Section 1 – General Information

1.1 Concept

This section contains storm water management criteria. Emphasis should be placed on detention and storage of rainfall to mitigate increased runoff due to development. This should result in a reduction of increased development runoff and related damage to downstream properties.

1.2 Conditions

1. The design provided by the Project Engineer should demonstrate:

   A. The streets function as part of the storm water system.

   B. Gutters and intakes are adequate to prevent excessive flooding of streets and parking.

   C. Culverts and storm pipes are designed to sufficient size.

   D. Adequate overland relief is present for storms larger than the design storm. Channels and respective easements are adequately sized.

   E. Street grades are coordinated with lot drainage with lot drainage slopes not less than 1.5 percent.

      1) Where such slopes are not possible in rear and side yards, spot elevations should be included at each rear lot corner and at the mid-point of the side yard line. Plans should note the builder will grade rear and side yard swales to drain to the right-of-way.

2. The Project Engineer should evaluate storm water management alternatives and select a design to best balance initial capital costs, maintenance costs, safety, and environmental protection.

3. Runoff analysis should be based upon proposed (including future) land use and consider contributing runoff from offsite areas.

4. All undeveloped land lying outside of the study area should be considered as fully developed based upon the Jurisdictions Comprehensive Plan. The project engineer should consider the future land use and develop assumptions for runoff and stormwater management.

   A. The probable future flow pattern in the undeveloped areas should be based on existing natural topographic features (existing slopes, drainage ways, etc.)

   B. Average land slopes in both developed and undeveloped areas may be used in computing runoff. Known and proposed drainage patterns and slopes should be utilized where possible.

5. Flows and velocities which may occur when the upstream area is fully developed should be considered. Drainage facilities should be designed to prevent erosion damage.

6. The computed amount of runoff in streets should not exceed the requirements set forth herein.

7. The preservation of natural drainageways is recommended and encouraged whenever possible. The changing of natural drainageway locations may not be approved unless shown to be without unreasonable hazard and liability, substantiated by thorough analysis and investigation.

8. Drainage and stormwater detention easements may be required for the protection and maintenance of drainage swales and detention areas. The Project Engineer should show that natural and constructed channels will have minimal adverse effect on adjacent properties and downstream areas.

9. The storm drainage system design should consider surface and subsurface sources. The discharge from subdrain systems should not flow over sidewalks or onto streets.

10. Grading of the project site should take advantage of existing contours and minimize soil disturbance. Steep slopes (>3:1) should be avoided. If steep slopes are necessary, an attempt should be made to save natural grasses, shrubs and trees on these slopes and reestablish ground cover and permanent erosion control measures as soon as possible.

11. During construction grading, temporary diversions, contour furrows, terraces and other remedial conservation practices should be used to reduce erosion and excessive water drainage to downstream adjacent properties. Sediment traps and basins should be used and maintained at the lower end of the drainageways.

12. Plan and design drainage systems so erosion and/or flooding problems are not transferred from one property to another.

13. Floodplain and floodway information will be required on drainage plans when known, and should include the area inundated by the major storm headwater.

14. Where a master drainage plan for a Jurisdiction is available, the flow routing for both the minor storm and major storm runoff should conform to this plan. Drainage easements conforming to the master plan will be required and should be designated on drainage plans and subdivision plats.

15. Buildings or structures including retaining walls, fences, etc., or the placement of fill material which will encroach on a drainage easement,

requires written approval of the Jurisdiction. Structures shall not impair surface or subsurface drainage from surrounding areas.

16. The design for storm water management facilities shall conform to this Manual and applicable regulations of the Iowa Department of Natural Resources and US Environmental Protection Agency. In case of a conflict between the design criteria, the more restrictive requirement should apply.

17. Construction standards shall be the Cedar Rapids Metropolitan Area Standard Specifications and Details for Public Improvements.

18. The Environmental Protection Agency (EPA) approved the Final Storm Water Rule under the National Pollutant Discharge Elimination System (NPDES). Under this rule, qualified projects are required to have storm water discharge permits.

19. Possible wetland areas shall be investigated and identified as appropriate.

1.3 Minor and Major Design Storms

Every urban area has two distinct drainage systems. One is the minor system corresponding to the minor storm recurring not less than 5 years. In addition, the two- year storm may be used to analyze low flow events. The other is the major system corresponding to the major storm generally considered the 100-year storm event. Since the effects and routing of the major storm runoff may not be the same for the minor storm, storm drainage plans submitted should include the routing path and effects of the major storm.

Table 2.1 Chance of a Storm Equaling or Exceeding
A Given Frequency for a Given Time Period

Time Period (years)

Frequency (years)	1	10	25	50	100
5	20%	89%	99.9%	99.9%	99.9%
10	10%	65%	94%	99.9%	99.9%
25	4%	34%	64%	87%	98%
50	2%	18%	40%	60%	86%
100	1%	9.6%	22%	39%	64%

1. Minor Storm Provisions

The minor storm drainage system should be designed to protect against regularly recurring damage, reduce street maintenance costs, provide an orderly urban drainage system and to provide public convenience. Storm sewer systems consisting of underground piping, natural drainageways and other required conveyance should be considered part of the minor storm drainage system.

2. Major Storm Provisions

The major storm drainage system should be designed to prevent major property damage or loss of life from storm runoff expected from the major storm. The effects of the major storm on the minor drainage system should be noted in the drainage report.

Section 2 – Drainage Report

2.1 Purpose

The purpose of the drainage report is to estimate and propose solutions for increased runoff due to proposed development. The report must include adequate analysis and discussion of off-site drainage and the capacity of downstream drainage systems to determine their ability to convey the developed discharge.

The drainage report and plan shall be reviewed and accepted by the Jurisdictional Engineer prior to acceptance of improvement plans. The Project Engineer may be required to submit a drainage report, plan, and permit application to the Iowa Department of Natural Resources and/or Corps of Engineers. The drainage report shall be certified by a Professional Engineer licensed to practice in the State of Iowa.

2.2 Instructions for Preparing the Drainage Report

1. Include a cover sheet with project name and location, name of firm or agency preparing the report, Professional Engineer's signed and sealed certification, and table of contents. Number each page of the report.

2. All analyses shall be performed according to the intent of professionally recognized methods. Any modifications to these methods shall be supported by well-documented and industry accepted research.

3. It is the designer's responsibility to provide all data requested. If the method of analysis (for example, a computer program) does not provide the required information, then the designer shall select alternate or supplemental methods to ensure the drainage report is complete and accurate.

4. Acceptance of a drainage report implies the Jurisdiction concurs with the project's overall stormwater management concept. This does not constitute full acceptance of the improvement plans, alignments, and grades, since constructability issues may arise in plan review.

5. The report format is shown in Appendix 2-1. Use all headings listed in the order given. A complete report will include all the information requested in this format. If a heading listed does not apply, include the heading and briefly explain why it does not apply. Include additional information and headings as required to develop the report.

6. This Design Standards Manual does not preclude the utilization of methods other than those referenced nor does it relieve the designer of responsibility for analysis of issues not specifically mentioned.

Section 3 – Storm Sewer Design

3.1 Storm Sewer Location

1. Storm Sewers in Public Right-of-Way

   A. Storm Sewers parallel to the street and in the right-of-way should be placed behind the back of curbs, as close as practical to fit specific manhole or intake connections and to avoid conflicts with other utilities.

2. Storm Sewer Easements

   A. Easements must be exclusively for the Jurisdiction.

   B. Permanent easements for storm sewer pipe 36" or less in diameter should be a minimum of 20 feet. The pipe should be located in the center of the easement. For pipe larger than 36" in diameter additional easement widths shall be required based on depth of invert, size of pipe, soil types, construction limits required to remove and replace pipe, and overflow conveyance requirements.

