In this tutorial you will learn:

- About Regional Storms and how to determine the precipitation values for different climatic regions in EWA.

Long Duration (Regional) Storms – Criteria For Use

Long-duration design storms are appropriate for designing stormwater detention and runoff treatment facilities where runoff volume is primarily of concern. The criteria for sizing both runoff treatment and flow control facilities is summarized in Tables 3-4 and 3-7 shown below, Chapter 3 of the Highway Runoff Manual. For the detention and infiltration pond examples in this tutorial we will use Table 3-7, which specifies the Regional or Type IA Storm depending on the climatic Region.

Table 3-4. Criteria for sizing runoff treatment facilities in eastern Washington.

Facility Type	Criteria	Model
Volume-based	Size facility using the runoff volume predicted for the 6-month, long duration* storm event under postdeveloped conditions for each TDA.	Single-event model (SCS or SBUH) Climatic Regions 1–4 Regional Storm; OR Type 1A for Climatic Regions 2 & 3 (10 minute time step)
Flow-based: upstream of detention/retention facility	Size facility using the peak flow rate predicted for the 6-month, short duration storm under postdeveloped conditions for each TDA.	Single-event model (SCS or SBUH) Short duration storm (5 minute time step)
Flow-based: downstream of detention facility	Size facility using the full 2-year release rate from the detention facility, under postdeveloped conditions for each TDA.	Single-event model (SCS or SBUH) Short duration storm OR the appropriate long duration storm depending on the Climate Region,, whichever produces the greatest flow

Table 3-7. Eastern Washington flow control criteria.

Facility Type	Criteria	Model
Detention/combination treatment and detention facilities	Provide storage volume required to match ½ of the 2-year predeveloped peak flow rate and match the predeveloped 25-year peak flow rate, and check the 100-year peak flow for property damage.	Single-event model (SCS or SBUH) Climatic Regions 1–4 Regional Storm; OR Type 1A Storm for Climatic Regions 2 & 3 only
Infiltration facilities	Size facility to infiltrate sufficient runoff volumes that the overflow does not exceed the 25-year peak flow requirement. Check the 100-year peak flow to estimate the potential for downstream property damage, or infiltrate 100 % of the 100-year runoff volume.	Single-event model (SCS or SBUH) Climatic Regions 1–4 Regional Storm; OR Type 1A Storm for Climatic Regions 2 & 3 only

Climatic Regions

As stated in the Beginning Storm Shed class, there are 4 climatic regions within eastern Washington. Climatic Regions 2 and 3 can use either the Type IA of Regional Storm, however Climatic Regions 1 and 4 are required to use the Long Duration Storm. Descriptions of the regions map can be found in section 4C of the HRM and are summarized below. A climatic regional map, also from Appendix 4C of the HRM, shows the location of the regions and is included on the next page of this tutorial.

Climatic Region Descriptions

Region 1 – East Slopes of Cascade Mountains

This region is comprised of mountain areas on the east slopes of the Cascade Mountains. It is bounded on the west by the Cascade crest and generally bounded to the east by the contour line of 16-inches mean annual precipitation.

