Iowa Storm Water Management Manual

Design Standards Chapter 1- General Information

A. Concept

This section sets forth concepts for stormwater management objectives. Urbanization significantly alters the hydrology of a watershed as residential and commercial development leads to an increase in impervious surfaces in the drainage area. As a result, the response of an urbanized watershed to precipitation is significantly different from the response of a natural watershed. Post-developed peak runoff is expected to exceed pre-developed runoff from a similar storm event. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharge rates and runoff volumes. Factors influencing the amount (volume) of runoff include precipitation depth, the infiltrative capacity of soils, soil moisture, antecedent rainfall, cover type, the amount of impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces. A variety of inorganic, organic, and bacteriological pollutants are added to the surface runoff as it moves across the urban landscape. The greater portion of the annual pollutant loading is added to local streams from the smaller, high frequency (<1-year) storms. To accommodate the higher rates and volumes of stormwater runoff in suburban and higher-density urban development, storm sewer conveyance systems are installed to provide efficient drainage of the landscape. Additional protection is provided through detention and storage structures to control release rates to downstream systems. Traditional design considerations have been the prevention of damage to the development site, streams, drainageways, streets, public and private property from flooding, and to the reduction of soil erosion. With the implementation of the stormwater NPDES Phase I and II regulations, stormwater runoff quality is now an additional management goal for some communities.

The purpose of this manual is to present planning and design guidelines for the management of stormwater quality *and* quantity in the urban environment. Jurisdictions with Phase I and Phase II NPDES stormwater permits may use alternative methods and design strategies for meeting post- construction requirements for stormwater quality improvement, including the information in this manual. While this manual includes most of the commonly-used stormwater management BMPs, it is not a comprehensive list. The material in this manual includes the hydrologic design and implementation of stormwater quality best management practices (BMPs) and traditional analysis and design of stormwater runoff conveyance for larger storm events to prevent flooding. Additional guidance is provided on improved site planning to reduce runoff volume through reduction of impervious area and increased emphasis on infiltration practices.

The traditional management goal for detention and storage has been to manage runoff from larger rainfall events, typically greater than the 5-year recurrence interval (RI). While traditional detention practices can reduce the peak runoff flows from urban development, the increase in runoff volume and frequency of peak flows is not reduced and very little improvement in stormwater quality is accomplished.

The Engineer is encouraged to use cost-effective designs that are hydrologically and hydraulically appropriate through the use of good engineering judgment.

B. Overview of stormwater discharges

Stormwater runoff from urbanized areas is generated from a number of sources including residential areas, commercial and industrial areas, roads, highways, and bridges. Essentially, any surface that does not have the capability to pond and infiltrate water will produce runoff during storm events. When a land area is altered from a natural, undeveloped ecosystem to an urbanized land use consisting of rooftops, streets, and parking lots, the hydrology of the system is significantly altered. Water which previously ponded on the forest floor or in depressional features in grasslands, infiltrated into the soil and converted to groundwater, utilized by plants and evaporated or transpired into the atmosphere is now converted directly into surface runoff. An important measure of the degree of urbanization in a watershed is the level of impervious surfaces. As the level of imperviousness increases in a watershed, more rainfall is converted to runoff. Figure C1-S1- 1 illustrates this transformation.

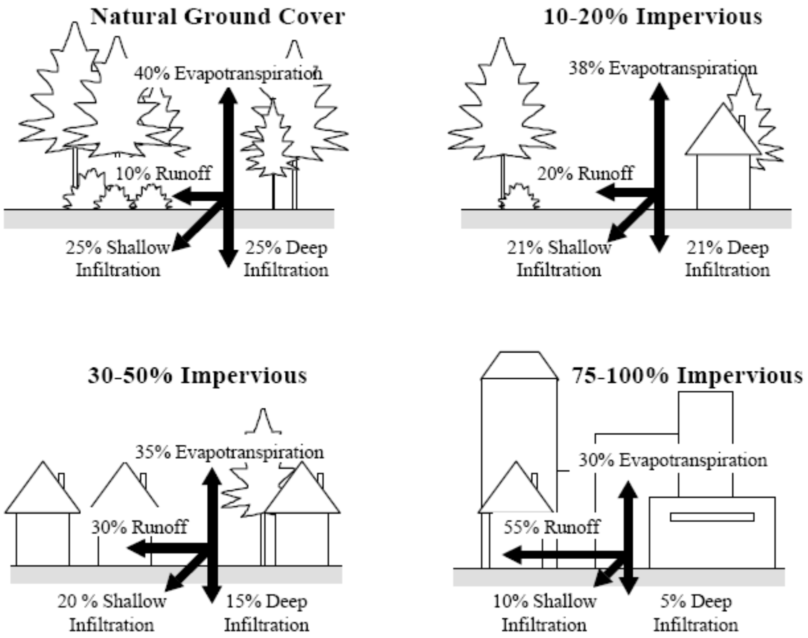

Figure C1-S1- 1: Effects of imperviousness on runoff and infiltration
Source: Adapted from Arnold and Gibbons, 1996

The traditional means of managing stormwater runoff in urban areas has been to construct a curb-and- gutter, catch basin, and storm drain network to transport the runoff volume quickly and efficiently away from the urbanized area and discharge the water to downstream surface waters. While some older and larger metropolitan areas may still have some areas served by combined sewers (storm and sanitary flow conveyance), most all communities maintain separate stormwater conveyance systems and wastewater collection systems. Several of the larger jurisdictions in Iowa still operate sections of combined sewers and these are now regulated under US EPA's Combined Sewer Overflow (CSO) regulations.

Historically, as urbanization occurred and storm drainage infrastructure systems developed in this country, the primary concern was to limit nuisance and potentially damaging flooding due to the large volumes of stormwater runoff that are generated. The environmental impacts of such practices were not considered. High flow rates of stormwater discharges can cause a number of impacts to receiving streams and may also increase the pollutant concentrations in stormwater runoff. As a result, streams that receive stormwater runoff frequently cannot convey the large volumes of water and increased flow velocity generated during runoff events, without significant degradation of the receiving stream. High velocity runoff can detach and transport significant amounts of suspended solids and associated pollutants such as nutrients and metals from the urban landscape. In addition, high flow rates in drainage channels and receiving waters can erode stream banks and channels, further increasing suspended solids concentrations in waters that receive stormwater discharges. To reduce the pollutant concentrations in runoff and receiving water impacts associated with high stormwater flow rates, best management practices (BMPs) that provide flow attenuation are frequently implemented. In areas undergoing new development or redevelopment, the most effective method of controlling impacts from stormwater discharges is to limit the amount of rainfall that is converted to runoff.

In addition to point sources such as municipal separate storm sewers and combined sewer overflows, stormwater runoff can enter receiving streams as a non-point source. Stormwater runoff from a variety of sources such as parking lots, highways, open land, agricultural land, residential areas, and commercial areas can enter waterways directly as sheet flow or as a series of diffuse, discrete flows. Due to the diffuse nature of many stormwater discharges, it is difficult to quantify the range of pollutant loadings to receiving streams that are attributable to stormwater discharges. It is much easier, however, to measure the increased stream flows during rainfall events that occur in urbanized areas and to document impacts to streams that receive stormwater runoff.

Awareness of the damaging effects stormwater runoff is causing to the water quality and aquatic life of receiving streams is a relatively recent development. Stormwater management traditionally was, and still is in many cases, a flood control, rather than a quality control, program. Local governments intending to improve the quality of their runoff-impacted streams are incorporating best management practices (BMPs) into their stormwater programs. The implementation of the stormwater NPDES Phase I and Phase II regulations require regulated jurisdictions with Municipal Separate Stormwater Systems (MS4s) to manage for water quality for construction activities and for post-construction conditions. BMPs which reduce the volume of runoff discharged to receiving streams, such as minimizing directly connected impervious surfaces, providing on-site storage and infiltration, implementing stream buffers, and restoring riparian cover along urban streams can help prevent further degradation and result in improvements of streams which receive stormwater discharges. However, in many existing urbanized areas, the cost of infrastructure changes necessary to retrofit existing stormwater drainage systems with structural BMPs – to provide for stormwater quality as well as quantity control – can be expensive. In these cases, non-structural BMPs can be implemented to reduce pollutant sources and to reduce the transfer of urban pollutants to runoff before more expensive structural controls are instituted.

The climate of a region can have a significant impact on the quantity and quality of stormwater runoff. Factors such as the length of the antecedent dry periods between storms, the average rainfall intensity, the storm duration, and the amount of snowmelt present can have significant impacts on the characteristics of runoff from an area. In areas where there is a significant amount of atmospheric deposition of particulates, stormwater runoff can contain high concentrations of suspended solids, metals, and nutrients. High-intensity, short-duration rainfall events can generate significant loadings of suspended solids in stormwater runoff. Many site factors can influence the nature and constituents contained in stormwater runoff. Factors such as the soil types, slopes, land use patterns, and the amount of imperviousness of a watershed can greatly affect the quality and quantity of runoff that is produced from an area.

C. Pollutants in urban stormwater

Urbanized areas contribute significant quantities of pollutants that accumulate on streets, rooftops and other surfaces. During rainfall or snowmelt, these pollutants are mobilized and transported from the streets and rooftops into the storm drain system, where they are conveyed and ultimately discharged to waterways. Contaminants enter stormwater from a variety of sources in the urban landscape. Urban stormwater runoff has been the subject of intensive research since the inception of the Water Quality Act in 1965. There have been numerous studies conducted to characterize the nature of urban stormwater runoff and the performance of stormwater BMPs. Data sources include the “208 Studies,” the area-wide waste treatment management plans conducted by states under section 208 of the 1972 Clean Water Act (CWA); EPA's Nationwide Urban Runoff Program (NURP); the US Geological Survey (USGS) Urban Stormwater Database; and the Federal Highway Administration (FHWA) study of stormwater runoff loadings from highways. In addition to these federal sources, there is a great deal of information in the technical literature, as well as data collected by states, counties and municipalities. A more recent data source is stormwater monitoring data collected by municipalities regulated by the Phase I NPDES storm water regulations. As part of the Phase I permit application, regulated municipalities were required to collect data from five representative sites during a minimum of three storm events.

The most comprehensive study of urban runoff was NURP, conducted by the EPA between 1978 and 1983. NURP was conducted in order to examine the characteristics of urban runoff and similarities or differences between urban land uses, the extent to which urban runoff is a significant contributor to water quality problems nationwide, and the performance characteristics and effectiveness of management practices to control pollution loads from urban runoff (US EPA, 1983). Sampling was conducted for 28 NURP projects including 81 specific sites and more than 2,300 separate storm events. NURP focused on the following ten constituents:

- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Phosphorus (TP)
- Soluble Phosphorus (SP)
- Total Kjeldahl Nitrogen (TKN)
- Nitrate + Nitrite (N)
- Total Copper (Cu)
- Total Lead (Pb)
- Total Zinc (Zn)

NURP examined both the soluble and the particulate fraction of pollutants, since the water quality impacts can depend greatly on the form that the contaminant is present. NURP also examined coliform bacteria and priority pollutants at a subset of sites. Median event mean concentrations (EMCs) for the ten general NURP pollutants for various urban land use categories are presented in Table C1-S1- 1.

Table C1-S1- 1: Median event mean concentrations for urban land use

Pollutant	Units	Residential		Mixed		Commercial		Open/Non-Urban	
		Median	COV*	Median	COV	Median	COV	Median	COV
BOD	mg/L	10	0.41	7.8	0.52	9.3	0.31	---	---
COD	mg/L	73	0.55	65	0.58	57	0.39	40	0.78
TSS	mg/L	101	0.96	67	1.14	69	0.85	70	2.92
Total Lead	µg/L	144	0.75	114	1.35	104	0.68	30	1.52
Total Copper	µg/L	33	0.99	27	1.32	29	0.81	---	---
Total Zinc	µg/L	135	0.84	154	0.78	226	1.07	195	0.66
Total Kjeldahl Nitrogen	µg/L	1900	0.73	1288	0.50	1179	0.43	965	1.00
Nitrate + Nitrite	µg/L	736	0.83	558	0.67	572	0.48	543	0.91
Total Phosphorous	µg/L	383	0.69	262	0.75	201	0.6	121	1.66
Soluble Phosphorous	µg/L	143	0.46	56	0.75	80	0.71	26	2.11

*COV: Coefficient of variation

Source: Nationwide Urban Runoff Program (US EPA 1983)

Results from NURP indicate that there is not a significant difference in pollutant concentrations in runoff from different urban land use categories. There is a significant difference, however, in pollutant concentrations in runoff from urban sources than that produced from non-urban areas.

The pollutants that are found in urban stormwater runoff originate from a variety of sources. The major sources include contaminants from residential and commercial areas, industrial activities, construction, streets and parking lots, and atmospheric deposition. Contaminants commonly found in stormwater runoff and their likely sources are summarized in Table C1-S1- 2.

The concentrations of pollutants found in urban runoff are directly related to degree of development within the watershed. This trend, shown in Table C1-S1- 3, is a summary of typical pollutant loadings from different urban land uses. A comparison of the concentration of water quality parameters in urban runoff with the concentrations in domestic wastewater is shown in Table C1-S1- 4.

Table C1-S1- 2: Sources of contaminants in urban stormwater runoff

Contaminant	Contaminant Sources
Sediment and Floatables	Streets, lawns, driveways, roads, construction activities, atmospheric deposition, drainage channel erosion
Pesticides and Herbicides	Residential lawns and gardens, roadsides, utility right-of- ways, commercial and industrial landscaped areas, soil wash-off
Organic Materials	Residential lawns and gardens, commercial landscaping, animal wastes
Metals	Automobiles, bridges, atmospheric deposition, industrial areas, soil erosion, corroding metal surfaces, combustion processes
Oil and Grease/ Hydrocarbons	Roads, driveways, parking lots, vehicle maintenance areas, gas stations, illicit dumping to storm drains
Bacteria and Viruses	Lawns, roads, leaky sanitary sewer lines, sanitary sewer cross-connections, animal waste, septic systems
Nitrogen and Phosphorus	Lawn fertilizers, atmospheric deposition, automobile exhaust, soil erosion, animal waste, detergents

Table C1-S1- 3: Typical pollutant loadings from runoff by urban land use (lbs/acre-yr)

Land Use	TSS	TP	TKN	NH_3-N	NO_2 + NO_3-N	BOD	COD	Pb	Zn	Cu
Commercial	1000	1.5	6.7	1.9	3.1	62	420	2.7	2.1	0.4
Parking Lot	400	0.7	5.1	2	2.9	47	270	0.8	0.8	0.04
HDR*	420	1	4.2	0.8	2	27	170	0.8	0.7	0.03
MDR**	190	0.5	2.5	0.5	1.4	13	72	0.2	0.2	0.14
LDR***	10	0.04	0.03	0.02	0.1	NA+	NA	0.04	0.04	0.01
Freeway	880	0.9	7.9	1.5	4.2	NA	NA	2.1	2.1	0.37
Industrial	860	1.3	3.8	0.2	1.3	NA	NA	7.3	7.3	0.5
Park	3	0.03	1.5	NA	0.3	NA	2	NA	NA	NA
Construction	6000	80	NA	NA	NA	NA	NA	NA	NA	NA

*HDR: High Density Residential
**MDR: Medium Density Residential
***LDR: Low Density Residential
+NA: Not available; insufficient data to characterize loadings

Source: Horner et al, 1994

Table C1-S1- 4: Comparison of water quality parameters in urban runoff with domestic wastewater

Parameter	Urban Runoff		Domestic Wastewater		
	Separate Sewers		Before treatment		After Secondary Treatment
	Range, mg/L	Typical, mg/L	Range, mg/L	Typical, mg/L	Typical, mg/L
COD	200-275	75	250-1,000	500	80
TSS	20-2,890	150	100-350	200	20
Total P	0.02-4.30	0.36	4-15	8	2
Total N	0.4-20.0	2	20-85	40	30
Lead	0.01-1.20	0.18	0.02-0.94	0.10	0.05
Copper	0.01-0.40	0.05	0.03-1.19	0.22	0.03
Zinc	0.01-2.90	0.02	0.02-7.68	0.28	0.08
Fecal Coliform per 100 mL	400-50,000		106 - 108		200

Source: Bastian, 1997

D. Management of stormwater quality and quantity

By utilizing site design techniques that incorporate on-site storage and infiltration and reduce the amounts of directly connected impervious surfaces, the amount of runoff generated from a site can be significantly reduced. This can reduce the necessity for traditional structural BMPs to manage runoff from newly developed areas. There are a number of practices that can be used to promote on-site storage and infiltration and to limit the amount of impervious surfaces that are generated. However, the use of on-site infiltration can be limited in certain areas due to factors such as slope, depth to the water table, and geologic conditions.

