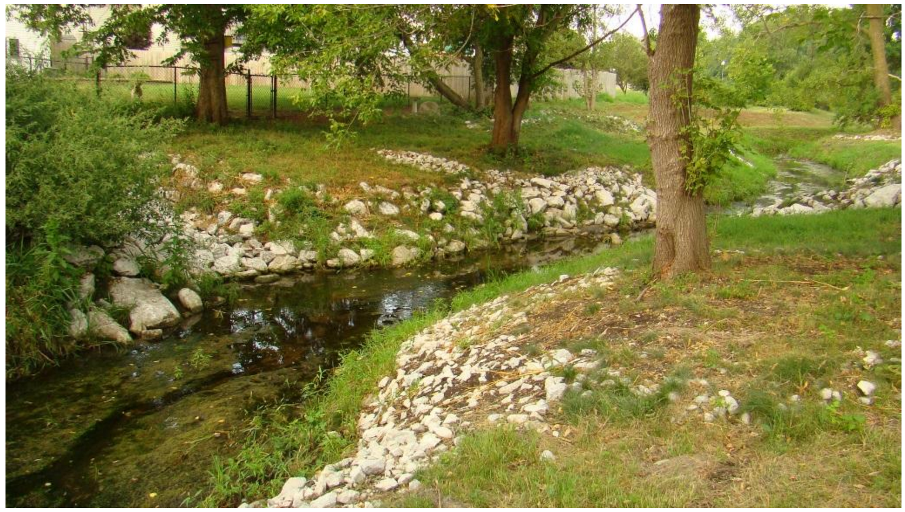
CITY OF Ames

Post-Construction Storm Water



smart WATERSHEDS

FOR CLEAN RIVERS AND STREAMS

Stormwater Technical Guidance Documents

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Introduction

On April 22, 2014, the City of Ames adopted a Post Construction Stormwater Management Ordinance. As a condition of the City's MS4 (Municipal Separate Storm Sewer System) Permit, the City is obliged to develop, implement and enforce a program to address stormwater runoff from new construction and reconstruction projects for which stormwater permit coverage is required.

As part of the new ordinance, the City has adopted the Iowa Stormwater Management Manual (ISWMM) and the Unified Sizing Criteria as the stormwater management standards 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 the City's ordinance.

The purpose of these technical documents is to provide additional guidance to developers, designers and City review staff in developing and reviewing designs for storm water 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 storm water management which are described in detail within the ISWMM, which 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 Ordinance 3819 – Non-stormwater Discharges to the Storm Drainage System
- City Ordinance 3875 – Construction Site Erosion and Sediment Control
- City Ordinance 4174 – Post Construction Stormwater Management
- The Iowa Stormwater Management Manual (ISWMM), as published by the Iowa Department of Natural Resources and as maintained by the Iowa Storm Water Education Partnership (ISWEP), including both the current edition as well as future modifications.
- Any local modifications to the ISWMM.
- Requirements of the City's Municipal Separate Storm Sewer System (MS4) Permit.
- Any other design standards, technical releases or other reports referenced by these documents.

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

Application

<u>City Post Construction Stormwater Management Ordinance Reference</u>: Section 5B.1 - (8)

The City's Post Construction Stormwater Management Ordinance are generally applicable to the following properties and/or development sites:

- Any new development or redevelopment disturbing more than one acre of land.
- Any new development or redevelopment creating more than 10,000 SF of impervious cover.
- New development includes any residential, commercial or industrial subdivision or individual site improvement requiring a site development plan.
- Exemptions:
    - Any agricultural activity.
    - Additions or modifications to an existing single family property.
    - Storm Water Management Design standards do not apply to any area within a 1,000 foot distance from any City of Ames drinking water well located in the Southeast Well Field and Youth Sports Complex Well Field. In these specific areas, developments will need to meet requirements for storm water quality-based treatment or a combination of quantity and quality based treatment as approved by both the Director of Public Works and the Director of Water and Pollution Control.

Smart Watershed Design Principles

Without proper management techniques, urban development increases the volume and flowrates of stormwater runoff through soil compaction by mass grading, removal of surface topsoil and creation of impervious surfaces. Efficient drainage systems like tiles, paved gutters and storm sewer pipe systems quickly convey those larger volumes to the receiving waters, shortening travel time which further increases the peak rates of flow. *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 impacts of urban development:*

- **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 envelope" 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 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. 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 both difficult and expensive to prevent erosion and re-establish desired vegetation on that landscape. Attempt to create layouts for the desired use which minimize the disturbed area as much as possible. 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 with reduce cuts and fills. Mass grading with heavy equipment compacts the soil to the extent that they can react 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 less 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 Best Management Practices (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 access for long-term maintenance.

- **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. Rainbarells, green roofs, permeable pavers, 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 leave runoff leaving a given 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 Smart Watershed Design Principles 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 installation of 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 Management Ordinance:

- Protect and safeguard the general health, safety and welfare of the public.
- Minimize increases in stormwater runoff from development within the City limits and within the two mile limit where the City has exercised subdivision authority fringe area in order to reduce flooding, siltation, increases in stream temperature and stream bank erosion to maintain the integrity of stream channels.
- Minimize the mass grading of sites to preserve natural features and drainageways as well as protection of open space and impervious cover minimization.
- Minimize increases in non-point source pollution caused by stormwater runoff from development which would otherwise degrade locally.
- Distribute and minimize runoff by utilizing vegetated areas for stormwater treatment. Encourage infiltration and soil storage of runoff through practices such as bioswales, soil quality improvement with compaction reduction and compost amendments, bioretention cells and raingardens.
- Plant vegetation that does not require irrigation beyond natural rainfall and runoff from the site.
- Mitigate stormwater 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 all BMPs are properly maintained and pose no threat to public safety.

