# Post-Construction StormwaterEngineering Technical Standards

Note: This document has been prepared as a template that can be used by jurisdictions that choose to adopt ordinances or policies that reference the Iowa Stormwater Management Manual (ISWMM). It gives brief summaries of key aspects of the manual and provides specific guidance on design methods or assumptions that should be used when preparing designs or studies for review.

This document can be viewed as a “supplemental design standard” which jurisdictions may use to tailor adoption and implementation of ISWMM within the scope of their review. It has been created as an editable Word document, so it may be adjusted to fit the needs of each individual jurisdiction.

Key pieces of information (such are ordinance references, local rainfall data, etc.) will need to be updated by each jurisdiction before publishing a version of these standards. Such areas are noted either through highlighted text or comments throughout this document.

Other aspects of this documents (such as a cover image, fonts, etc.) may also be edited at the user’s discretion.

Keep in mind that this document is intended to act in concert with ISWMM. It is not intended to be used as a standalone document to guide design related to stormwater conveyance or management practices. In some cases, it also references other related technical standards, as noted.

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## Introduction

Portions highlighted in yellow may be modified to suit local requirements and conditions.

As a condition of the City’s MS4 (Municipal Separate Storm Sewer System) Permit, the City is obliged to adopt and enforce a program to address stormwater runoff from new construction and reconstruction projects for which stormwater permit coverage is required.

This document provides guidance on the City’s preferred design and calculation methods when using the Iowa Stormwater Management Manual (ISWMM) to meet the Unified Sizing Criteria as the stormwater management standard for the City. Any best management practice (BMP) installation that complies with the provisions of the ISWMM-or future editions thereof, along with any locally adopted modifications at the time of the installation-shall be deemed to have been installed in accordance with this design reference.

The purpose of these technical documents is to provide additional guidance to developers, designers and City review staff in developing and reviewing designs for stormwater management techniques which are consistent with the ISWMM. Using these documents, the City hopes to achieve the following:

* Better understanding of the concepts and design techniques of stormwater management which are described in detail within the ISWMM and may be new concepts to some.
* Consideration of stormwater management as part of initial site selection and design.
* Stormwater design information being provided to City staff for development review that is complete, thorough and follows a consistent template of content to aid in its review.
* General consistency and uniformity in interpretation, selection and calculation of key design factors such as curve numbers, runoff coefficients, time of concentration and consideration of off-site runoff in design.

These documents are intended to help the user understand, interpret and apply local stormwater requirements and should be used in concert with the following documents and ordinances:

* City Codes
	+ Edit applicable code list
* The ISWMM, as published by the Iowa Department of Natural Resources, including both the current edition as well as future modifications.
	+ The manual can be downloaded from the [Iowa DNR Stormwater website](https://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Storm-Water-Manual)
* Any other local modifications to the ISWMM, as adopted by the City.
* Any requirements of the City’s MS4 Permit.
* Any other design standards, technical releases or other reports referenced by these documents.

**The Engineering Technical Standards are designed to provide brief summaries and application information from the documents referenced above (most specifically the ISWMM). On any topic where these Standards are silent, comply with the requirements of the documents listed above.**

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## Applicability

**City Ordinance Reference:** [Edit to match appropriate section of ordinance]

The City’s Post-Construction Stormwater Control Ordinance is generally applicable to the following properties and/or development sites:

* Any development or redevelopment disturbing more than one acre of land.
* Any development or redevelopment creating or re-creating more than [5,000] square feet of impervious cover.
* Exemptions:
	+ Any logging or agricultural activity which is consistent with an approved soil conservation plan or a timber management plan or approved by an appropriate agency, as applicable.
	+ Additions or modifications to an existing single-family structure.
	+ Developments that do not disturb more than 43,560 square feet of land, provided that they are not part of a larger common plan of development.
	+ Repairs to any stormwater BMPs deemed necessary by the City.

## Better Site Design Principles

**City Ordinance Reference:** [Edit to match appropriate section of ordinance]

Land development and associated increases in impervious cover alter the hydrologic response of local watersheds and increase stormwater runoff rates and volumes, flooding, stream channel erosion and sediment transport and deposition. This stormwater runoff contributes to increased quantities of water-borne pollutants. Stormwater runoff, soil erosion and non-point-source pollution can be controlled and minimized through the regulation of stormwater runoff from development sites. *To better mitigate these effects, stormwater management needs to be addressed early in the design process. Before initial design, consider the following methods to reduce the negative stormwater impacts of urban development:*

**Note: Each Stormwater Management Plan submitted for review should contain a narrative description of how these Better Site Design Principles (BSDPs) have been applied to the project under consideration.**

* **Evaluate natural resources before preparing a conceptual plan.** For a given site, gather information on the items included on the natural resources checklist provided as part of these guidance documents. Review existing soils, vegetation, topography, wetlands, prairie landscapes, streams, floodplains and any other feature which could influence design. Designate areas which need to be set aside to preserve high-quality soils, avoid excessively steep slopes, preserve wetlands or prairie remnants and provide for adequate stream buffers. An effective “buildable footprint” can be created by considering these features. Develop a plan which avoids unnecessary disturbance to such sensitive areas.
* **Prepare a soil management plan (SMP).** The SMP identifies where soils and vegetation will not be disturbed and the methods used to restore the health (quality) of disturbed or compacted soils. The plan shall include technical assessments such as Web Soil Survey data and geotechnical reports. Infiltration tests are required for areas where infiltration BMPs are planned (also consider how these soils may be affected by site construction). Soil conditions shall be considered when preparing a site conceptual layout and when selecting and designing stormwater BMPs.
* **Consider options which limit the area to be disturbed.** Once an area is disturbed, it can be difficult and expensive to prevent erosion and re-establish desired vegetation on that landscape. To the extent possible, create layouts for the desired use which minimize the disturbed area. If a project is to be built in phases, only disturb those areas necessary to build each phase. This limits the time that soils are exposed to erosion.
* **Review topography and work with the lay of the land.** Consider design options that reduce cuts and fills. Mass grading with heavy equipment compacts soil to the extent that it reacts almost like paved surfaces during rain events. Reducing cuts and fills will lessen subsoil compaction and the need for soil quality restoration techniques. Avoid disturbing steep slopes where possible. Reduce the length and grade of finished slopes as much as feasible to reduce the potential for sheet and rill erosion. Taller slopes may need to be divided by graded benches and wattles or covered with turf reinforcement mats to mitigate erosion.
* **Consider methods to reduce impervious surfaces.** Attempt to lay out a site to install fewer paved surfaces such as driveways, parking areas and streets, and to maximize the use of open spaces. Where that is not possible, pervious pavement systems may be considered on private development sites or as otherwise permitted by the City.
* **Early in the conceptual design phase, select the desired BMPs to manage stormwater runoff.** Review the natural resources identified on the site to determine which practices are most applicable at a given site. Prepare preliminary sizing calculations so that proper space is left to build the practice, with consideration for paths for long-term maintenance access.
* **Treat stormwater as close to the source as possible.** Techniques which capture runoff near the source-or prevent its creation in the first place-are most effective. Rain barrels, green roofs, permeable pavers and soil quality restoration are examples of practices which can be located close to the point where stormwater is created. *(Address runoff before the “snowball” gets too large.)*
* **Consider a “treatment train” of distributed practices.** Employing multiple practices which act in parallel or series is also recommended. That way, a failure of any one practice would not allow runoff to leave a site untreated. Consider required maintenance for each selected practice and put a plan in place with a responsible party designated to carry it out.