   C. No permanent structures or landscaping shall be placed in the easement. Fencing will not be allowed in overland flow easements.

   D. Storm sewers at intersection corners may require additional corner easements.

3.2 Pipe Material

Pipe material and pipe strength for sewers within the public right-of-way shall conform to the Cedar Rapids Metropolitan Area Standard Specifications.

3.3 Physical Requirements

1. Recommended minimum cover on storm sewers outside of pavement is 2' 6". Recommended minimum cover under 7" local street pavement for cross runs is 1' 6" from top of pavement. For greater pavement thickness or street classification other than local, provide structural calculations for minimum cover.

2. Minimum cover on subdrain within public ROW is 3'6".

3. Minimum and maximum cover based on structural calculations and manufacturers' recommendations.

4. Minimum pipe size for connection to public systems:

   A. Storm sewers - 15" diameter.

   B. Footing drain sewers in public right-of-way, 4" diameter.

   C. Building storm sewer stubs, 4" diameter.

5. Crossings and Clearances

   Storm sewers crossing sanitary sewers shall have no less than 6 inches of clearance. Special structural support will be required if there is less than 18 inches clearance. The minimum horizontal clearance shall be 5 feet. Clearance refers to the distance from the outside of the sewer pipe to the outside of the storm sewer pipe.

   A. Water supplies as stated in IDNR rules:

      1) "Wells: Sewers constructed of standard sewer materials shall not be laid within 75 feet of a public well or 50 feet of a private well. Sewers constructed of water main materials may be laid within 75 feet of a public well and within 50 feet of a private well but no closer than 25 feet to either."

      2) "Horizontal Separation of Gravity Sewers from Water Mains: Gravity sewer mains shall be separated from water mains by a horizontal distance of at least 10 feet unless:"

         a) the top of a sewer main is at least 18 inches below the bottom of the water main, and

         b) the sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of 3 feet from the water main. When it is impossible to obtain the required horizontal clearance of three feet and a vertical clearance of18 inches between sewers and water main the sewer shall be constructed of water main materials meeting both a minimum pressure rating of 150 psi and the requirements of Section 8.2 and 8.4 of the 'Iowa Standards for Water Supply Distribution Systems.' However, a linear separation of at least two feet shall be provided."

      3) "Separation of Sewer and Water Main Crossovers

Vertical separation of sewers crossing under any water main should be at least 18 inches when measured from the top of the sewer to the bottom of the water line. If physical conditions prohibit the separation, the sewer may be placed not closer than 6 inches below a water main or 18 inches above a water main. The separation distance shall be the maximum feasible in all cases.

When the sewer crosses over or is less than 18 inches below a water main one full length of water main material shall be located so both joints are as far as possible from the water main. The sewer and water pipes must be adequately supported and have watertight joints. Low permeability soil shall be used for backfill material within 10 feet of the point of crossing."

4) "Exceptions”

Should physical conditions exist such that exceptions to Sections 3.3.5 A2, and 3.3.5. A3 of this standard are necessary, the project engineer must detail how the sewer and water main are to be designed to provide protection equal to that required by these sections."

Min. grade

Storm Sewer Main to attain minimum velocity of 3 fps for two-year design storm

Subdrain- 0.5%.

Building storm sewer stubs - 1/8 inch per foot.

3.4 Horizontal Alignment

Sewer should be laid with a straight alignment between manholes with the following one exception: In subdivisions where street layouts make a straight alignment difficult the sewers may be curved, pending Jurisdiction Engineer’s approval. The curvature will be in accordance with the manufacturer's requirements and recommendations and should be concentric with the curvature of the street. The pipe manufacturer's recommended maximum deflection angle may not be exceeded.

3.5 Outlets

1. Where a storm sewer discharges to a receiving channel, an outlet structure should be provided that will blend the storm sewer discharge into the natural channel flow in a manner to prevent erosion of the bed or banks of the channel. As a minimum, all storm sewer pipe outlets will require flared end

sections with apron guards for pipe diameters 24" or larger. Storm sewer 30" diameter or greater requires a toewall at the outlet. Storm sewers smaller than 30" diameter may require a toewall as required by the Jurisdiction.

2. When the discharge velocity is greater than outlined in Tables 2.2 & 2.3, prevention of erosion of the natural channel bed or banks in the vicinity of the outlet might require an energy dissipating structure, such as riprap, concrete baffles, gabions, or stilling basin.

3. Storm Sewer along a side property line shall run the length of the property line and outlet past the rear property line to a receiving drainageway.

4. Outlets shall drain at a receiving drainageway or connect to an existing storm sewer. Outlets will not drain directly to streets. Outlets shall not be located on slopes without adequate erosion protection and means of conveyance between the outlet and receiving drainageway or storm sewer. Erosion protection on slope only at the outlet is often inadequate, as runoff velocity will increase down grade of the outlet.

3.6 Storm Sewer Structures

1. Location

Manholes or intakes will be required whenever there is a change in size, direction, elevation, grade or a junction of two or more storm sewers. Access structures will be required at the beginning and/or end of a curved section of a storm sewer. When feasible, access structures should be installed at street intersections. Manholes should be located in areas to allow direct access by maintenance vehicles. Structures will be spaced at distances not greater than 400 feet, regardless of gutter capacity. The most upstream structure of a storm sewer run shall be located a maximum 500 feet from a street high point to minimize gutter spread. Intakes near intersections should be located at least 10 feet from pedestrian ramps, as measured between near edge of flume and near edge of ramp, to avoid ponding water at the ramps.

2. Invert Drop

When there is a change in pipe size at a structure, the invert of the smaller sewer must be raised to maintain the same energy gradient. An approximate method of doing this is to place the 0.8 depth point of both sewers at the same elevation. When there is a change in alignment between storm sewer of 45^{o} or greater the suggested minimum manhole drop is 0.10'.

3.7 Hydraulic Design

Storm sewers should be designed to convey the five-year storm peak runoff without surcharging the sewer. Where surcharging is a concern, the hydraulic grade line may be calculated by accounting for energy losses. Total hydraulic losses will include friction, expansion, contraction, bend and junction losses. The design method shall generally follow procedures in FHWA Hydraulic Engineering Circular No. 22, “Urban Drainage Design Manual”, or as approved by the Jurisdiction.

1. Pipe Friction Losses

The Manning's "n" values to be used in the calculation of storm sewer capacity and velocity are shown as follows:

Type of Pipe	Manning's "n"
Vitrified clay pipe	0.013
Plastic pipe (smooth wall)	0.011
Concrete pipe	0.013
Corrugated plastic pipe	0.020

Values for materials other than listed above shall be approved by the Jurisdictional Engineer.

