WALNUT CREEK WATERSHED

master plan

JUNE 2016

RDG PLANNING • DESIGN
DES MOINES AREA MPO METROPOLITAN PLANNING ORGANIZATION
SNYDER & ASSOCIATES Engineers and Planners
Polk Soil & Water CONSERVATION DISTRICT

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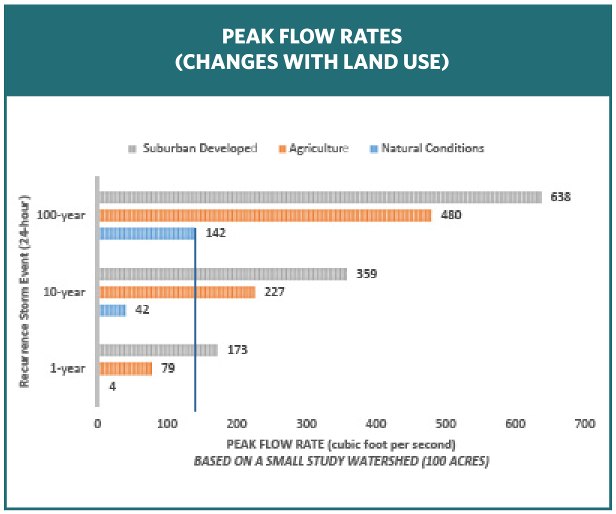
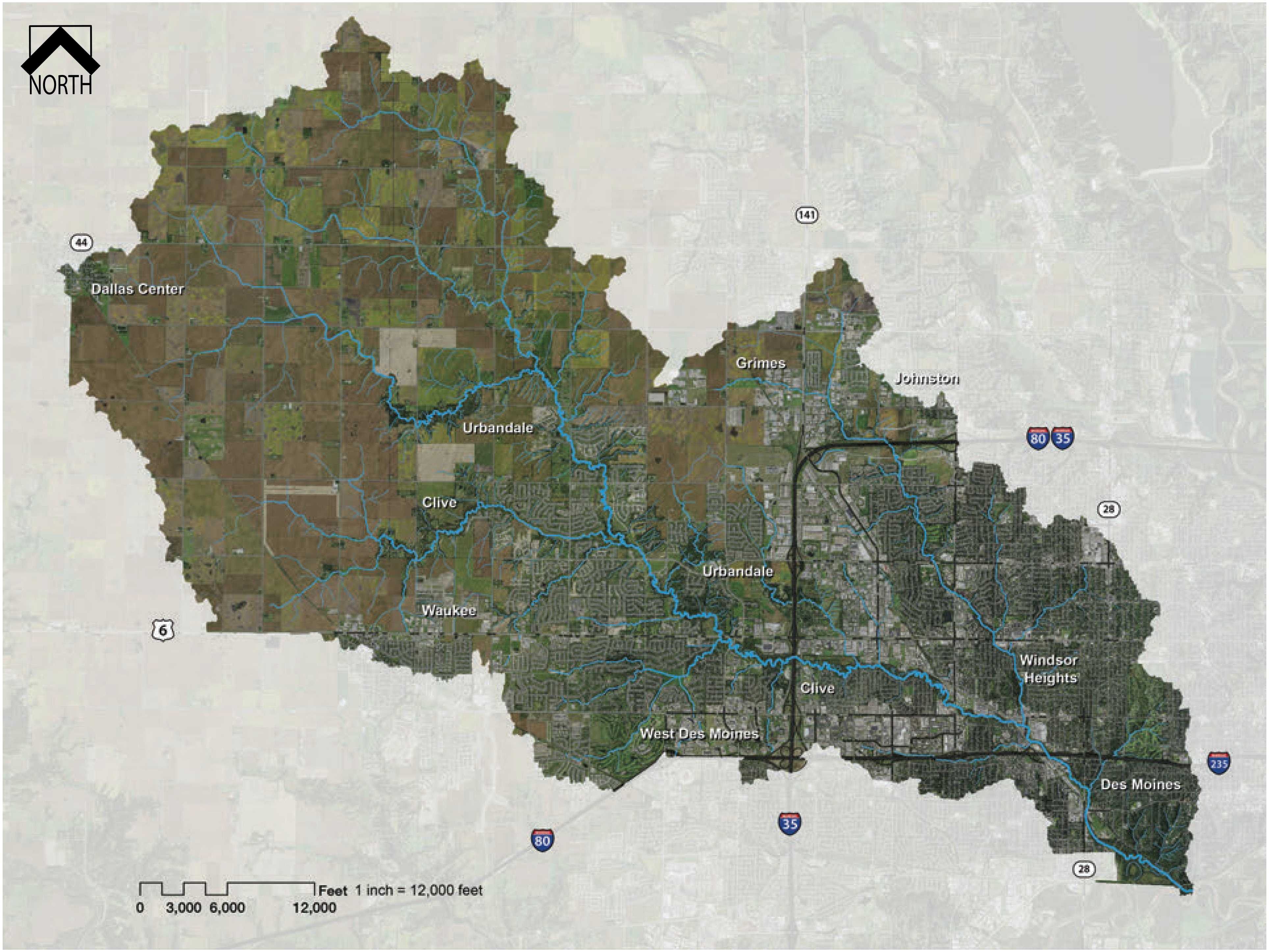


In small urban streams, peak rates of flow during common events may exceed levels rarely seen under natural conditions.

Introduction: The Big Challenge

The landscape of the 53,000-acre Walnut Creek Watershed has been changing constantly over the last 150 years. Some big changes have occurred gradually, unnoticed by many who live in or pass through this area. Recently, the rate of change has been more rapid as suburban growth has pushed across hundreds of acres each year. Collectively, these changes have drastically affected the landscape's ability to absorb water. Small streams in urban areas may see high flows nearly every year that used to occur only once every 100 years under natural conditions.

This significant change in how this watershed works increases runoff and degrades water quality. Loss of topsoil, streambank erosion, construction site pollution, pollutant loading and transport and flooding implications are all exacerbated by the way agricultural and urban uses have changed the character of this watershed. The goal of this plan is to improve water quality and prevent increases in flooding. To achieve this, the process to restore the watershed's ability to slow, absorb and store runoff must be started.


NORTH
44
Dallas Center
141
Grimes
Johnston
Urbandale
80
35
Clive
28
Urbandale
Waukee
6
Windsor
Heights
Clive
West Des Moines
235
Des Moines
80
35
28
0
3,000
6,000
12,000
Feet 1 inch = 12,000 feet

About the Watershed

Roughly half of the 83-square-mile watershed in Polk and Dallas counties is currently developed, with likely significant growth in housing and commercial development in its future. In the decade from 2001–2011, over six square miles (8.1% of the watershed) was developed into urban land uses.

Flooding, nutrient loading, bacteria and eroded soils (sediment) impact public health, reduce habitat and undermine the ability of Walnut Creek to serve as a Central Iowa amenity. Water quality monitoring data has been collected by the Iowa Soybean Association/Agriculture's Clean Water Alliance and IOWATER volunteers for more than 15 years. Nutrient and phosphorus counts are highest in the upper reaches of the watershed where agricultural uses dominate. In the lower, developed half of the watershed, bacteria counts and sediment loads provide challenges, along with flooding. The Iowa Department of Natural Resources (IDNR) lists Walnut Creek as an "impaired water body" due to high levels of bacteria.

The watershed touches two counties and eight communities, with its outlet into the Raccoon River located less than one mile from the Des Moines Water Works' (DMWW) intake for a public water supply serving nearly one-half million users.

STRATEGIC FRAMEWORK

VISION

Engaged residents working across political and property boundaries to create and sustain a healthy watershed.

MISSION

Through collaboration, education and research, implement science-based policies and practices for flood mitigation, water quality improvements, natural resources protection and improved recreation while maintaining economic health.

Approaches

The plan's strategy outlines six approaches to address stormwater management and soil health. The approaches address water quality improvements; enhanced recreation, public health, habitat restoration and access/connections; enriched conservation education programming and multi-purpose projects to sustain natural resources, public/economic health.

4,300 acres of land in this watershed were developed between 2001 and 2011

Throughout the process, the Watershed Management Authority and its executive team have routinely met to provide input and oversight of the planning process.

About the Plan

Stream Assessment and Hydrologic Study

Stream assessment work, coupled with available monitoring, informs this plan and include:

- 239 miles of stream length assessed using desktop technologies
- In-field assessment of streams using the RASCAL method (see Chapter 5)
- Prior work detailing stream assessments through the City of Clive
- Updated flood study information
- Prior studies which referenced conditions within this watershed

Public and stakeholder involvement

The planning team and partners facilitated two public events within the watershed (Windsor Heights and Clive), a half-day stakeholders' workshop to craft strategic direction, and two large group discussions with agricultural interests at the Heartland Co-op in Dallas Center. Planners have met with WMA member organizations (councils, Soil and Water Conservation Districts and supervisors) at the project outset and again with development of the planning draft. The Metropolitan Planning Organization and Walnut Creek Watershed directors have provided additional organization/coordination and outreach support throughout the project.

Conditions/Context

Climate

Variations in temperature and precipitation greatly influence flow patterns and pollutant loads within Walnut Creek. Rainfall has become more frequent and intense. **Six of the top eight wettest years on record have occurred since 1982**, while none of the driest years on record have occurred during that same period. The National Oceanic and Atmospheric Administration (NOAA) has updated its precipitation data and storm water facilities are now expected to handle runoff generated by more rainfall than expected in the past.

Top / Bottom Precipitation Years				
	HIGH		LOW	
Rank	Year	Precipitation (in inches)	Year	Precipitation (in inches)
1	**1993**	**55.89**	1956	17.08
2	**2010**	**51.78**	1910	18.25
3	**2008**	**49.43**	1930	19.58
4	1973	45.19	1933	19.68
5	**1982**	**44.81**	1901	19.78
6	**1990**	**43.94**	1953	20.01
7	1961	42.88	1894	20.07
8	**1986**	**42.59**	1967	21.83
9	1947	42.08	1966	21.86
10	1902	42.02	1955	21.99

Annual streamflow in Walnut Creek has increased 37% since 1982.

Flood

Flooding is a key concern within this watershed. A flood event occurred during the planning process and intensified the focus on this issue. Urban development has occurred within many flood-prone areas. Using the new NOAA data (mentioned above), this study updated hydrologic and hydraulic models as well as inundation/flood mapping for Walnut and North Walnut Creeks. The chart (right) demonstrates how much additional land is expected to fall within flood-prone areas and how much wider these flood plains are now compared to previous years.

It's important to note flash flooding can occur outside of areas with mapped flood risk. Flash flooding can be caused by clogged inlets, storm sewers and culverts; overloaded storm sewer systems; blocked overflow paths and urban small stream flooding.

Stream conditions

Walnut Creek is always in motion. In some areas, there is evidence of past stream meanders (curving stream segments) that were more than 500 feet from where the stream flows today. In other areas, the stream has moved several feet in only a few years. Streams are getting wider and lower. Nearly three quarters (71%) of the streams in the watershed have become incised or deeply incised—downcut over time. More than half (57%) of all field-assessed streams had moderate to severe erosion. Streams in the watershed are now 4–10x wider than they were prior to pioneer

Changes in Flood Risk Due to Increases in Rainfall

Stream	Length Modeled	Added Area of Flood Risk	Average Increase
			Flood Plain Width
North Walnut Creek	6 miles	16 acres	24 feet
Walnut Creek	18 miles	73 acres	34 feet

Pollutant Sources by Land Use

	N	P	Sediment
Urban	14%	26%	7%
Cropland	81%	49%	10%
Pastureland	2%	2%	0%
Forest	0%	1%	0%
Grasslands	0%	0%	0%
Gully	1%	5%	19%
Streambank	2%	10%	38%
Construction Site	1%	8%	25%

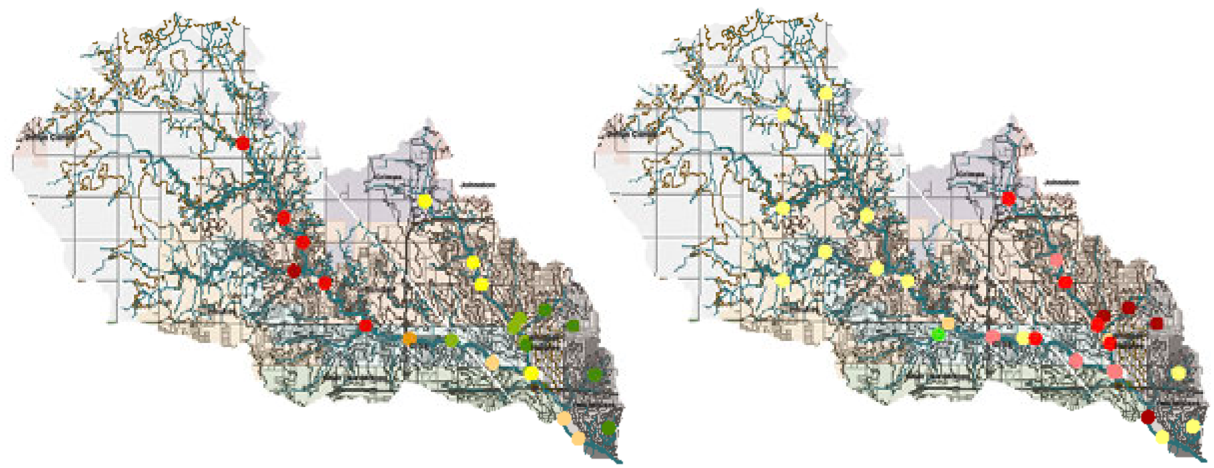
Construction sites, making up less than 0.1% of the overall watershed area are likely large contributors of sediment to Walnut Creek.

settlement. Improved stream buffers are needed. Nearly half of the smallest streams (48%) have no stream buffer or have a buffer less than 50 feet wide. Changes in land use and sources of increased sediment loads (such as cropland, gullies and construction sites with insufficient controls) can accelerate the cycle of stream evolution.

Pollution

The lowest 7.6 miles of Walnut Creek are listed by the State of Iowa as an impaired waterway. E.coli bacteria are often measured at levels several times higher than water quality standards set by the State of Iowa. This poses a potential risk to health when people fish, wade, canoe or participate in other recreational activities that would put them in contact with the water.

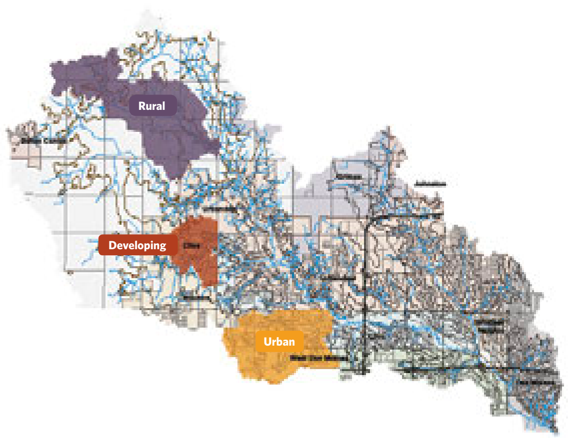
Nitrates **E-Coli**



Source "Monitoring Data from Iowa Soybean Association, IDNR Snapshot and Iowater"

57% of all field assessed streams had moderate or severe erosion.

Subwatershed Locations



The SubWatersheds

Use of subwatersheds

To help this plan provide meaningful information for recommendations to the whole of the watershed, planners focused their attention on three subwatersheds, representing the primary conditions found in Walnut Creek.

