IOWA STORM WATER MANAGEMENT MANUAL

3.01 UNIFIED SIZING CRITERIA

IOWA DEPARTMENT OF NATURAL RESOURCES

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Refer to the glossary for words in **bold black text**.
Some items of emphasis are listed in **bold blue text**.

3.01-1 DEFINITION AND GOALS

The Unified Sizing Criteria (USC) are a set of measurement standards used throughout this manual to evaluate management of the **quality** and **quantity** of stormwater runoff. These criteria are to be used in the design and review process to verify that proposed **best management practices** (BMPs) are provided with adequate size and storage to achieve desired treatment goals.

Their purpose is to provide a framework to meet the following objectives set forth in Section 1.04 (Stormwater Management Criteria):

- Minimum guideline #2: Remove stormwater runoff pollutants and improve water quality
- Minimum guideline #3: Prevent downstream streambank and channel erosion
- Minimum guideline #4: Reduce potential of surcharge of downstream storm sewer systems and overbank flooding
- Minimum guideline #5: Safely pass or reduce the runoff from extreme storm events
- Minimum guideline #7: Groundwater recharge (volume reduction)

TABLE 3.01-1.1: UNIFIED SIZING CRITERIA SUMMARY

CRITERIA	OBJECTIVE
SMALL STORM	
Recharge Volume (Rev)	Runoff volume reduction, groundwater recharge.
Water Quality Volume (WQv)	Provide water quality treatment, reduce total pollutant load.
Channel Protection Volume (CPv)	Protect downstream channels from increased flow rates, extended duration of high flows and erosive flow velocities.
LARGE STORM	
Overbank Flood Protection (Qp)	Reduce potential for downstream storm sewer network surcharge and overbank flooding in local urban watersheds.
Extreme Flood Protection (Qf)	Protect adjacent and downstream properties and infrastructure. Prevent increases in flood high water elevations downstream. Manage impacts of extreme storm events through detention controls and floodplain management.

Pretreatment is not listed as one of the Unified Sizing Criteria, but is critically important to be considered in the design of BMPs. Pretreatment practices are used upstream of Water Quality and Quantity BMPs to collect heavier sediments, trash and other debris. Without pretreatment measures, BMPs would require more intense maintenance or may even cease to function due to loss of storage volume, lost infiltration capacity (plugging), blocked outlets and poor aesthetic conditions. Pretreatment measures should be addressed in the planning and design of any stormwater BMP.

NOTE

Refer to Sections 1.05 and 9.03 for information to be included in the Stormwater Management Report and associated calculations

NOTE

Refer to Sections 5.01–5.07 for more information about Pretreatment practices.

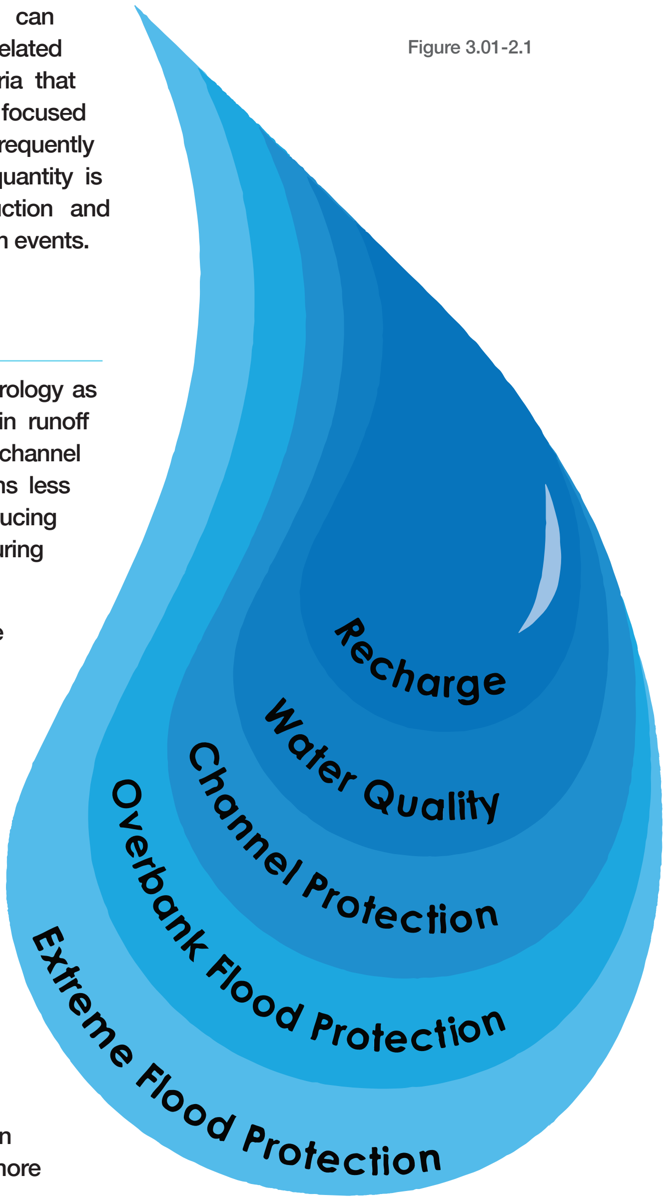
3.01-2 EVALUATION/MEASUREMENT

NOTE

Refer to Section 2.02 (Rainfall and Runoff Analysis) for more information about rainfall frequency and distribution.

The Unified Sizing Criteria (USC) can generally be grouped into standards related to water quality and quantity. Criteria that address water quality are primarily focused around the management of the most frequently occurring, smaller storms. Water quantity is primarily managed by volume reduction and limitation of runoff rates during all storm events.

Figure 3.01-2.1



A. SMALL STORM CRITERIA

The most fundamental change in hydrology as urban areas develop is an increase in runoff VOLUME. This directly impacts channel stability and flood risk. It also means less water is infiltrating into the ground, reducing baseflow levels in urban streams during periods of low precipitation.

Employing methods to mitigate increases in runoff volume should be given first priority.

1. Recharge Volume (Rev)

The Recharge Volume (Rev) standard is intended to reduce overall surface runoff volumes and improve stream baseflow by improving recharge of shallow groundwater levels.

It can be achieved by:

- Application of Soil Quality Restoration and direction of runoff from impervious areas to open spaces where SQR has been applied (refer to Section 7.03 for more information)
- Rainfall Collection and Reuse BMPs
- Use of Infiltration BMPs or Permeable Pavement Systems with elevated subdrains, to require a set volume to be infiltrated into subsoil layers or be retained within the soil media or aggregate layers for plant uptake and/or evapotranspiration
- Other methods as approved by local jurisdictions

The Recharge Volume is defined as:

EQUATION 3.01-2-1:

Rev (CF) = 0.95 x Impervious Area (SF) x Recharge Depth* (inches) / 12 (inches per foot)

Rev = Recharge Volume (CF)
0.95 = Runoff Coefficient for impervious surfaces
Impervious Surface Area (SF) = measured for a given site area or subwatershed
Recharge Depth = 1 inch

Projects need to demonstrate that practices and approaches have been employed to reach the recharge volume to the maximum extent possible. Simply stating that nothing is possible, should not be viewed as acceptable. Almost every site can employ soil quality restoration, rainfall collection and/or reuse or other methods to capture, use, or infiltrate water on-site.

Caution should be used when attempting to infiltrate water into subsoil layers on sites with contaminated soils, karst topography or high water tables and/or ultra urban locations. Even in these conditions practices such as green roofs, soil quality restoration and rainwater capture and reuse can be used to reduce runoff volume. Infiltration practices can also be used in such cases, if appropriate liners are installed and the system is configured to maintain saturated conditions within portions of the soil and aggregate layers.

If it can be demonstrated that the Recharge Volume requirement for a 1" rainfall event is fully achieved at a given site (or subwatershed), then the Water Quality Volume (WQv) requirements for that same area will be considered to be satisfied.

If it is not feasible to reach this goal, then additional practices need to be employed to address the WQv requirements. Any runoff volume reductions achieved may be credited toward the WQv to be treated for a given site (or subwatershed).

Examples of practices which could be used to achieve the Rev standard:

- Stormwater capture / re-use: Volume expected to be used on site within a typical 72 hour period.
- Soil quality restoration: Volume expected to be retained by soil materials (see Section 7.03).
- Tree filter systems and bioretention: Volume in aggregate layers below subdrain (able to be exfiltrated with 72 hours) or volume retained within void space within modified soil / aggregate layers by internal water storage (see Section 7.05 or 7.07).
- Infiltration trenches and bioswales: Volume in aggregate layers below subdrain (able to be exfiltrated with 72 hours - see Section 7.06 or 7.08).
- Permeable pavement systems: Volume in aggregate layers below subdrain (able to be infiltrated with 72 hours - see Section 8.01).
- Ponds / wetlands: Any volume lost through evapotranspiration. Requires water balance analysis to be performed (see Section 9.05).

Note: Individual practices should be sized as needed to meet the Water Quality volume standard, however if the 1" recharge volume is achieved at a given site, no additional practices would be needed to address the remainder of the site's Water Quality volume.

Open spaces with heavily compacted soils or those with insufficient organic content to support desired vegetation without intense irrigation will often generate runoff even during small storm events. For this reason, sites and/or subwatersheds without adequate topsoil or soil quality restoration (SQR) applied to a depth of at least 4 inches should be treated as if they were covered by 50% impervious cover, for the purposes of calculating Rev requirements. Refer to Section 7.03 (Soil Quality Management and Restoration) for more information.

NOTE

Exfiltration is the subsurface movement of water into subsoil layers, such as the movement of water from modified soils or aggregates into native soil materials below a bioretention cell.

Example #1 only shows how the required Rev to be treated is calculated.

Example #2 shows how to calculate how recharge volume is being achieved, if multiple practices are used at a given site.

Soil Quality Restoration
2 acres x (40% open space)
= 0.8 acres of SQR area
x 43,560 SF / acre
x 2.22 inches / 12 (inch/foot)
6,447 CF > 4,138 CF to treat

Bioretention Cell #1
Footprint of cell
= 1 acre x 70% impervious x 5%
= 0.035 acres
x 43,560 SF / acre
1,525 SF
x 3 feet (internal water storage)*
x 0.30 (porosity)
1,372 SF (Rev retained)

Bioretention Cell #2
Footprint of cell
= 1 acre x 40% impervious x 15%
= 0.060 acres
x 43,560 SF / acre
2,614 SF
x 3.083 feet
(internal water storage)*
x 0.30 (porosity)
2,421 SF (Rev retained)

Permeable Pavement
Footprint of permeable surface
= 2 acre x 90% impervious x (1/3) = 0.60 acres
x 43,560 SF / acre
26,136 SF
x 0.833 feet
(internal water storage)**
x 0.30 (porosity)
6,534 SF (Rev retained) > 6,207 CF to treat

* For this example it is assumed that an upturned elbow or water level control structure keeps an internal water storage depth that keeps the bottom 2 feet of modified soil and noted depth aggregate below subdrain saturated.

** 10" of aggregate below subdrain.

EXAMPLE PROBLEM #1:

Given: 1 acre of impervious cover (43,560 SF)

Rev = 0.95 x 43,560 SF x 1 inch x (1 foot / 12 inches)

Rev = 3,449 CF (cubic feet)

EXAMPLE PROBLEM #2:

This second scenario shows how a table could be provided that demonstrates compliance with this standard.

Parameters:

A. 2 acres (60% impervious -- building, sidewalks, etc.) draining to open spaces with 8" depth SQR, w/ 5% organic matter (2.22" of water storage available in 0.8 acres of open space -- reference Section 7.03).

B. 1 acre (70% impervious -- building, sidewalks, parking) draining to Bioretention Cell #1. Cell footprint area would be 5% of impervious area drained, with 12" of aggregate layer below the subdrain and internal water storage within 24" of aggregate / modified soil layer (porosity 30%).

C. 2 acres permeable pavement area (90% impervious). Permeable area assumed to be 1/3 of entire impervious parking area. 10" of aggregate storage below subdrain (porosity 30%).

D. 1 acre (40% impervious -- sidewalks, parking, driveways) draining to Bioretention Cell #2. Cell footprint area enlarged to be 15% of impervious area drained, with 13" of aggregate layer below the subdrain and internal water storage within 24" of aggregate / modified soil layer (porosity 30%).

Deepest depth of aggregate layer to be infiltrated = 13 inches. Required subsoil infiltration rate to drain this layer in 72 hours: 13 inches/72 hours = 0.183 inches/hour. If site soils can achieve this infiltration rate, the full Rev requirement would be met for this example.

