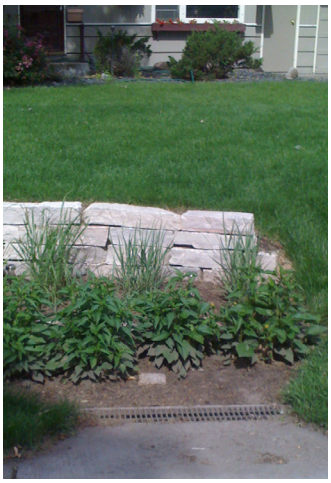
Prepared by:
Emmons & Olivier Resources, Inc.
for The City of Windsor Heights

City of Windsor Heights Stormwater Management Plan



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water | ecology | community

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1. BACKGROUND

1.1 Regulatory Framework

The federal Clean Water Act (CWA) is the primary basis for all federal and state water quality programs. The CWA was enacted with a goal of making all U.S. waters fishable and swimmable. The CWA established the Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) program to control water pollution by regulating sources that discharge pollutants into waters. The EPA set standards for federal water quality programs and assures that state programs are operating in accordance with the federal guidelines.

In Iowa, the Iowa Department of Natural Resources (DNR) is authorized by the EPA to administer the NPDES program and issues permits for storm water discharges subject to permit requirements. The DNR began Phase I of the storm water permitting process by requiring NPDES permits larger municipalities with separate storm sewer systems (MS4s). Des Moines and Cedar Rapids were the only Iowa cities required to obtain a permit to discharge storm water under the Phase I program. Effective in 2003, NPDES Phase II required that 41 more Iowa communities and two universities obtain permits and strive to improve storm water quality. Windsor Heights is included in Phase II.

The Phase II NPDES permit for Windsor Heights requires the City to develop and implement a comprehensive storm water quality management program.

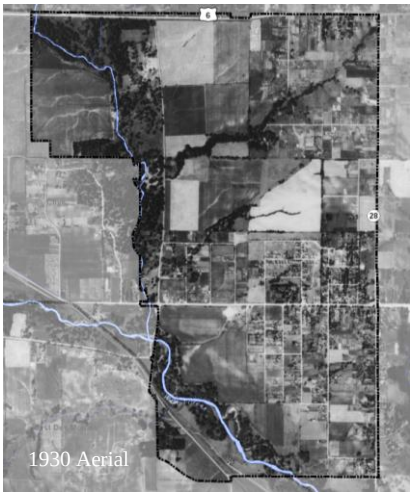
1.2 Overview

A significant component to an NPDES stormwater management program is to conduct a Watershed Assessment and a Stormwater Management Plan. The following document is The City of Windsor Heights Watershed Assessment and Stormwater Management Plan.

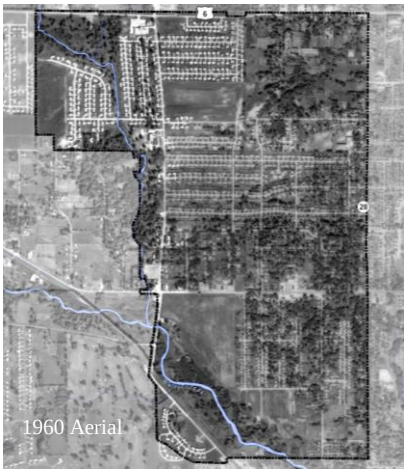
The watershed assessment was conducted during the summer of 2010. In addition to the typical watershed assessment work, a detailed creek assessment was conducted on the Walnut and North Walnut Creeks as they flow through the City. The assessment describes the hydrology of the City and the challenges for managing stormwater. The assessment is summarized in Section 2 of this document and the complete findings are included as an Appendix.

Development of the Stormwater Management Plan was conducted through a series of meetings with the City Stormwater Steering Committee and City Staff. Participants in this process were educated on urban stormwater management issues and asked to provide input on the long term vision of stormwater management in the City. Input from this group was used to develop specific approaches to addressing stormwater. The Plan includes programmatic and capital improvement approaches for stormwater management.

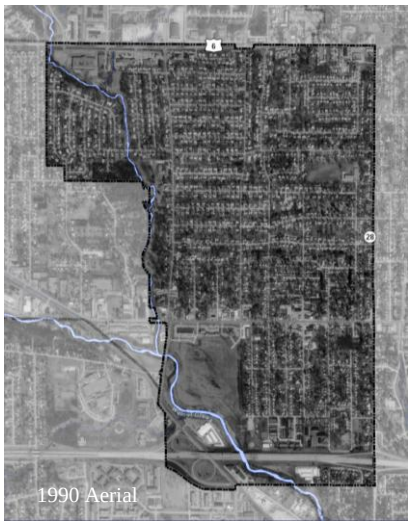
1.3 Development of Windsor Heights



Windsor Heights was officially incorporated in 1941 but, as the 1930 aerial photograph at right indicates, there was a significant population in the area much earlier. The major east-west roads, University Avenue and Hickman Road were in place at this point as were 63rd and 73rd streets. Agriculture was the dominant land use in the area but numerous homes were present, particular around University Avenue. Two small creeks with minor riparian areas are shown in the photograph. These would likely have been intermittent creeks but may have had a minor base flow, particularly the southern of the two creeks where some base flow can be seen within the stormsewer pipes today. The creeks have already been encroached upon by farm fields at this time with just the adjacent steep slopes undisturbed. Walnut Creek and North Walnut Creek are seen in this photograph to be essentially in the same location as they are today although in some points there is greater sinuosity of the creek. There is evidence of significant erosion taking place within the agricultural lands in the area. Numerous large gullies are present, particularly in the northwest corner of the City along the western edge of North Walnut Creek. As a result, large amounts of sediment would be delivered to the Creeks and it is likely that they were already significantly degraded at this point in time.



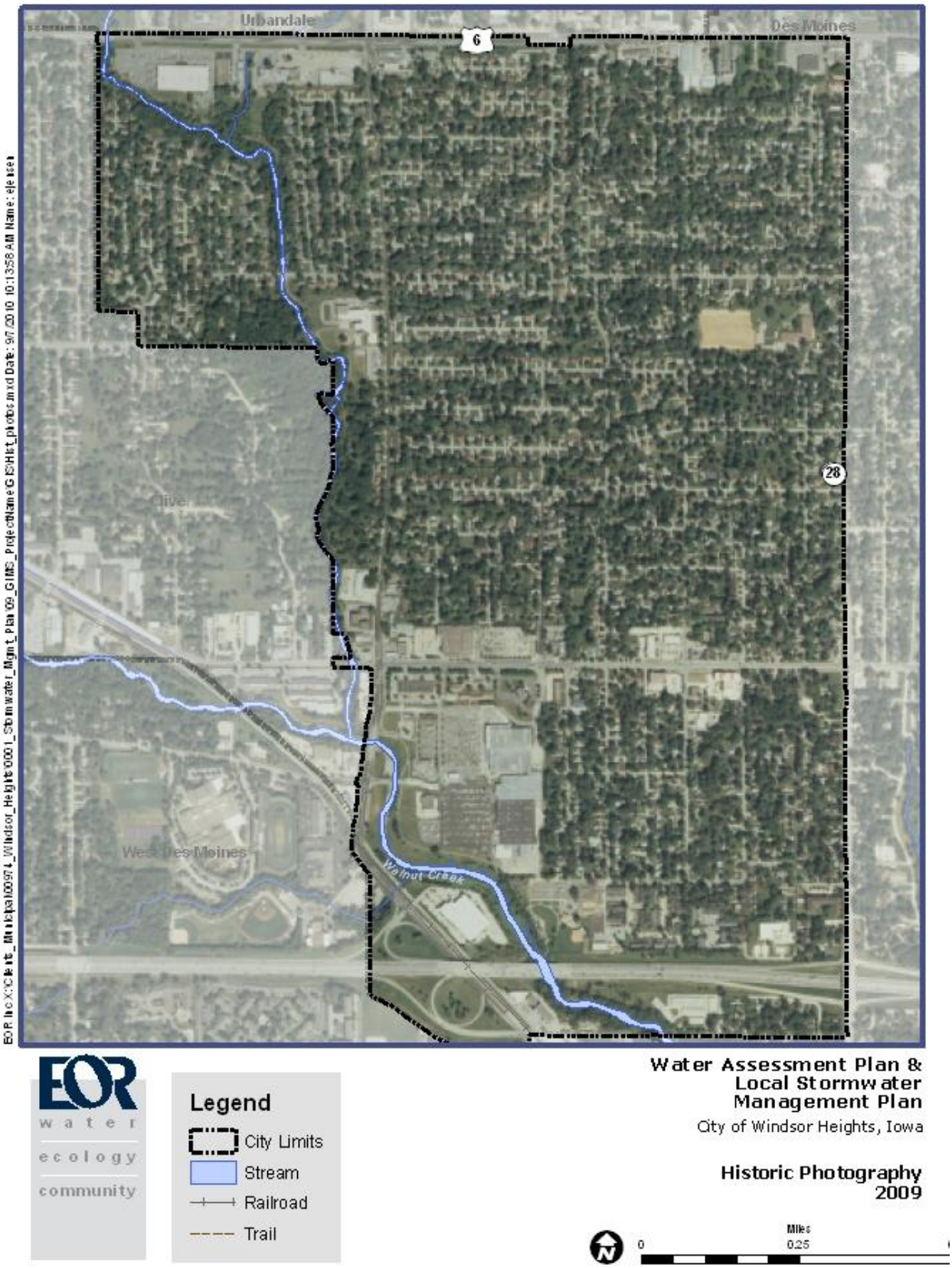
By the 1960's, much of the agricultural land has been converted to urban residential parcels. A subdivision has been constructed on either side of North Walnut Creek in the northwest corner of the City and the residential area centered along University Avenue has expanded northward to Washington Avenue. The expansion of this residential area has infringed completely on the southern creek corridor and on the lower portion of the more northerly creek. The development likely buried these creeks and replaced them with a stormsewer pipe to carry runoff down to the river. The City has become far more impervious at this point but the gully erosion that was present in the 1930 photograph is no longer seen. There would likely be more runoff reaching the Creeks (due to the increase in impervious surfaces) but there would have been less sediment delivery.



By the 1990's, Windsor Heights was nearly fully developed with the exception being the large area in the southwest corner which would ultimately become the large retail center. The Interstate Corridor has been built along the southern border of the City. The natural creek corridors have been completely lost. Walnut Creek near the Interstate 235 area has been straightened from its original meandering pattern. The land use within the City has now been completely transformed from agriculture to moderate density residential.

By 2009, Windsor Heights has been fully developed including the large retail area along Walnut Creek in the southwestern corner of the City (Figure 1). Of note is the dense, deciduous tree cover across most of the urban landscape in comparison to the bare soil of the agricultural landscape as seen in the 1930 aerial photo.

Figure 1 Windsor Heights 2009 Aerial Photograph



2. GENERAL WATERSHED ASSESSMENT

The City of Windsor Heights is located in southwestern Polk County in central Iowa. Windsor Heights borders Des Moines, Urbandale, Clive, and West Des Moines near Interstates 35/80 and 235. The following discussion is an overview of the Windsor Heights watershed. The discussion deals with the factors that determine the hydrologic characteristics of the watershed. Certain aspects of the discussion relate to the overall Walnut Creek Watershed while other portions discuss the particulars of the drainage areas within the City.

2.1 Climate and Precipitation

According to the National Weather Service, annual precipitation in Windsor Heights can vary anywhere from a minimum of about 17 inches to a maximum of about 56 inches. The average annual snowfall is 36 inches. Annual variation of snowfall is also large, ranging from a minimum of about 8 inches to as much as 72 inches. The average precipitation during winter is approximately 20 percent of the annual amount.

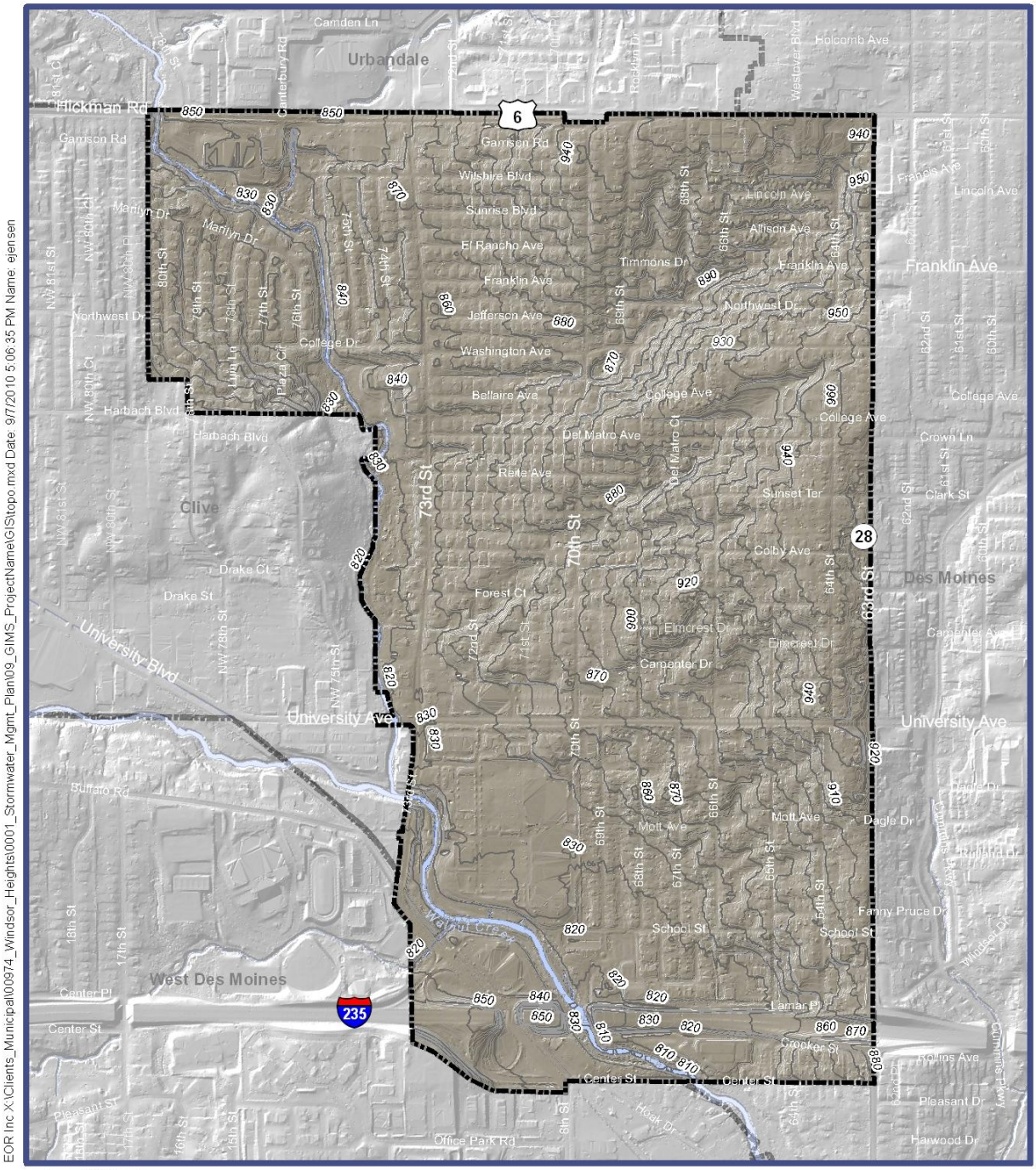
The average growing season (the period of time when temperatures remain above 32 degrees). normally spans 160 to 165 days between late April and mid-October. The growing season is characterized by prevailing southerly winds and precipitation falling primarily as showers and thunderstorms, occasionally producing damaging wind, erosive downpours or hail. Some 60 percent of the annual precipitation amount falls in the summer with the maximum rate normally in late May and June. Autumn is characteristically sunny with diminishing precipitation and generally decreasing temperature, conditions favorable for drying and harvesting crops.

2.2 Geography and Topography

The landscape within the City of Windsor Heights is characterized by glacial deposits. The most recent glacial deposit came from the Wisconsin glacier about 12,000 to 13,500 years ago. This glacier deposited calcareous, loamy material 30 to 60 feet thick over the northern four-fifths of Polk County (USDA-SCS). Most of northern Polk County is nearly level to undulating, though there are some steeper slopes along the major creeks. The southern part of the County, including Windsor Heights is much rougher and hillier than the northern part, and the glacial material is older and cut up extensively by creeks (USDA-SCS).

Windsor Heights has considerable relief, generally sloping to the south west. There are two fairly significant drainage-ways through the city. These are the former pathways of creeks as discussed in the Historical Context section above. The land surface elevations in Windsor Heights range from the lowest elevation of 808 feet above mean sea level along Walnut Creek in the southwest corner of the City, to the highest elevation at 966 feet above mean sea level in the northeastern area of the City (Figure 2). The steepness of the City has a significant role in its hydrology as is described below. The steepness will also impact the types of stormwater management practices that will be appropriate for the City.

Figure 2. Windsor Heights topography



2.3 Soils

A map identifying the soils of the city is included as Figure 3. As this map illustrates, the soils are classified into groups based upon the hydrologic characteristics of the soils. Soil Hydrologic Groups (HSG) are used to estimate the amount of runoff generated for a given rainfall event. There are four hydrologic soil groups: A, B, C and D. The amount of runoff expected from the soil is lowest for A soils. These soils have high sand and/or gravel content that allows water to move rapidly down into the soil instead of flowing off the soil. Runoff is highest for D soils. HSG D soils have a large clay content that prohibits the movement of water through the soil. Ultimately however, vegetation, organic/mineral or physical composition and slope all contribute to the runoff potential of a soil. Table 1 presents a description for each of the HSGs. Soils classified with multiple HSGs, for example, A/D are A soils that behave like D soils.

Table 1. Description of hydrologic soil groups

Hydrologic Soil Group	Description
A	Soils having high infiltration rates when thoroughly wet (low runoff potential). Deep, well drained to excessively drained sand or gravelly sand.
B	Soils having a moderate infiltration rate when thoroughly wet. Moderately deep or deep, moderately well drained or well drained with moderate to moderately coarse texture.
C	Soils having a slow infiltration rate when thoroughly wet: soils have a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.
D	Soils having very slow rates of infiltration when thoroughly wet (high runoff potential): soils consist of clays with high shrink-swell potential; soils have a high permanent water table; soils that have a claypan or clay layer at or near the surface and soils that are shallow over nearly impervious material.

Each of soil type found in the City of Windsor Heights is discussed below along with a description of its drainage characteristics.

Approximately 36% of the soils in the City of Windsor Heights are made up of the Clarion-Urban land complex (4138C). The slopes are 5 to 9 percent. This component is on till plains, ground moraines. The parent material consists of loamy supra-glacial till. It is a well drained soil, hydrologic group B. The depth to water table is 4 feet.

About 32% of the soils are Urban land (4000). It is a miscellaneous area and no information is available regarding hydrologic soil qualities. The depth to water table is greater than 6 feet.

The Clarion-Urban land complex (4138B) constitutes 19% of the soils. The slopes are 2 to 5 percent. This component is on till plains, ground moraines. The parent material consists of loamy supraglacial till. It is a well drained soil, hydrologic group B. The depth to water table is 4 feet.

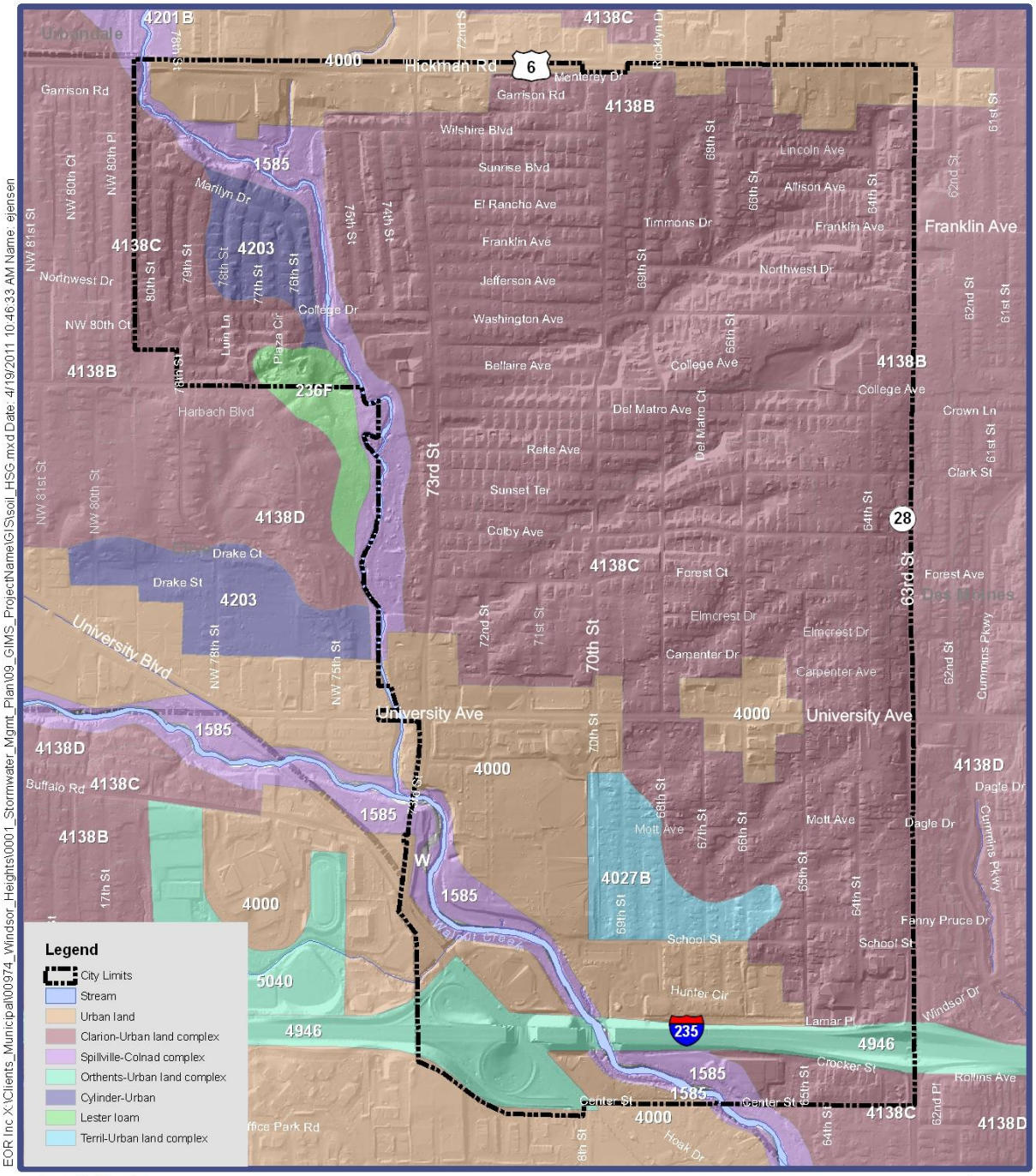
The Spillville-Coland complex (1585) makes up 5% of the soils. The slopes are 0 to 2 percent. This component is on river valleys, flood plains. The parent material consists of loamy alluvium. It is a well drained soil. The Coland slopes are 0 to 2 percent. This component is on flood plains, river valleys. The parent material consists of loamy alluvium. It is a poorly drained soil. The complex of Spillville and Coland soils are assigned to hydrologic group B. The depth to water table is 4 feet.

The Orthents-urban land complex (4946) makes up 4% of the soils. The slopes are 0 to 5 percent. This component is on hillslopes. The parent material consists of loamy sediments. It is a hydrologic group B soil. The depth to water table is greater than 6 feet.

The remaining soils each make up 1% of the soil within the city: Cylinder-Urban land complex (4203), Lester loam (236F), Terril-Urban land complex (4027B), and Water. Cylinder-Urban land complex slopes are 0 to 2 percent and are somewhat poorly drained. Lester loam soils have 18 to 25 percent slopes and are well drained. The Terril-Urban land complex has 2 to 5 percent slopes and is moderately well drained.

Residents report having wet basements in the City of Windsor. Based on types of soil found in the City, there should be relatively few problems related to buildings with basements. Possible explanations for the wet basements could be improper grading near home foundations, incorrectly placed downspouts, soil compaction from development, and excessive impervious area.

Figure 3. Windsor Heights soils



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Water Assessment Plan & Local Stormwater Management Plan

City of Windsor Heights, Iowa

Soils

Miles 0 0.25 0.5

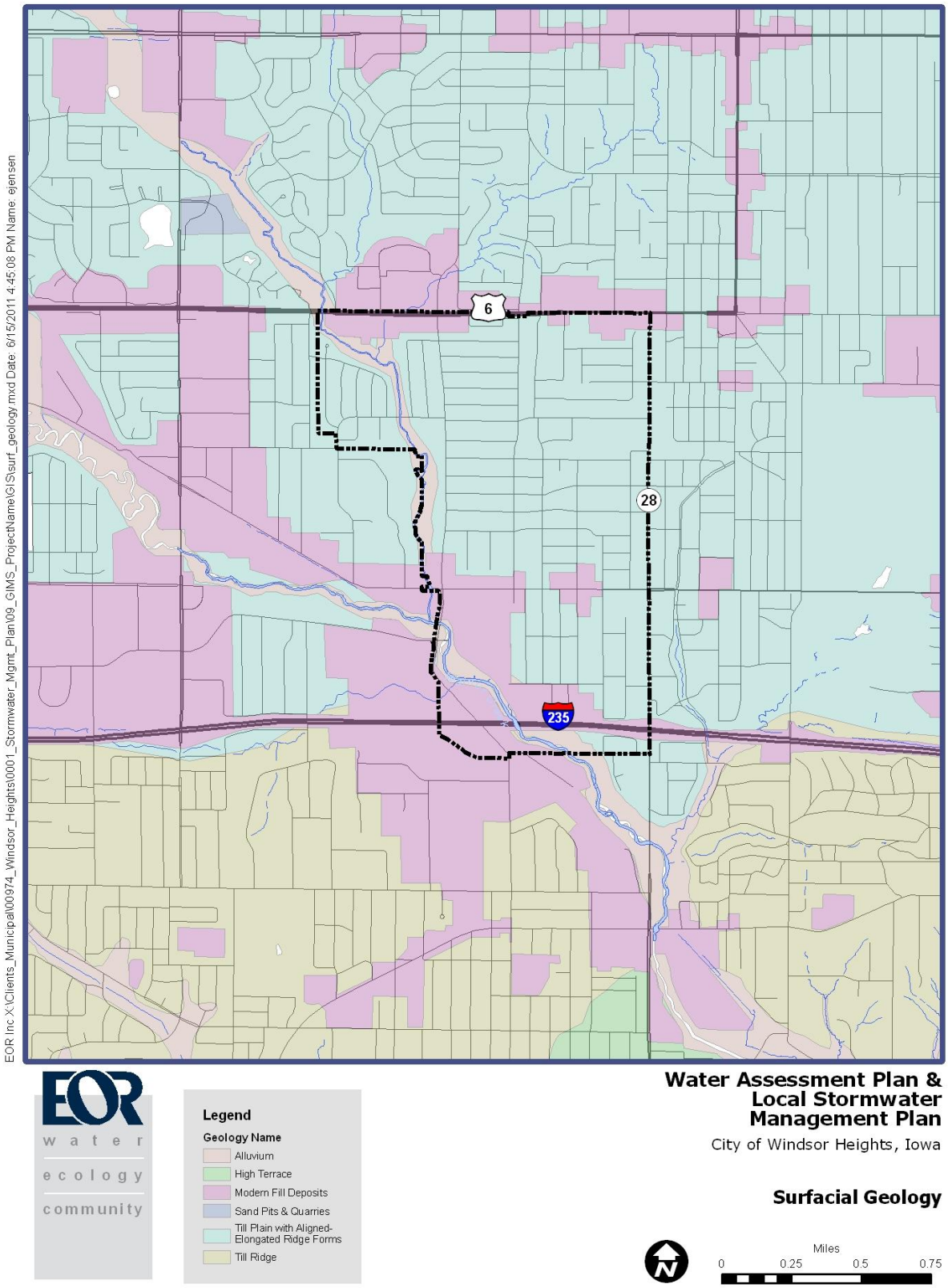
2.4 Geology

The surficial geologic deposits and landforms of the Windsor Heights area are primarily the result of glacial activity from the Quaternary Period (2 million years ago to present). The City of Windsor Heights lies to the north of till ridges left behind by the last glaciation to override Iowa. (Figure 4). Geologic deposits mapped in the City the Windsor Heights by the Iowa Geologic Survey fall into three types, fill (mapped as Qf), elongated till plain (mapped as Qtpl1), and alluvium (mapped as Qal). These three primary units were mapped at a scale of 1:100000 and shouldn't be used for site specific design.