By focusing scientific study on these three subwatershed types, the planners have been able to gain the most information from stream assessment field work and computer modeling. The recommendations for these three subwatersheds serve as a “template” of sorts for the balance of the watershed under similar conditions.

Three "Case Study" Subwatersheds

- A **developing area** in parts of Waukee, Clive and Urbandale along Little Walnut Creek expected to see rapid urban growth over the next ten years
- An **agricultural area** draining to Walnut Creek in rural Dallas County
- A largely **developed urban area** within parts of Waukee, Clive and West Des Moines that drains to South Walnut Creek (which flows through Country Club Lake)

Case Studies: Developing, Rural and Urban Areas

Developing Area Case Study

This 960-acre area lies within the Little Walnut Creek watershed, between Warrior Lane and Alice's Road. Planners expect rapid urban growth within this area over the next decade.

As the area develops, key concerns are:

- Increased risk of flooding and streambank erosion that could be caused by higher rates and volumes of surface runoff
- Additional pollutant loadings (primarily sediment and bacteria) that could be delivered to Little Walnut Creek

To address these concerns, this case study reviewed how design techniques described within the Iowa Stormwater Management Manual (ISWMM) compared to methods that have been more traditionally used across the Des Moines metro area. This comparison showed that using new methods outlined in ISWMM, significant reductions in surface runoff volume, rates and pollutant loads would be expected.

Approaches for Developing Case Study improvements include:

1. **Adopt use of the ISWMM manual for stormwater management design** - Use its Unified Sizing Criteria to manage runoff from both small and large storm events, to better mimic natural runoff conditions. For rainfall events that typically happen about once a year (2.67" in 24 hours), peak rates of runoff from developing areas would be expected to be reduced by over 95%, compared to traditional detention methods. Significant rate reductions would also be expected during larger events.
2. **Restore healthy soil layers to open spaces in developing areas** - Healthy soils have the ability to absorb rainfall closest to where it first lands. Their absence can significantly increase surface runoff volume and rates—increases that need to be considered in the design of downstream storm infrastructure. Using techniques described in ISWMM, healthy soils can be preserved or restored.
3. **Consider using low-impact design techniques** - Developments can be designed to reduce their impact on the landscape. Practices such as bioswales, wetlands and wet ponds can be incorporated into public greenbelts and private open spaces—creating a network of aesthetic features which also serve a stormwater management function. These practices are known to reduce delivery of key pollutants, such as bacteria and sediments.

Because of soil compaction, moisture is unable to percolate through the soil. Here it is forced to seep across the sidewalk and over the curb because it cannot penetrate subsoil layers.

Rural Area Case Study

Located at the headwaters of Walnut Creek, this 6.5-square-mile area is located between Dallas Center and Grimes. More than 80% of the area is row-crop farmland. Modeling results indicate croplands are the most significant sources of nutrient loadings (phosphorus and nitrogen). The plan recommends load reductions of at least 41% for nitrogen and 29% for phosphorus for this rural watershed. Croplands along with erosion of streambanks and gullies are expected to be the largest sources of sediment within this area.

Approaches for Rural Case Study improvements include:

1. **Tackle nitrogen and phosphorus** - Use Best Management Practices (BMPs) outlined in the Nutrient Reduction Strategy to achieve the nutrient reduction goals. Practices to apply broadly across this subwatershed would include: extended crop rotations, split-seasonal nitrogen applications, cover crops, increased use of nitrification inhibitors, increased use of no-till and adjusted nitrogen application rates. Additional practices would be more site-specifically located within the watershed.
2. **Stabilize streambanks and gullies** - Address key areas of gully and streambank erosion through stabilization/restoration and two-stage ditch conversions. Annual erosion could be reduced by more than 300 tons with a few targeted projects identified in this plan.
3. **Slow the flow** - Reduce peak rates of flow caused by small to moderate storm events. Multi-stage outlet designs that capture and slowly release small storms can achieve excellent results.

Expected Load Reductions from 10-year plan for Rural Case Study Area:
Nitrogen - 42%, Phosphorus - 62%, Sediment - 65%

Urban Area Case Study

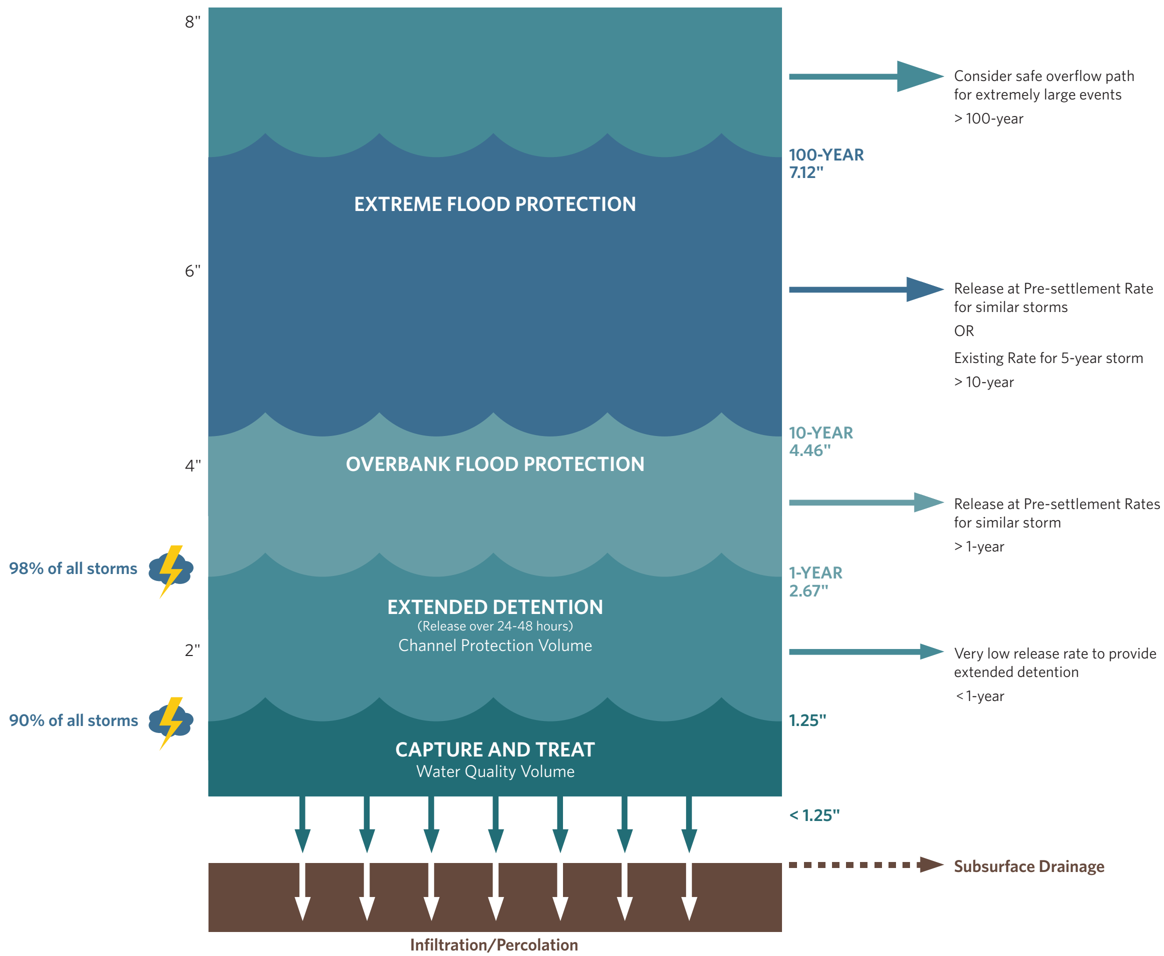
This 4.5-square-mile area is almost entirely developed. Most of this area drains through Country Club Lake in Clive. Cropland makes up 3% of the watershed but is projected to contribute 13% of nitrogen and 7% of phosphorus loading. The modeling shows construction sites, making up only 2–5% of this study area each year, are expected to account for 60% of the sediment load. Streambank erosion is the next-largest generator at nearly 24% of the expected load.

Strategies for Urban Case Study improvements include:

- Modify outlets of existing ponds and entrances to existing culverts to better manage small storm events.
- Complete streambank stabilization and restoration projects in key identified areas (see Chapter 8).
- Require compliance of urban stormwater management policies, with particular attention paid to Stormwater Pollution Prevention Plans (SWPPPs).

Stream restoration techniques can be used to repair and restore eroded stream corridors.

Levels of Stormwater Management Using ISWMM's Unified Sizing Criteria



What we learned from the case studies informs policy recommendations and over-arching initiatives for the urban and rural sectors.

Urban Policy Initiatives

Adopt ISWMM's Unified Sizing Criteria.

Walnut Creek's modeling demonstrates traditional stormwater detention practices limit ability to control runoff for smaller events. Small storm events (2.5" or less) make up 98% of Central Iowa's precipitation volume. The Unified Sizing Criteria provides standards that group rainfall events into four categories by size, capturing and treating the most common storms, providing extended detention of more moderate events, and reducing the potential for flooding by controlling releases from larger storms to more natural levels. Implementing these standards would result in significant reductions in peak flow rates, with the largest benefits coming during the smaller, most common events. Slowing the rapid rush of runoff from these events will lead to small urban streams remaining stable after development occurs.

Buffer streams

Establish stream buffers along all first, second and third order streams, and open drainage courses with a drainage area exceeding 40 acres. Refer to Chapter 5 of the plan for an explanation of stream order.

Using new standards could reduce outflow rates from new developing areas by 95% during "small storm events."

Improve planning and enforcement of Stormwater Pollution Prevention Plans (SWPPP)

While most construction sites apply for required permits and prepare SWPPPs, site visits performed during this study show room for improvement installing and maintaining practices that control erosion and sediment. SWPPPs should be treated as "living documents"—amended to accommodate changing conditions and on-the-ground realities.

Decisions should be informed by the fact that the ultimate purpose of SWPPPs is to prevent downstream pollution caused by construction sites.

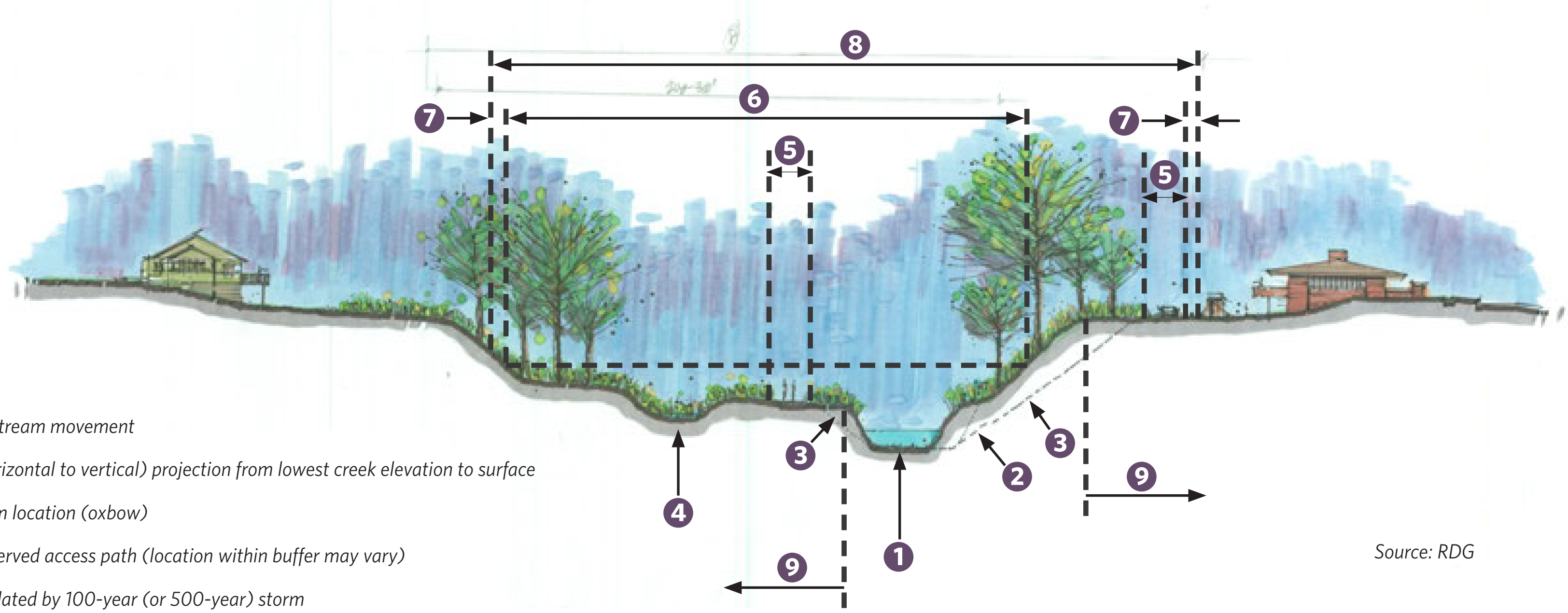
Implement local ordinances to protect or restore healthy soils in open spaces

Options include orienting sites to reduce grading volumes and the area disturbed by construction; protecting high-quality soils, topsoil stripping/replacing and using soil amendments like compost and sand to rebuild a healthy surface topsoil layer. Soil Management Plans could be included in the SWPPP (see above). Decisions should be informed by the fact that the ultimate purpose of SWPPPs is to prevent downstream pollution caused by construction sites.

Adopt or amend flood plain protections:

Considerations include:

- Prevent construction of new structures within the limits of the 100-year flood plain
- Evaluate potential for recurring losses and/or need for flood protection in redevelopment areas—cause no net increase in flood elevations
- Maintain flood storage capacity by limiting grading or placing fill materials within the flood plain
- Reserve areas as open space where future stream movement or flooding is expected
- Set new structures at least three feet above the regulatory 100-year flood elevations (beyond any current requirements) to account for flow increases predicted by NOAA's new data.



1. *Stream*
2. *Expected stream movement*
3. *4-to-1 (horizontal to vertical) projection from lowest creek elevation to surface*
4. *Past stream location (oxbow)*
5. *Trail of reserved access path (location within buffer may vary)*
6. *Area inundated by 100-year (or 500-year) storm*
7. *5-foot setback zone*
8. *Recommended buffer width*
9. *Recommended minimum building setback*

Source: RDG

Restoring healthy soils within open spaces after development could reduce surface runoff volume by 50% or more during "small storm events."

Rural Policy Initiatives

The rural recommendations here include:

- Apply best management practices (BMPs) as outlined in the Nutrient Reduction Strategy, targeting practices with multiple benefits
- Use precision business planning to help landowners and tenants identify lands that are least profitable for crop production. These areas could become new wetlands, buffers or CRP lands.
- Target the application of BMPs to achieve the greatest cost-benefit ratios
- Expand available technical assistance and funding sources
- Increase stream buffer protection corridors to include the five-year flood plain
- Connect rural partners routinely to ongoing research and demonstration
- Greatly enhance/expand access to information, including field monitoring
- Increase transparency of on-farm work/practices and funding

Implementation

The plan highlights a series of projects identified for each subwatershed. The plan further outlines organizational approaches to maximize coordination of Watershed Management Authorities in Central Iowa and support increased technical and grant/funding assistance.