TABLE 3.01-2-1A: EXAMPLE #2 REV CALCULATIONS

Practice	Area to be Treated by BMP	% Impervious	Rev of Area to be Retained	Unretained Rev from Upstream BMPs	Total Rev to BMP	Rev Retained by BMP	% of Rev Retained by BMP	Rev Directed to Downstream BMP	Downstream BMP
	(acres)	(%)	(CF)	(CF)	(CF)	(CF)	(%)	(CF)	
Soil Quality Restoration	2.00	60%	4,138	0	4,138	4,138	100%	0	Bioretention Cell #1
Bioretention Cell #1	1.00	70%	2,414	0	2,414	1,372	57%	1,042	Bioretention Cell #2
Permeable Pavement	2.00	90%	6,207	0	6,207	6,207	100%	0	Bioretention Cell #2
Bioretention Cell #2	1.00	40%	1,379	1,042	2,421	2,421	100%	0	Discharge from Site

EXAMPLE PROBLEM #3:

This third scenario is similar to Example #2, but the aggregate layers below the subdrain are omitted, showing an example where site soils are assumed to allow for no infiltration.

Parameters:

A. 2 acres (60% impervious -- building, sidewalks, etc.) draining to open spaces with 8" depth SQR, w/ 5% organic matter (2.22" of water storage available in 0.8 acres of open space -- reference Section 7.03).

B. 1 acre (70% impervious -- building, sidewalks, parking) draining to Bioretention Cell #1. Cell footprint area would be 5% of impervious area drained, with internal water storage within 24" of aggregate / modified soil layer (porosity 30%).

C. 2 acres permeable pavement area (90% impervious). Permeable area assumed to be 1/3 of entire impervious parking area. 3" of aggregate storage below subdrain (porosity 30%).

D. 1 acre (40% impervious -- sidewalks, parking, driveways) draining to Bioretention Cell #2. Cell footprint area enlarged to be 15% of impervious area drained, with internal water storage within 24" of aggregate / modified soil layer (porosity 30%).

TABLE 3.01-2-1B: EXAMPLE #3 REV CALCULATIONS

Practice	Area to be Treated by BMP	% Impervious	Rev of Area to be Retained	Unretained Rev from Upstream BMPs	Total Rev to BMP	Rev Retained by BMP	% of Rev Retained by BMP	Rev Directed to Downstream BMP	Downstream BMP
	(acres)	(%)	(CF)	(CF)	(CF)	(CF)	(%)	(CF)	
Soil Quality Restoration	2.00	60%	4,138	0	4,138	4,138	100%	0	Bioretention Cell #1
Bioretention Cell #1	1.00	70%	2,414	0	2,414	915	38%	1,499	Bioretention Cell #2
Permeable Pavement	2.00	90%	6,207	0	6,207	0	0%	6,207	Bioretention Cell #2
Bioretention Cell #2	1.00	40%	1,379	7,706	9,086	1,568	17%	7,518	Discharge from Site
Total Watershed Area	6.00	68%	14,139	*<= Rev Target to be Retained (CF)*			0.65	*<= Rev Target to be Retained (wtr-in)*	
Rev Retained (CF) =						6,621		7,518	<= Rev Discharged (CF)
Rev Retained (watershed-inches) =						0.30		0.35	<= Rev Discharged (wtr-in)
% of Rev Target Retained =						47%		53%	<= % of Rev Target Discharged

Example #3 shows how to document recharge volume when the runoff generated by the 1 inch storm event cannot be fully retained.

Soil Quality Restoration
2 acres x (40% open space)
= 0.8 acres of SQR area
x 43,560 SF / acre
x 2.22 inches / 12 (inch/foot)
6,447 CF > 4,138 CF to treat

Bioretention Cell #1
Footprint of cell
= 1 acre x 70% impervious x 5%
= 0.035 acres
x 43,560 SF / acre
1,525 SF
x 2 feet (internal water storage)*
x 0.30 (porosity)
915 SF (Rev retained)

Bioretention Cell #2
Footprint of cell
= 1 acre x 40% impervious x 15%
= 0.060 acres
x 43,560 SF / acre
2,614 SF
x 2 feet (internal water storage)*
x 0.30 (porosity)
1,568 SF (Rev retained)

Permeable Pavement

Due to poor site soils in this example, minimal infiltration is expected from aggregate below the subdrain. Only 3" of aggregate is to be provided below the subdrain to accommodate water entry into the subdrain.

* For this example it is assumed that an upturned elbow or water level control structure keeps an internal water storage depth that keeps the bottom 2 feet of modified soil saturated and no infiltration is accounted for in storage below the subdrain.

Open spaces with heavily compacted soils or those with insufficient organic content to support desired vegetation without intense irrigation will often generate runoff even during small storm events. For this reason, sites and/or subwatersheds without adequate topsoil or soil quality restoration (SQR) applied to a depth of at least 4 inches should be treated as if they were covered by 50% impervious cover, for the purposes of calculating WQv requirements. Refer to Section 7.03 (Soil Quality Management and Restoration) for more information.

2. Water Quality Volume (WQv)

The WQv criteria is focused on the capture and treatment of runoff from the most commonly occurring storm events. Statewide, approximately 90% of rainfall events on an annual basis are less than or equal a depth of 1.25 inches. The vast majority of runoff from a site will be captured and treated through installation of BMPs that are sized to address these most common, small storms. A 80% reduction in TSS can typically be expected from practices that address 90% of annual rainfall events.

This is a **volumetric standard**, calculated using the "Short cut method" (Schueler, 1987):

Step 1

For a given practice or subwatershed area, a volumetric runoff coefficient (Rv), needs to be calculated. Rv is based on the percentage of impervious cover in the area of interest.

EQUATION 3.01-2.2

Rv = 0.05 + 0.009 (I)

I = percentage of impervious cover, written as a percentage (i.e. for 73% impervious cover, I = 73)

Example #1	Given impervious cover (I) = 73%	Rv = 0.05 + 0.009(I) = 0.05 + 0.009 (73) = 0.7070
Example #2	Given impervious cover (I) = 73%; Topsoil/SQR (< 4 in.)	Effective impervious = 73% + (100% - 73%) x 0.50 = 86.5% Rv = 0.05 + 0.009 (I) = 0.05 + 0.009 (86.5) = 0.8285

Step 2

Calculate WQv by the equation below:

EQUATION 3.01-2.3

WQv = (43,560 SF / acre) [(P)(Rv)(A)] / 12

P = 1.25 inches (WQv storm event depth)

Rv = from *Equation 3.01-2.2*

A = area (in acres)

WQv will be in units of cubic feet.

Example #1	**Rv = 0.7070**	**WQv = (43,560 SF/acre) [(1.25 in)(0.7070)(1 ac)] / 12 = 3,208 CF**
Example #2	**Rv = 0.8285**	**WQv = (43,560 SF/acre) [(1.25 in)(0.8285)(1 ac)] / 12 = 3,759 CF**

Table 3.01-2.2 includes values of Rv and WQv based on various levels of site impervious cover. Values in this table may be used for estimation in preliminary design or for reference during design review. Final design calculations should calculate WQv using the preceding equations based on more detailed information about post-development site or subwatershed conditions.

TABLE 3.01-2.2: WATER QUALITY TREATMENT VOLUME AND ADJUSTED NRCS CURVE NUMBERS FOR THE WQV EVENT			
% IMPERVIOUS AREA	RV	WQv (PER ACRE)	ADJUSTED CN 1.25" EVENT
		(CF)	WQv
0%	-	-	73
5%	.095	431	77
10%	.140	635	80
15%	.185	839	82
20%	.230	1,044	85
25%	.275	1,248	86
30%	.320	1,452	88
35%	.365	1,656	89
40%	.410	1,860	90
45%	.455	2,065	92
50%	.500	2,269	93
55%	.545	2,473	93
60%	.590	2,677	94
65%	.635	2,881	95
70%	.680	3,086	96
75%	.725	3,290	97
80%	.770	3,494	97
85%	.815	3,698	98
90%	.860	3,902	98
95%	.905	4,106	99
100%	.950	4,311	99

Although WQv is a volumetric standard, in some cases it may be necessary to calculate peak flow rates or generate runoff hydrographs for this event. For example, bioswales are designed to pass the peak flow rate at a limited velocity for a certain length of time. Another example of this design problem is sizing structures to divert the WQv peak flow rate to an **off-line** practice. Adjusted curve numbers (CN) need be used to calculate runoff hydrographs for the WQv. Methods to calculate these adjusted CNs and develop hydrographs and peak flow rates for the WQv event are explained in detail within Section 3.02 (Small Storm Hydrology).

NOTE

Compliance with the WQv criteria is based on proper design of BMPs on a given site to address this standard, and calculations to demonstrate how such practices are collectively used to meet the requirements.

NOTE

CNs used to model the WQv event should be different than those used for larger storm events. One effective strategy is to create a watershed modeling using standard curve numbers, then save a copy of the model and enter the CNs for use in modeling the WQv event only.

NOTE

Tables 3.01–2.3–A and –B demonstrate that changes in runoff volume and peak rate above the natural baseline are greatest (by proportion) during the smaller, most frequently occurring storm events.

In this single–family development example, post–development flow volumes during a 1–year storm event are more similar to what would have been expected from a 10–year event under natural conditions.

NOTE

In the same example, post–development flow rates during a 1–year storm event are more similar to what would have been expected from a 25–year event under natural conditions.

If SQR was not implemented for this example, the peak flow rate for the 1–year event would be projected to increase to 36 cfs, which would be more similar to the 100–year peak flows for natural conditions.

3. Channel Protection Standard (CPv)

As watersheds develop into urban land uses, the largest increases in flow rates and volumes (by percentage) are expected during the smallest storm events. Under natural conditions, very little rainfall becomes surface runoff. Soil compaction and placement of impervious surfaces makes it much more likely that runoff is created by small rain events. Without practices to mitigate this effect, urban stream corridors will experience much higher flow rates for longer periods than would naturally occur. This increase in flow leads to higher velocities and erosive forces over an extended period of time. Channel and streambank instability is often observed as a result.

TABLE 3.01-2.3-A. EXAMPLES OF HYDROLOGY CHANGES - VOLUME

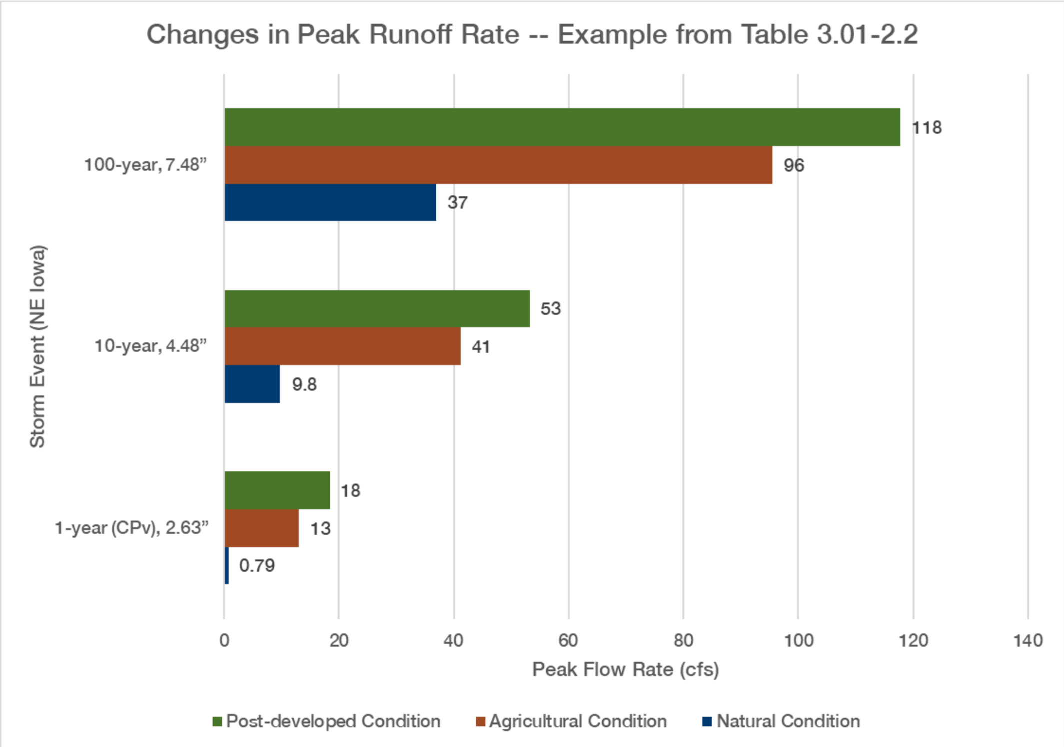
	Natural Condition	Agriculture	Increase Over Natural Condition	Post-developed	Increase Over Natural Condition
Storm Event	Volume (cf)	Volume (cf)		Volume (cf)	
1-year (CPv), 2.63”	12,100	50,500	317%	54,800	353%
2-year, 3.04”	21,000	69,000	229%	73,800	251%
5-year, 3.78”	41,600	106,100	155%	111,300	168%
10-year, 4.48”	65,600	144,600	120%	149,600	128%
25-year, 5.56”	109,200	208,300	91%	212,600	95%
50-year, 6.48”	151,200	265,500	76%	268,800	78%
100-year, 7.48”	200,900	329,800	64%	331,800	65%

TABLE 3.01-2.3-B. EXAMPLES OF HYDROLOGY CHANGES - PEAK RATE

	Natural Condition	Agriculture	Increase Over Natural Condition	Post-developed	Increase Over Natural Condition
Storm Event	Peak Flow (cfs)	Peak Flow (cfs)		Peak Flow (cfs)	
1-year (CPv), 2.63”	0.79	13	1,546%	18	2,229%
2-year, 3.04”	1.9	19	874%	25	1,223%
5-year, 3.78”	5.3	30	460%	39	637%
10-year, 4.48”	9.8	41	320%	53	442%
25-year, 5.56”	19	60	225%	76	310%
50-year, 6.48”	27	77	185%	96	255%
100-year, 7.48”	37	96	158%	118	218%

Basis of Example Above:
Study Area = 20 acres
Natural Conditions: Prairie, CN=58, Tc=41.7 minutes
Agricultural Conditions: CN=74, Tc=22.4 minutes
Post-Developed: 18 acres single family (40% impervious, HSG B soil, CN=76*), 2 acres park (CN=61*), Tc=16.1 minutes
*Assumes 8” SQR established on open spaces
NRCS TR-55 model based on the conditions above

FIGURE 3.01-2.2 -- GRAPH OF HYDROLOGY CHANGES



Figures 3.01-2.3 -- Tall vertical, bank erosion is undercutting trees along a creek in a urban watershed

NOTE

The rainfall depth value for the CPv event varies across the state. See Section 2.02 (Rainfall and Runoff Analysis) for values.

