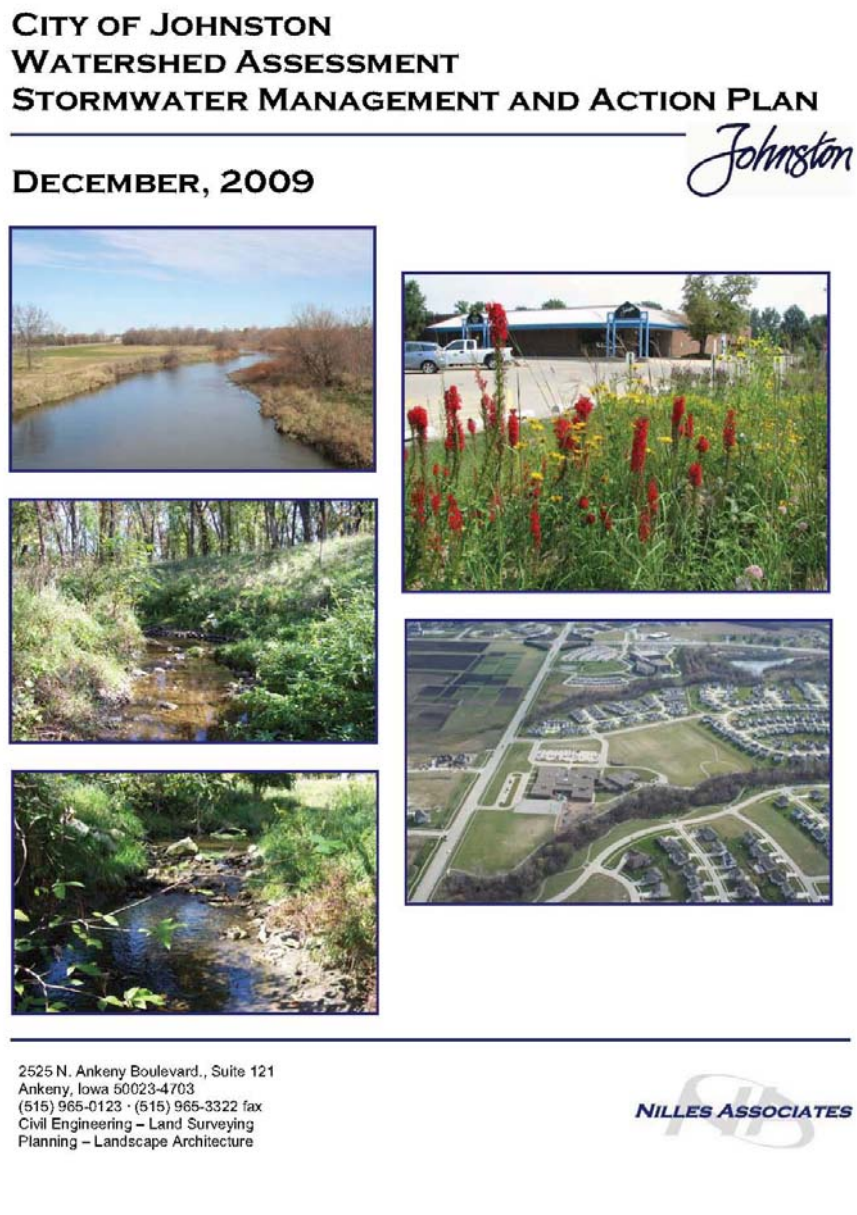
City of Johnston, Iowa

Technical Guidance Documents for stormwater calculations and stormwater management.

Goals include: improvement in water quality and reduction in water quantity leaving the site.

Source:
pages 121 – 134,
and 137



CITY OF JOHNSTON
WATERSHED ASSESSMENT
STORMWATER MANAGEMENT AND ACTION PLAN

DECEMBER, 2009

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General Information

Iowa Stormwater Management Manual Reference: Section 2A-1

These technical guidance documents are intended to work with the Iowa Stormwater Management Manual (ISWMM) to help developers, designers, City staff and officials to understand how the requirements within the Manual relate to achieving the City's overall stormwater management goals. It is recommended that all individuals that play a role in the development or review of site development plans within the City become familiar with these guidance documents and the ISWMM.

Section 2A-1 covers broad topics related to the design of management facilities to address both stormwater quality and quantity. Many of these issues are also addressed within the City's Watershed Assessment and Stormwater Management Plan.