A series of outreach strategies—for education and collaboration are included here with heavy reliance on field days and demonstrations in the agricultural sector, social media and speakers/workshops in the urban arena and ongoing efforts for the urban and rural sectors to dialogue, tour and connect to serve the watershed as a whole.

At the time this plan is being produced, the Greater Des Moines Partnership's Iowa Soil and Water Future Task Force has submitted its series of recommendations to the Governor and Legislature related to policy and funding highlights to promote soil and water health in Iowa. Those recommendations may ultimately influence the state's capacity to support recommendations outlined here.

This document details a decade-long plan to make significant improvements in water quality while attempting to restrain the potential for increased flood risk. To meet all water quality and flood protection goals will likely take decades to achieve. However, the Walnut Creek Watershed Management Authority has come together to work across political boundaries to begin this important effort. With a vision and mission emphasizing collaboration across urban and rural boundaries, Walnut Creek could serve the state as a model for cooperation and progress.

Assessment

Action

Note: Words that are **highlighted** throughout the plan are included in a glossary at the end of this report.

Although many different components may be included in a watershed plan, EPA has identified nine key elements that are critical for achieving improvements in water quality. EPA requires that these nine elements be addressed in watershed plans funded with incremental Clean Water Act section 319 funds and strongly recommends that they be included in all other watershed plans intended to address water quality impairments. In general, state water quality or natural resource agencies and EPA will review watershed plans that provide the basis for section 319-funded projects. Although there is no formal requirement for EPA to approve watershed plans, the plans must address these nine elements if they are developed in support of a section 319-funded project.

- Adapted from "Handbook for Developing Watershed Plans to Restore and Protect Our Waters,"
USEPA Office of Water – Nonpoint Source Control Branch, March 2008

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions and any goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed.
    - Chapter 2
      Factors related to hydrology and potential pollution sources such as terrain, soils and land use changes.
    - Chapter 3
      Current and historic climate data is reviewed, along with an analysis of historic streamflow patterns and flood risk.
    - Chapter 5
      Details regarding stream characteristics, evolution, stability and buffering.
    - Chapter 6
        1. Identification of the key pollutants of concern identified by this plan and the potential impacts of these pollutants.
        2. Existing available monitoring data is reviewed.
        3. Pollutant loading and sources are projected by subwatershed and land use type.
        4. Projected reduction targets are given.
2. An estimate of the load reductions expected from management measures.
    - Chapter 8
      For each of three case study subwatersheds (rural, urban and developing) a specific ten-year implementation plan has been developed which includes projected load reductions.
3. A description of the non-point source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed to implement this plan.
    - Chapter 8
      For each of three case study subwatersheds the ten-year plan details the type and location of management practices needed to meet the projected load reduction targets.
    - Chapter 9
      Proposed policy changes are non-structural management measures. The urban and rural policies outlined in this plan are those that are recommended for adoption to achieve the goals of this plan.
    - Chapter 10
      A list of priority practices and other improvement opportunities is included, with a projected cost for implementation.
    - Chapter 15
      A toolbox filled with a variety of rural and urban best management practices which could be implemented by various stakeholders across the watershed. A brief description of each practice is given with sources listed to direct the user to additional information.
4. Estimate of the amounts of technical and financial assistance needed, associated costs and/or the sources and authorities that will be relied upon to implement this plan.
    - Chapter 10
      A list of priority practices and other improvement opportunities is included, with a projected cost for implementation.
    - Chapter 13
      The technical, financial and staffing resources that are necessary to execute this plan are reviewed.
5. An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing and implementing the non-point source management measures that will be implemented.
    - Chapter 11
      This entire chapter is devoted to describing the plan to educate various audiences about the plan and how to encourage collaboration between stakeholders.
6. Schedule for implementing the non-point source management measures identified in this plan that is reasonably expeditious.
    - Chapter 12
      The schedule for implementing practices, policies and monitoring is described.
7. A description of interim measureable milestones for determining whether non-point source management measures or other control actions are being implemented.
    - Chapter 12
      Milestones related to the numbers of practices installed, policies adopted and improvements in water quality monitoring samples are listed.
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.
    - Chapter 6
      The benchmark goals for water quality improvements are listed here.
    - Chapter 12
      The timeline for meeting these benchmarks within the case study watersheds can be found here.
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item "8."
    - Chapter 12
      A monitoring plan which includes the methods of data collection, the parameters to be measured, the location of testing sites and the schedule for sampling is outlined.

CHAPTER 1

KEY CONCEPTS

1. **What is the Walnut Creek Watershed Management Authority?**
   The Walnut Creek WMA is a collection of cities, counties and other jurisdictions coming together to focus on water quality and quality issues through collaboration and education. Currently, the Walnut Creek WMA includes the communities of Clive, Dallas Center, Des Moines, Grimes, Johnston, Urbandale, Waukee and West Des Moines. The WMA includes Polk County as well as the Dallas and Polk County Soil and Water Conservation Districts.
2. **Public Interaction**
   Interaction with stakeholders has been critical in the development of this plan. This included monthly meetings with WMA representatives, two open house events and two meetings with key agricultural landowners and producers.
3. **Technical Analysis**
   A variety of technical data has been used to inform this plan. This includes local climate records, past water quality monitoring data, geographic information systems (GIS) data and direct in-field assessments of stream and land use conditions.
4. **How to Use this Plan**
   This section outlines how the information in the plan is arranged and how it can be best used by a variety of audiences.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

The information gathered through stakeholder meetings, public events and technical analyses helps us to answer these key questions:

- What do we know about the watershed? (Assessment)
- What do we need to do to address identified issues? (Action)
- How do we carry out those actions? (Implementation)
  - Who, what, when, where and why?

one

The Process and the Plan

Walnut Creek WMA

- Board Meetings
- Executive Committee

Public Interaction

- Open House Events
- Stakeholder Meetings
- Individual Discussions

Plan Development

- Windshield Survey
- Stream Assessment Walks
- Quadcopter Video Collection
- Water Quality Monitoring

Boots on the Ground

- GIS Analysis
- Computer Modeling & Simulation

Desktop Assessments

In 2010, the State of Iowa passed legislation to allow local governments to form Watershed Management Authorities (WMA). "Authority" here is a term the legislature often uses when referencing a convening body. In reality, AWMA has no actual authority. Instead, it is a collection of jurisdictions within a given watershed, coming together to focus on water quality and quantity issues through collaboration and education. By law, WMAs cannot be formed without inviting all of the Soil and Water Conservation Districts, communities and counties within the designated watershed to the table. It only takes two such jurisdictions, joining together by 28E agreement, to actually form the WMA.

The "authority," however, continues to rest with the local governments. For all practical purposes, a WMA can only recommend that its member-governments take action—it cannot force that action.

The Walnut Creek WMA in Central Iowa formed in the context of this legislation, with the Metropolitan Planning Organization spearheading the formation of the WMA. In partnership with others, the MPO secured a grant from the Iowa Department of Natural Resources for the development of this plan. As of this writing, with the exception of Dallas County, all of the jurisdictions originally invited to join the WMA have done so.

In late 2014, the Walnut Creek WMA selected a consultant team led by RDG Planning & Design to complete analysis and develop content for the plan. Snyder & Associates (Ankeny, Iowa) was also a member of the consultant team completing flood modeling updates. The team included the Polk County Soil and Water District (SWCD) whose staff completed field assessments of stream conditions, mapped rural erosion factors and aided in communication and coordination with rural landowners and producers.

Process

Public Interaction

Public involvement and input from key stakeholders has been central to plan development. Each member organization was able to send representatives to the WMA Board which typically met monthly through 2015. An executive committee also met with the consultant team to discuss ongoing work and to prepare for material presentation to the larger board.

Two public open houses were held during the planning process. One was held at Colby Park in Windsor Heights in April 2015. That day started with a planning session in the morning at the community center at that location, followed by an open forum held near the outdoor amphitheater within the park. A brief presentation was made to the public, preceded and followed by times for open discussions and questions. Other activities included water quality sampling education, a build-your-own rain barrel workshop, canoe paddle art and short video presentations that showed conditions filmed along several key stream segments. Approximately 100 people attended the afternoon event.

The second open house was held at the meeting room at the Clive Aquatic Center in October 2015. This was held concurrently with an open house for the Clive Greenbelt Master Plan study. The Clive Greenbelt is a key feature and large area of publicly owned land along the main branch of Walnut Creek. Many of the issues related to improving conditions within the Walnut Creek Watershed have a direct bearing on the way the Clive Greenbelt is planned and managed. This pairing drew from a larger audience and provided a larger watershed context for those discussions.

The planning process also involved two separate meetings with local agricultural producers and landowners. These meetings, held at the Heartland Co-op in Dallas Center in May and December 2015, informed planners about some of the barriers to broader implementation of practices to improve water quality and slow runoff in the rural landscape. It also provided the opportunity to gage the local interest in investing in improvements and gave a broader understanding of the challenges within the watershed and their potential solutions. Feedback from the December 2015 meeting was directly used to develop a 10-year plan to make improvements within a 6.5-square-mile area in the upper part of the Walnut Creek Watershed.

Numeric Data Collection and Analysis

To complete this plan, numeric data was collected and analyzed for several key factors:

- Climate data from the Des Moines Airport Natural Weather Service Station, including temperature, precipitation and length of growing season. This information was used to determine recent and historic trends for these factors.
- Stream gage flow data from a USGS station located along Walnut Creek, including daily average flow rates and gage height (measure of stream depth). This was used to look at seasonal and historic trends and patterns of runoff, stream flow and flood events.
- Water quality monitoring data from the USGS, Iowa Soybean Association / Agriculture's Clean Water Alliance and IOWATER volunteer monitoring. This data included measured levels of various pollutants and stream conditions recorded over a long period of time. This information was important in identifying the key pollutants of concern, how their levels compare to state water quality standards and their potential sources within the watershed. This data was used in concert with the stream gage data (measured concentrations x measured flow volumes) to develop more accurate estimates of annual pollutant loads. This data was later used to calibrate mathematical water quality models to better reflect real-world observations.

Desktop Analysis

Geographic Information System (GIS) data was reviewed to identify important conditions throughout the watershed. Aerial photographs (past and present), topographic information, soils data and other available information was analyzed. Surface information was used to more precisely identify the overall boundary of the Walnut Creek Watershed and subdivide it into smaller subwatershed and microwatershed areas. The other data collected regarding soils, land uses, surface covers, buffer conditions and stream locations were categorized and sorted at these smaller scales.

Field Assessments

Conditions noted in desktop assessments were verified by observations in the field. These included:

- Windshield surveys—following along roadways and trails to photograph and note conditions across the watershed. These assessments are done rapidly, in less detail, in order to verify conditions across the entire watershed.
- Rural land use and crop rotation surveys—Polk County SWCD staff identified two-year crop rotation patterns (e.g., corn-soybeans, corn-corn, etc.), tillage practices and use of cover crops and other conservation practices.
- In-field stream assessments—two separate detailed assessments were included for data analysis:
  - Polk County SWCD completed field assessments of 28 miles of stream length using a handheld GPS collector and digital cameras to catalogue observed conditions along each stream corridor. These assessments were completed during the summer of 2015.
  - The City of Clive had their 2014 Stream Assessment Report completed by Nilles Associates. This project detailed conditions along 13 miles of streams within Clive's city limits and used protocols similar to the Polk County SWCD work.

Other stream assessments, conducted across the watershed, were reviewed by the consultant team. These studies were used to develop a general awareness of stream conditions. However, some of these assessments were older or used different protocols which made it difficult to directly compare the results of the two studies listed above.

Source: Polk County SWCD

Detailing the Plan

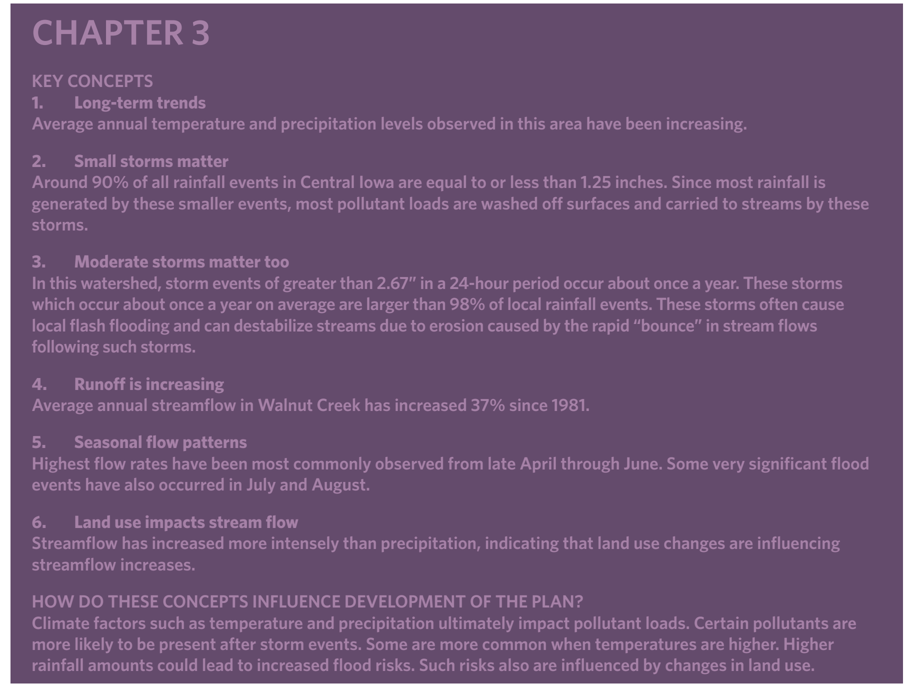
Information gathered through public interaction and data analysis has been developed into this plan. The plan is generally divided into three key parts:

- Assessment—Chapters 2–6:
  - What did we learn about the watershed?
- Action—Chapters 7–10:
  - What strategies, projects and policies are necessary to address the key concerns identified in the assessment?
- Implementation—Chapters 11–15:
  - How do we educate key stakeholders on what actions are necessary?
  - What is the timetable to complete improvements, adopt policies and monitor results?
  - What resources are needed to carry out the plan?
  - How should the plan be evaluated and adjusted to stay on track to meet project goals?
  - What options are there for the specific practices to address key watershed issues?

How to Use this Plan

This Watershed Plan can be viewed as a comprehensive effort, addressing a wide variety of issues. The discoveries of this plan need to be relayed to a variety of stakeholders with very different levels of awareness. Some findings are larger concepts and more general ideas. Other parts of the plan have to be more technical and detailed, to provide decision-makers with the level of information they need to support the findings of this plan, propose new policies and dedicate or acquire the financial resources to carry them out.

For this reason, each chapter features headers that highlight the most important concepts, both in outline and graphical forms. The content that follows in each chapter features graphs and sidebar discussions which highlight these key ideas. Each chapter also includes a more detailed explanation of these concepts, which is valuable to all, but may be more useful to implementers of the plan. Words that are **highlighted** throughout the plan are included in a glossary at the end of the report, to help explain more detailed concepts to a broader audience.



CHAPTER 3

KEY CONCEPTS

1. **Long-term trends**
Average annual temperature and precipitation levels observed in this area have been increasing.

2. **Small storms matter**
Around 90% of all rainfall events in Central Iowa are equal to or less than 1.25 inches. Since most rainfall is generated by these smaller events, most pollutant loads are washed off surfaces and carried to streams by these storms.