2. Velocity within Pipe

   A. Minimum for 5-year design storm flow = 3 fps

   B. Maximum for 5-year design storm flow = 20 fps

3. Velocity at Outlet of Pipe

   A. Energy dissipation is required when discharge velocities exceed those allowed for downstream channel. (See Tables 2.2 & 2.3)

   B. Max. with flared end section = 5 fps

   C. Max with flared end section, footing, rip-rap = 10 fps

   D. Max. with energy dissipation device = 20 fps

Table 2.2 – Permissible Velocities for Channels With Erodible Linings Based on Uniform Flow in Continuously Wet, Aged Channels[1]

	Maximum permissible velocities for--		
Soil type lining (earth; no vegetation)	Clear Water	Water carrying fine silts	Water carrying sand and gravel
	F.p.s.	F.p.s.	F.p.s.
Fine sand (non-colloidal)	1.5	2.5	1.5
Sand loam (non-colloidal)	1.7	2.5	2.0
Silt loam (non-colloidal)	2.0	3.0	2.0
Ordinary firm loam	2.5	3.5	2.2
Volcanic ash	2.5	3.5	2.0
Fine gravel	2.5	5.0	3.7
Stiff clay	3.7	5.0	3.0
Graded, loam to cobbles (non-colloidal)	3.7	5.0	5.0
Graded, silt to cobbles (colloidal)	4.0	5.5	5.0
Alluvial silts (non-colloidal)	2.0	3.5	2.0
Alluvial silts (colloidal)	3.7	5.0	3.0
Coarse gravel (non-colloidal)	4.0	6.0	6.5
Cobbles and shingles	5.0	5.5	6.5
Shale and hard pan	6.0	6.0	5.0
Fabric and excelsior mat	7.0	7.0	7.0
Dry riprap/gabions	10.0	10.0	10.0
Concrete pilot channel	Use grass permissible velocity - Table 2.3		

[1] Committee on Irrigation Research, American Society of Civil Engineers, 1926

Table 2.3 – Permissible Velocities for Channels Lined With Uniform Stands of Various Grass Covers, Well Maintained [2]

		Permissible velocity on--	
Cover	Slope range	Erosion resistant soils	Easily eroded soils
	Percent	fps	fps
Reed Canary Grass	0-5 5-10 Over 10	8 7 6	6 5 4
Buffalograss Kentucky bluegrass Smooth brome Blue grama Tall Fescue	0-5 5-10 Over 10	7 6 5	5 4 3
Grass mixture Switch Grass	0-5 5-10	5 4	4 3
Red Top Weeping lovegrass Yellow bluestem Alfalfa Crabgrass	0-5	3.5	2.5
Sudangrass[3]	[4]0-5	3.5	2.5

[2] Velocities over 5 fps accepted only where good cover and proper maintenance can be obtained.

[3] Annuals, used on mild slopes or as temporary protection until permanent covers are established.

[4] Use on slopes steeper than 5 percent is not recommended.

Section 4 – Storm Sewer Intakes

4.1 Introduction

1. A storm intake is an opening into a storm sewer system to collect surface storm runoff. There are three basic types of intakes:
   A. Curb-grate opening
   B. Curb opening (Metro RA intake)

C. Area Intake

Intakes are further classified as being at grade or at a low point. The term "at grade" refers to an intake located on the street grade with continuous slope, where ponding does not occur at the intake. The sump or low point condition exists whenever water is restricted to the inlet area because the intake is located at a low point. A low point condition can occur at a sag vertical curve or due to the crown slope of a cross street when the intake is located at an intersection.

4.2 Definitions

1. Design flow is the calculated quantity of storm runoff at a given point. For gutter applications, design flow shall include bypass flow from upstream intakes.

2. Bypass flow is gutter flow not intercepted by a given upstream intake. Bypass flow is calculated by subtracting the allowable capacity of the given intake from the design flow assigned to that intake. Bypass flow shall be added to the design storm runoff for the next downstream intake. As a minimum intakes at a low point shall have design capacity to intercept all storm runoff including upstream bypass flows.

4.3 Intercepting Flows

Storm sewer intakes shall be designed to intercept design flow with the following allowable bypass from the system:

1. Streets on Continuous Grade – The final downstream intake or intakes shall be designed to intercept no less than 50% of the design flow.

2. Temporary Dead-End Streets on Down Grade – Unless otherwise approved by the Jurisdictional Engineer, intakes shall be designed to intercept no less than 100% of the design flow.

3. Cul-de-sac Streets on Down Grade and Low Points – Intakes shall be designed to intercept no less than 100% of the design flow. Depending on downstream conditions, the Jurisdictional Engineer may require oversized intakes at low points.

4. Intersections – Intakes shall be placed at end of intersection returns to intercept design flow for reduced gutter spread at pedestrian ramp locations.

4.4 Street Capacity for Minor Storms

1. Pavement encroachment for the minor design storm shall not exceed the limitations in the following table:

Allowable Pavement Encroachment and
Depth of Flow for Minor Storm Runoff

Street Classification	Maximum Encroachment*
Local	No curb overtopping. Flow may spread to crown of street.
Collector/Minor Arterial	No curb overtopping. Flow spread must not encroach to within 8 feet of the centerline of a two-lane street. The flow spread for more than two-lane streets must leave the equivalent of two 12-foot driving lanes clear of water, one lane in each direction.
Major Arterial	No curb overtopping. Flow spread must not exceed ten feet from the face of the curb in the outside lane. The flow spread for more than two-lane streets must leave the equivalent of two 12-foot driving lanes clear of water, one lane in each direction. For special conditions, when an intake is necessary in a raised median, the flow spread should not exceed four feet from the face of the median curb for an inside lane.
Freeways	No encroachment on driving lanes is allowed on any traffic lane.

* Where no curbing exists, encroachment shall not extend past property lines.

2. The storm sewer system shall commence upstream from the point where the maximum allowable encroachment occurs. When the allowable pavement encroachment has been determined, the theoretical gutter carrying capacity for a particular encroachment shall be computed using the modified Manning's formula for flow in a small triangular channel. An "n" value of 0.016 shall be used unless special considerations exist.

4.5 Street Capacity for Major Storms

The allowable depth of flow and inundated area for the major design storm shall not exceed the following limitations:

Allowable Depth of Flow and Inundated Area for 100-Year Storm Runoff

Street Classification	Allowable Depth and Inundated Area
Local and Collector	The inundated area should not exceed the street right-of-way and the depth of water above the street crown should not exceed 6 inches, whichever is less.
Arterial	The inundated area should not exceed the street right-of-way and the depth of water above the street crown should not exceed 3 inches, whichever is less.

4.6 Cross Street Flow

Cross street flow can occur by two separate means. One is runoff flowing in a gutter and then across the street to the opposite gutter or inlet. The second case is surcharge or overland flow across the crown of the street when the storm sewer or ditch capacity is exceeded. If the inundated area exceeds the street right-of-way, drainage easements must be obtained. The maximum allowable cross street flow depth based on the worst condition shall not exceed the following limitations:

Allowable Cross Street Flow

Street Classification	Initial Design Storm Runoff	100-Year Design Storm Runoff
Local	6" depth at crown	9" depth at crown
Collector	3” depth at crown	6" depth at crown
Arterial	None	3" or less over crown

4.7 Design Method

The design method shall generally follow procedures in FHWA Hydraulic Engineering Circular No. 22, “Urban Drainage Design Manual”, or as approved by the Jurisdiction. Also refer to manufacturer’s specifications or IDOT Design Manual for grate and inlet capacity data.

Section 5 – Culvert Design

5.1 Limitation of Culvert Use

1. Culverts will be allowed in areas where the Jurisdictional Engineer has determined may be served by open channel.

2. Culverts with outlet control will only be allowed by approval of design Exception.

5.2 Culvert Capacity

100-year flood headwater at culvert will not overtop roadways or encroach beyond prescribed drainage easements.

5.3 Culvert Material

1. RCP - Minimum strength Class 3 under all streets and entrance pavement and Class 5 under railroad tracks.

2. CMP, multi-plate, PVC, and HDPE are to be approved by Jurisdictional Engineer.

5.4 Physical Requirements

1. Minimum grade shall be 1 percent for inlet control.

2. Maximum length shall be 200 feet for inlet control.

3. Fencing typically required around headwalls.

4. Headwall located to avoid steep slopes (>3:1) between headwall and top of embankment.

5. The minimum culvert size will be as determined by design and not less than 15-inch inside diameter.

5.5 Erosion Control at Inlet and Outlet

Energy dissipation shall be required for velocities higher than those outlined in table- "Permissible Flow Velocity for Channels" (Tables 2.2 and 2.3).

