# DRAINAGE LETTER

## 11925 MILAM ROAD

PART S1/2, SECTION 13, T.12S., R.66W. 6<sup>TH</sup> P.M. EL PASO COUNTY, COLORADO

Please add "PCD File No. VA-22-003".

March 31, 2022

prepared for

Chuck Runge

Oliver E. Watts, Consulting Engineer, Inc. Colorado Springs, Colorado

#### **OLIVER E. WATTS, PE-LS**

OLIVER E. WATTS, CONSULTING ENGINEER, INC.
CIVIL ENGINEERING AND SURVEYING
614 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907
(719) 593-0173
Fax (719) 265-9660
olliewatts@aol.com

Celebrating over 43 years in business

March 31, 2022

El Paso County Planning and Community Development 2880 International Circle Colorado Springs, CO 80910

ATTN: Jennifer Irvine, P.E.

SUBJECT: Drainage Letter

11925 Milam Road

#### Gentlemen

Transmitted herewith for your review and approval is the drainage letter for 11925 Milam Road, part of the South Half Section 13, T.12s., R.66W. of the  $6^{th}$  P.M. in El Paso County. This letter is to accompany the development plan for the construction of an additional residence on subject property.

There will be no significant change in the existing runoff as a result of this additional dwelling. Please contact our office if we may provide any further information.

Oliver E. Watts, Consulting Engineer, Inc.

| BY: |                            |  |
|-----|----------------------------|--|
| (   | Oliver E. Watts, President |  |

#### Encl:

Drainage Letter 2 pages
FEMA Flood Panel 08041C0315 G, December 7, 2018
Soils Map and Interpretation Sheet
Computations, 2 sheets
Backup Information, 5 sheets
Area Drainage Map
Drainage Plan, Dwg 22-5785-01

#### 1. ENGINEER'S STATEMENT:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the applicable master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

| Oliver E. Watts, Co                                   | onsulting Engineer, Inc.        |   |       |
|---|---------------------------------|---|-------|
|   |                                 |   |       |
| Oliver E. Watts                                       | Colo. PE-LS No. 9853            |   |       |
| 2. OWNERS / DE  | VELOPER'S STATEMENT             | <u>:</u>  |       |
| I the developer have report and plan.                 | e read and will comply with all | of the requirements specified in this dra                                   | inage |
| Chuck Runge   |                                 |   |       |
|   |                                 |   |       |
| By:   |                                 |   |       |
| 5315 Germaine Cor<br>Colorado Springs, (719) 260-0039 |                                 |   |       |
| 3. EL PASO COU  | NTY:                            |   |       |
|   | <u> </u>                        | El Paso Land Development Code, Draina<br>ering Criteria Manual, as amended. | ge    |
| Lauritan India DE                                     |                                 |   |       |
| Jennifer Irvine, P.E<br>County Engineer / I           | .,<br>ECM Administrator         | date  |       |
| Conditions:   |                                 |   |       |

#### **4. LOCATION AND DESCRIPTION:**

11925 Milam Road is located approximately two miles west of the community of Black Forest in the unplatted South Half of Section 13, Township 12 South, Range 66 West of the 6<sup>th</sup> P.M., in El Paso County, Colorado. The total size of the parcel is 60.01 Acres, of which approximately 1.93 acres is involved with the existing and proposed dwelling units. An existing residence exists on the property and an additional dwelling unit of 3000 SF of living area will be added as shown on the enclosed drainage plan. The site includes about <sup>3</sup>/<sub>4</sub> mile of Kettle Creek and is in that drainage basin.

#### 5. FLOOD PLAIN STATEMENT:

This subdivision is not within the limits of a designated flood plain or flood hazard area, as identified on FEMA panel no. 08041C0315 G, dated December 7, 2018, a copy of which is enclosed for reference. The portion of the 100-year flood plain is shown on the enclosed drainage plan. The entire flood plain is enclosed within the channel of Kettle Creek, and the building site is not affected by it.