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

Project Drainage Report

Iowa Stormwater Management Manual Reference: Section 2A-5

To provide a through and efficient review of the management program for a given development site, a project drainage report shall be presented at the time of initial submittal and shall identify all of the following items:

- ☐ Cover sheet with project name, location and name of firm preparing calculations
- ☐ Professional Engineer's signed and sealed certification
- ☐ Table of Contents (clearly identify individual elements of included calculations)
- ☐ City of Johnston Summary Data Sheet (included on next page)
- ☐ Brief Narrative Sections that Refer to Location of Included Calculations (Refer to Section 2A-5C)
  - ☐ Pre-settlement conditions and runoff analysis (meadow in good condition:CN=58 and pre-settlement Tc) [similar elements to Section 2A-5C.1.e]
  - ☐ Existing conditions and runoff analysis (current land uses) [similar to C.1.e]
  - ☐ Contributing off-site drainage [C.1.c]
  - ☐ Floodways, floodplains and wetlands [C.1.d]
  - ☐ Post-development conditions and runoff analysis [similar to C.2]
  - ☐ Stormwater Conveyance Design [C.3]
  - ☐ Stormwater Management Design [C.4] (include Small Storm Management BMP design)
  - ☐ Permits [C.5]
  - ☐ References [C.6]
- ☐ Appendix [C.7] (Clearly identify each subcategory in the table of contents)
  - ☐ Drawings [C.7.a]
  - ☐ Impervious area (in SF and % of area) for each sub-area and site total
  - ☐ Curve number (runoff coefficient) calculations for sub-areas and site total
  - ☐ Time of concentration calculations (pre-settlement, existing and developed for each sub-area and site total)
  - ☐ Runoff Hydrograph Determination Information (see tech guidance for Section 2C-7)
  - ☐ Calculations for WQv (based on the watershed sub-area of the BMP used for treatment)
  - ☐ Calculations for CPv
  - ☐ Calculations for storm sewer, intake and culvert design
  - ☐ Peak discharge calculations (see Section 2B-1 for requirements)
  - ☐ Detention basin design (see tech guidance for Section 2C-10)

For each development site complete the attached Summary Data Sheet
Attach a separate Summary Data Sheet for each stormwater detention area

Storm Water Summary Data Sheet

Project Name: ______________________________

Location: ______________________________

Site Sub-watershed: ______________________________

Date: ______________________________

City of Johnston Watershed Designation: ______________________________

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						
2-year						
5-year						
10-year						
25-year						
50-year						
100-year						

Detention Basin Summary

	Required	**Provided**
Water Quality Volume Storage		
CPv Release Rate		
CPv Storage Provided		
CPv 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		

Unified Sizing Criteria

Iowa Stormwater Management Manual Reference: Section 2B-1

Introduction

The sections that follow describe in more detail, the methods of performing stormwater design calculations in conformance with the Iowa Stormwater Management Manual, and special design requirements as per the City of Johnston.

Standards set by the City are intended to address the issues related to stormwater runoff quality and quantity that have been identified as part of the City of Johnston Watershed Assessment and Stormwater Management Plan. 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 Water Quality Volume [WQv]**, 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 Section).

2. **Provide extended detention of the 1-year, 24-hour storm event [Channel Protection Volume – CPv]** (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 streambanks.

3. **Restrict post-development peak discharge rates for the 5- and 10-year, 24-hour storm events to pre-settlement levels [Overbank Flood Protection – Qp]** (based on a land use of meadow in good condition – NRCS CN=58 and pre-settlement travel times for stormwater flows)..

4. **Provide safe conveyance of larger, rare storm events (25-, 50- and 100-year; 24-hour storm events) [Extreme flood protection – Qf] to planned or constructed downstream regional detention facilities or urban stream corridors.** These 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 easements, rights-of-way, etc.) to convey these developed storm flows to the receiving facility or stream corridor without significant risk to public or private property. If this cannot be demonstrated, additional stormwater detention may be required.

Rainfall and Runoff Analysis

Iowa Stormwater Management Manual Reference: Section 2C-2

Preferred Design Assumptions

Johnston is located within Climate Section 05, as shown in Figure 1 or Section 2C-2. Rainfall values used for stormwater design analysis should be taken from values from this section listed in Table 2 of this section.

Addressing Small Storm Hydrology:

Note that as per Table 1 of 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.