Region 2 – Central Basin

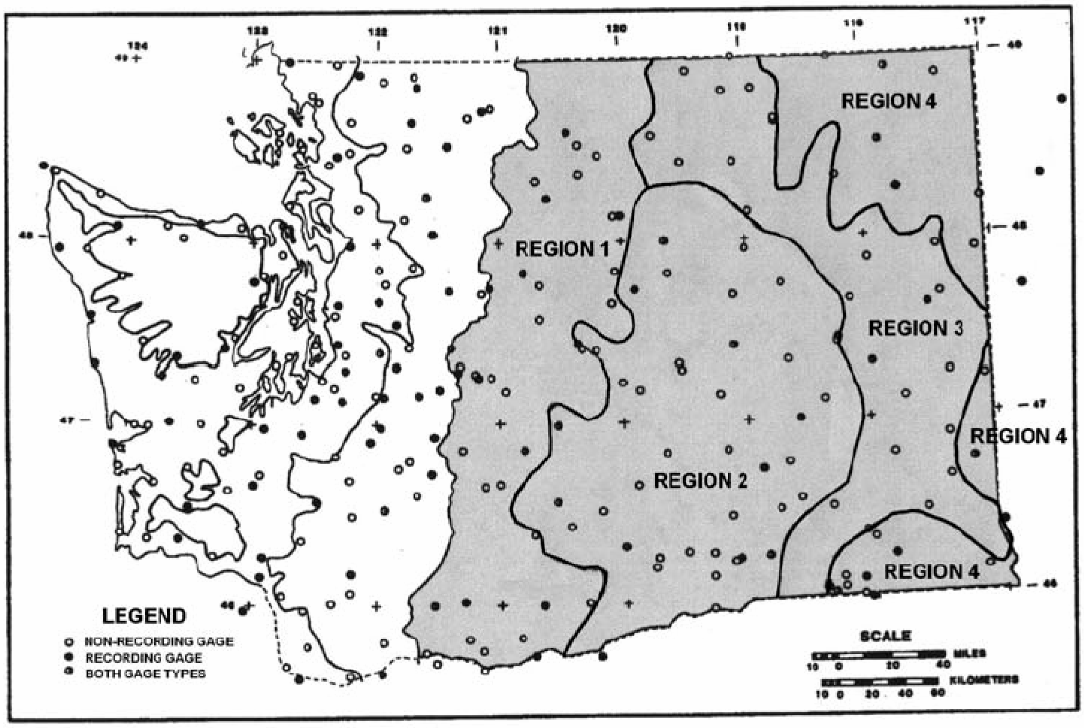
The Central Basin region is comprised of the Columbia Basin and adjacent low elevation areas in central Washington. It is generally bounded on the west by the contour line of 16-inches mean annual precipitation at the base of the east slopes of the Cascade Mountains. The region is bounded on the north and east by the contour line of 12-inches mean annual precipitation. Most of this region receives about eight inches of mean annual precipitation. Many of the larger cities in eastern Washington are in this region, including: Ellensburg, Kennewick, Moses Lake, Pasco, Richland, Wenatchee, and Yakima.

Region 3 – Okanogan, Spokane, Palouse

This region is comprised of inter-mountain areas and includes areas near Okanogan, Spokane, and the Palouse. It is bounded on the northwest by the contour line of 16-inches mean annual precipitation at the base of the east slopes of the Cascade Mountains. It is bounded on the south and west by the contour line of 12-inches mean annual precipitation at the eastern edge of the Central Basin. It is bounded on the northeast by the Kettle River Range and Selkirk Mountains at approximately the contour line of 22-inches mean annual precipitation. It is bounded on the southeast by the Blue Mountains, also at the contour line of 22-inches mean annual precipitation.

Region 4 – Northeastern Mountains and Blue Mountains

This region is comprised of mountain areas in the easternmost part of Washington State. It includes portions of the Kettle River Range and Selkirk Mountains in the northeast, and the Blue Mountains in the southeast corner of eastern Washington. Mean annual precipitation ranges from a minimum of 22-inches to over 60-inches. The western boundary of this region is the contour line of 22-inches mean annual precipitation.



Long Duration (Regional) Storms – Description

When rainfall patterns during storms were analyzed in eastern Washington, it was concluded that the SCS Type II rainfall distribution does not match the historical records for the two storm types of interest for stormwater analyses in eastern Washington: the short duration thunderstorm and the long-duration winter storm. Short duration storms are further discussed in the Beginning StormSHED Tutorial.