**Considering BSDPs early in the design process can reduce stormwater runoff rates and volumes, as well as reduce development costs by the following:**

* Reduced volumes of earthwork and topsoil respread (or cost of Soil Quality Restoration)
* Reduced cost of erosion and sediment control practices (such as mulching, seeding, silt fence, filter socks, wattles, turf reinforcement mats, sediment basins, etc.)
* Reduced cost of installing paved surfaces (and perhaps underground utilities)
* Reduced surface area devoted to stormwater management BMPs (such as biocells, bioswales, constructed wetlands, wet ponds, etc.) and reduced cost for their installation and maintenance

**These principles also are consistent with the following goals of the City’s Post-Construction Stormwater Control Ordinance:**

* Minimize increases in stormwater runoff from development within the City limits and fringe areas in order to reduce flooding, siltation, increases in stream temperature and stream bank erosion, and to maintain the integrity of stream channels
* Minimize increases in non-point-source pollution caused by stormwater runoff from development, which would otherwise degrade local water quality
* Minimize the total annual volume of surface water runoff, which flows from any specific development project site after completion, to not exceed the natural hydrologic regime (to the maximum extent practicable)
* Reduce stormwater runoff rates and volumes, soil erosion and non-point-source pollution, wherever possible, through establishment of appropriate minimum stormwater management standards and BMPs and to ensure that BMPs are properly maintained and pose no threat to public safety

**Site design should address open space protection, impervious cover minimization, and runoff distribution and minimization, and runoff utilization through considerations such as:**

1. **Open space protection and restoration**
2. Conservation of existing natural areas (upland and wetland)
3. Reforestation
4. Re-establishment of prairies
5. Restoration of wetlands
6. Establishment or protection of stream, shoreline and wetland buffers
7. Establishment or re-establishment of native vegetation into the landscape
8. **Reduction of impervious cover**
9. Reduce new impervious area through redevelopment of existing sites and use of existing roadways, trails, etc.
10. Minimize street width, parking space size, driveway length and sidewalk width
11. Reduce impervious surface footprint (e.g., two-story buildings, parking ramps)
12. **Distribution and minimization of runoff**
13. Use vegetated areas for stormwater treatment (e.g., parking lot islands, vegetated areas along property boundaries, front and rear yards, building landscaping)
14. Direct impervious surface runoff to vegetated areas or to designed treatment areas (roofs, parking lots and driveways drain to pervious areas, not directly to storm sewer or other conveyances)
15. Encourage infiltration and soil storage of runoff through grass channels, soil compost amendment, vegetated swales, raingardens, etc.
16. Plant vegetation that does not require irrigation beyond natural rainfall and runoff from the site
17. **Runoff utilization**
18. Capture and store runoff for irrigation in areas where irrigation is necessary

These principles have been adapted based on information prepared by the [Center for Watershed Protection](http://www.cwp.org). More detailed information on the Better Site Design Process is available on their website.

**Iowa Stormwater Management Manual Reference:** Section 1 (Formerly Chapter 1)

ISWMM Section 1 covers broad topics related to consideration of stormwater management in the design process, as well as the design of management facilities which address both stormwater quality and quantity. This section offers more detailed preliminary design guidance that should be reviewed and considered as early in the site development process as possible:

## Natural Resource Inventory

**City Ordinance Reference:** [Edit to match appropriate section of ordinance]

The stormwater management plan for a proposed development or other improvement shall include a written or graphic inventory of the site and immediate area as it exists prior to the commencement of the project. This inventory should include a description of the local watershed and its relation to the project site.

* It is strongly encouraged that designers collect this information prior to initial concept or site design and consider it when preparing plans for the proposed development. Refer to guidance document related to “Better Design Principles.”

**NOTE: Each Stormwater Management Plan submitted for review should contain a brief narrative overview of the Natural Resource Inventory items listed below.**

|  |  |
| --- | --- |
| [ ]  | Discussion of existing natural soil conditions |
|  | [ ]  | Soil types and hydrologic soil groups (from Web Soil Survey for County or other source)*Search for “Web Soil Survey” (operated by NRCS)* |
|  | [ ]  | Hydric soils |
|  | [ ]  | Soil conditions of areas for infiltration-based BMPs |
| [ ]  | Vegetative and forest cover |
| [ ]  | Topography (general description of slopes and drainage patterns, directions) |
| [ ]  | Wetlands |
|  | [ ]  | From National Wetlands Inventory-OR |
|  | [ ]  | Available current wetlands delineation/determination reports |
|  | [ ]  | As applicable, provide documentation of correspondence with Corps of Engineers, IDNR related to permitting requirements. |
| [ ]  | Native vegetative areas |
| [ ]  | Environmentally sensitive resources that provide opportunities or constraints for development |
| [ ]  | Existing streams and floodplains |
|  | [ ]  | Receiving water(s) (with known impairments or water quality issues) |
|  | [ ]  | Intermittent streams |
|  | [ ]  | Perennial streams (note stream order) |
|  | [ ]  | FEMA FIRM panel information |
|  | [ ]  | Floodplain projection or stream buffers required by Ordinance  |

Other factors related to streams and their buffers to be considered as part of the natural resource inventory:

* FEMA FIRM panels showing flood risk
* Adequate width for paths or other means for maintenance access
* Historical photos to evaluate meandering, streambank erosion or other signs of active stream movement

## Soil Management Plan

**City Ordinance Reference:** [Edit to match appropriate section of ordinance]

**Iowa Stormwater Management Manual Reference**: Section 7.03 (Formerly Chapter 5, Section 6)

**NOTE: The Soil Management Plan for each project needs to be included with the submittal of the Stormwater Management Plan.**

A soil management plan shall be provided that includes a site map identifying areas where soils and vegetation will not be disturbed, and where topsoil will be stripped and stockpiled. It shall include, if used, a description of soil health (quality) improvement methods such as tilling, ripping and amending soils with materials such as compost and topsoil. It shall also include a technical assessment of soils identifying the soil series and the site limitations based on soils data provided in the Web Soil Survey for County hosted by the NRCS. Soil borings shall be included when necessary to confirm suitable site conditions for placement of buildings with basements and related structures, especially in areas with hydric soils and shallow depth to groundwater.

Existing soil conditions should be considered when designing the site layout. If a stormwater BMP depends on the properties of soils, the assessment shall include the necessary information such as, but not limited to, organic content, percolation/infiltration rates, depth to groundwater and the depth to bedrock layers. The number and location of required soil borings and/or soil test sites shall be determined based on what is needed to determine the suitability and distribution of soil types present at the location of the BMP.

The information shall be used to provide a summary of the associated risks and potential for adequate drainage related to infiltration practices, groundwater mounding and basement flooding. Consultation with a Certified Professional Soil Scientist or Soil Classifier may be necessary.

Process for Developing Soil Management Plans:

1. Determine the site’s existing soil conditions.
2. Determine areas where soils and vegetation will not be disturbed. Identify those areas on a site map or scale drawing as part of Contract Documents or site Stormwater Pollution Prevention Plan (SWPPP).
3. Determine areas where topsoil can be stripped and stockpiled. Identify those areas on the site map or scale drawing.
4. Determine which method(s) of Soil Quality Restoration (SQR) are to be used and identify where they will be employed on the site map or scale drawing (refer to the ISWMM chapter for more information on the various options).
5. When using methods of SQR which involve tillage, determine the depth of tillage involved.
6. Determine and quantify types and amounts of materials to be provided to complete SQR requirements.
7. Specify methods for establishing permanent vegetative cover (e.g., sodding, seeding rates, etc.).
8. Incorporate the Soil Management Plan into site-specific SWPPP (if one is required) to be implemented from initial disturbance to final stabilization. *(SQR is considered a non-structural BMP)*

Methods of SQR are described within this section of ISWMM. Re-establishing the ability of site soils to absorb runoff is one of the most effective practices in reducing site runoff.

**Note: For sites with grading or soil compaction in areas where SQR is not applied, adjustements to curve numbers and runoff coeffients shall be made to account for reduced infiltration and the additional runoff generated due to soil compaction. Refer to guidance documents for the Rational Method and TR-55 Methodology for additional information. Also, on sites with grading or soil compaction, open space areas without SQR applied shall be considered as 50% impervious surface for calculating Water Quality Volume treatment requirements. Refer to guidance documents related to Small Storm Hydrology.**

## Unified Sizing Criteria

**City Ordinance Reference:** [Edit to match appropriate section of ordinance]

**Iowa Stormwater Management Manual Reference**: Section 3.01 (Formerly Chapter 2)

Standards set by the City are intended to ensure compliance with the City’s Post-Construction Stormwater Ordinance. The Unified Sizing Criteria is an integrated approach to managing stormwater runoff quality and quantity by addressing the adverse impacts of stormwater runoff from development.

The intent is to comprehensively manage stormwater to remove pollutants and improve water quality, prevent downstream streambank and channel erosion, reduce downstream overbank flooding and safely convey and reduce runoff from extreme storm events.