Rainfall Depths, Intensities for Frequently Used Storm Durations

Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
(minutes)	Intensity (inches/hour)						
5	3.48	4.20	5.28	6.12	7.44	8.40	9.48
10	3.00	3.66	4.56	5.40	6.48	7.38	8.34
15	2.56	3.16	3.92	4.60	5.56	6.32	7.12
20	2.29	2.83	3.51	4.12	4.98	5.66	6.38
25	2.03	2.49	3.11	3.64	4.40	5.00	5.64
30	1.76	2.16	2.70	3.16	3.82	4.34	4.90
35	1.65	2.03	2.54	2.97	3.59	4.08	4.60
40	1.55	1.90	2.37	2.78	3.35	3.81	4.30
45	1.44	1.77	2.21	2.59	3.12	3.55	4.01
50	1.33	1.63	2.04	2.39	2.89	3.29	3.71
55	1.23	1.50	1.88	2.20	2.65	3.02	3.41
60	1.12	1.37	1.71	2.01	2.42	2.76	3.11
90	0.91	1.11	1.38	1.63	1.96	2.23	2.51
120	0.69	0.85	1.06	1.24	1.50	1.70	1.92

Duration	1-year	2-year	5-year	10-year	25-year	50-year	100-year
(hours)	Rainfall depth (inches)						
1	1.12	1.37	1.71	2.01	2.42	2.76	3.11
6	1.79	2.18	2.73	3.20	3.86	4.40	4.96
24	2.38	2.91	3.64	4.27	5.15	5.87	6.61

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

Time of Concentration

Iowa Stormwater Management Manual Reference: Section 2C-3

Preferred Design Assumptions

The following values are recommended for use in completing calculations for time of concentration within the City of Johnston. Provided design calculations shall provide a detailed explanation and evidence supporting any variation from these recommended values:

Existing conditions for large areas of undeveloped agricultural lands or pre-settlement analysis:

To better quantify the effect of 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)" [Equations 5 and 6]**. 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 can often be used to compute this value.

Be aware of the limitations of this method as listed in note 2d of this section.

Existing and proposed conditions near or within urbanized areas:

Use the NRCS velocity method as described in Section 2C-3D. 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. It 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 at point of concentration)**
        - o **Pre-development conditions:** No greater than 100 feet total.
        - o **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 selected values below from Table 1.

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 Johnston, Iowa is 2.91".

- **Shallow concentrated flow.** Use the following equations to calculate flow velocity:

    Unpaved areas: $V = 16.1345 * \sqrt{(S)}$
    Paved areas: $V = 20.3282 * \sqrt{(S)}$

- **Channel flow.** Use Equation 4 based on channel cross-section properties and surface conditions.

    Refer to Table 2 for values of "n" for this equation.
    Include with submitted calculations details on the assumed cross-section and surface conditions used to select value of "n".

Rational Method

Iowa Stormwater Management Manual Reference: Section 2C-4

Preferred Design Assumptions

The rational method is not the preferred calculation method for developing storm water design flows within the City of Johnston. In 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. Design flow information generated from these calculations can best be applied to smaller sub-watersheds within the development area, based on weighted proportion (by product of area and curve number) of the sub-area as compared to the larger watershed review area.

In projects that flow routing is not required, the rational method may be used to generate peak flow runoff values for storm sewer design, provided the conditions of Section 2C-4B and 4C are met. 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 160 acres.

- **Take caution in selecting Tc in large hard surface areas.** Runoff from a portion of the drainage area that is highly impervious may result in a larger peak discharge than would occur if the entire area is considered. It may be necessary to ignore contributions from large open spaces that would extend Tc and actually lower the calculated values for peak flow rate.

- **Be aware of all limitations of the method listed in Section 2C-4C and determine if any apply.**

Runoff Coefficient Selection:

Select appropriate values from Table 1 of Section 2C-4, with the following provisions:

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

Unless influenced otherwise by county soils data, use Group B for undeveloped areas and areas where developed has occurred without mass grading activities.

Use Group C for developed areas where mass grading has occurred, unless methods to decompact surface soils after construction are specified.

- **Land Use Selection.** In new development areas where proportions of hard surfaces can be determined, calculate "C" by weighted average using lawn values (75% or more grass) for open spaces and appropriate value for type of hard surface. Use value for appropriate soil group.