3. **Moderate storms matter too**
In this watershed, storm events of greater than 2.67" in a 24-hour period occur about once a year. These storms which occur about once a year on average are larger than 98% of local rainfall events. These storms often cause local flash flooding and can destabilize streams due to erosion caused by the rapid "bounce" in stream flows following such storms.

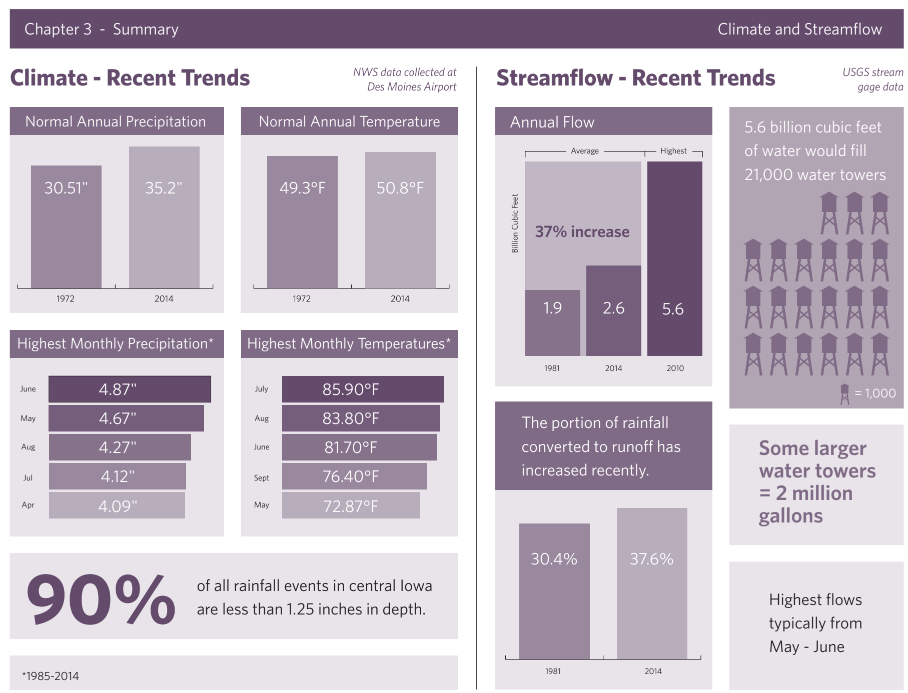
4. **Runoff is increasing**
Average annual streamflow in Walnut Creek has increased 37% since 1981.

5. **Seasonal flow patterns**
Highest flow rates have been most commonly observed from late April through June. Some very significant flood events have also occurred in July and August.

6. **Land use impacts stream flow**
Streamflow has increased more intensely than precipitation, indicating that land use changes are influencing streamflow increases.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?
Climate factors such as temperature and precipitation ultimately impact pollutant loads. Certain pollutants are more likely to be present after storm events. Some are more common when temperatures are higher. Higher rainfall amounts could lead to increased flood risks. Such risks also are influenced by changes in land use.

Header page



Summary page

The Grand Overview		
Chapter	**Title**	**Description**
Assessment		
2	Watershed Geography	Information about the overall character of the watershed, including soils, terrain, slopes and changes in land use.
3	Climate and Streamflow	Analysis of trends in temperature, precipitation, stream flow and flooding. These conditions have a direct impact on the challenges facing this watershed and the measures necessary to address them.
4	Background	This plan isn't the first study related to the Walnut Creek Watershed. A few past studies that influenced the development of this plan are reviewed here. These studies demonstrate what issues have already been identified within this watershed and how this area relates to other areas downstream.
5	Character of Streams	Stream conditions such as stream stability, character and buffer conditions are discussed in detail.
6	Key Pollutant and Sources	Available water quality monitoring information (pollutant levels) is reviewed and compared to water quality standards. The key pollutants of concern are identified. The results of computer water quality simulations are listed, including annual pollutant loads and identification of their sources (by location and land use).
Action		
7	Strategic Framework	The vision, mission and goals of this plan are outlined here.
8	Case Study: Subwatershed Strategic Plan	Three case study subwatersheds were selected that represent conditions of larger areas of the watershed. Each area is an example of a different land use: rural, urban and developing. These areas were studied in greater detail and unique plans developed for each. These plans are to be carried out over a ten-year period, focusing a greater amount of work in a smaller area. This allows water quality changes to be observed more quickly and the lessons learned can be implemented more broadly across the entire watershed.
9	Policy Recom-mendations	Local policies and procedures have a direct effect on implementation. Some changes can be made with voluntary efforts with committed resources. In other cases, local regulations may need to be changed to effect desired outcomes.
10	Projects and Priorities	This chapter lists projects recommended across the watershed, including those which are focused in the case study areas. A preliminary cost projection for each project is given.
Chapter	**Title**	**Description**
Implementation		
11	Education and Collaboration Plan	Educating the public, stakeholders and decision makers is essential to the success of this plan. This chapter reviews how to get these groups to understand this plan and how they can work together to carry it out.
12	Measures and Milestones	This chapter addresses these questions: • What is the proposed timeline to implement projects and policy changes? How is progress evaluated? • How do we monitor for improvements in water quality and share data with other groups? • How is progress to be reported back to the board and the public at large?
13	Resource Requirements	Resources are required to execute this plan. This chapter outlines the financial commitments required for coordination, project construction, maintenance and monitoring. It also details some potential methods to fund these needs.
14	Evaluation and Amendments	To be effective, this plan needs to be a "living document," adapted based on lessons learned and changing conditions as the plan is implemented. These conditions need to be regularly evaluated so that regular corrections can be made to the plan to keep it on course.
15	Best Managment Practices (BMP) Toolkit	This chapter gives a brief review of the different types of practices that can be used in both the rural and urban environments. Each practice has a brief description and most have directions on where to find more detailed information.
	Glossary	Over 150 key terms and abbreviations are defined here to make this document easier to understand by a broader audience.

The Next Steps

Since watershed management authorities are "authorities without authority," this plan is dependent on a variety of local communities, stakeholders and property owners to carry it out. Upon approval of the plan by the WMA Board, each community may take action to adopt the plan. Each city will need to review their ordinances and policies to determine what changes are needed to carry out the recommendations of this plan. Projects will need to be incorporated into city budgets or alternative sources of funding (grants, etc.) pursued. Ongoing resources and staff will need to be committed to carrying out water quality monitoring and the education and collaboration plan. Most of all, this plan needs champions—devoted local advocates that are committed to making sure that it is carried to its conclusion.

This plan outlines a ten-year process to initiate progress to improving water quality and watershed health. Land uses and other conditions within the watershed are rapidly changing. For this reason, it is difficult to accurately predict conditions that will need to be addressed for a longer period of time. At the end of a ten-year period, this planning effort should be recommissioned by the WMA Board in some fashion, to evaluate results, lessons learned and changed conditions. At that time the path forward for the next ten or twenty years should be set.

The conditions detailed in this plan have developed over a period of more than 150 years. It will certainly take several decades to make enough improvements to meet water quality goals for the entire watershed. The commitment of resources set forth in the plan may be daunting. However, a decision to not commit to these efforts will result in further deterioration in water quality, streambank instability and a potential for greater flood impacts in the future. Not addressing these issues will assuredly lead to greater costs in the future.

Source: Polk County SWCD

Source: Polk County SWCD

CHAPTER 2

KEY CONCEPTS

1. **What is the watershed?**
   The Walnut Creek Watershed is the 83-square-mile area in Central Iowa that drains toward Walnut Creek either by direct flow or through tributary streams, ditches, subsurface tiles and storm sewers.

2. **Soil characteristics**
   The properties of soils within the watershed influence how much rainfall is absorbed by the landscape and how much direct stormwater runoff is created during rain events.

3. **Terrain and topography**
   Areas with steeper slope may be more prone to erosion, instability and often will direct surface runoff more quickly toward receiving streams.

4. **Land use changes**
   This watershed is one of the most rapidly developing in the state. Currently urban and rural land uses are nearly evenly split. In a recent ten-year period, over 4,200 acres (6.6 square miles) was developed into suburban landscapes.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

The characteristics of this watershed have changed significantly over time. Reviewing past, present and expected future conditions allows critical areas and influential properties to be identified. Such factors affect stormwater runoff patterns, are indicators of potential pollution sources and can highlight other factors which could have a negative impact on water quality or stream stability.

two

Watershed Geography

Local Topography & Terrain

82.8
square miles

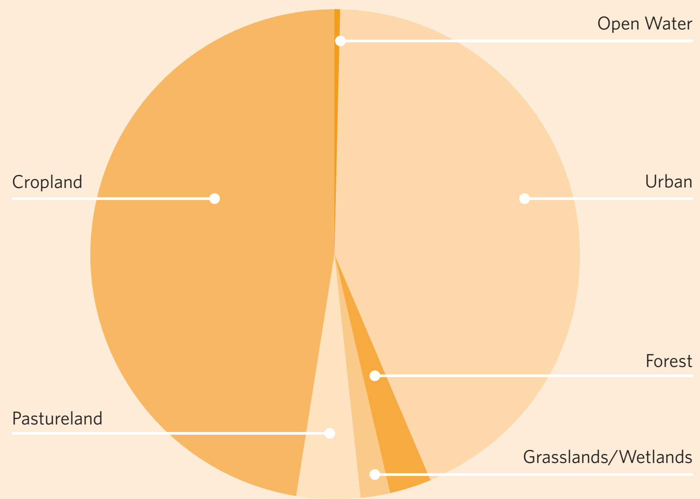
The area of land draining through Walnut Creek and its tributaries to the Raccoon River

53,000
acres

Past & Current Land Uses

During a recent 10-year period, 6.7 square miles were developed into urban land use.

Currently, the watershed is nearly evenly split between urban and agricultural land uses.



Soil Conditions

There are many types of soils within the watershed. We need to understand their properties, such as their ability to absorb water and resist erosion, in order to develop an effective plan.

Location and Geography

A **watershed** is an area of land that drains to a common point. The Walnut Creek watershed covers approximately 53,000 acres (82.8 square miles) across eastern Dallas and western Polk Counties. Its most western **source** falls within the community of Dallas Center. The footprint of the watershed extends across eight communities and other unincorporated areas within each county. Walnut Creek drains generally from northwest to southeast, meeting the Raccoon River northwest of Water Works Park in Des Moines, upstream of the water intake to the Des Moines Water Works plant.

The Raccoon River drains into the Des Moines River in downtown Des Moines. The Des Moines River then flows generally southeast, first through Red Rock Lake in Marion County, then on to the Mississippi River at Keokuk. The Mississippi River flows south, ultimately reaching the Gulf of Mexico in Louisiana.

Political Jurisdictions within the Walnut Creek Watershed	
Clive	Dallas Center
Des Moines	Grimes
Johnston	Urbandale
Waukee	West Des Moines
Dallas County	**Polk County**

In 2010, Iowa lawmakers authorized forming Watershed Management Authorities. A Watershed Management Authority (WMA) is a mechanism for cities, counties, Soil and Water Conservation Districts (SWCDs) and stakeholders to cooperatively engage in watershed planning and management.

What is a WMA?
The WMA is formed by an agreement (Chapter 28E) between two or more eligible political subdivisions within a specific watershed. A board of directors governs the WMA. *WMAs may:*

- Assess and reduce flood risk
- Assess and improve water quality
- Monitor federal flood risk planning and activities
- Educate residents of the watershed regarding flood risks and water quality
- Allocate moneys made available to the WMA for water quality and flood mitigation

Requirements of a WMA include:
per Iowa Code Chapter 466B Subchapter II

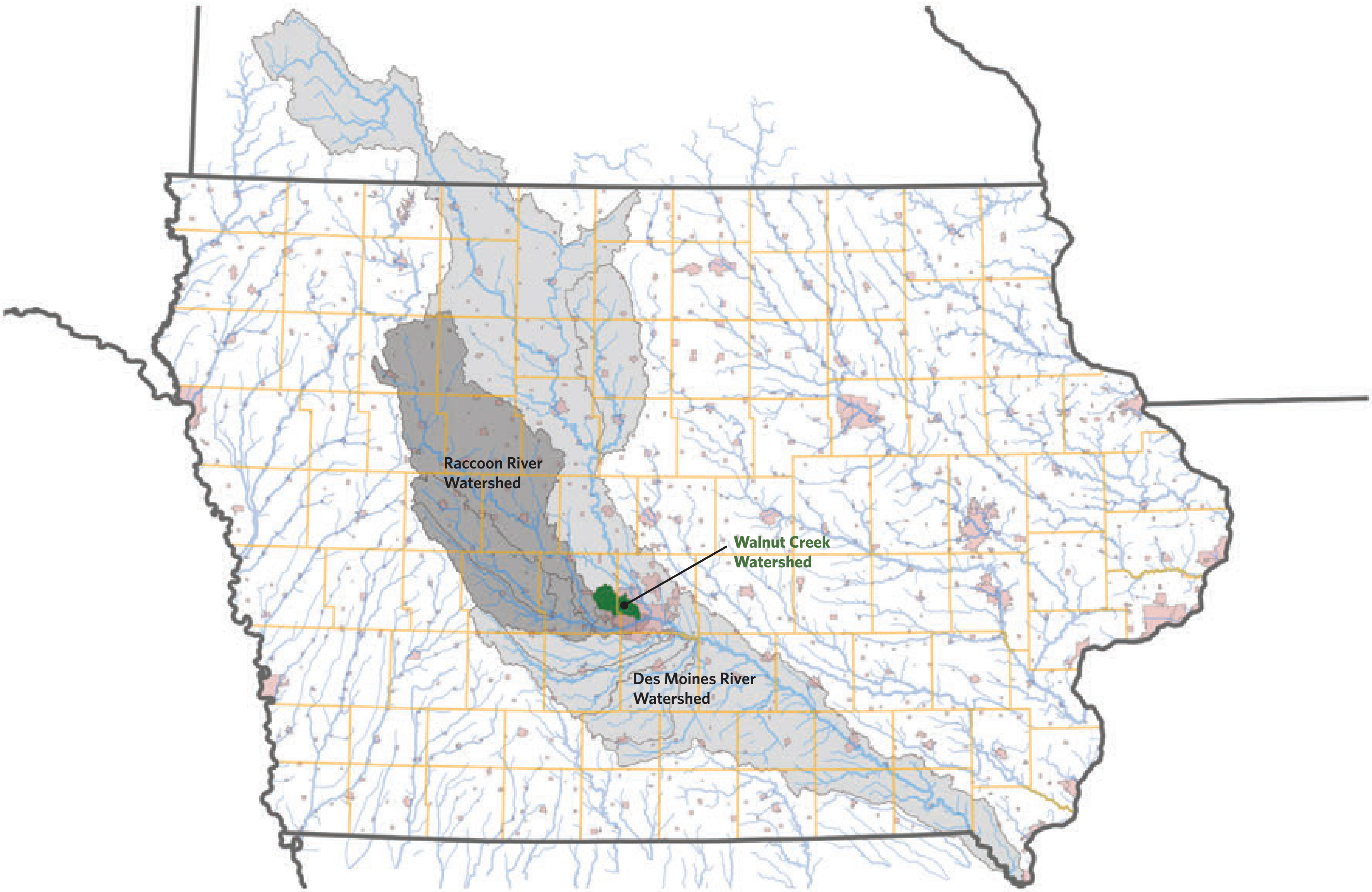
- All cities, counties and SWCDs of the watershed must be invited to participate in the WMA
- A Chapter 28E agreement that includes a map of the watershed must be filed with the Secretary of State
- Must be governed by a Board of Directors
- WMAs may not acquire land through eminent domain and do not have taxing authority