Without waivers (as allowed by Ordinance), stormwater calculations for all development sites should identify post-development conformance with the following design requirements:

**See also “Small-Storm Hydrology” and “Applying Stormwater Control Requirements” sections of this document.**

|  |  |
| --- | --- |
| **Water Quality Volume (WQv) Treatment** | **GREEN LEVEL** |

**Capture and infiltrate the Water Quality Volume,** or the runoff that is expected to be generated from a given site after development from a 1.25” rainfall event (reference Small-Storm Hydrology guidance document). **Approximately 90% of the rainfall which falls in Central Iowa is from storm events which are less than this amount.** Using BMPs to effectively manage runoff from these events could effectively eliminate direct surface runoff from a given site during most rainfall events, effectively managing many of the “first flush” pollutants of concern on-site.

|  |  |
| --- | --- |
| **Channel Protection Volume (CPv) Treatment** | **YELLOW LEVEL** |

**Provide infiltration or extended detention of the 1-year, 24-hour storm event or Channel Protection Volume** to reduce rapid fluctuations of flows in urban stream corridors that lead to erosive velocities and unstable stream conditions. In Central Iowa, the rainfall depth for such an event is 2.67 inches. **Practices which address this criterion through extended detention will capture this volume of runoff and slowly release it over a period of no less than 24 hours.**

|  |  |
| --- | --- |
| **Larger-Storm Detention Requirements (2-year to 100-year recurrence events)** | **RED LEVEL** |

**Restrict post-development peak discharge rates for the 2- to 100-year, 24-hour storm event to natural levels (Overbank Flood Protection [Qp] and Extreme Flood Protection [Qf]).** This standard is intended to prevent overbank flooding along urban stream corridors and to prevent surcharge of downstream storm sewer systems. **Allowable release rates for such events will be limited to peak rates that would be expected from a similar storm event under natural conditions (tall grass prairie and savanna) OR the peak rate from the 5-year, 24-hour storm event under existing conditions (use the lower of these two values).** Natural conditions will be modeled based on a land use of meadow in good condition (NRCS CN=58 and natural condition times of concentration for stormwater flows). Existing conditions (used to check existing 5-year release rate) will be modeled based on land uses and soil types that exist at the time that a development or site improvement is submitted for City review.

**Runoff from the extreme flood protection events shall be relased in a safe and non-erosive manner from a site (through an outlet pipe or properly designed emergency spillway) and it must be demonstrated that there are adequate flow paths (via storm sewers, easements, rights-of-way, etc.) to convey these developed storm flows to the receiving stream corridor without significant risk to public or private property.**

## Time of Concentration

**Iowa Stormwater Management Manual Reference**: Section 2.03 (Formerly Chapter 3, Section 3)

**Preferred Design Assumptions**

The following values and methods are recommended for use in completing calculations for time of concentration within the City of ####.

**Natural condition analysis:**

**To better reflect the retention of rainfall on large areas of natural landscape, use the NRCS lag method as described in Part E of Section 2.03: “Estimating time of concentration (NRCS lag method)”.**

* Note that the value for “Y” in the equation given is average watershed land slope, not slope along the stream length. Slope data from county soil surveys or LIDAR topographic information is often used to compute this value.
* Be aware of the limitations of this method as listed in note 2d of Part E of this Section of ISWMM.

**Existing and proposed conditions near or within urbanized areas:**

**Use the NRCS Velocity Method as described in Part D of this Section of ISWMM.**

**Apply the following additional information:**

* **Sheet flow.** Sheet flow is very shallow, uniform flow that usually occurs along the upper edges of a watershed. It only occurs until water reaches a point where flow will concentrate in a small depression or swale.

Sheet flow should never be measured past the point where contours indicate flow will begin to funnel to a common path. Follow the following guidelines for sheet flow calculation:

* **Flow Length** (maximum values - stop where water begins to funnel in each sub-area)
	+ **Natural conditions:** No greater than 100 feet.
	+ **Post-development conditions:** No greater than 50 feet of lawn, grass or wooded area unless specific practices are installed that encourage sheet flow conditions (level spreader, etc.). Total including paved surfaces no greater than 100 feet.
* **Roughness coefficient.** Use values below selected from ISWMM Tables.

| **Surface Description** | **n** |
| --- | --- |
| Pavement | 0.011 |
| Cultivated agriculture | 0.17 |
| Prairie vegetation | 0.15 |
| Turf grass lawns | 0.24 |
| Woods | 0.40 |

**Note that the above values for “n” are different than those for Manning’s equation which are for used open channel flow.**

* **P2.** The 2-year, 24-hour rainfall event for community name, Iowa is #.## inches.
* **Shallow concentrated flow.** Use the following equation to calculate flow velocity (from FHWA Hydraulic Engineering Circular No.22, Third Edition, September 2009):

$V=K\_{u}×k×\sqrt{S\_{p}}$ (From equation 3-4, page 3-9 of HEC-22

Where Ku = 3.28 (for English units)

V = Velocity (ft/s)

k = Intercept coefficient (from Table)

Sp = Slope along flow path (%, i.e. 2% = 2)

**Intercept Coefficients for Equation 3-4 (from Table 3-3 of HEC-22)**

|  |  |
| --- | --- |
| **Land Cover** | **k** |
| Forest with heavy ground litter; hay meadow | 0.076 |
| Trash fallow or minimum tillage cultivation; contour or stripped cropped; woodland | 0.152 |
| Short-grass pasture | 0.213 |
| Cultivated straight row | 0.274 |
| Nearly bare and untilled | 0.305 |
| Grassed waterway | 0.457 |
| Unpaved | 0.491 |
| Paved areas; small upland gullies | 0.619 |

* **Channel flow.** Use Manning’s equation for open channel flow-See ISWMM Chapter 2.03, based on channel cross-section properties and surface conditions.
* Refer to included tables for values of “n” for this equation.
* Include with submitted calculation details on the assumed cross-section of the channel and surface conditions used to select value of “n.”

**Note that these values for “n” are different than those to be used for sheet flow, discussed earlier.**

* Many software programs are able to calculate time of concentration. If you are using software to calculate Tc, verify that its processes comply with the requirements of this document. If not, prepare separate calculations meeting these requirements and manually input those values into the software input forms.
* If needed, a sample calculation form is available at the end of this Section of ISWMM.

Caution: Improper calculation of time of concentration can dramatically affect calculated peak flow rates. The Rational Method is very sensitive to this effect. To a lesser extent, it also impacts hydrographs developed using the NRCS TR-20 or TR-55 methods by affecting their shape and peak level.

## Rainfall and Runoff Analysis

**Iowa Stormwater Management Manual Reference**: Section 2.02 (Formerly Chapter 3, Section 2)

**Preferred Design Assumptions**

**NOTE: The rainfall values listed below should be used for the design of storm sewers and BMPs.**

Central Iowa is located within Climate Section 05, as shown in Figures in this section of ISWMM. Raidnfall values listed below have been taken from tables within this section of ISWMM. The numbers in the table below are for central Iowa. There are different values for different regions in Iowa. **It is recommended to interpolate as needed to obtain rainfall amounts for storm durations which are not listed within this table. The values are based on NOAA Atlas 14 rainfall data.**

* Generally, rainfall intensities are used for the Rational Method (storm sewer design only) and rainfall depths are used for NRCS TR-20 and TR-55 (hydrograph development for storage routing).
* A 24-hour storm duration shall be used in TR-20 or TR-55 analyses.