5.6 Design Method

The Design method shall be FHWA Hydraulic Data Series No. 5, “Hydraulic Design of Highway Culverts”, or other method approved by the Jurisdiction.

Section 6 – Storm Water Management

6.1 Introduction

Storm water detention can significantly reduce downstream flood hazards and pipe and channel requirements in urban areas. The main purpose of a detention facility is to store excess storm runoff resulting from increased basin imperviousness and discharge it at a rate similar to the rate experienced from the basin prior to development.

6.2 Definitions

1. Excess storm runoff shall be judged in comparison to the site in its pre-development condition and shall include all increases in stormwater resulting from any of the following:

   A. An increase in the impervious surface of the site, including all additions of buildings, roads and parking lots.

   B. Changes in soil absorption caused by compaction during development.

   C. Grade changes including the filling or draining of depression areas, alterations of drainageways or regrading of slopes.

   D. Clearing woodlands.

   E. Installation of storm sewer to intercept street flows or to replace existing drainageways.

   F. Alteration of subsurface flows, including any groundwater dewatering or diversion practices such as curtain drains.

2. Pre-developed conditions are hydraulic and hydrologic site characteristics existing prior to development and shall include all the natural storage areas and drainageways plus existing farm drainage tiles and highway drainage structures. The Jurisdictional Engineer may require the pre-developed condition to be equal to an undeveloped condition if drainage problems are occurring down stream due to existing development at the proposed site or in the basin.

3. Developed conditions are hydraulic and hydrologic site characteristics that occur following the completion of the proposed development.

4. Post-developed peak runoff is expected to exceed pre-developed runoff from a similar storm event. Even if calculated time of concentration or curve

number tables suggest lower post-developed runoff, developed sites generally have more impervious areas, compacted soils, change in soil horizon, and differing vegetation from undeveloped conditions. There may be exceptions, but careful consideration of the hydrologic method and sufficient engineering judgment are necessary to ensure calculated results meet reasonable expectations.

6.3 Limitation of Storm Runoff

1. No development shall cause downstream properties, channels or conduits to receive stormwater runoff from the proposed development site at a higher peak flow rate, or at higher velocities than would have resulted from the same storm event occurring over the site in its pre-developed condition.

2. The Jurisdiction shall determine if construction of storm detention facilities are required as a condition for approval of the development. Factors considered in making a determination include but are not limited to:

   A. The drainage report as outlined in Section 2.

   B. Historical or potential drainage or flood problems adjacent to the site.

   C. Historical or potential area wide drainage or flooding problems in the watershed.

   D. Location of the site relative to existing drainageways and/or stormwater conveyances.

   E. Extent of proposed site increase in impervious surface area.

3. Anticipated future development of the drainage basin.

4. Existing site features that may facilitate or impede detention design and/or construction.

5. Jurisdiction's stormwater management ordinance.

6. Jurisdiction's water quality standard, as applicable.

7. Parcels of land, of which only part will be initially developed but are contained in the same drainage area, will be evaluated for stormwater facilities, including detention, for the entire drainage area.

6.4 Stormwater Detention Requirements

If stormwater detention is required, the site owner shall construct stormwater detention facilities, designed by a professional engineer licensed in the State of Iowa, which meet the criteria of this section.

Detention basins with 18 ac. ft. or more of storage require a permit from the Iowa Department of Natural Resources (IDNR).

1. Design Storm

The design storm is the rainfall event having a return frequency of 100 years unless higher frequencies are required by the IDNR or Jurisdiction. Design storm duration is the critical duration of rainfall requiring the greatest detention volume.

2. Release Requirements

A. For rainfall events having an expected return frequency of five years to 100 years, inclusive, the rate of runoff from the developed site shall not exceed the existing, pre-developed peak runoff from a five-year frequency storm of the same duration unless if limited by downstream conveyance.

Example #1

A ten-acre site has a peak rate of runoff from a 5-year, 6-hour storm before development of 12 cfs.

Discharge from detention during the 100-year, 50-year, 25-year, or 10-year 6-hour storm after development shall not exceed 12 cfs.

B. Release of runoff generated off-site and routed through the detention basin should not increase the combined off-site and on-site release rate.

C. Release of stormwater runoff from the detention basins shall not damage private or public properties.

6.5 Detention Facilities Requirements

1. Basin Construction:

A. Side slopes shall be at least 4:1 or flatter and should have temporary and permanent erosion control stabilization.

B. Detention bottom cross-slopes to the main detention channel will be 2% minimum.

C. Subsurface drains from basin inlets to outlets shall be required unless waived by the Jurisdictional Engineer.

D. The embankment top shall be at least 6 ft. wide. Smaller widths may be approved by the Jurisdictional Engineer but shall not be less than 3 feet.

E. Freeboard shall be minimum of 1 ft. above the 100-year water surface elevation.

F. The embankment shall be protected from catastrophic failure due to overtopping following IDNR requirements where applicable. Overtopping can occur when the pond outlet becomes obstructed or when a larger than 100-year storm occurs. Failure protection for the embankment may be provided in the form of a buried, heavy rip rap layer on the entire downstream face of the embankment or a separate emergency spillway having a minimum capacity of the developed inflow rate for the 100-year storm from contributing on-site and off-site areas. The spillway is also needed to control the release point of the overflows. Structures shall not be permitted in the path of the emergency spillway or overflow. The invert of the emergency spillway should be set equal to or above the 100-year water surface elevation.

G. The outlet structure shall be protected by a debris rack. Debris will block most outlet structures at some point, and a well-designed debris rack can help ensure the outlet functions even under a heavy trash load. Debris racks vary in design and include for example, welded wire and hinged metal plates over low-flow orifices, a hinged gate over an outfall culvert, or rack placed over a standpipe. On larger structures, debris racks are locked to prevent children and animals from entering the structure. A slanted alignment seems to work best to keep larger structures functioning during extreme events.

2. Parking Lot Storage:

A. Paved parking lots may be designed to provide stormwater detention on a portion of their surfaces not to exceed fifty (50) percent of the parking lot area.

B. Outlets shall be designed to drain slowly and storage depth must be limited to 9" to minimize damage to parked vehicles. The minimum pipe size for the outlet is 12" diameter where a drop inlet is used to discharge to a storm sewer or drainageway. Where a weir and a small diameter outlet through a curb are used, the size and shape are dependent on the discharge/storage requirements. A minimum pipe size of 4" diameter is recommended.

C. Maintenance access shall be provided. The potential for pavement overlays shall be considered in the calculated detention.

3. Multipurpose Basins

A. Dry bottom basins may be designed to serve secondary purposes for recreation, open space or other use which will not be adversely affected by intermittent flooding.

B. Retention basins with potential to improve water quality may be approved by the Jurisdictional Engineer.

4. Acceptance of Storm Detention:

A. The Jurisdiction shall not guarantee the accuracy of certified engineering calculations and improvement plans, or the performance of the constructed facilities. Acceptance of stormwater detention plans and issuance of any permit should not be interpreted as alleviating the Project Engineer of responsibility for the accuracy and performance of the design and plans.

6.6 Water Quality Volume Design Standard

1. The water quality standard was established to provide for pollutant removal in detention basins and to fulfill requirements of the Jurisdictions' NPDES Permits. This standard is enforceable by the Jurisdiction under its NPDES permit.