Iowa Stormwater Management Manual Reference: Section 2A-1

Section 2A-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.

The following sections of the ISWMM offer more detailed preliminary design guidance that should be reviewed and considered as early in the site development process as possible:

Section 2A-2 – Planning and Design Principles
Section 2A-3 – Stormwater Regulations and Permitting
Section 2A-4 – Stormwater Management Criteria
Section 2A-5 – Project Drainage Report

Natural Resource Checklist

City Post Construction Stormwater Management Ordinance Reference: Section 5B.3 - (7f)

The stormwater management and maintenance plan 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 "Smart Watershed Design Principles".*

☐ Discussion of existing pre-development soil conditions	
	☐ Soil types and hydrologic soil groups (from Web Soil Survey for Story County or other source) *http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm*
	☐ Hydric soils
	☐ Soil conditions of areas for infiltration-based Best Management Practices (BMPs)
☐ Vegetative and forest cover	
☐ Topography	
☐ Wetlands	
	☐ From National Wetlands Inventory - or -
	☐ Current Wetlands Delineation / Determination Reports
☐ 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)
	☐ Waterways and/or dry channels with drainage areas of less than 50 acres
	☐ Waterways and/or dry channels with drainage areas of 50 acres or more
	☐ Intermittent streams
	☐ Perennial stream (1st and 2nd Order; refer to City of Ames Stream Designation Ref. Map)
	☐ Streams exceeding 3rd Order (refer to Stream Designation Ref. Map)
	☐ FEMA FIRM panel information

Stream Order and Buffer Requirements

<u>City Post Construction Stormwater Management Ordinance Reference</u>: Section 5B.3 - (7l)

Provisions shall be made for stream buffers. The area shall be defined within a recorded easement that includes a management plan. They shall be maintained with native vegetation along naturally occurring stream areas using the following requirements:

1. **Streams exceeding 3rd Order and above:**
   - Sketches, maps, studies, engineering reports, tests, profiles, cross-sections, construction plans and specifications shall be provided to the City as needed to determine adequate buffer widths. The buffer shall be wide enough to convey the 100-year flood event, or the event having a 1% chance or occurring in any given year.
   - Buffers shall include adequate width to provide paths or other means for maintenance access.
   - Historical meandering, streambank erosion or other signs of active stream movement should be considered when determining proper buffer width.
   - It is recommended that structures should be set outside of the footprint of past stream meanders with sufficient setback.
     - The setback distance should be such that a slope can be projected between the structure and the toe elevation of the adjacent stream (or past meander) of no steeper than 4:1 (horizontal : vertical).
     - Within this setback, it is also recommended to allow additional separation to provide a level path for access, with a minimum width of 15 feet and a cross-slope of no more than 4%.

2. **Perennial streams:**
   - The buffer width shall be 100 feet on <u>each</u> side perpendicular to the waterway measured from the outer wet edge of the channel during base flows. (Minimum total width of 200 feet plus the wetted width of the stream under base flow conditions)

3. **Intermittent streams:**
   - The buffer width shall be 50 feet on <u>each</u> side perpendicular to the waterway measured from the centerline of the channel during base flows. (Minimum total width of 100 feet)

4. **Waterways and/or dry channels:**
   - For streams having a drainage area of 50 acres or greater: the buffer width shall be 30 feet on <u>each</u> side perpendicular to the waterway measured from the centerline of the channel during base flows. (Minimum total width of 60 feet)
   - For streams having a drainage area of less than 50 acres: the buffer width shall be 20 feet on <u>each</u> side perpendicular to the waterway measured from the centerline of the channel during base flows. (Minimum total width of 40 feet)

The management plan for these buffers shall identify the types or maintenance activities required and the schedule for their proper implementation. The goal of the management plan is to provide for the full establishment of desired vegetation and provide for its long-term stability.

- ❖ *Without proper management, stream buffers can quickly become overgrown with volunteer trees and brush which can crowd out more desirable deep rooted native grasses and forbs. When this surface vegetation is lost, these areas are left prone to erosion. Overgrowth can also limit access for maintenance and hide developing streambank erosion issues from view.*

Soil Management Plan

Iowa Stormwater Management Manual Reference: Section 2E-5 (under development)

A soil management plan (SMP) shall be provided that includes a site map that identifies areas where soils and vegetation will not be disturbed and shows 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 that identifies the soil series and the site limitations based on soils data provided in the Web Soil Survey for Story 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 and percolation / infiltration rates. 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 or required.

Process for Developing Soil Management Plans (SMPs):

1. Determine existing site 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 Storm Water 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.

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 (i.e. sodding, seeding rates, etc.).

8. Incorporate SMP into site specific SWPPP (if one is required) to be implemented from initial disturbance to final stabilization. *(Soil Quality Restoration is considered a non-structural BMP)*

Methods of Soil Quality Restoration are described within ISWMM Section 2E-5. Re-establishing the ability of site soils to absorb runoff is one of the most effective practices in reducing site runoff.