Runoff Coefficients "C" for 5-year storm events

Percent Impervious Area	Soil Group B	Soil Group C
20%	0.29	0.37
40%	0.43	0.49
60%	0.57	0.61
80%	0.71	0.73

Rainfall Intensity:

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

NRCS TR-55 Methodology

Iowa Stormwater Management Manual Reference: Section 2C-5

Preferred Design Assumptions

TR-55 is the required design method for projects involving storm water management and detention basin routing within the City of Johnston. 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.

Curve Number (CN): For storms of a 2-year recurrence interval and larger, use Curve Numbers selected from Tables 2, 3 and 4 of Section 2C-5. (Refer to Small Storm Hydrology Section 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 Analysis.** Select by appropriate cover type. Use appropriate soil group, as per county soil survey data. Unless influenced otherwise by county soils data, use Group B for undeveloped areas and areas where developed has occurred without mass grading activities. Use Group C for developed areas where mass grading has occurred, unless methods to decompact surface soils after construction are specified.

    - **Agricultural Development.** Select by appropriate cover type. Use good conditions for analysis, unless clear reasons for using fair or poor conditions can be documented.
        - **Off-site detention and conveyance analysis:** 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.

    - **Urbanized Areas.** Select by appropriate cover type. In development areas where proportions of hard surfaces can be determined, calculate CN by weighted average 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

Percent Impervious Area	Soil Group B	Soil Group C
0 %	61	74
10 %	65	76
20%	68	79
30%	72	81
40%	76	84
50%	80	86
60%	83	88
70%	87	91
80%	91	93
90%	94	96
100 %	98	98

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

Small Storm Hydrology

Iowa Stormwater Management Manual Reference: Section 2C-6

Preferred Design Assumptions

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 24 to 48 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.

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

Percent Impervious Area	Rv	WQv (per acre) (CF)	Adjusted CN 1.25” event	Adjusted CN 1-year event
0%	--	--	73	59
10%	0.140	635	80	68
20%	0.230	1044	85	74
30%	0.320	1452	88	79
40%	0.410	1860	90	83
50%	0.500	2269	93	87
60%	0.590	2677	94	90
70%	0.680	3086	96	92
80%	0.770	3494	97	95
90%	0.860	3902	98	97
100 %	0.950	4311	99	99

Channel Protection Volume: The procedure listed in 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 based on previous sections.

2. The 1-year, 24-hour storm depth in Johnston, Iowa is 2.91 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).

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 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 (24- to 48-hour drawdown).

Runoff Hydrograph Determination

Iowa Stormwater Management Manual Reference: Section 2C-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 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-, 2-, 5-, 10-, 25-, 50- and 100-year events) consistent with prescribed values for Johnston, 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 Section 2C-10.

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 the 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 Section 2C-9, only the NRCS TR-55 Method is approved for storm water detention design within the City of Johnston. The formula listed in Table 1 of 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 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.

Channel and Storage (Reservoir) Routing

Iowa Stormwater Management Manual Reference: Section 2C-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 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-, 2-, 5-, 10-, 25-, 50- 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 retain 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 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 – WQv; 1-, 2-, 5-, 10-. 25-. 50-, and 100-year events).

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 four key design events identified in this report (WQv, 1-year, 10-year and 100-year) provide a numeric or graphic representation of the entire outlet hydrograph through the duration of the storm event. For other events reviewed (2-, 5-, 25-, and 50-year events) a summary sheet that identifies the peak flow rate and time of occurrence will be sufficient.

7. **A graph of storage volume or elevation versus time** for the key design events. Review drawdown for extended detention of small storms. (24-to 48-hour drawdown after storm event)

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

Inlet Sediment Forebays

Iowa Stormwater Management Manual Reference: Section 2C-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 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

Iowa Stormwater Management Manual Reference: 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 Section 2C-12.

Resources

Books

Andreas Atlas Company (1970). *A.T. Andreas' Illustrated Historical Atlas of Iowa, 1875.* Iowa City, Iowa: State Historical Society.

Brown, K. & Schueler, T. (2004). *Urban Subwatershed Restoration Manual Series*. Center for Watershed Protection. www.cwp.org

Center for Transportation Research and Education (2008). *Iowa Stormwater Management Manual*. Iowa State University. www.ctre.iastate.edu/pubs/stormwater/index.cfm

Chow, Ven Te (1988). *Applied Hydrology*. New York: McGraw-Hill.

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