Regions of the City mapped as fill are described as having variable soil texture ranging from sand and loam to concrete rubble. Stormwater infiltration in these areas may be achievable dependent on the type and thickness of the fill deposits. Areas mapped as elongated till plain exhibit a high degree of variability, ranging from stratified sand and gravel with inter-bedded stratified loam diamicton to stratified loam to silt loam to sandy loam diamicton. These deposits overly dense loam diamicton of the Dows Formation.-Alden Member and exhibit a seasonally high water table (Quade, 2002). Stormwater infiltration in areas with these deposits may be possible, but will require site specific design to identify soil texture and the range of the seasonally high water table. Areas mapped as alluvium vary in thickness from 1 to 5 meters and are predominately comprised of stratified silty clay loam, clay loam, loam to sandy loam alluvium and colluvium in stream valleys. Additional locations described as alluvium include hill slopes and closed depressions. Alluvium deposits exhibit a seasonally high water table and potential for frequent flooding. Stormwater infiltration in areas with alluvium may be possible, but will require site specific design to identify soil texture and the range of the seasonally high water table.

Underlying these surficial deposits are bedrock units that consist primarily of marine sedimentary rocks including limestone and dolomite, shale, mudstone, and sandstone deposited during the Carboniferous Period of the Paleozoic Era.

Figure 4. Surficial Geology



Quade, J. D., 2002, Surficial geologic map of the Des Moines Lobe of Iowa, Phase 4, D. J. Quade, J. D. Giglierano, E. A. Bettis III, and R.J. Wisner.

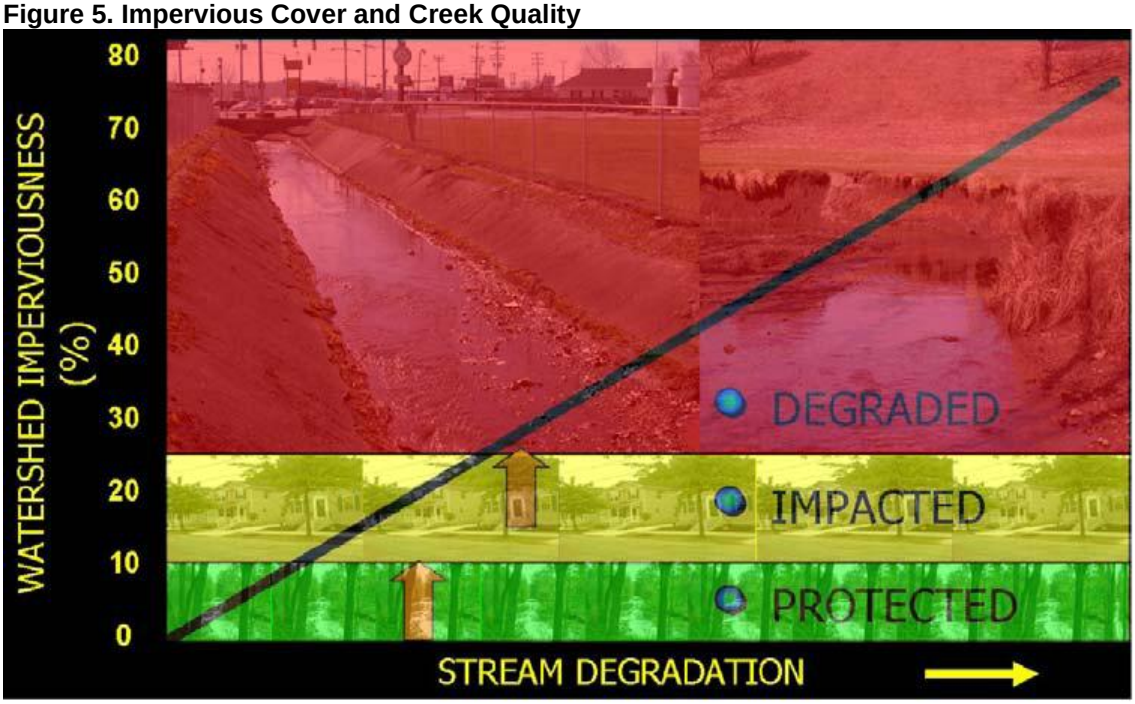
2.5 Land cover

As described in Section 1.3 the City of Windsor Heights is nearly completely developed. Land cover is primarily residential with some small commercial areas along major transit routes and a large box retail area in the southeast corner of the City.

As we move from the less to more intense land covers, the potential water quality and quantity problems increase. And the common thread throughout is the increasing amount of impervious surface. Materials like cement, asphalt, roofing, and compacted soil that prevent percolation of runoff into the ground. The surface is not necessarily a pollutant itself, but it transports pollutants, impedes infiltration and recharge of groundwater, increases the volume of runoff generated, and indicates more intensive & polluting land uses.

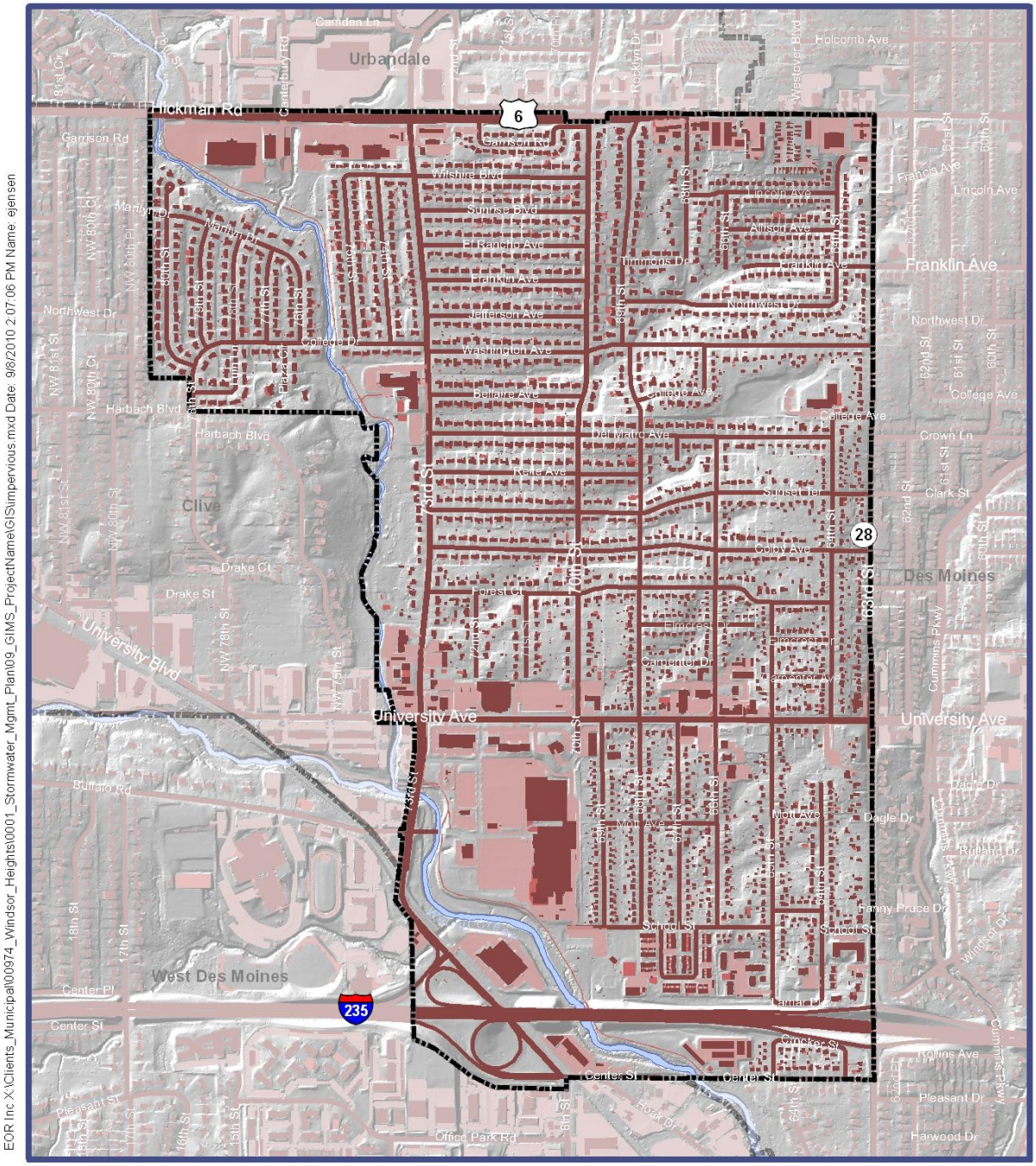
Impervious cover is integrative, in that it indicates overall water quality impacts of urbanization without regard to specific pollutants or resources. Study after study points to common thresholds for water quality degradation at 10% and 25% imperviousness (Figure 5). Where impervious cover is below 10%, water quality is typically protected (some studies show that more sensitive habitats may be impacted at lower levels of 7-8%. From 10% to about 25% imperviousness, we see impacted water quality. And above about 25% imperviousness, degradation is unavoidable. Certain measures can be taken to reduce impacts, but water quality is still going to suffer some level of degradation.

Figure 5. Impervious Cover and Creek Quality



It is important to get an estimate of the amount of impervious cover within an area in order to determine the level and type of treatment needed. Impervious cover can be estimated using satellite-derived land cover data and scientific literature on impervious levels for various land cover categories. Based on the land cover data available for the City of Windsor Heights, approximately 33% of the area within the City is impervious (Figure 6).

Figure 6. Windsor Heights Impervious Land Cover Map



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Impervious Areas

Legend

- City Limits
- Parking Area
- Misc. Structure
- Building Footprint
- Stream
- Paved Roadway

Water Assessment Plan & Local Stormwater Management Plan

City of Windsor Heights, Iowa

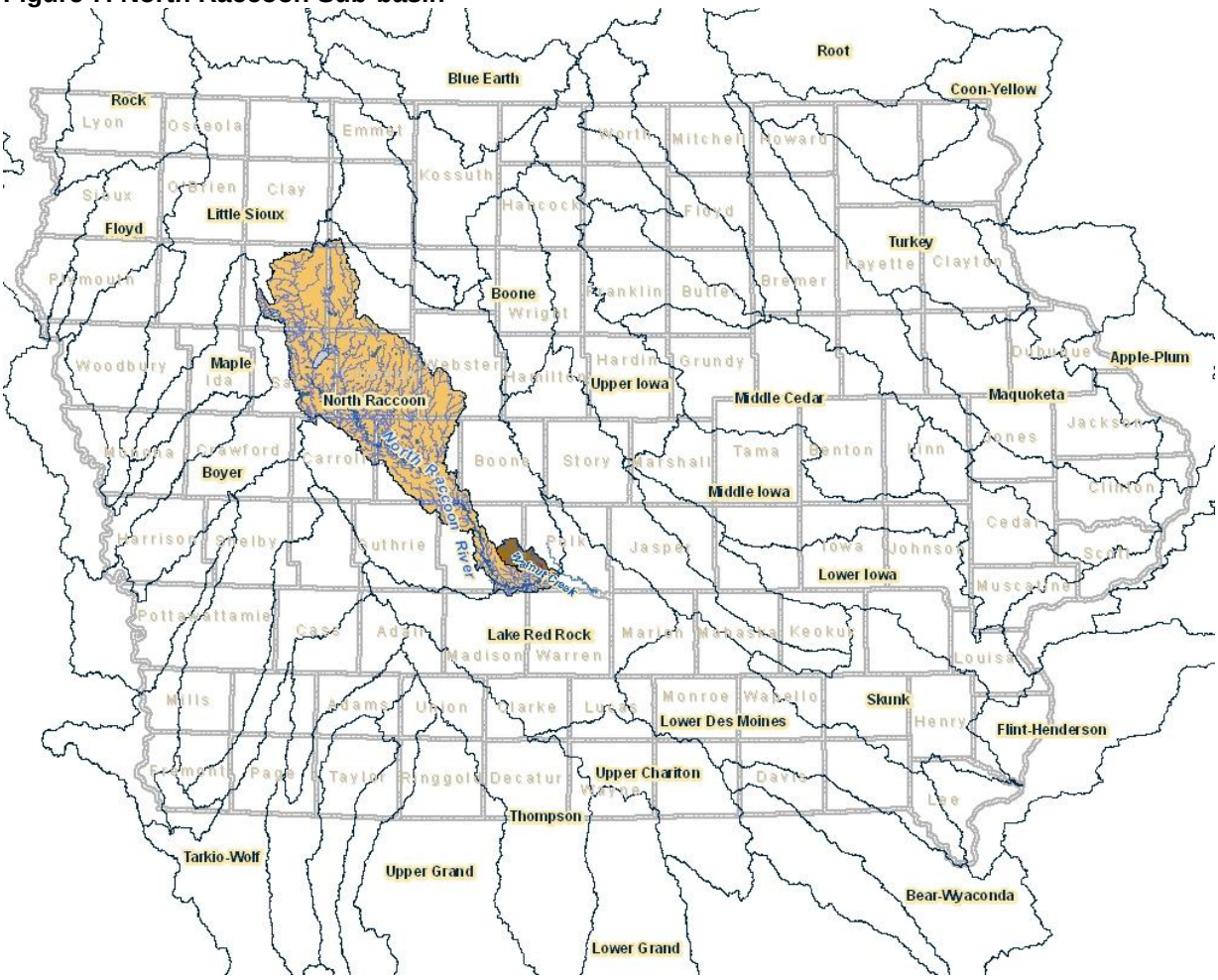
Impervious

Miles
0 0.25 0.5

2.6 Hydrologic Setting

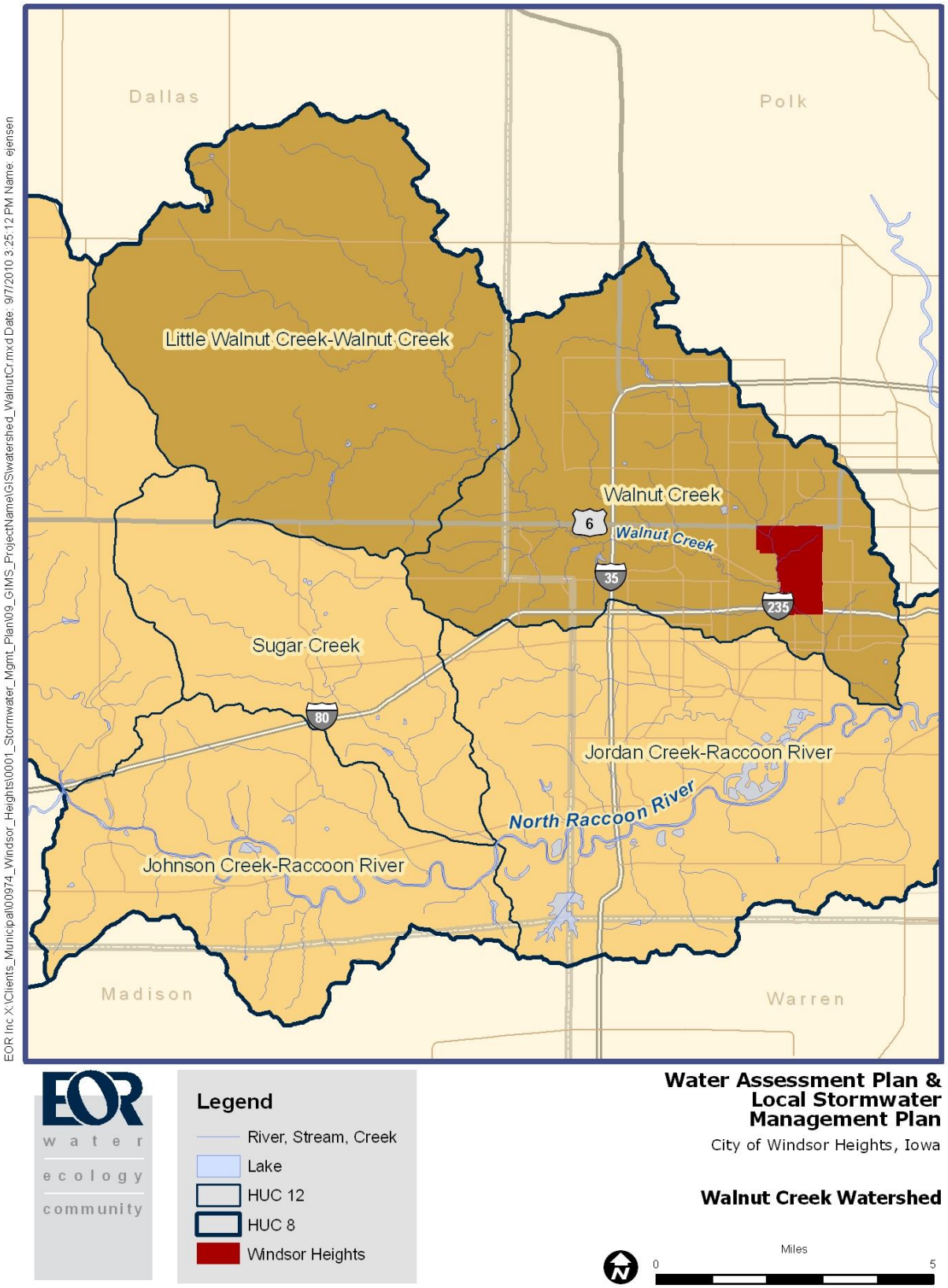
Every area of the earth in which water falls on land is called a "watershed." A watershed is an area of land that drains to a single outlet. Watersheds come in all shapes and sizes. Some are continental, like the Mississippi River Basin while others are smaller areas like the Walnut Creek Watershed. The City of Windsor Heights is located at the lower end of the Walnut Creek watershed, which is part of the larger North Raccoon watershed (Figure 7). The North Raccoon watershed lies within the Des Moines Basin, which is part of the Upper Mississippi River Basin.

Figure 7. North Raccoon Sub-basin



The Walnut Creek Watershed is split into two minor subwatersheds: Walnut Creek subwatershed (HUC 07100000616602) and Little Walnut Creek subwatershed (HUC 0700000061601) (Figure 8). Walnut Creek subwatershed is 24,167 acres and Little Walnut Creek subwatershed is 24,358 acres. The City of Windsor Heights is located at the bottom of the downstream Walnut Creek subwatershed. Also within the Walnut Creek subwatershed and the City of Windsor Heights is the North Walnut Creek subwatershed.

Figure 8. Little Walnut Creek and Walnut Creek Subwatersheds



3. HYDROLOGY/HYDRAULIC ASSESSMENT

The surface water system is described here based on the subwatersheds where the water accumulates and flows to a common outlet point to North Walnut Creek or Walnut Creek. There are also a few subwatersheds along and directly adjacent to the creek typically that have minimal storm sewer systems, identified as "Direct" tributary areas and therefore hydrologic/hydraulic modeling was not appropriate. There are also a few small subwatersheds that flow out of Windsor Heights to adjacent communities, either to Urbandale to the north or Des Moines to the east. The drainage areas have been aggregated into 12 subwatersheds based primarily on common outlet points to the Creeks. The subwatersheds are shown in Figure 9 and summarized in Table 2.

The hydraulic stormwater conveyance within Windsor Heights is primarily made up of urban drainage consisting of connected storm sewer. Stormwater ponds have not been constructed to limit flow rates into the sewer and no stormwater storage was modeled in the hydraulic model. Storm sewer structure data was surveyed in 2010 by Veenstra & Kimm and historic plans were used to model the appropriate diameters of a number of the pipes. Catch basin inlets were grouped by location and modeled at every pipe diameter size increase or primary connection groupings.

Some of the hydraulic connections between ravine flow and storm sewer conveyance were not evident to the survey crews and were modeled using the best available data. If flooding is occurring at locations not indicated from the modeling, a site level investigation is warranted. The model hydraulics were used to determine locations where the storm sewer is undersized and is not to the level of detail to be used for flood mapping studies or individual catch basin analysis.

The stormwater system was modeled for both the 5-year and 10-year storm events since these are the most commonly used design events for storm sewer systems. For larger storms, typically overland flow routes are available (ex. swales, streets, etc.) to carry these infrequent flows. It has been a common practice in municipal storm water systems to design and build the more expensive conveyance infrastructure, usually pipe systems, to carry these 5-year or 10 year events and tolerate the infrequent surface flows to keep the infrastructure costs to a manageable level. Many communities have been adapting their stormwater design to the 10-year event in recent years. The reasons for this are two-fold: a) based on efficiencies of scale, adding additional capacity such as increasing a pipe size, has relatively low incremental costs and b) given the uncertainties of changing weather patterns associated with climate change predictions, the additional capacity provides some extra level of safety factor that may be needed as storm events change magnitude and frequency over time. It would be our recommendation that the city adopt the 10-year storm as its design standard for stormsewer.

The incorporation of water quality BMPs throughout the city will improve water quality downstream as well as provide additional capacity and resiliency that likely will be needed with the uncertainties and higher risks of changing weather patterns associated with climate change predictions.

If there are specific situations where flooding can cause significant damage or safety concerns which warrant a higher design level, then that can be done on a case-by-case basis. The City staff have indicated that they are not aware of any significant concerns of flooding or safety that warrant a higher design level.

Table 2. Windsor Heights subwatersheds

Subwatershed	Acres	Flows to
Marilyn El Rancho Subwatershed	127	North Walnut Creek
Bellaire Subwatershed	252	North Walnut Creek
Forest Colby Subwatershed	112	North Walnut Creek
University East Subwatershed	124	Walnut Creek
University West Subwatershed	35	Walnut Creek
Windsor South Subwatershed	99	Walnut Creek
Direct - Marilyn Subwatershed	33	North Walnut Creek
Direct - 73rd Subwatershed	76	North Walnut Creek
Direct - Apple Valley Subwatershed	103	Walnut Creek
235 South Subwatershed	21	Walnut Creek
Hickman North Subwatershed	34	City of Urbandale
63rd East Subwatershed	28	City of Des Moines

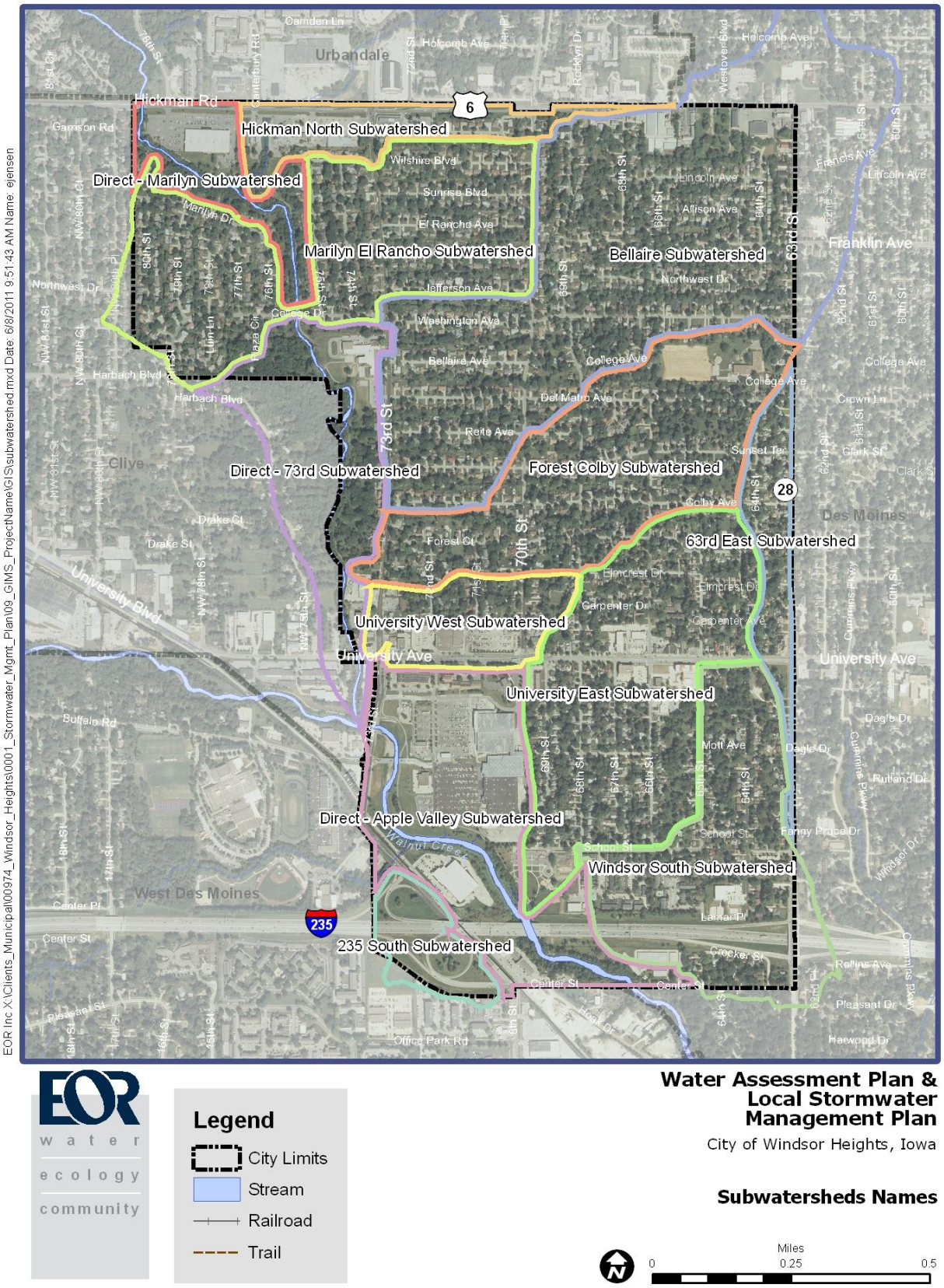
3.1 Assessment Methodology

To assess the capacity of the existing stormsewer system a hydrologic and hydraulic model of the city was created using StormNET. StormNET software is a state-of-the-art modeling program that takes advantage of full dynamic routing, including modeling reverse flows and backwater effects. The hydrologic portion of the model was developed using SCS Curve Number methodology based on soil type and landuse. Following recommendations in the Iowa Stormwater Manual, the 3-hour, 5-year (2.33 inches) and 3-hour, 10-year (2.73 inches) were used as the design storms for the stormsewer system.