#### **6. DESCRIPTION OF RUNOFF:**

As shown on the enclosed drainage plan and area drainage plan, only 8.17 acres of the total 60.01 acre site affects the building site. An offsite 5.16 acre drainage basin (Basin O-1) will discharge 0.9 cfs /7.2 cfs (5-year / 100-year runoffs) into the property in an existing drainage channel. It will combine with the 3.01 acre basin A to create a total runoff of 1.4 cfs / 11.3 cfs at the existing driveway to the dwellings. This runoff is historic in nature and not affected by existing or proposed development. An 18" CMP culvert will be adequate to contain this runoff on minimum slope of four percent, with a minimum of 0.9 feet of headwater. This runoff continues approximately 130 feet in the existing channel to Kettle Creek, and is not affected by development.

The total building site consists of 1.93 acres along the north side of Kettle Creek, and is approximately 30% impervious due to the residential construction. The total runoff from the site is 2.5 cfs / 8.0 cfs, which can be easily accommodated by standard grading practices on the residential site.

#### **7. FEES:**

Approximately half of the building site (0.965 acres) may be attributed to the proposed additional construction. At the impervious percentage of 30%, the total computed drainage fee is as follows:

0.965 acres @ 30% = 0.2895 Acres @ \$11,413.00 per acre = \$3,304.06

Drainage basin fees are assessed for lots being platted, replatted, and vacation plats. The applicant's Letter of Intent does not mention plating action being requested. Please revise drainage basin fees statement as fees are not due at this time.

## National Flood Hazard Layer FIRMette

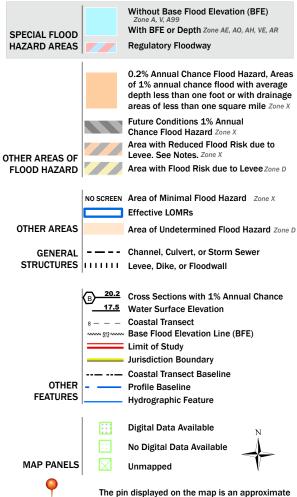


Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020



#### Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT



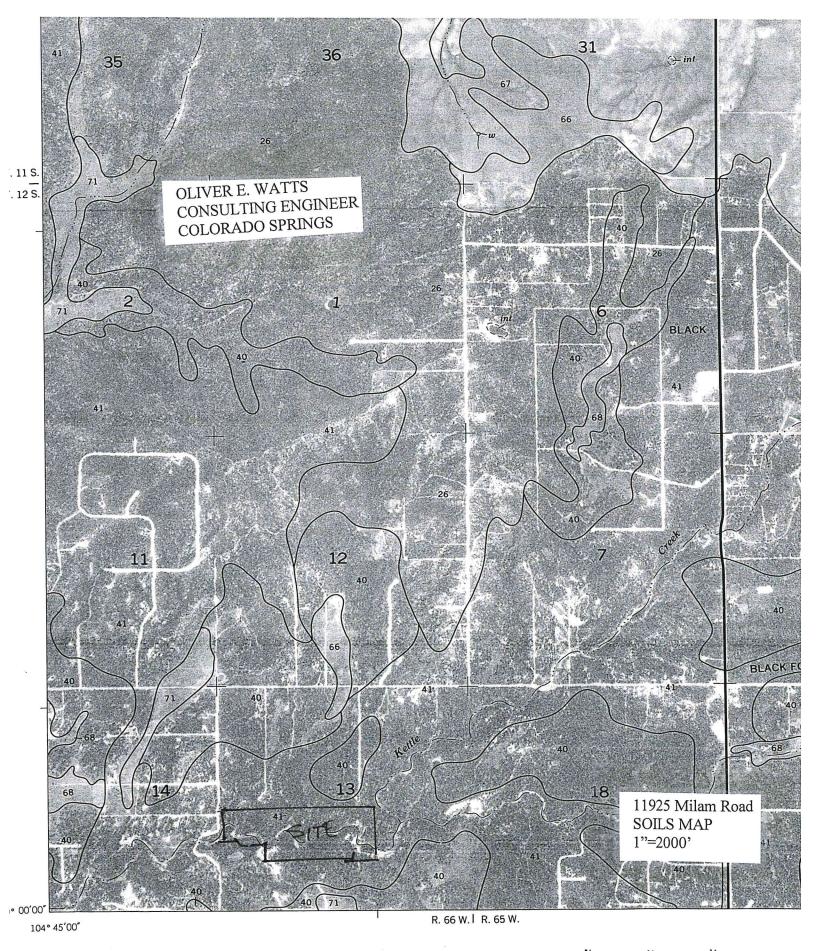
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