1. **Site design features** such as providing rain barrels, dry wells or infiltration trenches to capture rooftop and driveway runoff, maintaining open space, preserving stream buffers and riparian corridors, using porous pavement

systems for parking lots and driveways, and using grassed filter strips and vegetated swales in place of traditional curb-and-gutter type drainage systems can greatly reduce the amount of stormwater generated from a site and the associated impacts.

2. **Street construction features** such as placing sidewalks on only one side of the street, limiting street widths, reducing frontage requirements and eliminating or reducing the radius of cul-de- sacs also have the potential to significantly reduce the amount of impervious surfaces and therefore the amount of rainfall that is converted to runoff.

3. **Construction practices** such as minimizing disturbance of soils and avoiding compaction of lawns and greenways with construction equipment can help to maintain the infiltrative capacity of soils.

There are several guides that contain useful information regarding development practices that can limit the impacts associated with stormwater runoff (Delaware DNREC, 1997; US EPA, 1996b; Center for Watershed Protection, 1998). A general list of additional sources of BMP design information can be found at http://www.iowasudas.org/.

In areas that are already developed, flow control can be more complicated. Since a drainage infrastructure already exists, retrofitting these systems to provide flow control can be prohibitively expensive. Regional stormwater management systems can be used to manage runoff in these areas, but space considerations and high capital costs can limit their application.

Depending on site-specific constraints, however, there are a number of practices that can be incorporated on-site to reduce runoff volumes from these areas. Down spouts can be disconnected from the storm drain system and this rainfall can instead be collected and stored on a property in rain barrels to be used for watering lawns and landscaping during periods between events.

Infiltration and retention practices such as bioretention areas and infiltration trenches can be constructed to capture runoff from rooftops, lawns, and driveways and reduce the volume of runoff discharged to storm sewers. Alternatives such as using vegetated swales in place of traditional curb- and-gutter piped conveyance systems can be considered to provide treatment and infiltration of small storm runoff. Stormwater from commercial areas and golf courses can be collected and stored in ponds and subsequently used for irrigation.

Stormwater reuse can help to maintain a more natural, pre-development hydrologic balance in the watershed (Livingston et al, 1998). Parking lots can also be used as short-term storage areas for ponded stormwater, and bioretention facilities placed around the perimeter of parking lots can be used to infiltrate this water volume.

In order to reduce the impacts to receiving waters from the high concentrations of pollutants contained in the runoff, BMPs can be implemented to remove these pollutants. Where the generation of runoff cannot be avoided, end-of-pipe structural BMPs may be implemented to decrease the impacts of stormwater discharges to receiving streams. However, BMPs are limited in their ability to control impacts, and frequently cause secondary impacts such as increased temperatures of discharges to receiving streams. BMPs that can be designed to provide significant flow attenuation include grassed swales, vegetated filter strips, detention and retention basins, wetland basins, and wetland channels and swales. These BMPs can also provide the added benefit of removing pollutants such as suspended solids and associated nutrients and metals from stormwater runoff.

The environmental aspects of stormwater quantity control must be carefully balanced against the hazard and nuisance effects of flooding. Large or intense storm events or rapid snowmelt can produce significant quantities of runoff from urban areas with high levels of imperviousness. This runoff must be rapidly transported from urbanized areas in order to prevent loss of life and property due to flooding of streets, residences, and businesses. This is frequently accomplished by replacing natural drainage paths in the watershed with paved gutters, storm sewers, or other artificial means of drainage. These drainage systems can convey runoff at a faster rate than natural drainage paths, allowing rapid transport of runoff away from areas where flooding is likely to occur. However, as large quantities of runoff are conveyed rapidly from the urban landscape and discharged to receiving streams, downstream areas can flood. Following urbanization, large volumes of runoff can be produced from even small storm events due to the high amounts of impervious surfaces. The increased volume and rate of runoff to local urban streams often occurs much more frequently following urbanization. Therefore, design of stormwater drainage systems must always balance flood protection with ecological concerns.

In highly urbanized and densely populated cities, little opportunity exists for retrofitting storm drainage systems with BMPs to provide water quantity control due to flooding considerations. The large area of impervious surfaces in heavily urbanized areas produce large quantities of runoff. Rapid conveyance by the storm drain system is frequently the only option that exists in order to prevent flooding of yards, streets, and basements. In these areas, the most appropriate BMPs are those that limit the generation of pollutants or remove pollutants from the urban landscape. With this principle in mind, a unique opportunity exists in newly developing areas or in more sparsely populated suburban areas to use BMPs that control runoff at the point of generation, instead of trying to manage it at the point of discharge to the receiving stream.

When rainfall is managed as a *resource* instead of as a waste requiring treatment, future problems with quantity control may be avoidable. When rainfall is managed at the site level by promoting the concepts of conservation design and by providing on-site storage, infiltration, and usage of rainfall for irrigation of the urban landscape, the need for traditional curb-and-gutter storm drainage system can be reduced. The need for constructing and maintaining capital-, land-, and maintenance-intensive regional BMPs to manage large flows from developed watersheds may be reduced to some measurable extent by distributed, site-level BMPs that provide a water quality benefit as well as reducing the overall volume of downstream runoff.

It is important to note that there will always be a need in the urban environment to provide systems to convey the runoff from the larger, low frequency storm events to protect homes, businesses, and local infrastructure from damage due to flooding. Nuisance flooding of downstream areas can also be limited by reducing the overall volume of water draining from a watershed. Limiting the discharge of large volumes of stormwater to urban streams can help to prevent the degradation of these streams to the point of being non-supporting of a designated use. Comprehensive urban stormwater planning and design should include management of runoff from the entire range of storm events to improve water quality and prevent damage from flooding.

E. Permit requirement overview

NPDES Stormwater Permit Requirements

Phase I areas (large urban areas and major industries)

- Under permit since early 1990s
- Individual municipal permits all include a program element for new development or "post-construction" BMPs

Phase II areas (small urban areas and additional industries)

- Under Iowa Individual MS4 Permit since early 2003
- Permit includes new development requirements

Figure C1-S1- 2: NPDES stormwater permit requirements

New development BMPs are required under NPDES permits shown in Figure C1-S1- 2. The intent of incorporating BMPs in new private development and public capital projects is to prevent any net detrimental change in runoff quantity or quality resulting from new development and redevelopment. Typical permit requirements that are now being included in all Phase I MS4 permits and are incorporated in the Phase II Iowa General Permits include:

- Specific thresholds for "priority projects" that must include both source and treatment control BMPs in the completed projects (typical project thresholds are discussed in Chapter 1, section 3).
- A list of source control (both non-structural and structural) BMPs and treatment control BMPs to be included or considered
- Specific water quality design volume and/or water quality design flow rate for treatment control BMPs
- A requirement for flow control BMPs when there is potential for downstream erosion
- Adopt a standard model or template for identifying and documenting selected BMPs, including a plan for long-term operations and maintenance of BMPs

Permittees might also include the use of regional or watershed-based programs as alternatives to incorporating all of the BMPs to be on-site or project-based. Under this approach, programs would be developed and adopted that address specific water quality and pollutant concerns, achieve at least equivalent pollutant reduction as would have been required for all new development and redevelopment projects in the watershed through project-based BMPs, and can provide additional benefits by reducing impacts from existing developed areas. Where regional or watershed programs are developed, there will typically need to be a partnership between the planning agencies or permittees and the development community to clearly define the approach for satisfying the permit requirements and evaluating choices between project-based and regional BMPs. State and federal permit requirements are discussed in more detail in Chapter 1, section 3.

A. Project scope and analysis

Iowa has implemented individual Phase II Stormwater NPDES permits for selected jurisdictions in the State (see Chapter 1, section 3). The Phase II programs require BMPs to be implemented by developers, property owners, and public agencies engaged in new development or redevelopment activities. Understanding new development and redevelopment in the context of the project life cycle is important for proper selection and implementation of BMPs as shown in Figure C1-S2- 1. The concept, planning, and design phases of a project may be spread over a period of months to many years. BMPs incorporated into the concept, planning, and design phase are much more cost-effective than the retrofit of BMPs.

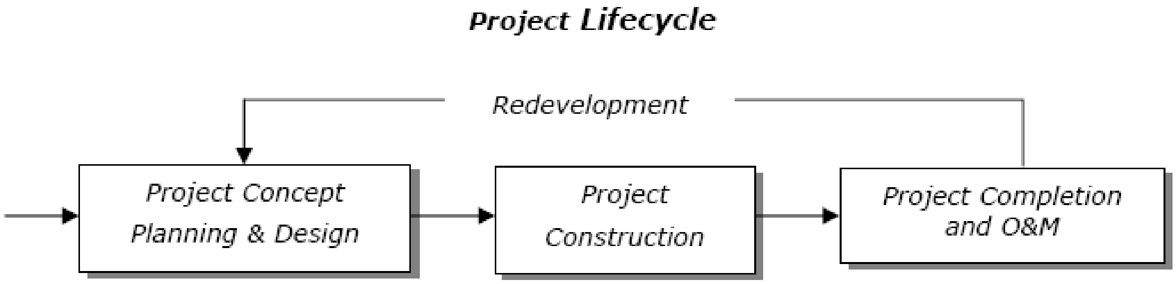

Figure C1-S2- 1: Project lifecycle
Source: California Stormwater BMP Handbook

An effective mechanism for documenting the incorporation of stormwater quality controls into new development and redevelopment projects on a site, regional, or watershed basis is to develop a written plan known as a Stormwater Management Plan, or SMP. An effective SMP clearly sets forth the means and methods for long-term stormwater quality protection.

B. Developing a stormwater management plan

Developing an effective stormwater management plan depends on making effective BMP choices. This section describes the basic steps and processes used to develop a plan with appropriate BMPs. Such a plan would include reviewing the full suite of BMPs that are available and identifying the dominant site factors that should go into the decision-making process. Assessment of the regional area, specific site conditions, site constraints, site hydrology, and project type are central to successful planning to minimize pollutants during development as well as during the life of the project. The basic steps in the stormwater management plan process are:

- Assess site and watershed conditions
- Understand hydrologic conditions of concern
- Evaluate pollutants of concern
- Identify candidate BMPs
- Develop the plan for BMP Maintenance

The specific requirements of a Stormwater Management Plan are usually specified by the local jurisdiction based on requirements in their MS4 permit or as part of a local design requirement for project development. A number of jurisdictions in Iowa use a Project Drainage Report format, as discussed in more detail in Chapter 1, section 5.

The three phases of the project planning process are:

1. **Phase 1: Collection and analysis:**
   a. Identify resource problems, opportunities, and concerns in the planning area.
   b. Identify the project scope, objectives, and engineering design tasks.
   c. Inventory the existing conditions at the project site and any specific economic and/or social constraints.
   d. Complete an analysis of the pre-development and post-development site conditions related to soils,

topography, and existing hydrology.

2. **Phase 2: Decision support:**
    a. Develop a set of alternative solutions that meet the project objective and meet the design criteria established for the project.
    b. Evaluate the alternatives to determine their relative effectiveness, technical and economic feasibility, and life-cycle considerations for operation and maintenance.
    c. Select the alternative that meets owner and jurisdiction requirements and establish a final design and construction cost estimate.

3. **Phase 3: Project implementation and evaluation:**
    a. Provide a final design and specification for project implementation.
    b. Conduct post-construction maintenance and performance evaluation.

A more detailed procedure related to stormwater management is provided below:

1. **Assess site conditions.** Site and watershed assessment includes assessing and describing the pre- and post-development site conditions and how the site fits into the overall watershed or drainage area. The assessment should include sufficient detail to allow for assessment of the need for and application of stormwater BMPs. Information typically required is listed below:

    a. Site information:
    1) Historic features
    2) Existing features
    3) Planned features
    4) Drainage patterns
    5) Discharge locations

    b. Vicinity information:
    1) Major roadways
    2) Geographic features or landmarks
    3) Area surrounding the site
    4) General topography
    5) Area drainage

    c. Watershed or drainage area information:
    1) Received waters
    2) Watershed drainage

2. **Understand hydrologic conditions of concern.** Development in urban areas increases the amount of impervious areas and changes the landform, and therefore the runoff hydrograph. Modifications to the runoff hydrograph change downstream hydrology. New development typically results in more runoff volume and higher rates of runoff. Many BMPs, such as detention basins which detain volume, effectively remove the top part of the hydrograph, but extend the duration of flow as illustrated in
3. Figure C1-S2- 2.

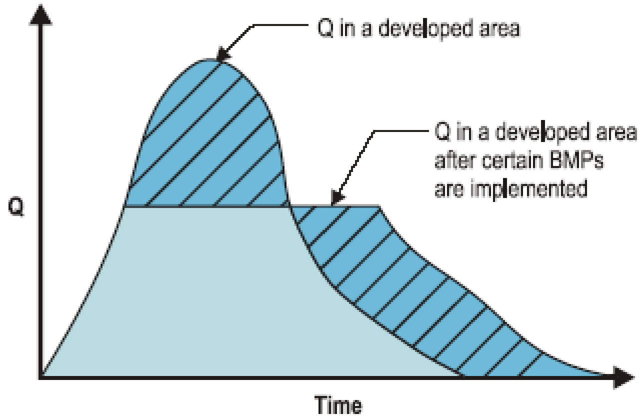

Figure C1-S2- 2: Hydraulic alteration after traditional detention
Source: California Stormwater BMP Handbook

Over the last 12-15 years, the emerging consensus is that while such actions mitigate peak flows, the increased duration associated with these actions has impacts as well. Problems include washing out habitat, eroding streambed and banks, and changing downstream ecosystems. In addition to volume, rate, and duration, other factors, such as the amount of energy in the water and peak flow, impact downstream conditions. A comprehensive understanding of these factors is necessary to develop meaningful stormwater management plans. To be effective, these solutions must be done on an individual watershed basis.

Ideally, the runoff hydrograph that exists after construction would parallel the pre-construction hydrograph. It is difficult to ask upstream developers to be concerned about what is happening several miles below them in a watershed. On the other hand, stormwater planners and policy makers must ask what can be done to make the watershed more stable, and what enhancements are needed to balance impacts to the watershed from development. A downstream assessment should be completed to make qualitative predictions concerning channel impacts due to changes in runoff or sediment loads within the watershed.

The best way to resolve the watershed stability and balance issues is through a comprehensive drainage master plan. A formal drainage study considers the project area’s location in the larger watershed, topography, soil and vegetation conditions, percent impervious area, natural and infrastructure drainage features, and any other relevant hydrologic and environmental factors. As part of the study, the drainage report includes:

- Field reconnaissance to observe downstream conditions
- Computed rainfall and runoff characteristics, including a minimum of peak flow rate, flow velocity, runoff volume, time of concentration, and retention volume
- Establishment of site design, source control, and treatment control measures to be incorporated and maintained to address downstream conditions of concern

4. **Evaluate pollutants of concern.** The stormwater management plan should identify anticipated pollutants of concern. Pollutants frequently identified in the 303(d) list for surface waters in Iowa include sediment, nitrogen, phosphorous, indicator bacteria (i.e., fecal coliform), and pesticides. For urban stream segments, additional pollutants of concern are loading of metals and gross pollutants (trash, debris, and floatables). With respect to metals, the most commonly listed metals are mercury, copper, lead, selenium, zinc, and nickel.

   The procedures should include, at a minimum, consideration of:
   - Receiving water quality (including pollutants for which receiving waters are listed as impaired under Clean Water Act section 303(d)
   - Land use type of the development project and pollutants associated with that land use type
   - Pollutants expected to be present on site
   - Changes in stormwater discharge flow rates, velocities, durations, and volumes resulting from the development project
   - Sensitivity of receiving waters to changes in stormwater discharge flow rates, velocities, durations, and

volumes

Pollutants of concern for a water body can extend beyond those pollutants listed in a 303(d) list as causing impairment. For example, trash is a pollutant of concern in most communities, yet very few, if any urban stream segments in Iowa are presently listed as impaired by trash. A pollutant need not be causing an immediate impairment to be considered when developing a stormwater management plan.