Benefits of forming a WMA:

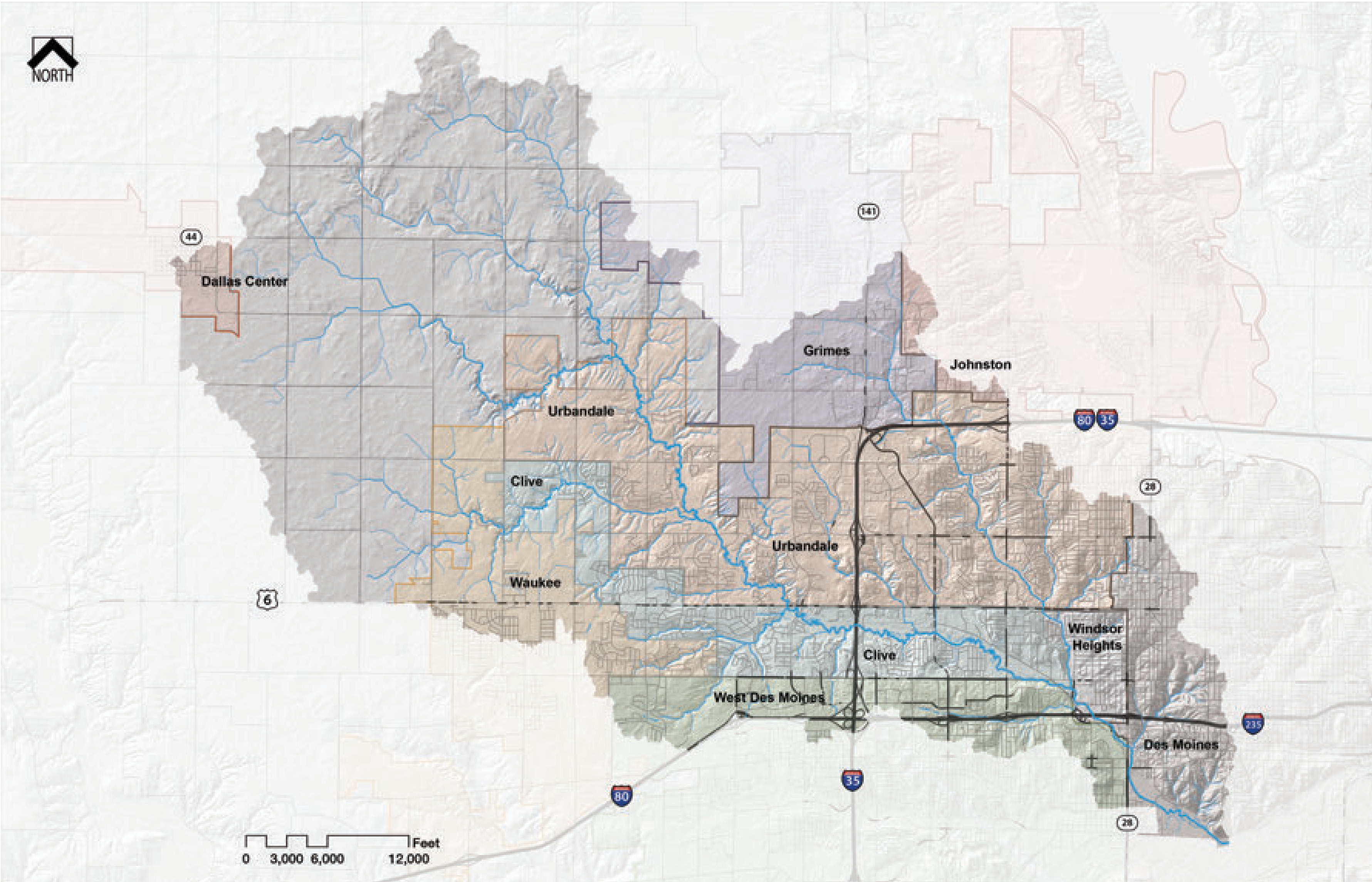
- To conduct planning on a watershed scale, which has greater benefits for water quality improvement and flood risk reduction
- To foster partnerships and cooperation
- To leverage resources such as funding and technical expertise
- To facilitate stakeholder involvement in watershed management

Information about forming a WMA:
Available on the Iowa Department of Natural Resources website at http://www.iowadnr.gov/Environment/WaterQuality/WatershedManagementAuthorities.aspx. *This website includes:*

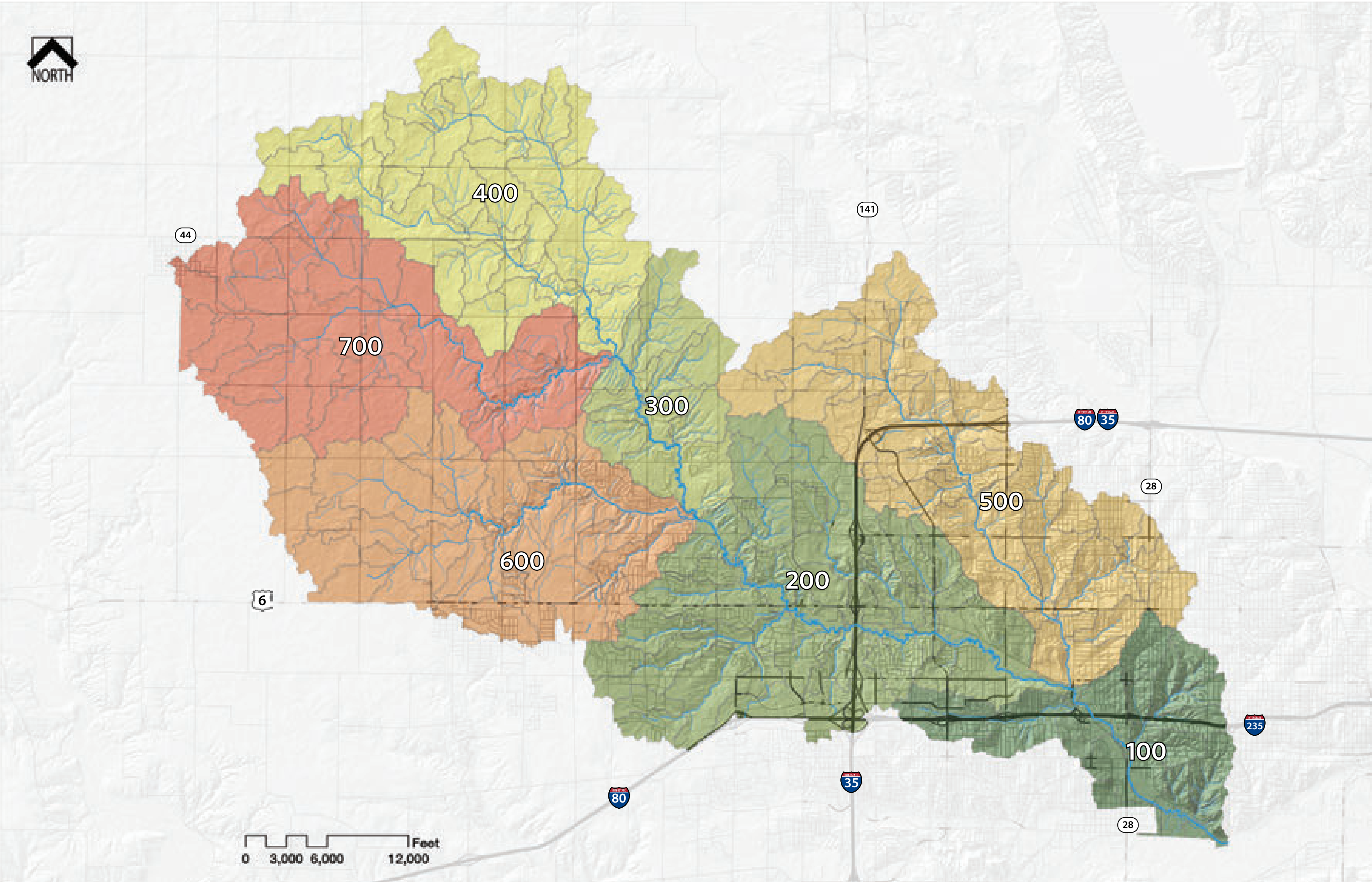
- A complete listing of existing WMAs in Iowa
- Example agreements and by-laws
- More information on setting up a WMA
- Contacts for technical assistance



Watershed Locations



Overall Watershed



Subtributaries

The Tributaries of Walnut Creek

Dozens of smaller streams and three major **tributaries** feed into Walnut Creek. North Walnut Creek runs generally from north to south, draining parts of Grimes, Johnston, Urbandale, Des Moines, Clive and Windsor Heights. South Walnut Creek is more commonly known as the stream which passes through Country Club Lake in Clive. This stream drains primarily southwest to northeast, collecting runoff from portions of West Des Moines and Waukee in addition to Clive. Little Walnut Creek generally flows from west to east, beginning in rural Dallas County and flowing through rapidly developing portions of Waukee, Clive and Urbandale.

Subwatershed Name	Number *	Area (acres) **	Area (square miles)
Lower Walnut Creek	100	4240	6.6
Walnut Creek	200	10830	16.9
Upper Walnut Creek	300	3170	5.0
Eastern Headwaters Walnut Creek	400	8330	13.0
North Walnut Creek	500	9150	14.3
Little Walnut Creek	600	8630	13.5
Western Headwaters Walnut Creek	700	8480	13.3
Total		**52830**	**82.5**

** This column represents a "tributary number." See page 54*
*** Rounded to nearest 10 acres*

This table shows the area draining to the key segments of Walnut Creek and its major tributaries.

Topography and Terrain

There are two distinct types of land forms within this watershed. The upland parts of the watershed are generally flat, featuring meandering flow paths and low spots. These features are what remains of the prairie **pothole wetlands** formed by the **Des Moines Lobe** of the **Wisconsin Glacier** (1). These pothole wetlands were drained after pioneer settlement to improve agricultural production. This was accomplished through installation of subsurface tile drains and engineered ditches during the last half of the 1800s and the early 1900s. Many of the smaller streams which exist today did not exist before this landscape was altered.

The **topography** in the lower parts of the watershed becomes steeper, with many more hills and valleys. The surface of these areas was shaped by large scale erosion caused by the melting of the Wisconsin glacier. Surface slopes in excess of 5% are typical, with slopes greater than 9% scattered throughout this part of the watershed. These areas are also within the historical footprint of the Des Moines Lobe. Its southern edge fell just north of where Walnut Creek flows into the Raccoon River.

Soils

There are many properties of soils that have a significant impact on the **quality** and **quantity** of stormwater runoff. Three of the key properties are **hydrologic soil group, hydric conditions** and **soil erodibility.** These properties are catalogued in various **GIS datasets** that are available for review and use.

Hydrologic Soil Group

The ability of water to move into and through the ground is different with every soil. Soils with more clay tend to be less **permeable**. Very little water can enter the surface of a clayey soil, and the water that does enter takes a long time to move through that soil. In contrast, sandy soils allow water to enter and move very freely. Soil properties like these influence how much surface runoff will be generated from open spaces when it rains. Different soils are classified into different hydrologic soil groups, on a scale from "A" to "D." Group "A" soils allow water to infiltrate into the soil and percolate through the soil very easily. These soils have a higher sand content and will absorb more rainfall, causing less runoff to be developed. Group "D" soils include clays and other soils that inhibit the free movement of water.

	Hydrologic Soil Group Properties			
	A	B	C	D
	Least Runoff Potential			Most Runoff Potential
Infiltration Rate (inches/hr)	> 2	0.5-2.0	0.14-0.5	<0.14

Source: USDA Web Soil Survey website.

Soil Compaction/Topsoil Removal

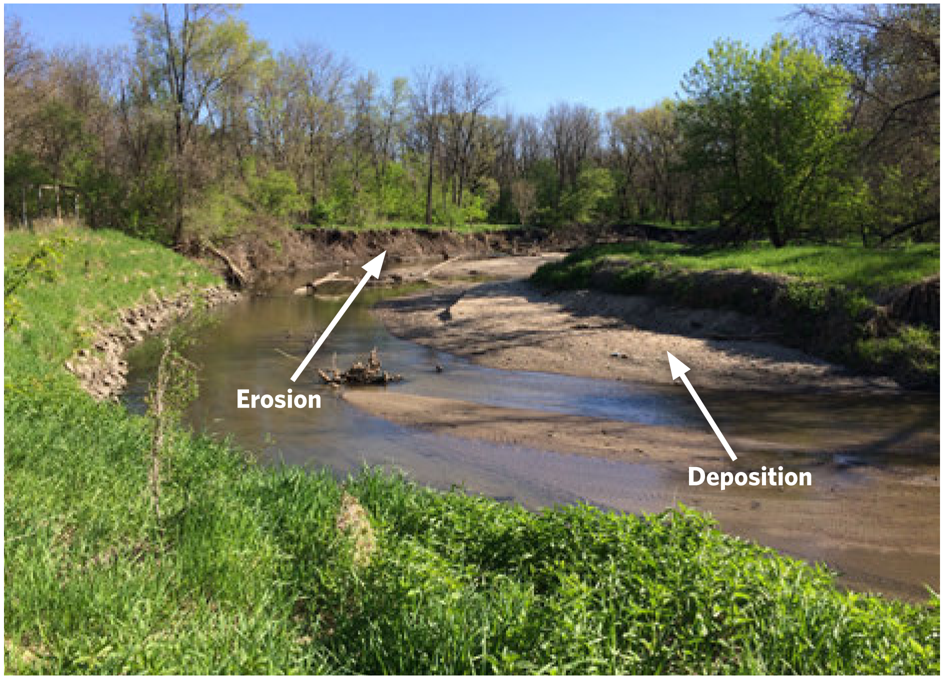
County soil maps typically designate soil groups for rural landscapes. When land uses change from rural to urban, the ability to infiltrate and store water by the soil is impacted by the removal of topsoil materials and compaction of subsoils by heavy equipment. This typically results in additional stormwater runoff after development, unless techniques are applied which restore these soil functions.

Source:
1. IDNR Website. taken from Iowa Wildlife Action Plan

STABLE: A moderately stable section of Lower Walnut Creek.

STABLE: This section of Walnut Creek is fairly stable, although a steep slope is close to a trail.

UNSTABLE: A section of Lower Walnut Creek with erosion along the outside bend and deposition inside.