point selected by the user and does not represent

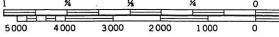
an authoritative property location.

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 3/28/2022 at 11:24 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



This soil survey map was compiled by the U.S. Department of Agriculture, Soil Conservation Service, and cooperating agencies. Base maps are orthophotographs prepared by the U.S. Department of the Interior, Geological Survey, from 1974 and 1975 aerial photography. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



#### SOIL SURVEY

#### TABLE 16.--SOIL AND WATER FEATURES--Continued

|   |                          | ·                        |                      |         |                  |                 |                        |
|---|--------------------------|--------------------------|----------------------|---------|------------------|-----------------|------------------------|
| Soil name and map symbol                    | Hydro-<br>logic<br>group | Frequency                | Flooding<br>Duration | Months  | Depth            | ock<br>Hardness | Potential frost action |
| Elbeth:<br>Pring part                       | В                        | None                     |                      |         | <u>In</u><br>>60 |                 | Moderate.              |
| Ellicott: 28                                | A A                      | <br>                     | Brief                | Mar-Jun | >60              |                 | Low.                   |
| Fluvaquentic<br>Haplaquolls:<br>29          | B/D                      | <br> <br> Frequent <br>! | Brief                | Mar-Jul | >60              |                 | High.                  |
| Fort Collins:<br>30, 31                     | В                        | None to rare             |                      |         | >60              |                 | Moderate.              |
| Fortwingate:<br>132:<br>Fortwingate<br>part | С                        | <br>  None               |                      |         | 20-40            | Hard            | Low.                   |
| Rock outerop                                | D                        |                          |                      |         |                  |                 |                        |
| Heldt:<br>33                                | C C                      | <br> <br> None           |                      |         | >60              |                 | Moderate.              |
| Holderness: 34, 35, 36                      | С                        | None                     |                      |         | >60              |                 | Moderate.              |
| Jarre:<br>37                                | !<br>!<br>! B            | <br>  None               |                      |         | >60              |                 | <br> Moderate.         |
| <sup>1</sup> 38:<br>Jarre part              | B                        | <br> None                | ,                    |         | >60              |                 | Moderate.              |
| Tecolote part                               | В                        | None                     |                      |         | >60              |                 | Moderate.              |
| Keith: 39                                   | i<br> <br>  B            | <br> <br>  None          |                      |         | >60              |                 | High.                  |
| Kettle:<br>40, 41                           | В                        | None                     |                      |         | >60              |                 | <br> Moderate.         |
| 1 <sub>42:</sub><br>Kettle part             | В                        | <br>  None               |                      |         | >60              |                 | <br> Moderate.         |
| Rock outcrop<br>part                        | D                        |                          |                      |         |                  |                 |                        |
| Kim:<br>43                                  | B                        | <br>  None               |                      |         | >60              |                 | <br> Moderate.         |
| Kutch:<br>44, 45                            | С                        | None                     | '                    |         | 20-40            | Rippable        | Moderate.              |
| Kutler: 146:                                | !<br>!                   |                          |                      |         |                  | !<br>!<br>!     |                        |
| Kutler part                                 | . C                      | None                     |                      |         | 20 <b>-</b> 40   | Rippable<br>    | Low.                   |
| Broadmoor part-                             | C                        | None                     |                      |         | 20-40            | Rippable        | Low.                   |
| Rock outcrop<br>part                        | D                        |                          |                      |         |                  |                 |                        |
| Limon:<br>47                                | С                        | Occasional               | Brief                | May-Sep | >60              |                 | <br> Moderate.         |
| Louviers:<br>48                             | D                        | None                     |                      | ,       | 10-20            | Rippable        | <br> Moderate.         |
| 49  | D                        | None                     | i                    |         | 10-20            | Rippable        | Low.                   |