All stormsewer of 24” diameter and greater were modeled explicitly. Model hydraulics such as pipe diameter, length and slope as well as manhole inverts and rims were defined based on stormsewer plans from the 1975 Storm Sewer Improvement Program and additional survey work completed for this project.

Where stormsewer capacity issues were found, options such as replacing undersized culverts or adding upstream storage were tested for there ability to eliminate the constraint without causing issues at other locations in the system. The stormwater system of each subwatershed is described in the following sections, including narrative on the identified capacity issues and solutions.

Figure 9. Windsor Heights Subwatersheds



EOR water ecology community

Legend

- City Limits
- Stream
- Railroad
- Trail

Water Assessment Plan & Local Stormwater Management Plan

City of Windsor Heights, Iowa

Subwatersheds Names

Miles 0 0.25 0.5

3.2 Assessment Findings

The following is a discussion of each of the main subwatersheds within the City and a description of the findings of the water quantity assessment work. Further details on the StormNet modeling can be found in Appendix 1 of the Plan.

Marilyn El Rancho Subwatershed – 127 acres

The Marilyn El Rancho subwatershed is located near the north of the city and consists of single family residential. This subwatershed is served primarily by two 48" (maximum pipe diameter) storm sewers on the east side of the river and two 24" stormsewer systems on the west.

The entire stormsewer network was modeled and no surcharging or flooding was discovered for the 5-year or 10-year event. No improvements are currently recommended.

Bellaire Subwatershed - 252 acres

The Bellaire subwatershed is the largest subwatershed in the city. Drainage is served primarily by two trunk systems; The 73rd North storm sewershed is drained by a large (66") trunk system that transverses the entire subwatershed. A parallel (60") system drains the 73rd Central storm sewershed in neighborhoods closer to the river. The 73rd North trunk drainage shows constraints under the 5 and 10-year storms.

The larger trunk line is undersized starting at the Washington Ave / 69th Street intersection. At this location the stormsewer decreases in size from 60" to 36" and constraints exist upstream from this point ~1240 feet to near Franklin Avenue for the 5-year event and throughout the extents of the system under the 10-year event.

Two options were explored to eliminate this flooding concern; increase pipe size and build storage in the watershed to achieve rate control. Increasing the size of pipe from 36" to 42" provides ample capacity throughout the constrained reach but the increased flows causes capacity issues downstream near 73rd St. This shifting of capacity issues is not recommended.

The second option is building storage into the landscape to provide rate control and/or reduce the volume of runoff using LID BMPs. Because some opportunity exists in the area of Hickman Rd and 62nd St where the city may be involved in some redevelopment, approximately 3 ac-ft of storage would need to be built into this area to alleviate flows to the downstream system as identified through modeling. An additional 1 ac-ft of storage would be needed in the area of 66th and Franklin to completely alleviate flooding in the system as identified through modeling.

Another creative alternative to investigate would be to reroute a portion of the Bellaire Subwatershed along Washington Ave. and 63rd St. to the south into the Forest-Colby Subwatershed and provide additional treatment for that drainage in or around the school grounds in that area. The school treatment could be underground or surface ponding, combined with water reuse (irrigation) and infiltration (into subsoils, if conditions are favorable) and bioretention (plant uptake). This has the dual benefit of water quantity control plus water quality benefits. The location may also allow for demonstration and educational opportunities.

A feasibility study should be undertaken to further evaluate these upstream retention/diversion and treatment options and determine the most feasible method to accomplish the storage and/or reduce runoff volumes to alleviate the capacity problems.

The additional storage and/or volume control discussed above would be appropriate to also design for water quality benefits. Coordinated design can be a very cost effective way to provide multiple benefits with one project. The feasibility study described above should include water quality benefits in the work.

The main open space/natural features in this subwatershed is the area in and around the school site which includes some wooded slopes and a low area along the historic stream bed. The features that are contemplated above for quantity and quality benefits should also consider what natural amenities can be provided. Some ability to provide walkable connections in this area may be beneficial to the school and community. By also designing in alternative (non-motorized) circulation/trails, it can make the area a safer and more pedestrian/biker friendly portion of the city. This can be seen as part of a community's efforts to be more sustainable and provides multiple benefits beyond water: walkability, reduced fuel use, reduced costs, reduced greenhouse gases, and improved exercise and health. Incorporating these aspects into the feasibility study above, if the city desires to, should review trail plans both within the city as well as in the neighboring communities.

Forest-Colby Subwatershed – 112 acres

The Forest-Colby Subwatershed is located in the central part of the city and contains primarily single family residential landuse. This subwatershed is served by one trunk system.

The storm sewer system is sized adequately up to the 10-year event. No improvements are currently recommended.

University East Subwatershed – 124 acres

The University East Subwatershed is located near the southern side of the city and serves residential and commercial landuses. This area is served by a trunk system with 3 major laterals.

The trunk system is adequately sized for the 5-year event although one constraint exists for the 10-year event. The constraint occurs on University Ave near 69th St where a large drainage area is served by a 24" pipe from the existing stormsewer prior to the storm sewer system upgrade in the 70's. Increasing the pipe size from 24" to 27" should be considered when street repairs are completed. Upstream small scale improvements should also be considered, as those considered for water quality below, to reduce the amount of flow reaching this undersized pipe. At the current scale of study, it is not easily apparent where these retrofits could be placed. A feasibility level study would be needed to look at the possibilities here at a finer level of detail.

Volume control that would benefit the above issue would be appropriate to also design for water quality benefits. Coordinated design can be a very cost effective way to provide multiple benefits with one project. A feasibility study for water quality benefits as well as quantity benefits should be implemented for this area and would be considered a higher priority due to the capacity issues in this subwatershed.

University West Subwatershed – 35 acres

The University West subwatershed is located near the river on the north side of University Avenue and serves Commercial and residential landuses. This subwatershed is drained by a 36" trunk system.

The storm sewer system is sized adequately for the 5-year and 10-year events. No improvements are currently recommended.

Windsor South Subwatershed – 99 acres

The Windsor South subwatershed is located on the southeast corner of the city. The single trunk line receives both residential and Highway 235 right of way drainage. This subwatershed is served by one trunk system.

The storm sewer system is sized adequately up to the 10-year event. No improvements are currently recommended.

Direct – Marilyn Subwatershed – 33 acres

The Direct Marilyn Subwatershed is located on and adjacent to North Walnut Creek between Hickman Road and College Drive. This subwatershed contains a mix of commercial, residential and natural landuses.

This subwatershed does not contain any major stormsewer. Flows from the subwatershed are directed to the Creek through a series of small pipes and by overland flow. Because of the threshold pipe size chosen for the modeling effort this subwatershed was not analyzed for stormsewer issues.

Direct – 73rd Subwatershed – 76 acres

The Direct 73rd Subwatershed is located on and adjacent to North Walnut Creek between College Drive and 73rd St. This subwatershed contains primarily natural, residential and institutional landuses.

This subwatershed does not contain any major stormsewer. Flows from the subwatershed are directed to the Creek through a series of small pipes and by overland flow. Because of the threshold pipe size chosen for the modeling effort this subwatershed was not analyzed for stormsewer issues.

Direct – Apple Valley Subwatershed – 103 acres

The Direct Apple Valley Subwatershed is located on and adjacent to Walnut Creek between 73rd St. and the city's southern boundary. This subwatershed contains primarily commercial and industrial landuses.

This subwatershed does not contain any major stormsewer. Flows from the subwatershed are directed to the Creek through a series of small pipes and by overland flow. Because of the threshold pipe size chosen for the modeling effort this subwatershed was not analyzed for stormsewer issues.

235 South Subwatershed – 21 acres

The 235 South Subwatershed contains the 235/Rancho Grande Blvd interchange. This subwatershed is served by two 24" trunk stormsewer.

The storm sewer system is adequately sized for the 5-year and 10-year events. No improvements are currently recommended.

Hickman North Subwatershed – 34 acres

The Hickman North Subwatershed is located at the northern boundary of the city on the south side of Hickman Road. This subwatershed drains primarily commercial landuses out of the city to the north.

This subwatershed does not contain any major stormsewer. Flows from the subwatershed are directed to the Creek through a series of small pipes and by overland flow. Because of the threshold pipe size chosen for the modeling effort this subwatershed was not analyzed for stormsewer issues.

63rd East Subwatershed – 28 acres

The 63rd East Subwatershed is located at the eastern boundary of the city on the south side of Hickman Road. This subwatershed drains primarily residential lands out of the city to the east.

This subwatershed does not contain any major stormsewer. Flows from the subwatershed are directed to the Creek through a series of small pipes and by overland flow. Because of the threshold pipe size chosen for the modeling effort this subwatershed was not analyzed for stormsewer issues.

4. WATER QUALITY ASSESSMENT

Stormwater runoff is considered non-point source water pollution. Unlike point source pollution, non-point source pollution comes from many diffuse sources. As runoff moves, it picks up and carries with it natural and man-made pollutants and deposits them into streams, lakes, rivers, wetlands, and groundwater. The most common non-point pollutants are sediment, nutrients, pathogens, toxic contaminants, debris, and thermal stress. Water quality may be affected by any number of these pollutants.

4.1 Pollutant Loading

Figure 10 shows the potential loading levels based on impervious cover averaged for each subwatershed. The green areas indicate low levels of imperviousness (most protective of water quality), yellow areas indicate moderate to high levels (definite impact on water quality), and red areas indicate high levels (unavoidably degrade water quality). By looking at these levels of impervious cover, we can begin to visualize the overall impact of our current land cover on our water resources. We see patterns on the landscape of where we are protecting, impacting or degrading the waters.

Sediment

The EPA defines sediment as fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water. Suspended and bedded sediments are particulate organic and inorganic matter that suspend in or are carried by the water, and/or accumulate in a loose, unconsolidated form on the bottom of water bodies.

Sediment that is deposited in streams can smother aquatic habitat, carry pollutants, and reduce water clarity. Common sources of sediment are construction sites, agricultural fields, disturbed areas and road sanding.

Nutrients

The most common nutrients of concern are phosphorus and nitrogen. Typical urban nutrient sources include animal waste, failing or improperly maintained septic systems, and fertilizers. Excess nutrients can cause a health hazard in drinking water and stimulate excessive aquatic plant growth, which can ultimately lower dissolved oxygen levels.

Pathogens

Pathogens are disease-causing bacteria and viruses associated with the presence of fecal matter, most commonly found in failing septic systems and animal waste. Pathogenic contamination is most important for waters designated for recreation (primary and secondary contact); public water supplies; aquifer protection; and protection and propagation of fish, shellfish, and wildlife.

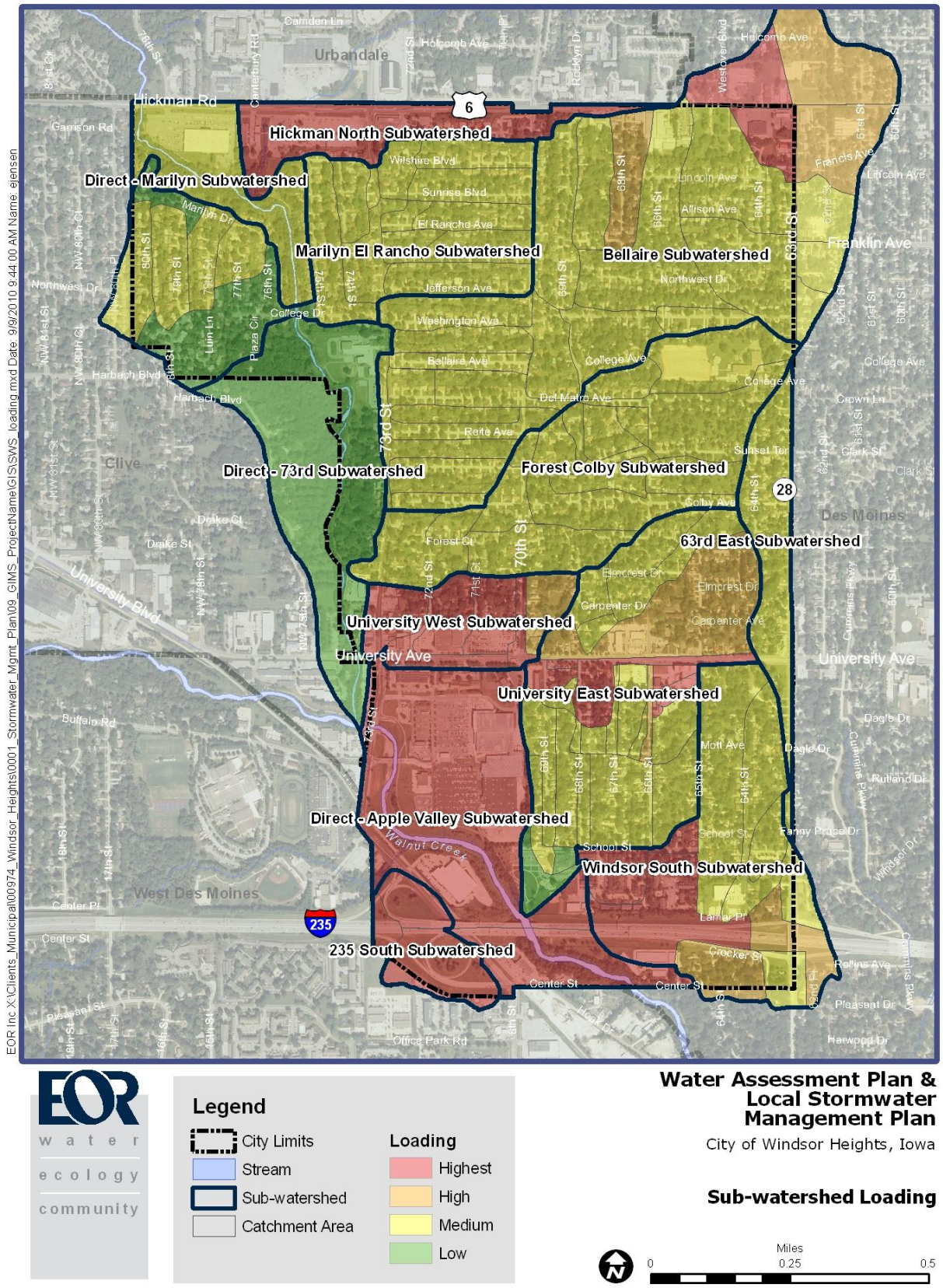
Toxic contaminants

Toxic contaminants are compounds like heavy metals and pesticides that can threaten the health of both aquatic and human life, and are often resistant to breakdown. Urban sources include industrial, commercial, household and agricultural chemicals and auto emissions.

Debris

Debris includes plastics and other trash that threaten aquatic life and detract from recreational and aesthetic values. Street litter is a common source of urban debris, but illegal dumping can also be a source.

Figure 10. Windsor Heights Pollutant Loading Ratings



4.2 Water Quality Priority Drainage Areas

Those subwatersheds identified as having the highest average annual TP and TSS loading rates on a per acres basis are priority subwatersheds for water quality improvements. In assessing opportunities to incorporate water quality improvements it is recommended that the City first consider projects within the priority drainage areas. Table 3 identifies the priority drainage areas within each subwatershed based on model results under existing landuse conditions.

Table 3. Priority Drainage Areas.

Subwatershed	Priority Drainage Area
235 South	235S-136
	235S-137
	235S-138
Bellaire	Bell-187
	Bell-196
	Bell-204
Direct – Apple Valley	DApp-111
	DApp-139
Hickman North	Hick-116
University East Subwatershed	UnvE-141
	UnvE-156
	UnvE-157
	UnvE-160
	UnvE-161
University West Subwatershed	UnvW-126
	UnvW-140
	UnvW-163
	UnvW-164
	UnvW-165
Windsor South	Wind-132
	Wind-135

4.3 Water Quality Improvements

There are limited opportunities for constructing significant water quality improvement projects in Windsor Heights due to the highly developed nature of the City. The following is a description of the proposed approach for siting water quality improvements throughout the City. An assessment of greater detail is recommended for determining the specific location for each improvement. It is recommended that these BMPs be incorporated into redevelopment projects (in addition to the stormwater management that would be required by City ordinance), in conjunction with City projects such as street reconstruction and through retrofitting.

The goal for water quality improvements was to capture 0.5" of runoff from 10% of the impervious surfaces within all of the subwatersheds within the City and from 25% of the impervious surfaces in the subwatersheds with stormwater volume issues. The type of BMP that is most appropriate for each subwatershed was determined based on land use, proximity to the Creek and topographic setting. Table 4 shows the relative rating of each type of BMP with green shading indicating that the BMP is best suited, yellow indicating that the BMP may be appropriate and pink shading indicating that the BMP may not be appropriate. This is a general assessment only; greater investigation of specific areas may establish a different conclusion as to appropriate BMP types. A further description of the BMPs can be found in Section 6.

Table 4. Appropriate BMPs by Subwatershed.

Subwatershed	Bioretention	Vegetated Swales and Buffers	Pervious Pavements	Infiltration Trench	Stormwater Wetlands	Stormwater Ponds	Sediment Traps	Amended Soils	Urban Forestry	Native Landscaping	Reducing Impervious Surfaces
Marilyn El Rancho Subwatershed *											
Bellaire Subwatershed*											
Forest Colby Subwatershed*											
University East Subwatershed											
University West Subwatershed											
Windsor South Subwatershed											
Direct - Marilyn Subwatershed											
Direct - 73rd Subwatershed											
Direct - Apple Valley Subwatershed											
235 South Subwatershed											
Hickman North Subwatershed											
63rd East Subwatershed											

*Subwatershed with stormwater volume issue

Marilyn El Rancho Subwatershed

This residential subwatershed, which straddles the North Walnut Creek in the northwest corner of the City, has low to medium loading rates and limited opportunities for large scale water quality BMPs. The focus for water quality improvements in this subwatershed will be small scale residential practices such as bioretention, infiltration trenches and native landscaping as described in Section 6.

Bellaire Subwatershed

This large residential subwatershed is located along the drainageway of one the buried streams in the northeast corner of the City. This subwatershed has capacity/volume issues as discussed in Section 3 and has medium pollutant loading rates with the exception of the drainage area around Hickman and 63rd Street which has very high loading rates. Any improvements to the hydraulics of this subwatershed will have a water quality improvement component. The focus for water quality improvements in this subwatershed will be on small scale residential practices such as bioretention, infiltration trenches and native landscaping but there may be opportunities to incorporate stormwater ponds and stormwater wetlands. Refer to Section 6 for a description of these BMPs. One specific location for a possible water

quality improvement project is in the Bellaire & 70th Street area as shown in Figure 11 As discussed in Section 3 there may be opportunities to incorporate stormwater management practices into the redevelopment area along Hickman and there may be an opportunity to direct water from this subwatershed to be treated in the Forest Colby Subwatershed. Another potential area for water quality improvement in this subwatershed is the boulevard along 73rd Street which is fairly wide.

Figure 11. Bellaire & 70th Street

Forest Colby Subwatershed

This subwatershed is similar to the Bellaire Subwatershed in that it is located along the drainageway of a buried creek but in this case the subwatershed does not have capacity issues. Loading rates in this subwatershed are medium. There has been a recent stormwater management project in this subwatershed in the school grounds at Washington and 66th. There is likely an opportunity to maximize the water quality benefit of this area, perhaps even routing additional flows into the area. There are also opportunities to incorporate small scale residential practices such as bioretention, infiltration trenches and native landscaping. Refer to Section 6 for a description of these BMPs.

University East Subwatershed

This subwatershed consists of mixed land use; mainly residential with some retail/commercial properties along University Avenue. Pollutant loading rates are very high. The focus for water quality BMPs in this subwatershed will be to incorporate practices into redevelopment projects and street improvements. Along the retail/commercial areas the focus will be on reducing impervious surfaces and in the residential areas there are opportunities to incorporate small scale residential practices such as bioretention, infiltration trenches and native landscaping. Refer to Section 6 for a description of these BMPs. A water quality improvement project could be constructed at City Hall to serve as a demonstration project.

University West Subwatershed

This subwatershed is located along and north of University Avenue from 70th to 73rd. The subwatershed is highly impervious and manly retail/commercial property. Pollutant loading rates are very high in this subwatershed. The focus for water quality improvements will be to reduce impervious surfaces and incorporating bioretention, infiltration trenches and pervious pavements. There is a potential for demonstration projects in this subwatershed.

Windsor South Subwatershed

This subwatershed is located along the southern end of the City and contains Highway 235 and other highly impervious areas. As such, loading rates are very high in this subwatershed. The approach for water quality improvements will be to work with redevelopment and to incorporate bioretention practices.

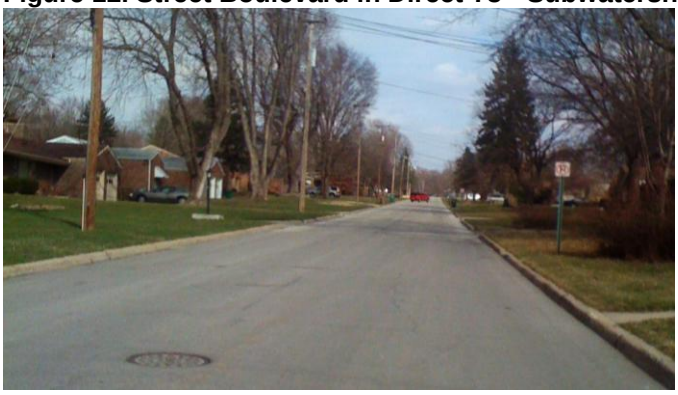
Direct - Marilyn Subwatershed

This subwatershed drains directly to North Walnut Creek. The area is mixed residential and commercial. Pollutant loading is medium in this subwatershed. Potential water quality improvements in this subwatershed include a demonstration project at the Iowa DNR building, buffering of the creek and various small scale practices such as vegetated swales.

Direct - 73rd Subwatershed

This subwatershed is the least impervious of any of the areas within the City and has low pollutant loading rates. The emphasis for this area would be to incorporate creek buffers to maintain the quality of the area. Since there is some open space in this subwatershed it may be possible to divert flow from other subwatersheds into this area for treatment.

Figure 12. Street Boulevard in Direct-73rd Subwatershed



Direct - Apple Valley Subwatershed

This subwatershed is the most impervious area of the City. It contains the large retail area and has very high pollutant loading rates. Drainage from the retail area is discharged into a greenbelt along the creek. There are several opportunities to incorporate water quality treatment in this subwatershed. The emphasis for this subwatershed will be to reduce impervious surfaces (Figure 13) and to incorporate any of a suite of BMPs. This is a very visible area and would make an excellent demonstration project site.

Figure 13. Large impervious surface at retail center

235 South Subwatersheds

This subwatershed is located across Highway 235 in the very southwest corner of the City and is very impervious. The area has very high pollutant loading due to the impervious surfaces. There are limited opportunities for incorporating BMPs in this area without the cooperation of the Iowa Department of Transportation. The interior areas of the highway off ramps is a potential site for stormwater treatment.

Hickman North Subwatershed

This subwatershed drains out of the City but eventually drains back into North Walnut Creek via the small tributary that runs through the retail area along Hickman. Loading in this subwatershed is very high due to the level of imperviousness. The approach for water quality treatment in this subwatershed should be on reducing impervious surface but there is also potential to incorporate BMPs into redevelopment projects. In some areas the boulevard of Hickman is wide enough to incorporate bioretention practices or vegetated swales.

63rd East Subwatershed

This subwatershed is a small strip of residential land located along 63rd Street along the eastern boundary of the City. The pollutant loading is medium and the flow of stormwater is actually out of the City. The appropriate practices in this area would be bioretention and possible reduction of impervious surface.

Catch Basin Retrofits

In addition to the standard suite of BMPs that is discussed in Section 6 there are numerous opportunities for stormwater management in retrofitting the stormsewer catch basins throughout the City. Figure 14 depicts some of the catch basins that are found in the City, many of which are not up to current standards. These catch basins each have an opportunity to have water quality component as they are rebuilt or replaced.

Figure 14. Catch basins in Windsor Heights

5. CREEK ASSESSMENT

5.1 Background

A creek is a complex ecosystem in which several biological, physical, and chemical processes interact. Changes in any one characteristic or process have cascading effects throughout the system and result in changes to many aspects of the system.

Often several factors can combine to cause profound changes. For example, increased nutrient loads alone might not cause a change to a forested creek. But when combined with tree removal and channel widening, the result is to shift the energy dynamics from an aquatic biological community based on leaf litter inputs to one based on algae and macrophytes. The resulting chemical changes caused by algal photosynthesis and respiration and elevated temperatures may further contribute to a completely different biological community. Many creek processes are in a delicate balance. For example, stream power, sediment load, and channel roughness must be in balance. Hydrologic changes that increase stream power, if not balanced by greater channel complexity and roughness, result in "hungry" water that erodes banks or the creek bottom. Increases in sediment load beyond the transport capacity of the creek leads to deposition, lateral channel movement into streambanks, and channel widening.

Most systems would benefit from increased complexity and diversity in physical structure. Structural complexity is provided by trees fallen into the channel, overhanging banks, roots extending into the flow, pools and riffles, overhanging vegetation, and a variety of bottom materials. This complexity enhances habitat for organisms and also restores hydrologic properties that often have been lost.

Chemical pollution is a factor in most creeks. The major categories of chemical pollutants are oxygen depleting substances, such as manure, ammonia, and organic wastes; the nutrients nitrogen and phosphorus; acids, such as from mining or industrial activities; and toxic materials, such as pesticides and salts or metals contained in some drain water. It is important to note that the effects of many chemicals depend on several factors. For example, an increase in the pH caused by excessive algal and aquatic plant growth may cause an otherwise safe concentration of ammonia to become toxic. This is because the equilibrium concentrations of nontoxic ammonium ion and toxic un-ionized ammonia are pH-dependent.

Finally, it is important to recognize that creeks and flood plains need to operate as a connected system. Flooding is necessary to maintain the flood plain biological community and to relieve the erosive force of flood discharges by reducing the velocity of the water. Flooding and bankfull flows are also essential for maintaining the instream physical structure. These events scour out pools, clean coarser substrates (gravel, cobbles, and boulders) of fine sediment, and redistribute or introduce woody debris.

5.2 Assessment Methodology

The Stream Visual Assessment Protocol (USDA Technical Note 99-1) was utilized to assess the general condition of the reaches of Walnut Creek and North Walnut Creek through Windsor Heights. This commonly used protocol for Iowa creek assessments was developed by the Natural Resources Conservation Service (NRCS) Aquatic Assessment Workgroup. The field work for this survey was completed on June 22nd 2010.