- *For sites with grading or soil compaction involved for areas without SQR applied, adjustments to curve numbers and runoff coefficients will 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 grading, open space areas without SQR applied shall be considered as **50%** impervious surface for the purpose of calculating Water Quality Volume treatment requirements. Refer to guidance documents related to Small Storm Hydrology.*

Unified Sizing Criteria

<u>Iowa Stormwater Management Manual Reference</u>: Section 2B-1

Standards set by the City are intended to ensure compliance with the City's Post-Construction Ordinance. The Uniform 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 special exemption by City staff, stormwater calculations for all development sites should identify post-development conformance with the following design requirements:

1. **Capture and treat the <u>Water Quality Volume [WQv]</u>**, 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 managing 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.

2. **Provide extended detention of the 1-year, 24-hour storm event or <u>Channel Protection Volume [CPv]</u>** (with a drawdown time of 24- to 48-hours) to reduce rapid fluctuations of flows in urban stream corridors that lead to erosive velocities and unstable stream conditions. In Ames, the rainfall depth for such an event is 2.67 inches. Practices which address this criteria will capture this volume of runoff and slowly release it over a period of no less than 24 hours.

3. **Restrict post-development peak discharge rates for the 5-year, 24-hour storm event to pre-settlement levels or <u>Overbank Flood Protection [Qp]</u>** 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 based on a land use of meadow in good condition, Soil Group B – (NRCS CN=58 and pre-settlement travel times for stormwater flows). Adjustments to release rates to account for pass through flows from off-site areas will be made by determining runoff rates and volumes from those areas based on their existing conditions.

4. **Provide safe conveyance of larger, rare storm events (10- and 100-year; 24-hour storm events) <u>Extreme flood protection [Qf]</u>** to prevent damage to the stormwater management system, downstream infrastructure and adjacent properties. Employ detention controls and/or floodplain management as needed. Allowable release rates for such events will be based on a land use of meadow in good condition, Soil Group B – (NRCS CN=58 and pre-settlement travel times for stormwater flows). Adjustments to release rates to account for pass through flows from off-site areas will be made by determining runoff rates and volumes from those areas based on their existing conditions.

    - *Runoff from the extreme flood protection events shall be released 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.*

Rainfall and Runoff Analysis

Updated to NOAA atlas 14 rainfall Data January 2015 (Use NOAA Atlas Data provided in table).

<u>Preferred Design Assumptions</u>

Ames is located within Climate Section 05. as shown in Figure 1 of ISWMM Section 2C-2. Rainfall values used for stormwater design analysis should be taken from values from NOAA Atlas 14 rainfall Data. It is recommended to interpolate as needed to obtain rainfall amounts for storm durations which are not listed within this table.

- *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).*

Rainfall Intensities for Frequently Used Storm Durations

Duration	1-year	5-year	10-year	100-year
(minutes)	Intensity (inches/hour)			
5	4.78	6.91	8.1	12.4
10	3.51	5.08	5.92	9.15
15	2.84	4.12	4.82	7.44
20	2.56	3.72	4.35	6.72
25	2.33	3.39	3.97	6.14
30	1.99	2.91	3.40	5.27
35	1.87	2.74	3.21	4.98
40	1.76	2.57	3.01	4.70
45	1.64	2.40	2.82	4.41
50	1.52	2.23	2.62	4.12
55	1.41	2.06	2.43	3.84
60	1.29	1.89	2.23	3.55
90	1.04	1.53	1.81	2.89
120	0.79	1.16	1.38	2.23

Rainfall Depths for Frequently Used Storm Durations

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

Note: Data from 5-minute intervals is linearly interpolated from Table 2 values.

Addressing Small Storm Hydrology:

Note that as per Table 1 of ISWMM Section 2C-2, 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 best management practices (BMPs) that address these types of events, runoff from these storms will go largely unmanaged, leading to more frequent storm discharges and greater runoff volumes being released to urban stream corridors. Refer to the Small Storm Hydrology Section for more information.

Time of Concentration

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-3

<u>Preferred Design Assumptions</u>

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

- ❖ *Design calculations shall include a detailed explanation and evidence supporting any variation from these recommended methods or values.*

Pre-settlement analysis or existing conditions for areas of undeveloped agricultural lands:

To better reflect the retention of rainfall on large areas of undeveloped landscapes, use the NRCS lag method as described in **Section 2C-3E "Estimating time of concentration (NRCS lag method)" [Eq. 5 & 6]**.

- ❖ *Note that the value for "Y" in the equation given is <u>average</u> watershed land slope, <u>not slope along the stream length</u>. Slope data from county soil surveys or LIDAR topographic information can often be used to compute this value.*

- ❖ *<u>Be aware of the limitations of this method as listed in note 2d of ISWMM Section 2C-3.</u>*

Existing and proposed conditions near or within urbanized areas:

Use Manning's kinematic solution method as described in Section 2C-3D [Equation 3].

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.

- ❖ *<u>Sheet flow should never be measured past the point where contours indicate flow will begin to funnel to a common path</u>. Follow the following guidelines for sheet flow calculation:*

  - **Flow Length (<u>maximum</u> values – stop at point of concentration for each sub-area)**

    - **Pre-development 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 Table 1 (ISWMM Section 2C-3).

  - ❖ *<u>Note that these values for "n" are different than those to be used for Manning's equation used for open channel flow.</u>*

Surface Description	n
Pavement	0.011
Cultivated agriculture	0.17
Prairie grasses	0.15
Turf grass lawns	0.24
Woods	0.40

  - **P_2.** The 2-year, 24-hour rainfall event for Ames, Iowa is 3.08 inches.