See footnote at end of table.

| MAJOR<br>BASIN<br>KETTLE<br>CREEK    | SUB<br>BASIN |                | AI                  | REA           | BA            | SIN  | Tc<br>MIN |          | I<br>/hr. | SOIL<br>GRP | DEV.<br>TYPE | (     | C           | FL<br>5-ry  | OW<br>100-yr |            | TURN<br>RIOD |
|--------------------------------------|--------------|----------------|---------------------|---------------|---------------|------|-----------|----------|-----------|-------------|--------------|-------|-------------|-------------|--------------|------------|--------------|
|                                      |              | PLANIM<br>READ | ACRES               | LENGTH<br>-FT | HEIGHT<br>-FT |      |           |          |           |             |              |       | qp<br>-CFS- | qp<br>-CFS- | -years-      |            |              |
|                                      | O-1          | 225 k          | 5.16                | 300           | 60            | 29   |           |          | В         | FOREST      | 0.08         | 0.35  |             |             | 5            | 100        |              |
|                                      |              |                | V=5.8               | +200          | 30            | +0.6 |           |          |           |             |              |       |             |             |              |            |              |
|                                      |              |                |                     |               |               | 29.6 | 2.2       | 4.0      |           |             |              |       | 0.9         | 7.2         | 5            | 100        |              |
|                                      | +A           | COGO           | 3.01                | +250          | 12            | +1.3 |           |          |           |             |              |       |             |             |              |            |              |
|                                      | TOTAL        |                | 8.17                | V=3.3         |               | 30.5 | 2.1<br>7  | 3.9<br>6 | В         | FIREST      | 0.08         | 0.35  | 1.4         | 11.3        | 5            | 100        |              |
|                                      | В            | COGO           | 1.93                |               |               | MIN  | 5.2       | 8.8      | В         | 30%         | 0.25         | 0.47  | 2.5         | 8.0         | 5            | 100        |              |
|                                      |              |                |                     |               |               |      |           |          |           |             |              |       |             |             |              |            |              |
|                                      |              |                |                     |               |               |      |           |          |           |             |              |       |             |             |              |            |              |
|                                      |              |                |                     |               |               |      |           |          |           |             |              |       |             |             |              |            |              |
|                                      |              |                |                     |               |               |      |           |          |           |             |              |       |             |             |              |            |              |
|                                      |              |                |                     |               |               |      |           |          |           |             |              |       |             |             |              |            |              |
| HYD<br>ROJ: 11925 MII<br>ATIONAL MET |              | BY:            | UTATION<br>O.E. WAT | TS            | PATA          |      | OL        | IVEF     | R E. WA   | ATTS, CON   | SULTI        | NG EN | GINEE       | R, INC.     |              | GE 1<br>OF |              |

RATIONAL METHOD DATE: 3-30-22 614 ELKTON DRIVE COLORADO SPRINGS, CO 80907

2

### STREET AND STORM SEWER CALCULATIONS

| STREET   | LOCATION   | DISTANCE<br>-ft | ELEVATION<br>& SLOPE | TOTAL<br>RUNOFF<br>-cfs-<br>5-yr./100-yr | STREET FLOW / CAPACITY -cfs- 5-yr./100-yr | PIPE<br>FLOW<br>-cfs-      | TYPE PIPE,<br>BASIN & S | , CATCH<br>LOPE %         |
|----------|--|-----------------|----------------------|--|---|----------------------------|-------------------------|---------------------------|
| DRIVEWAY | BASIN A  |                 |                      | 1.4/11.3                                 | , , ,                                     | 11.3                       | 18" CMP S=4%<br>MIN     |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          |  |                 |                      |  |   |                            |                         |                           |
|          | STREET AND STORM SEWER CALCULATIONS PROJECT: 11925 MILAM ROAD BY: O.E. WATTS DATE: 3/30/22 |                 |                      | OLIVER E. W. 614 ELKTO                   | <br>ATTS, CONSULTI<br>N DRIVE COLORADO    | I<br>NG ENGI<br>SPRINGS, O | NEER, INC.              | Page: 2<br>Of<br>Pages: 2 |