This assessment protocol provides a basic level of creek health evaluation. It can be successfully applied by conservationists with little biological or hydrological training. It is intended to be conducted with the landowner and incorporates talking points for the conservationist to use during the assessment. This protocol is the first level in a four-part hierarchy of assessment protocols. Tier 2 is the NRCS Water Quality Indicators Guide, Tier 3 is the NRCS Stream Ecological Assessment Field Handbook, and Tier 4

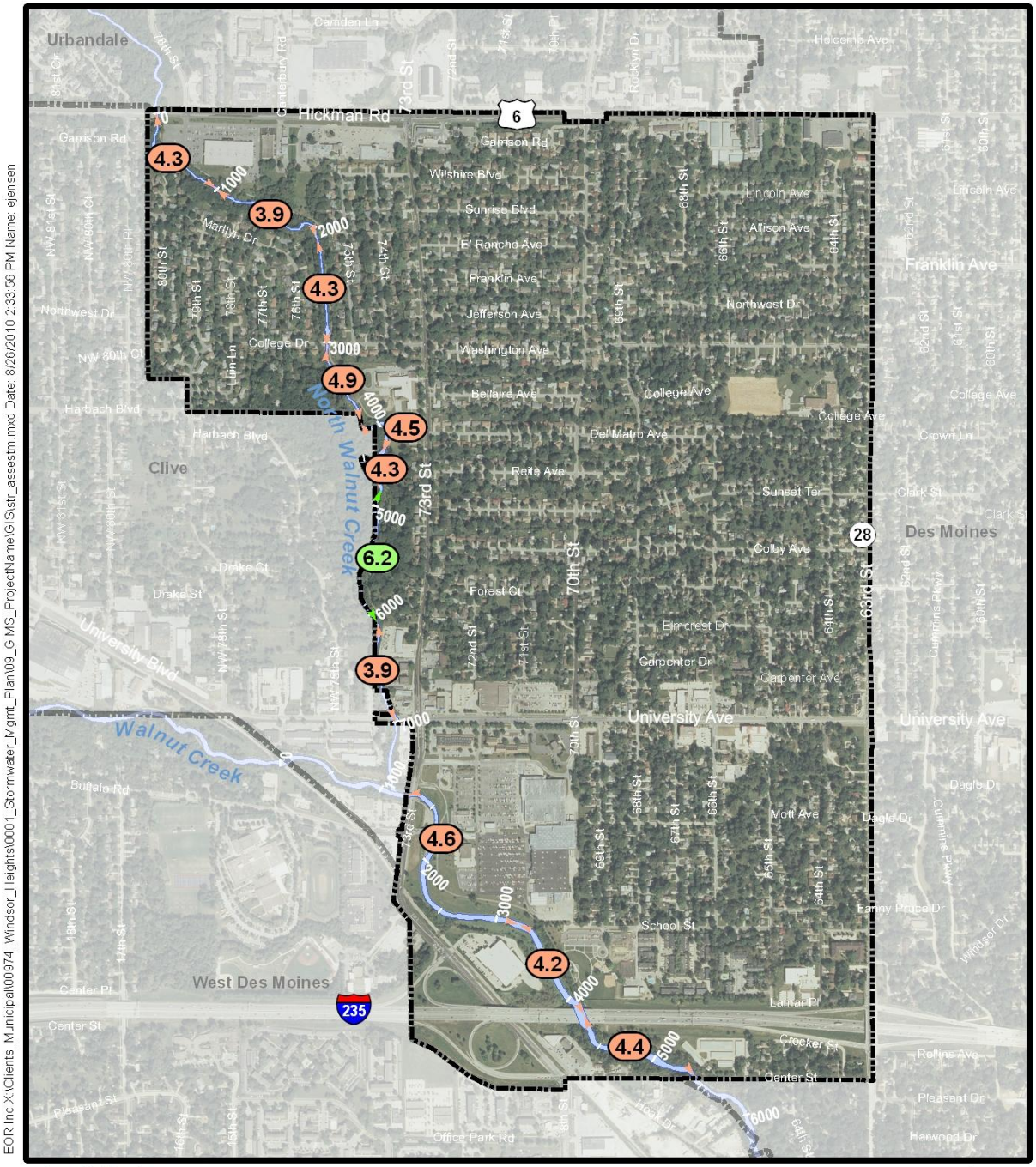
is the intensive bioassessment protocol used by your State water quality agency. This protocol provides an assessment based primarily on physical conditions within the assessment area. It may not detect some resource problems caused by factors located beyond the area being assessed. The use of higher tier methods is required to more fully assess the ecological condition and to detect problems originating elsewhere in the watershed.

Upon completion of the data analysis North Walnut Creek and Walnut Creek were divided into discernable reaches of similar characteristics. Representative photographs and generalized descriptions of these reaches can be found in Appendix 2. Both North Walnut Creek and Walnut Creek within the community of Windsor Heights received low Visual Stream Assessment scores. Of the eleven unique reaches identified ten received *POOR* rankings. Due to the associated conditions of a wider and healthier stream buffer, a single reach of North Walnut Creek received a *FAIR* ranking. The detailed results of the Tier 1 assessment for can be found in Table 5 and the location of the reaches is illustrated in Figure 15.

Table 5. Stream Visual Assessment for North Walnut Creek and Walnut Creek

Stream	Up-stream Station	Down-stream Station	Reach Length (ft)	Channel Condition	Hydrologic Alteration	Riparian Zone	Bank Stability	Water Apperance	Nutrient Entrichment	Barries to Fish Movement	Instream Fish Cover	Pools	Invertebrate Habitat	Canopy Cover	Manure Present	Salinity	Riffle Embeddedness	Macroinvertabrates	Overall Score (Total divided by number scored)	Ranking < 6.0 Poor 6.1-7.4 Fair 7.5-8.9 Good > 9.0 Excellent
North Walnut Creek	0	1000	1000	2	6	8	3	5	5	3	3	3	3	7	-	-	3	-	4.3	Poor
	1000	2100	1100	2	6	5	2	5	5	3	3	3	3	7	-	-	3	-	3.9	Poor
	2100	3050	950	1	5	9	9	5	5	3	3	1	1	7	-	-	3	-	4.3	Poor
	3050	3800	750	3	6	5	8	5	5	3	3	3	3	10	-	-	5	-	4.9	Poor
	3800	4300	500	3	6	5	6	5	5	3	3	3	3	7	-	-	5	-	4.5	Poor
	4300	4850	550	2	6	6	1	5	5	3	3	3	3	7	-	-	8	-	4.3	Poor
	4850	6100	1250	6	5	10	8	5	5	3	7	3	7	7	-	-	8	-	6.2	Fair
	6100	7000	900	1	3	6	5	5	5	1	3	3	3	7	-	-	5	-	3.9	Poor
Walnut Creek	1250	3200	1950	1	8	3	8	5	5	7	5	3	1	1	-	-	8	-	4.6	Poor
	3200	4200	1000	4	7	4	3	5	5	7	3	3	3	1	-	-	5	-	4.2	Poor
	4200	5400	1200	2	6	5	1	5	5	7	3	3	3	10	-	-	3	-	4.4	Poor

Figure 15. Visual Creek Assessment Locations



EOR
water
ecology
community

Legend

Ranking and Overall Score

Fair (6.0)

Poor (3.5)

500' Stationing

Water Assessment Plan & Local Stormwater Management Plan

City of Windsor Heights, Iowa

Visual Stream Assessment

Miles
0 0.25 0.5

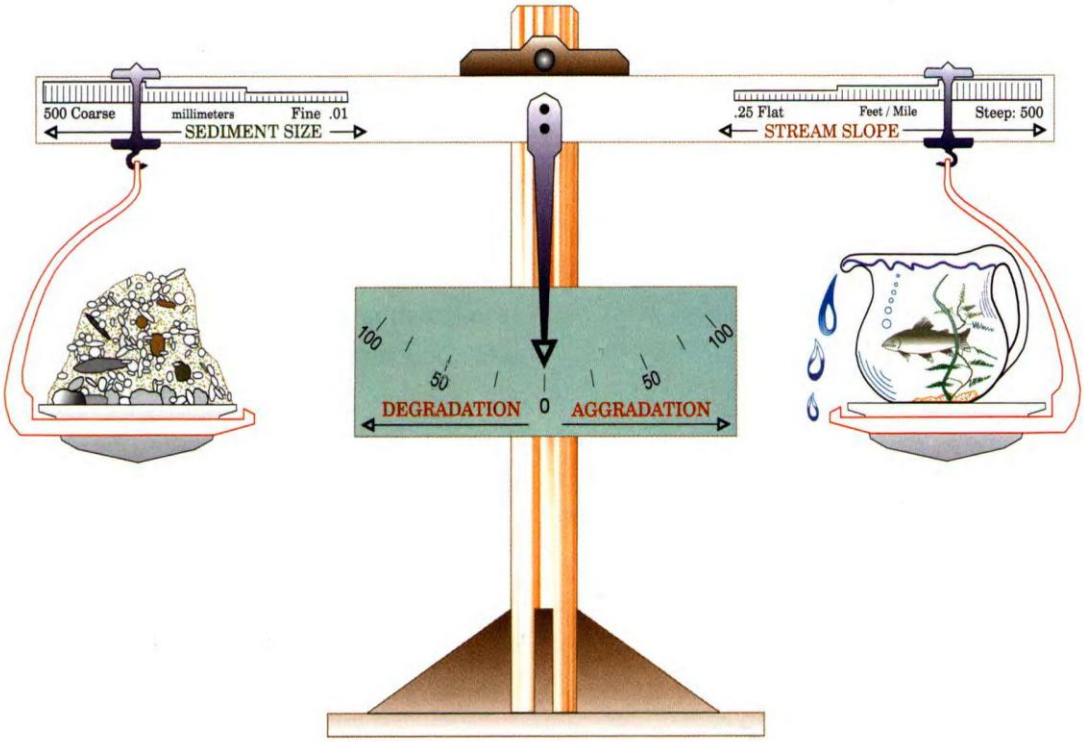
5.3 Assessment Findings

Creeks, being very dynamic, are subject to change when the variables that shape and maintain their morphological form are altered. These variables include velocity, roughness of the boundary, slope, width, depth, discharge, size of sediment debris, and concentration of sediment (Rosgen 1997). Dramatic compounding changes within the Walnut and North Walnut Creek Watersheds, such as channel straightening (increase in slope) and increase in impervious surface coupled with loss of wetlands (change in discharge) has resulted in a response (i.e. incision and erosion) to seek a new equilibrium to the current variables (see Figure 16).

Left alone, with no further disturbances, (although not likely or possible) the system would naturally evolve through the next stages and reach equilibrium. A precise timeline for this succession is unknown, but would likely be on the order of hundreds of years.

Flooding, erosion and degraded creek resources are to be expected from the land disturbances (first agriculture and more recently urban development) and the lack of measures (i.e. volume based stormwater criteria) to mitigate the effects of the alteration.

Figure 16. A generalized relationship indicating the stable channel balance (Rosgen 1996)



5.4 Recommendations for Creek Improvements

Solutions for stabilizing the identified eroding banks of Walnut and North Walnut Creeks can occur within the creek, but restoration of creek health and stability can not be realized without a watershed approach. The community should first address the erosion concerns posing an immediate threat to infrastructure and secondly reach out to the upstream communities while implementing stormwater Best Management Practices (BMP's) throughout Windsor Heights.

Priority 1 – Stabilize reaches posing an immediate threat to infrastructure
Direct – Apple Valley Subwatershed: Walnut Creek (Station 5000-5500)
Direct – Marilyn Subwatershed: North Walnut Creek (Station 1000-2100)
Direct – 73rd Street Subwateshed: North Walnut Creek (Station 4300-4850)

Priority 2 - Overarching Priorities
Restore local hydrologic balance by implementing stormwater BMP's throughout Windsor Heights (Section 4)
Restore hydrologic balance of the Walnut and North Walnut Creek Watersheds by engaging the cities and counties making up these watersheds and implementing a regional stormwater management plan (See Section 6.2)

Priority 3 – Look at opportunities to restore floodplain connectivity and alleviate entrenchment via property access and creek restoration
Direct – 73rd Street Subwateshed: North Walnut Creek (Station 6100-7000)
Direct – 73rd Street Subwateshed: North Walnut Creek (Station 7000-7500)
(Note: outside of Windsor Heights)

Priority 4 – Stabilize 2nd tier erosion instabilities with soil bioengineering measures throughout the City.

6. STORMWATER BEST MANAGEMENT PRACTICES

The following is a set of stormwater best management practices (BMPs) identified for the City of Windsor Heights as techniques worth considering in order to meet the city's stormwater management goals. In general, these goals entail reducing stormwater runoff, reducing flooding, providing stormwater treatment, and improving the quality and aesthetic and recreational value of the city's water resources. Stormwater BMPs take the form of both structural stormwater treatment and city programming.

Structural BMPs are the types of practices that could be used in proposed BMP locations. Structural practices identified herein are:

- Bioretention
- Vegetated Swales and Buffers
- Pervious Pavements
- Infiltration (Infiltration Trench / French Drain and Underground Infiltration)
- Stormwater Wetlands
- Stormwater Ponds
- Sediment Traps
- Amended Soils
- Urban Forestry
- Native Landscaping
- Reducing Impervious Surfaces
- Open Space Design

City programming can take the form of public or staff education initiatives, training programs, city practices on city land or rules and ordinances. Program activities can be implemented citywide or within priority drainage areas as identified in Section 4.2. Programmatic stormwater BMPs identified herein are:

- Regional Watershed Management
- Rules and Ordinances
- Rainwater Harvesting / Stormwater Reuse
- Vacuum Sweeping of Streets and Parking Lots
- Erosion and Sediment Control Training Programs
- Fertilizer/Chemical Application Management
- Stormwater Utility
- Public and Municipal Staff Education
- Winter Road Materials Management
- Potential Discharge Identification and Risk Reduction
- Hazardous Material Storage and Handling

6.1 Structural BMPs

Stormwater management through the use of low impact development (LID) can achieve stormwater management goals for the City. The principal goal of LID is to ensure maximum protection of receiving waters by mimicking the natural hydrology of the watershed. This goal is accomplished by using design techniques for development and retrofits that minimize, store, infiltrate, evaporate, treat and retain runoff. Many of the typical BMPs associated with LID are presented in this section including bioretention, vegetated swales and buffer strips, pervious pavements, infiltration, infiltration trenches / french drains, amended soils, native landscaping, reducing impervious surfaces, and open space design. Stormwater ponds are also included among the structural BMPs herein.

All structural BMPs and in particular LID BMPs, require proper siting and sizing. BMPs are sited downslope of impervious surfaces in permeable soils. BMPs are sited in HSG A (sand/loamy sand) and B (loam/silty sand) soils wherever feasible to maximize stormwater infiltration (refer to Soils discussion in Section 2.3. Soil borings are necessary in the locations of proposed BMPs in order to assess the infiltration capacity of the soil as characterized by the hydrologic soil group. Soil boring results guide the selection of BMPs and help to ensure the BMP will function properly. Onsite soil verification during construction enables siting or sizing adjustments in the case of spatial heterogeneity of HSGs. Underdrains with removable caps facilitate management of water levels during establishment of vegetation and provide operational flexibility.

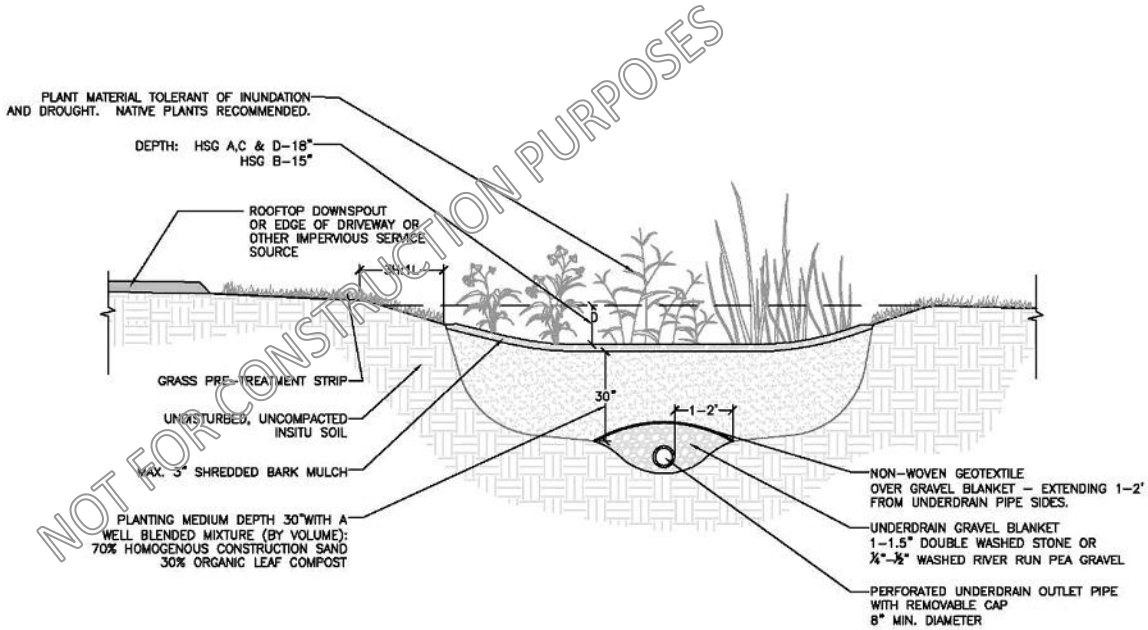
Pretreatment is also an important design element for structural BMPs (and in particular LID BMPs) in order to facilitate long-term effectiveness. Grass filter strips and sediment traps are two techniques. Finally, as with all stormwater management systems, BMPs require proper operation and maintenance.

Bioretention

Bioretention is a stormwater treatment practice that utilizes the chemical, biological and physical properties of soils, microbes and plants for infiltrating and/or filtering stormwater runoff. Bioretention facilities capture stormwater runoff to be filtered through an engineered soil medium. Stormwater can infiltrate in suitable soils and/or discharge through an underdrain providing filtration (treatment). Bioretention facilities can be designed to capture the first flush of runoff and discharge through an overflow outlet connected to existing storm sewer. The versatility of the practice allows for bioretention areas to serve as effective stormwater retrofits. Figure 17 illustrates specific design recommendations. Typical applications of bioretention include:

- Parking lot islands and margins
- Commercial setbacks
- Road right-of-way or cul-de-sacs
- Homeowner raingardens
- Regional stormwater infiltration basins
- Open space

Figure 17. Design recommendations for bioretention cell.



NOT FOR CONSTRUCTION PURPOSES

Contamination Consideration

Whenever runoff is directed to an infiltration BMP, there is a danger of groundwater contamination by the pollutants being carried in the runoff. In short, any surface runoff source that exposes or generates toxic or highly contaminating material should not be routed to an infiltration device unless some form of pretreatment is provided to remove the contaminant.

Vegetated Swales and Buffer Strips

Swales and buffer strips are a type of stormwater treatment composed of vegetation and a porous subsoil medium. Buffer strips are vegetated areas adjacent to a waterway that prohibit stormwater runoff from flowing directly into a water body. The vegetation catches pollutants carried by stormwater, decreases the rate of flow and volume of runoff, and stabilizes the soil on the shoreline or bank, lessening erosion caused by runoff. A swale is a long, vegetated depression often used as a water conveyance system which is also designed to infiltrate water and remove sediment and pollutants from runoff. A swale, therefore, assists in recharging ground water and managing stormwater runoff quantity and quality. Maintaining a buffer or swale upstream of surface waters reduces pollutant impacts from sediment, phosphorus, nitrogen and high temperature waters.

Vegetated Swale Design

Vegetated swales are linear, channel-like surface depressions that can be utilized as conveyance to direct stormwater away from or around a structure, for treatment to remove pollutants from stormwater, to promote infiltration of runoff into the ground and as volume control for stormwater runoff. Vegetated swales can also be landscaped to provide an aesthetic appeal and provide natural habitat within an urban setting. Vegetation can range from tall plants and grasses to a short turf grass depending upon the desired application of the swale. Any vegetation used should be water tolerant. Native vegetation is preferred with its ability to uptake water and filter pollutants like phosphorus and sediment. Roots of native vegetation grow deep to stabilize the soil and promote infiltration, and native vegetation does not require irrigation after the first year of establishment. Figure 18 and Figure 19 illustrate design recommendations

for vegetated swales. Checkdams are recommended in order to provide retention and facilitate infiltration.

The following are example applications for vegetated swales:

- Natural drainage on a residential lot
- Along local roads in place of curb and gutter
- Parking lot islands and medians
- Highway medians
- First line of defense upstream of the stormwater system
- Aesthetic amenity at civic, commercial or residential sites
- Low flow conveyance in place of structural conveyance
- Pretreatment prior to discharge to open water or stormwater treatment facilities such as infiltration basins

Figure 18. Design recommendations for vegetated swale (cross-section).

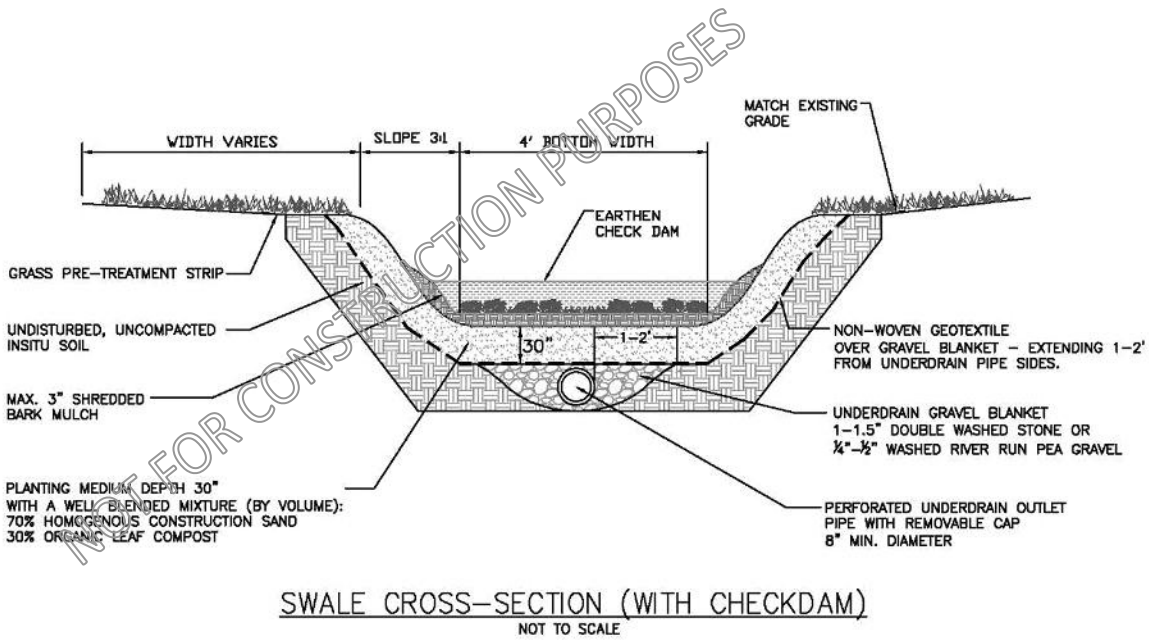
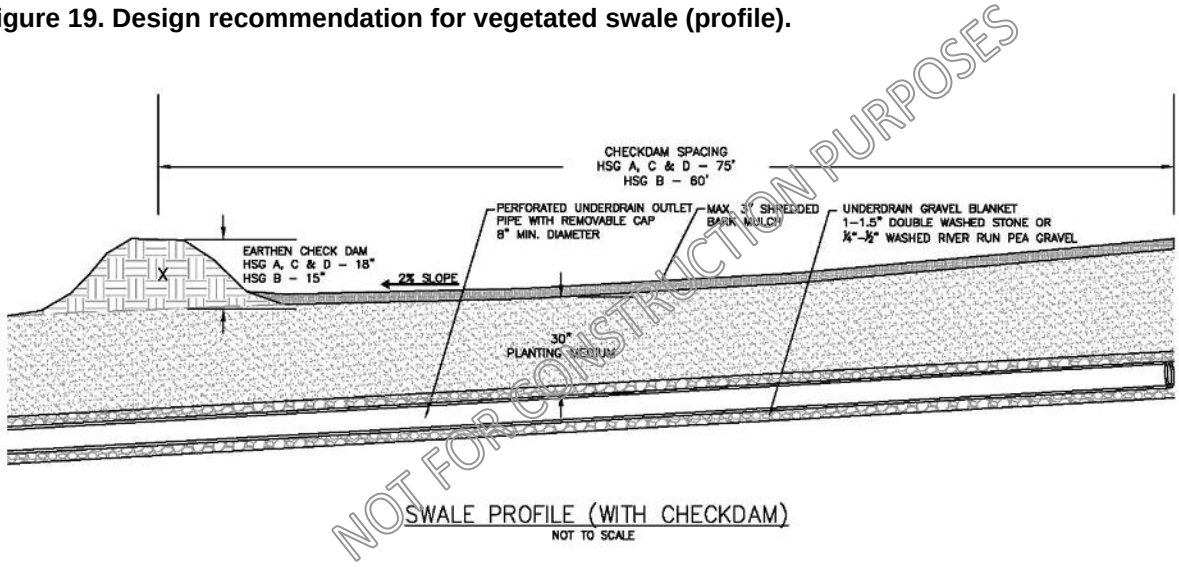


Figure 19. Design recommendation for vegetated swale (profile).



Buffer Design

Buffers can provide many different environmental and economic benefits, including:

- Protection of downstream stormwater treatment BMPs
- Protection of wetlands, creeks, lakes or other waterbodies
- Reduced small drainage problems and complaints
- Reduced risk of flood damage
- Reduced creek bank erosion
- Increased adjacent property values
- Enhanced pollutant removal
- Location for greenways and trails
- Sustained integrity of creek ecosystems and habitat
- Prevention of disturbance of steep slopes
- Mitigation of creek warming
- Protection of important creek corridor habitat for wildlife

The determination of buffer widths on individual waterbodies could be based on the following minimum guidelines:

- 35 – 50 feet for reduction of human impact
- 50 – 100 feet for overall water quality protection
- 50 – 200 feet for habitat protection and species diversity

Use the high end of the range for sensitive water bodies, steep slopes and surrounding land uses that could adversely impact the water body. Add buffer width to off-set the adverse impacts of slope, poor soils, human land use pressures, or to add extra protection for sensitive aquatic organisms or wildlife. Flexibility in application of buffer width requirements can be achieved through buffer width averaging, variances and conservation easements. Overall, the U.S. Fish and Wildlife Service and the Center for Watershed Protection agree that bigger is better in terms of many factors including water quality treatment, erosion control and habitat.

A vegetative mix of trees, shrubs and groundcover are recommended to provide several layers of protection. Native prairie planting may be best for the groundcover portion of any buffer. The deep roots, hardiness, aesthetic appeal, unique habitat character and filtering ability all make prairies an ideal vegetative ecosystem for a conservation buffer. Trees and shrubs can also be used as a vegetative transition from the waterbody. Trees and shrubs can provide for enhanced infiltration and nutrient uptake while stabilizing soil and dissipating rainfall. Specific plantings will depend upon your application and area within the state. Vegetation and grading of any buffer area enables runoff to occur as sheet flow rather than forming channels and rills.

Typical Cost

The cost of installation of a vegetated swale or buffer strip varies greatly based on width, soil amendments, the use of check dams and vegetation. The cost of the installation of a vegetated swale is estimated at $0.50 per square foot, according to a 2004 study done by the Army Corps of Engineers. There will also be costs associated with labor and supplies for necessary maintenance. Financial help may be available through cost share programs and grants to offset the cost of installation.

Pervious Pavements

When rainfall hits impervious pavements such as conventional concrete and asphalt, the water runs off, collecting pollutants along the way and ends up in stormdrains and waterways. Pervious pavements allow water to pass through the surface and infiltrate into the soil below rather than running off impervious surfaces and into surface water (Figure 20). Pervious pavements have the dual benefit of serving as a parking or drive surface and a stormwater management BMP.

Figure 20. Alley with impervious pavement and poor drainage (left); alley with pervious pavement resulting in no standing water (right).

Image Source: Chicago Green Alley Handbook, CDOT.