2. One-inch of rainfall over the developed site shall be detained in the basin for 24 hours. The detention volume in cubic feet is determined by multiplying the site area in square feet, by one inch (0.083 ft). One inch of rainfall typically occurs during the 6-month to 1-year storm event over an average duration of one hour. Frequent storm events smaller than the 1-year storm, known as "first-flush events" carry the majority of storm water pollutants. The 24-hour water quality detention time has been used around the country for the past 10-15 years. This standard was implemented because available research indicates the 24-hour detention time will typically result in 60-80 percent total suspended solids (TSS) removal.

3. Start with the water quality volume to design an outlet structure, typically one or more orifices or a perforated riser, to release the runoff in 24 hours. Verify the minimum 24-hour detention time with the following methods:

A. Use the detention basin stage-storage-discharge relationship to calculate the time to drain the runoff volume between each stage (maximum 1-foot increments). Add the detention times between stages. If the total detention time is at least 24 hours, the outlet should release runoff per the water quality standard. If not, reconfigure the outlet. A sample calculation is given (following page):

Figure 2.1 - Sample Water Quality Detention Time Calculation

Stage (ft)	Storage (cu ft)	Outflow (cfs)	Detention time between stage (hr)
67.6	0	0	
			4.17
68	300	0.04	
			0.46
68.5	400	0.08	
			5.58
69	2712	0.15	
			2.56
69.5	4416	0.22	
			2.09
70	6443	0.32	
			1.81
70.5	8819	0.41	
			1.98
71	12133	0.52	
			1.59
71.5	15426	0.63	
			1.85
72	20053	0.76	
			2.01
72.5	26000	0.88	
		Total Detention Time	24.10

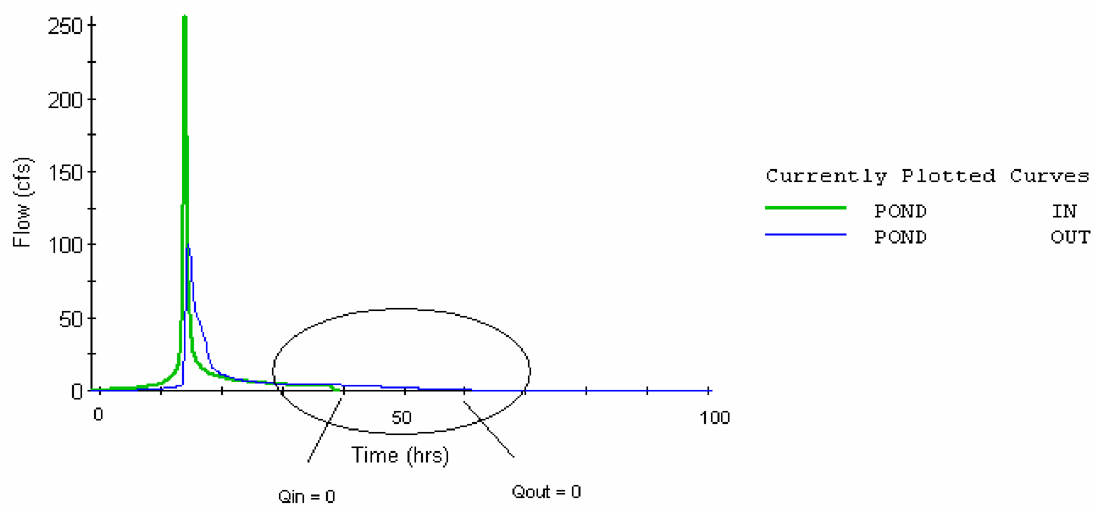
The detention time between stages:

$$T(hr) = \frac{V_2 - V_1 (ft^3)}{0.5(O_1 + O_2)(\frac{ft^3}{s})} \times \frac{1}{\frac{3600s}{hr}}$$

Where V = storage and O = outflow at a given stage.

B. Using the detention basin inflow-outflow hydrograph, subtract the time when the outflow decreases to zero from the time when the inflow decreases to zero. The difference between these times should be at least 24 hours to meet the water quality standard. See the sample hydrograph below. The circled area shows where zero discharge occurs for the inflow and outflow hydrograph.

Figure 2.2 - Sample Inflow-Outflow Hydrograph



4. The maximum release rate from the detention basin will continue to be the 5-year onsite pre-developed peak discharge plus appropriate bypass discharge from contributing offsite areas.

5. For small site areas (typically 5 acres or less), the water quality detention volume may be disproportionately larger than the 100-year storm runoff volume. To meet the water quality standards within the size of a basin designed to detain the 100-year storm,

   A. Combine runoff from individual lots into one basin for the entire subdivision (preferred).

   B. Provide alternate methods to remove TSS (only accepted if the site or subdivision does not have other sites to consolidate detention with. Some examples are underground storage, oil/grit separators, and storm sewer structures modified with treatment devices.

   C. Use best management practices described in Section 6.8. More information can be found on the EPA website http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm. The following table summarizes typical practices and benefits:

Table 2.4 Typical Water Quality Practices

Practices	Benefits			
	Runoff Reduction	Infiltratio n	Reduce Water Quality Storage Volume	TSS Removal
Infiltration Trench	X	X		X
French Drain	X	X		X
Dry Well	X	X		
Porous Pavement	X	X	X	
Vegetated Filter Strip	X	X	X	X
Vegetated Swale	X	X	X	X
Bioretention (Rain Garden)	X	X	X	
Wet Pond			X	X
Level Spreader	X			
Soil Amendment	X	X		

6.8 Description of Water Quality Practices

1. This section describes typical water quality practices and provides general guidelines for their use.

A. Infiltration trench/French drain – A rock-filled trench with no outlet that receives storm water runoff. Storm water runoff passes through some combination of pretreatment measures, such as a swale into the trench. Runoff is stored in the void space between the aggregate and infiltrates into the surrounding soil. The desired infiltration time is 24 hours. The primary pollutant removal mechanism of this practice is filtering through the soil. Infiltration trenches have select applications due to concerns such as potential ground water contamination, soils, and clogging. Infiltration trenches generally can be applied to relatively small sites less than 5 acres, with relatively high impervious cover. Application to larger sites generally causes clogging, resulting in high maintenance. A French drain is a rock-filled trench with subdrain for overflow.

B. Dry well – A subsurface storage facility that receives and temporarily stores roof runoff. This runoff is discharged through infiltration to the surrounding soil. A dry well may be either a structure and/or excavated pit filled with aggregate. A dry well is not considered for pollutant removal due to relatively low level of expectant pollutants in roof runoff. Runoff should drain within 72 hours. The maximum drainage area to a dry well is 1 acre and dry wells should be applied to relatively small sites.

C. Porous pavement – A permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface replaces traditional pavement, allowing parking lot storm water to infiltrate directly and receive water quality treatment. Porous pavement options include porous asphalt, and pervious concrete. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. The ideal application for porous pavement is for low-traffic or overflow parking areas. The base of the stone reservoir should be below the frost line to reduce the risk of frost heave. Porous pavement cannot be used where sand is applied because sand will clog the surface of the material. Care must also be taken when applying salt to a porous pavement surface as chlorides from road salt may migrate into the ground water.

D. Vegetated filter strip – Treats sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. With proper design and maintenance, filter strips can provide relatively high pollutant removal. However, it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment. In some situations filter strips may consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from streets, roof downspouts, small parking lots, and pervious surfaces. Typically, filter strips are used to treat very small drainage areas. The limiting design factor, however, is not the drainage area but the length of flow leading to it. As storm water runoff flows over the ground's surface, it changes from sheet flow to concentrated flow. When flow concentrates, it moves too rapidly to be effectively treated by a grassed filter strip. As a rule, flow concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces. Using this rule, a filter strip can treat one acre of impervious surface per 580-foot length.