Figure 3.01-2.4: City staff noted that the small urban stream in this area was 2 feet wide and 1 feet deep when the area was platted about 30 years before this photo was taken. In this photo, the stream had a top width of around 40 feet and a depth of 15 feet.

NOTE

Alternatively, CPv may be addressed by increasing the size of water quality BMPs. In this case, the CPv volume would be used in place of the WQv volume in the sizing calculations for such practices.

Practices designed to meet this standard, will better mimic natural site hydrology for small storm events. Management of this condition is typically addressed by providing extended detention of the 1-year, 24-hour storm event (CPv event). Extended detention greatly reduces allowable outflow from this event, providing a drawdown period of no less than 24 hours. To meet this criteria, a BMP with sufficient temporary storage volume is needed to capture runoff from the rainfall event, while not exceeding the calculated allowable release rate.

Section 3.02 (Small Storm Hydrology) details a step-by-step approach to design practices to provide extended detention meet the CPv criteria.

NOTE

BMPs also must meet any practice–specific design criteria related to the CPv, such as allowable ponding depth.

A few notes to reinforce when referring to that procedure in Section 3.02:

- The initial steps of that procedure (steps 1-4) use software running TR-20 or TR-55 calculation methods to calculate runoff hydrographs for pre- and post-developed site conditions.
- Step 5 computes the peak outflow discharge required to provide the extended drawdown period. This becomes the metric used later to measure compliance.
- Steps 6 and 7 are used to calculate a PRELIMINARY ESTIMATE of storage volume. This value should be used early in the design process, to get an initial idea of the volume and surface area required for the BMP. This is just an estimate of the storage that will be needed to meet the release rate goals, this is NOT a storage volume to be used to show compliance with the CPv standard.
- The remaining steps guide the final design of the BMP, including the outlet controls.

To demonstrate compliance with the CPv criteria, the final design routing calculations will need to show that the release rate from the site does not exceed the allowable peak outflow discharge rate (from Step 5 in the procedure summarized above).

B. LARGE STORM CRITERIA

Installation of BMPs to address Water Quality, will likely also lead to reductions in the quantity of runoff. However, the following criteria are grouped under this heading as they primarily relate to the design of practices that control the rate and volume of surface runoff during larger storm events.

1. Overbank Flood Protection (Qp)

This criteria is primarily intended to address the following issues:

a. Prevent local flash flooding due to surcharge of downstream storm sewer networks.
Most jurisdictions require new developments to size storm sewer systems to be designed to convey runoff from either the 5- or 10-year storm event without surcharge of the system. Some older systems may have been designed to a lesser standard (i.e. convey the 2-year storm). There is a need to control runoff rates from development sites so that they do not exceed the capacity of downstream storm sewer networks during these types of events.

b. Reduce the potential overbank flooding in small urban watersheds.
Runoff from development sites should not increase the likelihood of out of bank flooding during these moderate storm events.

Practices designed to meet this standard, should better mimic natural site hydrology for these types of events. Management to meet this standard requires BMPs with sufficient temporary storage volume to limit runoff rates from the site area to not exceed maximum allowable rates.

> To demonstrate compliance with the Qp criteria, the final design routing calculations will need to show that the release rate from the site does not exceed the rate based on natural conditions for an event of the same type (or local jurisdictional requirements).

Natural conditions shall be defined as a land use of "meadow in good condition" with time of concentration calculated based on characteristics consistent with that land use and local Hydrologic Soil Group (refer to margin at right for more information).

For reference, *existing conditions* shall be defined as land uses and site conditions as they exist immediately prior to the proposed development.

Advisory: The modified rational method should not be used for preliminary OR final design of stormwater detention storage BMPs.

TABLE 3.01-2.4: OVERBANK FLOOD PROTECTION CRITERIA SUMMARY	
STORM EVENT	ALLOWABLE RELEASE RATE
2-year storm	2-year peak rate, based on natural conditions
5-year storm	5-year peak rate, based on natural conditions
10-year storm	10-year peak rate, based on natural conditions*

* Some jurisdictions may require to check that release rate from this event also does not exceed 5-year peak rate, based on existing conditions.

When calculating the CN to be used for natural conditions, determine the proportion of the site area that falls into each HSG category. Then use those ratios to calculate the weighted average of CNs for meadow in good condition, based on the local soil properties. However, if the calculated value exceeds the maximum value set by the local jurisdiction, then the maximum value allowed should be used when modeling "natural" conditions.

NOTE

For additional details, refer to the following sections:

Section 2.02
(Rainfall and Runoff Analysis)

Section 2.03
(Time of Concentration)

Section 2.05
(NRCS TR-55 Methodology)

Section 2.06
(Runoff Hydrograph Determination)

Sections 9.01-9.12
(Detention BMP sections)

NOTE

Regardless of local soil types, a maximum value of CN=71 should be used to represent "natural" conditions. This would limit runoff rates to levels similar to what would occur from HSG C soils.

Jurisdictions may decide to adopt standards with a more restrictive maximum value. For example, setting a maximum value of CN=58 for "natural" conditions would set release rates to be similar to what would occur from HSG B soils.

The more restrictive standard would be recommended for use in jurisdictions or locations with the greatest need to minimize release rates to reduce potential downstream flood impacts (areas where there has been frequent flooding or where existing homes are located close to the flood plain). The jurisdiction may choose to enforce that standard on a watershed basis or on the jurisdiction as a whole.

NOTE

CNs for Meadow in Good Condition:

HSG A = 30
HSG B = 58
HSG C = 71
HSG D = 78

Note guidance on maximum CNs to use for meadow in good condition on previous page.

NOTE

The "same event, natural condition" standard is usually more restrictive than the "5–year existing condition standard" for events smaller than the 50–year storm. It is possible that the "5–year existing condition standard" may be more restrictive for the 50– and/or 100–year events.

2. Extreme Flood Protection (Qf)

This standard focuses on runoff generated by the largest of events, up to and beyond the 100-year storm event. It is intended to prevent increases in peak runoff rates caused by urban development during these large storm events. Through this, the goal is to prevent flood damage to downstream properties and infrastructure and maintain or reduce the boundaries of areas expected to be inundated by the 100-year event.

Management to meet this standard requires BMPs with sufficient temporary storage volume to limit runoff rates from the site area to not exceed maximum allowable levels. Practices designed to meet the "same storm event, natural condition" standard, should mimic natural site hydrology for small storm events.

To demonstrate compliance with the Qf criteria, the final design routing calculations will need to show that the release rate from the site does not exceed the rate based on natural conditions for an event of the same type (or local jurisdictional requirements).

Advisory: The modified rational method should not be used for preliminary OR final design of stormwater detention storage BMPs.

TABLE 3.01-2.5: OVERBANK FLOOD PROTECTION CRITERIA SUMMARY

STORM EVENT	ALLOWABLE RELEASE RATE
25-year storm	25-year peak rate, based on natural conditions*
50-year storm	50-year peak rate, based on natural conditions*
100-year storm	100-year peak rate, based on natural conditions*

* Some jurisdictions may require to check that release rate from these events also does not exceed 5-year peak rate, based on existing conditions.

Some jurisdictions within Iowa have historically required new developments to restrict the peak outflow from the 100-year storm event to not exceed the peak flow rate that would have been created by a 5-year event under existing conditions. This standard was based on the desire to limit outflows from new development areas to levels that theoretically would not surcharge a downstream storm network that was sized to convey the 5-year storm event.

In the recent past, many management areas were sized using the Modified Rational Method, or other methods that likely would have resulted in less temporary storage being provided than the methods included in this manual. Those practices also rarely included methods to control runoff from the smaller, more frequently occurring events which comprise most of the annual runoff volume.

In some locations, jurisdictions may also want to impose further restrictions on release rates where limitations in capacity of downstream storm sewers, channels or management areas exist.

C. MULTI-STAGE OUTLET DESIGN

Practices planned to address both water quality and quantity criteria will typically include an outlet designed to operate with multiple stages. Large weirs and pipes are too large to restrict flows as needed to provide extended detention of small storms. Smaller outlets won't have capacity to convey allowable outflow from larger events. A multi-stage design will feature lower stages with greater restrictions (i.e. perforated risers, small diameter pipes or openings, etc.) that are generally set in the lower levels of the BMP. When larger storm events happen, water levels will rise to a point where it reaches secondary stages of the outlet (i.e. larger opening, overflow weir, etc.).

A structure of this type will have several stages, which are often set in the top and sides of the outlet structure. This outlet structure is often connected to a storm sewer pipe or other spillway structure, which may provide the final control restriction for the largest events. Most storage BMPs will also feature a separate auxiliary spillway to define an overflow path for runoff that may be used in very large events.

Design examples for specific BMPs within this manual go into greater detail on these types of outlet structures and their proper sizing.