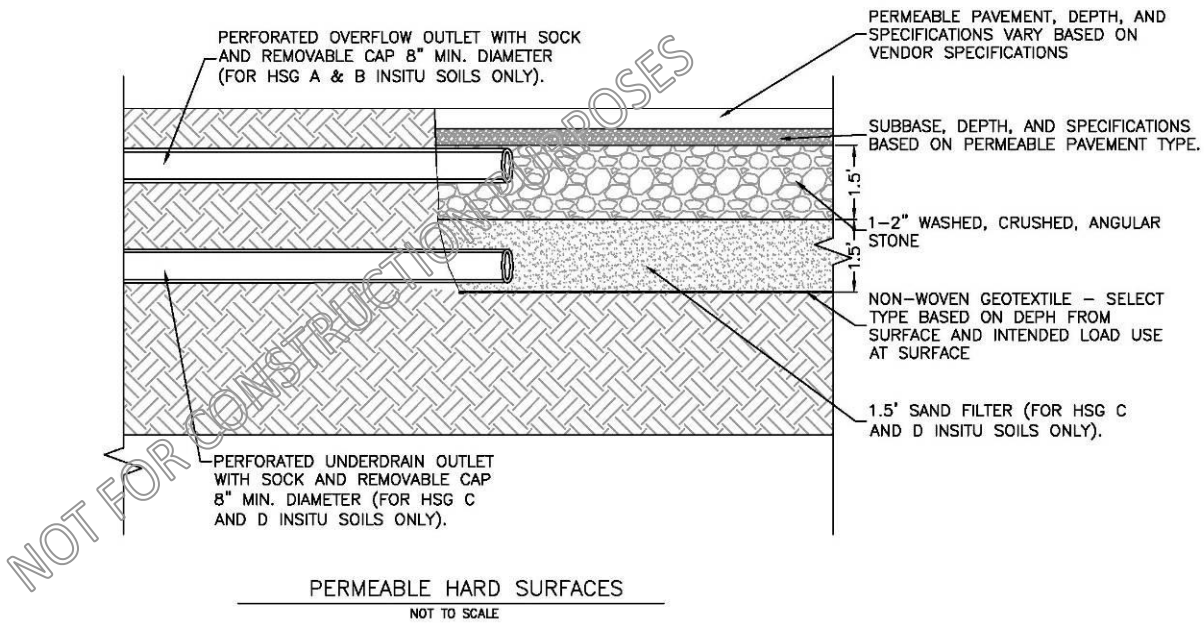
Pervious pavements include pervious asphalt, pervious concrete, pervious interlocking concrete pavers and plastic grid systems:

- **Pervious asphalt** consists of fine and course aggregate stone bound by a bituminous-based binder. The amount of fine aggregate is reduced to allow for a larger void space of typically 15 to 20 percent.
- **Pervious concrete** is a mixture of Portland cement, fly ash, washed gravel, and water. Unlike conventional concrete, pervious concrete usually contains a void content of 15 to 25 percent which is achieved by the addition of a fine, washed gravel.
- **Pervious interlocking concrete pavers**, when installed, form patterns that create openings through which rainfall can infiltrate. These openings, generally 8 to 20 percent of the surface area, are typically filled with pea gravel aggregate.

- **Plastic grid systems**, sometimes referred to as geocells, consist of flexible plastic interlocking units that allow for infiltration through large gaps filled with gravel or topsoil planted with turf grass. Empty grids are usually at least 90 percent open space, so void space depends on the fill media.

Figure 21 illustrates design recommendations for pervious pavements, also called permeable hard surfaces.

Figure 21. Design recommendations for pervious pavements.



Typical Cost

Construction costs of pervious pavements should be viewed with caution, given the wide range of site conditions and design requirements. It is recommended that each potential application be evaluated on a site-by-site basis. However, a range of cost estimates for the basic installation of pervious paver materials (including minimum base requirements) is given in Table 6. Range of cost estimates for basic installation of pervious paver materials (including minimum base requirements). for comparison purposes. These costs should not be compared directly to the cost of conventional pavements because pervious pavements are also stormwater management systems. An accurate price comparison would include the costs for full stormwater management and paving systems; that is, curbs, gutters, piping and storage.

Table 6. Range of cost estimates for basic installation of pervious paver materials (including minimum base requirements).

Paver System	Cost Per Square Foot Installed (2009 $)
Permeable Asphalt	$4.00 to $9.00
Permeable Concrete	$6.00 to $12.00
Pavers	$7.00 to $15.00
Plastic Grid System	$3.00 to $9.00
Amended Soils	$12.00 to $16.00

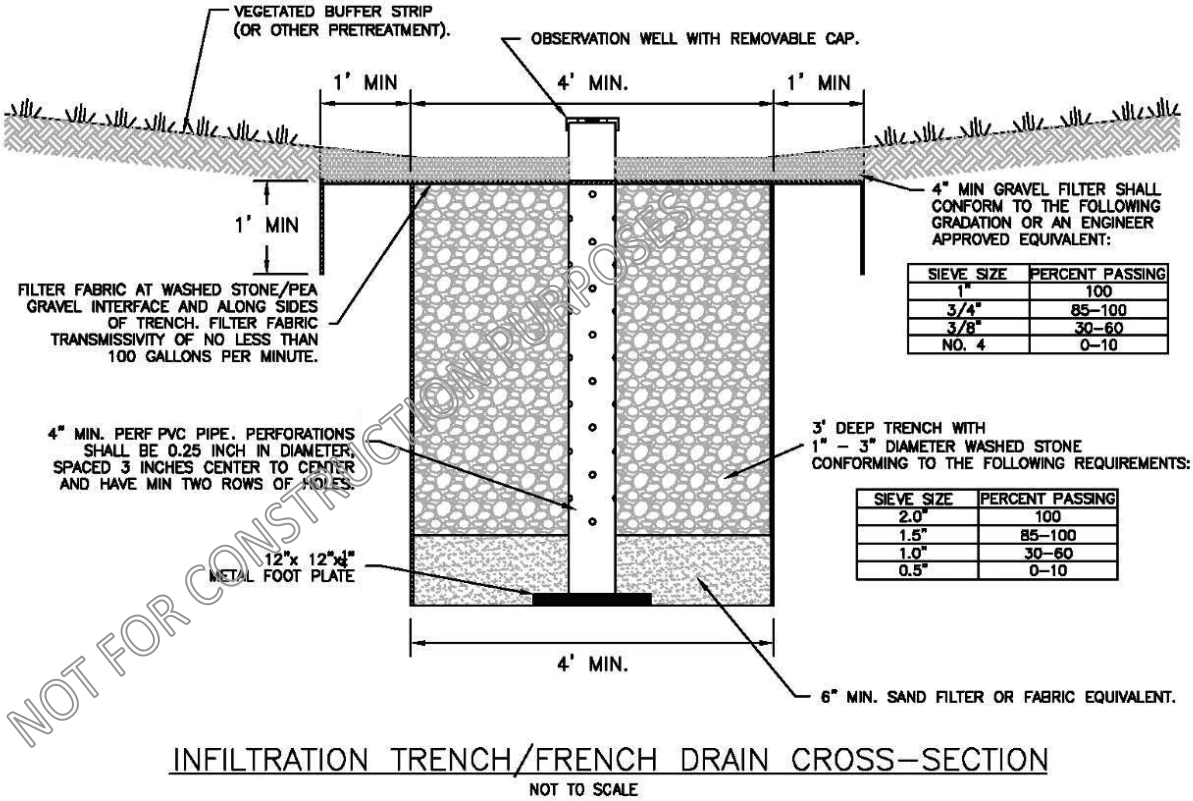
Infiltration

Stormwater infiltration practices capture and temporarily store stormwater to facilitate infiltration into the soil. Infiltration reduces stormwater pollutant discharges to receiving waterbodies, increases groundwater recharge and baseflow in creeks, reduces peak flow rates volume of stormwater runoff and reduces thermal impacts of stormwater runoff. Infiltration design variants include the infiltration basin, the infiltration trench or French drain, and the underground infiltration system. Bioretention facility designs often incorporate the infiltration mechanism. For discussion regarding infiltration basins, see *Bioretention* on page 39. This section addresses infiltration trenches / French drains and underground infiltration.

Infiltration Trench / French Drain

Typically, infiltration trenches (also called French drains) are designed for small sites (e.g. five acres or less) but can be applied to larger areas if designed properly. Consideration should be given to the slopes of the contributing drainage area. Figure 22 illustrates design recommendations for infiltration trenches.

Figure 22. Design recommendations for infiltration trenches / french drains.



Underground Infiltration

Underground infiltration systems, including pre-manufactured pipes or modular structures, have been developed as alternatives to infiltration basins and trenches for space-limited sites and stormwater retrofit applications. These systems are similar to infiltration basins and trenches in that they are designed to capture, temporarily store and infiltrate the design volume of stormwater over several days. Underground infiltration systems should be installed in areas that are easily accessible to routine and non-routine maintenance. Figure 23 through Figure 25 illustrate design recommendations for underground infiltration systems; underground infiltration systems can be constructed with or without modular structures though modular structures substantially increase storage volume. Typical applications for underground infiltration systems include:

- Below parking lots or ball fields
- Retrofits in more densely developed areas

Figure 23. Design recommendations for underground infiltration systems (cross-section).

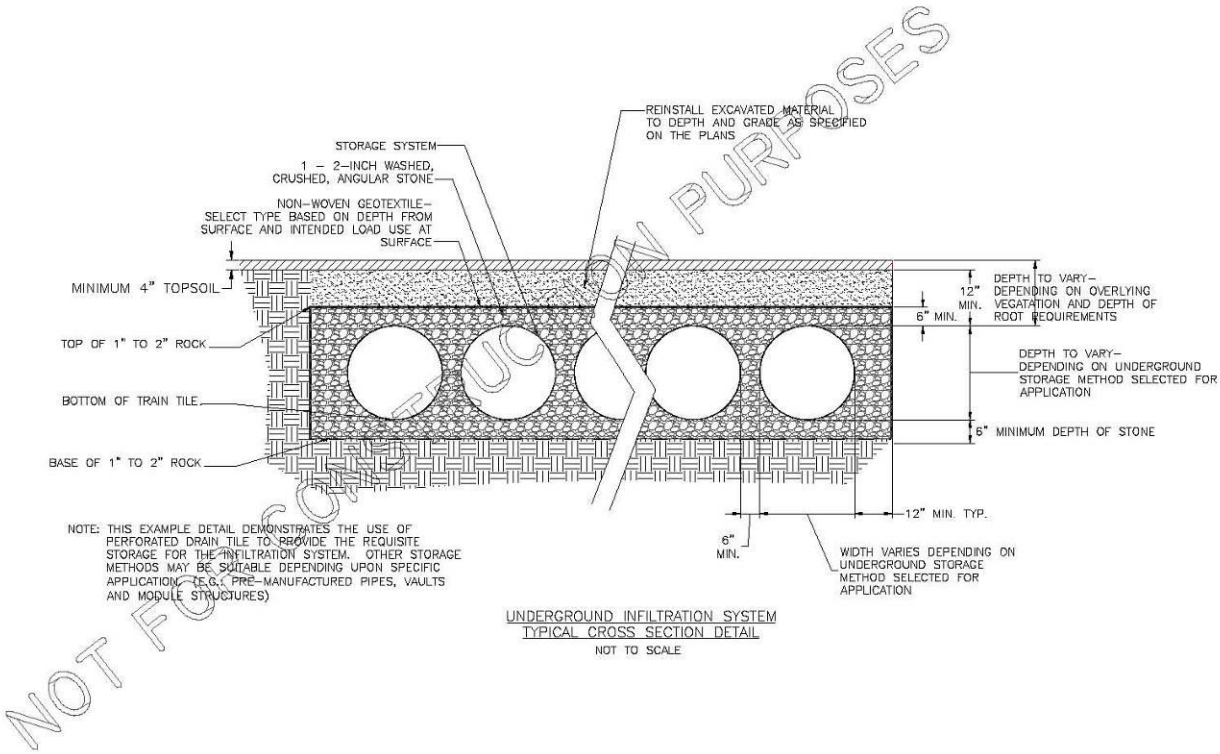
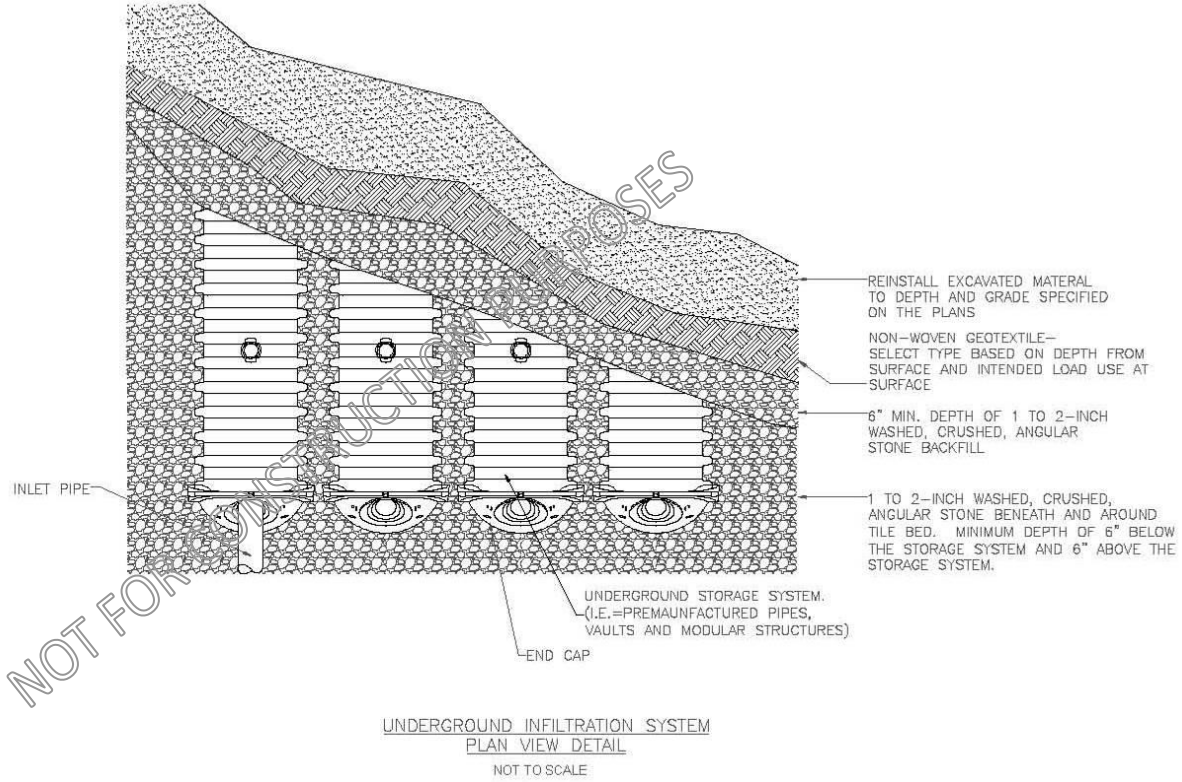
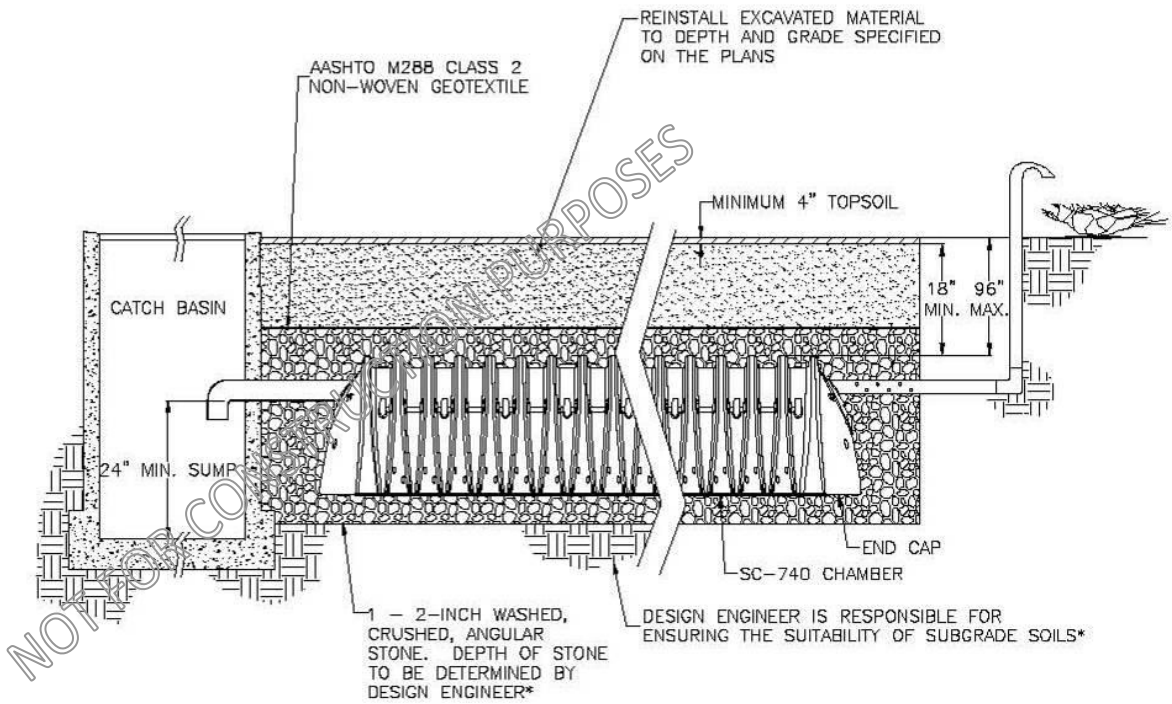


Figure 24. Design recommendations for underground infiltration (plan view).



UNDERGROUND INFILTRATION SYSTEM
PLAN VIEW DETAIL
NOT TO SCALE

Figure 25. Design recommendations for underground infiltration (vent detail).

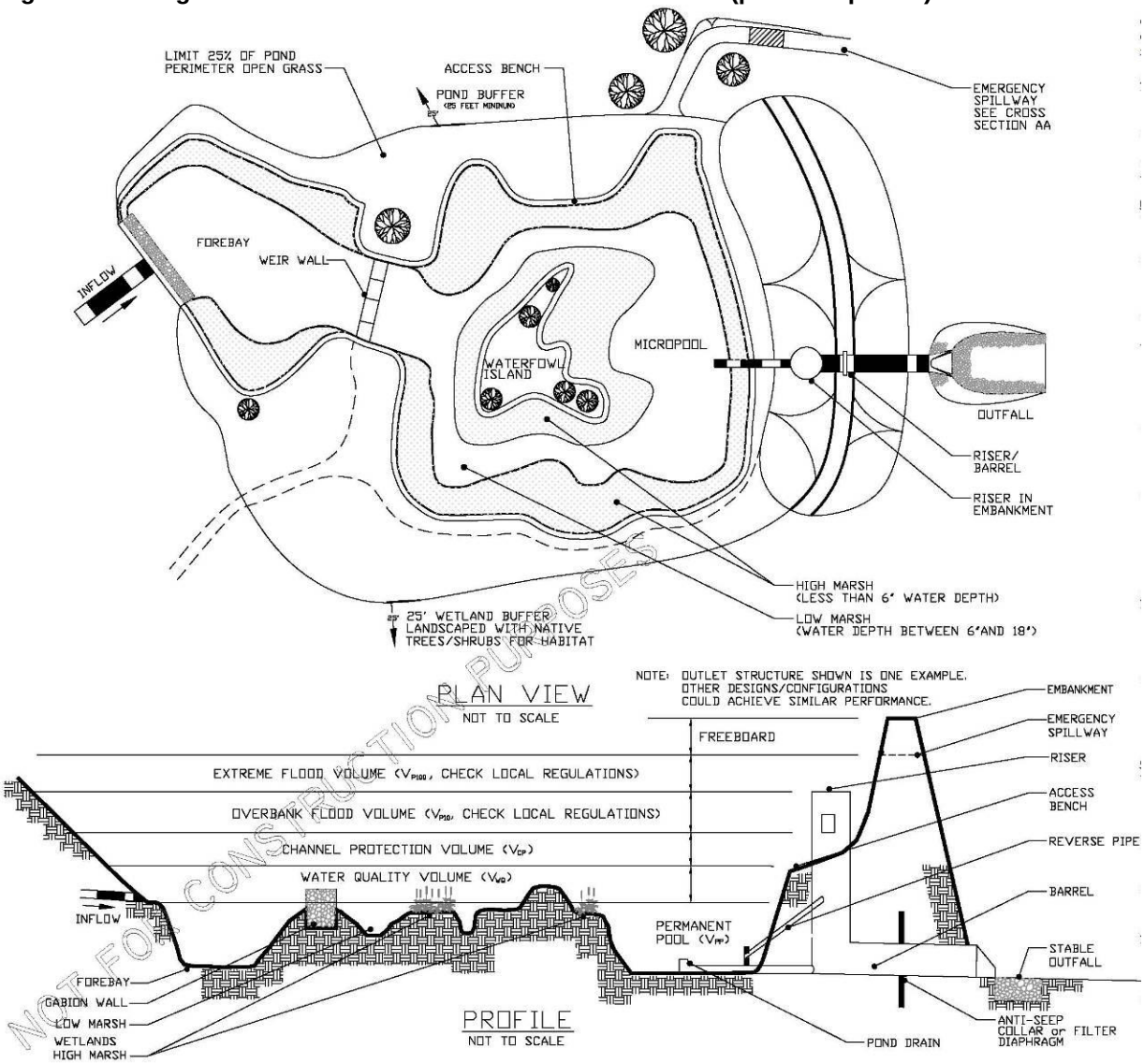


NOT FOR CONSTRUCTION PURPOSES

Stormwater Wetlands

Constructed wetland systems are implemented to store and treat runoff by emulating the function of natural wetlands. However, stormwater wetlands are not natural wetlands and natural wetland areas should not be utilized as stormwater wetlands. Stormwater wetlands are similar in design to stormwater ponds and mainly differ by their variety of water depths and associated vegetative complex. They require slightly more surface area than stormwater ponds for the same contributing drainage area. Stormwater wetlands are widely applicable stormwater treatment practices that provide both water quality treatment and water quantity control. They are typically installed at the downstream end of a stormwater treatment train. When designed and maintained properly, stormwater wetlands can be a valuable aesthetic feature of a site. Figure 26 illustrates design recommendations for a shallow stormwater wetland.

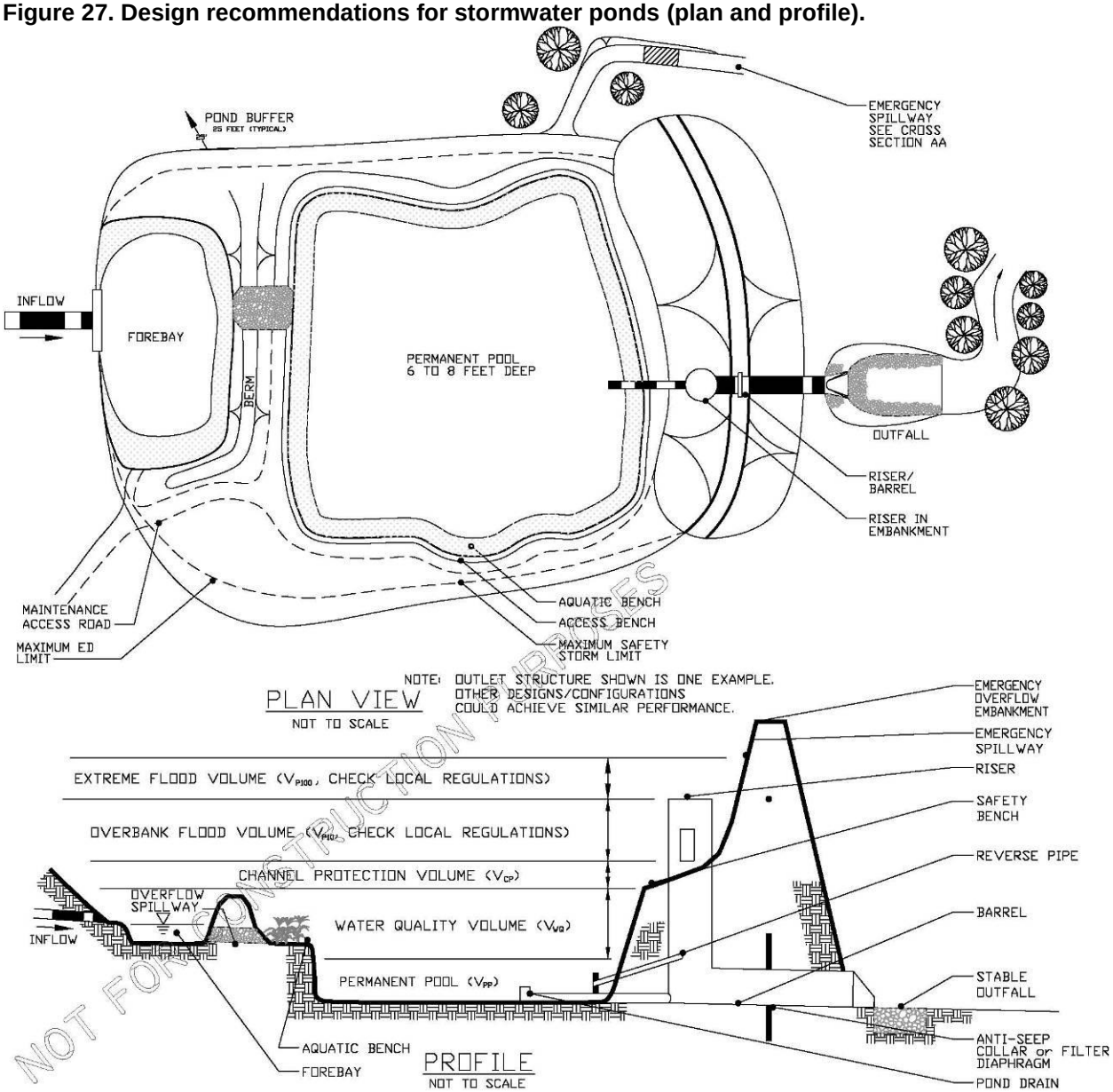
Figure 26. Design recommendations for stormwater wetlands (plan and profile).



Stormwater Ponds

Stormwater ponds are constructed basins that receive and hold stormwater runoff. The have been a tool in the stormwater management toolbox for almost 30 years. The objectives of stormwater ponds are to improve water quality through settling and biological uptake and to prevent downstream channel degradation or flood damage through outflow rate reduction and storage. During and following a storm event, runoff is stored above the permanent pool and released at a specified rate through a control structure. The actual stormwater rate control performance of stormwater ponds has been variable at best. However, stormwater ponds can be an effective stormwater management tool for its settling properties. Figure 27 illustrates design recommendations for stormwater ponds.

Figure 27. Design recommendations for stormwater ponds (plan and profile).



Sediment Traps

Sediment traps, also called grit chambers or water quality inlets, are designed to remove trash, debris and some amount of sediment, oil and grease from stormwater runoff prior to discharge to downstream stormwater treatment facilities and/or receiving waterbodies. Typically, these devices only capture coarse sediment and provide little to no removal of pollutants such as nutrients or metals. They do not provide volume control or flow control. There are a variety of propriety (more typically called oil/grit separators) and non proprietary devices ranging from chambered designs to manhole drop-ins. These devices include some combination of filtering, hydrodynamic sediment removal, screening or oil and grease removal. Typical applications for sediment traps include:

- Pretreatment of stormwater runoff from impervious surfaces
- Small site retrofits in absence of or in combination with stormwater treatment BMPs

Amended Soils

Land development including landscaping practices damage soil structure and function by removing or compacting topsoil. These practices decrease infiltration and increase erosion thereby impairing fish habitat and increasing the need for downstream stormwater management. These practices also create chemically dependent landscapes which are difficult and expensive to maintain and contribute to polluted runoff. Soil compaction also reduces the water retention capacity of soil which requires additional irrigation and increased public water supply demand.