**Rainfall Intensities for Frequently Used Storm Durations\***

| **Duration (minutes)** | **1-year** | **5-year** | **10-year** | **100-year** | **500-year** |
| --- | --- | --- | --- | --- | --- |
| **Intensity (inches/hour)** |
| 5 | 4.78 | 6.91 | 8.10 | 12.40 | 15.90 |
| 10 | 3.51 | 5.08 | 5.92 | 9.15 | 11.60 |
| 15 | 2.84 | 4.12 | 4.82 | 7.44 | 9.50 |
| 20 | 2.56 | 3.72 | 4.35 | 6.72 | 8.58 |
| 25 | 2.27 | 3.31 | 3.87 | 5.99 | 7.65 |
| 30 | 1.99 | 2.91 | 3.40 | 5.27 | 6.73 |
| 35 | 1.87 | 2.74 | 3.21 | 4.98 | 6.38 |
| 40 | 1.76 | 2.57 | 3.01 | 4.70 | 6.03 |
| 45 | 1.64 | 2.40 | 2.82 | 4.41 | 5.68 |
| 50 | 1.52 | 2.23 | 2.62 | 4.12 | 5.32 |
| 55 | 1.41 | 2.06 | 2.43 | 3.84 | 4.97 |
| 60 | 1.29 | 1.89 | 2.23 | 3.55 | 4.62 |
| 90 | 1.04 | 1.53 | 1.81 | 2.89 | 3.78 |
| 120 | 0.79 | 1.16 | 1.38 | 2.23 | 2.94 |

**Rainfall Depths for Frequently Used Storm Durations**

| **Duration (hours)** | **1-year** | **5-year** | **10-year** | **100-year** | **500-year** |
| --- | --- | --- | --- | --- | --- |
| **Depth (inches)** |
| 1 | 1.29 | 1.89 | 2.23 | 3.55 | 4.62 |
| 6 | 2.05 | 3.03 | 3.61 | 5.98 | 8.02 |
| 24 | 2.67 | 3.81 | 4.46 | 7.12 | 9.37 |

**\*Note: Data for 5-minute intervals for rainfall intensity are linearly interpolated from Table 2 values.**

**Addressing Small Storm Hydrology:**

Note that 90% of the rainfall events that typically occur in central Iowa have been of 1.25” depth or less. Without proper planning and installation of appropriate BMPs that address these types of events, runoff from these storms will go largely unmanaged, leading to more frequent stormdischarges and greater runoff volumes released to urban stream corridors. Refer to the Small-Storm Hydrology Section for more information.

## Rational Method

**Iowa Stormwater Management Manual Reference**: Section 2.04 (Formerly Chapter 3, Section 4)

**Preferred Design Assumptions**

**The rational method is not to be used for preliminary or final detention storage and routing design for projects.**

* It may be used in the design of storm sewers, swales and channels for watersheds of less than **20 acres**, when only a peak rate of flow is needed for sizing.
* For projects involving stormwater management and detention design, the TR-20 or TR-55 methods are required to be used to develop more detailed hydrographs for stage-storage routing and outlet design.

The rational method may be used to generate peak flow runoff values for design of storm sewers and conveyance systems, provided the conditions of Part B and C of this Section of ISWMM are met. Be aware of all limitations of the method listed in this Section of ISWMM and determine if any apply. A few of the key constraints are highlighted:

* **Carefully select a value for “C.”** A 20% increase or decrease in the value of “C” has the effect of changing a 5-year recurrence interval to a 15-year or 2-year interval, respectively.
* **Use the method only for small watersheds.** Apply to drainage areas of less than 20 acres.
* **Take caution in selecting Tc where hard-surface areas are concentrated in the lower part of a drainage area.** Rainfall intensity (i) is selected based on the calculated Tc. When impervious surfaces are concentrated in a portion of the sub-area nearest the outlet, sometimes a larger peak flow rate will be found if the more distant open space is ignored (reduces area, but also reduces Tc and increases “C”). In such cases, it should be checked if a larger peak flow rate is found by including or ignoring more distant, upland open spaces.

**Rational method equation:**

$$Peak flow \left(in cfs\right)=runoff coeffiecient ×rainfall intensity \left({in}/{hr}\right)×area(acres)$$

$$Q=C×i×A$$

Runoff Coefficient Selection:

Select appropriate values from tables within this ISWMM Section, with the following provisions:

**Hydrologic Soil Groups.** Refer to County soil survey data with the following conditions:

Select Soil Group based on County Soil Map data for undeveloped areas and areas where development has occurred without mass grading activities. If no HSG is designated, or if soil type is listed as “Urban” assume HSG Type D for design of storm sewer systems or provide geotechnical tests to validate the characteristics of site soils.

For developed areas where grading or soil compaction has occurred or is planned, consider open spaces in such graded areas as being in poor conditionunless methods of SQR are specified and are to be field verified after construction.

**Selection for Urban Land Uses.** In urban areas, calculate runoff coefficient “C” using the values below for open spaces and impervious surfaces. Compute a weighted average value for “C” based on the expected percentage of impervious cover. Use the value for the appropriate soil group.

**Runoff Coefficients “C” for 5-year storm events**

| **Percent Impervious Area** | **Soil Group A** | **Soil Group B** | **Soil Group C** | **Soil Group D** |
| --- | --- | --- | --- | --- |
| open space (poor, w/o SQR) | 0.25 | 0.45 | 0.65 | 0.70 |
| open space (good, w/ SQR) | 0.05 | 0.15 | 0.35 | 0.50 |
| impervious | 0.95 | 0.95 | 0.95 | 0.95 |
| example 1 - 40% imp. w/o SQR | 0.53 | 0.65 | 0.77 | 0.80 |
| example 2 - 40% imp. w/ SQR | 0.41 | 0.47 | 0.59 | 0.68 |

**Example 1: Group A HSG, 40% impervious, w/o SQR**

$$C=60\%×0.25+40\%×0.95=0.53$$

**Example 2: Group A HSG, 40% impervious, w/ SQR**

$$C=60\%×0.05+40\%×0.95=0.41$$

**Rainfall Intensity:**

**Use appropriate values from “Rainfall and Runoff Analysis” section for calculated time of concentration.**

In selecting rainfall intensity do not use an assumed value for Tc, unless the calculated value is less than 5 minutes. In that case, use 5 minutes as the minimum value for Tc.

## NRCS TR-55 Methodology

**Iowa Stormwater Management Manual Reference**: Section 2.05 (Formerly Chapter 3, Section 5)

**Preferred Design Assumptions**

TR-55 is the required design method for projects involving stormwater management and detention basin routing within the City of ####. The TR-20 program is also acceptable, as it is the basis for calculations for TR-55, but it includes additional calculation features for stream and basin routing and allows for a larger number of subwatersheds to be analyzed. Any program that runs the TR-55 calculation method may be used to complete these calculations. (Many commercial software options run the TR-55 method, but some are more user-friendly, have greater flexibility and provide data output that is easier to interpret.)

**Rainfall:** Use Type II distribution, based on 24-hour rainfall depths for storm recurrence interval of interest.

Shape Factor: 484

**Curve Number (CN):** For urbanized areas, use values from the table on the next page. Otherwise use values selected from tables within this section of ISWMM, as advised below.

**For events less than two inches in depth (the Water Quality event), adjustments to Curve Number are needed to adapt TR-20 and TR-55 to properly model these smaller rainfall depths. Refer to the “Small Storm Hydrology” section of this document for required adjustments to curve numbers for these smaller, more frequent events.**

* **Natural Condition Analysis.** Use meadow in good condition, for analysis (CN=58).
* **Existing Condition Analyses**.
	+ Select by appropriate cover type.
	+ Select by Soil Group based on County Soil Map data for undeveloped areas and areas where developed has occurred without mass grading activities. If no HSG is designated, or if soil type is listed as “Urban” assume HSG Type D for design of storm sewer systems or provide geotechnical tests to validate the characteristics of site soils.
	+ For developed areas where grading or soil compaction has occurred or is planned, consider open space in such areas as being in poor condition unless methods of SQR have been specified and are to be field-verified after construction (or were verified for past development).
* **Agricultural Conditions**
	+ Use good conditions for analysis, unless clear reasons for using fair or poor conditions can be documented. For row crops and seed grains, use curve numbers for contoured land with crop residue (C+CR) in good condition, unless clear reasons for using other conditions can be documented.

For off-site analysis for determining conveyance of flows through a site and detention release rate requirements see ISWMM Section 3.01-5 and 3.01-6.

When reviewing off-site agricultural areas to determine flows allowed to “pass through” on-site detention areas, care must be given to not over-estimate CN to allow a larger release rate from the detention facility. It is also important to not underestimate CN while designing for proper conveyance of said flows, either through or around the site work area.

**See Water Quality BMP Design Information for additional information on modeling water quality BMPs.**

* **Urbanized Areas.** Use these values for storm events of a 1-year recurrence or greater.

