

**WWE**  
**MEMORANDUM**

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**To:** Bill Alspach  
City of Woodland Park  
**Via Email**

**From:** Wright Water Engineers, Inc.  
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**Date:** July 6, 2015

**Re:** Modification of UD-Detention Workbook for Woodland Park

This memorandum has been prepared by Wright Water Engineers, Inc. (WWE) to summarize the modifications made to UD-Detention v2.35 for the City of Woodland Park, Colorado to reflect differences in local drainage criteria. The “Intro” and “Modified FAA” worksheets are the only two worksheets that have been modified from the UDFCD workbook. The modified workbook has been renamed WP-Detention v2.35 to maintain version tracking with the UDFCD workbook.

The workbook was updated with the goal of allowing the “Modified FAA” calculations to utilize IDF curves, runoff coefficients, and allowable unit release rates specific to the City of Woodland Park. A detailed description of the specific updates to the workbook are outlined below.

### **“INTRO” WORKSHEET**

The “Intro” worksheet was updated to make it clear to the user that the workbook has been modified for the City of Woodland Park. Specific updates included:

- Changing the initial pop-up box that appears when the workbook opens and the revision history button to provide a brief explanation of the changes made to the workbook.
- The version release date was edited to reflect both the UDFCD version release date (January 2015) and the Woodland Park modification date (July 2015).
- Providing a link to the City of Woodland Park webpage as well as maintaining the link to the UDFCD webpage.
- Adding Wright Water Engineers, Inc. to the Acknowledgements section.
- Changing the Comments section to provide the phone number for the Woodland Park Public Works Department.

## **“MODIFIED FAA” WORKSHEET**

The “Modified FAA” worksheet was updated to reflect default input parameters outlined in the City of Woodland Park Drainage Criteria Manual dated March 2014. These parameters include runoff coefficients and Intensity-Duration-Frequency (IDF) curves. The updates to the spreadsheet also included new analysis to establish allowable unit release rates specific to Woodland Park for use in the Modified FAA worksheet. These updates are described below.

### **Runoff Coefficients**

Runoff coefficients for the Rational Method provided in Table 6-5 of the City of Woodland Park Drainage Criteria Manual are lumped into Hydrologic Soil Groups (HSG) A and B and HSG C and D. UDFCD does not lump the HSG A and B soils together, instead they provide unique runoff coefficients for HSG A and B. The Woodland Park runoff coefficients for HSG A and B match the runoff coefficients provided by UDFCD in Table RO-5 for HSG B, but not the UDFCD values for HSG A. The UD-Detention workbook calculates the runoff coefficient based on imperviousness, return period, and HSG using equations developed by UDFCD. These equations produce consistent results with Table 6-5 for HSG B and C and D. Therefore, to make sure the updated WP-Detention workbook calculates runoff coefficients consistent with Table 6-5, the workbook code was modified so that if a user enters HSG A, the program automatically assumes HSG B in calculating the runoff coefficient. In the vicinity of Woodland Park HSG A soils typically occur along drainageways and comprise only a modest fraction of soils in the area. Steep slopes and shallow bedrock also influence runoff. HSG B soils cover much of the urban area of Woodland Park (NRCS web soil survey mapping). This change was made in two places in subroutine “FAA” and in one location in subroutine “FAA Tc”. Comments provided in cells E26 and L26 of the worksheet were updated to reflect this change.

### **IDF Formula**

The IDF formula utilized in the worksheet to calculate rainfall intensity was updated to reflect design rainfall values specific to Woodland Park as provided in Tables 6-1 and 6-2 of the City of Woodland Park Drainage Criteria Manual. The rainfall depths from Table 6-1 were added to the comments for cells E18 and L18. The rainfall intensity is approximated by the equation:

$$I = \frac{C_1 * P_1}{(C_2 + T_c)^{C_3}}$$

in which:

I = rainfall intensity (inches per hour)

P<sub>1</sub> = 1-hour point rainfall depth (inches)

T<sub>c</sub> = time of concentration (minutes)

$C_1, C_2, C_3$  = regression coefficients

The three regression coefficients were determined for the Woodland Park area by using Excel's Solver to minimize the sum of squared errors between Table 6-2 and the equation results. The resulting regression coefficients are:  $C_1 = 34.36$ ,  $C_2 = 6.55$ , and  $C_3 = 0.842$ . A new button was added to the "Modified FAA" worksheet in rows 20 through 22 to allow the user to select the default coefficients determined for Woodland Park and have them populate cells E20:E22.