Figure 3.01-2.5-A: Features of a multi-stage outlet

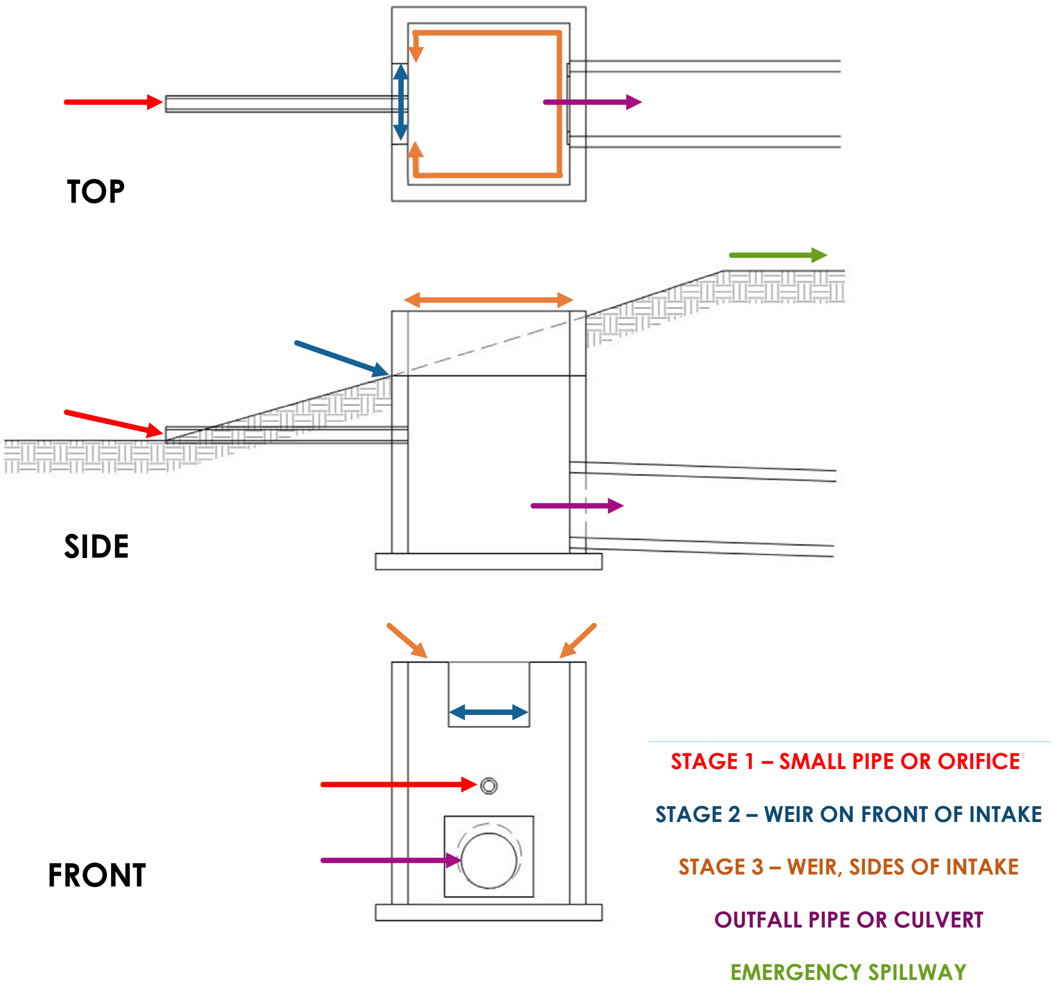
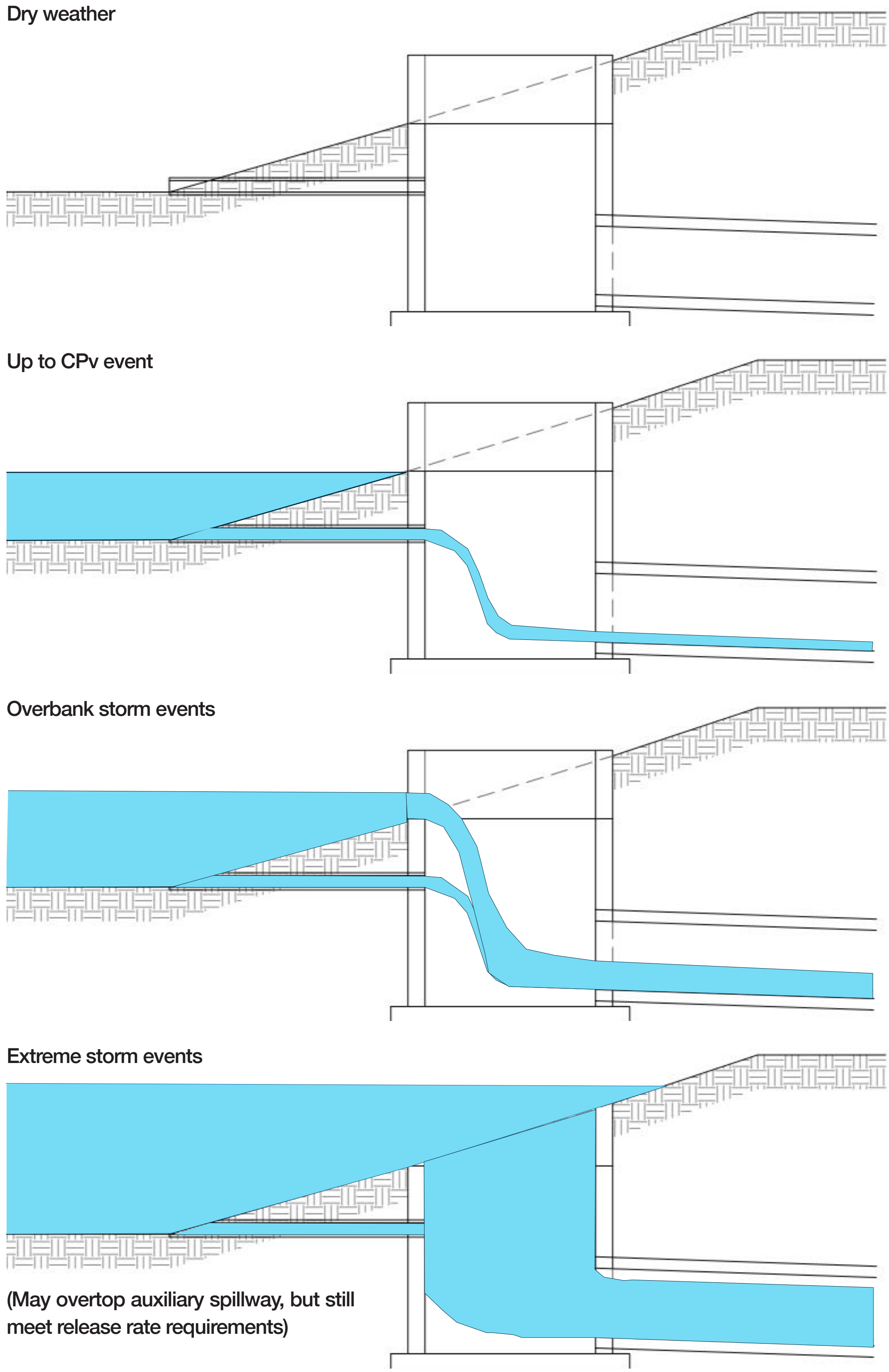


Figure 3.01-2.5-B: Multistage outlet at different levels of operation



3.01-3 IMPLEMENTATION

A. TOOLBOX OF BEST MANAGEMENT PRACTICES FOR WATER QUALITY AND QUANTITY

The various BMPs that are included within this manual operate in different ways. By their design, some are more effective at addressing water quality. Some practices are designed to have more capacity for storage, which may make them more effective at addressing the quantity of direct runoff. The table below reviews the various Water Quality and Quantity BMPs included by this manual and how they are most effective in addressing the various levels of the Unified Sizing Criteria.

TABLE 3.01-3.1: APPLICATION OF BEST MANAGEMENT PRACTICES TO ADDRESS UNIFIED SIZING CRITERIA

	Small Storm			Large Storm	
PRACTICE	Rv	WQv	CPv	Qp	Qf
Green Roofs [1]	PR	PR	PO	RE	RE
Rainwater Harvesting [1]	PR	PR	PO	RE	RE
Soil Quality Management and Restoration [1]	PR	PR	RE	RE	RE
Native Landscaping [1]	PR	PR	RE	RE	RE
Tree Filter Systems [1]	PR	PR	RE	RE	RE
Infiltration Trenches [1]	PR	PR	PO	RE	RE
Bioretention Systems	PR	PR	PO	AD	AD
Bioswales [2]	PR	PR	RE	NA	NA
Infiltration Basins	PR	PR	PR	PO	PO
Permeable Pavement [3]	PR	PR	PO	AD	AD
Constructed Stormwater Wetlands	NA	PR	PO	PO	PO
Traditional Dry Detention	NA	NA	NA	PR	PR
Extended Dry Detention	NA	NA	PR	PR	PR
Wet Ponds	NA	PR	PR	PR	PR
Combinations of Water Quality & Quantity Practices	PR	PR	PR	PR	PR
Detention Retrofits	AD	AD	AD	AD	AD

PR = Primary Application
PO = Possible Application
AD = May be Adapted to Address
RE = May Reduce Requirement or Partially Address
NA = Not Typically Applicable or Little Impact

1 These BMPs may result in reduction of runoff, adjustments in Curve Numbers, etc. that result in small required volumes to address water quantity requirements.

2 Bioswales convey runoff from larger events, but generally lack volume to significantly reduce runoff rates leaving the practice.

3 Subusrface detention chambers may need to be paired with permeable pavement systems to address requirements for Qp and Qf.

B. LOCATION OF PRACTICES

When developing a stormwater management strategy for urbanizing areas, it needs to be understood where practices are going to be located, what entity will retain ownership and who will be responsible for maintaining their proper operation. Practices may be integrated into individual site design, or used as a resource to create areas of public access such as ponds or wetlands. Ownership of facilities may be private or public. The details that follow are intended to guide discussions in defining the methods of stormwater management for a given location.

1. "Site/Development Scale" vs. "Regional" Approach

Stormwater BMPs can be installed at smaller scales that meet requirements for a single site or development area (Site/Development Scale) or as larger practices that address the common needs for multiple development parcels or subwatershed areas (Regional Management Areas). The principles of addressing runoff closest to its source and developing "treatment trains" of BMPs are greatly encouraged. However, there are challenges with this approach and other benefits that can be realized by using water as a resource at a larger scale. Table 3.01-3.2 summarizes the benefits and challenges of addressing stormwater management at each of these scales. Hybrids of these approaches may also be considered (i.e. requiring individual commercial sites to address water quality requirements at the development scale, while addressing quantity management at a larger scale using ponds and wetlands on public lands or common areas).

Figure 3.01-3.1: Site/Development Scale Example—a bioretention and detention BMP at a small commercial site

Figure 3.01-3.2: Regional Example—a wet detention pond BMP that manages runoff from several development areas covering hundreds of acres.

TABLE 3.01-3.2: COMPARISON OF DEVELOPMENT SCALE VS. CONSOLIDATED BMP APPROACHES

SITE/DEVELOPMENT SCALE APPROACH	
BENEFITS	**CHALLENGES**
Capture and treat runoff closest to the source.	Multiple practices to install, inspect and maintain.
If implemented and maintained properly, considered to be most effective at addressing water quality and quantity.	Can be difficult on small sites to work around or protect BMP sites during site construction.
The "treatment train" approach -- routing through multiple practices. May treat a wider variety of pollutants. If one practice fails to perform, others can "pick up the slack".	Generally relies on private ownership to construct and for ongoing maintenance.
Cost savings can be realized through reduction of storm sewer pipes, culverts and channels between and downstream of practices.	Relies on more parties having the expertise to establish permanent vegetation and perform operation and maintenance.
Can be integrated into landscaping plans on private property.	Jurisdictions may need to consider maintenance agreements, easement (rights of entry, access routes) and other means to assure ongoing maintenance and repairs are completed. Difficult to ensure practices will be kept and maintained within single-family residential properties due to changes in ownership. No assurance ongoing funds will be dedicated to maintenance within properties managed by homeowner association. Addressing sizing requirements on parcels receiving "off-site" runoff may be complicated. (see Subsection 3.01-5)
REGIONAL MANAGEMENT APPROACH	
BENEFITS	**CHALLENGES**
Fewer practices to install, inspect and maintain.	
Can be constructed on a separate site, away from site development construction. Can be staged to be constructed during or after upstream project construction.	Takes less advantage of a "treatment train" approach. More urgency in correct installation and maintenance to meet overall quality and quantity goals.
Requires fewer parties to be responsible for or have the expertise to establish permanent vegetation and perform operation and maintenance.	Generally relies on public ownership or maintenance. However, a private ownership association (beyond the scale of an individual homeowners association) could be used to collect funds and manage.
Cost savings are realized through "economy of scale" - installing one larger practice to meet quality and quantity goals.	May require larger sized infrastructure to convey storms from individual sites to management area.
Access for maintenance can be provided within publicly owned land, or via easements on private "outlot" parcel dedicated for stormwater management.	If private ownership is maintained -- no assurance ongoing funds will be dedicated to maintenance.
Can integrate stormwater management needs into a site with public access that can serve as a local amenity (park, natural area where access paths can also provide potential locations for trails, etc.).	Funding mechanisms and land dedication. Challenge is how to pay for regional practices or set aside land for their construction, prior to or concurrent with development of upstream areas. Training and dedication of public staff and financial resources for ongoing maintenance. Often, existing staff may not have the time or skills required to establish, maintain native landscaping or facilities associated with stormwater BMPs.

NOTE

For every development, the strategy of stormwater management should be defined. Elements of the Unified Sizing Criteria that are not designated to be addressed by downstream consolidated management facilities should be addressed at the development scale, unless such requirements are specifically exempted by the local jurisdiction.

2. Private vs. Public Ownership and Maintenance

Discussion of private or public ownership and maintenance of BMPs often parallels decisions related to the scale of BMPs used to manage stormwater. Public ownership and maintenance will rarely be extended to Site/Development Scale BMPs. Regional management areas often serve multiple parcels, potentially with varied ownership. Bringing these areas under public ownership allows for permanent public access, for recreation as well as maintenance.

Another scenario to consider for public ownership, are practices installed along a concentrated flow path or stream with a significant drainage area. Maintenance needs for such facilities, as well as a higher hazard level to the public in the case of system failure might drive the decision to take public ownership of a practice. Location of shared use paths, greenbelt corridors and other adjacent public uses should also be considered when reviewing potential ownership.

Figure 3.01-3.3A: This trail provides public and maintenance access along a stream segment and pond

Figure 3.01-3.3B: This trail provides public and maintenance access to a constructed wetland

C. OVERLAND FLOW AND FLOODPLAIN MANAGEMENT

1. Overland Flow Requirements

Extreme flood events will often exceed the capacity of storm sewer systems. Events even larger than the 100-year event can and will occur, exceeding the capacity of detention BMPs. Criteria requirements:

- Auxiliary spillways from BMPs should be used to clearly define the direction of overflow for storms exceeding the capacity of the BMP. Flows should be directed away from adjacent buildings and infrastructure and should be directed toward a concentrated flow path.
- The extent of concentrated overland flow paths across private property expected to be inundated by the 100-year storm event should be contained within an easement to prevent blockage by placement of structures or grading.
- Structures adjacent to detention BMPs or concentrated flow paths should be elevated or protected from flooding to an elevation at least 1 foot above the expected 100-year high water elevation.
- Structures adjacent to streams with designated floodplains on FEMA Flood Insurance Rate Maps (FIRMs) or watersheds greater than 80 acres in size should be protected from flooding to an elevation 3 feet above the expected 100-year high water elevation.
- It is recommended to review expected inundation or overflow paths caused by a 500-year storm event and make sure that the flow path for such an event is well defined and buildings or other structures are located outside of the inundation limit.