**For developed areas where grading or soil compaction has occurred or is planned, consider open space in such areas as being in poor condition unless methods of SQR have been specified and are to be field-verified after construction (or were verified for past development). Calculate CN by weighted average based on percent impervious area using “Open Space in poor condition” for open spaces and “Paved parking lots, roofs and driveways” (CN=98) for hard-surface areas. (See chart below.)**

**Weighed Curve Numbers by Percent Impervious Area for Urbanized Areas
For Areas WITHOUT SQR or Soils in Poor Condition**

| **Percent Impervious Area** | **Soil Group A** | **Soil Group B** | **Soil Group C** | **Soil Group D** |
| --- | --- | --- | --- | --- |
| 0% | 68 | 79 | 86 | 89 |
| 10% | 71 | 81 | 87 | 90 |
| 20% | 74 | 83 | 88 | 91 |
| 30% | 77 | 85 | 90 | 92 |
| 40% | 80 | 87 | 91 | 93 |
| 50% | 83 | 89 | 92 | 94 |
| 60% | 86 | 90 | 93 | 94 |
| 70% | 89 | 92 | 94 | 95 |
| 80% | 92 | 94 | 96 | 96 |
| 90% | 95 | 96 | 97 | 97 |
| 100% | 98 | 98 | 98 | 98 |

*Note: Use these values for storm events of a 2-year recurrence or greater.*

**In areas where SQR is known (or is proposed) to be employed, calculate CN by weighted average based on expected percent impervious area using “Open Space in good condition” for open spaces and “Paved parking lots, roofs and driveways” (CN=98) for hard-surface areas. (See chart below.)**

**Weighed Curve Numbers by Percent Impervious Area for Urbanized Areas**

**For Areas WITH 8” SQR or Soils in Good Condition**

| **Percent Impervious Area** | **Soil Group A** | **Soil Group B** | **Soil Group C** | **Soil Group D** |
| --- | --- | --- | --- | --- |
| 0% | 39 | 61 | 74 | 80 |
| 10% | 45 | 65 | 76 | 82 |
| 20% | 51 | 68 | 79 | 84 |
| 30% | 57 | 72 | 81 | 85 |
| 40% | 63 | 76 | 84 | 87 |
| 50% | 69 | 80 | 86 | 89 |
| 60% | 74 | 83 | 88 | 91 |
| 70% | 80 | 87 | 91 | 93 |
| 80% | 86 | 91 | 93 | 94 |
| 90% | 92 | 94 | 96 | 96 |
| 100% | 98 | 98 | 98 | 98 |

*Note: Use these values for storm events of a 2-year recurrence or greater.*

**For off-site developed residential areas that were constructed prior to 1980, calculate CN by weighted average based on percent impervious area using “Open Space in fair condition” for open spaces and “Paved parking lots, roofs and driveways” (CN=98) for hard-surface areas. (See chart below.)**

**Weighed Curve Numbers by Percent Impervious Area for Urbanized Areas**

**For Areas WITH 4” Topsoil Soils in Fair Condition**

| **Percent Impervious Area** | **Soil Group A** | **Soil Group B** | **Soil Group C** | **Soil Group D** |
| --- | --- | --- | --- | --- |
| 0% | 49 | 69 | 79 | 84 |
| 10% | 54 | 72 | 81 | 85 |
| 20% | 59 | 75 | 83 | 87 |
| 30% | 64 | 78 | 85 | 88 |
| 40% | 69 | 81 | 87 | 90 |
| 50% | 74 | 84 | 89 | 91 |
| 60% | 78 | 86 | 90 | 92 |
| 70% | 83 | 89 | 92 | 94 |
| 80% | 88 | 92 | 94 | 95 |
| 90% | 93 | 95 | 96 | 97 |
| 100% | 98 | 98 | 98 | 98 |

## Small Storm Hydrology

**Iowa Stormwater Management Manual Reference**: Section 3.02 (Formerly Chapter 3, Section 6)

**Preferred Design Assumptions**

Management practices that address runoff from smaller storms will either capture and infiltrate (or filter) runoff from such events, and/or release runoff much more slowly than under previous design methods (slow drawdown over a minimum 24-hour period). This section provides guidance information for completing calculations that address smaller storm events. (see also the “Applying Stormwater Control Requirements” section of this document)

**Water Quality Volume:** For Central Iowa, 90% of rainfall events are smaller than or equal to 1.25” in rainfall depth. For quick reference, the chart below contains values for the Water Quality Volume (WQv) and Adjusted NRCS Curve Numbers (CN) adapted from equations in this section of ISWMM.

To determine a preliminary value for WQv for a given site, multiply the WQv value from the table (based on expected site impervious area percentage) by total development site area (or sub-area) to determine site WQv requirements. *On sites with grading or soil compaction grading, open space areas without SQR applied shall be considered as 50% impervious surface for the purpose of calculating WQv treatment requirements.*

If calculation of peak flow rate is needed (e.g., for diversion structures, bioswales, etc.), use the adjusted values for CN for any TR-55 (or TR-20) modeling of runoff from the 1.25” rainfall event.

**Water Quality Treatment Volume and Adjusted NRCS Curve Numbers for Small Storms**

| **Percent Impervious Area** | **Rv****(WQ Runoff Coefficient)** | **WQv****(per acre)****(CF)** | **Adjusted CN****1.25” event*****WQv*** |
| --- | --- | --- | --- |
| 0% | -- | -- | 73 |
| 5% | 0.095 | 431 | 77 |
| 10% | 0.140 | 635 | 80 |
| 15% | 0.185 | 839 | 82 |
| 20% | 0.230 | 1044 | 85 |
| 25% | 0.275 | 1248 | 86 |
| 30% | 0.320 | 1452 | 88 |
| 35% | 0.365 | 1656 | 89 |
| 40% | 0.410 | 1860 | 90 |
| 45% | 0.455 | 2065 | 92 |
| 50% | 0.500 | 2269 | 93 |
| 55% | 0.545 | 2473 | 93 |
| 60% | 0.590 | 2677 | 94 |
| 65% | 0.635 | 2881 | 95 |
| 70% | 0.680 | 3086 | 96 |
| 75% | 0.725 | 3290 | 97 |
| 80% | 0.770 | 3494 | 97 |
| 85% | 0.815 | 3698 | 98 |
| 90% | 0.860 | 3902 | 98 |
| 95% | 0.905 | 4106 | 99 |
| 100% | 0.950 | 4311 | 99 |

Use the values above for reference but perform calculations for a given site based on impervious percentage (and SQR application) using equations for Rv and WQv in Section 3.02.

**Example 1:** 3-acre site area, 60% impervious, SQR applied

$$WQv=3 acres×\left(2,677 {CF}/{acre}\right)=8,031 CF$$

**Example 2:** 3-acre site area, 60% impervious, no SQR applied

$$effective impervious=60\%+\left(40\%×50\%\right)=80\%$$

$$WQv=3 acres×\left(3,494 {CF}/{acre}\right)=10,482 CF$$

**Channel Protection Volume:** The procedure listed in ISWMM Part C of Section 3.02 is used to determine the initial estimate of the Channel Protection Volume (CPv), which is the extended detention volume required to capture and slowly release runoff from the 1-year, 24-hour storm event.

* This type of management reduces the flashy nature of runoff from urban development sites during small storm events, reducing the potential for erosion in downstream urban stream corridors.

Note the following items when applying the step-by-step procedure for estimating CPv (refer to the full procedure listed in Part C of this section of ISWMM):

1. Calculate the NRCS curve number and time of concentration for a given watershed or subwatershed.

Refer to NRCS TR-55 Methodology section of this document.

1. The 1-year, 24-hour storm depth in Central Iowa, Iowa is 2.67 inches.
2. When reviewing the output from a TR-55 (or TR-20) analysis, know the following:

Note: The City of #### provides no exemption of CPv, based on small peak discharge values from a given site.

1. If the software used to run the analysis provides total runoff volume in cubic feet, the runoff volume in inches can be calculated as:

$$Q\_{a}=\frac{Runoff Volume (cf)×12({in}/{ft})}{43560\left({sf}/{acre}\right)×Watershed Area (ac)}$$

1. The unit peak discharge can be calculated as:

$$q\_{u}=\frac{Peak Discharge (cfs)}{Watershed Area \left(sq mi\right)×Q\_{a}(inches)}$$

1. Draw a line up from qu in the figure below (from ISWMM) to the 24-hour curve, then over to the left to find the ratio (qo/qi). This is the ratio of outflow to inflow. *You will multiply this ratio times the inflow rate to the storage practice to determine the allowable peak release rate (in Step 5).*

**Example:**

For Unit Peak Discharge

qu = 750 csm/in

Ratio of Outflow to Inflow

(qo/qi) ratio = 0.02

1. Solve for the peak release rate from the extended detention basin during a 1-year event. For this equation, qi is the Peak discharge from the TR-55 model output (in cfs).

$$q\_{o}=\left({q\_{o}}/{q\_{i}}\right)xq\_{i}$$

**Example:** For a site with a calculated 1-year peak inflow of 10 cfs, and a (qo/qi) ratio of 0.02:

Peak allowable discharge rate for Extended Detention:

$$q\_{o}=\left({q\_{o}}/{q\_{i}}\right)xq\_{i}=0.02×10cfs=0.2cfs$$

1. Use the equation below to solve for the estimated ratio of extended detention storage required compared to the runoff volume from the study area during the storm event (Vs/Vr).