- **Shallow concentrated flow.** Use the following equation to calculate flow velocity (from FHWA Hydraulic Engineering Circular No.22, Third Edition, September 2009):

$$V = K_u * k * \sqrt{S_p} \qquad \text{(From equation 3-4, page 3-9 of HEC-22)}$$

Where K_u = 3.28 (for English units)
V = Velocity (ft/s)
K = Intercept coefficient (from Table)
S_p = 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 -- Equation 4 (ISWMM Section 2C-3, page 6) based on channel cross-section properties and surface conditions.

    - Refer to Table 2 for values of "n" for this equation (ISWMM Section 2C-3, page 12).

    - Include with submitted calculations 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.*

❖ *Caution: Improper calculation of time of concentration can dramatically affect calculated peak flow rates, especially when the Rational Method is being used. To a lesser extent, it will affect the shape and peak of hydrographs developed using the NRCS TR-20 or TR-55 methods.*

Rational Method

Iowa Stormwater Management Manual Reference: Section 2C-4

Preferred Design Assumptions

- ❖ *The rational method is not to be used for detention storage and routing design for projects within the City of Ames. 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 storm water 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, provided the conditions of ISWMM Section 2C-4B and 4C are met. Be aware of all limitations of the method listed in ISWMM Section 2C-4C 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 in large hard surface areas.** When impervious surfaces are concentrated in a portion of the subarea nearest the outlet, it should be checked if ignoring the more distant open space (reduced area, but reduced Tc) may result in calculating a larger peak flow than would occur if the entire area (including the more distant open space) is considered.

Runoff Coefficient Selection:

Select appropriate values from Table 2B-4.01 of SUDAS Section 2B-4, 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 developed has occurred without mass grading activities.

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

- **Selection for Urban Land Uses.** In new development areas where proportions of hard surfaces can be determined, calculate runoff coefficient "C" by weighted average using lawn values (see below) for open spaces and appropriate value for type of hard surface. 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 (fair, w/ SQR)	0.10	0.25	0.45	0.60
impervious	0.95	0.95	0.95	0.95
example - 40% imp. w/o SQR	0.53	0.65	0.77	0.80
example - 40% imp. w/ SQR	0.44	0.53	0.65	0.74

Rainfall Intensity:

Use appropriate values from "Rainfall and Runoff Analysis" section for calculated time of concentration.

NRCS TR-55 Methodology

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-5

<u>Preferred Design Assumptions</u>

TR-55 is the required design method for projects involving storm water management and detention basin routing within the City of Ames. The TR-20 program is also acceptable, (being the basis for calculations for TR-55) but includes additional calculation features for stream and basin routing, and allows for a larger number of subwatersheds to be analyzed.

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 2, 3 and 4 of Section 2C-5 as advised below.

- ❖ *For smaller events (the Water Quality event and the Channel Protection 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 Guidance Document for required adjustments to curve numbers for smaller, more frequent events.*

- **Pre-settlement Condition Analysis.** Use Soil Group B, Meadow in good condition for analysis (CN=58).

- **Existing and Developed 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.
  - For developed areas where grading or soil compaction has occurred or is planned, consider open space in such area as being in <u>poor condition</u> unless methods of Soil Quality Restoration have been specified and are to be field verified after construction (or was verified for past development).

- **Agricultural Development.**
  - Use good conditions for analysis, unless clear reasons for using fair or poor conditions can be documented.
  - ❖ *Off-site analysis for determining conveyance of flows through a site and detention release rate requirements:*
    - *When reviewing off-site agricultural areas to determine flows to be 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 not to under-estimate CN while designing for proper conveyance of said flows either through or around the site work area.*
    - *For row crops and seed grains, use curve numbers no larger than those for contoured land w/ crop residue (C+CR) in good condition, unless clear reasons for using other conditions can be documented.*

NRCS TR-55 Methodology (Continued)

- **Urbanized Areas.**

  - In development areas where proportions of hard surfaces can be determined, calculate CN by weighted average using “Open Space in <u>fair</u> condition” for open spaces and “Paved parking lots, roofs and driveways” (CN=98) for hard surface areas. (See chart below).

  ❖ *<u>Again note:</u> 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 Soil Quality Restoration have been specified and is to be field verified after construction (or was verified for past development).*

Weighed Curve Numbers by Percent Impervious Area for Urbanized Areas
For Areas <u>WITHOUT</u> 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

<u>Note</u>: Use these values for storm events of a 2-year recurrence or greater.

Weighed Curve Numbers by Percent Impervious Area for Urbanized Areas
For Areas <u>WITH</u> SQR or 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

<u>Note</u>: Use these values for storm events of a 2-year recurrence or greater.

Small Storm Hydrology

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-6

<u>Preferred Design Assumptions</u>

Management practices that address runoff from smaller storms will either capture and infiltrate (or filter) runoff from such events, 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.

Water Quality Volume: For Central Iowa, 90% of rainfall events are smaller than or equal to 1.25" in rainfall depth. The chart below contains values for the Water Quality Volume (WQv – volume to be captured and treated by selected BMPs to remove 80% of the annual total suspended solids (TSS) load) and adjusted NRCS Curve Numbers (CN) adapted from Equations 1, 2 and 3 of Section 2C-6.