2. Floodplain Management

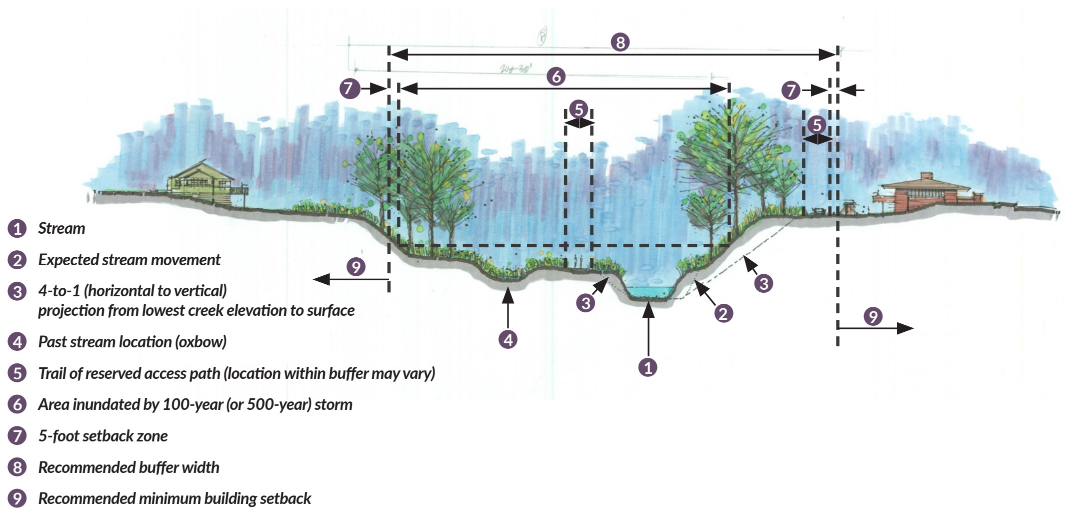
Adequate floodplain width and storage volume help to slow flow velocities during flood events. Reducing floodplain volume and area can increase flood depths and accelerate movement of the flood crest downstream.

- To the greatest extent possible, development or placement of fill within areas expected to be inundated by the 100-year storm event should be avoided.
- Abide by other local, state and federal floodplain regulations.
- Local ordinances should define required protection of new or existing structures placed within the floodplain, including required finished floor (or flood protection elevations), allowable uses, methods of flood proofing, etc.

3. Buffers along overland flow paths, streams and floodplains

Buffers should be maintained along streams and other significant concentrated flow paths. These buffers preserve flood plain width, critical habitat and provide access routes if improvements or repairs are needed along the corridor. It is recommended that public ownership or easements be established to protect these buffers. The width of a given buffer will need to vary, to meet the needs of a given location. The width should be established to include the uses as noted in Table 3.01-3.3.

Figure 3.01-3.4: Stream Buffer



SOURCE: RDG; Walnut Creek Watershed Master Plan

TABLE 3.01-3.3: STREAM BUFFER PRESERVATION CONSIDERATIONS		
FEATURE WITHIN OR ADJACENT TO BUFFER	PUBLIC OWNERSHIP	PRIVATE OWNERSHIP
Stream width (bottom width or wetted area at normal base flow)	X	X
Consideration for expected or historic stream movement	X	First order stream or larger
Stable slope projection from lowest creek elevation to grades above streambank (4:1 maximum)	X	X
Reserved path for access / maintenance	X - at least one side First order stream or larger - Reserve path on both sides, consider paved or improved surface along access path on one side	X - at least one side First order stream or larger - Reserving path on both sides is preferred, consider paved or improved surface along access path on one side where public access is allowed
Area inundated by 100-year * flood event	X	X
Additional 5 foot setback within easement beyond all items above	X	First order stream or larger
Additional building setback outside of buffer easement	X	First order stream or larger

* Some jurisdictions may require the buffer to contain the 500-year flood event

- For small drainage paths on private properties, required buffer elements may be reserved within an easement.
- For streams that are first order or larger that are to remain on private property after development, it is recommended that the stream buffer be contained where occupiable building structures are not allowed.

3.01-4 COMPLIANCE

During the design process, the designer needs to demonstrate to the jurisdictional authority how the locally applicable aspects of the Unified Sizing Criteria are intended to be satisfied for a given project.

A. NARRATIVE OF MANAGEMENT APPROACH

The strategy of stormwater management for a given project should be defined. Elements of the Unified Sizing Criteria that are not designated to be addressed by downstream Regional Management facilities should be addressed at the Site/Development Scale, unless such requirements are specifically exempted by the local jurisdiction.

Supporting calculations will be attached to the narrative demonstrating that all pre- and post-development models have been correctly developed and proposed BMPs are properly sized. In addition, drainage maps should be provided for both pre- and post-project conditions that clearly identify the area draining to each practice and it characteristics. Refer to Section 1.05 and 9.03 for additional information on requirements for Stormwater Management Plans and the supporting documentation.

B. RECHARGE VOLUME (REV)

1. Identify the Site/Development Scale BMPs used to address the required Rev volume. Identify any Regional Management BMPs or other off-site practices used to address the remainder of the required Rev.

2. The management plan for a given project should include narrative information and supporting calculations to show that each BMP is properly designed to address the portion of the Rev they are intended to provide.

    a. If Regional Management areas are used to meet Rev requirements, the supporting information should validate that such BMPs have sufficient capacity to treat the Rev for the project site and the other areas served by that practice.

    b. If multiple BMPs are used to address Rev, a summary table should be provided showing the portion of the total Rev addressed by each location.

Example -- A development site is proposed where a Rev of 4,700 CF has been calculated to be required. Two bioretention cells are proposed, one sized to manage 2,000 CF and the other 3,000 CF. A summary table could appear as follows:

TABLE 3.01-4.1: EXAMPLE SUMMARY TABLE FOR REV COMPLIANCE

PRACTICE	REV PROVIDED
Bioretention Cell A	2,000 CF
Bioretention Cell B	3,000 CF
Total Provided	5,000 CF
Total Required	4,700 CF

C. WATER QUALITY VOLUME (WQV)

1. Identify the Site/Development Scale BMPs used to address the required WQv. Identify any Regional Management BMPs or other off-site practices used to address the remainder of the required WQv.

2. The management plan for a given project should include narrative information and supporting calculations to show that each BMP is properly designed to address the portion of the WQv they are intended to provide.

    a. If Regional Management areas are used to meet WQv requirements, the supporting information should validate that such BMPs have sufficient capacity to treat the WQv for the project site and the other areas served by that practice.

    b. If multiple BMPs are used to address WQv, a summary table should be provided showing the portion of the total WQv addressed by each location.

Example -- A development site is proposed where a WQv of 19,500 CF has been calculated to be required. A downstream stormwater wetland has been planned to manage runoff from multiple parcels. Calculations have been provided showing it can provide 10,000 CF of treatment for this parcel. The remaining volume is proposed to be treated by two bioretention cells (sized to manage 2,000 and 3,000 CF each) and a bioswale (addressing 5,000 CF). A summary table could appear as follows:

TABLE 3.01-4.2 : EXAMPLE SUMMARY TABLE FOR WQv COMPLIANCE

PRACTICE	REV PROVIDED
Bioretention Cell A	2,000 CF
Bioretention Cell B	3,000 CF
Bioswale	5,000 CF
Regional Management Area -- Stormwater Wetland	10,000 CF
Total Provided	20,000 CF
Total Required	19,500 CF

D. CHANNEL PROTECTION VOLUME (CPV)

1. Identify the Site/Development Scale or Regional Management BMPs (or other off-site practices) used to address the CPv.

2. Supporting calculations should include final routing design results, verifying that the peak outflow rate during the CPv event does not exceed the allowable release rate calculated to provide for a 24-hour extended drawdown period.

NOTE

Any software running the TR–20 or TR–55 calculation methods may be used for project design. If the study area has subareas smaller than 10 acres in size, software should be used that is capable of calculating hydrographs in no less than 1–minute intervals. For projects with larger subareas, a 2–minute interval may be used.

E. OVERBANK FLOOD PROTECTION (QP) AND EXTREME FLOOD PROTECTION (QF)

1. Identify the Site/Development Scale or Regional Management BMPs (or other off-site practices) used to manage runoff from these events.

2. Supporting calculations should include final routing design results, verifying that the peak outflow rate during these events does not exceed the allowable release rate required by the local jurisdiction.

For items D and E above, complete a summary table for each BMP providing temporary detention storage, similar to the format provided in Table 3.01-4.3:

TABLE 3.01-4.3

STORM EVENT	Allowable Release Rate for Area Served (cfs)	Adjustment in Release Rate for Upstream Areas (cfs)	Target Release Rate (cfs)	Post-development Release Rate (cfs)	Peak Volume Stored (CF)	PV Stored [1] (wtshd-inches)	High Water Elevation [2] (feet)
1-year storm (CPv)							
2-year storm							
5-year storm							
10-year storm							
25-year storm							
50-year storm							
100-year storm							

[1] Converting the peak volume stored into an equivalent depth of runoff over the area to be served (watershed-inches) is also a good metric to review. (This helps to answer an important question -- Does the volume stored seem adequate, compared to the depth of the given rainfall event?)

[2] This value demonstrates the depth of water that is expected to be temporarily stored in the practices for a given event. Design guidance is given for certain practices for maximum depths advisable to establish and maintain desired vegetation and land uses.

F. OVERLAND FLOW AND FLOODPLAIN MANAGEMENT REQUIREMENTS

Provide narrative information demonstrating how the overland flow and floodplain management conditions detailed in Section 3.01-3 have been addressed by the proposed design. Provide documentation of required easements to the local jurisdiction, as applicable.

3.01-5 SPECIAL CASES

It is important to emphasize that designers need to look beyond the limits of their site when planning and designing stormwater management practices. There will be locations where runoff enters and leaves the project limits. These flows need to be considered in the design process, which lead to special cases that need to be evaluated when determining what is necessary to meet the elements of Unified Sizing Criteria.

A. DIRECT DISCHARGE FROM PROJECT LIMITS

Historically, with "traditional detention" design, it was often allowed to offset the effects of runoff from project site areas that bypass a detention basin by reducing the allowed outflow rate from a basin to compensate for the rate of flow that would not pass through the basin. This approach is difficult when designing for water quality.

In theory, no direct surface runoff should leave a project area without passing through a treatment practice during the WQv event. There is no amount of "extra treatment" that can be done to runoff from one area to offset the impact of runoff from a another area of significant size leaving the site without treatment. To manage the CPv event, the allowable outflow rates for extended detention is usually small. This also makes it difficult to reduce allowable flow rates from a practice by an adequate amount to off-set impacts from areas that leave the project area directly.

For this reason, impervious **direct discharge** areas should be minimized to the greatest extent possible. It is recognized that it might be impossible to eliminate direct discharge in all circumstances (i.e., near project entrances and site perimeters). *For this reason, it is recommended that each jurisdiction establish a policy related to the allowable area or portion of a project site that would be allowed to bypass Development Scale BMPs and leave the site via direct discharge.*

NOTE

Open-space areas may be allowed to directly discharge the site without passing through a Water Quality treatment practice, if Soil Quality Restoration has been applied.

B. MULTIPLE DISCHARGE POINTS

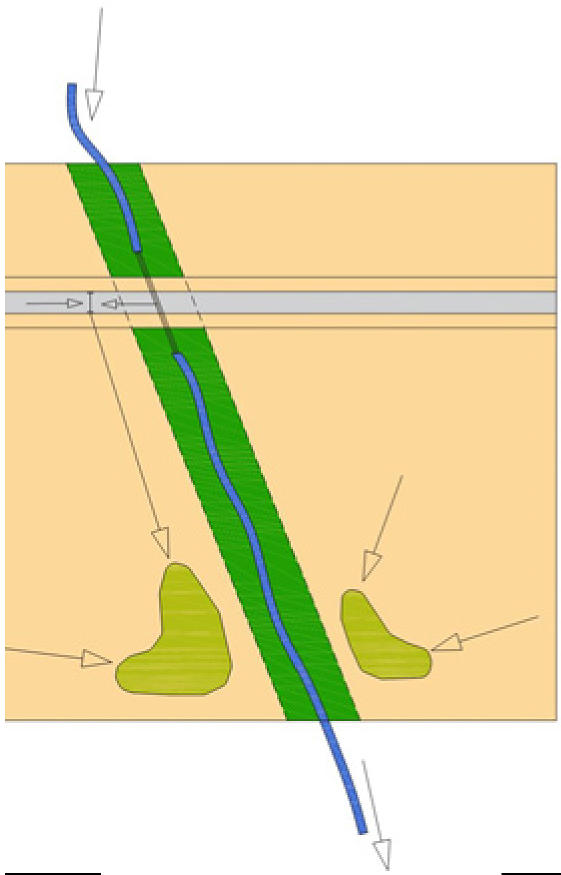
For project site areas with multiple points of discharge, the Unified Sizing Criteria should be addressed at each outlet point. Project calculations should be divided into separate watershed areas for analysis and design of BMPs at every point of discharge.