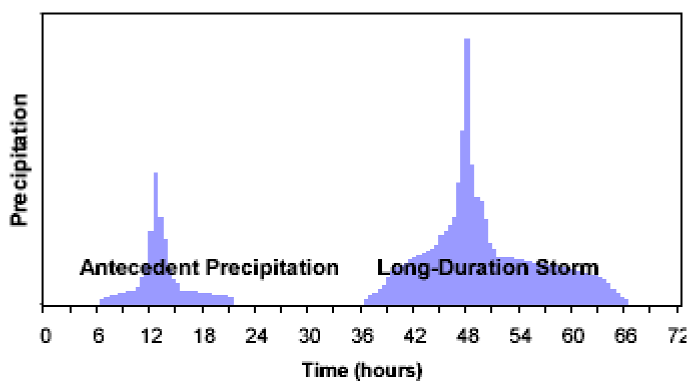


Figure 4D-4. Sample long-duration storm hyetograph

Long-duration general storms can occur at any time of the year, but are most common in late fall through winter, and in late spring and early summer. General storms in eastern Washington vary by region and are characterized by sequences of storms and intervening dry periods, occurring over 72 hours, see Figure 4D-4 above. Low to moderate storm intensity precipitation is typical during the periods of storm activity. These types of events can produce floods with moderate peak discharge and large runoff volumes. The runoff volume can be augmented by snowmelt when precipitation falls on snow during winter and early spring storms. These types of storms are important where runoff volume and peak discharge are design considerations.

The smaller event (Antecedent Precipitation from 6 to 21 hours, Figure 4D-4) is insufficient to generate runoff that is present when the larger precipitation commences. For that reason, it is not necessary to directly model the smaller precipitation event. Only the larger portion (commencing at 36 hours as shown above) is necessary to directly model.

The larger portion is similar to the 24-hour SCS Type 1A storm. For climate regions 2 and 3, the SCS Type IA storm is sufficiently similar to the applicable regional long-duration storm hyetographs to use directly.

Tabular values of the regional long-duration storm hyetographs are in Tables 4D-8 to 11.

Long Duration (Regional) Storms – Precipitation Adjustment

If the 24-hour SCS Type 1A storm is used for the long-duration storm, the precipitation totals are the 24-hour amounts and do not need to be adjusted. If the regional long-duration hyetographs are used, the precipitation totals need to be adjusted as indicated for Regions 1, 3, and 4 in Table 4C-11.

Table 4C-11 provides the multipliers, by region, for the conversion of the 24-hour precipitation to the regional long-duration storm precipitation. Using the precipitation values from the Isopluvial Maps and the conversion factor below, the precipitation can be adjusted for the long-duration hyetograph.

Table 4C-11. Conversion factor for 24-hour to Regional Long-Duration Storm precipitation.

Region #	Region Name	Conversion Factor
1	East Slope Cascades	1.16
2	Central Basin	1.00
3	Okanogan, Spokane, Palouse	1.06
4	NE & Blue Mountains	1.07

$$P_{sds} = C_{sds} (P_{N\text{-}yr\ 24\text{-}hr})$$

Where:

P_{sds} = the precipitation adjusted for the long duration hyetograph.
C_{sds} = a conversion factor Table 4C-11
$P_{N\text{-}yr\ 24\text{-}hr}$ = The precipitation from the Isopluvial maps for N years, 24 hours.

Long Duration (Regional) Storms – Antecedent Moisture Content

Regardless whether the 24-hour SCS Type 1A or regional hyetographs are used for long-duration storm modeling, the prior soil wetting produced by the smaller storm event (antecedent precipitation from 6 hours to 21 hours) that is not modeled needs to be accounted for. The Antecedent Moisture Content (AMC), can have a significant effect on both the volume and the rate of runoff. Recognizing this, the SCS developed three antecedent soil moisture conditions, labeled conditions I, II, and III.

AMC I: Soils are dry but not to the wilting point

AMC II: Average Conditions

AMC III: Heavy rainfall, or light rainfall and low temperatures, has occurred within the last 5 days; near saturated or saturated soil.

The amount of antecedent precipitation can be expressed as a percentage of the total precipitation modeled, as shown in Table 4C-1. Using the Table, the precipitation for the 25 year storm should be multiplied by the percentage from the far right column for an applicable Region. The value is compared to Table 4C-2 to determine the 5-day antecedent rainfall for the soil. Since the long duration storm occurs mostly in late fall through winter and late spring through early summer, most all long duration storms occur during the dormant season and designers should use the dormant column.

Table 4C-1. Antecedent precipitation prior to long-duration storm.