1. Multiply WQv value from the table by total development site area (or subarea) to determine site WQv requirements. *On sites with grading or soil compaction grading, open space areas <u>without SQR applied shall be considered as 50% impervious surface</u> for the purpose of calculating Water Quality Volume treatment requirements. Refer to guidance documents related to Small Storm Hydrology.*

2. 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

<u>Percent Impervious Area</u>	**<u>Rv</u>**	**<u>WQv (per acre)</u>** (CF)	**<u>Adjusted CN 1.25" event</u>**	**<u>Adjusted CN 1-year event</u>** (minimum*)
0%	--	--	73	59
5%	0.095	431	77	64
10%	0.140	635	80	68
15%	0.185	839	82	72
20%	0.230	1044	85	74
25%	0.275	1248	86	77
30%	0.320	1452	88	79
35%	0.365	1656	89	81
40%	0.410	1860	90	83
45%	0.455	2065	92	85
50%	0.500	2269	93	87
55%	0.545	2473	93	88
60%	0.590	2677	94	90
65%	0.635	2881	95	91
70%	0.680	3086	96	92
75%	0.725	3290	97	94
80%	0.770	3494	97	95
85%	0.815	3698	98	96
90%	0.860	3902	98	97
95%	0.905	4106	99	98
100 %	0.950	4311	99	99

- *Values are calculated from Equations 1, 2 and 3 of ISWMM Section 2C-6.*

- *<u>*Note:</u> Values for adjusted Curve Number for the 1-year event are the minimum values to be used when using TR-20 or TR-55 to model runoff from this event. Use values for CN from the table on page 15 when they exceed the values in this table, based on impervious area and soil group.*

Small Storm Hydrology (Continued)

Channel Protection Volume: The procedure listed in ISWMM Section 2C-6C is used to determine the initial estimate of the Channel Protection Volume (CPv) or 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:

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

2. The 1-year, 24-hour storm depth in Ames, Iowa is 2.67 inches.

3. When reviewing the output from a TR-55 (or TR-20) analysis, know the following:

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

      Q_a = Runoff Volume (cf) x 12 (in/ft) / [43,560 (sf / ac) x Watershed Area (ac)]

   b. The unit peak discharge can be calculated as below:

      q_u = Peak discharge (cfs) / [Watershed Area (sq. mi) x Qa (inches)]

4. Draw a line up from q_u in Figure 1, then over to the left to find the ratio (qo / qi).

5. Solve for the peak release rate from the extended detention basin during a 1-year event. For this equation, q_i is the Peak discharge from the TR-55 model output (in cfs). $\boldsymbol{q_o = (q_o / q_i) \times q_i}$

   - ❖ *An alternate method to demonstrate extended detention compliance would be to show graphically that no more than one-half of the Channel Protection Volume (Runoff Volume in cubic feet from Step 3) is released during the first one-third of the drawdown period (i.e. for a 24-hour drawdown, no more than one-half the runoff volume from the 1-year event would be allowed to be released within eight hours after the high water elevation has been reached for that storm).*

6. Solve for the estimated ratio of extended detention storage required compared to the runoff volume from the study area during the storm event.

7. 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.

8. When a preliminary site design has been developed that accommodates the storage above, solve for the preliminary size of the control outlet. Note that q_o comes from Step 5, and h_o depends on the design of the basin and the depth of storage required to achieve the required extended detention volume.

9. 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).

10. Use preliminary basin design to develop stage-storage-discharge relationships for flow routing. Then perform an actual reservoir routing calculation (see ISWMM Section 2C-10) to verify that the initial design means the release peak rate requirements (from step 5) and an extended drawdown of the basin can be observed (minimum 24-hour drawdown; full drawdown of CPv within 72 hours is recommended).

Runoff Hydrograph Determination

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-7

<u>Introduction</u>

Given the variety of available software packages capable of performing calculations consistent with TR-55 methodology, it is assumed that designers will rarely use techniques to manually 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 storm water drainage reports:

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

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

3. **Details of calculations of time of concentration**, consistent with preferred design assumptions.

4. **Details of selected curve numbers**, as the basis of their selection consistent with preferred design assumptions.

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

6. For hydrograph routing through a detention basin, pond or outlet structure, refer to ISWMM Sections 2C-10 and 2C-12.

Storm Sewer System Design

Iowa Statewide Urban Design and Specifications – 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 can be used as 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.
  - Provide calculations used to determine 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 meet the requirements of this section.
  - Provide any calculations used to determine MPEs in the immediate area.
- **Section 2F.** Open Channel Flow.
  - 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.

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 be used to 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.