C. INFLOW FROM AREAS BEYOND PROJECT LIMITS

It is quite common for runoff to enter a project site from upstream areas. In some cases, this runoff has already been treated by other BMPs. In other cases it has not. Projects designed at the Site/Development Scale often have not been required to provide management or detention for runoff generated from off-site areas. However, how this runoff is routed through or around planned BMPs may impact their operation and effectiveness. There are alternatives to consider for these circumstances:

1. *Route off-site runoff around or through the project limits in a manner that bypasses proposed BMPs.*
   This may involve installing a swale, pipe or other method to collect this runoff and direct it through the site to an outlet point of the project. For example, if a concentrated flow path passes through a given site provide a swale with a buffer through the site and locate Site/Development Scale BMPs outside the buffer on either side.

   Figure 3.01-5.1: BMPs located off-line from the major drainageway that conveys upstream flows through the site.



2. *If this approach is not feasible, the design of the proposed Site/Development Scale BMPs will need to be adjusted to account for the off-site runoff. While Site/Development Scale BMPs may not usually be required by jurisdictions to manage runoff from off-site area, ignoring the effects of these flows may lead to practices that have insufficient area or storage to operate as needed to provide the desired water quality and quantity benefits.*

a. Scenario "A" -- Drainage entering project limits is from a developed area which has already passed through BMPs that fully satisfy the Unified Sizing Criteria.

  i. Rev and WQv -- Size Site/Development Scale practices to account for only areas within the project area limits. There should be minimal direct surface runoff from upstream areas during these events, if the upstream BMPs were sized adequately to address these events.

  ii. CPv -- Use method described in Chapter 3.02 to calculate allowable release rate. Use an adjusted flow volume to calculate "qu" used to select qo/qi ratio from the graph. Adjusted flow volume is found by adding hydrographs for natural conditions for UPSTREAM areas treated by other BMPs plus proposed condition for areas draining directly to the proposed BMP.

  iii. Qp and Qf -- Release rate should be based to comply with Water Quantity Criteria as described in Section 3.01-2.B (as adopted by the local jurisdiction) for the entire watershed area at the proposed BMP location. (e.g natural conditions for the entire watershed area at the BMP location)

  iv. For i and ii, perform routing calculations to verify that final design meets outflow rate limits and complies with other BMP design requirements such as maximum high-water levels for this event.

b. Scenario "B" -- Drainage entering project limits is from a developed area which has not passed through BMPs that fully satisfy the Unified Sizing Criteria.

  i. Rev and WQv -- Size Site/Development Scale practices to account for the areas within the project area limits and unmanaged upstream areas.

    01. If water quality BMPs are not increased in size to address runoff from these areas, they will not have sufficient ability to manage runoff from these events. Such practices would likely fill and overflow during events smaller than the WQv, leading to untreated water leaving the project area during such an event.

    02. Alternatively, consider design alternatives for practices that treat runoff from these events from the project site before it is mixed with flows from upstream areas.

  ii. CPv -- Consider the entire watershed area (project area and upstream areas), when completing calculations to determine the allowable outflow rate from Site/Development Scale practice. The allowable outflow rate should be based on a minimum drawdown time of 24 hours. This will result in an increase in required storage volume within the BMP for this event, compared to if the practice was only sized to consider areas within the project limits. Without this additional storage, outflow rates from the proposed BMP would exceed desired levels.

  iii. Qp and Qf -- Release rate should be based to comply with Water Quantity Criteria as described in Section 3.01-2.B (as adopted by the local jurisdiction) for the site area intended to be served by the practice. Add hydrographs for natural conditions for the site service area to hydrographs for existing conditions for upstream areas to determine the allowable release rates.

  iv. For i and ii, perform routing calculations to verify that final design meets outflow rate

NOTE

Refer to Section 3.02 for procedure to determine allowable release rate to demonstrate extended detention with 24 hour minimum drawdown time.

limits and complies with other BMP design requirements such as maximum high-water levels for this event.

c. Scenario “C” -- Drainage entering project limits is from an undeveloped area.

i. Rev and WQv - **It is not advisable to route runoff from undeveloped areas through BMPs designed to address these events. Sediment from row–crop areas or future construction site runoff could potentially impact these BMPs. Consider design alternatives for practices that treat runoff from these events from the project site before it is mixed with flows from upstream areas. Advisory**

ii. To manage CPv and larger storm events, two scenarios will need to be analyzed:

01. A future condition where practices are constructed to manage the upstream area based on future developed conditions.

02. A current condition where there are no practices to manage the upsteram area, based land uses that are existing at time of design.

iii. CPv management

01. Future condition

- Release rates should be set to provide extended detention of this event, with a 24-hour minimum drawdown period.
- Use method described in Chapter 3.02 to calculate allowable release rate.
  - Use an adjusted flow volume to calculate “qu” used to select qo/qi ratio from the graph.
  - The adjusted flow volume is found by adding hydrographs for natural conditions for UPSTREAM areas treated by other BMPs plus proposed condition for areas draining directly to the proposed BMP.

02. Current condition

- Release rates are established by adding hydrographs for existing conditions for undeveloped, upstream areas plus natural conditions for site areas draining directly to the proposed BMP.

iv. Storms Larger than CPv

01. Future condition

- Release rate should be based to comply with Water Quantity Criteria as described in Section 3.01-2.B (as adopted by the local jurisdiction) for the entire watershed area at the proposed BMP location (e.g., natural conditions for the entire watershed area at the BMP location).
  - This will typically be natural conditions under the same storm event type for the entire watershed area at the BMP location (some jurisdictions may also limit release rates not exceed existing levels generated by a 5-year storm event).

02. Current condition

- Release rate should be based to comply with Water Quantity Criteria as described in Section 3.01-2.B (as adopted by the local jurisdiction) for the site area intended to be served by the practice.

- To determine this, add hydrographs for natural conditions for the site service area to hydrographs for existing conditions for upstream areas to determine the allowable release rates.

- Since the multi-stage outlet designed for the future condition will have higher flow restrictions, flow may overtop the auxiliary spillway during larger storm events.
- Set the auxiliary spillway length and elevation to limit release rates below allowable levels. Check freeboard requirements between the high-water level of the 100-year event and the crest of the dam.

v. Design procedure for Scenario "C":

Step 1: Prepare a preliminary design of future upstream basin.

A. Develop a TR-55 model of the upstream, off-site watershed area to get the data needed to estimate required storage.

B. Use modeling output to determine allowable release rates for future basin, estimate required storage (refer to Section 9.02 for more information about Detention Basin Estimation procedure).

C. Prepare a preliminary basin design that meets these parameters.

- The design of any basin(s) in the future will likely not exactly match this preliminary design, but the preliminary design meeting the release rate requirements above should approximate future performance.

Step 2: Prepare preliminary design of the proposed site basin.

A. Develop a TR-55 models for:

- Natural and existing conditions for ENTIRE WATERSHED at proposed basin location
- Proposed conditions for the SITE AREA draining directly to the proposed basin location
- Add flows from UPSTREAM BASIN to flows for proposed conditions from the SITE AREA to find projected FUTURE inflow rates to the basin

B. Use modeling output to determine allowable release rates for future basin, estimate required storage (refer to Section 9.02 for more information about Detention Basin Estimation procedure).

C. Prepare a preliminary basin design for the on-site basin that meets these parameters.

Step 3: Recheck preliminary design of proposed basin for Current Proposed Conditions.

A. Recalculate the allowable outflow rate from the basin by adding the hydrographs for UPSTREAM flow during existing conditions and SITE AREA flow for natural conditions.

B. Calculate the flow into the basin by combining hydrographs for UPSTREAM flow during existing conditions and SITE AREA flow for proposed conditions.

C. Route combined flows calculated in Step 3(B) through the proposed basin and check resulting outflow rates against allowable release rates calculated in Step 3(A). Adjust basin design as needed to meet desired flowrate reductions.

3.01-6 SPECIAL CASE DESIGN EXAMPLES

OFF-SITE FLOW ROUTING EXAMPLE

WATERSHED PROPERTIES FOR THIS EXAMPLE

Assumptions:

- Site Location: Central Iowa (Region 5)

Local Requirements:

- ISWMM USC Criteria—Provide extended detention of CPv event
- Release rates of larger storms no greater than natural conditions for same event OR existing conditions for 5-year storm event

TABLE 3.01-6-1: UPSTREAM OFF-SITE CHARACTERISTICS

AREA	1 (FUTURE)	2 (FUTURE)	1 + 2 (EXISTING)	1 + 2 (NATURAL)
Land Use	Mixed Uses (Single-, Multi-Family & Commercial)	Primarily Single-Fam. (with some townhomes)	Row Crop Agriculture (good condition)	Meadow (good condition)
Area	40 acres	40 acres	80 acres	80 acres
% Imperv.	65%	45%	0%	0%
HSG	B	B	B	B
SQR	Yes	Yes	N/A	N/A
CN	85	78	74	58
Tc	17.0 min	17.0 min	31.9 min	97.4 min

Runoff from Areas 1 and 2 join together before entering project site.

TABLE 3.01-6-2: PROJECT SITE CHARACTERISTICS

AREA	PROPOSED	EXISTING	NATURAL	NATURAL (UPSTREAM + SITE)
Land Use	Mixed Uses (Single-, Multi-Family & Commercial)	Row Crop Agriculture (good condition)	Meadow (good condition)	Meadow (good condition)
Area	80 acres	80 acres	80 acres	160 acres
% Imperv.	0.65	0	0	0
HSG	B	B	B	B
SQR	Yes	N/A	N/A	N/A
CN	85	74	58	58
Tc	21.8 min	31.9 min	97.4 min	128.6 min

Step 1. Prepare preliminary design of future upstream basin.

1. Develop a TR-55 model of the upstream, off-site watershed area to get the data needed to estimate required storage.

TABLE 3.01-6-3: TR-55 MODEL OUTPUT—UPSTREAM, OFF-SITE AREA					
		PEAK RATES			VOLUME
EVENT	RAINFALL (IN)	NATURAL (CFS)	EXISTING (CFS)	FUTURE DEVELOPED (CFS)	FUTURE DEVELOPED (CFS)
1-year	2.67	2.5	44	106	318,000
2-year	3.08	5.2	62	137	408,000
5-year	3.81	12	99	194	598,000
10-year	4.46	21	134	248	737,000
25-year	5.44	38	190	330	986,000
50-year	6.26	54	239	399	1,200,000
100-year	7.12	73	292	472	1,428,000

2. Use modeling output to determine allowable release rates for future basin, estimate required storage (Refer to Section 9.02 for more information about Detention Basin Estimation procedure).

TABLE 3.01-6-4: REQUIRED STORAGE VOLUME ESTIMATION							
STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF)	VS (CF)	VS *1.15 (CF)
1	2.1	106	0.02	0.655	318,000	208,306	239,600
2	5.2	137	0.04	0.631	408,000	257,465	296,100
5	12	194	0.06	0.601	598,000	359,177	413,100
10	21	248	0.08	0.573	737,000	422,435	485,800
25	38	330	0.12	0.539	986,000	531,308	611,000
50	54	399	0.14	0.518	1,200,000	621,015	714,200
100	73	472	0.15	0.498	1,428,000	711,271	818,000

3. Prepare a preliminary basin design that meets these parameters. The design of any basin(s) in the future will likely not exactly match this preliminary design, but the preliminary design meeting the release rate requirements above should approximate future performance.

NOTE

For this example, for the 1–year (CPv) through 100–year storm events, the peak flow rate for natural conditions is less than the peak rate for existing conditions during a 5–year storm event (99 cfs); so the natural conditions rate is the more restrictive and is used for design.

The outflow rate to provide the extended drawdown for the CPv event is calculated using methods detailed in Section 3.02 (Small Storm Hydrology) .

NOTE

The multi–stage outlet in this example could be constructed out of a 4' x 4' inlet structure, with Stage 2 being the opening in the front wall (closest to the basin), Stage 3 extending halfway along the left and right sides and Stage 4 being the back wall of the structure.

For this example, it is assumed that either a wet detention pond or stormwater wetland are going to be used as the future detention BMP.