E. Vegetated swale – Vegetated, open channel management practices designed specifically to treat and attenuate storm water runoff. As storm water runoff flows through these channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. Swales are well suited for treating street runoff. Vegetated swales should generally treat small drainage areas of less than 5 acres. If the practices are used to treat larger areas, the flows and volumes through the swale become too large to design the practice to treat storm water runoff through infiltration and filtering.

F. Bioretention – Landscaping features adapted to provide on-site storm water treatment. They are commonly located in parking lot islands or within small pockets of residential land. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm sewer system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated subdrain and returned to the storm sewer system. Bioretention should be used on small sites of 5 acres or less. When used to treat larger areas, they tend to clog. In addition, it is difficult to convey flow from a large area to a bioretention area.

G. Wet pond (a.k.a. storm water pond, retention pond, wet extended detention pond) - Constructed basins that have a permanent pool of water. Ponds treat incoming storm water runoff by settling and algal uptake. The primary removal mechanism is settling as storm water runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used storm water practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain storm water runoff to provide settling. Wet ponds need sufficient drainage area to maintain the permanent pool, typically about 25 acres.

H. Level Spreader – An outlet constructed at zero grade consisting of a vegetated or rock-surfaced structure, used to disperse or "spread" concentrated flow thinly over a receiving area. The purpose is to spread runoff over a wide area to prevent erosion of the receiving area. Additional benefits of infiltration and filtration may also occur. This practice applies where concentrated flow is dispersed within wooded areas adjacent to bodies of water and in areas requiring a filter strip to treat water. Its use should also be limited to drainage areas less than ten acres and where receiving areas have relatively flat slopes of four percent or less; 1 to 2 percent slope is recommended.

I. Soil amendment – Material added to a soil to improve its physical properties, such as water retention, permeability, infiltration, drainage, aeration and structure. Soil amendments increase the spacing between soil particles so that the soil can absorb and hold more moisture. This in turn reduces runoff. The amendment of soils changes physical, chemical and biological characteristics so the soils become more effective in maintaining water quality. Compared to compacted, un-amended soils, amended soils provide greater infiltration and subsurface storage and thereby help to reduce a site's overall runoff volume, helping to maintain the predevelopment peak discharge rate and timing. The volume of runoff that needs to be controlled to replicate natural watershed conditions changes with each site based on the development's impact on the site's curve number (CN). Organic amendments include peat, wood chips, grass clippings, straw, compost, manure, biosolids, and sawdust.

Section 7 – Subdrain System Design

7.1 Subdrain Design Criteria

1. All roadways shall be provided with a subsurface drainage system to drain roadway subgrade and to provide direct outlets for building sump pumps.

2. Design flow for subdrain capacity will be based on sump pump flows as follows:
   less than 50 lots.................5.0 gpm/lot
   more than 50 lots...............2.5 gpm/lot

3. Down spouts from buildings or yard surface drainage are not allowed to be directly connected to the subdrain or tiled to the sump pump pit.

4. Subdrain shall be installed to the same grade as the roadway.

5. Increased flow into the storm sewer from subdrains will not be considered in the design of storm sewers.

6. Subdrains shall be located at the back of curb line according to the Standard Details.

7.2 Subdrain Standards

1. Storm sewer systems which run parallel to and behind the roadway curb line shall serve as the subsurface drainage system in addition to the storm drainage system and be installed with unsealed, fabric-wrapped joints.

2. Subdrain pipe shall be a minimum 6 inch diameter perforated PVC or polyethylene pipe meeting the Cedar Rapids Metropolitan Area Standard Specifications.

3. Subdrain shall be installed at the back of curbs on both sides of the roadway unless RCP storm sewer pipe has been installed to collect and convey subsurface drainage.

4. Subdrain installation shall include provisions for connection of private sump hoses. A 4-inch diameter plastic pipe shall be connected and extended to 10 feet beyond the right-of-way at each property line. The property end shall be

capped until the building sump hose is installed.

5. Subdrain shall have access from manholes, storm sewer intakes, open channels or cleanouts. The upstream end of subdrain extending into storm sewer intakes shall be capped to prevent conveyance of surface storm drainage through the tile system. Maximum spacing of access is 400 feet. Cleanouts are required at the beginning of subdrain lines.

Section 8 – Waterways and Wetland Permits in Iowa

8.1 Introduction:

Two agencies administer permit programs for the Iowa's water resources. The agencies are:

1. The U.S. Army Corps of Engineers (COE)

   The Army Corps of Engineers administers the 404 permit program. The 404 permit program regulates the non point source discharges of dredged or fill material into waters of the United States. Some projects may fall under a nationwide permit but require a "pre-discharge notification" from the Corps of Engineers before a nationwide permit is applicable. The pre-discharge notification gives the Corps of Engineers a chance to review an activity to determine if potential impacts warrant processing under an individual 404 permit.

2. The Iowa Department of Natural Resources (IDNR)

   The Iowa Department of Natural Resources administers permit programs for conserving and protecting Iowa's water, recreational and environmental resources, and, for the prevention of damage resulting from unwise floodplain development. The Department also has jurisdiction over sovereign lands and waters and certain fee title lands of the State. On meandered streams and lakes, sovereign State property is land below the ordinary high water mark.

   A summary of the Department's permit programs relating to protection of water and recreational resources and adjacent lands, is as follows:

   A. Floodplain Construction Permits
   B. Water Quality Certification
   C. Construction permits on fee title and sovereign lands and waters
   D. Permits requiring special applications
      1) nonpermanent docks
      2) commercial sand and aggregate removal from meandered streams

8.2 Regulated Activities

Construction, excavation or filling in streams, lakes, wetlands or on flood plains may require permits from both agencies. A permit application shall be submitted for any of the following activities:

1. Cutting the bank of a river or stream;

2. Any excavation or dredging in a stream of river channel;

3. Channel changes or relocations (including stream straightening);

4. Construction of any permanent dock, pier, wharf, seawall, boat ramp, beach, intake or outfall structure on a stream, river or lake;

5. Placement of any fill, riprap, or similar material in a stream, river channel, lake or wetland;

6. Construction of a dam across any waterway;

7. Placement of fill, construction of levees, roadways and bridges, and similar activities on a floodplain; or

8. Construction of buildings on a floodplain.

8.3 The Permit Process

The Joint Application Form can be obtained from the IDNR. Once the application form is completed, submit one copy to the Rock Island District of the U.S. Army Corps of Engineers and two copies to the Iowa Department of Natural Resources. Each agency will review the application form to determine whether a permit will be required. If a permit is required, the applicant will be notified and whether any additional information will be needed before the permit can be processed. If a permit is not required from either agency receiving the application, the applicant will be notified by that agency. Allow 60 to 90 days for application review and processing. Proceeding without the necessary permits is against State and Federal laws and may result in legal action and fines. If determined that no permits are required, the joint application is not required.

8.4 Contacting the Corps of Engineers

There are other instances during the design process when to contact the US Army Corps of Engineers. They are as follows:

1. When the project will disturb more than 0.10 Acres of waters of the US and/or wetlands.
   a. Waters of the US constitute any body of water or stream that is wet year-round, draining to a larger stream, as opposed to just during heavy rains.

b. If the stream is a "blue line" on the USGS Map, it may be a water of the US.
c. http://www.usace.army.mil/inet/functions/cw/cecwo/reg/33cfr328.htm

2. When there will be more than 500 LF of total crossings along waters of the US.

3. When there will be mechanized land clearing or clearing of low-lying timber.

If any of the above conditions exists in your project, submit a pre-construction notice to the Army Corps of Engineers. This can be done via the joint application found at http://www2.mvr.usace.army.mil/Regulatory/default.cfm?cat=afi. The contact information for the Rock Island Division is found below.