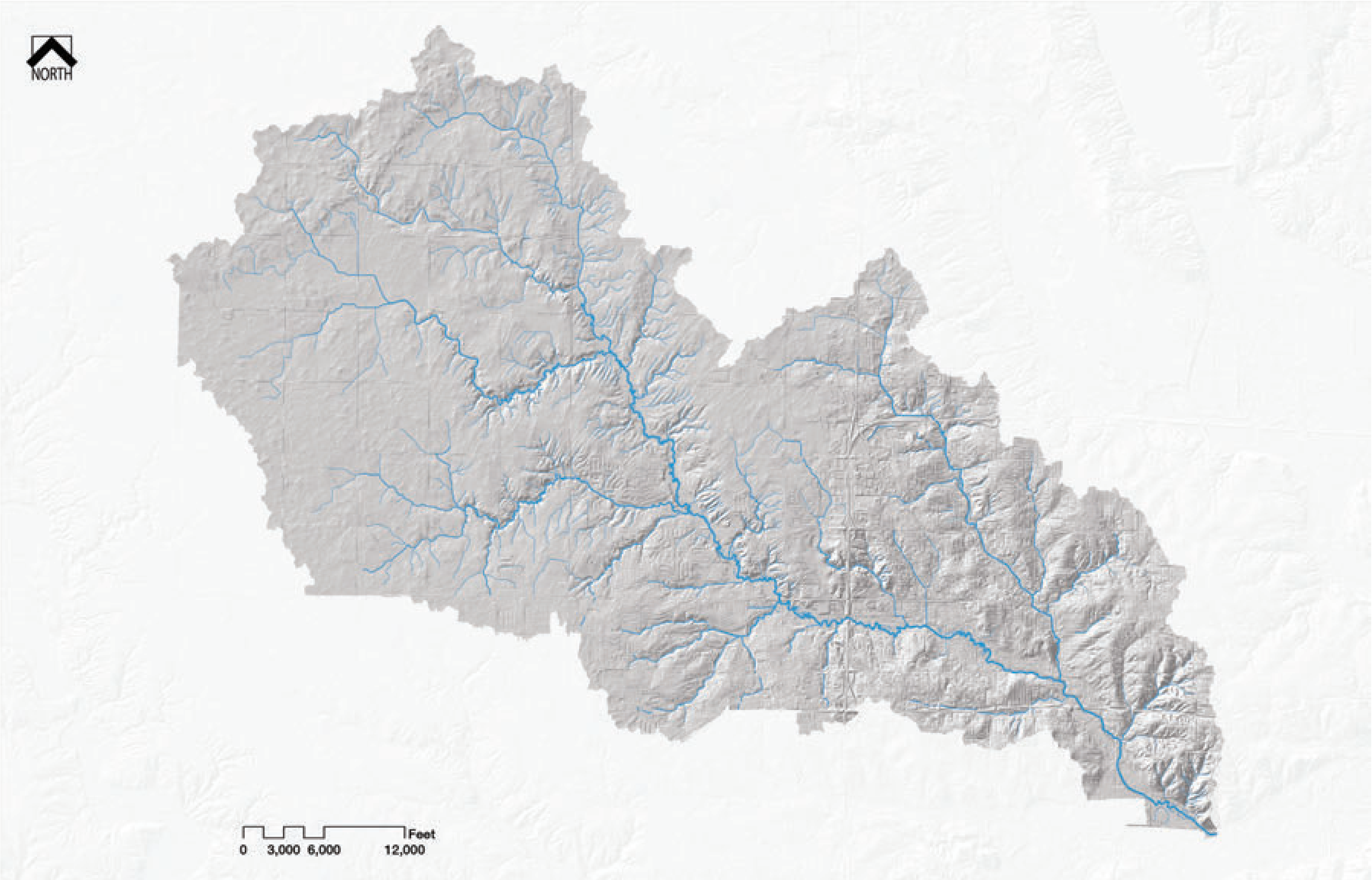
UNSTABLE: Rapid erosion occurring along Upper Walnut Creek.

STABLE: This section of North Walnut Creek is currently well protected from erosion.

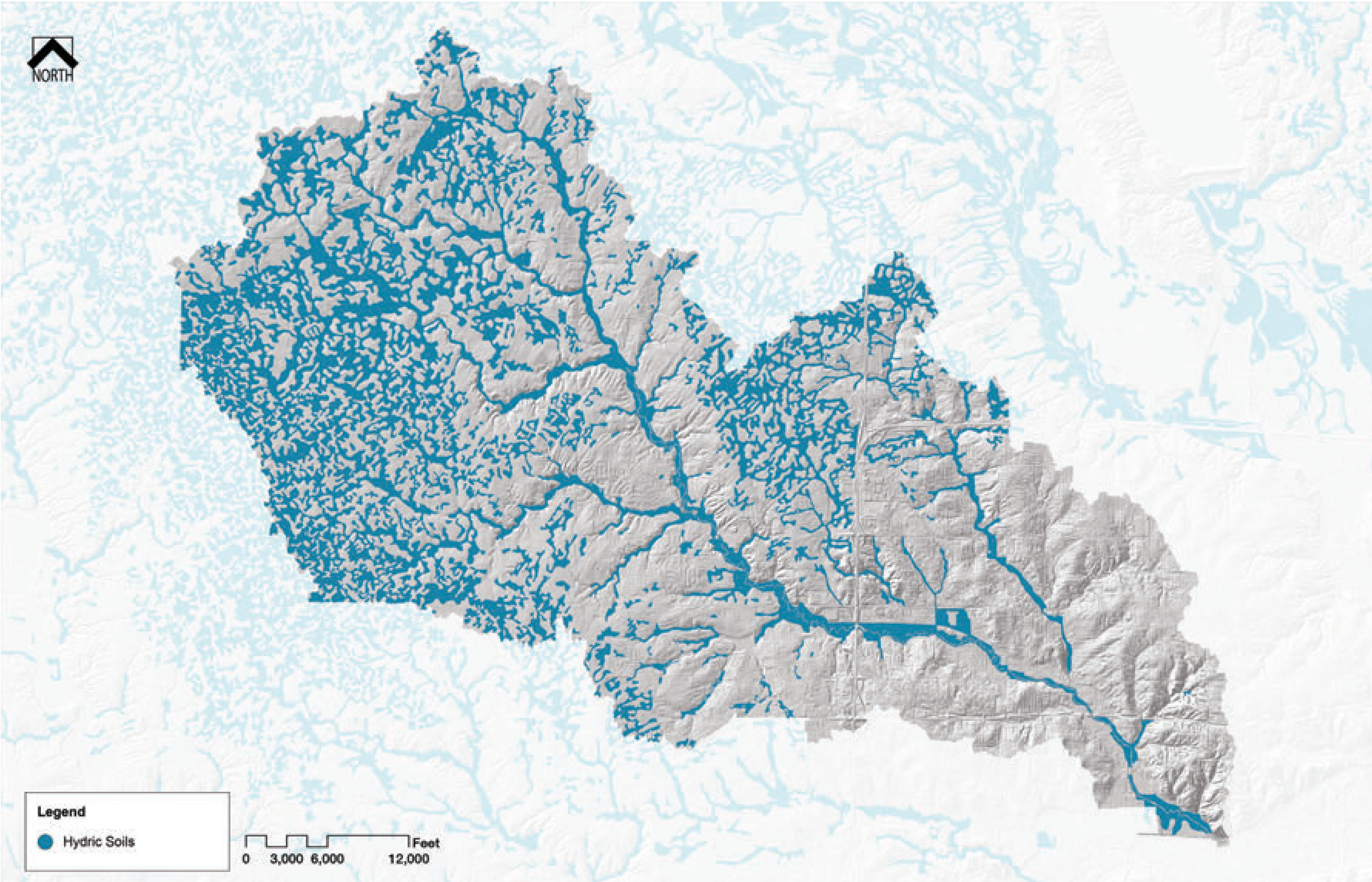
STABLE: Little Walnut Creek, in a stable rural section.

UNSTABLE: This part of North Walnut Creek is downcutting with bank erosion.

UNSTABLE: A moderately unstable part of Little Walnut Creek.

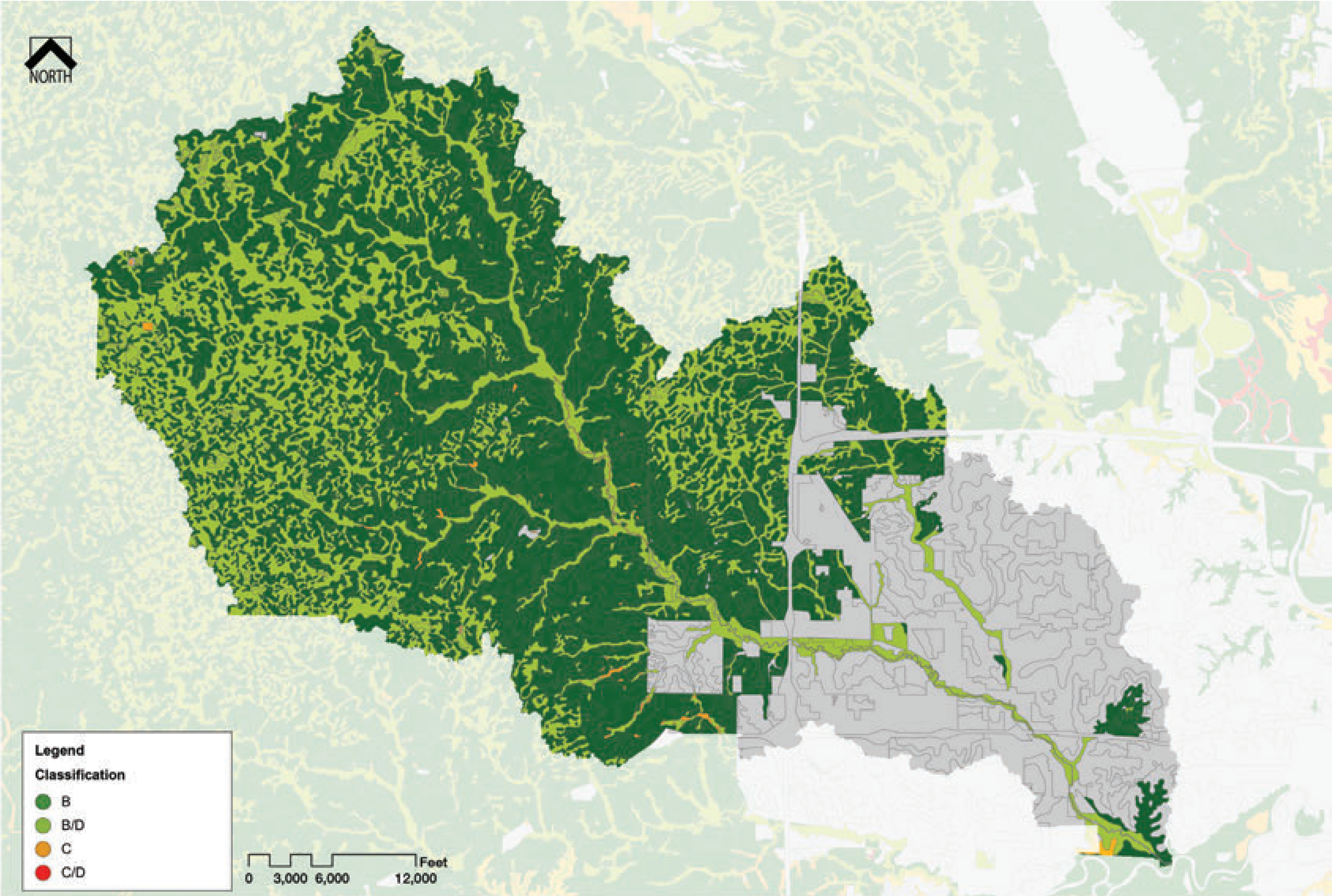


LIdar Topography DEM



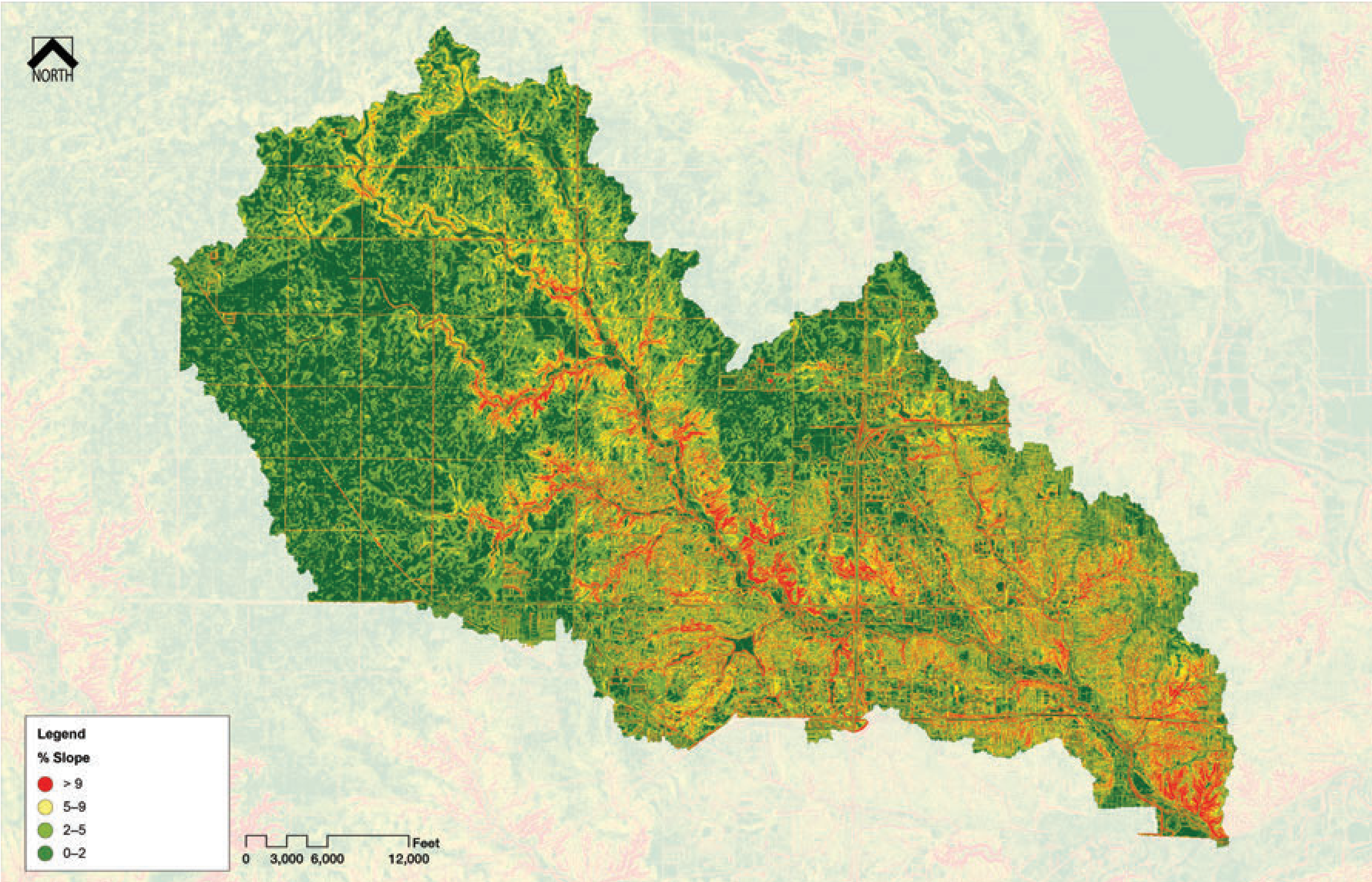
Source: USDA Web Soil Survey website.

Hydric Soils



Source: USDA Web Soil Survey website.

Soil Group



Source: Analysis by RDG from data by USDA Web Soil Survey website.

Slope Map

Hydric Soils

The presence of **hydric soils** indicates wetlands are present or were in the past. Finding these soils highlights opportunities to protect or restore wetland features. Wetlands capture and filter runoff, improving water quality and reducing its volume.