Table 6-6. Runoff Coefficients for Rational Method

(Source: UDFCD 2001)

| Land Use or Surface                                  | Percent    | Runoff Coefficients |         |         |         |         |         |         |         |         |         |          |         |
|--|------------|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|---------|
| Characteristics                                      | Impervious | 2-year              |         | 5-year  |         | 10-year |         | 25-year |         | 50-year |         | 100-year |         |
|  |            | HSG A&B             | HSG C&D | HSG A&B | HSG C&D | HSG A&B | HSG C&D | HSG A&B | HSG C&D | HSG A&B | HSG C&D | HSG A&B  | HSG C&D |
| Business   |            |                     |         |         |         |         |         |         |         |         |         |          |         |
| Commercial Areas                                     | 95         | 0.79                | 0.80    | 0.81    | 0.82    | 0.83    | 0.84    | 0,85    | 0,87    | 0.87    | 0.88    | 0,88     | 0.89    |
| Neighborhood Areas                                   | 70         | 0.45                | 0.49    | 0.49    | 0.53    | 0.53    | 0.57    | 0.58    | 0.62    | 0.60    | 0.65    | 0.62     | 0.68    |
| Residential  |            |                     |         |         |         |         |         |         |         |         |         |          |         |
| 1/8 Acre or less                                     | 65         | 0.41                | 0.45    | 0.45    | 0.49    | 0.49    | 0.54    | 0.54    | 0.59    | 0.57    | 0.62    | 0.59     | 0.65    |
| 1/4 Acre   | 40         | 0.23                | 0.28    | 0.30    | 0.35    | 0.36    | 0.42    | 0.42    | 0.50    | 0.46    | 0.54    | 0.50     | 0.58    |
| 1/3 Acre   | 30         | 0.18                | 0.22    | 0.25    | 0.30    | 0.32    | 0.38    | 0.39    | 0.47    | 0.43    | 0.52    | 0.47     | 0.57    |
| 1/2 Acre   | 25         | 0.15                | 0.20    | 0.22    | 0.28    | 0,30    | 0.36    | 0.37    | 0.46    | 0.41    | 0.51    | 0.46     | 0.56    |
| 1 Acre   | 20         | 0.12                | 0.17    | 0.20    | ე.26    | 0.27    | 0.34    | 0.35    | 0.44    | 0.40    | 0.50    | 0.44     | 0.55    |
| Industrial   |            |                     |         |         |         |         |         |         |         |         |         |          |         |
| Light Areas  | 80         | 0.57                | 0.60    | 0.59    | 0.63    | 0.63    | 0.66    | 0.66    | 0.70    | 0.68    | 0.72    | 0.70     | 0.74    |
| Heavy Areas  | 90         | 0.71                | 0.73    | 0.73    | 0.75    | 0.75    | 0.77    | 0.78    | 0.80    | 0.80    | 0.82    | 0.81     | 0,83    |
| Parks and Cemeteries                                 | 7          | 0.05                | 0.09    | 0.12    | 0.19    | 0.20    | 0.29    | 0.30    | 0.40    | 0.34    | 0.46    | 0.39     | 0,52    |
| Playgrounds  | 13         | 0.07                | 0.13    | 0.16    | 0.23    | 0.24    | 0.31    | 0.32    | 0.42    | 0.37    | 0.48    | 0.41     | 0.54    |
| Railroad Yard Areas                                  | 40         | 0.23                | 0.28    | 0.30    | 0.35    | 0.36    | 0.42    | 0.42    | 0.50    | 0.46    | 0.54    | 0.50     | 0.58    |
| Undeveloped Areas                                    |            | -                   |         |         |         |         | -       |         |         |         |         |          |         |
| Historic Flow Analysis<br>Greenbelts, Agriculture    | 2          | 0.03                | 0.05    | 0.09    | 0.16    | 0.17    | 0.26    | 0.26    | .0,38   | 0.31    | 0.45    | 0.36     | 0.51    |
| Pasture/Meadow                                       | 0          | 0.02                | 0.04    | 0.08    | 0.15    | 0.15    | 0.25    | 0.25    | 0.37    | 0.30    | 0.44    | 0.35     | 0.50    |
| Forest   | 0          | 0.02                | 0.04    | 0.08    | 0.15    | 0.15    | 0.25    | 0.25    | 0.37    | 0.30    | 0.44    | 0,35     | 0,50    |
| Exposed Rock   | 100        | 0.89                | 0.89    | 0.90    | 0.90    | 0.92    | 0.92    | 0.94    | 0.94    | 0,95    | 0.95    | 0.96     | 0.96    |
| Offsite Flow Analysis (when<br>landuse is undefined) | 45         | 0.26                | 0.31    | 0,32    | 0.37    | 0.38    | 0.44    | 0,44    | 0.51    | 0.48    | 0.55    | 0.51     | 0.59    |
|  |            |                     |         |         |         |         |         |         |         |         |         |          | -       |
| Streets  | 100        | 0.00                | 0.89    | 0.90    | 0.90    | 0.92    | 0.92    | 0.94    | 0.94    | 0.95    | 0.95    | 0.96     | 0.96    |
| Paved<br>Gravel                                      | 100<br>80  | 0.89                | 0.60    | 0.59    | 0.90    | 0.92    | 0.66    | 0.66    | 0.70    | 0.68    | 0.72    | 0.70     | 0.74    |
|  |            |                     |         |         |         |         |         |         |         |         |         |          |         |
| Drive and Walks                                      | 100        | 0.89                | 0.89    | 0.90    | 0.90    | 0.92    | 0.92    | 0.94    | 0.94    | 0.95    | 0.95    | 0.96     | 0.96    |
| Roofs  | 90         | 0.71                | 0.73    | 0.73    | 0.75    | 0.75    | 0.77    | 0.78    | 0.80    | 0.80    | 0.82    | 0.81     | 0.83    |
| Lawns  | 0          | 0.02                | 0.04    | 0.08    | 0.15    | 0.15    | 0.25    | 0.25    | 0.37    | 0.30    | 0.44    | 0.35     | 0.50    |