A check was performed on the rainfall intensity equation by using slightly different 1-hour precipitation depths from the values provided in Table 6-1 of the city of Woodland Park Drainage Criteria Manual. Precipitation depths for the far extents of the City boundaries were obtained from NOAA Atlas 14 and plugged into the rainfall intensity equation. In all locations, the equation results were within 0% to 3% of the directly calculated rainfall intensities.

### **Allowable Unit Release Rates**

The UD-Detention workbook provided a button to select default allowable unit release rates based on Table SO-1 of the USDCM. Since the rainfall depths are higher in Denver than in Woodland Park, the unit release rates were also higher than they would be in Woodland Park. Therefore, new allowable unit release rates were developed for the Woodland Park area. In lieu of detailed watershed rainfall-runoff modeling to establish release rates, multiple analyses were conducted to determine reasonable release rates within ranges generally bound by UDFCD, Colorado Springs and Rational Formula calculations for undeveloped land. Analysis also included comparison of ratios of hourly precipitation depths for a range of return periods as another check on reasonableness of values. The attached spreadsheet contains supporting calculations, and recommended values are presented in Table 1 and 2 with comparisons to bounding conditions considered. Figures 1 and 2 illustrate comparisons for HSG A and B and HSG C and D, respectively.

Rational Formula calculations based on times of concentration of 60 to 90 minutes using Woodland Park hourly rainfall depths were found to produce rates in the ranges of UDFCD release rates but somewhat higher than Colorado Springs release rates. While Colorado Springs release rates were considered in this analysis it is important to realize that these release rates were determined based on a Natural Resource Conservation Service (NRCS) 2-hour storm and Antecedent Moisture Condition (AMC) Type I (dry antecedent conditions with high infiltration potential). This assumption is appropriate for the inter-event period typical in Colorado Springs, especially for grasslands and rangeland; however, it is not representative of the climate of Woodland Park. The AMC assumption has significant implications on the amount of runoff generated; therefore, the release rates for Woodland Park would be expected to be higher than those in Colorado Springs. Steep slopes and shallow bedrock in many locations in Woodland Park also lead to a greater natural runoff response.

The WP-Detention workbook code was updated to use the allowable unit release rates in Tables 1 and 2 when the "Use Default q" button is selected. The comments in cells E17 and L17 were updated to reflect the method used to determine the default allowable unit release rates.

### **Table 1. Allowable Unit Release Rates for HSG A&B**

Return Period (year)	Q <sub>allow</sub> UDFCD A/B Avg	Q <sub>allow</sub> C Springs A/B Avg	Rational T <sub>c</sub> = 60 min	Rational T <sub>c</sub> = 90 min	Q <sub>allow</sub> WP A/B	Q <sub>allow</sub> UDFCD/ Q <sub>allow</sub> WP (Ratio)	1-hour Rainfall Depth Ratio (Denver Stapleton/ Woodland Park)
	cfs/acre	cfs/acre	cfs/acre	cfs/acre	cfs/acre		
2	0.03	0.01	0.02	0.02	0.02	1.25	0.00
5	0.10	0.02	0.08	0.06	0.08	1.25	1.12
10	0.18	----	0.20	0.15	0.16	1.13	1.15
25	0.33	----	0.39	0.28	0.28	1.16	1.17
50	0.45	----	0.54	0.40	0.40	1.11	1.18
100	0.68	0.20	0.73	0.54	0.57	1.18	1.18

**Table 2. Allowable Unit Release Rates for HSG C&D**

Return Period (year)	Q <sub>allow</sub> UDFCD C/D Avg	Q <sub>allow</sub> C Springs C/D Avg	Rational T <sub>c</sub> = 60 min	Rational T <sub>c</sub> = 90 min	Q <sub>allow</sub> WP C/D	Q <sub>allow</sub> UDFCD/ Q <sub>allow</sub> WP (Ratio)	1-hour Rainfall Depth Ratio (Denver Stapleton/ Woodland Park)
	cfs/acre	cfs/acre	cfs/acre	cfs/acre	cfs/acre		
2	0.04	0.04	0.05	0.03	0.04	1.00	1.12
5	0.17	0.30	0.16	0.11	0.15	1.13	1.15
10	0.30		0.30	0.22	0.26	1.15	1.17
25	0.52		0.56	0.41	0.44	1.18	1.18
50	0.68		0.79	0.58	0.58	1.17	1.18
100	1.00	0.50	1.04	0.76	0.84	1.19	1.19

### Figure 1 Comparison of Allowable Release Rates for HSG A&B Soils