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

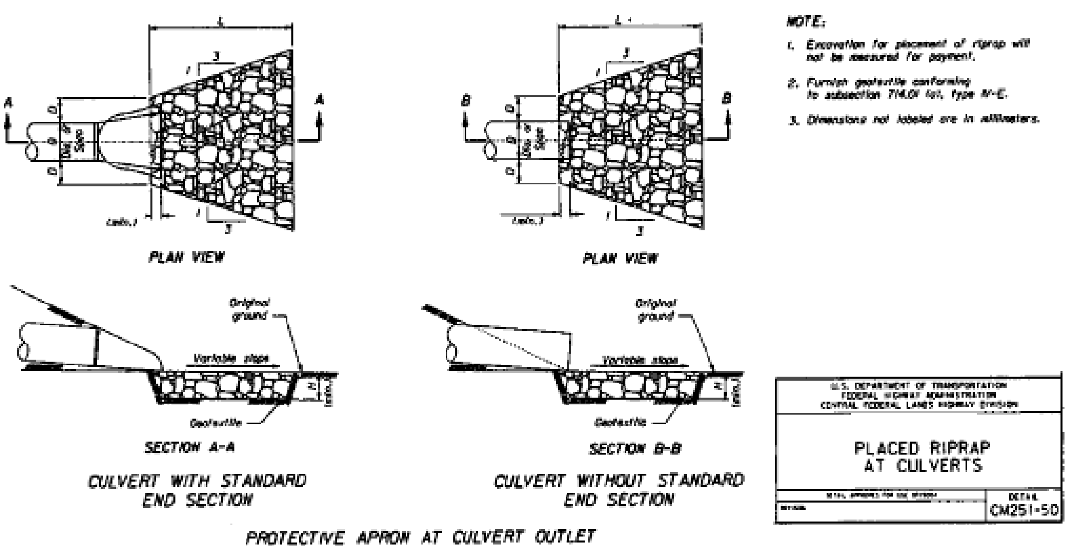
Where			
	D50	=	median revetment stone size (ft)
	Q	=	design discharge (cfs)
	D	=	culvert diameter, circular (ft)
	TW	=	tailwater depth (ft)
	g	=	gravitational acceleration constant (32.2 ft/s^2)

- The revetment size calculated in the equation above can be used to select the "CLASS" of the revetment outfall apron, used to determine the length and depth of the installation.

Class	D_{50} (inches)	Apron Length	Apron Depth
1	5	4D	$3.5D_{50}$
2	6	4D	$3.3D_{50}$
3	10	5D	$2.4D_{50}$
4	14	6D	$2.2D_{50}$
5	20	7D	$2.0D_{50}$
6	22	8D	$2.0D_{50}$

Note: D is the culvert rise, in inches.

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



Detention Storage Design

Iowa Stormwater Management Manual Reference: Section 2C-9

Introduction

This supplement is intended to provide guidance related to Section 2C-9, to achieve better designed, constructed and maintained management practices related to storm water detention.

Discouraged Design Practices

The following design practices reduce the ability of stormwater detention systems to address runoff quality and quantity from small storm events. Storm water management practices should be designed to avoid these types of practices:

1. **Passive detention systems.** These systems direct captured runoff through a storm sewer network to the outlet from the site. At that point, a restriction is placed, such as an orifice plate, which causes water to surcharge and back up out of an intake into a surface depression for temporary storage during large storm events. This design method allows runoff from smaller storm events to leave the site directly, without the opportunity to remove suspended pollutants and debris.

2. **Low flow flumes and directly connected impervious areas.** These systems prevent infiltration of storm water runoff and reduce or eliminate the possibility of providing water quality treatment or small storm management. Virtually any storm event will direct surface runoff from paved areas to the receiving storm sewer system or stream.

3. **Flow path shortcutting.** When runoff enters a basin or treatment practices at nearly the same point where it outlets from the practice, the opportunity for absorption, infiltration or treatment of storm water runoff is severely reduced. For this reason, it is recommended that storm water runoff enter a basin or other treatment practice as far from the outlet as possible. Pipe outlets, flumes or other points of concentrated stormwater flows should enter a treatment practice or basin at a distance from the outlet of no less than twice the width of the practice (a pipe entering a 15' wide bioretention cell should be located no closer than 30' from the point where water would leave the treatment area).

Approved Detention Storage Design Methods

Of the alternatives listed in ISWMM Section 2C-9, only the NRCS TR-55 Method is approved for storm water detention design within the City of Ames. The formula listed in Table 1 of ISWMM Section 2C-9 should only be used to obtain a preliminary estimate of required storage. Final storage volume requirements should be based on stage-storage routing of developed hydrographs through a proposed basin and outlet design.

Note: LID methodology (as described in ISWMM Section 2C-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

The allowable release rate for a given site for the 5-year through 100-year events [Overbank and Extreme Flood Protection] shall be determined by developing a hydrograph which represents the combination of upstream off-site areas which will flow through a given practice based on their existing condition (for both CN selection and Tc calculation) and on-site areas based on a pre-settlement condition (<CN=58> with pre-settlement Tc calculation).

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.

Channel and Storage (Reservoir) Routing

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-10

<u>Introduction</u>

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 techniques to manually perform these calculations as described within this section. The designer should be familiar with the basis of such calculations, and the following information should be clearly indicated in storm water 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 hydrograph routing is required for the 1-, 5-, 10-, and 100-year events to verify that after development, a given site does not violate peak release rate restriction requirements for these storms.

- ❖ *Additional routing of the WQv event may be required if selected practices intended to meet the Water Quality Volume requirements for a given area have inadequate capacity to capture and infiltrate the required volume and therefore use extended detention (slow release through a surface inlet) to allow settling of suspended pollutants and treatment to occur.*

1. **Inflow hydrograph** (numeric or graphic) through the duration of the storm event. Maximum time steps of 0.1 hour or 6-minutes (2-minutes preferred).

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, 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 calculation output from used software package.

4. **Energy loss coefficients** for weir and orifice conditions.

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, time of occurrence in relation to the rainfall event. For analyses involving the design events identified in this report provide a numeric or graphic 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 small storms. (minimum 24-hour drawdown after storm event)

8. **Identify maximum storage volume and water surface elevation for each event reviewed.**

Inlet Sediment Forebays

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-11

<u>Introduction</u>

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 where heavier sediments and debris can be captured before they enter the BMP itself.

These should be located in areas where they can be accessed for maintenance and sediment (and 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 that can accommodate expected maintenance equipment (trucks, small excavators, etc.). In some cases this may require a hard surface access path.