#### 3.2 Time of Concentration

One of the basic assumptions underlying the Rational Method is that runoff is a function of the average rainfall rate during the time required for water to flow from the hydraulically most remote part of the drainage area under consideration to the design point. However, in practice, the time of concentration can be an empirical value that results in reasonable and acceptable peak flow calculations.

For urban areas, the time of concentration  $(t_c)$  consists of an initial time or overland flow time  $(t_i)$  plus the travel time  $(t_i)$  in the storm sewer, paved gutter, roadside drainage ditch, or drainage channel. For non-urban areas, the time of concentration consists of an overland flow time  $(t_i)$  plus the time of travel in a concentrated form, such as a swale or drainageway. The travel portion  $(t_i)$  of the time of concentration can be estimated from the hydraulic properties of the storm sewer, gutter, swale, ditch, or drainageway. Initial time, on the other hand, will vary with surface slope, depression storage, surface cover, antecedent rainfall, and infiltration capacity of the soil, as well as distance of surface flow. The time of concentration is represented by Equation 6-7 for both urban and non-urban areas.

$$t_c = t_t + t_t \tag{Eq. 6-7}$$

Where:

 $t_c$  = time of concentration (min)

 $t_i$  = overland (initial) flow time (min)

 $t_t$  = travel time in the ditch, channel, gutter, storm sewer, etc. (min)

#### 3.2.1 Overland (Initial) Flow Time

The overland flow time,  $t_i$ , may be calculated using Equation 6-8.

$$t_i = \frac{0.395(1.1 - C_5)\sqrt{L}}{S^{0.33}}$$
 (Eq. 6-8)

Where:

 $t_i$  = overland (initial) flow time (min)

 $C_5$  = runoff coefficient for 5-year frequency (see Table 6-6)

L = length of overland flow (300 ft <u>maximum</u> for non-urban land uses, 100 ft <u>maximum</u> for urban land uses)

S = average basin slope (ft/ft)

Note that in some urban watersheds, the overland flow time may be very small because flows quickly concentrate and channelize.