Compost, an organic material, absorbs and infiltrates rainwater, reduces flooding and soil erosion and filters out pollutants typically associated with stormwater runoff. Compost also stores water and nutrients for plants to use during drought conditions, promoting healthy plants and better looking lawns that require less irrigation, pesticides and fertilizers. In addition, healthy amended soils require less irrigation and reduce municipal water demand.

The following are design recommendations for implementation of compost-amended soils applicable to new construction:

- Remove topsoil and stockpile prior to grading.
- Once rough grade is achieved and other disturbances are completed, plow or till compacted subsoil at least 2-inches deep or rototill some of the stockpiled topsoil into the subsoil.
- Reapply stockpiled soil to a minimum depth of 8 inches. If necessary to achieve 8-inch depth, import and apply a topsoil mix with 8-13% soil organic matter, which should contain 30-40% compost by volume and clean sand or sandy soil.
- Continue with the steps for *in-place soil amendment* below.

The following are design recommendations for in-place soil amendment:

- Apply a 2.5-inch deep layer of compost to the existing soil.
- Rototill compost into the soil to a depth of at least 8-inches. Note that tilling to this depth will require repeated passes with a large machine, such as a tractor-mounted or heavy reartine rototiller. Avoid plowing or tilling within the drip line of trees.
- Final soil depth should be a minimum of 8 inches.

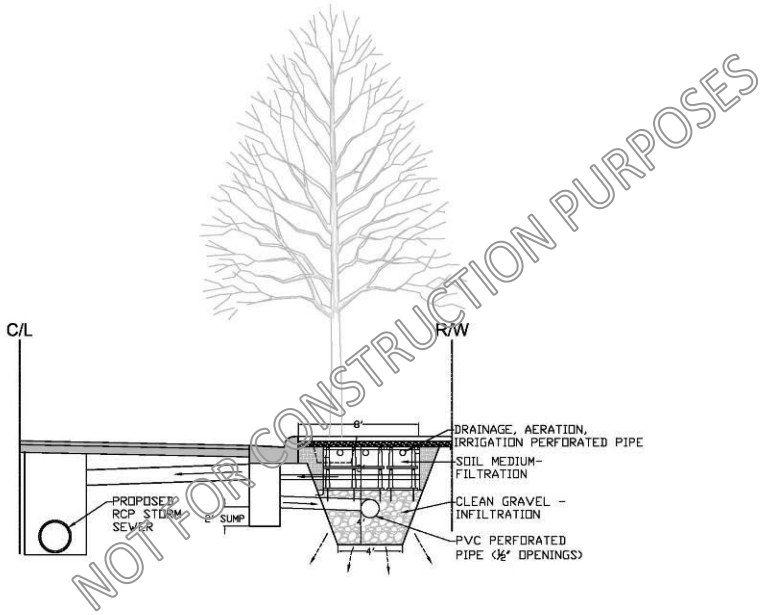
Typical Cost

Amending with compost is often the most economical way to uncompact/loosen soils and bring them up to the desired soil organic matter content. On sites with the original, undisturbed, native soil and where space permits, stockpiling and reapplying topsoil may be less costly. Importing topsoil usually costs more than amending existing soil, although it may be easier where subsoil conditions make cultivation difficult. Reductions in the need for irrigation and fertilizer can provide payback for up front costs in the range of 2 to 7 years. Implementation of amended soils can also result in a cost savings due to reduced downstream stormwater management requirements.

Urban Forestry

Trees dissipate the energy of falling raindrops to help prevent erosion and buffer intense rainfalls. Urban tree roots have the potential to penetrate compacted soils and increase infiltration rates in open space areas, stormwater basins and subsurface stormwater storage (structured soil). Uptake of water from trees limits the volume of runoff discharged downstream, and their canopies offer interception of rainfall and shading (cooling) in an urban environment. Trees also absorb nutrients that could otherwise run off to local receiving waters. Figure 28 illustrates a typical cross-section of a tree-box filter as an urban retrofit.

Figure 28. Typical cross-section of a tree box filter adjacent to a parking lot or roadway.



Typical Cost

The cost of preventing tree loss during development and redevelopment and the incorporation of trees into stormwater management BMPs will largely be at the expense of developers, except for staff time for ordinance and detail development. For incentivizing planting of trees in existing development, costs will vary depending on the intensity of the effort and the set maximum cost-share or rebate.

Cost savings as a result of increasing tree cover in urban areas was studied in Fayetteville, Arkansas where increasing tree canopy from 27 percent to 40 percent was estimated to reduce stormwater runoff by 31 percent. This runoff reduction was estimated to result in a savings of $43 million in capital improvement based on a $2/cubic ft. cost for stormwater management (American Forests, 2002). A similar study on Portland's declining tree canopy found that tree replacement would cost at least $5 billion, but the volume reduction and pollutant removal benefits from the trees were estimated to save the city $11 million per year in stormwater management costs. Volume and pollutant removal benefits increase with the age of the trees. Trees planted for stormwater management are planted in uncompacted soils to maximize the stormwater management benefits; this practice increases the lifetime of the tree as compared to the general practice of planting trees in compacted soil.

Native Landscaping

Traditionally, landscaping and stormwater management have been treated separately in site planning. In recent years, engineers and landscape architects have discovered that integrating stormwater into landscaping features can improve the function and quality of both. The basic concept is to adjust the planting area to accept stormwater runoff from adjacent impervious areas and utilize plant species adapted to the modified runoff regime. Excellent guidance on how to match plant species to stormwater conditions can be found in the MPCA publication Plants for Stormwater Design: Species Selection for the Upper Midwest (Shaw and Schmidt, 2003) and in Cappiella et al. (2005).

A landscaping area may provide full or partial stormwater treatment, depending on site conditions. An excellent example of the use of landscaping for full stormwater treatment is bioretention (see *Bioretention* on page 39). In other cases, landscaping can provide supplemental treatment such as green rooftops and

stormwater planters. Even small areas of impervious cover should be directed into landscaping areas since stormwater or melt water help to reduce irrigation needs.

Table 7. Environmental factors to consider when integrating stormwater and landscaping.

Factor	Problem Addressed
Duration and depth of inundation	Increased duration and depth of water changes the physical and chemical environment in ways that may favor invasive plants
Frequency of inundation	Increased frequency of inundation can carry increased levels of pollutants and toxins
Available moisture during dry weather	Soil compaction can affect plant species success at a site and also the ability of the soil to infiltrate stormwater efficiently
Sediment loading	Susceptibility to erosion and sedimentation from stormwater affects placement of stormwater management BMP as well as selection of plant material
Salt exposure	Browsers (deer and beaver) may be attracted by increased levels of salt in areas that treat roadway and parking lot runoff
Nutrient loading	Increased slopes increase ability to transport nutrients in stormwater

Typical Cost

Native landscaping as compared to non-native landscaping can be equivalent in cost depending on the supplier. Design and consideration of appropriate native plant material can add to the overall cost if staff need more time than would otherwise be used for non-native landscaping design. Native landscaping in formerly turf or bare soil areas is an added expense but, if paired with the costs of other structural BMPs (e.g. bioretention), stormwater management costs can still be ultimately lower than for conventional stormwater infrastructure.

Reducing Impervious Surfaces

Impervious areas such as road and parking pavement, building surfaces, and walkways/driveways significantly increase stormwater runoff volumes. Impervious surfaces also facilitate the wash-off and transport of pollutants like oil, grease and sediment into downstream rivers, lakes and wetlands. Reducing imperviousness reduces stormwater discharge which thereby reduces flooding, erosion and pollutant loading. Reduced runoff can also reduce the size and cost of stormwater infrastructure. Increased greenspace can facilitate recreational and community activities that enhance the quality of life of residents/employees.

Managing the extent of impervious area of buildings, roads and parking pavements occurs through the site planning and design process. Example methods to reduce imperviousness include but are not limited to, narrower road sections, alternative road layouts, reduced application of sidewalks and on-street parking,

cul-de-sac design, parking lot design, house setbacks, structure/building impervious area limits and driveway designs. Impervious area can also be effectively removed by routing runoff flow to an area that will absorb the water, such as a yard, swale or bioretention area. These methods are a component of design methodologies such as low impact development, design with nature, sustainable development and conservation design, and could become a part of standard building codes.

Typical Cost

Reducing impervious surfaces reduces maintenance and construction costs. In addition, reduced imperviousness reduces the size and cost of both the stormwater conveyance system and stormwater management practices. Additional resources may be required at the planning stages until familiarity with the design concepts and standards are established. The adoption of new ordinances requires an investment in training for the plan reviewer, the consultant, and possibly the public. Cities must also consider the cost of enforcement, including staff and equipment requirements.

Open Space Design

Open space design is a form of residential development that concentrates development in a compact area of the site to allow for greater conservation of natural areas. This form of development may also be called cluster design, conservation design, or low impact development (LID) (Figure 29). A mixed-use approach that integrates usable grassed park space with a trail system among restored native ecosystems and preserved drainageways and wetlands can be a very effective approach. Shared driveways and utilities is one example of impervious surface reduction that can facilitate the preservation of open space. Open space design overlaps with several other LID BMPs *Reducing Impervious Surfaces*, *Pervious Pavements*, *Rainwater Harvesting*, *Urban Forestry*, *Vegetated Swales and Buffers*, and *Establishing an Infiltration Standard* also presented as structural or programmatic BMPs.

Figure 29. A conventional subdivision (left - 72 lots) with alternative layouts (center - 72 lots; right - 66 lots) implementing open space design.

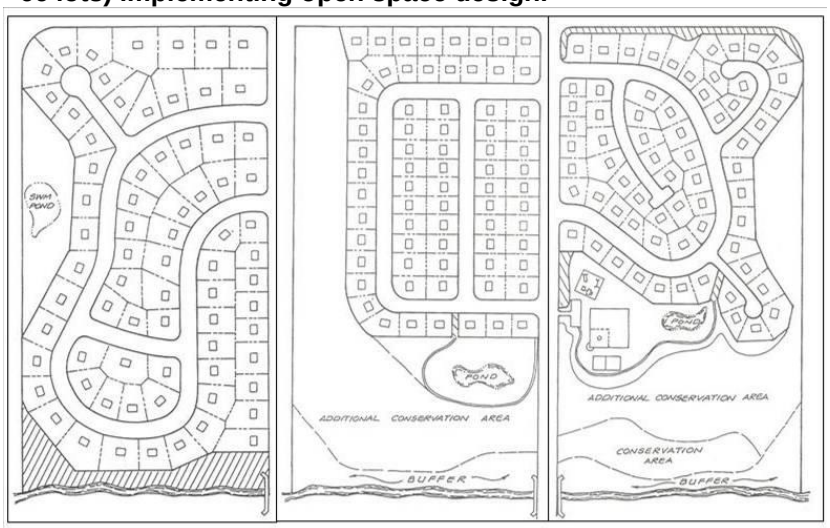


Image Source: Schueler (1995)

Open space design and LID practices are not limited to new construction. Most of the techniques can be done on existing developed land. For example, raingarden networks can be incorporated into existing neighborhoods to capture street runoff, reducing the amount of runoff generated locally.

Typical Cost

Open space development, having lower built acreage and imperviousness than conventional development, results in lower costs for grading, erosion control, stormwater and site infrastructure (Mohamed, 2006). Research has shown that on average, lots in subdivisions applying open space design (conservation subdivisions) carry a premium, are less expensive to build, and sell more rapidly than lots in conventional subdivisions (Mohamed, 2006; Zielinski 2001). Mohamed (2006) quantified the average savings at $7,400 per lot based on the results of 169 subdivisions.

A cost/benefit analysis was done in 2006 in the upper midwest on three alterative site designs: low impact development (LID), a conventionally designed development, and the actual built development which contained some LID components. Though the LID design was most profitable because of lower costs for stormwater infrastructure and thirty-year maintenance, the difference in profitability was not statistically significant. Therefore, both installation and long term maintenance costs can be said to be equal between the three designs.

The Green Values® Stormwater Calculator (http://greenvalues.cnt.org/) is a cost calculator that can help cities conduct cost/benefit analyses to optimize implementation of some of the open space design techniques discussed above.

6.2 Programmatic BMPs

Municipal stormwater management programs are *front-end* methods to decrease costs, risks, and environmental concerns of water quality and flood control. In contrast to managing stormwater after it is created, programming reduces or eliminates pollutants and wastes at its source. Well-intentioned solutions sometimes remove stormwater pollutants and volume from one medium only to transfer them, and their liabilities, to another, therefore thoughtful planning and implementation is needed to ensure overall stormwater management. Programming is a multimedia approach to solve environmental problems. As residents of a community become involved in the development and implementation of municipal programs, a sense of ownership evolves and results in broader public support for the city's overall stormwater management program.

Programmatic stormwater BMPs identified herein are:

- Regional Management Opportunities
- Rules and Ordinances
- Rainwater Harvesting / Stormwater Reuse
- Vacuum Sweeping of Streets and Parking Lots
- Erosion and Sediment Control Training Programs
- Fertilizer/Chemical Application Management
- Stormwater Utility
- Public and Municipal Staff Education
- Winter Road Materials Management
- Potential Discharge Identification and Risk Reduction
- Hazardous Material Storage and Handling

Regional Management Opportunities

Many of the urban areas around the country are addressing the long-standing problems with their waters by updating their stormwater standards and development practices to reflect the knowledge gained in the last 20 years since the NURP program first identified stormwater as a major contributor polluting our lakes, creeks, river, and wetlands. Having clean water available for potable water uses, agriculture, and recreation are all driving forces behind the consistent efforts to improve our stormwater management. Increasingly, urban centers, more often than not historically founded along rivers and bodies of water, are rediscovering these waterbodies and utilizing them as anchors for major urban renewal and redevelopment initiatives. The innate draw of water for humans is powerful and undeniable. With this renewed interest in our local water courses, we are again reminded how important it is to our well being and economic prosperity to have clean and usable waters nearby.

Aside from the benefits that the region's waterbodies can provide to the community, Iowa communities have also suffered from major water problems in the form of flooding over the past several years. With the changes in the watersheds, more water comes down into the rivers and much more quickly, causing natural flooding to be increased. Since the communities are often located along natural creeks and rivers in the state, this brings the risk for significant damage and safety concerns to the forefront. Additional water management thus also brings the hope of better managing the risks that inherently threaten communities along creeks and rivers. This is not limited to Windsor Heights, but just as watersheds know no political boundaries, the flooding of creeks and rivers impact multiple communities in the region.

Windsor Heights in fortunate to have a few significant water courses flow through the city, North Walnut Creek which then joins the main stem, Walnut Creek. But just as the city is examining how to improve their treatment of the surface waters to enhance their community, it is also obvious that these waterways

are part of a bigger system. The Walnut Creek watershed shares several urban/suburban communities and some fringe rural areas. While the city can do its part to manage and address its water issues, efforts at the larger, wathershed scale would have even more dramatic effects. Certainly Windsor Heights can turn to its neighbors downstream and plainly state that they are doing their part to responsibly manage their water. Likewise, the city will want to turn to its neighbors up stream and ask the same question.

While the scale here requires looking outside of the city's boundaries, there are many examples and precedents of communities coming together and working cooperatively or under a joint authority to manage water issues. There are numerous examples of watershed groups forming for the purpose of managing water issues at the watershed level. Higher profile examples that have existing for longer periods of time include the Chesepeake Bay, which is at a fairly large scale. In the neighboring state to the north, Minnesota has an active program of special purpose units of government that focus on watershed management: Watershed Districts (independent legal organizations) and Watershed Management Organizations (joint powers authorities, usually made up of cities). Locally there is the Des Moines Area Metropolitan Planning Organization (MPO) which is beginning a large effort to look at Sustainable Community efforts that will look at many factors affecting a community, including water. In fact, sustainable water management may include the reuse of stormwater for irrigation or indoor use, and this relieve pressures on the potable water system, providing regional benefits.

With the scale of Walnut Creek it seems very reasonable that an organization, formal or informal, could begin to coordinate efforts to manage the watershed and creek for this area. The city can be and has begun to take on that leadership or catalyst role in discussing the needs of the watershed and coordinating activities to make improvements. In order to further advance this effort, follow up actions that would be appropriate are:

Institutional

- Form a working group to identify needs and opportunities
- Develop a shared vision and goals
- Agree on a formal or informal Joint Management framework

Technical

- Identify and inventory opportunities/problems/issues
- Develop analytic tools/model for the watershed
- Discuss what implementation methods would address issues

Financial

- Consider Funding models – stormwater utility, development fee, sales tax, state funding, etc.
- Pursue grants and/or government loans as exploratory/start-up funding

Rules and Ordinances

Development rules are frequently in conflict with alternate design standards that limit the amount of impervious surface associated with a development. Development rules can refer to subdivision codes, zoning regulations, parking and street standards and other local ordinances that regulate development. In this section, rules and ordinances are discussed for the following topics:

- Volume Control
- Open Space Design
- Buffers
- Reducing Impervious Surfaces

Volume Control

The City of Windsor Heights current stormwater standards provide good guidance for practices largely by referencing the State's SUDAS document. The SUDAS document provides good guidance for stormwater design for flood control, ponding, and conveyance infrastructure but is not as in-depth on the more recent emphasis on volume control for urban runoff. The City's current ordinance does reference the need to address runoff volume in section 161.02(3) and 161.02(4). The purpose statement does not, however, give very specific numeric standards, which can make it difficult for designers and reviewers in determining what is sufficient in terms of volume control practices.

It is recommended that the city update its city ordinances to address the volume control issue more explicitly. The city should consider adding a requirement that stormwater volume control shall be maintained post project compared to natural runoff conditions for the 1.5" storm event over 24 hours. While this may not be the most protective standard available, it is a reasonable standard and a good first step toward volume control that can later be revised or amended as the local design community becomes more familiar with volume control BMPs and local conditions. The method of calculating the standard is sometimes referred to as a pre/post analysis. The variables for runoff conditions (runoff CN, timing, etc.) should be defined for the "natural condition" based on the local soils and should also address the assumptions for developed conditions methodology. Allowances for areas with more difficult soil conditions can be addressed in the amendments and methods appropriate for these areas, such as bioretention and stormwater reuse/harvesting, can be defined.

Open Space Design

Development rules can be in conflict with alternate design standards that maximize the amount of open space associated with a development. Development rules can refer to subdivision codes, zoning regulations, parking and street standards and other local ordinances that regulate development. These rules will likely require review and adjustment to allow for open space design. Municipal fire, police and public works operations (ex. snow plowing) must be an integral part of the rule/ordinance planning so that their perspective is incorporated into any changes being considered.

Many open space ordinances now require 20 percent of upland buildable area (excluding area dedicated to stormwater treatment, protected wetlands, and other non-buildable space) to be maintained as undisturbed, natural area. In addition, the code allows an increased mixture of housing types for each zoning district in order to promote and enable cluster development to facilitate open space design.

Most local codes contain front yard setback requirements that dictate driveway length. In many communities, front yard setbacks for certain residential zoning categories may extend 50 or 100 feet or even longer, which increases driveway length well beyond what is needed for adequate parking and

access to the garage. Shorter setbacks reduce the length and impervious cover for individual driveways (e.g. a 20-foot setback).

City code can introduce an option for additional units in large lot residential zoning districts. Additional units could be allowed if total preserved open space represents at least 50 percent of the total buildable land area. Qualified preserved open space could include agricultural lands, natural habitat, pedestrian corridors, or neighborhood or community recreational areas. All preserved open space could be subject to a conservation easement.

Reducing Impervious Surfaces

Municipal ordinances and initiatives that encourage the use of pervious could include:

- For all development, pervious pavements must be used for the portion of parking over the minimum required off-street parking spaces. If proposed parking exceeds the maximum required off-street parking spaces, 50 percent of all parking spaces shall be pervious pavement.
- Various types of road surfaces could be incorporated in combination to create an environmentally friendly lane. The design of the first lane could include the use of pervious pavers, plastic mats and formed concrete driving strips.
- Require 20 percent of a parking lot to be made of pervious pavement or a suitable, LID stormwater management practice.

Rainwater Harvesting / Stormwater Reuse

Rainwater harvesting programs collect runoff from rooftops, parking lots and other surfaces and reuse the water for such things as irrigation of gardens and municipal ballparks, washing patio furniture and lawn watering. Additionally, harvested rainwater when approved could be used indoors for non-potable uses such as toilet and urinal flushing. Indoor use designs are subject to review by state plumbing code. The effect of rainwater harvesting is volume control, reduced flooding and erosion, and less demand for treated potable water.

Rain Barrels

Rainwater harvesting can be accomplished using rain barrels and/or cisterns. Rain barrels are typically small scale (25-100 gallons) and located at the downspout of a gutter system. They can also be linked to expand the overall storage volume (right). They are used to collect and store rainwater for watering landscapes and gardens or washing patio furniture. The simplest method of delivering water is by the force of gravity. However, more complex systems can be designed to deliver the water from multiple barrels connected in a series with pumps and flow control devices.

Cisterns

Cisterns have a greater storage capacity than rain barrels and may be located above or below ground. Due to their size and storage capacity, these systems (often large polyethylene drums) typically collect runoff from areas larger than residential rooftops such as commercial parking lots. Collected water is typically used to irrigate landscapes, gardens, and ballparks on a regular basis (e.g. feeding an automated irrigation system) reducing the strain on municipal water supplies during peak summer months. Again, cisterns may be used in series and water is typically delivered using a pump system. Pump systems in cisterns can be designed with a floating level that shuts off the pump and converts the water source to a municipal supply when cistern levels are too low.

Programming

Many cities have offered a $10 to $30 rebate to water customers for rain barrel purchases of over 40 gallons in volume. Cities have also provided a limited supply of rain barrels to residents at a reduced cost. Communities have also coordinated with the food industry to salvage their 55 gallon food-grade drums to recycle for use in a rain barrel program. Food-grade barrels can be retrofit into rain barrels and have been sold for $30. Innovative initiatives could include a Rain Barrel Decorating Event with optional art competition. The city could supply rain barrels at a discounted price and free painting supplies for decorating the barrels onsite.

Typical Cost

Rain barrels typically cost between $50 and $230 dollars for a 55 gallon drum depending on the manufacturer and inclusion of accessories and/or installation. Rain barrels can be easily constructed by residents using a standard food-grade plastic 55-gallon barrel which can be obtained for approximately $15 to $20. The Low Impact Design Urban Design Tools website, designed by the Low Impact Development Center, provides additional cost guidelines.

Cisterns are considerably more expensive than rain barrels ranging from $200 to $10,000 due to size, materials, and structural requirements. Very large scale stormwater reuse systems (e.g. at public buildings or commercial sites) vary in cost based on complexity of the system, the scale of the system and the existing land use prior to installation.

Vacuum Sweeping of Streets and Parking Lots

Pollutants collect on surfaces in between storm events as a result of atmospheric deposition, vehicle emissions, winter road maintenance, construction site debris, trash, road wear and tear, and litter from adjacent lawn maintenance (grass clippings). Sweeping of materials such as sand, salt, leaves and debris from city streets, parking lots and sidewalks prevents them from being washed into storm sewers and surface waters. Timing, frequency and targeting critical areas greatly influences the effectiveness of sweeping.

Table 8 identifies percent removal of total solids (TS), total phosphorus (TP) and total nitrogen (TN) from a conceptual model developed by the Center for Watershed Protection based on research findings from a variety of studies. The lower removal efficiencies represent are achieved through monthly street sweeping by a mechanical street sweeper. The highest removal efficiencies are achieved through weekly sweeping using a regenerative air or vacuum street sweeper at weekly frequencies. Note that even the highest removal efficiencies are relative low when compared to potential removal from structural BMPs or other programming.

Table 8. Percent removal of pollutants from street sweeping for total solids, total phosphorus and total nitrogen.

Frequency	Technology	TS	TP	TN
Monthly	Mechanical	9	3	3
	Regenerative Air/Vacuum	22	4	4
Weekly	Mechanical	13	5	6
	Regenerative Air/Vacuum	31	8	7

Source: Deriving Reliable Pollutant Removal Rates for Municipal Street Sweeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin. Center for Watershed Protection.

Typical Cost

Staffing and equipment are the largest costs for street sweeping programs. Conventional street sweepers can range from $60,000 to $125,000, depending on the make, model and equipment enhancements. Prices can be as high as $180,000 for newer technologies. The average useful life is about four years, varying based on frequency of use. Cost savings can be seen by using equipment that can be converted to other uses, for example, a sweeper that converts to a sander and snowplow in the winter. Training for operators must be included in operation and maintenance budgets. Costs are small for parking restriction notifications/signage. Parking tickets are an effective reminder to obey parking restrictions and can be used as a source of revenue for the program.

Erosion and Sediment Control Training Programs

Erosion and sedimentation is the natural process in which soil and rock material is weathered and carried away by wind, water or ice. Construction activities can increase erosion by removing vegetation, disturbing soil and exposing sediment to the elements. Eroded soil quickly becomes a sedimentation problem when wind and rain carry the soil off the construction site and sediment is deposited in surface waters.

Erosion and sediment control BMPs are necessary at all construction sites to keep soil onsite and prevent unnecessary water pollution. Training individuals responsible for installing, constructing, repairing, maintaining and/or inspecting erosion and sediment control measures and post-construction stormwater management practices at construction sites will result in properly designed, installed and maintained BMPs, and protecting water quality.

There are many types of erosion and sediment controls that could be covered in a training program. The following is a condensed list of recommended BMPs to discuss in a training program.

- Site phasing
- Construction entrances
- Protecting natural vegetation and undisturbed areas
- Low impact development
- Temporary diversions
- Temporary down drains
- Sediment retention basins
- Dewatering
- Perimeter control (Figure 30)
- Stockpile protection
- Surface roughening and slope tracking
- Minimize slopes
- Stormdrain inlet protection
- Outlet protection
- Temporary and permanent stabilization
- Specific BMPs related to working near or around water

Figure 30. Installed silt fence will minimize sediment from leaving a site and entering surface waters.

Typical Cost

The development of a training program will require staff time; however, there are numerous resources and examples of training programs and certification requirements from around the state and the country. By utilizing currently established training programs as an alternative to developing a new program or to enhance a program in development, the city can save time and money.

Fertilizer/Chemical Application Management

Fertilizers, herbicides, and insecticides have various ecological effects, toxicity, and chemical fate and transport based on the product's chemical components. Depending on the chemicals' characteristics, they can have unintended harmful effects on terrestrial and aquatic plants and animals, and can end up in our soil, water, and air through conveyance by stormwater. Nitrates from fertilizers can migrate through the soil profile and contaminate ground water supplies beyond safe drinking water levels. Phosphorus from fertilizers contributes to eutrophication of surface water bodies that depletes oxygen levels and can lead to fish kills.

Programs designed to manage and minimize chemical application typically include a combination of the elements identified below. The following BMPs and chemical alternatives can provide the content for training programs and public education materials:

- Integrated Pest Management (IPM): employs mechanical, biological, cultural, and/or chemical mechanisms as determined by a thorough evaluation of the conditions rather than addressing every condition with chemicals.
- Chemical preparation and handling BMPs to select lower toxicity products, reduce spills, and provide secure containment.
- Chemical application BMPs: manages application rates, application sites (not on bare soils or near surface waters) and weather (no application when windy or when rain is forecasted).