5. **Identify candidate BMPs.** Selecting BMPs based on pollutants of concern is a function of site constraints, constituents of concern, BMP performance, stringency of permit requirements, and watershed specific requirements such as TMDLs. Pollutants of concern are especially important in water-limited stream segments and must be carefully reviewed in relationship to BMP performance. BMP performance is discussed further in Chapter 4. When no specific pollutant has been targeted for removal, local jurisdiction requirements may address pollutant removal through flow- and/or volume-based requirements. Under these circumstances, cost can become an important criterion in BMP selection.

   Large reductions in treatment BMP size and investment can be made by:
   - Reducing runoff that needs to be captured, infiltrated, or treated
   - Controlling sources of pollutants

   These two strategies are the most effective in managing stormwater. A third strategy includes implementation of treatment BMPs. The principles and methodologies for incorporating these strategies into site facility planning and design are discussed in Chapter 4.

   Determine BMP size/capacity. Based on the selected BMPs, the capacity and primary design sizing criteria must be established using a combination of local hydrology, project drainage characteristics (e.g., percent imperviousness or runoff coefficient), and the local permit and jurisdictional sizing requirements. BMPs will be either volume-based or flow-based, as discussed in more detail later in this manual and must be able to effectively treat the design quantity.

   Peak storm event flows must also be taken into account if the BMP is a flow-based BMP, or a volume-based BMP that must also safely pass the design storm (e.g., an in-line detention basin). The volume-based BMP can safely pass the design peak event while maintaining its water quality functions up to the water quality design volume.

6. **Develop plan for BMP ownership and maintenance responsibility.** BMP maintenance arrangements take should place during the planning phase of development and redevelopment projects. A permittee is committed to providing for water quality protection by requiring that a mechanism for ongoing, long-term maintenance of BMPs is in place. To ensure that BMP maintenance will take place, permittees should require evidence that project proponents have executed an approved method of BMP maintenance, repair, and replacement before construction approvals are issued. Mechanisms used by permittees to assign responsibility for maintenance to public and private sector project proponents include:
   - Covenants
   - Maintenance agreements
   - Conditional use permits
   - Deed restrictions
   - Other legal agreements

   The jurisdiction may also require an Operation and Maintenance (O&M) plan be prepared by the project proponents if the ownership of the stormwater management BMPs remains with the project owner or designated successor legal entity. These plans are normally attached to approved maintenance agreements and describe a designated party to manage:
   - BMPs
   - Employee training program and duties
   - Operating schedule
   - Maintenance frequency
   - Routine service schedule
   - Specific maintenance activities

- Copies of resource agency permits
- Funding
- Other necessary activities

Permittees often require annual inspection and servicing of all BMPs within maintenance agreements, and O&M forms documenting all required maintenance activities. The party responsible for the O&M plan may be required to retain O&M forms for at least five years. A BMP maintenance plan is particularly valuable during ownership transitions. For example, when a developer transitions maintenance to a homeowners association, or when a developer turns over maintenance to a new owner. The BMP maintenance plan is also important when valuating properties for acquisition, allowing long-term costs associated with BMPs to be factored into the property purchase agreement.

C. Planning and design principles

Planning and design for water quality protection employs three basic strategies in the following order of relative effectiveness (See Figure C1-S2- 3):

- Reduce post-project runoff
- Control sources of pollutants
- Treat contaminated stormwater runoff before discharging it to natural water bodies

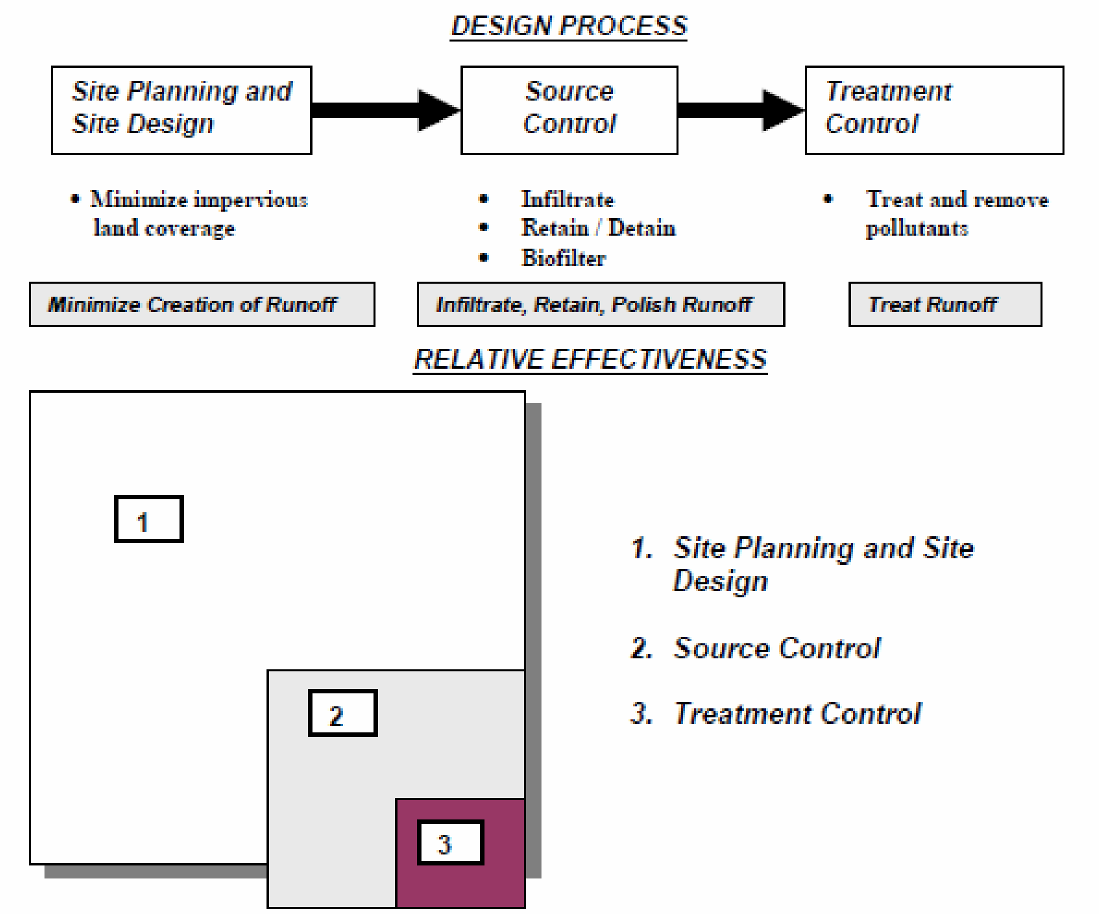

Figure C1-S2- 3: Planning principles

These principles are consistent with the typical permit and local program requirements for projects that require a consideration of a combination of source control BMPs (that reduce or eliminate runoff and control pollutant sources) and treatment control BMPs with specific quantitative standards. The extent to which projects can incorporate strategies that reduce or eliminate post project runoff will depend upon the land use and local site characteristics of each project.

Reduction in post project runoff offers a direct benefit by reducing the required size of treatment controls to meet the requirements included in the local permit. Therefore, project developers can evaluate tradeoffs between the incorporation of alternative site design and source control techniques that reduce runoff and pollutants, and the size of required treatment controls either included as part of the project or as a commitment to an offsite watershed-based program.

1. **Reduce runoff.** The principle of runoff reduction begins by recognizing that developing or redeveloping land within a watershed inherently increases the imperviousness of the areas and therefore the volume and rate of runoff and the associated pollutant load; and outlines various approaches to reduce or minimize this impact through planning and design techniques. The extent of impervious land covering the landscape is an important indicator of stormwater quantity and quality and the health of urban watersheds. Impervious land coverage is a fundamental characteristic of the urban and suburban environment -- rooftops, roadways, parking areas and other impenetrable surfaces cover soils that, before development, allowed rainwater to infiltrate. The results of the NURP studies in the 1980's indicated a predictable relationship between runoff volume and the % imperviousness of the drainage area (US EPA 1983). Without these impervious coverings, inherent watershed functions would naturally filter rainwater and prevent receiving water degradation.

   Impervious surfaces associated with urbanization can cause adverse receiving water impacts in the following ways:
   - Rainwater is prevented from filtering into the soil, adversely affecting groundwater recharge, and reducing base stream flows.
   - Because it cannot filter into the soil, more rainwater runs off, and runs off more quickly; causing increased flow volumes, accelerating erosion in natural channels, and reducing habitat and other stream values. Flooding and channel destabilization often require further intervention. As a result, riparian corridors are lost to channelization, further reducing habitat values.
   - Pollutants that settle on the impervious pavements and rooftops are washed untreated into storm sewers and nearby stream channels, increasing pollution in receiving water bodies.
   - Impervious surfaces retain and reflect heat, increasing ambient air and water temperatures. Increased water temperature negatively impacts aquatic life and reduces the oxygen content of nearby water bodies.

   Techniques for reducing runoff range from land use planning on a regional scale by local jurisdictions (permittees) or other local planning agencies, to methods that can be incorporated into specific projects. These techniques include actions to:
   - Manage watershed impervious area
   - Minimize directly connected impervious areas
   - Incorporate reduced discharge areas
   - Include self-treatment areas
   - Consider runoff reduction areas.

   a. **Manage watershed impervious area.** Land use planning on the watershed scale is a powerful tool to manage the extent of impervious land coverage. This planning has two elements. First, identify open space and sensitive resource areas at the regional scale and target growth to areas that are best suited to development; and second, plan development that is compact to reduce overall land conversion to impervious surfaces and reliance on land- intensive streets and parking systems.

   Impervious land coverage is a practical measure of environmental quality because:
   - It is quantifiable, meaning that it can be easily recognized and calculated.
   - It is integrative, meaning that it can estimate or predict cumulative water resource impacts independent of specific factors, helping to simplify the intimidating complexity surrounding non-point source pollution.
   - It is conceptual, meaning that water resource scientists, municipal planners, landscape architects, developers, policy makers, and citizens can easily understand it.

   Water resource protection at the local and regional level is complex. A wide variety of regulatory agencies, diverse sources of non-point source pollution, and a multitude of stakeholders make it difficult to achieve a consistent, easily understandable strategy for watershed protection. Impervious land coverage is a scientifically sound, easily communicated, and practical way to measure the impacts of new development on water quality.

b. **Minimize directly connected impervious areas (DCIA).** Any impervious surface that drains into a catch basin, area drain, or other conveyance structure is a "*directly connected impervious area*." As stormwater runoff flows across parking lots, roadways, and paved areas, the oils, sediments, metals and other pollutants are collected and concentrated. If this runoff is collected by a drainage system and carried directly along impervious gutters, into surface or curb intake openings, or in closed underground pipes; it has no opportunity for filtering by plant material or infiltration into the soil. It also increases in speed (reducing the runoff time of concentration) and volume, which may cause higher peak flows downstream, and may require larger capacity storm drain systems, and increasing flood and erosion potential.

Impervious areas directly connected to the storm drain system are the greatest contributor to non-point source pollution. The first effort in site planning and design for stormwater quality protection is to minimize the directly connected impervious area, as shown in
Figure C1-S2- 4.

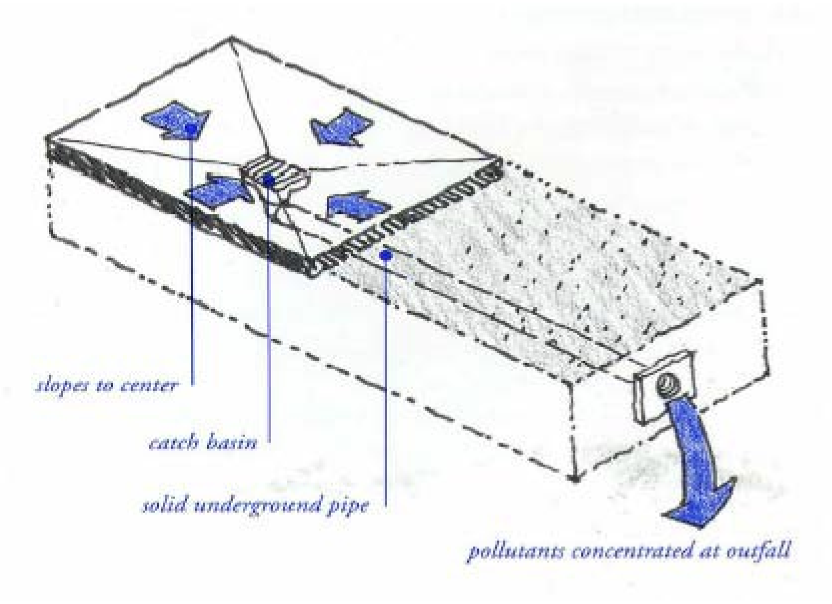

Figure C1-S2- 4: Directly connected impervious area
Source: California Stormwater BMP Handbook

Minimizing directly connected impervious areas can be achieved in two ways:

- Limiting overall impervious land coverage
- Directing runoff from impervious areas to pervious areas for infiltration, detention, or filtration

Strategies for reducing impervious land coverage include:

- Cluster rather than sprawl development
- Taller narrower buildings rather than lower spreading ones
- Sod or vegetative "green roofs" rather than conventional roofing materials
- Narrower streets rather than wider ones
- Pervious pavement for light duty roads, parking lots and pathways

Example strategies for infiltration, retention/detention, and bio-filtration include:

- Vegetated swales
- Vegetated basins (ephemeral – seasonally wet)
- Constructed ponds and lakes (permanent- always wet)
- Crushed stone reservoir base rock under pavements or in sumps
- Infiltration trenches
- Infiltration basins
- Bioretention areas and raingardens

Unlike conventional storm drain systems that convey water beneath the surface and work independently of surface topography, a drainage system for stormwater infiltration can work with natural landforms and land uses to become a major design element of a site plan. Solutions that reduce DCIA prevent runoff, detain or retain surface water, attenuate peak runoff rates, benefit water quality and convey stormwater. Site plans that apply stormwater management techniques use the natural topography to suggest the drainage system, pathway alignments, optimum locations for parks and play areas, and the most advantageous locations for building sites. In this way, the natural landforms help to generate an aesthetically pleasing urban form integrated with the natural features of the site. This planning approach is often referred to as the “better site design” methodology.

c. **Incorporate reduced discharge areas.** An area within a development project can be designed to infiltrate, retain, or detain the volume of runoff requiring treatment from that area. The term “reduced discharge” in this philosophy applies at stormwater treatment design storm volumes. For example, consider an area that functionally captures and then infiltrates the 80th percentile storm volume. If permits require treatment of the 80th percentile storm volume, the area generates no treatment-required runoff.

Site design techniques available for designing areas that could produce no treatment-required runoff include:

- Retention/detention ponds
- Wet ponds
- Infiltration areas
- Large fountains
- Retention rooftops
- Green roofs (roofs that incorporate vegetation)

Infiltration areas, ponds, fountains, and green roofs can provide dual functionality as stormwater retention measures and development amenities. Detention ponds and infiltration areas can double as playing fields or parks. Wet ponds and infiltration areas can serve dual roles when meeting landscaping requirements. When several reduced discharge areas are incorporated into a development design, significant reductions in volumes requiring treatment may be realized.

Figure C1-S2- 5 illustrates a residential tract, and a tract incorporating reduced discharge area techniques (infiltration areas). The reduced discharge area-designed tract represents a design to infiltrate (i.e., achieve reduced discharge from) a portion of the tract’s runoff, reducing total runoff from the tract. The application of reduced discharge methodology in site design requires a careful consideration of the overall site characteristics, local jurisdiction planning and design requirements, and overall acceptance of the site features and individual BMPs by the residents in the development.