Soil Erosion Prediction Factors

The erosion potential for soils has been classified on county soil maps. These maps identify a number, or coefficient, which can be input into the **Revised Universal Soil Loss Equation (RUSLE)**. This equation was developed by the USDA to predict erosion rates from landscapes (not including streambank or gully erosion). This coefficient changes with soil type and surface slope. This coefficient is a decimal value between 0 and 1. It is one factor that predicts how much soil would be expected to be washed off the surface of a given area. The RUSLE formula also includes factors that vary based on the length and steepness of a given slope, and other surface conditions.

Slopes

The change in surface elevation over a given length has many impacts. Longer and steeper slopes have greater potential for erosion. Steeper slopes also lead to faster runoff velocities. This decreases the time it takes for water to reach a receiving stream, resulting in a larger pulse of water (or peak flow rate) reaching a given point.

As runoff rates increase, steeper streams may be vulnerable to incision, or downcutting of the stream bottom. As downcutting continues, the stream bottom will flatten and sideslopes will cave in, widening the stream until a point is reached where the stream can convey the larger runoff volumes and rates at a velocity that causes less erosion. Surrounding steep slope areas can also become unstable, sloughing or sliding—especially during extended periods of wet weather. (Refer to Chapter 5 of the plan for details about streambank stability.)

The Native Landscape

The Walnut Creek watershed was a much different place when initial land surveys were performed in the mid-1800s. Much of the landscape was covered by tallgrass prairie. Grasses and wildflowers, reaching eight feet in height, would have stretched to the horizon in every direction. The deep roots of these plants (some up to 15 feet below the surface) combined with worms and burrowing animals to create several feet of the loose, fertile, porous black topsoil that Iowa is known for. These soils allowed nearly all of the rainfall that fell on the landscape to soak into the ground through infiltration. Most streams were formed from natural groundwater outflows or springs. Prairie lands were kept largely clear of trees and shrubs by regularly occurring grass fires, limiting the opportunity for less fire tolerant species to flourish.

The prairie pothole landscape featured a largely flat surface with depressed areas. These pothole areas usually featured wetlands fed by natural springs. Runoff from very large storms would collect in these areas until it either evaporated, infiltrated or overflowed into an adjacent depressed area or receiving stream.

Source: sweetlightgallery.com, Flint Hills Tallgrass Prairie Preserve, Kansas

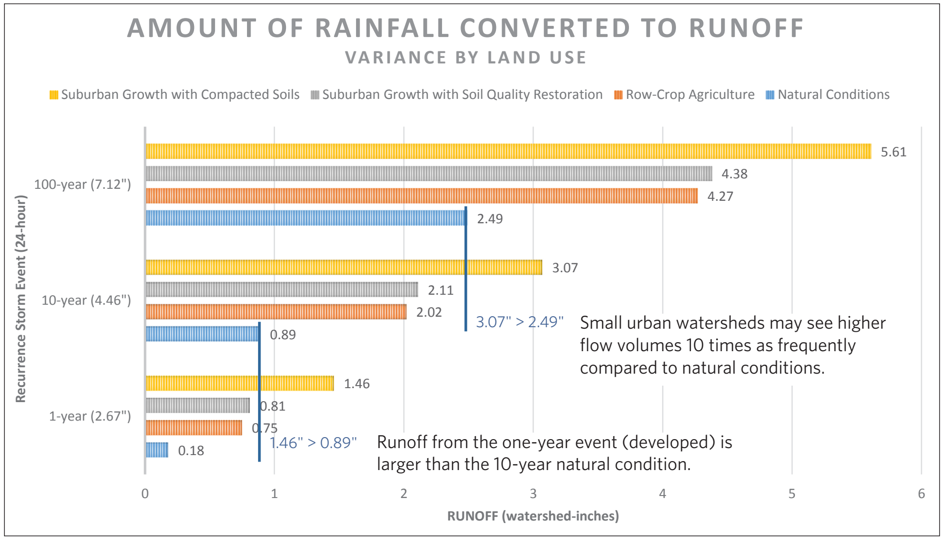
Savannas would have covered the remainder of the landscape, usually along the larger streams and hills in the southeastern part of the watershed. These savannas would have also been quite different from the woodlands that are familiar to us today. Savannas lacked much of the **understory** brush and **invasive species** that currently make many of our forested lands difficult to walk through. Many of the current invasive species did not arrive within the watershed until the early 20th century, brought over from Europe and Asia. The lack of understory growth allowed more sunlight in to the floor of the forest, supporting shade tolerant native plants. The presence of these deeper rooted plants would have made the surface below the **canopy** significantly more resistant to erosion than what exists today.

Source: Greg Pierce

Pioneer Settlement and Agriculture

The deep, fertile soils created by the prairie supported agricultural development. During the late 1800s and early 1900s, drainage projects installed tiles and ditches allowing the pothole wetlands to be dried out and farmed. The draining of wetlands, removal of vegetation and soil compaction by use of heavy farm equipment reduced infiltration and increased **runoff volume**. As a result, a larger portion of rainfall was transported to streams by surface or tile flow. Installation of tiles, culverts and ditches allow this larger volume of water to flow downstream more quickly. Water was allowed to rush downstream, with larger portions arriving at given points downstream at nearly the same time. Shortening the travel time for water flow allows a larger portion of the runoff to arrive at a given point at nearly the same time, making the **rate of runoff** increase even more dramatically than the runoff volume.

Today, virtually all native prairie is gone from the watershed. Grass swales and buffers need maintenance through controlled burns, mowing or grazing to keep out tree growth. Without this maintenance, forested areas along waterways and ravines have become crowded with invasive species and underbrush. This shades out the native erosion-resistant ground cover. Many of these areas have experienced significant soil erosion from surfaces and stream channels.



Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see Chapter 8 and appendix resources).

Recent Land Use Change

This watershed includes some of the most rapidly growing urban areas in the state. Aerial photos from the 1930's and 1950's show a watershed with limited urban growth primarily within the far eastern (downstream) parts of the watershed. Shortly thereafter, development of the interstate system including I-235 and I-35/80 facilitated westward expansion of the metro area.

During the 1990's urban growth began to significantly push past the I-35/80 corridor. Over the following decades, the communities of West Des Moines, Clive, Urbandale and Waukee saw significant growth in the western part of the watershed. More recently, the communities of Grimes and Johnston have seen more rapid growth in the North Walnut Creek basin.

During the period between 2001 and 2011, eight percent of the watershed developed into urban land uses. This included nearly 4,300 acres of land, or about 6.7 square miles. This period included both times of intense economic growth as well as the 2–3-year recession period late in the first decade of the 21st century. As of 2011, urban land uses covered 43% of the Walnut Creek watershed.

Between 2001 and 2011, 8.1% of the watershed developed into urban uses. The landscape is nearly evenly split between cropland and urban areas.

Almost seven square miles of land was developed between 2001 and 2011.

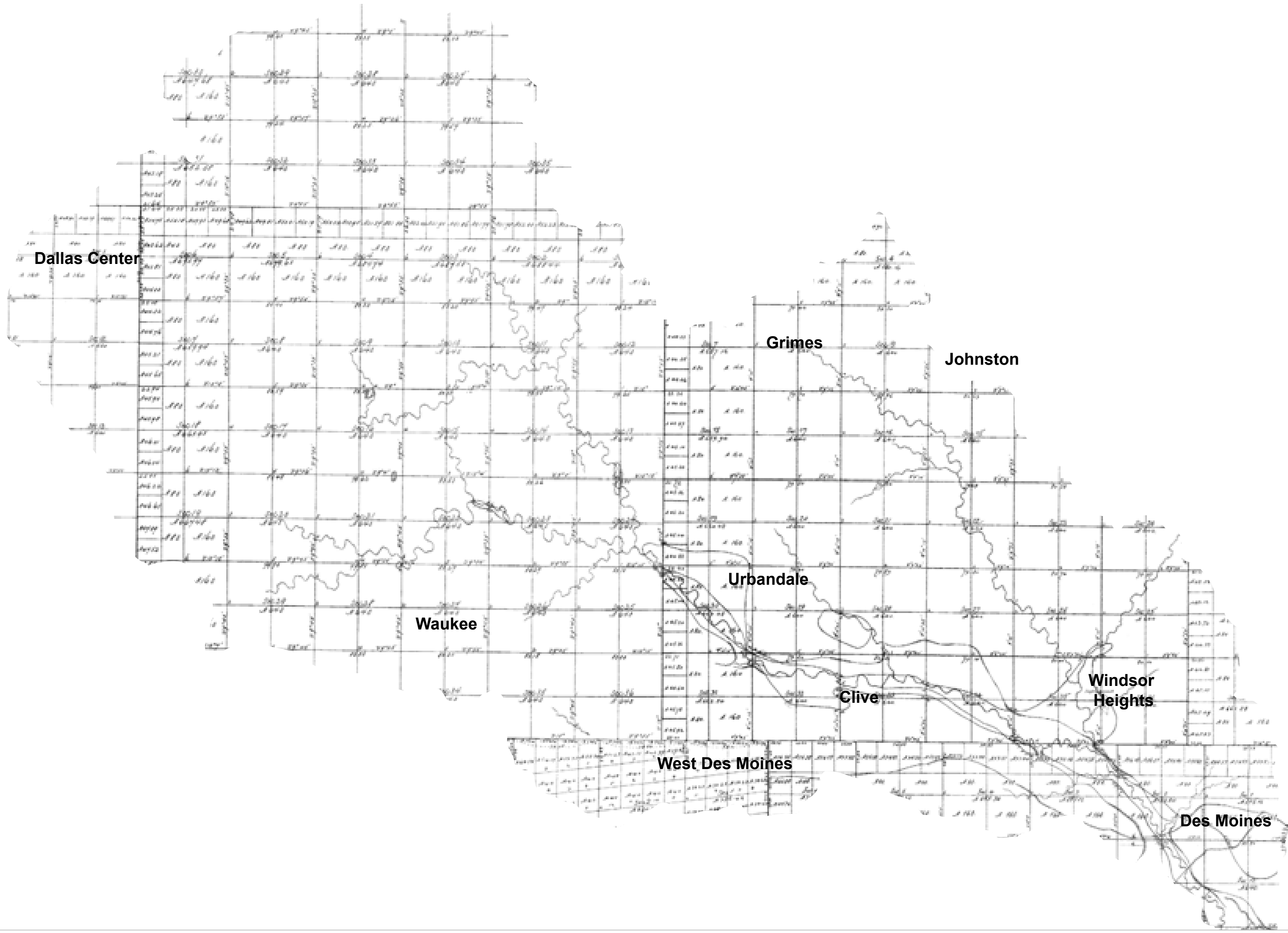
Land Use	2001		2011		2001-11
	area (in acres)	% of watershed	area (in acres)	% of watershed	% change
Open Water	146	0.3%	147	0.3%	0.0%
Urban	18663	35.3%	22936	43.4%	8.1%
Forest	1650	3.1%	1446	2.7%	-0.4%
Grasslands /Wetlands	1209	2.3%	1135	2.1%	-0.1%
Pastureland	3530	6.7%	2147	4.1%	-2.6%
Cropland	27626	52.3%	25013	47.4%	-4.9%
Total	**52825**		**52825**		

Source: National Landcover Dataset (USGS) – 2001 and 2011.

These photos show the rapid urban growth that occurred within a part of the watershed between 2002 and 2014.

2002 CIR Aerial

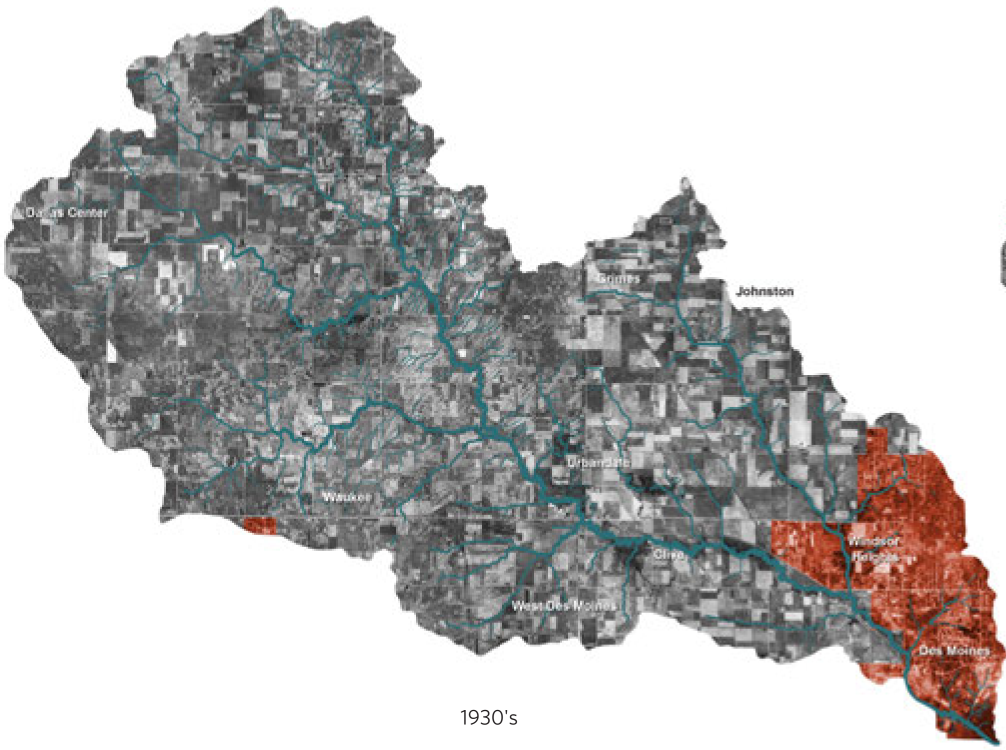
2014 CIR Aerial (same area)