Typical cost

A soil sample and nutrient test costs less than $25 per sample and is easily the best value for fertilizer minimization. Soybean and organic fertilizers can be up to three times the cost of standard chemical fertilizer. Reduced labor costs associated with fewer applications in larger amounts can help to offset this

cost. However, alternative practices employed in place of fertilizers (identified through IPM) can easily be less expensive than chemical application. Similarly, practicing IPM can reduce herbicide and pesticide application costs.

Stormwater Utility

Stormwater utilities entail accounting for stormwater management costs in the same manner that other city services are counted, with a line item on a bill. Funds are generated through per-plot fees based on the amount of runoff leaving each plot that enters the city's stormwater conveyance system. The fee payer is given methods to reduce this fee, such as infiltrating or treating a volume of runoff from their property.

Typical Cost
This is a revenue-generating program that also has the potential to reduce the need (and cost) of downstream stormwater management facilities.

Public and Municipal Staff Education

An education program can be paired with any stormwater management BMP (structural or programmatic) to create an awareness of and appreciation for the city's water resources. Public and municipal staff can be educated on the city's goals for both stormwater management and the state of its water resources. Education can address how citizen and staff actions impact stormwater quality and quantity and, therefore, receiving waters. Developing programs that involve activities to eliminate pollution sources and/or prevent contaminants from entering waterways are a means in and of itself of public and staff education. Public and city staff education programs include, but are not limited to:

- Education on the importance of keeping lawn clippings and leaf litter off impervious surfaces, of rain barrels and rainwater harvesting, or of any other topic on water resource protection
- Public event for stenciling/marking storm drains with *No dumping. Drains to Lake.*
- Benefits of rain barrels and rainwater harvesting
- City staff workshop on how to meet city stormwater management goals through operations/management of city property and activities/practices of city staff.

Typical Cost
Costs of education programs vary based on format (e.g. flyers, email or workshop) and extent of implementation.

Winter Road Materials Management

Chloride and sand accumulate in surface and groundwaters due to stormwater runoff from road salt storage piles, areas of excessive application, or simply from years of repeated application. Chloride in road salt and road salt additives (e.g. ferrocyanide for anti-caking) can create toxic conditions for fish, insects and vegetation. Proper winter road materials storage, handling, and application reduce the risk of downstream water resources pollution and can reduce die-off of exposed vegetation, fish, and other aquatic organisms.

A municipal sand/salt management plan is a commitment to implementing BMPs while fulfilling a community's obligation to provide safe, efficient and cost-effective roads. The plan should identify BMPs (e.g. securely cover storage piles, calibrate applicator equipment) to reduce the negative environmental impacts of sand and road salt. The plan should apply to all winter maintenance personnel including staff and contractors. Training of staff and contractors should accompany all sand and salt management policies.

A snow management plan identifies the city's methods for managing the accumulation, removal and potential collection of snow so that procedures are in place for both during and after a snowfall event. This plan should not only address city operations, but also examine how commercial entities are conducting their operations. Snow storage areas should be on paved bermed surfaces if sand is used; this allows the area to be swept after snowmelt and the sand to be contained during runoff. Runoff should be pretreated prior to discharge to receiving stormwater facilities or waterbodies. If salt is used, storage should be on pervious surfaces to prevent direct discharge to surface waters, but storage should be outside of stormwater treatment areas in order to prevent clogging from sediment and allow for runoff capacity during snowmelt.

Typical Cost
Rather than creating an additional expense, implementation of BMPs can reduced material usage by upwards of 50 percent. Materials reductions translated directly into cost savings. Increased efficiencies from operator training can similarly save a city both staff and materials costs.

Potential Discharge Identification and Risk Reduction

Illicit discharges are those wastes and wastewaters from non-stormwater sources which city's cannot legally discharge down storm drains. Sources include:

- Sanitary wastewater illegally connected to the storm drain system
- Residential laundry washwaters
- Effluent from septic tanks
- Industrial wastewaters
- Auto and household toxics such as used motor oil
- Liquid fertilizers and pesticides
- Pet waste
- Drained pool water
- Spills from roadways
- Paint waste
- Anything that isn't rain down the storm drain is a potential illicit discharge.

The result of illicit discharges entering the storm drain is untreated discharges to receiving water, contributing high levels of pollutants including heavy metals, toxics, oil and grease, solvents, nutrients, viruses, and bacteria.

A program to detect and address illicit discharges is central to the ultimate elimination of illicit discharges. The EPA recommends in their *Illicit Discharge Detection and Elimination Program Development* guidance that the program include the following four components:

- Locate problem areas
- Find the source
- Remove/correct illicit connections
- Document actions taken.

Strategies for education and incentives can include: passive education (Figure 31), active training, provision of direct city services, subsidies and discounts, home/business-owner recognition programs,

stewardship group formation. Regulations might include: adoption of a local ordinance, notifications/signs/hotlines, restrictions or bans, enforcement, utility pricing.

Figure 31. Storm drain stenciling can remind homeowners of the consequences of dumping waste.

Typical Cost

The cost of detecting and reducing the risk of illicit discharges will vary depending on the intensity of the effort and the approach(es) chosen. Costs attributable to detection and correction of illicit discharges are based on the total staff involvement driven by the problem area identification methods employed and the number and extent of discharge incidences. Public education program costs are determined by the type of materials produced and the method of distribution selected. Volunteer efforts can reduce program costs, as determined by staff hours required for program implementation and leadership of volunteers. An important consideration is that prevention of illicit discharges is much less costly than detection and subsequent correction.

Hazardous Material Storage and Handling

A hazardous material is any biological, chemical, or physical material with properties that make it dangerous or potentially harmful to human health or the environment. Hazardous materials can be released to the environment in a variety of ways. A spill of only one gallon of oil can contaminate one million gallons of water. Potential hotspots for higher levels of stormwater pollutants and/or risk for spills, leaks or illicit discharges include:

- Equipment storage and maintenance yards
- Incinerators
- Landfills
- Hazardous waste handling and transfer facilities
- Public works yards
- Vehicle storage and maintenance yards

Minimizing or eliminating contact of hazardous materials with stormwater can significantly reduce pollution of downstream waters. Starting with a spill prevention plan provides a framework for city or facility operations and a training tool for personnel. Proper hazardous material handling and storage also contributes to employee health, an organized work place, and efficient operation. Proper practices include:

- Confine material storage indoors to the greatest extent feasible, and plug or disconnect floor drains that lead to the stormwater system
- Confine outdoor material storage to designated areas that are covered, away from high traffic areas, outside of drainage pathways, and on impervious surfaces
- Prevent run-on of stormwater into fueling areas using diversion dikes, berms, curbing, surface grading or other measures or use catch basin inserts to prevent discharge into storm drains
- Avoid loading/unloading materials in the rain and/or provide cover for the activity
- When conducting vehicle and equipment maintenance use drip pans, drain boards, and drying racks to direct drips back to a fluid holding tank for reuse or proper disposal

Typical Cost
Pollution prevention measures are not inherently costly and are more a matter of culture. However, providing cover over hazardous materials stored outdoors can be equivalent to the cost of a pole building ($5 to $12 per square foot) and a concrete slab ($3 to $6 per square foot). If waste reduction measures are taken, an accurate inventory is maintained, and regular waste disposal is implemented, cities can minimize the amount of materials stored onsite, decreasing costs.

6.3 Public Outreach, Information & Education Framework

Substantial water quality improvements are made with structural best management practices (BMPs), but part of the solution to water quality improvement is public education. Education programs create an awareness of and appreciation for the City's water resources and teach people how to reduce polluted runoff from their areas of influence (yards, community centers, places of work). Education programs can stand alone among city initiatives as a broadcast effort to inform the community of stormwater management and associated water quality issues, or they can be effective tools to generate public understanding (and therefore support) of city stormwater management initiatives (e.g. structural or programmatic BMPs, stormwater utility, ordinance revisions). Education can address how citizen and staff actions impact stormwater quality and quantity and, therefore, receiving waters. Developing programs that involve the public in activities to eliminate pollution sources and/or prevent contaminants from entering waterways are an additional means of education. The purpose of this section is to develop a framework for education programs that facilitate implementation of Stormwater Management Plan.

Target Audiences

The target audiences for achieving water quality improvement and stormwater volume reduction inform program design, content and outreach mechanisms. Target audiences are identified based on their ability to bring about change, their contribution to the problem or their geographic proximity to the problem. Table 9 identifies the target audiences within the City of Windsor Heights.

Table 9. Target audiences for educational programming

Construction Professionals	Students	Landowners	Private Sector	Policy Makers and Government Staff
Developers / Redevelopers	Students K-12	Landlords	Big Business Owners	Elected & Appointed Officials
Consultants (architects, engineers)	Student/ Youth Groups	Property Owners	Facility Managers	Municipal Staff
Home Builders		Creekside Residents	Small Business Owners	School Administrators
Contractors				

Objectives

Information about the target audiences' interests, preferences and activities can be gathered through surveys, focus groups, discussions, and review of reports and databases. This information helps to tailor educational programming (e.g. delivery methods, communication methodologies) to the audiences.

Based on the understood interests and preferences of the target audience and the goals of the Stormwater Management Plan, the following objectives have been identified for each.

All Audiences

These objectives pertain to all target audiences and are not repeated under each target audience.

- All audiences understand the impacts of stormwater discharge rates and volumes on water resources (e.g. flooding, soil erosion, bank failure and storm sewer sediment deltas) and the effects of impervious surface on runoff rates and volumes.
- All audiences understand what stormwater management BMPs are and why they are important.
- All audiences understand where to obtain information on stormwater management BMPs including the city's Stormwater Management Plan and other local, regional and statewide resources.
- All audiences understand where stormwater goes, the conveyance of stormwater through stormwater infrastructure (e.g. storm sewer grates and pipes) and into the creeks of the City.
- All audiences understand the water quality impacts of stormwater on water resources (e.g. temperature, pollutants and sediment) and the effects of impervious surface on water quality (e.g heat and pollutant build-up and washoff).
- All audiences understand who to contact in the case of stormwater pollution through illicit discharges or spills.
- All audiences understand the environmental consequences of stormwater runoff (volume, rate and quality) on aquatic habitats.

Construction Professionals

The following objectives relate specifically to those individuals who plan, implement and construct land developments, new construction and redevelopment. Construction professionals, including designers, have the ability to protect and improve the resources of Windsor Heights through their actions as developments and buildings are designed, constructed or re-built. The objectives for this audience focus on increasing the understanding of the benefits of BMPs to increase implementation and to ensure communication with landowners and building managers on the function and maintenance of BMPs.

- Contractors implement measures to protect water resources during construction.
- Consultants, homebuilders and developers understand the benefits of stormwater management BMPs in terms of hydrology, water quality, financial and community aesthetics.
- Consultants, homebuilders and developers implement stormwater BMPs.
- Contractors understand the innovative nature of stormwater BMPs in order to effectively install them using potentially non-traditional approaches (e.g. construction sequencing, traffic control).

Students

The following objectives relate specifically to K-12 students. Students learn about their natural environment in school and can be active participants in the City's educational efforts. The objectives for students are focused on active participation and understanding of resources and the interaction of the built environment with the city's natural resources.

- Students participate in active community education initiatives (e.g. resource monitoring, streambank planting, raingarden planting, storm drain stenciling).

Landowners

Homeowners, landlords, property owners, and residents need specific knowledge and skills in order to implement and maintain simple small-scale stormwater BMPs that have a big impact with high rates of implementation. The objectives for landowners and residents are focused on BMPs that can be implemented and maintained by residents and landowners: streambank vegetation, fertilizer and leaf management, and small scale BMPs such as raingardens.

- Creekside Residents understand the benefits of healthy native streambank habitat on stormwater runoff and aquatic resources.
- Creekside Residents establish and/or restore and maintain native creekside buffers.
- Property owners and residents construct and maintain upland stormwater management BMPs (e.g. raingardens).
- Property owners and residents limit the use of fertilizers and ensure that leaves are managed properly in the fall.

Private Sector

Businesses and industrial facilities as well as gas stations and fleet handling facilities have the potential to discharge through stormwater runoff, pollutants such as fertilizers, pesticides, heavy metals, petroleum products and other chemicals. Small business owners typically manage their own parking lots and landscaping; whereas owners of a unit in a strip mall do not. Particular companies of interest include, but are not limited to, lawn care companies, painters, golf courses, mobile cleaning operations and any business or facility with outdoor storage. Business owners and people working in the private sector do not necessarily live in the City and, therefore, require a delivery method and message different than those who, as residents, have an inherent stake in the City and the state of its aquatic and natural resources. The objectives for business owners and those working in Windsor Heights are focused on increasing the understanding of site design and property management decisions.

- Business owners/operators understand stormwater rules and regulations and the importance of meeting them.
- Business owners/operators understand the positive impact of BMPs and reduced impervious on water resources and company image.
- Business owners/operators implement and maintain stormwater management BMPs.

Policy Makers and Government Staff

Elected officials and government staff have the unique ability to make policy decisions for the stormwater program. Included in this category are education administrators and municipal staff. Each of these audiences has high visibility and is able to set the bar for stormwater management and to lead by example. Policy makers and staff involved in planning, zoning, land conservation, parks and public works are of particular importance. The objectives for policy makers and municipal staff focus on consistent understanding of regulations, BMPs, and communication with the community.

- Policy makers and municipal staff understand the City's stormwater management standards and the importance of BMPs

- Policy makers and municipal staff communicate the City's stormwater management standards to landowners, developers, contractors and consultants.
- Municipal staff provide technical support for residents and construction professionals regarding stormwater management standards and BMP design.
- Municipal staff hire engineers who design stormwater BMPs and education program managers that understand water resource management.
- Policy makers and municipal staff install stormwater BMPs at their facilities, leading by example.

Recommended Educational Programming

Based on Stormwater Management Plan goals and the education and outreach objectives for each target audience, Table 10 identifies educational programming options. Education can be delivered to target audiences through guidance documents, educational flyers, hands-on activities and workshops. Programs are meant to utilize a delivery method that speaks to the target audience.

Some programming may be best achieved through partnerships with Polk County, the Iowa Department of Natural Resources or other entities involved in education and outreach on water resource issues.

Table 10. Recommended educational programming based on target audiences.

Education Programming	Audience					
	All Audiences	Construction Prof's	Students	Landowners	Private Sector	Policy Makers + Staff
Involvement in stormwater utility development and abatement eligibility education		x		x	x	x
Storm drain stenciling (e.g., No Dumping, Drains to Creek) with introductory presentation on stormwater runoff and environmental impacts			x			
Conservation Day for grade school students			x			
Guidance documents on directing downspouts to pervious areas, reducing impervious areas, constructing raingardens, using rain barrels and having watershed-friendly landscape maintenance techniques including creekside buffers, leaf litter and grass clipping management				x	x	x
Recognition of landowners who implement BMPs – BMP tours, newsletter/newspaper write-up or Creek Stewards award program				x	x	x
Raingarden workshops including identification of local resources (e.g. raingarden plant kits)				x		
Shoreland buffer workshops including identification of local resources (e.g. shoreland plant kits)				x		
Water conservation informational flyers sent with water bills				x		
Cost-share programming for creekside habitat restoration, raingarden and rain barrel implementation				x		
Educational flyer regarding rules, regulations and environmental impacts of illicit discharges to storm sewers				x	x	x
Pollution Prevention Program for City addressing property management and City staff practices; could include development of a Stormwater Pollution Prevention Plan (SWPPP)						x
Rain barrel incentive program – (e.g. City provides rebates or sells rain barrels at reduced cost)				x		
City staff workshop on how to meet City stormwater management goals through operations/management of City property and activities/practices of City staff						x
Utilize the following public involvement forums as opportunities for education on the state of the City's water resources and impacts of pollution from stormwater runoff: Planning Commission Meetings City Council Meetings Walnut Creek Watershed Meetings						x

7. IMPLEMENTATION PLAN

7.1 Introduction

The implementation section of the City's Stormwater Management Plan includes water quantity improvement, City-wide and specific water quality improvement projects, streambank restoration projects, and stormwater management programs. The implementation plan includes the specific projects and other activities necessary to implement the City's goals as identified through the public involvement process of the Plan development. The activities contained in the implementation plan seek to protect and improve City water resources and stormwater infrastructure.

Inclusion of an activity in the implementation plan is a statement of intent by the City of Windsor Heights. Final decisions on implementation rest with future decisions by the City Public Works department and, ultimately, the City Council to budget for and authorize the activity. The City will regularly evaluate the water resources needs within the City and make appropriate changes in priorities during the 10-year term of the implementation plan.

Over the 10-year period of this implementation plan, as information becomes available, priorities evolve, new concerns emerge, or new technical approaches are developed, the City will likely adapt the implementation plan to reflect this new information. The listing of initiatives in the implementation plan is not intended to exclude other initiatives consistent with the goals identified in this Stormwater Management Plan. If the new activity is widely different in scope or cost from that detailed in the implementation plan, plan amendments may be warranted. If not, the City could proceed with a new initiative under the existing implementation plan.

All projects in the implementation plan (including any future additions) will only be implemented with landowner approval and a formal agreement.

7.2 Implementation Plan Structure

Activities are classified into three main categories: Subwatershed Improvements, City-wide Watershed Management Program and Creek Restoration. Subwatershed improvements include water quantity projects that were identified in the hydraulic modeling and water quality improvements needed to meet the City goals. City-wide Watershed Management Programs generally consist of the ongoing initiatives of the city with respect to stormwater management and are typically conducted by city staff. The implementation plan for the 10 year management plan is shown in Table 14.

Subwatershed Improvements

Included within the Subwatershed Improvements are three water quantity improvements that are needed to address the issues identified in Section 3.2. There is one pipe upgrade and two rate control ponds recommended. The rate control ponds will be constructed for water quality benefits, reducing the need in Bellaire Subwatershed. Details on how the cost estimate was developed for these water quantity improvements is shown in Table 11.

Table 11. Water Quantity Improvement Costs

Sub watershed	Pipe Designation	Type	Qty	Unit Cost* $/Ut	Subtotal Cost ($)	Additional Cost** ($)	Total Cost ($)
University East Subwatershed	Col-111 to COL-109	Pipe Upgrade to 27" RCP	260 feet	44.2	$11,500	$6,900	$18,400
Bellaire Subwatershed Bell-204	73R-111	Rate Control Pond	4840 CY	15	$72,600	$43,600	$116,200
Bellaire Subwatershed Bell-123	73R-108	Rate Control Pond	1613 CY	15	$24,200	$14,500	$38,700

*Includes material, installation, bedding, manholes, compaction, and restoration but does not include land acquisition.
**Additional costs include contingencies (10%); engineering, administration, interest (25%),planning contingencies (25%)

The subwatershed improvements shown in Table 14 also include the water quality improvements to meet the City goal to capture 0.5" of runoff off of 10% of all the impervious surfaces in the City and off of 25% of the impervious surfaces in subwatersheds that were identified as having volume issues. The City may chose to incorporate treatment for more of its impervious surfaces but this amount was chosen as a realistic level of effort. Table 12 shows the amount of storage and the costs required in each subwatershed to meet this goal. Land costs are not included in the estimated cost. In cases where a specific opportunity has been identified in Section 4.3 for incorporating water quality improvements that site has been included in Table 14. The costs shown are ballpark estimates of the amount of effort that would be needed at each site.

Table 12. City-wide Water Quality Improvement Costs

BMP Location		Storage Needed (CY)	Unit Cost*** ($/CY)	Subtotal Cost ($)	Additional Cost*** ($)	Total Cost ($)
Subwatershed	Junction ID - Flows To					
Marilyn El Rancho Subwatershed	N Walnut Creek	300	$365	$109,300	$65,600	$174,900
Bellaire Subwatershed	N Walnut Creek	1,481	$365	$539,800	$323,900	$863,700
Forest Colby Subwatershed	N Walnut Creek	661	$365	$241,100	$144,700	$385,800
University East Subwatershed	Walnut Creek	729	$365	$265,700	$159,400	$425,100
University West Subwatershed	N Walnut Creek	83	$365	$30,300	$18,200	$48,500
Windsor South Subwatershed	Walnut Creek	232	$365	$84,700	$50,800	$135,500
Direct - Marilyn Subwatershed	N Walnut Creek	78	$365	$28,300	$17,000	$45,300
Direct - 73rd Subwatershed	N Walnut Creek	179	$365	$65,100	$39,100	$104,200
Direct - Apple Valley Subwatershed	N Walnut Creek	243	$365	$88,600	$53,200	$141,800
235 South Subwatershed	Walnut Creek	50	$365	$18,300	$11,000	$29,300
Hickman North Subwatershed	N Walnut Creek	80	$365	$29,100	$17,500	$46,600
63rd East Subwatershed	N Walnut Creek	65	$365	$23,600	$14,200	$37,800
City-wide Water Quality Improvements Total		**4,181**				**$2,438,500**

***Includes Excavation, Disposal and Site Restoration.

City-wide Watershed Management Programs

The programmatic approaches to stormwater management that are described in Section 6.2 are included in Costs are shown Table 14 as annual and total costs. The costs estimates use either known costs that the City is currently expending or a nominal amount that accounts for staff time working on a given effort.

Streambank Restoration

The cost to restore only the high priority streambank reaches as described in Section 5.4 are included in Table 14. The cost is included as an annual amount needed to reach the estimated total project cost rather than as a one time cost. The detail of how the cost estimate was developed is shown in Table 13. Costs for streambank stabilization can range dramatically depending on the size of the waterway, extent of necessary excavation, permitting requirements, materials utilized and access constraints. Ranges from $30 to $1000 per linear foot are possible. A per unit foot cost of $200 is plausible for the reaches identified for North Walnut Creek.

The estimated cost includes construction, design, permitting, basic monitoring (2 years), routine maintenance (2 years), reestablishing the site to prior conditions, and project management costs that are normally associated with implementing a capital project. More general administrative, enforcement, and long-term maintenance costs are not included.

Table 13. Creek Restoration Costs

Creek Reach	Subwatershed	Length (ft)	Estimated Cost Per Foot	Total Cost ($)
North Walnut Creek Station 1000-2100	Direct–Marilyn Subwatershed	1100	$200	$220,000
North Walnut Creek Station 4300-4850	Direct–73rd Street Subwatershed	550	$200	$110,000

Table 14. 10 Year Watershed Management Plan Budget

Subwatershed Improvements	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	10 Year Plan Total
Marilyn El Rancho Subwatershed											
Water Quality Improvements[1]	$17,490	$17,490	$17,490	$17,490	$17,490	$17,490	$17,490	$17,490	$17,490	$17,490	$174,900
Subwatershed Total											$174,900
Bellaire Subwatershed											
Rate Control Pond - Bell-204[2]				$10,000	$50,000	$56,200					$116,200
Rate Control Pond - Bell-123[2]				38,700							$38,700
Bellaire Avenue & 70th Street Improvements							$50,000				$50,000
Hickman Redevelopment BMPs	$25,000	$25,000									$50,000
73rd Street Boulevard Improvements			$25,000								$25,000
Forest Colby Diversion								$50,000	$25,000		$75,000
Other Water Quality Improvements[1]	$50,880	$50,880	$50,880	$50,880	$50,880	$50,880	$50,880	$50,880	$50,880	$50,880	$508,800
Subwatershed Total											$863,700
Forest Colby Subwatershed											
Washington Avenue & 66th Street			$25,000								$25,000
Other Water Quality Improvements[1]	$36,080	$36,080	$36,080	$36,080	$36,080	$36,080	$36,080	$36,080	$36,080	$36,080	$360,800
Subwatershed Total											$385,800
University East Subwatershed											
Pipe Improvements[2]	$18,400										$18,400
City Hall Demonstration Project	$10,000										$10,000
Other Water Quality Improvements[1]	$41,510	$41,510	$41,510	$41,510	$41,510	$41,510	$41,510	$41,510	$41,510	$41,510	$415,100
Subwatershed Total											$443,500
University West Subwatershed											
Water Quality Improvements[1]	4,850	$4,850	$4,850	$4,850	44,850	44,850	44,850	44,850	44,850	44,850	$48,500
Subwatershed Total											$48,500
Windsor South Subwatershed											
Water Quality Improvements[1]	$13,550	$13,550	$13,550	$13,550	$13,550	$13,550	$13,550	$13,550	$13,550	$13,550	$135,500
Subwatershed Total											$135,500
Direct - Marilyn Subwatershed											
Iowa DNR Building Parking Lot Improvements		25,000									$25,000
Other Water Quality Improvements[1]	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$2,030	$20,300
Subwatershed Total											$45,300
Direct - 73rd Subwatershed											
Water Quality Improvements[1]	$10,420	$10,420	$10,420	$10,420	$10,420	$10,420	$10,420	$10,420	$10,420	$10,420	$104,200
Subwatershed Total											$104,200
Direct - Apple Valley Subwatershed											
Retail Center Parking Lot Improvements									$25,000	$25,000	$50,000
Other Water Quality Improvements[1]	$9,180	$9,180	$9,180	$9,180	$9,180	$9,180	$9,180	$9,180	$9,180	$9,180	$91,800
Subwatershed Total											$141,800
235 South Subwatershed											
Water Quality Improvements[1]	$2,930	$2,930	$2,930	$2,930	$2,930	$2,930	$2,930	$2,930	$2,930	$2,930	$29,300
Subwatershed Total											$29,300
Hickman North Subwatershed											
Hickman Boulevard Improvements										$25,000	$25,000
Other Water Quality Improvements[1]	$2,160	$2,160	$2,160	$2,160	$2,160	$2,160	$2,160	$2,160	$2,160	$2,160	$21,600

Subwatershed Total											$46,600
63rd East Subwatershed											
Water Quality Improvements[1]	$3,780	$3,780	$3,780	$3,780	$3,780	$3,780	$3,780	$3,780	$3,780	$3,780	$37,800
Subwatershed Total											$37,800
Subwatershed Improvements Subtotal	$248,260	$244,860	$244,860	$243,560	$244,860	$251,060	$244,860	$244,860	$244,860	$244,860	$2,456,900
City-Wide Watershed Management Programs	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	10 Year Plan Total
Regional Watershed Management	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$2,500
Ordinance Update	$250	$250	$250	$250	$250	$250	$250	$250	$250	$250	$2,500
Street Sweeping	$12,730	$12,730	$12,730	$12,730	$12,730	$12,730	$12,730	$12,730	$12,730	$12,730	$127,300
Municipal Good Housekeeping	$500	$500	$500	$500	$500	$500	$500	$500	$500	$500	$5,000
Education / Outreach	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$4,000	$40,000
City-Wide Watershed Management Programs Subtotal	$17,730	$17,730	$17,730	$17,730	$17,730	$17,730	$17,730	$17,730	$17,730	$17,730	$177,300
Creek Restoration[3]	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	10 Year Plan Total
North Walnut Creek Station 1000-2100	$22,000	$22,000	$22,000	$22,000	$22,000	$22,000	$22,000	$22,000	$22,000	$22,000	$220,000
North Walnut Creek Station 4300-4850	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000	$11,000	$110,000
Creek Restoration Subtotal	33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$33,000	$330,000
Watershed Management Plan Totals	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	10 Year Plan Total
	$298,990	**$295,590**	**$295,590**	**$294,290**	**$295,590**	**$301,790**	**$295,590**	**$295,590**	**$295,590**	**$295,590**	**$2,964,200**

7.3 Overview of Meeting Implementation Goals and Financial Approaches

In order to implement the various projects and programs needed and mandated listed in the Plan, there will need to be a funding approach that matches the city's financial means and abilities. There are many competing needs for the city's funds and it is very difficult when water management is solely funded through the city's general funds. The good news is that there are other options to help ensure the priorities set in the Plan can be paired with an implementation framework that internalizes some costs and use creative funding approaches for other aspects.