**Note: This same equation can be used to estimate detention storage volume required for larger storm events, based on the calculated inflow and allowable release rates.**

$$\frac{V\_{s}}{V\_{r}}=0.683-1.43\left(\frac{q\_{o}}{q\_{i}}\right)+1.64\left(\frac{q\_{o}}{q\_{i}}\right)^{2}-0.804\left(\frac{q\_{o}}{q\_{i}}\right)^{3} $$

1. Multiply the (Vs/Vr) ratio calculated in Step 6 to solve for the estimated extended detention storage volume required. This is an estimate for initial basin sizing to be used for preliminary site design. Software packages may give results for runoff volume in either inches or cubic feet. Note the required conversions for desired volume measurement.

**This value is not the final storage volume required. This is an initial estimate to allow the designer to locate a storage area on-site with the approximate volume required.**

1. When a preliminary site design has been developed that accommodates the storage above, solve for the preliminary size of the outlet control stage for this type of event. Note that qo comes from Step 5, and ho (elevation difference between the expected high-water elevation and the center of the outlet orifice) depends on the design of the basin and the depth of storage required to achieve the required extended detention volume.

$$A\_{o}=\frac{q\_{o}}{C(2gh\_{o})^{0.5}}=\frac{q\_{o}}{4.81(h\_{o})^{0.5}}$$

**It is highly recommended to limit depth of storage during this event to 2.5 feet or less, in order to limit water depth in the basin during these frequently occurring events. Deeper ponding during an event as frequent as the CPv could lead to maintenance and safety issues.**

1. A perforated riser pipe may be required in lieu of an orifice of 4-inches in diameter or smaller (or other means applied to prevent clogging of the basin outlet).
2. Use the preliminary basin design to develop stage-storage-discharge relationships for flow routing. Then perform an actual reservoir routing calculation (see ISWMM Section 9.03) to verify that the initial design meets the release peak rate requirements (from Step 5) and an extended drawdown of the basin can be observed. Include routing results in the Stormwater Management Plan.

**A minimum 24-hour drawdown is required; full drawdown of CPv within 72 hours is recommended.**

**Note: Infiltration practices may be enlarged to accommodate the CPv requirements. In this case, the volume to be used to size infiltration practices can be solved by adapting the equation within ISWMM as follows:**

$$CPv \left(cubic feet\right)=({Rv×2.67 inches ×A \left(acres\right)}/{12})×43,560({SF}/{acre})$$

## Runoff Hydrograph Determination

**Iowa Stormwater Management Manual Reference**: Section 2.06 (Formerly Chapter 3, Section 7)

**Introduction**

Given the variety of available software packages capable of performing calculations consistent with TR-55 methodology, it is assumed that designers will rarely use manual techniques to develop runoff hydrographs in the methods described. The designer should be familiar with the basis of such calculations, and the following information should be clearly indicated in stormwater drainage reports:

1. **Rainfall depths for reviewed storms** (WQv, 1-, 5-, 10-, 25-, 50- and 100-year events) consistent with prescribed values for community, Iowa. Models for 24-hour storms should indicate that a Type-II rainfall distribution was used.

Rainfall depths should be consistent with information in the “Rainfall and Runoff Analysis” section of this document.

1. **Drainage maps** identifying watershed (and subwatersheds) areas. Flow paths and land uses for both pre-developed, existing and post-development conditions should be identified.

Clearly identify drainage boundaries, areas and flowpaths on the drainage maps.

1. **Details of calculations of time of concentration**, consistent with preferred design assumptions listed earlier in this document.

Include software input/output, spreadsheets or other calculations used in an appendix to the Stormwater Management Plan. Refer to “Time of Concentration” section of this document for more information.

1. **Details of selected curve numbers**, as the basis of their selection consistent with preferred design assumptions listed earlier in this document.

Include software input/output, spreadsheets or other calculations used in an appendix to the Stormwater Management Plan. Refer to “Small Storm Hydrology” and “TR-55 Methodology” sections of this document for additional information.

1. For models with multiple sub-areas, where hydrographs are to be combined with or routed through downstream areas or basins; **provide a flow** **chart, schematic plan or map that identifies how separate hydrographs have been routed or combined**.

This will help to clarify how models were built to route flows from various areas through proposed management practices.

1. For hydrograph routing through a detention basin, pond or outlet structure, refer to ISWMM Sections 9.03 and 9.04.

Methods, assumptions and calculations used in routing should be consistent with these sections, except as amended by this document.

## Applying Stormwater Control Requirements

**City Ordinance Reference** (if applicable)**:** [Edit to match appropriate section of ordinance]

**Introduction**

Generally, all sites must provide stormwater management to meet all of the green, yellow and red levels, unless the site has been exempted by the City for a certain reason (e.g., regional or off-site detention practice downstream that meets some or all of those requirements for a given site). Early in the design process, the designer should discuss what level of management is required at a given site with City staff. For clarity, this document divides these requirements into three management levels:

|  |  |
| --- | --- |
| **Water Quality Volume (WQv) Treatment** | **GREEN LEVEL** |
| **Channel Protection Volume (CPv) Treatment** | **YELLOW LEVEL** |
| **Larger-Storm Detention Requirements (5-year to 100-year recurrence events)** | **RED LEVEL** |

How management requirements are applied, especially in areas receiving off-site flows, can significantly impact the actual performance of control BMPs.

**Stormwater analyses must not be limited to the boundaries of a given site. Watershed context, including the effects of run-on from off-site flows and downstream conditions needs to be considered.**

For this reason, the following guidance is provided when designing practices to comply with City Ordinance Control requirements:

|  |  |
| --- | --- |
| **Water Quality Volume (WQv) Treatment** | **GREEN LEVEL** |

**Water Quality BMPs shall be provided-sized according to this document and the ISWMM manual as applicable-to demonstrate treatment of the WQv. (see also the “Small-Storm Hydrology” section of this document)**

1. Calculate the required WQv volume to be treated and design a practice or series of practices that addresses that volume.
2. Development sites that drain to multiple outlet locations shall be divided into separate watershed areas that are tributary to each outlet for separate analysis.
3. The WQv requirements for a given watershed area must be met by infiltration practices that are installed within that area. BMPs within the same watershed area may be used in a “treatment train” to achieve the overall treatment volume for that area. However, trading volumes between watershed areas or providing additional management in one area to offset flows leaving the site untreated are generally discouraged, except as noted in #4 and #5 below.
4. City Engineering staff may allow for special consideration in cases where multiple outlet points drain to a common point near the site, or where other special circumstances exist (such as existing downstream practices with capacity or where a regional stormwater management plan has been adopted).
5. Special considerations may be given for retrofits and redevelopment areas that provide a similar net result on a square-foot-to-square-foot-treated basis. Such considerations (as per #4 and #5) should be discussed with City staff prior to preparation of a Stormwater Management Plan.

|  |  |
| --- | --- |
| **Channel Protection Volume (CPv) Treatment** | **YELLOW LEVEL** |

**Provide practices which temporarily store and slowly release runoff from this type of storm event over a period of not less than 24 hours (extended detention). Infiltration practices may also be oversized to manage this type of event. (see also the “Small-Storm Hydrology” section of this document)**

1. Treatment of the CPv requires infiltration or capture and slow release of the 1-year storm event over a period of at least 24 hours (extended detention). This requires very low outflow rates from a developed area to accomplish this goal (outflow rates will generally be less than 5% of inflow rates).

Providing extended detention for CPv can be difficult to accomplish if there are sizable unmanaged off-site areas draining through a certain storage practice. This requires either enlarging the practice to manage this runoff or increasing the outflow rate which can reduce the effectiveness of the practice.
2. It is recommended, to the extent possible, that practices to manage CPv are designed “off-line” from significant off-site flows that pass through a given site area. In this way, a practice can be designed to provide CPv for site areas, while allowing off-site flows to be safely conveyed through a given site.