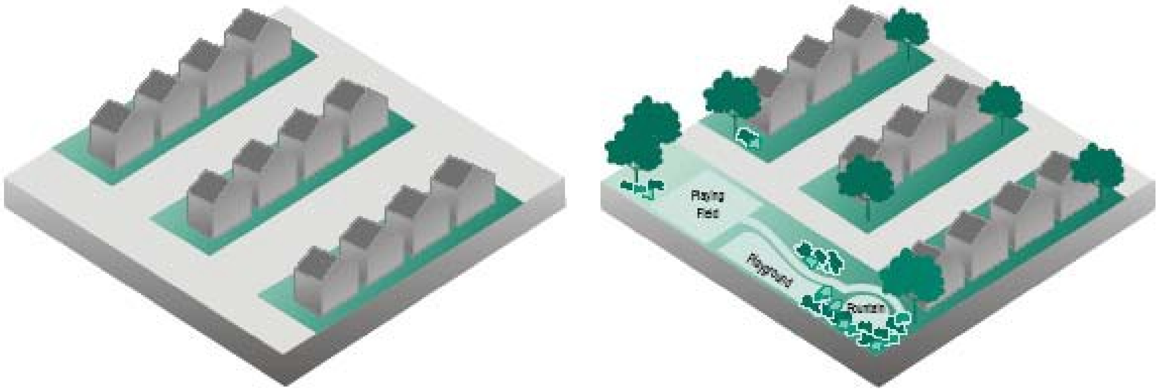

Figure C1-S2- 5: Use of reduced discharge areas to reduce runoff volume
Source: California Stormwater BMP Handbook

d. **Include self-treatment areas.** Developed areas may provide self-treatment of runoff if properly designed and drained. Self-treating site design techniques include:

- Conserved natural spaces

- Large landscaped areas (including parks and lawns)
- Grass/vegetated swales
- Turf block paving areas

The infiltration and bio-treatment inherent to such areas may provide the treatment control necessary. These areas therefore act as their own BMP, and no additional BMPs to treat runoff should be required. As illustrated in Figure C1-S2- 6, site drainage designs direct runoff from self-treating areas away from other areas of the site that require treatment of runoff. Otherwise, the volume from the self-treating area will only add to the volume requiring treatment from the impervious area. Likewise, under this philosophy, self-treating areas receiving runoff from treatment-required areas would no longer be considered self-treating, but rather would be considered as the BMP in place to treat that runoff. These areas could remain self-treating or partially self-treating areas, if adequately sized to handle the excess runoff addition.

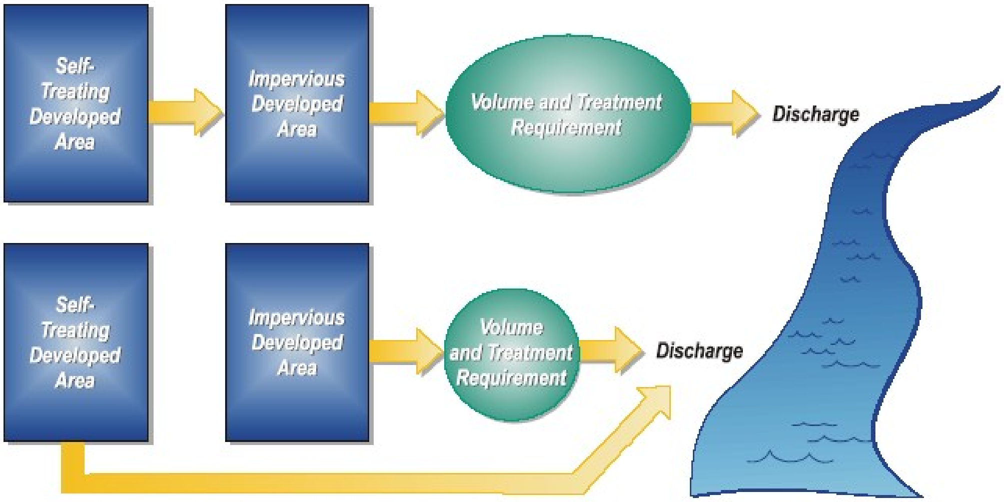

Figure C1-S2- 6: Use of self-treatment areas to reduce runoff volume
Source: California Stormwater BMP Handbook

e. **Consider runoff reduction areas.** Using alternative surfaces with a lower coefficient of runoff or C-Factor may reduce runoff from developed areas. The C-Factor is a representation of the surface's ability to produce runoff. The runoff coefficient C is used in the rational method to predict peak runoff rate from a drainage area. Other coefficients of runoff include the CN used in the NRCS TR-55 method, and the volumetric runoff coefficient Rv used in the calculation of the Water Quality Volume (WQv). Surfaces that produce higher volumes of runoff are represented by higher C-Factors, such as impervious surfaces. Surfaces that produce smaller volumes of runoff are represented by lower C-Factors, such as more pervious surfaces. Table C1-S2-1 compares the C-Factors of conventional paving surfaces to alternative, lower C-Factor paving surfaces. By incorporating more pervious, lower C-Factor surfaces into a development (see

f. Figure C1-S2- 7), lower volumes of runoff may be produced. Lower volumes and rates of runoff translate directly to lower treatment requirements.

Table C1-S2- 1: Conventional paving surface small storm C-factors vs. alternative paving C-factors

Conventional Paving Surface C-Factors	Reduced C-Factor Paving Alternatives
Dense PC Concrete Patio/Plaza (0.80 to 0.97)	Decorative Unit Pavers on Sand (0.10)
Asphalt Parking Area (0.73 to 0.95)	Turf Block Overflow Parking Area (0.15)
	Pervious Concrete (0.4)
	Porous Asphalt (0.55)
	Open jointed blocks w/0.8 to 0.2 aggregate fill (0.30 to 0.50)

	Crushed Aggregate (0.3 to 0.7)
	Turf, grass cover > 50% (0.05 to 0.53)

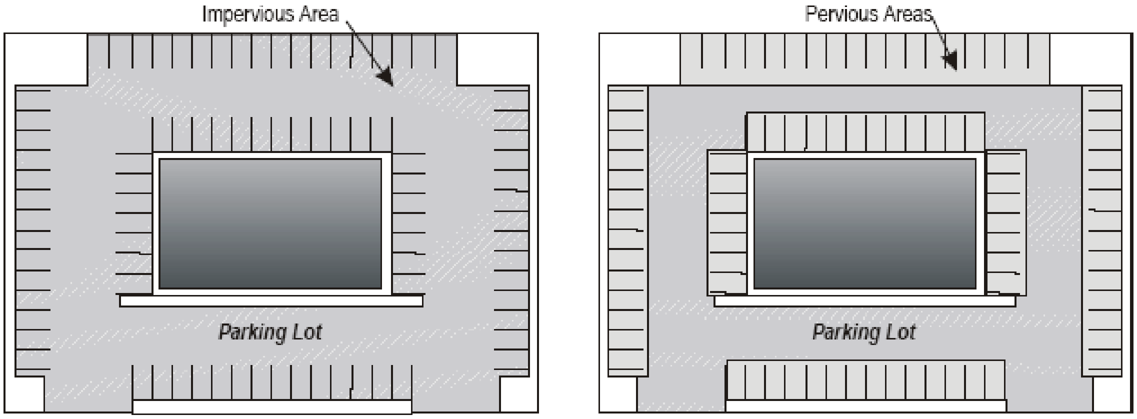

Figure C1-S2- 7: Impervious parking lot vs. parking lot with some pervious surfaces
Source: California Stormwater BMP Handbook

Site design techniques that incorporate pervious materials may be used to reduce the C-Factor of a developed area, reducing the amount of runoff requiring treatment. These materials include:

- Portland cement pervious concrete
- Porous asphalt
- Turf block
- Brick (un-grouted)
- Natural stone
- Concrete unit pavers
- Crushed aggregate
- Cobbles
- Wood mulch

Other site design techniques, such as disconnecting impervious areas, preservation of natural areas, and designing concave medians may be used to reduce the overall C-Factor of development areas. A summary list of site design and landscaping techniques is included in

Table C1-S2- 2 and indicates whether they are applicable for use in reduced discharge areas, self- treating areas, and runoff reduction areas. Several different techniques can be implemented within the same design philosophy. Where feasible, combinations of multiple techniques may be incorporated into new development and redevelopment projects to minimize the amount of treatment required.

Table C1-S2- 2: Site design and landscaping techniques

Site Design and Landscape Techniques	Design Criteria		Design Philosophy		
	Volume-Based Design	Flow-Based Design	Reduced Discharge	Self – Treating	Runoff Reduction
Permeable Pavements	X				X
Pervious concrete	X				X
Porous asphalt	X				X
Turf block	X			X	X
Un-grouted brick	X				X
Un-grouted natural stone	X				X
Un-grouted concrete unit pavers	X				X
Unit pavers on sand	X				X
Crushed aggregate	X				X
Wood mulch	X				X
Streets					
Urban curb/swale system	X	X			X
Rural swale system	X	X			X
Dual drainage system	X	X			X
Concave median	X	X	X		X
Pervious island	X	X			X
Parking Lots					
Hybrid surface parking lot	X				X
Pervious parking surface	X				X
Pervious overflow parking	X			X	X
Driveways					
Not directly connected impervious driveway		X			X
Paving only under wheels	X			X	X
Landscape					
Grass/vegetated swales	X	X		X	X
Extended detention (dry) basins	X		X	X	X
Wet ponds	X		X	X	X
Bioretention areas	X		X	X	X

Adapted from California Stormwater BMP Handbook

2. **Control sources of pollutants.** There are a number of items that can be routinely designed into a project that function as source controls once a project is completed. They include such items as marking new drain inlets and posting informational signs, improving landscape planning and efficient irrigation methods, using water quality-friendly building materials, implementing roof runoff controls, properly designing outdoor material and trash storage areas, and permanently protecting slopes and channels from erosion. They also include design features for specific workplace or other activity areas, such as vehicle washing areas, outdoor processing areas, maintenance bays and docks, and fueling areas.

Design of BMPs to control workplace exposure to pollutants is guided by three general principles:

a. **Prevent water from contacting work areas.** Work and storage areas should be designed to prevent stormwater runoff from passing through shipping areas, vehicle maintenance yards, and other work places before it reaches storm drains. The objective is to prevent the discharge of water laden with grease, oil, heavy metals, and process fluids to surface waters or sensitive resource areas.

b. **Prevent pollutants from contacting surfaces** that come into contact with stormwater runoff. Precautionary measures should be employed to keep pollutants from contacting surfaces that come into contact with runoff. This means controlling spills and reviewing operational practices and equipment to prevent pollutants from coming into contact with storm or wash water runoff.

c. **Treat water before discharging it to the storm drain.** Treatment of polluted runoff should be employed as a last resort. If source control options are not possible, treatment measures that comply with NPDES permit requirements must be adopted.

d. **Community programs to educate** homeowners and commercial facilities on protocols to improve management of fertilizer application on lawns, and associated controls for managing the use of other pollutants can be effective as well.

3. **Treat runoff.** In the traditional sense, stormwater and street design systems were designed to achieve a single objective – to convey water off-site as quickly as possible. The primary concern of conveyance systems is to protect property from flooding during large, infrequent storms. Drainage systems designed to meet this single volume control objective fail to address the environmental effects of non-point source pollution and increases in runoff volume and velocity caused by development. Future drainage systems must meet multiple purposes: protect property from flooding, control stream bank erosion, and protect water quality. To achieve this, designers must integrate conventional flood control strategies for large, infrequent storms with stormwater quality control strategies.

There are several basic water quality strategies for treating runoff:
- Convey runoff slowly through vegetation, infiltrate into the soil
- Retain/detain runoff for later release with the detention providing treatment
- Treat runoff on a flow-through basis using various treatment technologies

Solutions should be based on an understanding of the water quality and economic benefits associated with design and construction of systems that utilize or mimic natural drainage patterns.

Site designs should be based on site conditions and use them as the basis for selecting appropriate stormwater quality controls. The drainage system design process considers variables such as local climate, the infiltration rate and erosion potential of the soils, and slope. Many of the negative impacts associated with urban development can be alleviated if policy alternatives encourage developers to protect and restore habitat quality and quantity, include measures to improve water quality, and provide buffers between development and stream corridors.

Unlike conveyance models, which are assessed by simple quantitative measures (flood control volumes and economics), water quality designs must optimize for a complex array of both quantitative and qualitative standards, including engineering worthiness, environmental benefit, horticultural sustainability, aesthetics, functionality, maintainability, economics, and safety.

D. Planning and design conditions

1. Planning and design data provided by the Engineer should demonstrate that investigations include:

a. Documentation of the pre-existing site conditions and site hydrology. Characterization of the development site with respect to soils (HSG), topography, and existing natural drainage.
b. The function of the proposed and/or existing streets as part of the storm water system, including level of anticipated flooding of street surfaces and encroachment into driving lanes.

   c. Gutters and intakes are adequate to prevent excessive flooding of streets and right-of ways.
   d. Culverts and storm pipes are designed to sufficient size (flow-based design).
   e. Adequate overland relief with proper easements for storms larger than the design storm for local flooding (see Chapter 2).
   f. Street grades are coordinated with lot drainage; lot drainage slopes will not be less than 1-½% to minimize ponding, and not excessive to cause uncontrollable erosion.
   g. Spot elevations should be listed at each rear lot corner, at the mid-point of the side yard line, and along the proposed drainage ways and easements.

2. The Engineer should evaluate the management alternatives to handle the runoff and select the optimum design that will strike a balance between initial capital costs, maintenance costs, and public protection. Consideration should also be given to safety, environmental protection, and maintenance of the drainage system. Care should be exercised in developing drainage systems that depend solely on a specified protection level. Designers need to keep in mind that rainfall and runoff events seldom, if ever, occur at a specified frequency or duration. Therefore, at critical locations, additional protection should be considered, depending upon the drainage basin characteristics and the degree of protection necessary downstream.

   The following are examples that include but are not limited to, situations where damage can occur on the specified design frequency and duration in which emergency spillways or outlets are not made available.
   - Surface water flow conveyances between buildings, such as housing, and in backyards
   - Enclosed storm sewers adjacent to private property, where a single inlet could be plugged, resulting in significant damage to adjacent property
   - Single-lot or multiple-lot storm water detention

3. In addition to the potential damage in these particular areas, maintenance of stormwater BMPs and conveyance systems needs to be considered. Private-owner or homeowner association maintenance has the advantage of simplified responsibilities, without direct cost to the general taxpayer. The disadvantage is when the homeowner or association is not capable of maintaining a stormwater system on a continuous basis. Other options to be considered are delayed transfer of ownership from builder to homeowner’s association, to ensure proper stormwater conveyance system operation; or the issuance of a performance or maintenance bond by the builder, valid for a specified period of time. When the stormwater conveyance system is significant enough that the normal individual or group of individuals does not have the means for continuous maintenance, other maintenance alternatives need to be developed that involve Jurisdiction-owned facilities. This would involve construction and maintenance by the Jurisdiction, funded through:
   - A one-time charge to the developer that is placed into a stormwater escrow account for immediate or future stormwater improvements
   - A stormwater utility assessment (either a one-time lump sum or monthly charge)
   - Construction of the stormwater facility BMPs by the developer to meet the local jurisdictions post-construction runoff control requirements (i.e. ordinance) that would be owned and maintained by the Jurisdiction (similar to streets, water mains, and sanitary sewer infrastructure)

4. Runoff analysis should be based upon proposed land use, and should take into consideration all contributing runoff from areas outside of the study areas.

5. For previously undeveloped land, the recommended land use for determination of pre- development runoff discharge is meadow/pasture in good condition.

6. All undeveloped land lying outside of the study area should be considered as fully developed based upon the Jurisdiction’s comprehensive plan. The designer should check with the Jurisdiction regarding upstream conditions.

7. If future land use of a specific undeveloped area is unknown, the runoff coefficient should be established on a conservative basis. The probable future flow pattern in undeveloped areas should be based on existing natural topographic features (existing slopes, drainageways, etc.). Average land slopes in both developed and undeveloped areas may be used in computing runoff. However, for areas in which drainage patterns and slopes are established, these should be utilized.

8. Flows and velocities that may occur at a design point when the upstream area is fully developed should be considered. Drainage facilities should be designed such that increased flows and velocities will not cause erosion damage.

9. The primary use of streets should be for the conveyance of traffic. The computed amount of runoff in streets should not exceed the requirements set forth herein.

10. The use of detention and natural drainage-ways is recommended and encouraged whenever possible. The changing of natural drainage-way locations may not be approved unless such change is shown to be without unreasonable hazard and liability, substantiated by thorough analysis and investigation.

11. Restrictive covenants, surface flowage easements, and impoundment easements may be required to be executed and recorded to provide for the protection and maintenance of grassed drainage swales and grassed drainage detention areas within build-up areas.