#### 3.2.2 Travel Time

For catchments with overland and channelized flow, the time of concentration needs to be considered in combination with the travel time,  $t_t$ , which is calculated using the hydraulic properties of the swale, ditch, or channel. For preliminary work, the overland travel time,  $t_t$ , can be estimated with the help of Figure 6-25 or Equation 6-9 (Guo 1999).

$$V = C_{\nu} S_{\nu\nu}^{0.5}$$
 (Eq. 6-9)

Where:

V = velocity (ft/s)

 $C_v = \text{conveyance coefficient (from Table 6-7)}$ 

 $S_w$  = watercourse slope (ft/ft)

Table 6-7. Conveyance Coefficient,  $C_{\nu}$ 

| Type of Land Surface                 | $C_{\nu}$ |
|--------------------------------------|-----------|
| Heavy meadow                         | 2.5       |
| Tillage/field                        | 5         |
| Riprap (not buried)*                 | 6.5       |
| Short pasture and lawns              | 7         |
| Nearly bare ground                   | 10        |
| Grassed waterway                     | 15        |
| Paved areas and shallow paved swales | 20        |

For buried riprap, select C<sub>v</sub> value based on type of vegetative cover.

The travel time is calculated by dividing the flow distance (in feet) by the velocity calculated using Equation 6-9 and converting units to minutes.

The time of concentration  $(t_c)$  is then the sum of the overland flow time  $(t_l)$  and the travel time  $(t_l)$  per Equation 6-7.

#### 3.2.3 First Design Point Time of Concentration in Urban Catchments

Using this procedure, the time of concentration at the first design point (typically the first inlet in the system) in an urbanized catchment should not exceed the time of concentration calculated using Equation 6-10. The first design point is defined as the point where runoff first enters the storm sewer system.

$$t_c = \frac{L}{180} + 10 \tag{Eq. 6-10}$$

Where:

 $t_c$  = maximum time of concentration at the first design point in an urban watershed (min)

L =waterway length (ft)

Equation 6-10 was developed using the rainfall-runoff data collected in the Denver region and, in essence, represents regional "calibration" of the Rational Method. Normally, Equation 6-10 will result in a lesser time of concentration at the first design point and will govern in an urbanized watershed. For subsequent design points, the time of concentration is calculated by accumulating the travel times in downstream drainageway reaches.

#### 3.2.4 Minimum Time of Concentration

If the calculations result in a  $t_c$  of less than 10 minutes for undeveloped conditions, it is recommended that a minimum value of 10 minutes be used. The minimum  $t_c$  for urbanized areas is 5 minutes.

#### 3.2.5 Post-Development Time of Concentration

As Equation 6-8 indicates, the time of concentration is a function of the 5-year runoff coefficient for a drainage basin. Typically, higher levels of imperviousness (higher 5-year runoff coefficients) correspond to shorter times of concentration, and lower levels of imperviousness correspond to longer times of