◄ Location of Off-Line Practices

*In this example, stormwater BMPs are located “off-line” or outside of the path of runoff from a larger watershed area upstream. Stormwater from the new development would be directed to these practices, where runoff could be managed before it is discharged into the main flow path. In some cases, these practices may need to be set outside of required stream buffers.*

**BMP**

**BMP**

**Off-site Flow**

**New development**

1. If this approach is not feasible, follow guidance in the ISWMM Section 3.01-5 and 3.01-6 regarding routing of off-site flows.
2. Allowable outflow rates for extended detention of the CPv event are usually small. This makes it difficult to reduce allowable flow rates from a practice to offset impacts from direct discharge areas (or other outlet points from a site that exceed CPv release rate control requirements). For this reason, impervious direct discharge areas should be minimized as much as possible and CPv release rate requirements should be met at each site outlet point.

|  |  |
| --- | --- |
| **Larger-Storm Detention Requirements (5-year to 100-year recurrence events)** | **RED LEVEL** |

Provide practices which temporarily store runoff and reduce peak flow rates to required levels.

1. The peak allowable flow rate from the site shall not exceed levels expected to be produced during a similar storm event under natural conditions or the 5-year, 24-hour storm event under existing conditions (whichever value is less).
2. Even with larger storm events, caution needs to be taken when passing flows from off-site areas through a detention practice. In the past, increasing allowable outflow rates from detention practices had been allowed, so that flow from off-site areas can “pass through.” This can lead to the installation of larger weirs, pipes and structures to allow higher release rates to accommodate these flows. However, this approach means that when future upstream developments install practices to comply with this ordinance, the outlet structures at the site currently under consideration may continue to allow larger release rates.
3. For this reason, the guidance within ISWMM Section 3.01-5 related to this issue should be followed.

## Detention Storage Design

**Iowa Stormwater Management Manual Reference**: Section 9

**Introduction**

This supplement is intended to provide guidance related to this section of ISWMM, to achieve better designed, constructed and maintained management practices related to stormwater detention.

**Approved Detention Storage Design Methods**

Only the NRCS TR-55 Method is approved for stormwater detention design within the City of ####. The formula from ISWMM shown below should only be used to obtain a preliminary estimate of required storage. Final storage volume requirements should be based on stage-storage-discharge routing of hydrographs for post-developed conditions through a proposed basin and outlet design. (Refer to ISWMM Section 9.02)

$$\frac{V\_{s}}{V\_{r}}=0.683-1.43\left(\frac{q\_{o}}{q\_{i}}\right)+1.64\left(\frac{q\_{o}}{q\_{i}}\right)^{2}-0.804\left(\frac{q\_{o}}{q\_{i}}\right)^{3} $$

**Note: LID methodology (as described in ISWMM Section 2.07 (Formerly Chapter 3, Section 8) may also be applied for projects that use a comprehensive system of practices to address both water quantity and quality and mimic pre-settlement hydrology.**

**Allowable Release Rate**

Refer to the prior section of this document titled, “Applying Stormwater Control Requirements.”

**Maintenance and Equipment Access**

Provide clear paths from adjacent streets to the facility that can accommodate expected maintenance equipment (trucks, small excavators, etc.). In some cases, this may require a hard-surface access path. Refer to portions of Section 9 that refer to access requirements for various types of detention practices.

## Channel and Storage (Reservoir) Routing

**Iowa Stormwater Management Manual Reference**: Section 9.03 (Formerly Chapter 3, Section 10)

**Introduction**

Given the variety of available software packages capable of performing calculations consistent with the routing methods described within this section, it is assumed that designers will rarely use manual techniques to perform the calculations described within this section. The designer should be familiar with the basis of such calculations, and the following information should be clearly indicated in stormwater drainage reports:

**Channel Routing**

1. Clearly identify the **channel length, slope** (along channel length) **and Manning roughness coefficient** (n) used for design. Document surface conditions considered for selection of “n” and identify length and elevation used for slope calculation on drainage map.
2. Provide a **sketch showing the assumed cross-section of the channel** (triangular, rectangular, trapezoidal, etc.) with bottom width and side slopes clearly labeled.

**Reservoir Routing:** For detention design analysis, a stage-storage-discharge hydrograph routing is required for all the events reviewed to verify that, after development, a given site does not violate peak release rate restriction requirements for these storms. For the 2-, 25- and 50-year storm events, a summary table of peak levels is sufficient. For the 1-, 5-, 10- and 100-year storms, detailed inflow and outflow hydrograph results for each basin (and the site as a whole) shall be provided. *(Refer to the City Stormwater Checklist for requirements.)* The provided calculations should include all of the following (as applicable):

1. **Inflow hydrograph** (numeric or graphic) through the duration of the storm event. Maximum time steps of 2 minutes (1 minute preferred), refer to Section 9.03, as applicable.
2. **Stage-storage volume relationship** of the reservoir area. No less than one-foot intervals.
3. **Stage-discharge relationship of basin outlet.** Calculations should identify all stages of outflow design (riser pipe, orifice, weir, discharge pipe, overflow spillway, etc.) and include characteristics of each (elevation, size, etc.) that match plan dimensions. Calculations should include either detailed calculations of flow through each outlet stage, or graphical representation of stage-discharge relationship from the calculation output of the software package used. The calculations should note whether the flow from a given stage is routed through the primary spillway or a secondary overflow. Refer to section of this document titled, “Detention Basin Outlet Structures.”
4. **Weir and/or orifice coefficients** that account for energy loss (resistance to flow).
5. **Target peak discharge allowed** from the reservoir (for each event to be considered).
6. **Outflow hydrograph** from routing output identifying flow rate (in cfs) versus time, the peak flow rate and time of occurrence in relation to the rainfall event. For analyses involving the 5- and 100-year events identified in this report, provide a numeric or graphical representation of the entire outlet hydrograph through the duration of the storm event.
7. **A graph of storage volume or elevation versus time** for the key design events. Review drawdown for extended detention of the CPv (1-year storm event - minimum 24-hour, maximum 72-hour drawdown after storm event).
8. Identify maximum storage volume and water surface elevation for each event reviewed.
9. For each event, calculate the **maximum storage volume in watershed-inches** (equivalent depth of water over the area served by the basin) and as a **percentage of total runoff** (maximum storage volume divided by total runoff volume).

## Inlet Sediment Forebays

**Iowa Stormwater Management Manual Reference**: Section 5.04 (Formerly Chapter 3, Section 11)

**Introduction**

Sediment forebays are essential to long-term maintenance and performance of proposed stormwater management BMPs. A forebay is an area near a concentrated point of discharge to a certain BMP, where stormwater flows can be slowed to an extent that heavier sediments and debris can be captured before they enter the BMP itself.

Forebays should be placed in areas where they can be accessed for maintenance and sediment/debris removal. This helps reduce the amount of heavy pollutants that enter a proposed treatment practice (pollutants that could clog or otherwise negatively affect the performance or appearance of those practices).

**Key design considerations**

1. Sediment forebays should be sized for 0.10–0.25 inches of runoff per impervious acre within the watershed upstream of the forebay. **A typical sizing criterion is 10% of the WQv to be treated**.
2. **Forebays are often separated from the BMP they protect by a physical barrier** of some type (berm, spillway, gabion or revetment stone wall, etc.) that forces water entering the BMP to pool temporarily near the entrance to the facility, reducing velocities and allowing suspended materials to settle out.
3. **Forebays should be located where they can be directly accessed for maintenance.** Provide clear paths from adjacent streets to the facility to accommodate expected maintenance equipment (trucks, small excavators, etc.). In some cases, this may require a hard-surface access path.
4. **A hardened-bottom surface** or depth marker should be considered to help avoid over-excavation during cleanout operations.
5. **Plan for sediment cleanout at least every 3–5 years (for stabilized watershed)**, or when 6–12 inches of sediment have accumulated, whichever occurs first. The forebay should be cleaned near the end of construction activities after surrounding areas are stabilized with vegetation and prior to acceptance by the city (if practice is to be dedicated to the City for ownership or maintenance).

## Detention Basin Outlet Structures

**Iowa Stormwater Management Manual Reference**: Section 9.04 (Formerly Chapter 3, Section 12)

**As per the reservoir routing design guidance section, calculations should identify all stages of outflow design (riser pipe, orifice, weir, discharge pipe, etc.) and include characteristics of each (elevation, size, etc.) that match plan dimensions.**

Calculations should include either detailed calculations of flow through each outlet stage, or graphical representation of stage-discharge relationship from the calculation output of the software package used. Methods to calculate release rates through a variety of types of storm outlets are included in this section of the ISWMM.