12. If the Engineer's approval is given to the use of existing natural flow conveyances, the Project Engineer should show that the project will have minimum disruption of the existing environment (see requirement for downstream channel protection under unified sizing criteria – Cpv) and covenants may be required to be executed and recorded to provide protection. The Engineer may allow changes in the flow channel, provided state and federal guidelines and regulations will be followed.

13. In the design of storm drainage systems, consideration should be given to both surface and subsurface sources. Subsurface drainage systems should be designed where required. The discharge from such underdrain systems should not flow over sidewalks or onto streets after completion of the project.

14. Land grading of the project site should be performed to take advantage of existing contours and minimize soil disturbance. Better site design techniques should be used to preserve or minimize the impact to the existing site hydrology. Steep slopes should be avoided. If steep slopes are necessary, an attempt should be made to save natural grasses, shrubs, and trees on these slopes and re-establish ground cover and permanent erosion control measures as soon as possible.

15. During construction grading phases, 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 at the lower end of the drainageways and provisions should be made for their maintenance.

    An erosion control plan should be developed according to the design guidelines provided in Chapter 7 of the Iowa SUDAS Design Manual. Additional information on construction site runoff control can be found in the "Iowa Construction Site Erosion Control Manual," (Iowa DNR, 2006). An on-line electronic erosion and sediment planning guide is also available (http://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Permits-Guidance-Forms).

16. Acquire stormwater discharge permits from the Iowa Department of Natural Resources (http://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Permits-Guidance-Forms) for construction sites exceeding one acre in area. If the local jurisdiction maintains a stormwater NPDES permit, there may be additional local requirements.

17. The planning and design of drainage systems should be such that problems are not transferred from one location to another. Outfall points and velocities should be designed in such a manner that will not create flooding hazards downstream.

18. 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 said plan. Drainage easements conforming to the master plan will be required and should be designated on all drainage drawings and subdivision plats. (See Chapter 16).

19. Any proposed building or construction of any type of structure including retaining walls, fences, etc., or the placement of any type of fill material which will encroach on any utility or drainage easement, requires written approval of the Jurisdiction. Such structure will not impair surface or subsurface drainage from surrounding areas.

20. The design for stormwater management BMPs and conveyance systems should be in conformance with the following, if applicable:

    a. The jurisdictional MS4 post-construction runoff control regulations ("stormwater ordinance"), and supplemental guidelines, minimum standards, and applicability criteria established by the Iowa Department of Natural Resources.
    b. Iowa Statewide Urban Design Standards and Urban Standard Specifications for Public Improvements.
    c. Jurisdiction Plumbing Code.

E. Floodplain management

1. Although not a direct element of the municipal stormwater conveyance design, floodplain management should be considered along with the overall stormwater management plan to manage the floodplain as it relates to the various stormwater conveyance means, pipes, culverts, streams, and open channels.

2. According to *Municipal Stormwater Management, Second Edition*, "This duty (to manage the floodplain) is assigned by virtue of need and federal, state, and local regulations. The Floodplain Management Act of 1978 requires the floodplain manager to perform a number of duties."

   Furthermore, it states "FEMA (1986) provides an overview of the pertinent details of floodplain management and provides a conceptual framework for floodplain management that stands on four important legs:

   - Reduce flood losses and threats to health and safety
   - Preserve and restore the natural and beneficial uses of floodplains
   - Take a balanced view that minimizes exposure to loss rather than one that promotes either floodplain abandonment, or intense floodplain development
   - Develop and use the tools available to provide careful and technically sound consideration of all information and alternative uses of floodplains

Floodplain management, when integrated with the overall stormwater management program, provides a regulatory means to improve the surface water system throughout the municipality."

A. Introduction

During the first 15 years of the national program to abate and control water pollution (1972–1987), EPA and the states focused most of their water pollution control activities on traditional point sources. These point sources have been regulated by the EPA and the states through the National Pollutant Discharge Elimination System (NPDES) permit program established by Section 402 of the Clean Water Act. The NPDES program functions as the primary regulatory tool for assuring that water quality standards are met. NPDES permits, issued by either EPA or an authorized state, contain discharge limits designed to meet water quality standards and national technology-based effluent regulations.

In 1987, in view of the progress achieved in controlling point sources and the growing national awareness of the increasingly dominant influence of non-point source (NPS) pollution on water quality, Congress amended the Clean Water Act to focus greater national efforts on non-point sources. Under this amended version, referred to as the 1987 Water Quality Act, Congress revised Section 101, "Declaration of Goals and Policy," to add the following fundamental principle:

> *It is the national policy that programs for the control of non-point sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and non-point sources of pollution.*

The Water Quality Act of 1987 also included language that required comprehensive stormwater permitting using a two-phased approach. (Detailed information on both phases of the NPDES Storm Water Program is available at http://www3.epa.gov/region9/water/npdes/index.html.) Phase I, in place since October 1992, required operators of medium and large municipal separate storm sewer systems (MS4s) located in incorporated places and counties with populations of more than 100,000; certain industrial activities; and construction activities disturbing 5 acres or more (now reduced to 1 acre) to obtain an NPDES permit to discharge stormwater runoff. Iowa has two Stormwater Phase I communities – Des Moines and Cedar Rapids. Under the permit, regulated operators must develop and implement stormwater management programs/plans.

In October 1999, EPA expanded the federal stormwater program with the promulgation of the Phase II rule. Phase II requires operators of small MS4s (non-Phase I regulated MS4s) in "urbanized areas" (as defined by the Bureau of the Census) and small construction activities disturbing 1 acre or more of land to obtain an NPDES permit and develop stormwater management programs or plans. Further, the Iowa DNR may require operators of small MS4s not in urbanized areas and small construction activities disturbing less than 1 acre to obtain an NPDES permit if deemed necessary to protect water quality.

For small MS4 permits, Phase II prescribes a set of six minimum control measures, as well as requirements for evaluation and assessment efforts. The minimum measures are:

1. Public education and outreach on stormwater impacts
2. Public involvement/participation
3. Illicit discharge detection and elimination
4. Construction site runoff control
5. Post-construction stormwater management in new development and redevelopment
6. Pollution prevention/good housekeeping for municipal operations

The regulated operators must choose and implement appropriate best management practices and measurable goals for each measure. The operators must also periodically evaluate and assess program compliance, the appropriateness and effectiveness of their chosen BMPs, and progress toward achieving their identified measurable goals. This guidance is expected to be consistent with any guidance issued for regulated small MS4 operators to meet the requirements of Phase II NPDES stormwater discharge permits. Therefore, the management measures and practices herein can serve as a guide in developing a community's stormwater management program. It is important to note however, that additional requirements not addressed in this guidance may be imposed under an NPDES stormwater permit.

The Clean Water Act establishes several reporting, funding, and regulatory programs to address pollutants carried in runoff that is not subject to confinement or treatment. These programs relate to watershed management and urban non-point source control. Readers are encouraged to use the information contained in this guidance to develop non-point source management programs/plans that comprehensively address the following EPA reports and programs:

a. **Section 303(d) lists and TMDLs.** Under Section 303(d) of the Clean Water Act, states are required to compile a list of impaired waters that fail to meet any of their applicable water quality standards or cannot support their designated or existing uses. This list, called a 303(d) list, is submitted to Congress every two years, and states are required to develop a Total Maximum Daily Load (TMDL) for each pollutant causing impairment for water bodies on the list. More information on the TMDL program and 303(d) lists can be found at: http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Impaired-Waters.

b. **Section 305(b) and the National Water Quality Inventory: report to Congress.** Every two years, states are required to submit a report to Congress detailing the health of their waters. These periodic reports allow Congress to gauge progress toward meeting the goals of the Clean Water Act and to help identify priorities for future pollution control funding and activities. More information on the 305(b) program and the National Water Quality Inventory can be found at: https://programs.iowadnr.gov/adbnet/index.aspx.

c. **Section 404 discharge of dredged and fill material.** Under Section 404 of the Clean Water Act, persons planning to discharge dredged or fill material to wetlands or other waters of the United States generally must obtain authorization for the discharge from the US Army Corps of Engineers (USACE), or a state-approved agency to administer the Section 404 program. Such authorization can be through issuance of an individual permit or may be subject to a general permit, which applies to certain categories of activities having minimal adverse environmental effects. Implementation of Section 404 is shared between the USACE and EPA. The USACE is responsible for reviewing permit applications and deciding whether to issue or deny permits. EPA, in consultation with the USACE, develops the Section 404(b)(1) guidelines, which are the environmental criteria that the USACE applies when deciding whether to issue permits. EPA also has authority under Section 404(c) to veto USACE issuance of a permit in certain cases. More information about the 404 program can be found at: http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Wetlands-Permitting.

d. **Clean water state revolving fund.** EPA established the clean water state revolving fund (CWSRF) to provide states with low- or no-interest loans for projects that improve water resources. These funds can be used to support urban non-point source pollution programs and projects. To receive CWSRF loans from EPA for water quality projects, states must develop annual Intended Use Plans that outline the expected use of these funds. More information on the CWSRF program can be found at: http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Wastewater-Construction/State-Revolving-Fund.

The *National Water Quality Inventory: 1998 Report to Congress* identified urban runoff as one of the leading sources of water quality impairment in surface waters (US EPA, 2000c). Of the 11 pollution source categories listed in the report, urban runoff/storm sewers was ranked as the sixth leading source of impairment in rivers, fourth in lakes, and second in estuaries, as shown in Table C1-S3- 1.

Table C1-S3- 1: Leading sources of water quality impairment related to human activities for rivers, lakes, and estuaries

	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Pollutants	Siltation (38%)[1]	Nutrients (44%)[1]	Pathogens (47%)[1]
	Pathogens (36%)	Metals (27%)	Organic enrichment (42%)
	Nutrients (28%)	Siltation (15%)	Metals (27%)
Sources[2]	Agriculture (59%)	Agriculture (31%)	Municipal point sources (28%)
	Hydromodification (20%)	Hydromodification (15%)	Urban runoff/storm sewers (28%)
	Urban runoff/storm sewers (12%)	Urban runoff/storm sewers (12%)	Atmospheric deposition (23%)

[1] Values in parentheses represent the percentage of surveyed river miles, lake acres, or estuary square miles that are classified as impaired.

[2] Excluding unknown, natural, and “other” sources.

Source: US EPA, 2000c

B. Regulated activities

In Iowa, two agencies administer permit programs for protecting the state's water resources and ensuring their wise use. The agencies are:

1. **The Iowa Department of Natural Resources (DNR).** The DNR 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. In addition, the DNR has jurisdiction over sovereign lands and waters, and certain fee title lands of the state, and land below the ordinary high water mark on meandered streams and lakes.

   a. Clean Water Act Section 401 permit program. The DNR administers the 401 permit program. A Section 401 Water Quality Certification is DNR's certification that a project will not violate state water quality standards, and is required before the US Army Corps of Engineers can issue a Section 404 permit. Short and long-term impacts on water quality and water-related uses are evaluated in the Section 401 certification review. Information on the 401 permit can be found at: http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Wetlands-Permitting.

   b. Clean Water Act NPDES permit program. The EPA has assigned the DNR the responsibility of administering the NPDES (National Pollutant Discharge Elimination System) program (402 permit program) for activities within the state of Iowa. The DNR issues NPDES permits, conducts inspections, and provides enforcement. While the EPA has delegated program responsibilities to the DNR, it retains the authority to conduct its own inspections and issue fines to the offender.

   Additional information on the Iowa stormwater regulation and permit process can be found at http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Watershed-Improvement/Stormwater. Once permit coverage is obtained, the jurisdiction must satisfy the conditions of the permit and submit periodic reports on the status and effectiveness of the program at reducing pollutants to the MEP.

2. **Stormwater permits.** With respect to stormwater discharge, two types of permits are available: individual and general.

   a. General permits are developed to cover many different users. The conditions of these permits have been developed to cover activities that have similar types of discharges. The DNR has adopted three general permits for stormwater. General permits are applicable to discharges which are composed of stormwater only. Iowa's stormwater general permits do not cover mixtures of stormwater with non-stormwater, where the non-stormwater would require a NPDES permit from the DNR (refer to the specific general permit for additional details). Discharges that have a federal effluent limit may not be covered by a general permit.

      1) **General Permit No. 1** – For "stormwater discharge associated with industrial activity" (excludes construction). Industrial activities that have the potential for contamination of stormwater runoff are required to obtain and comply with an NPDES permit. These activities include storage of chemicals or fuel in areas that are exposed to precipitation or runoff. The intent of this permit is to reduce chemical pollutants in runoff.
      2) **General Permit No. 2** – For "stormwater associated with industrial activity for construction activities" (land disturbing 1 acre or more). Construction activities that result in the disturbance of more than one acre of ground cover are required to obtain an NPDES general permit normally associated with earthwork, grading, or any other non- agricultural land-disturbing activity. Construction of animal feeding operations and confinement buildings are covered under this permit. The goal of the permit is to reduce the amount of sediment being transported from construction site by stormwater runoff.
      3) **General Permit No. 3** – For "stormwater discharge associated with industrial activity from asphalt plants, concrete batch plants, rock crushing plants, and construction sand and gravel facilities".

   b. Individual permits are unique and developed specifically for the facility or jurisdiction it covers. This type of permit rarely applies to construction activities.

   Municipal Separate Storm Sewer Systems (MS4s). The NPDES program requires certain designated operators of MS4s to develop a stormwater management plan, with the purpose of reducing pollutant levels in the runoff discharged by publicly-owned storm sewer systems. Additional discussion on the Phase II Stormwater NPDES regulations and requirements are provided below. The MS4 program generally covers municipalities between 10,000 and 100,000 population. The affected entities must develop a stormwater management program that provides best management practices and addresses six minimum control measures under the MS4 program. See Table C1-S3- 2 for a current list of MS4 jurisdictions in Iowa (as of date of publication).

Table C1-S3- 2: Cities and universities in Iowa required to obtain stormwater permits for their MS4s

Altoona	Ames	Ankeny	Asbury
Bettendorf	Bondurant	Buffalo	Carter Lake
Cedar Falls	Cedar Rapids	Clive	Coralville
Council Bluffs	Davenport	Des Moines	Dubuque
Eldridge	Elk Run Heights	Ely	Evansdale
Grimes	Hiawatha	Hudson	Iowa City
Iowa State University	Johnston	Le Claire	Marion
Marshalltown	North Liberty	Norwalk	Ottumwa
Pleasant Hill	Raymond	Riverdale	Robins
Sergeant Bluff	Sioux City	Storm Lake	University Heights
University of Iowa	University of Northern Iowa	Urbandale	Waterloo
Waukee	West Des Moines	Windsor Heights	

Local communities may implement additional regulations, such as requiring additional permits. It should be noted that even if an erosion and sediment control permit is required by a local jurisdiction, a stormwater NPDES permit must still be obtained for sites one acre or larger. Additional detailed information can be found at:
http://www.iowadnr.gov/Environmental-Protection/Water-Quality/Watershed-Improvement/Stormwater.

3. **Other DNR permits** (relating to protection of water and recreational sources or adjacent lands):
   - **a. Floodplain construction permits.** The DNR has authority to regulate construction on all floodplains and floodways in the state. Local governments may have obtained transfer of this jurisdiction from the DNR. http://www.iowadnr.gov/Environmental-Protection/Land-Quality/Flood-Plain-Management

   - **b. Construction permits.** Pursuant to the Iowa Code, no person, association, or corporation can build or erect a pier, wharf, sluice, piling, wall, fence, obstruction, building, or erection of any kind, upon or over any state-owned land or water under the jurisdiction of the DNR, without first obtaining a permit from the DNR. http://www.iowadnr.gov/Environmental-Protection/Land-Quality/Sovereign-Lands-Permits

   - **c. Special permits.** Projects involving a standard recreational boat dock require authorization by the DNR. Permits are also required by commercial operations removing sand or aggregate from meandered streams. www.iowadnr.gov

4. **The US Army Corps of Engineers (USACE).** The USACE has authority over public waterways. This jurisdiction includes:
   - All waters susceptible to use in interstate or foreign commerce
   - All interstate waters, including interstate wetlands
   - All other waters, such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce
   - All impoundments of waters
   - Tributaries of waters identified above
   - Wetlands adjacent to waters (other than waters that are themselves wetlands)

a. **Clean Water Act Section 404 permit program.** This program regulates the non-point source discharges of dredged or fill material into waters of the United States, including wetlands. Information on the 404 permit can be found at: http://search.usa.gov/search?affiliate=u.s.armycorpsofengineersheadquart&query=section%20404.