To implement the plan, there are several key tools that can be used to accomplish the goals, and do not rely primarily on the city's general fund. The approaches are:

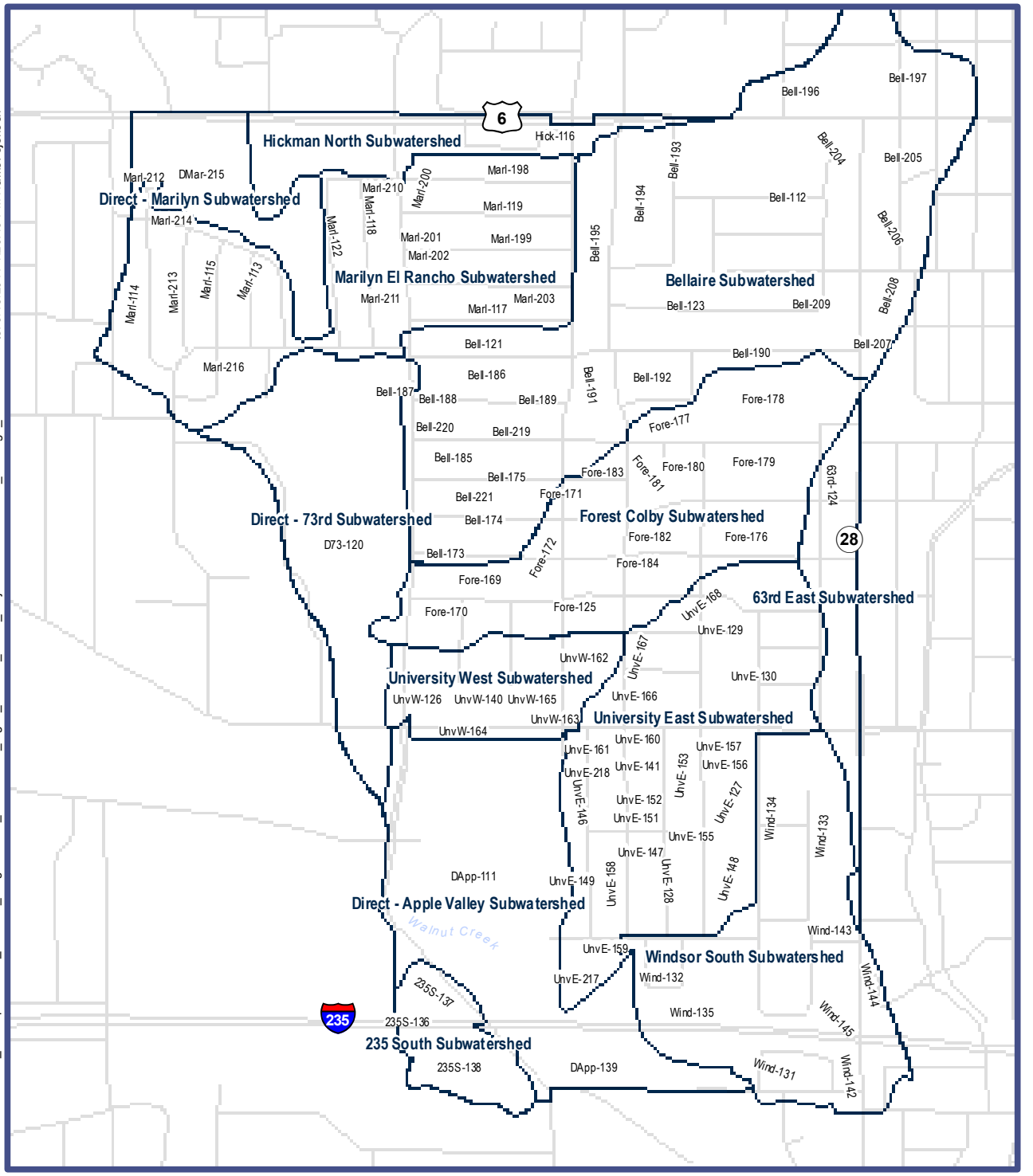
- Updated Redevelopment Standards
- City CIP
- Stormwater Utility Credits
- Education and Stewardship
- Grants

The City of Windsor Heights has established a goal of accomplishing a volume-based treatment of its stormwater runoff. For a fully developed community that is located in an urban center, the goal of treating 0.5 inches of runoff for impervious surfaces has been established as an attainable goal. This is certainly a change from past practice, but should also be acknowledged as a partial step forward. There are upcoming federal standards that are being discussed and likely to come out sometime in 2012 that may have a volume reduction goal closer to 1.0 inch.

The flow chart below shows how a combination of implementations tools and explanation of the assumptions can reasonably put the city on track to accomplish this goal over a 10 year planning period.

Table 15. 10-Year Implementation Projection/Framework

	Tool	Description	Assumptions	Calculations	% of Goal Accomplished over 10 yrs
	Redevelopment Standard (1.5" Volume Control)	Redevelopment incrementally mitigates past impacts	1-2% Redevelopment/yr 1.5" vol. standard	1-2%/yr **x** 10 yrs **x** (1.5" stand. /0.5" goal)	30% - 60%
Grants	City CIP - General Fund/Utility	City Street Reconstruction including stromwater retrofits	30-yr lifespan of streets 1/30 = 3%/yr 0.25" vol. standard for street reconstr.	3%/yr **x** 10 yrs **x** (0.25" street stand. /0.5" goal)	15%
	Stormwater Utility Credits	Home/Business owners implement voluntary BMPS for utility credit	1-2%/yr 50% Utility credit for 0.5" volume control	1-2%/yr **x** 10 yrs **x** (0.5" street stand. /0.5" goal)	10% - 20%
	Education & Stewardship	Small, voluntary actions by landowners	Ex. Downspouts to lawns, native landscaping, etc. Mix of volume and water quality benefits - 1%/yr	1%/yr **x** 10 yrs **x** (0.5" credit /0.5" goal)	10%
				Total	**70% - 110%**



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EOR water ecology community

Water Assessment Plan & Local Stormwater Management Plan

City of Windsor Heights, Iowa

Sub-watershed Drainage Areas

Legend

- Sub-watershed
- Drainage Area

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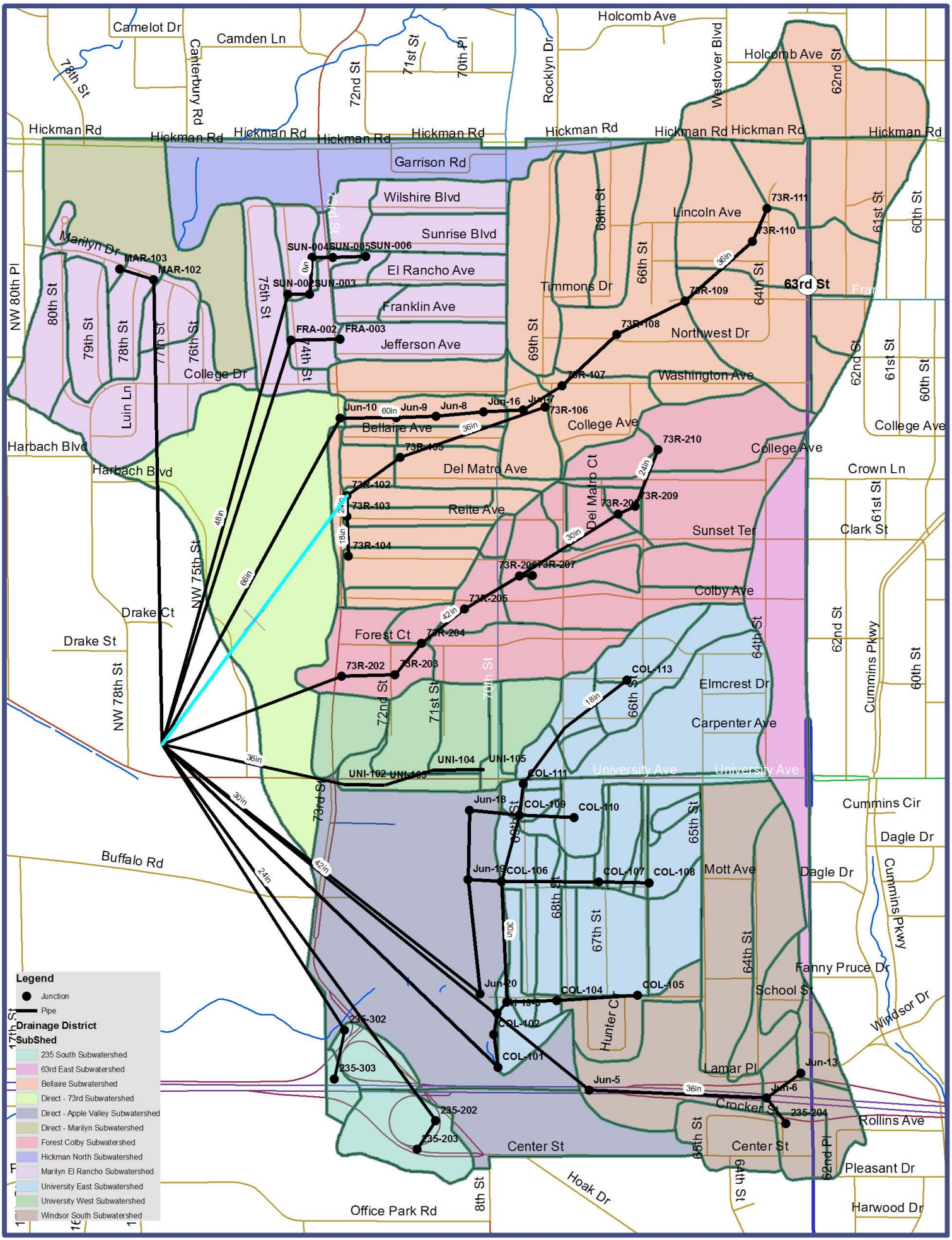

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STORMSEWER JUNCTION ID

Drainage Areas for Windsor Heights					
Subwatershed Drainage Area ID	StormNET ID	Junction ID - Drains to	Area (acres)	Composite CN	Time of Concentration (minutes)
235S-136	Sub-136	235-303	2.5	72	13
235S-137	Sub-137	235-302	6.0	72	15
235S-138	Sub-138	235-203	12.9	72	18
63rd-124	Sub-124	Out-2	27.5	75	24
Bell-112	Sub-112	73R-110	20.5	75	21
Bell-121	Sub-121	Stor-1	10.2	72	17
Bell-123	Sub-123	73R-108	28.5	75	24
Bell-173	Sub-173	73R-104	3.3	72	14
Bell-174	Sub-174	73R-104	8.0	72	16
Bell-175	Sub-175	73R-103	5.9	72	15
Bell-185	Sub-185	73R-102	4.5	72	14
Bell-186	Sub-186	Jun-9	7.3	72	15
Bell-188	Sub-188	73R-102	1.6	75	13
Bell-189	Sub-189	73R-105	3.4	72	14
Bell-190	Sub-190	73R-108	4.2	72	14
Bell-191	Sub-191	73R-106	8.4	72	16
Bell-192	Sub-192	73R-107	10.9	72	17
Bell-193	Sub-193	73R-108	9.5	77	16
Bell-194	Sub-194	73R-108	9.5	74	16
Bell-195	Sub-195	73R-107	15.6	72	19
Bell-196	Sub-196	73R-111	10.5	84	17
Bell-197	Sub-197	73R-111	17.8	79	20
Bell-204	Sub-204	73R-111	6.7	82	15
Bell-205	Sub-205	73R-111	13.4	79	18
Bell-206	Sub-206	73R-110	6.9	72	15
Bell-207	Sub-207	73R-109	2.5	72	13
Bell-208	Sub-208	73R-109	4.5	72	14
Bell-209	Sub-209	73R-109	18.9	72	20
Bell-219	Sub-219	73R-105	7.8	72	16
Bell-220	Sub-220	73R-102	3.6	76	14
Bell-221	Sub-221	73R-102	7.7	75	15
D73-120	Sub-120	Stor-1	75.9	66	45
DApp-111	Sub-111	Stor-1	83.8	80	49
DApp-139	Sub-139	Stor-1	19.5	80	21
DMar-215	Sub-215	Stor-1	33.1	71	26
Fore-125	Sub-125	73R-204	14.1	72	18
Fore-169	Sub-169	73R-204	2.7	72	13
Fore-170	Sub-170	73R-202	12.6	71	18
Fore-171	Sub-171	73R-205	1.5	72	13
Fore-172	Sub-172	73R-205	5.3	72	14
Fore-176	Sub-176	73R-207	6.7	72	15
Fore-177	Sub-177	73R-209	4.5	72	14
Fore-178	Sub-178	73R-210	15.5	72	19
Fore-179	Sub-179	73R-209	17.6	72	20
Fore-180	Sub-180	73R-208	1.9	72	13
Fore-181	Sub-181	73R-206	4.6	72	14
Fore-182	Sub-182	73R-207	4.9	72	14

Drainage Areas for Windsor Heights					
Subwatershed Drainage Area ID	StormNET ID	Junction ID - Drains to	Area (acres)	Composite CN	Time of Concentration (minutes)
Fore-183	Sub-183	73R-206	1.7	72	13
Fore-184	Sub-184	73R-206	18.8	72	20
Hick-116	Sub-116	Out-1	33.9	86	27
Marl-113	Sub-113	Stor-1	5.5	70	15
Marl-114	Sub-114	Stor-1	9.1	72	16
Marl-115	Sub-115	MAR-102	6.4	71	15
Marl-117	Sub-117	FRA-003	10.0	72	16
Marl-118	Sub-118	SUN-002	5.3	74	14
Marl-119	Sub-119	SUN-006	8.6	72	16
Marl-122	Sub-122	Stor-1	12.1	72	17
Marl-198	Sub-198	SUN-006	7.1	72	15
Marl-199	Sub-199	SUN-006	6.5	72	15
Marl-200	Sub-200	SUN-005	4.2	75	14
Marl-201	Sub-201	SUN-006	1.9	72	13
Marl-202	Sub-202	FRA-003	3.2	72	14
Marl-203	Sub-203	FRA-003	6.9	72	15
Marl-210	Sub-210	SUN-004	0.9	72	13
Marl-211	Sub-211	FRA-002	7.0	72	15
Marl-212	Sub-212	Stor-1	1.0	61	13
Marl-213	Sub-213	MAR-103	8.5	72	16
Marl-214	Sub-214	MAR-103	2.5	70	13
Marl-216	Sub-216	Stor-1	20.7	68	21
UnvE-127	Sub-127	COL-108	5.1	72	14
UnvE-128	Sub-128	COL-105	11.8	72	17
UnvE-129	Sub-129	COL-111	8.6	72	16
UnvE-130	Sub-130	COL-111	29.1	78	25
UnvE-141	Sub-141	COL-110	7.8	82	21
UnvE-146	Sub-146	COL-103	6.6	72	15
UnvE-147	Sub-147	COL-104	2.5	72	13
UnvE-148	Sub-148	COL-105	7.7	72	15
UnvE-149	Sub-149	COL-103	3.2	70	14
UnvE-150	Sub-150	COL-106	0.5	72	12
UnvE-151	Sub-151	COL-106	1.4	72	13
UnvE-152	Sub-152	COL-107	1.4	75	13
UnvE-153	Sub-153	COL-107	4.6	75	14
UnvE-154	Sub-154	COL-107	0.9	72	13
UnvE-155	Sub-155	COL-108	1.3	77	13
UnvE-156	Sub-156	COL-108	1.4	80	13
UnvE-157	Sub-157	COL-108	1.9	90	13
UnvE-158	Sub-158	COL-103	5.8	72	15
UnvE-159	Sub-159	COL-104	1.1	67	13
UnvE-160	Sub-160	COL-111	0.6	90	12
UnvE-161	Sub-161	COL-109	2.6	90	13
UnvE-166	Sub-166	COL-111	1.8	75	13
UnvE-167	Sub-167	COL-111	3.8	72	14
UnvE-168	Sub-168	COL-113	6.8	72	15
UnvE-217	Sub-217	COL-101	4.4	64	14

Drainage Areas for Windsor Heights					
Subwatershed Drainage Area ID	StormNET ID	Junction ID - Drains to	Area (acres)	Composite CN	Time of Concentration (minutes)
UnvE-218	Sub-218	COL-109	1.3	75	13
UnvW-126	Sub-126	UNI-102	7.3	85	15
UnvW-140	Sub-140	UNI-103	7.4	81	15
UnvW-162	Sub-162	UNI-105	6.1	77	15
UnvW-163	Sub-163	UNI-105	2.6	84	13
UnvW-164	Sub-164	UNI-103	4.9	90	14
UnvW-165	Sub-165	UNI-104	7.0	80	15
Wind-131	Sub-131	Stor-1	8.9	76	16
Wind-132	Sub-132	Jun-5	9.1	82	16
Wind-133	Sub-133	Jun-5	14.7	72	18
Wind-134	Sub-134	Jun-5	23.6	73	22
Wind-135	Sub-135	Jun-5	20.1	88	21
Wind-142	Sub-142	235-204	4.9	73	14
Wind-143	Sub-143	Jun-6	4.2	72	14
Wind-144	Sub-144	Jun-13	4.7	72	14
Wind-145	Sub-145	Jun-6	8.6	80	16

Pipe Flows for Windsor Heights

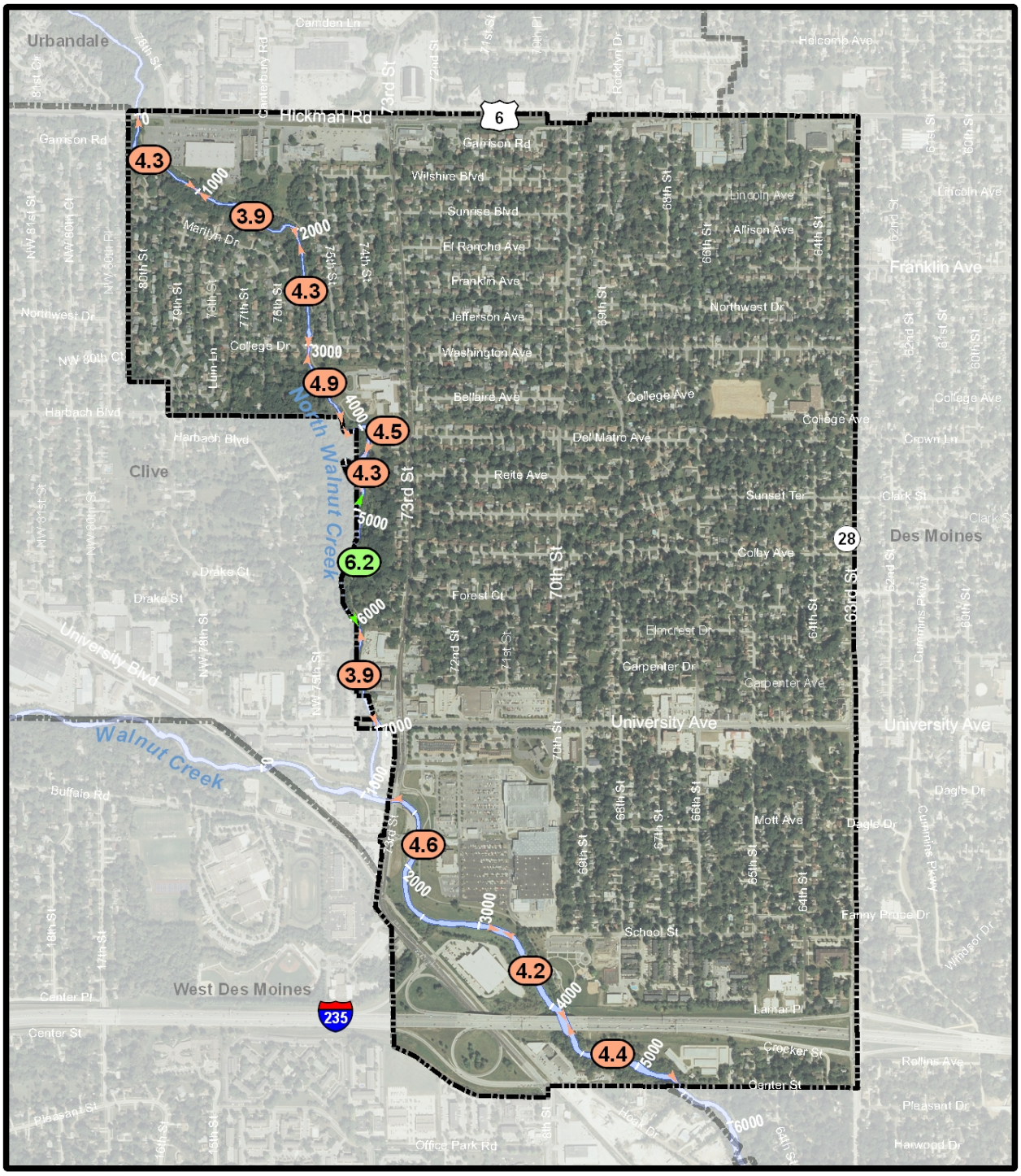
Conduit ID	Junction ID - Flow From	Junction ID - Flow To	Capacity (cfs)	Pipe Shape	Pipe Length (ft)	Pipe Size (inches)
235	Jun-13	Jun-6	21	Circular	351	24
73R	73R-102	Stor-1	119	Circular	380	48
COL	COL-113	COL-111	17	Circular	1,224	18
Con-103	Jun-7	Jun-16	249	Circular	329	60
Con-104	Jun-16	Jun-8	323	Circular	395	60
Con-105	Jun-8	Jun-9	249	Circular	328	60
Con-106	Jun-9	Jun-10	225	Circular	462	60
Con-112	Jun-10	Stor-1	118	Circular	1,457	66
Con-116	COL-101	Stor-1	122	Arch	188	42
Con-120	COL-103	MH 19-3	135	Arch	50	36
Con-121	COL-109	Jun-18	27	Circular	215	24
Con-122	Jun-18	Jun-19	65	Circular	531	30
Con-123	Jun-19	Jun-20	37	Circular	900	30
Con-124	Jun-20	Stor-1	51	Circular	430	30
Con-125	COL-106	Jun-19	19	Circular	215	24
Con-51	73R-111	73R-110	95	Circular	298	36
Con-52	73R-110	73R-109	95	Circular	743	36
Con-53	73R-109	73R-108	95	Circular	628	36
Con-54	73R-108	73R-107	96	Circular	616	36
Con-55	73R-107	Jun-7	176	Circular	479	60
Con-56	73R-106	73R-105	92	Circular	1,266	36
Con-57	73R-105	73R-102	81	Circular	541	36
Con-58	73R-210	73R-209	20	Circular	504	24
Con-59	73R-209	73R-208	52	Circular	152	30
Con-60	73R-208	73R-206	57	Circular	964	30
Con-61	73R-207	73R-206	12	Circular	110	24
Con-62	73R-206	73R-205	91	Circular	530	36
Con-63	73R-205	73R-204	159	Circular	454	42
Con-64	73R-204	73R-203	120	Circular	338	48
Con-65	73R-203	73R-202	145	Circular	441	48
Con-66	73R-202	Stor-1	220	Circular	354	48
Con-67	73R-104	73R-103	7	Circular	329	18
Con-68	73R-103	73R-102	18	Circular	173	24
Con-69	COL-111	COL-109	34	Circular	260	24
Con-70	COL-106	COL-103	66	Arch	977	30
Con-71	COL-109	COL-106	37	Circular	569	24
Con-72	COL-110	COL-109	17	Circular	422	24
Con-73	COL-108	COL-107	13	Circular	418	18
Con-74	COL-107	COL-106	29	Circular	800	24
Con-75	COL-102	COL-101	143	Arch	243	42
Con-76	COL-105	COL-104	82	Arch	672	30
Con-77	COL-104	COL-103	61	Arch	326	30
Con-78	MH 19-3	COL-102	144	Arch	142	42
Con-79	235-204	Jun-6	21	Circular	264	24
Con-80	Jun-6	Jun-5	56	Circular	1,467	36
Con-81	Jun-5	Stor-1	83	Circular	110	42
Con-82	235-203	235-202	17	Circular	280	24
Con-83	235-202	Stor-1	21	Circular	266	24

Pipe Flows for Windsor Heights

Conduit ID	Junction ID - Flow From	Junction ID - Flow To	Capacity (cfs)	Pipe Shape	Pipe Length (ft)	Pipe Size (inches)
Con-84	235-303	235-302	19	Circular	412	24
Con-85	235-302	Stor-1	17	Circular	131	24
Con-86	UNI-105	UNI-104	37	Circular	424	24
Con-87	UNI-104	UNI-103	34	Circular	415	24
Con-88	UNI-103	UNI-102	69	Circular	334	36
Con-89	UNI-102	Stor-1	77	Circular	284	36
Con-92	FRA-002	Stor-1	204	Circular	448	48
Con-93	SUN-005	SUN-004	56	Rectangular	175	36
Con-95	SUN-003	SUN-002	81	Circular	181	36
Con-96	SUN-002	Stor-1	204	Circular	448	48
Con-97	MAR-103	MAR-102	14	Circular	294	18
Con-98	MAR-102	Stor-1	27	Circular	266	24
FRA	FRA-003	FRA-002	47	Circular	404	30
SUN	SUN-006	SUN-005	17	Circular	270	21

APPENDIX – 2

Stream Assessment – Visual Characterization of Reaches



EOR Inc X:\Clients_Municipal\00974_Windsor_Heights\0001_Stormwater_Mgmt_Plan\09_GIMS_ProjectName\GIS\str_assestm.mxd Date: 8/26/2010 2:33:56 PM Name: ejensen

EOR
water
ecology
community

Legend

Ranking and Overall Score

Fair 6.0

Poor 3.5

500' Stationing

Water Assessment Plan & Local Stormwater Management Plan

City of Windsor Heights, Iowa

Visual Stream Assessment

Miles
0 0.25 0.5

North Walnut Creek – Sta0000-1000
Many attempts to stabilize stream banks using construction debris;
Viable opportunities for stormwater treatment north side of corridor

North Walnut Creek – Sta1000-2100
Multiple severe bank failures threatening property and infrastructure;
Handful of private encroachments negatively impacting stability and health

North Walnut Creek – Sta2100-3050
Very straight; heavy armored; stable but low habitat value

North Walnut Creek – Sta3050-3800
Relatively stable - heavily armored;
Stormsewer daylight and/or stormwater management opportunities in conjunction with School property

North Walnut Creek – Sta3800-4300
High gradient; relatively stable

North Walnut Creek – Sta4300-4850
Significant bank failures associated with tight radius of curvature and grade change (due to active bypass)

North Walnut Creek – Sta4850-6100
Better stability and health – due in part to wider buffer and less encroachment

North Walnut Creek – Sta6100-7000
High level of entrenchment and encroachment (both banks)

Walnut Creek – Sta1250-3200
High degree of stability from recent stability work (secondary terrace and rip-rap);
Feasible potential for ecological health improvements

Walnut Creek – Sta3200-4200
Entrenchment and high flow are actively eroding Reed Canary Grass dominated corridor

Walnut Creek – Sta4200-5350

Most unstable reach – failure of 10’ banks threatening Hwy 235 bridge and utility line