TABLE 3.01-6-5: PRELIMINARY STAGE/STORAGE RELATIONSHIPS—FUTURE UPSTREAM BASIN			
STAGE	CONTOUR AREA (SF)	CUMULATIVE STORAGE (CF)	COMMENTS
100	112,300		Normal pool elevation
101	119,800	116,000	
102	127,600	239,700	Target storage for CPv is around 2 feet above pool
103	172,500	389,700	
104	223,500	587,700	Target storage for 10-year event falls between 3-4 feet above pool
105	280,700	839,800	Target storage for 100-year event is around 5 feet above pool
106	344,000	1,152,000	
107	413,600	1,531,000	Crest of dam

TABLE 3.01-6-6: PRELIMINARY OUTLET DESIGN—FUTURE UPSTREAM BASIN					
	TYPE AND SIZE	PARAMETERS	ELEVATION	MULTI-STAGE FLOW THROUGH CULVERT "A"?	DESCRIPTION
Culvert "A"	33"-diameter pipe	120.0 LF @ 1%	Invert at multi-stage outlet: 96.00	N/A	Primary spillway from outlet
Culvert "B"	8"-diameter orifice		Invert: 100.00	Yes	Stage 1: Extended detention control
Weir "A"	4' long	Rectangular*	Crest: 102.00	Yes	Stage 2: Weir above CPv
Weir "B"	4' long	Rectangular*	Crest: 103.75	Yes	Stage 3
Weir "C"	8' long	Rectangular*	Crest: 104.50	Yes	Stage 4
Weir "D"	30' long	Broad-crested**	Crest: 105.50	No	Auxiliary Spillway

* Weir coefficient “C” for rectangular weirs is 3.33

** Weir coefficient “C” for broad-crested weirs is 2.60

TABLE 3.01-6-7: PERFORMANCE TABLE—FUTURE UPSTREAM BASIN				
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (FEET)	MAX. TEMP. STORAGE ABOVE POOL (CF)
1-year (CPv)	2.1	2.1	101.93	232,000
2-year	5.2	4.1	102.26	279,000
5-year	12	11	102.72	348,000
10-year	21	19	103.15	420,000
25-year	38	35	103.79	546,000
50-year	54	53	104.26	653,000
100-year	73	69	104.73	771,000

Step 2. Prepare preliminary design of the proposed site basin.

1. **Develop a TR-55 models for:**
   - Natural and Existing conditions for ENTIRE WATERSHED at proposed basin location
   - Proposed conditions for the SITE AREA draining directly to the proposed basin location
   - Add flows from UPSTREAM BASIN to flows for proposed conditions from the SITE AREA to find projected FUTURE inflow rates to the basin

TABLE 3.01-6-8: TR-55 MODEL OUTPUT—PROPOSED BASIN LOCATION						
		PEAK RATES			VOLUME	
STORM EVENT	RAINFALL (IN)	NATURAL* (CFS)	EXISTING* (CFS)	FUTURE DEVELOPED** (CFS)	FUTURE DEVELOPED (CF)	ADJUSTED FOR ESTIMATION*** (CF)
1	2.67	4.3	72	118	614,000	456,000
2	3.08	8.9	103	149	788,000	572,000
5	3.81	21	163	206	1,138,000	840,000
10	4.46	35	222	258	1,464,000	1,100,000
25	5.44	62	315	347	1,974,000	1,520,000
50	6.26	88	397	423	2,413,000	1,900,000
100	7.12	118	484	505	2,880,000	2,300,000

* Entire 160-acre watershed to proposed basin site

** Flow directly to basin from 80-acre site area plus projected flow from upstream basin

*** Adjusted flow volume = Natural Condition for UPSTREAM areas plus Proposed Condition for SITE AREA

Because of the effects of the future upstream basin, using total flows for future conditions in the estimation calculation may result in over–estimation of required storage. For this example, the hydrograph for upstream flows for natural conditions was added to the hydrograph for site flows for proposed conditions to determine the volumes for use in the estimation procedure. The detention effects of upstream basins may make this method less accurate, so the designer may need to make more iterations than usual to refine final stage–storage–discharge relationships, to minimize the size of the practice while still achieving the desired release rates.

NOTE

For this example, for the 1–year (CPv) through 100–year storm events, the peak flow rate for natural conditions is less than the peak rate for existing conditions during a 5–year storm event (163 cfs); so the natural conditions rate is the more restrictive and is used for design.

2. Use modeling output to determine allowable release rates for future basin, estimate required storage (Refer to Section 9.02 for more information about Detention Basin Estimation procedure).

TABLE 3.01-6-9: REQUIRED STORAGE VOLUME ESTIMATION

STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF)	VS (CF)	VS *1.15 (CF)
1	2.4	118	0.02	0.655	456,000	298,703	343,500
2	8.9	149	0.06	0.603	572,000	345,067	396,800
5	21	206	0.10	0.553	840,000	464,868	534,600
10	35	258	0.14	0.517	1,100,000	568,900	654,200
25	62	347	0.18	0.475	1,520,000	722,404	830,800
50	88	423	0.21	0.449	1,900,000	853,567	981,600
100	118	505	0.23	0.428	2,300,000	984,735	1,132,400

3. Prepare a preliminary basin design for the on-site basin that meets these parameters.

For this example, it is assumed that either a wet detention pond or stormwater wetland are going to be used as the onsite detention BMP.

TABLE 3.01-6-10: PRELIMINARY STAGE/STORAGE RELATIONSHIPS—ON-SITE BASIN

STAGE	CONTOUR AREA (SF)	CUMULATIVE STORAGE (CF)	COMMENTS
100	162,000		Normal pool elevation
101	171,000	166,500	
102	181,000	342,500	Target storage for CPv is around 2 feet above pool
103	187,000	526,500	
104	193,000	716,500	Target storage for 10-year event falls between 3–4 feet above pool
105	200,000	913,000	Target storage for 100-year event falls between 5–6 feet above pool
106	206,000	1,116,000	
107	214,000	1,326,000	Crest of dam

TABLE 3.01-6-11: PRELIMINARY OUTLET DESIGN—ON-SITE BASIN					
	TYPE AND SIZE	PARAMETERS	ELEVATION	MULTI-STAGE FLOW THROUGH CULVERT "A"?	DESCRIPTION
Culvert "A"	36"-diameter pipe	120.0 LF @ 1%	Invert at Multi-stage outlet: 96.00	N/A	Primary spillway from outlet
Culvert "B"	8"-diameter orifice		Invert: 100.00	Yes	Stage 1: Extended detention control
Weir "A"	6' long	Rectangular*	Crest: 102.50	Yes	Stage 2: Weir above CPv
Weir "B"	6' long	Rectangular*	Crest: 103.75	Yes	Stage 3
Weir "C"	12' long	Rectangular*	Crest: 104.50	Yes	Stage 4
Weir "D"	30' long	Broad-crested**	Crest: 105.50	No	Auxiliary Spillway

* Weir coefficient "C" for rectangular weirs is 3.33

* Weir coefficient "C" for broad crested weirs is 2.60

TABLE 3.01-6-12: ON-SITE BASIN (FUTURE CONDITIONS)				
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (FEET)	MAX. TEMP. STORAGE ABOVE POOL (CF)
1-year (CPv)	2.4	2.3	102.23	384,000
2-year	8.9	5.3	102.76	482,000
5-year	21	14	103.19	563,000
10-year	35	26	103.61	642,000
25-year	62	54	104.20	755,000
50-year	88	84	104.74	862,000
100-year	118	118	105.39	991,000

Step 3. Recheck preliminary design of proposed basin for Current Proposed Conditions.

1. Recalculate the allowable outflow rate from the basin by adding the hydrographs for UPSTREAM flow during existing conditions and SITE AREA flow for natural conditions.
2. Calculate the flow into the basin by combining hydrographs for UPSTREAM flow during existing conditions and SITE AREA flow for proposed conditions.
3. Route combined flows calculated in Step 3(2) through the proposed basin and check resulting outflow rates against allowable release rates calculated in Step 3(1). Adjust basin design as needed to meet desired flowrate reductions.

NOTE

The multi–stage outlet in this example could be constructed out of a 6' x 6' inlet structure, with Stage 2 being the opening in the front wall (closest to the basin), Stage 3 extending halfway along the left and right sides and Stage 4 being the back wall of the structure.

TABLE 3.01-6-13: PERFORMANCE TABLE—ON-SITE BASIN (CURRENT PROPOSED CONDITIONS)					
STORM EVENT	INFLOW[1] (CFS)	ALLOWED[2] (CFS)	OUTFLOW[3] (CFS)	HIGH-WATER ELEVATION (FEET)	MAX. TEMP. STORAGE ABOVE POOL (CF)
1-year (CPv)	153	44	3.7	102.64	461,000
2-year	200	63	8.8	102.95	517,000
5-year	290	102	25	103.56	633,000
10-year	373	140	54	104.21	757,640
25-year	502	203	108	105.28	970,000
50-year	612	258	202	106.00	1,115,000
100-year	729	319	319	106.63	1,248,000

1. Inflow rate to basin from Step 3(2)

2. Allowable rate for current conditions from Step 3(1)

3. Modeled outflow rate from routing from Step 3(3), after final adjustments

For this example, the initial routing through the basin developed in Step 2 ended up meeting all the release rate requirements except for the 100–year event. During that event, the crest of the dam was projected to be overtopped. The final design was adjusted to change the length and elevation of the auxiliary spillway to meet the desired goals.

The dam crest may need to be adjusted up from 107.00 to provide at least 1.0’ of freeboard between the 100–year high–water level and the crest of the dam.

TABLE 3.01-6-14: ADJUSTED OUTLET DESIGN—ON-SITE BASIN					
	TYPE AND SIZE	PARAMETERS	ELEVATION	MULTI-STAGE FLOW THROUGH CULVERT "A"?	DESCRIPTION
Weir "D"	**40'** long (from 30')	Broad-crested	Crest: 105.**00** (from 105.50)	No	Auxiliary Spillway

In the long term, the basin will not overtop the auxiliary spillway during the 100-year event. However, at the time of site development, the outfall structure needed for long-term performance won’t be able to pass all of the un-detained off-site flows, which will cause the auxiliary spillway to be overtopped by storms approaching the 25-year event.

Projected high-water depths in the basin in this example may slightly exceed the desired design guidelines in the current situation, but are close enough to not cause significant maintenance concerns.

TABLE 3.01-15: PERFORMANCE TABLE —ON-SITE BASIN (CURRENT VS. FUTURE)								
	CURRENT				FUTURE			
STORM EVENT	INFLOW (CFS)	ALLOWED (CFS)	OUTFLOW (CFS)	HIGH-WATER ELEV. (FEET)	INFLOW (CFS)	ALLOWED (CFS)	OUTFLOW (CFS)	HIGH-WATER ELEV. (FEET)
1	153	44	3.7	102.64	118	2.4	2.3	102.23
2	200	63	8.8	102.95	149	8.9	5.3	102.76
5	290	102	25	103.56	206	21.0	14.0	103.19
10	373	140	54	104.21	258	35.0	26.0	103.61
25	502	203	108	105.28	347	62.0	54.0	104.20
50	612	258	202	106.00	423	88.0	54.0	104.74
100	729	319	319	106.63	505	118.0	118.0	105.39

3.01-7 LOCAL ORDINANCE & POLICY GUIDANCE

There are important aspects of this manual to consider when jurisdictions seek to create stormwater ordinances or policies that reference of adopt this manual. The Iowa Department of Natural Resources (IDNR) is responsible for the creation and maintenance of this manual, working with a technical committee of local volunteers. However, regulation and enforcement of post-construction stormwater management is primarily left to local jurisdictions. Therefore, the IDNR does not enforce as requirements, the sizing and design criteria set for this document. For this reason, the language used within this manual has purposefully written as a guideline, rather than a standard. This means certain language that conveys something is required (i.e. shall, must, etc.) is generally avoided. This has the potential to leave "gray areas" as to what may be interpreted to be required and what is recommended or optional, if this manual is adopted and referenced by local jurisdictions as a standard.

The manual is constantly being updated. Updated sections may include the following terms:

Essential - An element of the design of a BMP seen as critical to its proper performance, operation or aesthetics. These aspects should be most important for inclusion and compliance and should rarely be deviated from.

Target - An element of the design of a BMP seen as important to its proper performance, operation or aesthetics. These aspects should be included in designs, if at all possible. However, there is more flexibility to allow deviations if it can be demonstrated that it is infeasible to meet the requirement at a given location, or if a certain requirement is in conflict with other requirements. Designers should explain any reason for deviation from targets, for the consideration of the jurisdiction as part of their review.

Advisory - These are practices, techniques or potential deviations from the design ethic that should be avoided in most circumstances.

Local jurisdictional ordinances or policies that refer to this manual should address the following:

1. Clearly identify which element(s) of the Unified Sizing Criteria are to be enforced by the jurisdiction. When applicable, clearly define the basis for allowable release rates for various storm events (i.e. natural conditions for a similar event, 5-year storm existing conditions, etc.). See Section 3.01-2. Note any limits related to the Curve Numbers (CNs) to be used when calculating the allowable release rates for the specified conditions.