Mr. Mike Hayes
US Army Engineer District, Rock Island
Clock Tower Building
P.O. Box 2004
Rock Island IL, 61204-2004
Phone: (309) 794-5351
Website: http://www.mvr.usace.army.mil/

Appendix 2-1 Drainage Report Format

I. Executive Summary

Summarize report results with a narrative and tabular data. Provide tabular data for peak discharge, detention pond characteristics, and release rates according to the format below:

Table 1: Runoff Summary

	Onsite		Contributing Offsite	
Runoff Recurrence Interval	Pre-Development Peak Discharge (cfs)	Post-Development Peak Discharge (cfs)	Existing Discharge (cfs)	Developed Discharge (cfs)
5 yr				
10 yr				
25 yr				
50 yr				
100 yr				

Table 2: Detention Basin Characteristics

Stage (ft)	Storage (acre-ft)	Inflow (cfs)	Outflow (cfs)
(Max. 1 foot intervals)			

Table 3: Allowable Release Rate

Allowable Release Rate (cfs)		On Site Pre-developed Peak Discharge Rate – 5 yr		Contributing Off Site Developed Peak Discharge – 100 yr.(1)
	=		+	

Table 4: Overflow Release Rate

Overflow Release Rate (cfs)		On Site Post-developed Peak Discharge Rate – 100 yr		Contributing Off Site Developed Peak Discharge – 100 yr. (2)
	=		+	

(1) From offsite areas that are routed through the basin.

(2) This value is the larger of either the existing peak discharge or developed peak discharge.

(3) Post-developed peak discharge may be reduced with water quality best-management practices. Any proposed reduction must be adequately justified in the drainage report with narrative and calculations.

II. Site Characteristics

A. Pre-Development Conditions

Describe pre-developed land use, topography, drainage patterns including overland conveyance of the 100-year storm event, natural and man-made features. Describe ground coverage, soil type, and physical properties, such as hydrologic soil group and infiltration. If a geotechnical study of the site is available, provide boring logs and locations in the appendix of the Drainage Report. If a soil survey was used, cite it in Section VIII, References.

B. Post-Development Conditions

Describe post-developed land use and proposed grading, change in percent of impervious area, and change in drainage patterns. *Note if an existing drainage way is filled, the runoff otherwise stored by the drainage way shall be mitigated with storm water detention, in addition to the post-development runoff.*

C. Contributing Off-Site Drainage

Describe contributing off-site drainage patterns, land use, and storm water conveyance. Identify undeveloped contributing areas with development potential and list assumptions about future development runoff contributed to the site.

D. **Identify areas of the site located within the floodway or floodplain boundaries** as delineated on Flood Insurance Rate Maps, or as determined by other engineering analysis. Identify wetland areas on the site, as delineated by the National Wetlands Inventory, or as determined by a specific wetland study.

III. Pre-Development Runoff Analysis

A. Watershed Area

Describe overall watershed area and relationship between other watersheds or sub-areas. Include a pre-development watershed map in the report appendix.

B. Time of Concentration

Describe method used to calculate the time of concentration. Describe runoff paths and travel times through sub-areas. Show and label the runoff paths on the pre-development watershed map.

C. Precipitation Model

Describe the precipitation model and rainfall duration used for the design storm. Typical models may include one or more of the following:

1. SCS Type-II Distribution
2. Huff Rainfall Distribution. Select the appropriate distribution based on rainfall duration.
3. Frequency-Based Hypothetical Storm.

4. Rainfall Intensity Duration Frequency (IDF) Curve.
5. User-defined model based on collected precipitation data, subject to City Engineer's approval.

   Total rainfall amounts for given frequency and duration shall be obtained from Bulletin 71, "Rainfall Frequency Atlas of the Midwest." This publication supersedes Technical Paper Number 40, "Rainfall Frequency Atlas of the United States."

D. Rainfall Loss Method

List runoff coefficients or curve numbers applied to the drainage area. The Green-Ampt infiltration model may also be used to estimate rainfall loss by soil infiltration.

E. Runoff Model

Describe method used to project runoff and peak discharge. Typical models are as follows:

1. Rational Method – for drainage areas up to 20 acres, and where flow routing is not required. Often used in storm sewer design.
2. TR-55 Graphical Discharge Method – for drainage areas from 20 to 200 acres, and flow routing is not required.
3. For drainage areas larger than 20 acres and flow routing is required, use one of the following methods:
   a. TR-20 Model
   b. TR-55 Tabular Hydrograph Method
   c. Routines contained in HEC-1 or HEC-HMS computer models
   d. Regression Equations and other hydrologic models approved by the Jurisdiction
4. The methods listed in item #3 are not recommended for small drainage areas less than 20 acres.

F. Summary of Pre-Development Runoff

Provide table(s) including drainage area, time of concentration, frequency, duration, and peak discharge.

IV. Post-Development Runoff Analysis

A. Watershed Area

Describe overall watershed area and sub-areas. Discuss if the post-development drainage area differs from the pre-development drainage area. Include a post-development watershed map in the report appendix.

B. Time of Concentration

The method used will be the same as used in the pre-development analysis. Describe change in times of concentration due to development (i.e. change in drainage patterns). Show and label the runoff paths on the post-development watershed map.

C. Precipitation Model

Storm event, total rainfall, and total storm duration will be the same as used for the pre-development model. If IDF curves are used, describe the change in design rainfall intensity.

D. Rainfall Loss Method

Method will be the same as pre-development analysis. Describe the change in rainfall loss due to development.

E. Runoff Model

The runoff method will be the same as used in the pre-development analysis, except for variables changed to account for the developed conditions.

F. Summary of Post-Development Runoff

1. Provide table(s) including drainage area, time of concentration, frequency, duration, and peak discharge. Summarize in narrative form the change in hydrologic conditions due to the development. Provide a runoff summary table in Section I, Executive Summary.

2. Post-developed discharge should take into account any upstream offsite detention basins and undeveloped offsite areas assumed to be developed in the future with storm water detention.

3. Calculate the allowable release rate from the site. This equals the onsite 5-year pre-developed peak discharge plus the contributing offsite 100-year post-developed peak discharge. Include this calculation in Section I, Executive Summary.

V. Stormwater Conveyance Design

A. All stormwater conveyances shall be designed according to the Cedar Rapids Metropolitan Area Engineering Design Standards at a minimum. The following references may be used for supplemental design information:

1. Federal Highway Administration (1996) *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22, Washington D.C.
2. Federal Highway Administration (1988) *Design of Roadside Channels with Flexible Linings*. Hydraulic Engineering Circular No. 15, Washington D.C.
3. Federal Highway Administration (1985) *Hydraulic Design of Highway Culverts*. Hydrologic Design Series Number 5, Washington D.C.
4. US Geological Survey (1968) *Measurement of Peak Discharge at Culverts by Indirect Methods*. Book 3, Applications of Hydraulics, Washington D.C.

5. American Society of Civil Engineers (1986) *Design and Construction of Sanitary and Storm Sewers.* Manual of Practice No. 37, New York, N.Y.

B. Storm Sewer

1. List design criteria, including storm event and runoff model. Describe the hydraulic grade line and whether pressure flow or surcharging is possible. Provide a graphic of the hydraulic grade line.
2. List design criteria for intake size and spacing. Describe the anticipated gutter flow and spread at intakes.
3. List any special considerations for sub-drainage design, such as high water tables.
4. Provide tables of storm sewer and intake design data.