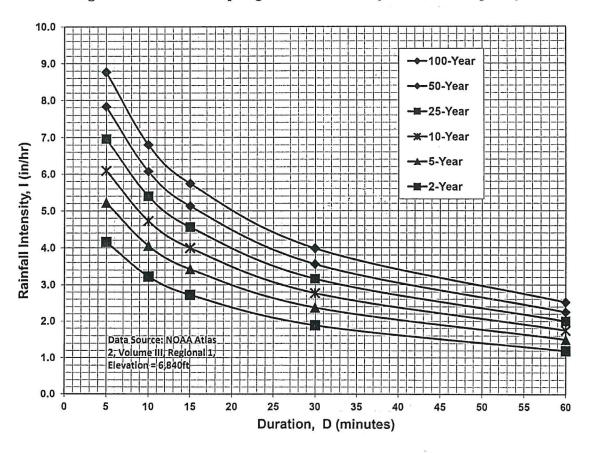


Figure 6-5. Colorado Springs Rainfall Intensity Duration Frequency

#### **IDF** Equations

$$I_{100} = -2.52 \ln(D) + 12.735$$

$$I_{50} = -2.25 \ln(D) + 11.375$$

$$I_{25} = -2.00 \ln(D) + 10.111$$

$$I_{10} = -1.75 \ln(D) + 8.847$$

$$I_5 = -1.50 \ln(D) + 7.583$$

$$I_2 = -1.19 \ln(D) + 6.035$$

Note: Values calculated by equations may not precisely duplicate values read from figure.

| IAMETER         | AREA     | D 8/3      | 1        | K         |           |           |
|-----------------|----------|------------|----------|-----------|-----------|-----------|
| -IN             | -FT2-    | - FT -     | N=0.010  | N=0.013   | N = 0.024 | N = 0.026 |
|                 |          |            |          | - 3<br>3  |           |           |
| 2               | 0.02182  | 0.008413   | 0.3895   |           |           |           |
| 4               | 0.08727  | 0.053420   | 2.4733   | ·         |           | ·         |
| 6               | 0.19630  | 0.157500   | 7.2922   | 5.609     |           |           |
| 1 8             | 0.34910  | 0.339200   | 15.7050  | 12.081    |           |           |
| 10              | 0.54540  | 0.615000   | 28.4745  | 21.903    |           |           |
| 12              | 0.78540  | 1.000000   | 46.3000  | 35.615    |           |           |
| 15              | 1.22720  | 1.813100   | 83.9465  | 64.574    |           |           |
| 18              | 1.76710  | 2.948300   | 136.5100 | 105.000   | 56.88     | 52.50     |
| $\frac{16}{21}$ | 2.40530  | 4.447400   | 205.9100 | 158.400   | 85.80     | 79.20     |
| $\frac{21}{24}$ | 3.14160  | 6.349600   | 293.9900 | 226.140   | 122.49    | 113.07    |
| 27              | 3.97610  | 8.692700   | 402.4700 | 309.590   | 167.70    | 154.79    |
| 30              | 4.90870  | 11.512600  | 533.0300 | 410.030   | 222.10    | 205.02    |
| 33              | 5.93960  | 14.844100  |          | 528.680   |           |           |
| 36              | 7.06860  | 18.720800  | 866.7700 | 666.700   | 361.20    | 333.30    |
| 39              | 8.29580  | 23.175100  |          | 825.400   |           |           |
| 42              | 9.62110  | 28.238900  |          | 1005.000  | 544.80    | 502.50    |
| 48              | 12.56640 | 40.317500  |          | 1436.000  | 777.80    | 718.00    |
| 54              | 15.90430 | 55.195000  |          | 1966.000  | 1065.00   | 983.00    |
| 60              | 19.63500 | 73.100400  |          | 2604.000  | 1410.00   | 1302.00   |
| 66              | 23.75830 | 94.254200  |          | 3357.000  | 1818.00   | 1678.00   |
| 72              | 28.27430 | 118.869400 |          | 4234.000  | 2293.00   | 2117.00   |
| 78              | 33.18310 | 147.152900 |          | 5241.000  | 2839.00   | 2620.00   |
| 84              | 38.48450 | 179.306000 |          | 6386.000  | 3459.00   | 3193.00   |
| 90              | 44.17860 | 215.524500 |          | 7676.000  | 4158.00   | 3838.00   |
| 96              | 50.26550 | 256.000000 |          | 9118.000  | 4939.00   | 4559.00   |
| 108             | 63.61730 | 350.466600 |          | 12480.000 | 6761.00   | 6140.00   |
| 120             | 78.53980 | 464.158900 |          | 16530.000 | 8954.00   | 8265.00   |
| 120             | , 0.0000 |            |          |           |           |           |

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