Region #	Region Name	Antecedent Precipitation as Percentage of 24-Hour SCS Type 1A Storm Precipitation
1	East Slope Cascades	33%
2	Central Basin	19%
3	Okanogan, Spokane, Palouse	27%
4	NE & Blue Mountains	36%

Region #	Region Name	Antecedent Precipitation as Percentage of Regional Long-Duration Storm Hyetograph Precipitation
1	East Slope Cascades	28%
2	Central Basin	19%
3	Okanogan, Spokane, Palouse	25%
4	NE & Blue Mountains	34%

The chart below was developed for other states and is more applicable in the Midwest where the long duration storm occurs during the growing season.

Table 4C-2. Total 5-day antecedent rainfall (inches).

AMC	Dormant Season	Growing Season
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	Over 1.1	Over 2.1

Long Duration (Regional) Storms – CN Adjustments from AMC Values

Curve numbers in Appendix 4B of the HRM as well as the values found in StormSHED 3G are based on AMC values of II. If the AMC is determined to be other than II, designers should consult Table 4B-4 to adjust the CN value as specified. As noted in the Overview and Project Configuration tutorial, StormSHED goes through this process automatically.

Table 4B-4. Curve number conversions for different antecedent moisture conditions (case Ia = 0.2 S).

CN for AMC II	CN for AMC I	CN for AMC III	CN for AMC II	CN for AMC I	CN for AMC III
100	100	100	76	58	89
99	97	100	75	57	88
98	94	99	74	55	88
97	91	99	73	54	87
96	89	99	72	53	86
95	87	98	71	52	86
94	85	98	70	51	85
93	83	98	69	50	84
92	81	97	68	48	84
91	80	97	67	47	83
90	78	96	66	46	82
89	76	96	65	45	82
88	75	95	64	44	81
87	73	95	63	43	80
86	72	94	62	42	79
85	70	94	61	41	78
84	68	93	60	40	78
83	67	93	59	39	78
82	66	92	58	38	76
81	64	92	57	37	75
80	63	91	56	36	75
79	62	91	55	35	74
78	60	90	54	34	73
77	59	89	50	31	70

Source: SCS-NEH4. Table 10.1.

Long Duration (Regional) Storms – Example Problem

A section of highway near the city of Spokane is to be improved and the Regional Storm will be used for flow control. The soil in the project vicinity has been identified as type B, meadow.

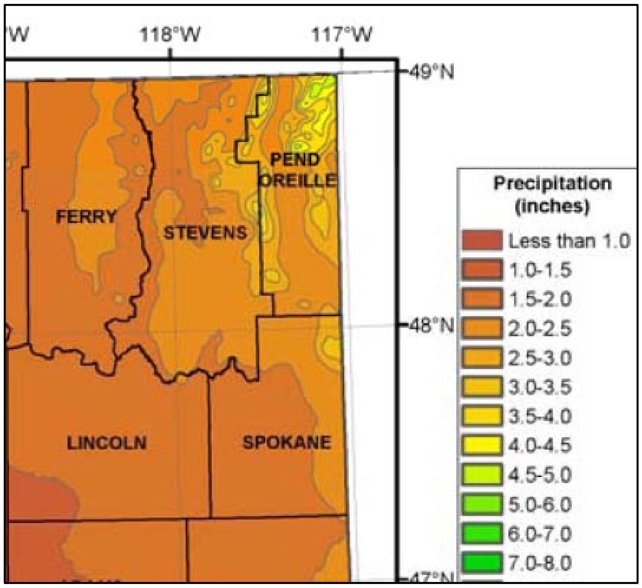
1. Using the climatic region descriptions and map found earlier in this tutorial, the climatic region for Spokane is region 3. From Table 3-7, climatic region 3 can use either the Type IA storm or the regional long duration storm. For this example we will use the regional storm.