2. Address how items categorized by the manual as "essential," "target" or "advisory" are viewed as a standard, by local jurisdictional requirements. (This aids in defining within the jurisdiction what elements of the manual are considered to be standards and which are guidelines.)

3. Identify thresholds for new or redevelopment projects initiate local stormwater management requirements (i.e. area of new impervious surface, disturbed acreage, size of building addition, changes in land use, removal of existing vegetation, etc.).

4. Identify if there are geographic locations or watershed conditions that would exempt specific aspects of the USC or prohibit installation of certain BMPs (i.e. location within the watershed, wellhead protection areas, implementation of Consolidated Management areas, etc.).

5. Identify if there are geographic locations or watershed conditions that would require going beyond the guidelines set forth in this manual (i.e. presence of Outstanding Iowa Waters, individual watershed goals, source water protection, TMDL requirements, etc.)

6. Identify if there specific restrictions to BMP application required by the jurisdiction. For example, some communities WQv must be addressed through use of infiltration based practices (this could be interpreted as restricting wet ponds or stormwater wetlands as not eligible BMPs to address WQv).

7. Define what studies or plans are required to be submitted by the jurisdiction. These may include any or all of the following:

   – Natural Resource Inventory
   – Soil Management Plans
   – Stormwater Management Plan

8. Require enforcement documents that need to be provided as part of the review or approval process, such as maintenance agreements, covenants and easements to allow enforcement to allow action to assure ongoing operation of BMPs that fall within private ownership.

9. Define methods of inspection of BMPs during construction to be completed by staff or consultants employed by the local jurisdiction (if applicable).

10. Create specific local ordinances or polices related to floodplain management and buffers along streams and concentrated flow paths, as described within Section 3.01-2.

11. Create a checklist of materials to be submitted as part of various plan review steps. This checklist should clearly identify documentation related to design calculations that should be included with the narrative section of the Stormwater Management Plan.

12. Consider development of a set of local "Stormwater Technical Documents" or other polices that clarify how the local jurisdiction is interpreting or enforcing certain elements.

    a. These policies may be referred to by ordinance, but the ordinance should be written so that these standards may be produced and updated by jurisdictional staff or employed consultants and enforced without additional action by the local governing council or board.

    b. These documents may also further define preferred design assumptions used in sizing calculations, beyond those referred to within this manual.

    c. They may also be used to further design what aspects of various BMP design are seen by the jurisdiction as "essentials", "targets" or "advisories" (primarily pertaining to sections of this manual where these terms have not yet been identified).

    d. These documents should also identify any design techniques or practices which are discouraged by the jurisdiction.

    e. These documents (or other ordinances or policies) should establish policy related to "direct discharge" near project limit entry points and perimeters (see Section 3.01-5).

13. Encourage or require use of a "Better Site Design" process that seeks to preserve of open space, reduce of impervious cover, minimize runoff and use water as a resource. Refer to the Center for Watershed Protection (www.cwp.org) for additional information.

14. Note that the Iowa Stormwater Management Manual does not include guidance on topics related to design of storm sewer systems, culverts and stream stabilization practices. For these topics, it is recommended that local jurisdictions reference the Iowa Statewide Urban Design and Specifications manuals and Iowa River Restoration Toolboxes. However, local ordinances should note that use of those standards is limited to items other than the practices and methods of stormwater management that are described within this manual. (ISWMM should be given preferred position in the design and sizing of BMPs used to address water quality and quantity.)

3.01-8 APPENDIX—SETTING “NATURAL” CONDITION CN STANDARDS

This brief is intended to give jurisdictions additional technical information when considering what maximum value to allow to represent “natural” conditions. This value would be used when developing models to determine allowable release rates from stormwater detention practices. Counties or communities may desire to set more restrictive standards to further restrict outflow rates to improve conditions downstream. One example for more restrictive enforcement would be for greater outflow control for new developments that drain to areas that have experienced frequent or significant flood damage, or when structures have been constructed close to the downstream flood plain. In such circumstances, it may be wise for the jurisdiction to use the lower cap in order to maximize flow reduction levels as areas are developed into urban land uses.

THIS STUDY BUILDS ON CALCULATIONS THAT WERE COMPLETED AS PART OF THE ANKENY STORMWATER MANAGEMENT STUDY.

When considering a more restrictive standard, cities may get questions about what benefits would be expected and the additional land area that may need to be dedicated to stormwater management. This brief provides information related to those questions.

COMPARING RESULTS

Allowable Release Rate Based on Meadow in Good Condition, CN=58 vs. Meadow in Good Condition, CN=71

This study calculated stormwater storage volume projections for combinations of the following conditions:

- Watershed Size: (9 sizes) 2.5, 5, 10, 20, 40, 80, 160, 320, 640 acres
- Soil Type (2 conditions): HSG B and C
- Impervious Cover: (4 conditions) 25%, 45%, 65%, 85%
- Soil Quality Restoration?: (2 conditions) Yes or No
- Average Basin Slope: (2 conditions) 2% and 4%

Question: *Assuming a development of a given size and impervious cover with HSG C soils, compare the results of attempting to provide stormwater detention to limit release rates to (CN=58) levels compared to (CN=71) levels.*

Procedure: *Estimation procedures outlined in Section 9.02 were used to estimate the required storage to meet all storage aspects of the Unified Sizing Criteria (Channel Protection through Extreme Flood Protection).*

Primary Conclusion: *Based on the modeled conditions, using allowable release rates based on HSG B soils (CN=58) is expected to result in only a minimal increase in the footprint area of each practice required to manage the 100-year storm event in most cases, while significantly reducing outflow rates (for areas with HSG C soils, where meadow in good condition would have a CN of 71).*

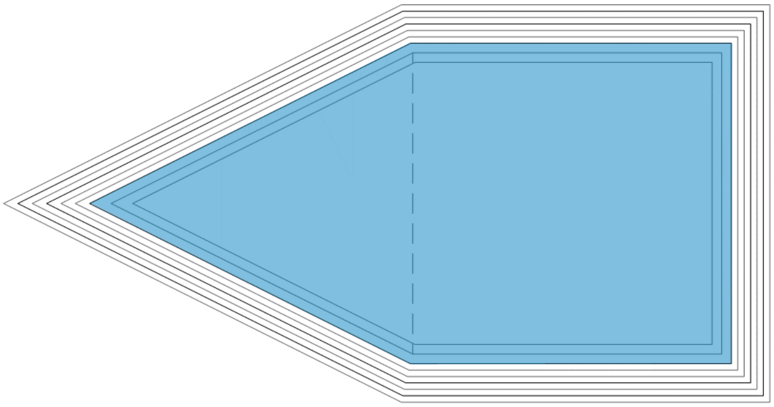
In these models, the area inundated by a 100-year storm event would need to between 1% and 14% larger to restrict outflow rates to levels consistent with natural conditions for HSG B soils. Put another way, the increased area to be set aside for detention represent less than 0.1% to 0.8% of the tributary area to the basin. Largest increases were noted in watersheds with lower impervious cover (more open space) and smaller watersheds.

TABLE 3.01-8-1: INCREASE IN BASIN TOP AREA		
WATERSHED (ACRES)	MIN	MAX
2.5	8.4%	13.3%
5	7.7%	13.4%
10	7.1%	13.6%
20	5.6%	11.3%
40	4.3%	9.3%
80	3.2%	6.0%
160	2.3%	5.5%
320	1.8%	2.7%
640	1.2%	1.9%

SUPPORTING CONCLUSION #1: THE AREA REQUIRED TO MEET THE MORE RESTRICTIVE STANDARD DOES NOT INCREASE SIGNIFICANTLY BECAUSE MEETING THE CHANNEL PROTECTION VOLUME (CPV) EXTENDED DETENTION CRITERIA IS DRIVING THE FOOTPRINT AREA REQUIRED.

Maintaining required high-water depths (see Sections 9.08-9.11) while meeting the requirements of the CPV criteria is typically the limiting factor that establishes the footprint area of the basin. The allowable outflow rate for the Channel Protection event is not based on soil type, but rather is based on a required reduction percentage compared to the inflow rate (qo/qi) needed to achieve a 24-hour drawdown period. So, any decision on the CN to be used to model "natural" conditions for larger storm events does not impact the required release rate for this event.

Figure 3.01-8-1: Simplified Basin Shape Assumed for Study Calculations



Assumed basin shape:

A simplified basin shape was used to project storage volumes and areas. The basin is essentially twice as long as it is wide from the tip of the triangle to the midpoint of the square on the opposite side. Slopes below the CPv elevation were assumed to be 6:1, which slopes above the CPv line were assumed to be 4:1, except in some of the larger watersheds with lower impervious cover, where slopes had to be reduced to achieve the required large-storm volume.

TABLE 3.01-8-2: PORTION OF WATERSHED AREA REQUIRED TO MANAGE CPV		
WATERSHED (ACRES)	MIN	MAX
2.5	3.9%	7.7%
5	3.6%	7.3%
10	3.3%	6.9%
20	3.1%	6.5%
40	2.9%	6.3%
80	2.9%	6.3%
160	2.8%	6.1%
320	2.7%	5.9%
640	2.6%	5.7%

The percentage of the watershed required to meet this standard ranges from 2% to 8%, with higher levels required in smaller watersheds and those with higher impervious cover (more paved surfaces).

SUPPORTING CONCLUSION #2: ONCE THE FOOTPRINT AREA REQUIRED TO MEET CPV STORAGE REQUIREMENTS IS SET, RESTRICTING RELEASE RATES TO MEET THE NATURAL CONDITION OF HSG B SOILS REQUIRES ONLY A SLIGHT INCREASE IN THE DEPTH OF STORAGE, WHICH DOES NOT RESULT IN A SIGNIFICANT INCREASE IN THE AREA INUNDATED BY THE 100-YEAR STORM EVENT.

An increased water level of 0.6 to 1.7 feet would be enough to provide the additional storage volume needed to meet the higher level of release rate control. This increase in water depth, projected up the side slopes, is what causes the increase in inundated area noted in Table 3.01-8-1.

The primary conclusion of this study—that minimal additional area will be needed—will prove true, provided that site elevations allow for basin high-water depths to be increased by the amounts shown in this table.

TABLE 3.01-8-3: PROJECTED HIGH WATER ELEVATIONS ABOVE BASIN OUTLET						
	Release Rate (CN=71)		Release Rate (CN=58)		Projected Change	
WATERSHED (ACRES)	MIN (FT)	MAX (FT)	MIN (FT)	MAX (FT)	MIN (FT)	MAX (FT)
2.5	3.0	3.4	3.5	4.1	0.6	0.7
5	3.0	3.5	3.7	4.4	0.7	0.9
10	3.1	3.8	4.0	5.0	0.9	1.2
20	3.2	4.0	4.1	5.4	0.9	1.4
40	3.3	4.3	4.3	5.9	1.0	1.5
80	3.5	4.7	4.6	6.0	1.0	1.4
160	3.6	4.9	4.7	6.6	1.1	1.7
320	3.7	5.1	4.9	6.0	1.1	0.9
640	3.9	5.4	5.1	6.1	1.2	0.7

SUPPORTING CONCLUSION #3: THERE IS A SIGNIFICANT DIFFERENCE IN RELEASE RATE WHEN BASED ON CN=58 COMPARED TO CN=71.

TABLE 3.01-8-4: INCREASES IN ALLOWABLE OUTFLOW RATE IF CN=71 IS ALLOWED COMPARED TO CN=58		
WATERSHED	10-YR	100-YR
2.5	184%	91%
5	192%	95%
10	213%	109%
20	206%	105%
40	208%	107%
80	214%	114%
160	206%	112%
320	203%	114%
640	197%	115%

Using existing soil conditions for a site with HSG C soils to determine allowable outflow rate would result in increased outflow rates. These increases range between 180–220% for the 10-year storm event and the 90–110% for the 100-year storm event. Increases would be even higher for smaller events (such as the 2- and 5-year events, which weren't directly reviewed as part of this study) and would decline between for storms between the 10- and 100-year events.

For example, for an 80-acre watershed, the allowable release rate from a basin during a 10-year event in central Iowa using CN=58 would be 21.3 cfs, whereas the rate using CN=71 would be 66.9 cfs, an increase of 214%.

(Note that the Lag Equation was used to calculate Time of Concentrations for each scenario, which considers CN in its computation; therefore, the Tc for the CN=58 scenario was 97.4 min, while the TC for the CN=71 scenario was 69.5 min.)

FINAL REMARKS: THIS SUMMARY IS INTENDED TO PROVIDE A QUICK OVERVIEW OF THE IMPACTS OF ESTABLISHING THE REQUIREMENT IN ISWMM FOR ALLOWABLE RELEASE RATES.

Note this comparison reviews the changes between HSG B and C soils, which typically make up the majority of soil types in Iowa. HSG D soils are present in some areas and increases in allowable outflow rates would be even higher for those areas, as compared to Table 3.01-8-4.