C. Culverts

1. Describe culvert capacity, inlet or outlet control conditions, estimated tailwater and headwater. Determine if 100-year or lesser storm event will flood roadway over culvert.
2. Sketch a contour of the 100-year headwater elevation on a topographic map and/or grading plan. This delineated 100-year flood elevation is used to determine drainage easement and site grading requirements.

D. Open Channel Flow – Swales and Ditches

1. Describe swale and ditch design. State the assumed Manning's roughness coefficients. State the anticipated flow velocity, and whether it exceeds the permissible velocity based on soil types and/or ground coverage. If the permissible velocity is exceeded, describe channel lining or energy dissipation.
2. Discuss design calculations. Depending on the complexity of the design, these may range from a single steady-state equation (i.e. Manning's) to a step calculation including several channel cross-sections, culverts and bridges.
3. Discuss the overall grading plan in terms of controlling runoff along lot lines and preventing runoff from adversely flowing onto adjacent lots.

E. Storm Drainage Outlets and Downstream Analysis

1. Discuss soil types, permissible and calculated velocity at outlets, energy dissipator design, and drainage impacts on downstream lands. Provide calculations for the energy dissipator dimensions, size, and thickness of riprap revetment (or other material) and filter layer.
2. Include a plan and cross-sections of the drainage way downstream of the outlet, indicating the flow line slope and bank side-slopes. Identify soil types on the plan.

3. Downstream Analysis
The downstream analysis will show what impacts, if any, a project will have on the drainage systems downstream of the project site. The analysis consists of three elements: review of resources, inspection of the affected area, and analysis of downstream effects.

a. During the review of resources, review any existing data concerning drainage of the project area. This data will commonly include area maps, floodplain maps, wetland inventories, stream surveys, habitat surveys, engineering reports concerning the entire drainage basin, known drainage problems, and previously completed downstream analyses.

b. Physically inspect the drainage system at the project site and downstream of it. During the inspection, investigate any problems or areas of concern that were noted during the review of resources. Identify any existing or potential capacity problems in the drainage system, flood-prone areas, areas of channel destruction, erosion and sediment problems, or areas of significant destruction of natural habitat.

c. Analyze the information gathered during the review of resources and field inspection, to determine if the project will create any drainage problems downstream or will make any existing problems worse. Note there are situations that even when minimum design standards are met the project will still have negative downstream impacts. Whenever this situation occurs, mitigation measures must be included in the project to correct for the impacts.

F. Hydraulic Model

If the design warrants hydraulic modeling, state the method used. Typical modeling programs include:

1. HEC-RAS - River Analysis Systems
2. HEC-2 - Water Surface Profiles
3. SWMM - Storm Water Management Model
4. WSPRO - Water Surface Profiles
5. HY-8 – Hydraulic Design of Highway Culverts
6. Other commercial or public domain programs approved by the Jurisdiction.

VI. Stormwater Management Design

A. **All stormwater management facilities shall be designed according to the Cedar Rapids Metropolitan Area Engineering Design Standards** at a minimum. The following references may provide helpful design information for stormwater detention and water quality issues:

1. Federal Highway Administration (1996) *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22, Washington D.C.

2. American Society of Civil Engineers (1985) Final report of the Task Committee on Stormwater Detention Outlet Control Structures. Am. Soc. Civ. Eng., New York, N.Y.

3. American Society of Civil Engineers (1992) *Design and Construction of Urban Stormwater Management Systems*. Manual of Practice No.77, New York, N.Y.

4. American Society of Civil Engineers (1998) *Urban Runoff Quality Management*. Manual of Practice No. 87, New York, N.Y.

5. Stahre, P and Urbonas, B (1990) *Stormwater Detention for Drainage, Water Quality, and CSO Management.* Prentice-Hall, Englewood Cliffs, N.J.

6. American Public Works Association (1991) *Water Quality Runoff Solutions.* Special Report No. 61, Chicago, IL.

B. Detention Basin Location

Describe basin site. Discuss existing topography and relationship to basin grading. Determine if construction will be affected by rock deposits. Also determine if a high water table precludes basin storage. Floodplain locations should be avoided.

C. Detention Basin Performance

1. For rainfall events having an expected return frequency of 10 years to 100 years inclusive, the rate of runoff from the developed site will not exceed the existing, pre-developed peak runoff from the 5-year frequency storm of the same duration unless if limited by downstream conveyance. Provide a table summarizing these release rates. Also provide a stage-storage-discharge table. These tables are also to be shown in Section I, Executive Summary. State the minimum freeboard provided, and at what recurrence interval the basin overtops.

2. Discuss the effects on the overall storm water system by detention basins in contributing offsite areas. If contributing offsite areas are presently undeveloped, discuss assumptions about future development and storm water detention.

3. Calculate the basin overflow release rate. This equals the onsite 100-year post-developed peak discharge plus the contributing offsite 100-year post developed peak discharge. Include this calculation in Section I, Executive Summary.

D. Detention Basin Outlet

1. The single-stage outlet (i.e. one culvert pipe) is not recommended because of its inability to detain post-developed runoff from storms less than the 5-year interval. In many cases, runoff from storm events less than the 5-

year recurrence interval has created erosion and sedimentation problems downstream of the detention basin.

1. A more desirable outlet has two or more stages. An orifice structure serves to detain runoff for water quality purposes and release runoff for low-flow events less than the 5-year storm. Greater storm events are usually discharged by a separate outlet.
2. Discuss the basin outlet design in terms of performance during low- and high-flows, downstream impact (discuss in Section V), and improvement of water quality (discuss in Section VI. G).
3. State whether the detention basin volume is controlled by the required flood control volume or the water quality volume.

E. Spillway and Embankment Protection

1. Design the spillway for high flows using weir and/or spillway design methods. The steady-state open channel flow equation is not intended for use in spillway design.
2. Describe methods to protect the basin during overtopping flow.

F. Note the TR-55 method of sizing detention basins may result in storage errors of 25%, and should not be used in final design. The detention basin size in final design shall be based upon actual hydrograph routing.

VII. Permits

Indicate what permits have been applied for and received. Submit IDNR approval letter and report for sites affecting unnumbered A-zones, as delineated on Flood Insurance Rate Maps.

VIII. References

Provide a list of all references cited, in bibliographical format.

IX. Appendix

A. Provide the following exhibits and calculations in the Appendix:

1. Exhibits
   a. Pre- and post-developed drainage area maps, including all contributing areas, both on-site and off-site. Also label flow patterns used to determine times of concentration.
   b. Soils map or geotechnical information.
   c. Drainage schematics - Indicate flow routings through drainage areas and detention basins.
   d. IDF Curves

e. List rainfall totals and distributions in tabular format
f. Delineated 100-year flood elevation as warranted by culvert or bridge analysis, or special drainage considerations (i.e. existing roadway with history of flooding).
g. Grading plan
h. Map showing extents of downstream analysis.
i. Wetlands report as applicable.

2. Calculations
   a. Determine runoff coefficients and curve numbers
   b. Determine times of concentration
   c. Calculations for intake capacity, sewer design, and culvert design
   d. Peak discharge calculations – Show results in tabular format and pre- and post-developed hydrographs
   e. Detention basin design – Show tabular stage-storage-discharge results and inflow/outflow hydrographs
   f. Detention basin outlet design
   g. Open channel flow calculations
   h. Erosion protection design

3. Computer Calculations
   Attach computer-generated reports and output if software was used. Underline and label results, such as the peak discharge.