**Note: Some software packages note if an outlet feature is considered “multi-stage” or not. If an outlet is considered “multi-stage,” that means it acts in series with flow ultimately passing though the outlet pipe of the control structure (the outlet pipe is usually designated as “Culvert A”). If it is not “multi-stage,” then runoff passing through that feature does not pass through the outlet pipe of the control structure (i.e., an overflow spillway, parallel pipe, etc.).**

Sample from Hydraflow Hydrographs Extension for AutoCivil 3D 2015 ►

**Refer to ISWMM Section 9 for other key design considerations for various types of detention BMPs.**

## Storm Sewer System Design

Iowa Statewide Urban Design and Specifications (SUDAS) Design Manual: Sections 2C, 2D, 2E and 2F.

The ISWMM does not contain information regarding storm sewer system design. Chapter 2 of the SUDAS Design Manual is the proper reference for system design. The following sections are relevant:

* **Section 2C.** Pavement Drainage and Intake Capacity.
* Provide calculations regarding intake capacity and spread of flow across the street and or right-of-way. *The spacing requirements per SUDAS Section 2C-3, Part G.5.b may be waived if BMPs are employed to reduce surface runoff, reducing the need for surface inlet structures*.
* Provide calculations used to determine Minimum Protection Elevations (MPEs) near rear yard swales or inlets.
* **Section 2D.** Storm Sewer Design.
* Provide calculations demonstrating that the storm sewer network will operate without surcharge during a 5-year storm event.
* **Section 2E.** Culvert Design.
* Provide calculations demonstrating that the capacity of any culverts meets the requirements of this section.
* Provide any calculations used to determine MPEs in the immediate area.
* **Section 2F.** Open Channel Flow (not including bioswales).
* Refer to the Channel and Reservoir Routing section of these Guidance Documents.
* Provide details regarding cross-section, slope, selection of roughness coefficients, etc., as needed to determine depth of flow and velocity within the channel.
* Provide any calculations used to determine MPEs in the immediate area.

## Water Quality BMP Design Information

The table below lists a variety of BMPs that are described in the ISWMM and their general application toward meeting the requirements of the Unified Sizing Criteria in the City of ####.

| **BMP Practice Application** | **Pretreatment** | **WQv** | **CPv** | **Large-Storm Detention** |
| --- | --- | --- | --- | --- |
| Grass Swales |  |  |  |  |
| Vegetative Filter Strip |  |  |  |  |
| Sediment Forebay |  |  |  |  |
| Hydrodynamic Devices |  |  |  |  |
| Gravity Separators |  |  |  |  |
| Catch Basin Sumps and Inserts |  |  |  |  |
| Green Roofs |  |  |  |  |
| Rainwater Harvesting |  |  |  |  |
| Native Landscaping |  |  |  |  |
| Tree Filter Systems |  |  |  |  |
| Bioretention Systems |  |  |  |  |
| Bioswales |  |  |  |  |
| Permeable Pavement |  |  |  |  |
| Constructed Stormwater Wetlands |  |  |  |  |
| Dry Detention |  |  |  |  |
| Subsurface Stormwater Detention |  |  |  |  |
| Extended Dry Detention |  |  |  |  |
| Wet Ponds |  |  |  |  |

Refer to the ISWMM for more detailed information on site selection and design of these practices.

The following are a few highlighted design issues in applying these standards in community name:

**Stormwater Diversion Structures**

In some cases, it is desired to divert runoff from smaller storms to a water quality BMP, while allowing larger flows to bypass. This reduces the potential for erosion or other damage caused by rare, large storm events within these “off-line” practices. An example of how to design such a diversion structure is included in ISWMM Section 7.07 (Formerly Chapter 5, Section 4) within the design example (Step 3).

**Community can add items to this list, as applicable**

**Green Roofs** Refer to ISWMM Section 6.02 (Formerly Chapter 17, Section 1)

**Native Landscaping** Use “Meadow in good condition” based on local HSG

* CN=30 for HSG A
* CN=58 for HSG B
* CN=71 for HSG C
* CN=78 for HSG D

**Bioretention Systems** If native plants used, use “Meadow in good condition” based on HSG A (CN=30) for level surface ponding area

**Bioswales** Use “Meadow in good condition” based on local HSG

**Permeable Pavement** Use CN=98 when determining flow rates and volumes to subsurface storage.
Perform hydrograph detention routing to account for reduced flow rates and volumes downstream of practice.

**Constructed Wetlands** Use CN=98 for areas covered by permanent pool. Use “Meadow in good condition” based on local HSG for areas above permanent pool. Perform hydrograph detention routing to account for reduced flow rates and volumes downstream of practice.

**Dry/Extended Dry Detention** For native landscaping, use “Meadow in good condition” based on local HSG. For other areas, refer to NRCS TR-55 Methodology section of this document.

**Wet Ponds** Use CN=98 for areas covered by permanent pool. For native landscaping areas above pool, use “Meadow in good condition” based on local HSG. For other areas, refer to NRCS TR-55 Methodology section of this document.

## Outlet Revetment Protection

**Reference:** “Hydraulic Design of Energy Dissipators for Culverts and Channels”
FHWA-Hydraulic Engineering Circular No. 14, Third Edition (July 2006)

**Chapter 10 of HEC-14 provides guidance on design of riprap basins and aprons. The “RIRAP APRON” design procedure is often applicable at the outlets of most storm sewer pipes (recommended for 60-inch diameter or smaller).**

* Equation 10.4 (page 10-17) can determine the average size of revetment stone that should be used for a given location. This equation can be applied when tailwater depth is between 0.4D and 1.0D. If tailwater depth is unknown, use 0.4D.

$$D\_{50}=0.2D\left(\frac{W}{\sqrt{g}D^{2.5}}\right)^{^{4}/\_{3}}\left(\frac{D}{TW}\right)$$

Where D50 = median revetment stone size (ft)

Q = design discharge (cfs)

D = culvert diameter, circular (ft)

TW = tailwater depth (ft)

g = gravitational acceleration constant (32.2 ft/s2)

* The revetment size calculated in the equation above indicates the “CLASS” of the revetment outfall apron, used to determine the length and depth of the installation.

| **Class** | **IDOT Gradation** | **D50 (inches)** | **Apron Length** | **Apron Depth** |
| --- | --- | --- | --- | --- |
| 1 | Class D or E | 5 | 4D | 3.5D50 |
| 2 | Class D or E | 6 | 4D | 3.3D50 |
| 3 | Class B | 10 | 5D | 2.4D50 |
| 4 | \*\* | 14 | 6D | 2.2D50 |
| 5 | \*\* | 20 | 7D | 2.0D50 |
| 6 | \*\* | 22 | 8D | 2.0D50 |
| D = Culvert rise (inches)D50 = median revetment stone size\*\*Beyond standard IDOT gradations, special specification of material required |

* Shape the revetment to generally comply with Figure 10.4 (page 10-16) as shown below.

When Class 3 or larger stone is required, mix with smaller stone to help interlock revetment together.

It is recommended to omit engineering fabric under revetment installations, as such fabric limits rock / soil contact and may allow rock materials to slide along the fabric surface.

## Stormwater Management Plan

**Iowa Stormwater Management Manual Reference:** Sections 1.05 (Formerly Chapter 1, Section 5) and 9.03-5

With each project, a stormwater management plan (SWMP) shall be submitted for review, in accordance with local ordinance requirements. The City has a preferred format for the narrative part of the SWMP and the way appendices with information is organized. A SWMP template is available, which may be edited as needed to include the relevant information for a given project. Templates for certain calculation report forms are also available for use. These can be obtained from the following sources:

1. List here the sources where any template can be obtained. (Does the jurisdiction have their own version of these forms they wish to use, or can they be downloaded from the IDNR website, for example).

To streamline the review process, these templates should be used to ensure that complete information is being provided for review, and to organize that information in a similar fashion from project to project. It is encouraged / required for the SWMPs and supporting information to be formatted in this fashion.

ISWMM Section 1.05 includes more detailed descriptions of the information to be included in the ISWMM. Section 9.03-5 provides additional information about supporting calculations that need to be provided for review for projects which include stormwater management.