4. **A hardened bottom surface** 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, which ever occurs first.

Detention Basin Outlet Structures

<u>Iowa Stormwater Management Manual Reference</u>: Section 2C-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 calculation output from used software package. Methods to calculate release rates through a variety of types of storm outlets are included in ISWMM Section 2C-12.

- *<u>Note:</u> 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.).*

Storm Water Summary Data Sheet

Project Name: ______________________________

Location: ______________________________

Site Sub-watershed: ______________________________

Date: ______________________________

Tributary Stream: ______________________________

(provide a separate summary sheet for each watershed or basin)

Watershed Characteristic Summary

	Off-site area within watershed			**Site development area within watershed**		
	Pre-settlement	Existing	Developed	Pre-settlement	Existing	Developed
Size (acres)						
Impervious area (acres)						
Impervious area (%)						
Time of concentration (Tc)						
NRCS Curve Number (CN)	58			58		
Runoff Peak Rate (cfs)						
1-year (CPv)						
5-year						
10-year						
100-year						

Detention Basin Summary

	Required	**Provided**
Water Quality Volume Treated (list for each BMP, if multiple used)		
CPv Release Rate		
CPv Storage Provided		
CPv Water Surface Elevation		
5-year Release Rate		
5-year Storage Provided		
5-year Water Surface Elevation		
10-year Release Rate		
10-year Storage Provided		
10-year Water Surface Elevation		
100-year Release Rate		
100-year Storage Provided		
100-year Water Surface Elevation		

Project Drainage Report
Checklist
SITE NAME

Site Plan Preparer:
DESIGNER

City Received: DATE
Reviewed: DATE
Page 1/2

No.	Item	Ordinance Section	ISWMM Section	Y	N	NA	OK?	Comments
	Report or Narrative Information							
1.)	Cover sheet with project name, location and name of firm preparing calculations.		2A-5C					
2.)	Contact information for owner and developer.	5B.3(7d)						
3.)	Signed and sealed certification by PE or LA.	5B.3(7a,c)						
4.)	Table of Contents.							
5.)	City of Ames Data Summary Sheet.							
6.)	Brief narrative section summarizing the results of calculations included in the appendix.		2A-5C					
7.)	Summary of pre-settlement conditions and runoff analysis.	5B.3(7g)	2A-5C.1.e					
8.)	Summary of existing conditions and runoff analysis.	5B.3(7g)	2A-5C.1.e					
9.)	Summary of contributing off-site drainage and runoff analysis.	5B.3(7g,t)	2A-5C.1.c					
10.)	Summary of items identified within the natural resource inventory checklist.	5B.3(7f)	2A-5C.1.d					
11.)	Summary of post-development conditions and runoff analysis.	5B.3(7g,h,u)	2A-5C.2					
12.)	Description of BMPs and/or LID practices to be employed.	5B.3(7b,j)						
13.)	Description of storm water management design features.	5B.3(7b)	2A-5C.4					
14.)	Description of provided stream buffers.	5B.3(7l)						
15.)	Description of detention outlet structure design.		2A-5C.4					
16.)	Summary of any permits required.		2A-5C.5					
17.)	Summary of references used.		2A-5C.6					

No.	Item	Ordinance Section	ISWMM Section	Y	N	NA	OK?	Comments
	Calculations (in Appendix)							
18.)	Calculations of impervious area (by area and by %)	5B.3(7s)						
19.)	Curve number or runoff coefficient calculations for sub-areas and site total.	5B.3(7s)	2C-4, 5					
20.)	Time of concentration calculations (pre-settlement, existing and developed for each area as applicable).	5B.3(7s)	2C-3					
21.)	Runoff hydrograph determination information.	5B.3(7g)	2C-5, 6					
22.)	Calculations for WQv (based on the watershed sub-area for the BMP used for treatment).	5B.3(7g)	2C-6					
23.)	Calculations for CPv for each extended detention practice.	5B.3(7g)	2C-6					
24.)	Calculations for storm sewer, intake and culvert design (for site plans or construction drawings).	5B.3(7s)	SUDAS Chapter 2					
25.)	Calculations for design of open channels.	5B.3(7s)	SUDAS Chapter 2					
26.)	Detention basin routing calculations for the Qp and Qf events. Detail control structures, stage-storage relationships, high water elevations and maximum storage.	5B.3(7g)	2C-10, 12					
27.)	Calculations to determine allowable release rates from detention basins.	5B.3(7g)	2C-10					
28.)	Calculations for MPEs.	5B.3(7r)						
	Other Attachments or Required Information							
29.)	Topographic base watershed map.	5B.3(2)						
30.)	Drawings (as needed).		2A-5C.7.a					
31.)	Soil Management Plan	5B.3(7k)	2E-5					
32.)	SWPPP and COSESCO application.	5B.3(7q)						
33.)	Maintenance, repair and landscaping plan for storm water features and BMPs.	5B.3(7m)						
34.)	Easements for maintenance and drainage.	5B.3(7n,o)						
35.)	Maintenance agreements.	5B.3(7p)						

Elevation Certificate

PART A: To be completed and provided with Building Permit Application
(APPLICANT SHOULD RETAIN A COPY TO SUBMIT WHEN APPLYING FOR CERTIFICATE OF OCCUPANCY)

The applicant shall certify that they are aware that a Minimum Protection Elevation (MPE) has been established for the property in question and what that elevation has been determined to be:

Property Address:	
Legal Description:	
MPE (feet and datum):	Source of MPE information: ☐ Subdivision Plat ☐ FEMA FIRM Map Panel ____________ ☐ Other ____________
Applicant (print name and company, as applies):	
Signature:	Date:

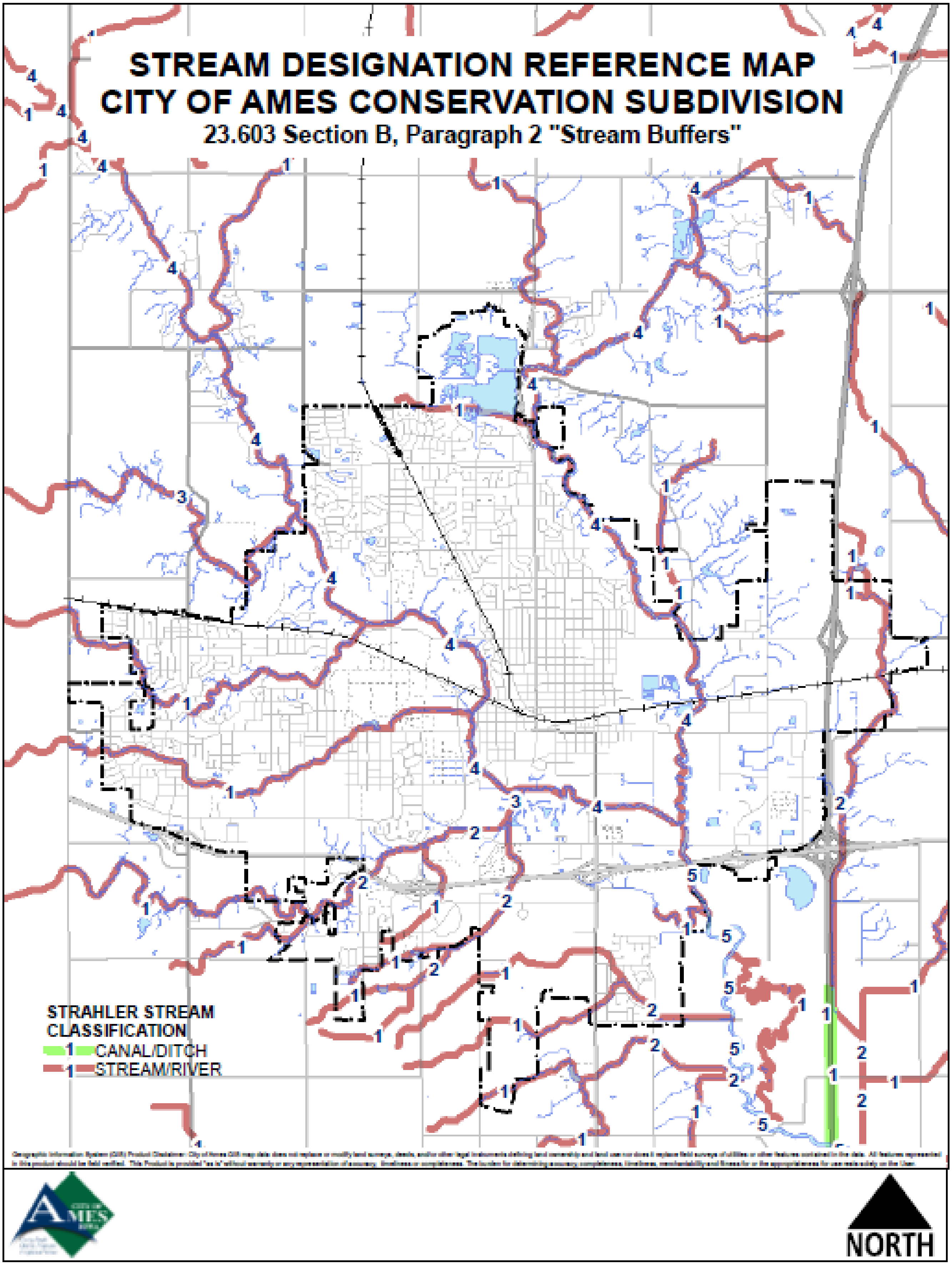
PART B: To be completed and certified prior to Certificate of Occupancy

The applicant shall have a professional land surveyor, engineer or architect certify that the lowest protected level (lowest opening or protective flood barrier that achieves the same result) complies with requirements acknowledged by the applicant at the building permit application stage.

For the property listed above, the lowest protected elevation has been verified to be: __________ feet.	
The following method of flood protection has been employed: ☐ Lowest floor opening (walkout) ☐ Window well (water resistant) ☐ Other ____________	 ☐ Lowest floor foundation wall opening ☐ Earthen Berm (grade)
Signature (Professional Land Surveyor, Engineer or Architect):	Date:

A building permit may be issued with the condition that the lowest protected level (lowest opening or protective flood barrier that achieves the same result) will be protected to a minimum of three (3) feet above the one-hundred (100) year water surface elevation within the adjacent swale, stream or stormwater management best management practice (BMP).

See section 5B.3(7)(r) of the City of Ames Post Construction Stormwater Ordinance.


STREAM DESIGNATION REFERENCE MAP
CITY OF AMES CONSERVATION SUBDIVISION
23.603 Section B, Paragraph 2 "Stream Buffers"
STRAHLER STREAM CLASSIFICATION
1 CANAL/DITCH
1 STREAM/RIVER
NORTH