The USACE issues two types of 404 permits, individual and general:

1) Individual permits are issued to a single entity (individuals or companies) to authorize specific activities. Once a complete permit application is received by the USACE, a public notice is issued, which describes the proposed project. The USACE evaluates all comments received and makes a final permit decision.
2) A general permit authorizes specific activities that have minimal environmental impacts, such as bank stabilization activities, construction of farm buildings, and filling of relatively small areas, if the permitted activity is consistent with the Clean Water Act regulations. A general permit can be issued on a nationwide basis. Activities authorized by a general permit require less review than an individual permit would require.

Some projects may fall under a nationwide permit but require a “Pre-Construction Notification” (PCN) and wetland delineation to the USACE before a nationwide permit is applicable. The PCN gives the USACE a chance to review an activity to determine if potential impacts warrant processing under an individual Section 404 permit. Detailed information on existing nationwide general permits, called Nationwide Permits (NWP), may be found in the Federal Register. Summary information regarding Nationwide Permits may be found at: http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/NationwidePermits.aspx.

Refer to this source to determine if your project exceeds the threshold for formal regulatory involvement. Several activities, although generally authorized under a Nationwide Permit, require Pre-Construction Notification (PCN) and wetland delineation.

Typical activities addressed under Nationwide Permits include:

- Linear transportation projects (NWP 14)
- Residential, commercial, and institutional developments (NWP 39)
- Agricultural activities (NWP 40)
- Recreational facilities (NWP 42)
- Stormwater management facilities (NWP 43)

The Nationwide Permit Program Fact Sheet No. 7 (IA) is being developed and information can be found at: http://www.mvr.usace.army.mil/Portals/48/docs/regulatory/Permits/NW-IA/FactSheetNo7IA.pdf.

b. **Wetlands.** Wetlands are defined as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Wetlands have three essential characteristics, all of which must be present for an area to be identified as a wetland:

- Hydrophytic (water-loving) vegetation
- Hydric soils
- Wetland hydrology

Examples of wetlands include, but are not limited to:

- Seasonally flooded basins or floodplains
- Wet meadows
- Shallow marshes
- Deep marshes
- Shrub swamps
- Woodland swamps and bogs

CAUTION: *If affected wetlands are on agricultural land, the Natural Resource Conservation Service (NRCS) should be contacted for assistance in making wetland determinations and permitting requirements.*

c. **Wetland delineation.** Identification of Section 404-regulated wetlands requires wetland delineation by the USACE, the EPA, or by submission of a wetland delineation report to the USACE by a qualified wetland specialist. Wetland delineation is often requested or contracted by a property owner who needs to know restrictions on the development or use of the land. In particular, a property owner may need wetland delineation when seeking an individual or general permit.

d. **Wetland mitigation.** Every effort should be made at the beginning of a project to avoid or minimize impacts. Any project that does not meet the conditions of any one of the Nationwide Permits must be sent to the USACE and probably will require satisfactory mitigation for the loss of wetlands. Mitigation is defined as wetland restoration, creation, enhancement, or preservation for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial. Compensation of impacted resources is only accepted if mitigation occurs in the following sequence:

1) Avoid direct or indirect impact by not taking a certain action
2) Minimize impacts by limiting the degree of action
3) Rectify the impact by repairing, rehabilitating, or restoring the affected environment
4) Reducing or eliminating the impact over time by preservation and maintenance operations
5) Discharge of stormwater into jurisdictional wetlands is to be avoided
6) Compensating for unavoidable impact by replacing or providing substitute resources:
    a) Replace or provide substitute resources on-site
    b) Replace or provide substitute resources off-site at an approved location, owned by either the project sponsor or a federal, state, or local conservation entity
    c) Purchase compensatory credits at an approved wetland bank

CAUTION: *Wetland mitigation by repair, rehabilitation, restoration, or replacement requires monitoring and maintenance plans to ensure mitigation goals are met in perpetuity.*

If there is any doubt about a project, contact the appropriate office for a ruling:

Iowa Department of Natural Resources, Wallace State Office Building, ATTN: Floodplain Permits Section, Sovereign Lands Section, 502 E 9th St, Des Moines, IA 50319-0034; 800-849-0321.

USACE District Engineer Operations Division, Clock Tower Building, PO Box 2004, Rock Island, IL 61204-6361 309-794-5373

US Army Engineer District Omaha Corps of Engineers, PO Box 5, Omaha, NE 68102, 402-896-0896

CAUTION: *The USACE District Engineer now has discretionary authority to require an individual permit on a case by case basis. Highly controversial projects, in particular, should be examined carefully. (These should be submitted to the USACE regardless of the amount of wetlands involved).*

C. Requirements for regulated MS4s

As a Phase II regulated MS4, the jurisdiction is required to submit a permit application and obtain coverage under an NPDES stormwater permit. Under the permit, the jurisdiction is required to develop and implement a stormwater management program that includes six minimum control measures, evaluation/assessment and reporting efforts, and recordkeeping, as described below.

Design a stormwater management program that:

- Reduces the discharge of pollutants to the maximum extent practicable (MEP)
- Protects water quality
- Satisfies the appropriate water quality requirements of the Clean Water Act

MEP is a standard that establishes the level of pollutant reductions that MS4 operators must achieve through implementation of a stormwater management program. The strategies used to reduce pollutants to the MEP may be different for each small MS4 because of unique local hydrologic, geologic, and water quality concerns in different areas.

The EPA envisions that permittees will determine what the MEP is on a location-by-location basis and consider such factors as conditions of receiving waters, specific local concerns, and other aspects of a comprehensive watershed plan. Since many diverse factors can dictate the specifics of a stormwater management program, the jurisdiction should determine appropriate BMPs to satisfy each of the minimum control measures through an evaluative process. The definition of MEP should adapt continually to both current conditions and BMP effectiveness, but ultimately, successive iterations of the mix of BMPs and measurable goals should be made to achieve the objective of meeting water quality standards. If, after implementing the minimum control measures and completion of a local watershed assessment, there is still water quality impairment associated with discharges from the MS4, the jurisdiction may need to expand BMP implementation in the watershed.

The intent of this manual is to provide guidance to local jurisdictions on planning and implementation of BMPs for water quality improvement.

D. Stormwater management programs

The Phase II Rule defines a stormwater management program for a small MS4 as a program composed of six elements that, when implemented together, are expected to reduce pollutants discharged into receiving surface waters to the MEP. These six program elements, or minimum control measures, are:

- Public education and outreach on stormwater impacts
- Public involvement/participation
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction stormwater management in new development and redevelopment
- Pollution prevention/good housekeeping for municipal operations

For each minimum control measure, the jurisdiction selects and implements BMPs and measurable goals that comprehensively address the specific stormwater problems within their area.

The process for developing a stormwater management program is described in Chapter 1, section 2 of this manual. Guidance on the selection and design of structural BMPs for water quality is included in later sections. Selection and design of BMPs for construction site runoff control (erosion and sediment) is covered in Chapter 7 of the Iowa SUDAS Design Manual. Guidance on selection of measurable goals for post-construction runoff control is provided below.

1. **Post-construction runoff minimum control measures.** The Phase II Final Rule requires an operator of a regulated small MS4 to develop, implement, and enforce a program to reduce pollutants in post-construction runoff to their MS4 from new development and redevelopment projects that result in the land disturbance of 1 acre or more. The small MS4 operator is required to:
   - Develop and implement strategies which include a combination of structural and/or non- structural BMPs
   - Have an ordinance or other regulatory mechanism requiring the implementation of post- construction runoff controls to the extent allowable under state, tribal or local law
   - Ensure adequate long-term operation and maintenance of controls
   - Determine the appropriate BMPs and measurable goals for this minimum control measure

   The Phase II Final Rule applies to redevelopment projects that alter the footprint of an existing site or building in such a way that there is a disturbance of 1 acre or more of land.

   Redevelopment projects do not include such activities as exterior remodeling. Because redevelopment projects may have site constraints not found on new development sites, the Phase II Final Rule provides flexibility for implementing post-construction controls on redevelopment sites that consider these constraints.

   The requirements of the post-construction runoff control minimum measure can be achieved through the use of both non-structural and structural BMPs. It is important to recognize that many BMPs are climate-specific, and not all BMPs are appropriate in every geographic area. Because the requirements of this measure are closely tied to the requirements of the construction site runoff control minimum measure (see Chapter 7 of the Iowa SUDAS Design Manual), it is recommended that small MS4 operators develop and implement these two measures in tandem. A short summary is provided below with a more detailed discussion provided in other sections of this manual.

a. **Non-structural BMPs.**
   1) **Planning Procedures**. Runoff problems can be addressed efficiently with sound planning procedures. Local master plans, comprehensive plans, and zoning ordinances can promote improved water quality in many ways, such as guiding the growth of a community away from sensitive areas to areas that can support it without compromising water quality.
   2) **Site-based BMPs**. These BMPs can include buffer strip and riparian zone preservation, minimization of disturbance and imperviousness, and maximization of open space.

b. **Structural BMPs.**
   1) **Stormwater Detention BMPs.** Retention or detention BMPs control stormwater by gathering runoff in wet ponds, dry basins, or multi-chamber catch basins and slowly releasing it to receiving waters or drainage systems. These practices can be designed to both control stormwater volume and settle out particulates for pollutant removal.
   2) **Infiltration BMPs**. Infiltration BMPs are designed to facilitate the percolation of runoff through the soil to groundwater, and thereby result in reduced stormwater runoff quantity and reduced mobilization of pollutants. Examples include infiltration basins/trenches, bioretention area, rain gardens, dry wells, and pervious and porous pavements.
   3) **Vegetative BMPs**. Vegetative BMPs are landscaping features that, with optimal design and good soil conditions, remove pollutants, and facilitate percolation of runoff, thereby maintaining natural site hydrology, promoting healthier habitats, and increasing aesthetic appeal. Examples include grassy swales, filter strips, artificial wetlands, and rain gardens.

2. **Stormwater management measurable goals.** Measurable goals are described in the Phase II rule as BMP design objectives or goals that quantify the progress of program implementation and the performance of your BMPs. Measurable goals are required for each minimum control measure and are intended to gauge permit compliance and program effectiveness. They are objective markers or milestones the DNR can use to track the progress and effectiveness of BMPs in reducing pollutants to the MEP. A jurisdiction should develop a program with a variety of short- and long-term goals. At a minimum, measurable goals should contain descriptions of actions taken by the jurisdiction to implement each BMP, what can likely be achieved by each goal, and the frequency and dates for such actions to be taken. BMPs and measurable goals can help establish a baseline against which future progress at reducing pollutants to the MEP can be measured. For example, information on current water quality conditions, numbers of BMPs already implemented, and the public’s current knowledge/awareness of stormwater management would be useful in setting this baseline.

   Measurable goals can be stated in a variety of ways. The jurisdiction can consider developing measurable goals based on one or more of the following general categories:

   a. **Tracking implementation over time.** Where a BMP is continually implemented over the permit term, a measurable goal can be developed to track how often, or where, this BMP is implemented.

   b. **Measuring progress in implementing the BMP.** Some BMPs are developed over time, and a measurable goal can be used to track this progress until BMP implementation is completed.

   c. **Tracking total numbers of BMPs implemented.** Measurable goals also can be used to track BMP implementation numerically, e.g., the number of wet detention basins in place or the number of people changing their behavior due to the receipt of educational materials.

   d. **Tracking program/BMP effectiveness.** Measurable goals can be developed to evaluate BMP effectiveness, for example, by evaluating a structural BMPs effectiveness at reducing pollutant loadings, or evaluating a public education campaign's effectiveness at reaching and informing the target audience to determine whether it reduces pollutants to the MEP. A measurable goal can also be a BMP design objective or a performance standard.

   e. **Tracking environmental improvement.** The ultimate goal of the NPDES stormwater program is environmental improvement, which can be a measurable goal. Achievement of environmental improvement can be assessed and documented by ascertaining whether state water quality standards are being met for the receiving surface water or by tracking trends or improvements in water quality (chemical, physical, and biological) and other indicators, such as the hydrologic or habitat condition of the stream segments within the watershed.

Measurable goals should include, where appropriate, the following three components:

- The activity or BMP to be completed
- A schedule or date of completion
- A quantifiable target to measure progress toward achieving the activity or BMP

Measurable goals that include these three components and are easy to quantify will allow the jurisdiction and the DNR to assess progress at reducing pollutants to the MEP. Measurable goals guidance for Phase II MS4s has been developed by EPA to help program managers comply with the requirement to develop measurable goals. The guidance presents a methodology for MS4 operators to develop measurable goals as part of the jurisdiction's stormwater management plan. This can be found at: http://www3.epa.gov/npdes/pubs/measurablegoals.pdf.

For example, an MS4 program goal might choose to reduce by 30 percent the road surface areas directly connected to storm sewer systems (using traditional curb and gutter infrastructure) in new developments and redevelopment areas over the course of the first permit term. Using "softer" stormwater conveyance approaches, such as vegetated swales, will increase infiltration and decrease the volume and velocity of runoff leaving development sites. Progress toward the goal could be measured by tracking the linear feet of curb and gutter not installed in development projects that historically would have been used.

Some examples of measurable goals for post-construction BMPs (from EPA guidance document):

1) **Bioretention:**
   - Reduction in impervious cover
   - Reduction in runoff quantity
   - Changes in runoff water quality (nutrients, sediments, metals, organics, etc.)
   - Number of new bioretention cells installed (both commercial and residential)
   - Number of acres that are drained by bioretention cells

2) **BMPs:**
   - Develop a program for maintenance of structural stormwater controls
   - The frequency of inspection and maintenance activities
   - The number of problems that were identified and remedied
   - The change in the proportion of BMPs that are well-maintained as a result of inspection and maintenance
   - Whether or not an inventory of BMPs requiring maintenance was completed and is regularly updated
   - Changes in water quality from BMPs

3) **Measurable goals.** In the first year, conduct an inventory of structural runoff controls. In Year 2, develop a GIS inventory to integrate the location of these controls with schedules for regular inspection and maintenance. Conduct four inspections of each structural control per year and conduct regular maintenance as prescribed for each type of practice.

4) **Justification.** There are many structural controls located throughout the municipality that are owned and operated by both public and private entities. Before a comprehensive maintenance plan can be implemented to address all of the practices, a complete list of BMPs and their locations and site conditions needs to be compiled. An inspection and maintenance schedule can be developed to maximize efficiency and minimize labor requirements. The system can be expanded to include other types of MS4 maintenance, including street sweeping, catch basin cleaning, storm drain flushing, etc.

5) **Buffer zones:**
   - Whether or not development codes were changed to require buffer zones

- The acreage of land conserved as buffers
- The acreage of land converted to buffers
- Changes in water quality of runoff leaving buffer areas
- Changes in the physical characteristics of streams downstream from areas with buffer zones
- The frequency of inspections and maintenance activities in buffer zones
- The acreage that drains to buffer zones

6) **Vegetated swales:**
   - The number of new grassed swales installed
   - The miles of streets with grassed swales
   - The reduction in runoff quantity
   - The reduction in runoff velocity
   - Changes in water quality of runoff from areas with grassed swales
   - The number of acres drained by grassed swales

7) **Infrastructure planning:**
   - Whether or not development codes were modified
   - The number of new developments using stormwater BMPs
   - The reduction in impervious surface area and infrastructure

8) **On-lot treatment:**
   - Reduction in runoff quantity
   - Reduction in runoff peak flow
   - Number of lots that use on-lot treatment
   - Acreage of impervious surfaces that drain to on-lot treatment BMPs
   - Number of manufactured products sold to store runoff onsite (i.e., rainbarrels)
   - Changes in water quality downstream from areas that use on-lot treatment

9) **Open space design:**
   - Whether or not development codes were modified to accommodate open space developments
   - Number of new developments that use open space design principles
   - Number of acres of open space preserved with open space design

10) **Wet detention or extended detention ponds:**
    - Changes in water quality
    - Reduction in runoff quantity
    - Number of wet ponds or extended detention ponds installed
    - Acreage of impervious surface that drains to wet ponds and/or extended detention ponds

Chapter 1- Section 4 Stormwater Management Criteria

A. Development criteria

This section presents a set of recommended minimum criteria for stormwater management for development activities in the state of Iowa in those communities with regulations. The overall aim is to provide an integrated approach to address both the water quality and quantity problems associated with stormwater runoff due to urban development.