2. From the Isopluvial Maps below, the 24 hour precipitation values for the following storms were found to be:

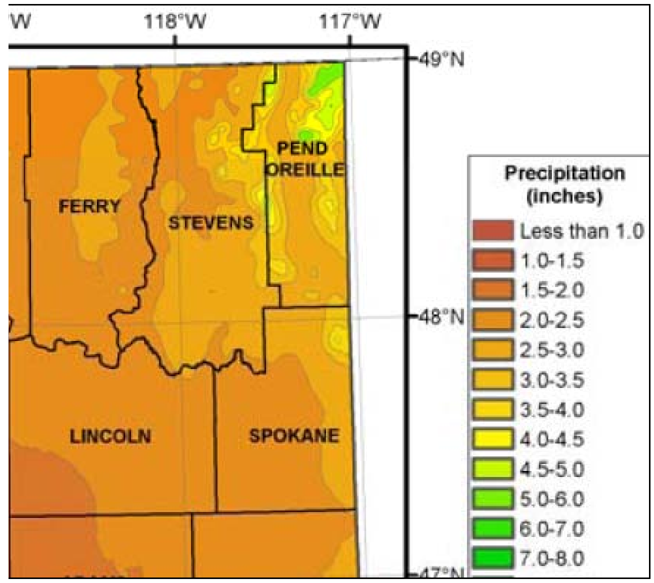
   $P_{2\text{-yr 24-hr}}$ = 1.4 in

   $P_{25\text{-yr 24-hr}}$ = 2.2 in

   $P_{100\text{-yr 24-hr}}$ = 2.6 in



25 year 24 hour



100 year 24 hour

3. From Table 4C-11, adjust the precipitation for the long duration storm. These values will be input into StormShed and used to size the ponds. *(Remember if the Type IA storm were used, this step would be skipped.)*

$P_{2\text{ yr long duration storm}} = 1.06\ (1.4\text{ in}) = 1.48\text{ in}$

$P_{25\text{ yr long duration storm}} = 1.06\ (2.2\text{ in}) = 2.33\text{ in}$

$P_{100\text{ yr long duration storm}} = 1.06\ (2.6\text{ in}) = 2.76\text{ in}$

4. Next we will determine the CN value for our project. Table 4B-3 provides a list of CN values for EWA, as shown on the next page. Given the project soil type is B and the ground cover is classified as Meadow, the CN value would be 58.

5. Determine the total 5-day antecedent rainfall by multiplying the value for Region 3 in the long duration storm section (lower table) of Table 4C-1 and the precipitation calculated for the 25 year event in step three above.

$P_{\text{total 5-day antecedent rainfall}} = 2.33\text{in x } 25\% = 0.58\text{in}$

6. Finally to determine if the CN value needs to be modified based on the effects of AMC, reference Table 4C-2. Since the value is 0.58 (between 0.5 and 1.1 in the dormant season column), the CN value does not need to be adjusted and the CN for AMC II should be selected. If the value was less than the range shown in Table 4C-2, the CN would need to be adjusted to AMC I where as if the value were greater than the range listed the CN would need to be adjusted to AMC III. See Table 4B-4 for adjusted values.

Table 4B-3. Runoff curve numbers for selected agricultural, suburban and rural areas (eastern Washington).

	CNs for hydrologic soil group			
Cover Type and Hydrologic Condition	**A**	**B**	**C**	**D**
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.):[1]				
Poor condition (grass cover on <50% of the area)	68	79	86	89
Fair condition (grass cover on 50% to 75% of the area)	49	69	79	84
Good condition (grass cover on >75% of the area)	39	61	74	80
Impervious Areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)	98	98	98	98
Porous Pavers and Permeable Interlocking Concrete (assumed as 85% impervious and 15% lawn):				
Fair lawn condition (weighted average CNs)	95	96	97	97
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, Grassland, or Range – Continuous Forage for Grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch)	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed)	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Cultivated Agricultural Lands:				
Row Crops (good) e.g., corn, sugar beets, soy beans	64	75	82	85
Small Grain (good) e.g., wheat, barley, flax	60	72	80	84
Meadow (continuous grass, protected from grazing, and generally mowed for hay):	30	58	71	78
Brush (brush-weed-grass mixture, with brush the major element):				
Poor (<50% ground cover)	48	67	77	83
Fair (50% to 75% ground cover)	35	56	70	77
Good (>75% ground cover)	30[2]	48	65	73