The goal of a set of minimum stormwater management criteria for areas of new development and significant redevelopment is to reduce the impact of post-construction stormwater runoff on the watershed. This can be achieved, as discussed in Chapter 1, section 1, by:

- Maximizing the use of site design and nonstructural methods to reduce the generation of runoff and pollutants
- Managing and treating stormwater runoff though the use of structural stormwater controls
- Implementing pollution prevention practices to limit potential stormwater contaminants

It should be noted that the criteria presented here may be used in all communities in Iowa. They may be adopted by local jurisdictions as stormwater management development requirements as part of the jurisdiction post-construction runoff control ordinance and/or may be modified to meet local or watershed-specific stormwater management goals and objectives. Please consult your local review authority for more information.

The minimum guidelines for development are designed to assist local governments that are regulated, to comply with regulatory and programmatic requirements for various state and federal programs, including the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit program, and the National Flood Insurance Program under FEMA.

1. **Applicability.** The stormwater management guidelines for new development and redevelopment are intended to apply to any development site in a regulated agency that meets one or more of the following criteria and are intended to assist in the development of measurable goals for the post- construction runoff minimum control measure:

    a. New development and/or redevelopment that involves land disturbing activity of 1 acre or more. Based on local conditions and the need for additional measurable water quality improvement, jurisdictions may consider including controls on development based on the addition of a threshold amount of impervious area. Examples of impervious area threshold values in other states are 5,000 ft^2 and 10,000 ft^2. A jurisdiction may consider an impervious area threshold to provide an incentive to reduce the increase in developed impervious area and encourage better site design planning.

    b. Any commercial or industrial new development or redevelopment, regardless of size, with a Standard Industrial Classification (SIC) code that falls under the NPDES Industrial Stormwater Permit program or a hotspot land use as defined below.

2. **Definitions.**

    a. **New development** is defined as land disturbing activities, structural development (construction, installation, or expansion of a building or other structure), and/or creation of impervious surfaces on a previously undeveloped site.

    b. **Redevelopment** is defined as structural development (construction, installation, or expansion of a building or other structure), creation or addition of impervious surfaces, replacement of impervious surface not part of routine maintenance, and land disturbing activities associated with structural or impervious development. Redevelopment does not include such activities as exterior remodeling.

    c. **Hotspot** is defined as a land use or activity on a site that produces higher concentrations of trace metals, hydrocarbons or other priority pollutants than are normally found in urban stormwater runoff. Examples of hotspots include gas stations, vehicle service and maintenance areas, salvage yards, material storage sites, garbage transfer facilities, and commercial parking lots with high-intensity use.

3. **Special Requirements.** New development or redevelopment in critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria. Furthermore, these sites may need to utilize or restrict certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area.

B. Minimum stormwater management guidelines

The following guidelines are recommended minimum stormwater management requirements for new development or redevelopment sites falling under the applicability criteria.

1. **Use of enhanced design practices for stormwater management.** Site designs are developed to preserve the natural drainage and treatment systems and reduce the generation of additional stormwater runoff and pollutants to the fullest extent practicable. All site designs are encouraged to implement a set of practices collectively known as "stormwater better site design" and/or "low impact development" (LID) to the fullest extent possible. Through the use of these practices and techniques, the impacts of urbanization on the natural hydrology of the site and water quality can be significantly reduced. The goal is to reduce the amount of stormwater runoff and pollutants that are generated, provide for natural on-site control and treatment of runoff, and optimize the location of stormwater management facilities. Better site design concepts can be viewed as both water quantity and water quality management tools and can reduce the size and cost of required structural stormwater controls.

2. **Stormwater runoff quality.** The post-construction stormwater runoff from the development site is managed to improve the water quality. A common water quality goal is to remove at least 80% of the calculated average annual post-development loading of total suspended solids (TSS) from the site. However, based on local water quality conditions, jurisdictions might use other parameters, i.e., nutrients. This can be achieved through the use of site design practices and structural stormwater controls. This requirement may be quantified and expressed in terms of engineering design criteria through the specification of a water quality volume (WQv) that is treated to the 80% TSS removal performance goal. The water quality volume is equal to the runoff generated on a site from the design rainfall event. The water quality volume is one of the unified stormwater sizing criteria, which are used in conjunction to size and design stormwater management facilities to address stormwater impacts. The unified stormwater sizing criteria and methods to calculate the WQv are discussed in Chapter 2.

   It is presumed that a stormwater management system complies with this guideline if:

   a. It is sized to capture and treat the prescribed WQv. The design rainfall event that is recommended for computing the WQv is 1.25 inches and is equal to the 90% cumulative frequency rainfall depth for the area. In numerical terms, it is equivalent to the rainfall depth in inches (the 90% cumulative frequency rainfall depth) multiplied by the volumetric runoff coefficient (Rv) for the site, and the site drainage area. A statewide WQv of 1.25 inches is recommended for use or jurisdictions can use a similar value derived from an analysis of local historical rainfall data, i.e., adjusted based on location factors in Iowa (climate districts 1-9).

   b. Appropriate structural stormwater controls are selected, designed, constructed, and maintained according to the specific criteria in this manual.

   c. This design guideline is based on treatment of the WQv from a site to reduce post- development TSS loadings by 80%, as measured on an average annual basis. This performance goal is based upon EPA guidance and has been adopted nationwide by many local and statewide agencies. TSS is used as the representative stormwater pollutant for measuring treatment effectiveness for several reasons:
      1) The use of TSS as an indicator pollutant is well established.
      2) Sediment and turbidity, as well as other pollutants of concern that adhere to suspended solids, are a major source of water quality impairment in Iowa surface waters due to urban development and agricultural production activities.
      3) A large fraction of many other pollutants of concern are either removed along with TSS, or at rates proportional to the TSS removal.
      4) The 80% TSS removal level is reasonably attainable using well-designed structural stormwater controls (for typical ranges of TSS concentration found in stormwater runoff).

d. Runoff from hotspot land uses and activities is adequately treated and addressed through the use of appropriate structural stormwater controls and pollution prevention practices.

Provide for treatment of the WQv for all developments where stormwater management is required. A minimum WQv of 0.2 inches per acre should be met at sites or in drainage areas that have less than 15% impervious cover. Drainage areas having no impervious cover and no proposed disturbance during development may be excluded from the WQv calculations. Designers are encouraged to use these areas as non-structural practices for WQv treatment. Structural stormwater controls are sized and designed to treat the WQv. Depending on their removal efficiency or site constraints, more than one structural control may need to be used in parallel or in series (treatment train) to meet the water quality treatment requirement. Further, this guideline assumes that structural stormwater controls will be designed, constructed and maintained according to the criteria in this manual. Stormwater discharges from land uses or activities with higher or special potential pollutant loadings may require the use of specific structural controls and pollution prevention practices. A detailed overview of structural stormwater controls is provided in Chapter 4.

3. **Stream channel protection.** Protection of stream channels is accomplished through three complementary criteria:
   a. Extended detention of the 1-year, 24-hour storm for a period of 24 hours using structural stormwater controls. It is known that the increase in runoff due to development can dramatically increase stream channel erosion. This standard is intended to reduce the frequency, magnitude, and duration of post-development bank full flow conditions. The volume to be detained is also known as the channel protection volume (Cpv). The channel protection volume is one of the unified stormwater sizing criteria which are used in conjunction to size and design stormwater management facilities to address stormwater impacts. The use of nonstructural site design practices that reduce the total amount of runoff will also reduce Cpv by a proportional amount. This requirement may be waived by a local jurisdiction for sites that discharge directly into piped stormwater drainage systems, larger streams, rivers, wetlands, lakes, or other situations where the reduction in the smaller flows will not have an impact on streambank or channel integrity.

   b. Implement velocity control, energy dissipation, streambank stabilization, and erosion prevention practices and structures as necessary in the stormwater management system to prevent downstream erosion and streambank damage.

   c. Establishment of riparian stream buffers on the development site. Stream buffers not only provide channel protection but also water quality benefits and protection of streamside properties from flooding. It is recommended that 100-foot buffers be established where feasible. For new development, an appropriate stream buffer is established by requiring a development setback from the centerline of the stream. In previously developed areas, where erosion of the bank material is an issue, structural controls may be required for bank stabilization. Providing a buffer strip planted with native vegetation in the boundary area between the developed property and the streambank can provide effective control.

4. **Overbank flood protection.** Overbank flood protection for downstream channels, and/or flooding from surcharging of downstream piped conveyances, is provided by controlling the post- development 5-year, 24-hour storm peak discharge rate (denoted Q_{p5}) from exceeding the predevelopment (or natural conditions) discharge rate using structural stormwater controls. The overbank flood protection peak rate is one of the unified stormwater sizing criteria, which are used in conjunction to size and design stormwater management facilities to address stormwater impacts. The use of nonstructural site design practices that reduce the total amount of runoff will also reduce Q_{p5} by a proportional amount. See also the related discussion on minor and major design storms later in this section.

   Smaller storm events (e.g., 2-year and 10-year) are often effectively controlled through the combination of the extended detention for the 1-year, 24-hour event (channel protection criterion) and the control of the 25-year peak rate for overbank flood protection. These design guidelines are intended to be used together. If the control of the 1-year, 24-hour storm under guideline #3 is exempted, then for overbank flood protection, peak flow attenuation of the 2-year (Q_{p2}) through the 50-year (Q_{p50}) return frequency storm events must be provided. This guideline may be adjusted by a local jurisdiction for areas where all downstream conveyances and receiving waters have the natural capacity to handle the full build-out 50-year storm through a combination of channel capacity and overbank flood storage without causing flood damage. Evaluation of the impact of peak rate control under this guideline is evaluated in conjunction with guideline #6 to ensure the downstream effect on timing of release rates from single or multiple detention structures does not increase downstream flooding.

5. **Extreme flood protection.** Extreme flood protection is provided by controlling and/or safely conveying the 100-year, 24-hour storm event (denoted Q_f). This is accomplished either by:
   - Controlling Q_f through structural stormwater controls to maintain the existing 100-year floodplain, or
   - Sizing the onsite conveyance system to safely pass Q_f and allowing it to discharge into a receiving water whose protected floodplain is sufficiently sized to account for extreme flow increases without causing damage. In this case, the extreme flood protection criterion may be waived by a local jurisdiction in lieu of provision of safe and effective conveyance to receiving waters that have the capacity to handle flow increases at the 100-year level.

   The extreme flood protection peak rate is one of the unified stormwater sizing criteria, which are used in conjunction to size and design stormwater management facilities to address stormwater impacts. The use of nonstructural site design practices that reduce the total amount of runoff will also reduce Q_f by a proportional amount.

6. **Downstream analysis.** A downstream hydrologic analysis is performed to determine if there are any additional impacts in terms of peak flow increase or downstream flooding while meeting guidelines #1-#5. Due to peak flow timing and runoff volume effects, some structural controls fail to reduce discharge peaks to predevelopment levels downstream from the development site. A downstream peak flow analysis may be needed to the point in the watershed downstream of the site or the stormwater management system where the area of the site comprises 10% of the total drainage area. This is to help ensure that there are minimal downstream impacts from the developed site. The downstream analysis may result in the need to resize structural stormwater controls, or may allow the waiving of some unnecessary peak flow controls altogether. The use of a downstream analysis and the “ten-percent” rule are discussed in Chapter 3.

7. **Groundwater recharge.** Recharge to groundwater is implemented to the extent practicable through the use of nonstructural better site design techniques that allow for recharge of stormwater runoff into the soil. The annual recharge from the post-development site should approximate the annual recharge from the pre-development or existing site conditions, based on soil types. Stormwater runoff from a hotspot should not be infiltrated without effective pretreatment.

   The recommended stormwater runoff volume to be recharged to groundwater should be determined using the existing site (pre-development) soil conditions. The recommended rates of recharge for various hydrologic soil groups are as follows:

NRCS Hydrologic Soil Group	**Volume to Recharge** **(x total impervious area)** *(in acre-inches of runoff)*
A	0.51
B	0.34
C	0.17
D	0.08

   Groundwater recharge is included as part of the water quality volume and is computed as recharge volume (Rev). Additional information is provided in Chapter 2.

   More information on site design practices that promote infiltration is found in Chapter 5. Annual groundwater recharge rates should be maintained to the extent practicable through the use of nonstructural methods.

8. **Construction erosion and sediment control.** All new development and redevelopment sites should meet the regulatory requirements for land disturbance activities under the “Iowa Erosion Regulations” (i.e. <5 tons/acre/year). See Iowa Code Section 161A.64, subsection 2 and/or the applicable NPDES General Permit #2 for construction activities. This involves the preparation and implementation of an approved Stormwater Pollution

Prevention Plan (SWPPP), including appropriate best management practices, during the construction phase of development. Further guidance on practices for construction site erosion and sediment control can be found in Chapter 7 of the Iowa SUDAS Design Manual– Erosion and Sediment Control, and DNR's Iowa Construction Site Erosion Control Manual, which can be found at www.ctre.iastate.edu/erosion.

Better site design practices and techniques that can reduce the total amount of area that needs to be cleared and graded should be implemented wherever possible. It is essential that erosion and sediment control be considered and implemented in stormwater concept plans and throughout the construction phase to prevent damage to natural stormwater drainage systems and previously constructed structural stormwater controls and conveyance facilities.

9. **Stormwater management system operation and maintenance.** Implement a comprehensive operation and maintenance plan for the stormwater management system. An operation and maintenance plan is one of the required components of the post-construction minimum control measure for permitted MS4 jurisdictions. This is to include all of the stormwater management system components, including drainage facilities, structural stormwater controls, and conveyance systems. To ensure that stormwater management systems function as they were designed and constructed, the operation and maintenance plan provides:
   - A clear assignment of stormwater inspection and maintenance responsibilities
   - The routine and non-routine maintenance tasks to be undertaken
   - A schedule for inspection and maintenance
   - Any necessary legally binding maintenance agreements

10. **Pollution prevention.** Consider pollution prevention measures in the design and operation for new development and redevelopment sites, and prepare a stormwater pollution prevention plan. Specific land use types and hotspots may need to implement more rigorous pollution prevention practices.

11. **Stormwater management plan.** Develop a stormwater management site plan for all new development and redevelopment sites. The stormwater site plan provides a narrative, technical information, and analysis, indicating how the proposed development meets minimum guidelines #1-10 (or the applicable local jurisdiction stormwater requirements).

C. Minor and major design storms

The concept of minor and major design storms is related primarily to the conveyance capacity design for storm sewer and surface drainage systems. Chapter 3 provides a discussion of rainfall/runoff analysis and the selection of the appropriate design storm for a particular component of the stormwater management system. The concept of the unified sizing criteria is covered in Chapter 2. This discussion of minor and major design storms is related to the selection of the overbank flood protection (Q_p), which is one of the five components of the unified sizing criteria. Every urban area has two separate and distinct drainage systems, whether or not they are actually planned for and designed. One is the minor system corresponding to the minor (or ordinary) storm recurring at regular intervals, generally 2-10 years. The other is the major system corresponding to the major or extraordinary storm, generally 50-100 year or greater storm event. Since the effects and routing of stormwater for the major storm may not be the same for the minor storm, all storm drainage plans submitted for approval should be submitted showing the routing path and effects of the major storm.

Table C1-S4- 1: Chance of a storm equaling or exceeding a given frequency during a given time period

Frequency (years)	**Time Period in Years**					
	1	**5**	**10**	**25**	**50**	**100**
2	50%	97%	99.9%	99.9%	99.9%	99.9%
5	20%	67%	89%	99.6%	99.9%	99.9%
10	10%	41%	65%	93%	99%	99.9%
25	4%	18%	34%	64%	87%	98%
50	2%	10%	18%	40%	64%	87%
100	1%	5%	10%	22%	40%	63%

1. **Minor storm provisions.** The minor storm drainage system should be designed to provide protection against regularly recurring damage, to reduce street and stormwater conveyance maintenance costs, to provide an orderly urban drainage system, and to provide convenience and protection to the urban residents. Storm sewer systems consisting of underground piping, natural drainage ways and other required appurtenances should be considered as part of the minor storm drainage system.

2. **Major storm provisions.** The major storm drainage system should be designed to not cause 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.

D. Design frequencies for conveyance facilities

Design storms for drainage facilities are described below. A minimum cleaning velocity of 2 ft/s should be used for the 2-year storm, and 3 ft/s for the design storm. When detention or overland flow provisions for storms greater than 10 years are not available, regardless of the street system, the 100-year or greater storm is required for the design to minimize impact to private properties.

1. **Intakes** should have a minimum capacity to convey the 5-year storm under developed conditions for local streets and minor collectors during the peak flow rate. The Engineer may require 10-year frequency for intakes for major collectors, arterials, expressways, and freeways.

2. **Storm sewers** should have capacity to convey a 5-year storm under developed conditions within the pipe for local streets and minor collectors. The Engineer may require 10-year frequency for storm sewers for major collectors, arterials, expressways, and freeways. Provisions should be made for the minimum 100-year storm, greater in critical areas, when overland flow is not allowed or available to prevent damaging private property. Storm and/or surface water conveyance easements should be provided to the Jurisdiction.

3. For those storm sewers that will handle footing drains, the following discharge (Q) values should be used:
   a. For less than 50 houses, Q=5.0 gpm per house.
   b. For greater than 50 houses, Q=250 gpm plus 2.5 gpm per house for each additional house over 50.

4. **Culverts** should have capacity to convey the following:
   a. 10-year storm without the headwater depth exceeding the diameter of the culvert
   b. 50-year storm without the headwater depth exceeding 1 foot over the top of the culvert
   c. 100-year storms should be conveyed through the culvert without the headwater depth exceeding one foot below the low point of the roadway/embankment, unless there are other, more restrictive elevations.
   d. For culverts that drain areas over two square miles, the DNR rules and regulations will apply.

5. **Ditches** should have capacity to convey a 50-year storm within the ditch banks. Provisions should be made for the 100-year storm to flow overland within the flowage easement. Surface water flowage easements should be provided to the Jurisdiction for all designed drainageways. For ditches that drain areas over two square miles, the DNR rules and regulations will apply. Additional design guidance for vegetated swale BMPs is provided in Chapter 9.

6. **Detention basins** should have the capacity to retain a 100-year storm at critical duration or safely pass the 100-year discharge over an auxiliary spillway. The top of the detention dike should be a minimum of 1 foot above the 100-year storage elevation. The detention basin design requires the DNR approval for 18 acre-feet of storage or greater. Additional design guidance for detention basins is provided in Chapters 3 and Chapter 7.

E. Street flow criteria

1. Street capacity for minor storms.

   a. Pavement encroachment for minor design storms should not exceed the limitations set forth in Table C1-S4-2:

Table C1-S4- 2: Allowable pavement encroachment and depth of flow for minor storm runoff

Street Classification	Maximum Encroachment[1]
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. For one-way streets, a single 12-foot lane is allowed.
Major Arterials (4 lanes or greater)	No curb overtopping. Flow spread must not exceed 10 feet from the face of the curb of 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 one-way streets, two 12-foot lanes are required. 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.

[1] Where no curbing exists, encroachment shall not extend past property lines.

b. The storm sewer system will 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 will be computed using the modified Manning's formula for flow in a small triangular channel as shown in Chapter 13. An “n” value of 0.016 will be used unless special considerations exist.

2. **Street capacity for major storms.** The allowable depth of flow and inundated area for the major design storm should not exceed the limitations set forth in Table C1-S4- 3:

Table C1-S4- 3: Allowable depth of flow and inundated area for 100-year storm runoff

Street Classification	Allowable Depth and Ponded Area
Local and Collector	The ponded area should not exceed the street right-of- way and the depth of water above the street crown should not exceed 6-in. There may be situations where other restrictions are necessary.
Major and Minor Arterial	A 12-ft lane is the minimum travel lane to be passable in the center of the street.

3. **Cross street flow.** Cross street flow (called cross pan) can occur by two separate means. One is runoff which has been flowing in a gutter and then flows across the street to the opposite gutter or inlet. The second case is flow across the crown of the street when the conduit capacity beneath the street is exceeded. If the inundated area exceeds the street right of way, flow easements must be obtained. The maximum allowable cross street flow depth based on the worst condition should not exceed the limitation stipulated in Table C1-S4- 4.

Table C1-S4- 4: Allowable cross street flow

Street Classification	Initial Design Storm Runoff	100-Year Design Storm Runoff
Local	6-inch depth at crown or in cross pan	9-inch depth at crown or in cross pan
Collector	Where cross pans are allowed, depth of flow or in cross pan should not exceed 3”	6-inch depth at crown
Arterial	None	3-inch or less over crown

A. Purpose

The purpose of the Project Drainage Report is to identify and propose specific solutions to stormwater runoff and water quality problems resulting from existing and proposed development. The report must include adequate topographic information (pre- and post-development) to verify all conclusions regarding offsite drainage. Unless known, the capacity of downstream drainage structures must be thoroughly analyzed to determine their ability to convey the developed discharge.

The drainage report and plan will be reviewed and approved by the Engineer prior to preparation of final construction drawings. Approval of these preliminary submittals constitutes only a conceptual approval and should not be construed as approval of specific design details. The Project Engineer may be required by law to submit the drainage report and plan to the Iowa Department of Natural Resources (DNR) and/or US Army Corps of Engineers (USACE). An application for a permit to construct will follow the DNR and NPDES applicable permit requirements and USACE rules and regulations, and the application will be the responsibility of the Project Engineer.

B. Instructions for preparing 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. Perform all analyses according to the intent of professionally-recognized methods. Support any modifications to these methods with 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 must select alternative 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. Use all headings listed in the Contents. 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 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.

C. Contents

The following information contains summaries for hydrology and detention (see Table C1-S5- 1, Table C1-S5- 2, and Table C1-S5- 3), as well as design considerations for the preparation of project drainage reports. They are provided as a minimum guide and are not to be construed as the specific information to be supplied on every project drainage report, and other information may be required. Existing and proposed conditions for each development will require analysis unique to that area.

1. **Site characteristics.**
   a. **Pre-development conditions.** Describe pre-developed land use, topography, drainage patterns (including overland conveyance of the 100-year storm event), and natural and man- made features. Describe ground coverage, soil type, and physical properties, such as hydrologic soil group and infiltration. For the pre-development analysis where the area is rural and undeveloped, a land use description of “meadow/good condition” is recommended. If a geotechnical study of the site is available, provide boring logs and locations in the appendix of the report. If a soil survey was used, cite it in the references.

b. **Post-development conditions.** Describe post-developed land use and proposed grading, change in percent of impervious area, and change in drainage patterns. If an existing drainageway is filled, the runoff otherwise stored by the drainageway will be mitigated with stormwater detention, in addition to the post-development runoff.

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

d. **Floodways, floodplains, and wetlands.** 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.

e. **Pre-development runoff analysis.**
    1) **Watershed area.** Describe overall watershed area and relationship between other watersheds or sub-areas. Include a pre-development watershed map in the report appendix.
    2) **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.
    3) **Precipitation model.** Describe the precipitation model and rainfall duration used for the design storm. Typical models may include one or more of the following:
        a) NRCS Type-II distribution
        b) Huff rainfall distribution (select the appropriate distribution based on rainfall duration)
        c) Frequency-based hypothetical storm.
        d) Rainfall intensity duration frequency (IDF) curve.
        e) User-defined model based on collected precipitation data, subject to the Engineer's approval. Total rainfall amounts for given frequency and duration should be obtained from Bulletin 71, "Rainfall Frequency Atlas of the Midwest." (See Table 2 in Chapter 3, section 2) This publication supersedes Technical Paper Number 40, "Rainfall Frequency Atlas of the United States."

    4) **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.
    5) **Runoff model. (See Chapter 3).** Describe method used to project runoff and peak discharge. Typical models are as follows:
        a) Use the Rational Method for drainage areas up to 160 acres, and where flow routing is not required. Often used in storm sewer design.
        b) Use the WinTR-55 Method for drainage areas up to 2000 acres.
            - TR-20 Model
            - Routines contained in HEC-1 or HEC-HMS computer models
            - Regression equations and other hydrologic models approved by the Jurisdiction

    6) **Summary of pre-development runoff.** Provide table(s) including drainage area, time of concentration, frequency, duration, peak discharge, routing, and accumulative flows at critical points where appropriate.

2. **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. Include an analysis of the proposed increase in impervious area. Provide a summary of the total impervious area and the % impervious are for each sub-watershed/catchment.

    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 using Table C1-S5- 1 and Table C1-S5- 2.
   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 stormwater detention.
   3) Provide a summary of the respective volumes and discharge rates from the unified sizing criteria: WQv, Cpv, Q_p, and Q_f for the project area.
   4) Calculate the allowable release rate from the site, based on three conditions:
      a) The peak runoff rate for the 1-year, 24-hour design storm based on the Cpv. See Chapter 3, section 6.
      b) After development, the release rate of runoff for rainfall events having an expected return frequency of two years and five years should not exceed the existing, pre- developed peak runoff rate from those same storms.
      c) For rainfall events having an expected return frequency of 10-years to 100 years inclusive, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff from a five-year frequency storm of the same duration. The allowable discharge rate may be restricted due to downstream capacity. Include this calculation in the Executive Summary.

3. Stormwater conveyance design.

a. **Design information references.** All stormwater conveyances should be designed according to this manual, 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 DC.
   2) Federal Highway Administration (1988) *Design of Roadside Channels with Flexible Linings*. Hydraulic Engineering Circular No. 15, Washington DC.
   3) Federal Highway Administration (1985) *Hydraulic Design of Highway Culverts*. Hydrologic Design Series Number 5, Washington DC.
   4) US Geological Survey (1968) *Measurement of Peak Discharge at Culverts by Indirect Methods*. Book 3, Applications of Hydraulics, Washington DC.
   5) American Society of Civil Engineers (1986) *Design and Construction of Sanitary and Storm Sewers*. Manual of Practice No. 37, New York, NY.

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 (inlet and pipe) and intake design data.
   5) Water spread on the street for intake design year and 100-year elevation in all streets in which the curb is overtopped.

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.
  4) The limits of swale and ditch easements will be established based upon the required design frequency. This includes 100-year overflow easements from stormwater controlled structures.

e. **Storm drainage outlets and downstream analysis.**
  1) Discuss soil types, permissible and calculated velocity at outlets, energy dissipater design, and drainage impacts on downstream lands. Provide calculations for the energy dissipater 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) Perform 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 the site. 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 – stormwater 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

4. Stormwater management design.

a. **Design standards.** All stormwater management facilities should be designed according to these 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 DC.
  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, NY.
  3) American Society of Civil Engineers (1992) *Design and Construction of Urban Stormwater Management Systems*. Manual of Practice No.77, New York, NY.
  4) American Society of Civil Engineers (1998) *Urban Runoff Quality Management*. Manual of Practice No.

    87, New York, NY.
    5) Stahre, P and Urbonas, B (1990) *Stormwater Detention for Drainage, Water Quality, and CSO Management.* Prentice-Hall, Englewood Cliffs, NJ.
    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 two, five, and 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 limited by downstream conveyance. Provide a table summarizing these release rates. Also provide a stage-storage-discharge table. These tables are shown in Table C1-S5- 3. State the minimum freeboard provided, and at what recurrence interval the basin overtops.
    2) Discuss the effects on the overall stormwater system by detention basins in contributing offsite areas. If contributing offsite areas are presently undeveloped, discuss assumptions about future development and stormwater 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 with Table C1-S5- 3.

  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 sediment problems downstream of the detention basin.
    2) 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 of a 2-year storm. Greater storm events are usually discharged by a separate outlet.
    3) Discuss the basin outlet design in terms of performance during low and high flows, downstream impact (see Chapter 3, section 13 and Chapter 7).
    4) 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. **TR-55 design limitations.** 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 should be based upon actual hydrograph routing for the design storms controlled by the basin.

5. **Permits.** Indicate what permits have been applied for and received. Submit DNR approval letter and report for sites affecting unnumbered A-zones, as delineated on flood insurance rate maps.

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

7. **Appendix.** Drawings and calculations in the Appendix should include, but not be limited to:
  a. **Drawings.**
    1) A preliminary plat (pre-and post-topography) may be used to show the proposed development. Minimum scale of 1 inch = 500 feet or larger to ensure legibility should be used for all drainage areas. (Drawings no larger than 24 inches by 36 inches should be inserted in 8 ½-inch by 11-inch sleeves in the back of the

bound report). The plat is to show street layout and/or building location on a contour interval not to exceed 2 feet. The map must show on- and off-site conditions. Label flow patterns used to determine times of concentration.

2) Drainage plans (preliminary plat or topography map) must extend a minimum of 250 feet from the edge of the proposed preliminary plat boundary, or a distance specified by Jurisdiction. The limits of swale and ditch easements should be established based upon the required design frequency. This includes 100-year overflow easements from stormwater controlled structures.
3) Soil map or geotechnical information.
4) Location and elevations of Jurisdictional benchmarks. All elevations should be on Jurisdictional datum.
5) Proposed property lines (if known).
6) If the preliminary plat does not include proposed grades, submit a grading and erosion control plan showing existing and proposed streets, names, and approximate grades.
7) Existing drainage facilities and structures, including existing roadside ditches, drainageways, gutter flow directions, culverts, etc. All pertinent information such as size, shape, slope location, 100-year flood elevation, and floodway fringe line (where applicable), should also be included to facilitate review and approval of drainage plans.
8) Proposed storm sewers and open drainageways, right-of-way and easement width requirements, 100-year overland flow easement, proposed inlets, manholes, culverts, erosion and sediment control, water quality (pollution) control and energy dissipation devices, and other appurtenances.
9) Proposed outfall point for runoff from the study area.
10) The 100-year flood elevation and major storm floodway fringe (where applicable) are to be shown on the plans, report drawings, and plats (preliminary and final). In addition, the report should demonstrate that the stormwater system has adequate capacity to handle a 100-year storm event, or provisions are made for overland flow.
11) Show the critical minimum lowest opening elevation of a building for protection from major and minor storm runoff. This elevation is to be reviewed with the Jurisdiction to confirm if previous changes were made to the minimum lowest opening elevation for major storm event.

b. **Calculations.**
   1) Determine runoff coefficients and curve numbers
   2) Total impervious area (ft^2 and % of total drainage area)
   3) Determine times of concentration
   4) Calculations for WQv, rev, peak flow rate for the water quality design storm (cfs), and Cpv.
   5) Calculations for intake capacity, sewer design, and culvert design
   6) Peak discharge calculations – Show results in tabular format and pre- and post-developed hydrographs
   7) Detention basin design – Show tabular stage-storage-discharge results and inflow/outflow hydrographs
   8) Detention basin outlet design
   9) Open channel flow calculations
   10) Erosion protection design

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

d. **Stormwater quantity and quality.** See Chapter 1 of this manual for submittal of stormwater quality and quantity information.

Table C1-S5- 1: Hydrology summary

	Area 1				**Area 2**			
	Onsite		**Offsite**		**Onsite**		**Offsite**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Size (acres)								
Predominant land use								
Impervious area (acres or ft^2)								
Watershed length								
Time of concentration								
Runoff coefficient (C)								
NRCS CN								
Runoff (Q) 1 yr								
2 yr								
5 yr								
10 yr								
25 yr								
50 yr								
100 yr								

Table C1-S5- 2: Hydrology summary (critical points)

Design Flows	**Critical Point 1**	**Critical Point 2**	**Critical Point 3**	**Critical Point 4**
1 yr				
2 yr				
5 yr				
10 yr				
25 yr				
50 yr				
100 yr				

Table C1-S5- 3: Detention Summary

Detention Basin

A. Inlet design storm frequency: ______________

B. Outlet design storm frequency: ______________

Standard Release Rate

A. Allowable release rate: ______________ cfs

B. Offsite (developed) rate: ______________ cfs

WQv release rate: ______________ cfs (if applicable)

Cpv rate: ______________ cfs

Total release: ______________ cfs

Overflow Release Rate

A. Onsite pre-developed (100-yr) ______________ cfs

B. Offsite developed (100-yr)* ______________ cfs

Total release: ______________ cfs

Structures

A. Inflow structure: ______________

B. Outflow structure: ______________

	Stage**	Storage (ac-ft)	Inflow (cfs)	Outflow (cfs)	Comments
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

*Routed through basin
**Max. 1-foot interval