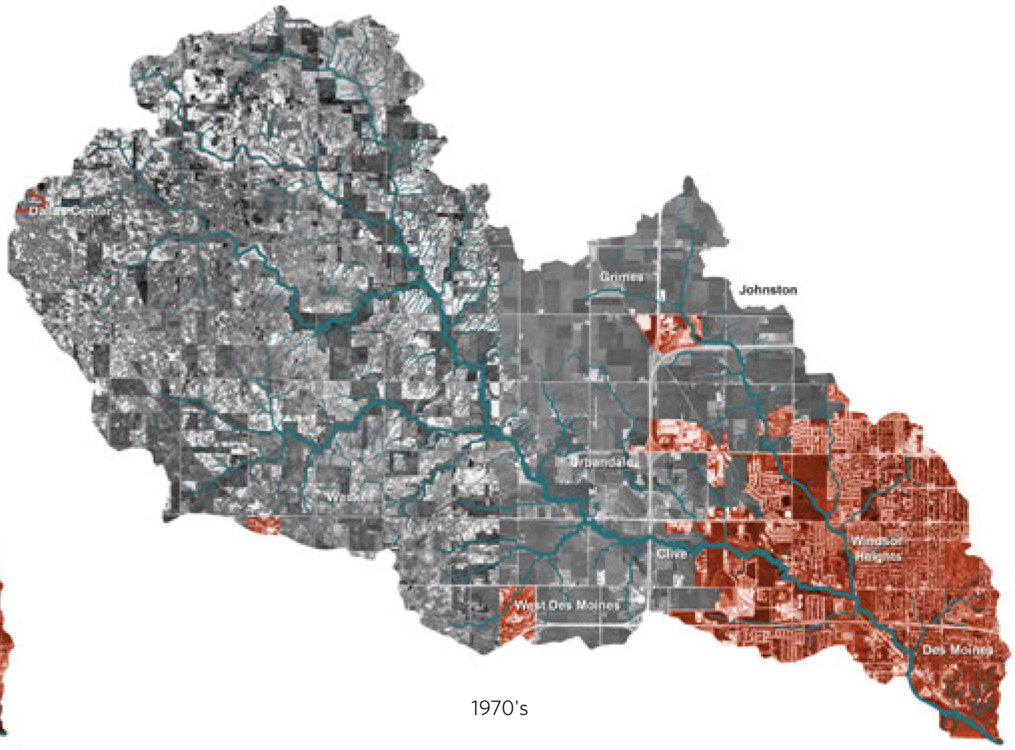
Mid-1800's

Source: Iowa Geographic Map Server website

Landscape Change



1930's

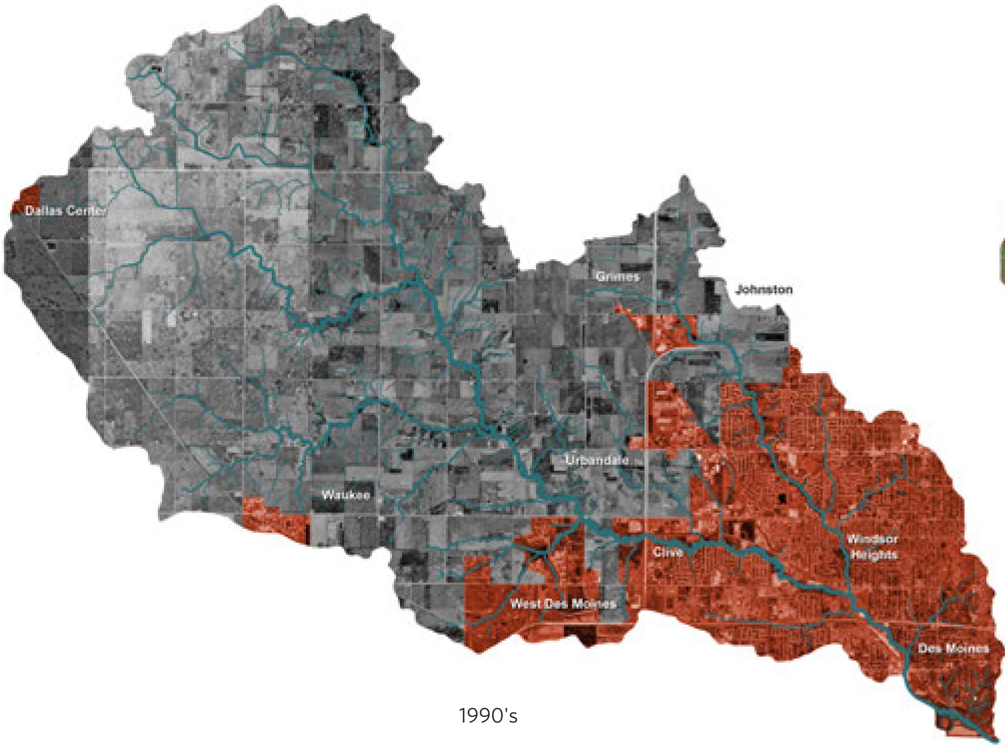


1970's

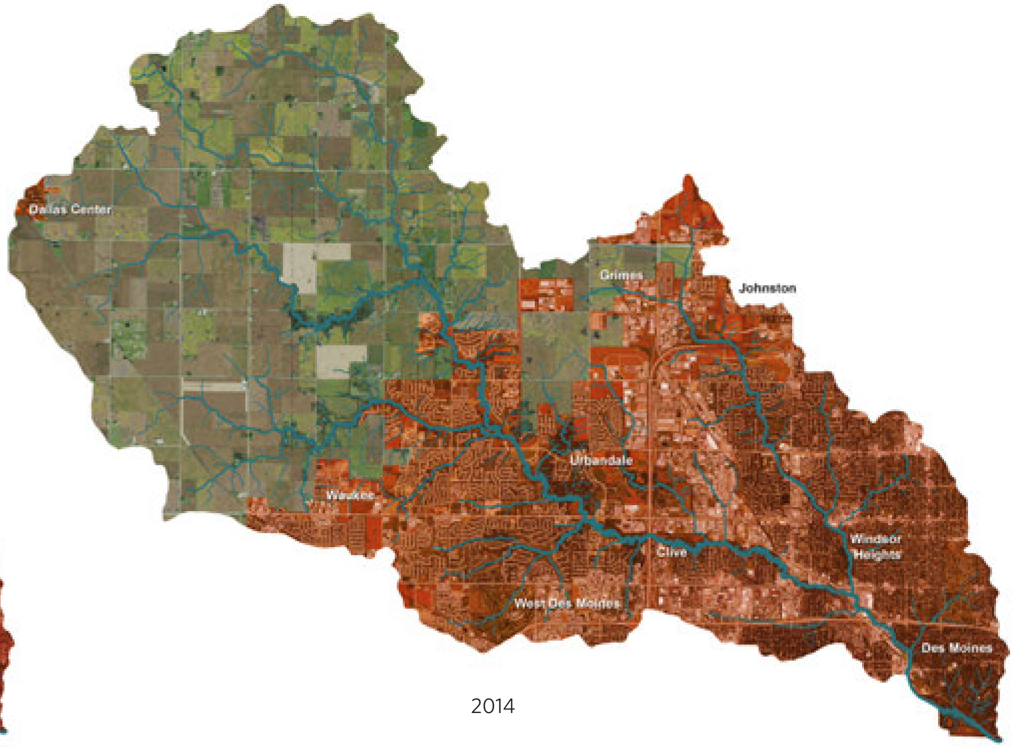
Urbanized area

Source: Iowa Geographic Map Server website

Landscape Change



1990's

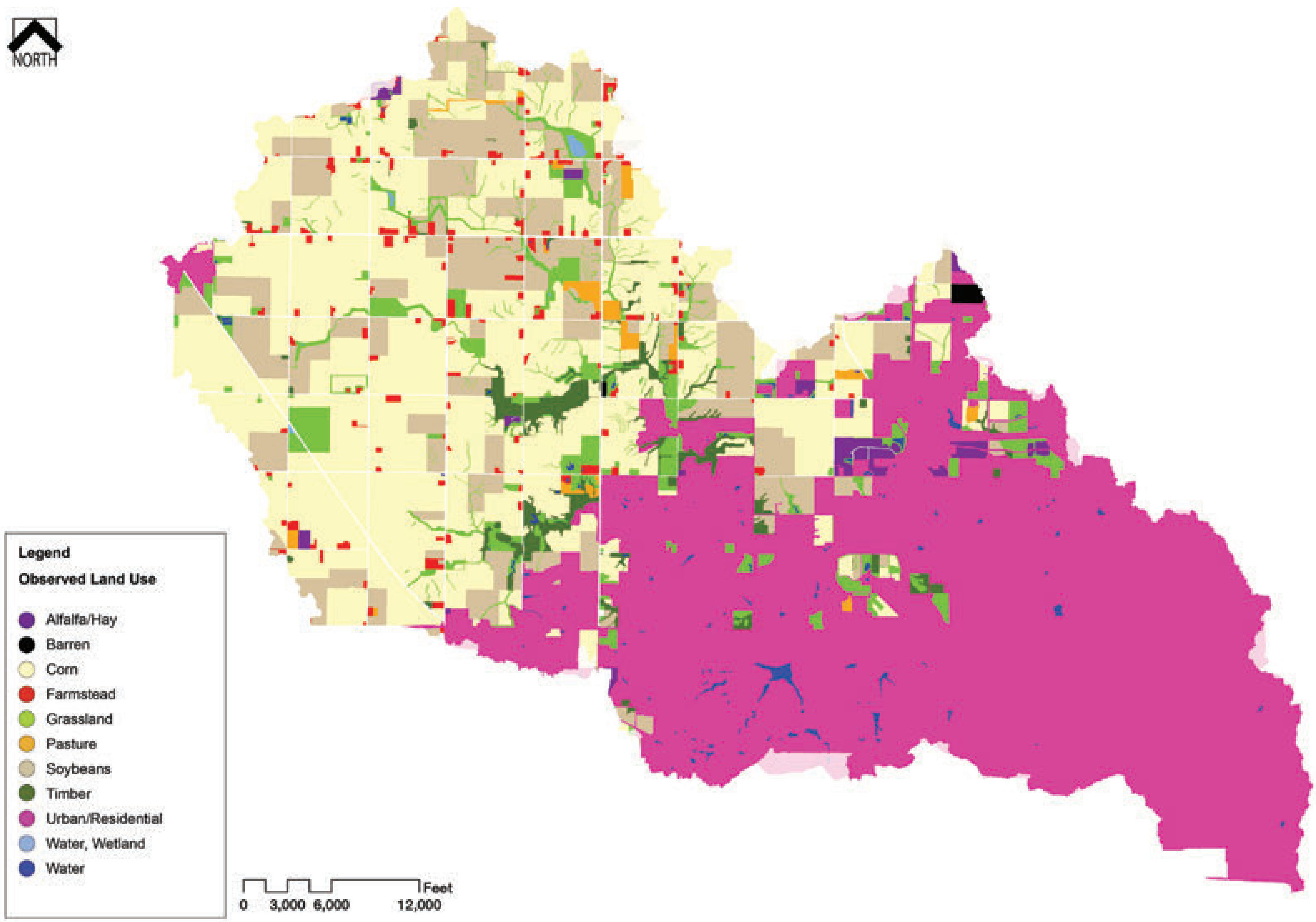


2014

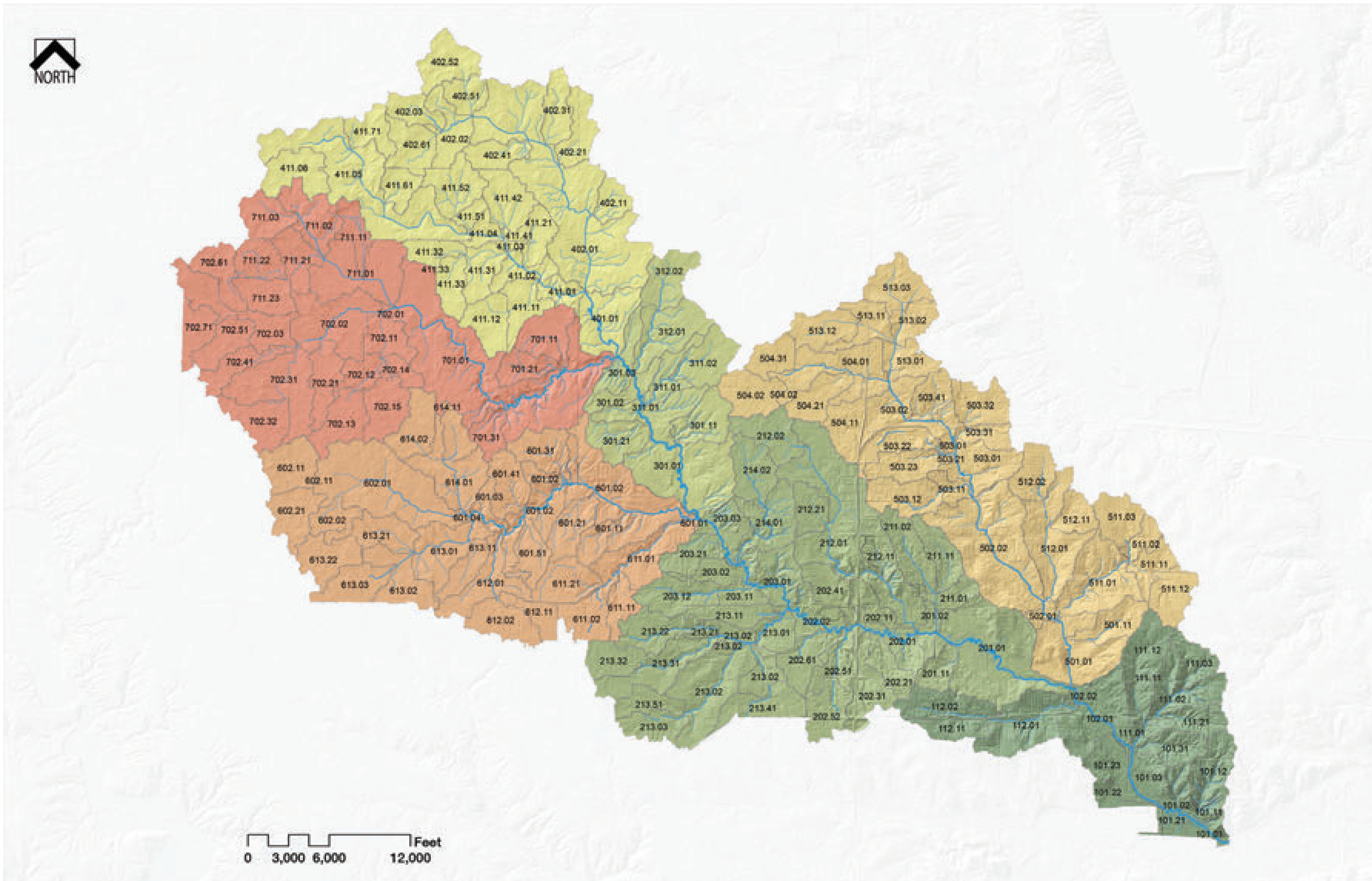
Urbanized area

Source: Iowa Geographic Map Server website

Landscape Change



Current Land Use



Subwatersheds

Walnut Creek Management Plan: Subwatershed Identification System

This plan includes a unique subwatershed numbering system, so that there is an organized method of referencing smaller areas within the Walnut Creek watershed. The primary numbering system is made up of a five digit code, with three digits to the left of a decimal point and two to the right. This code is written in the format “000.00.” This format allows collected data to be organized from larger tributary areas down to very small microwatersheds.

At the highest level, the watershed has been divided into seven key areas, each representing either a certain segment of Walnut Creek or one of its larger tributaries. This division is represented by the first number of the code (starting at left) and ranges from one to seven. (See page 39, "Tributaries of Walnut Creek")

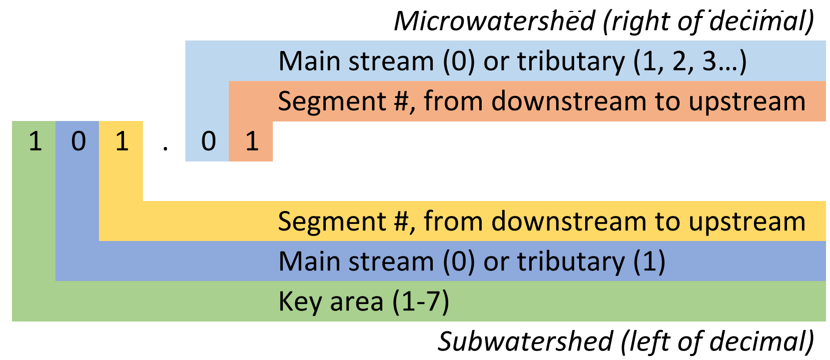
The second number of the code is either “0” or “1.” A zero means that this area primarily drains directly to the main segment of the stream. A value of one means that the area drains to a smaller stream which is tributary to the main segment.

The third number of the code identifies each of the smaller subwatersheds. These are numbered in order starting at “1,” with the furthest downstream areas being numbered first. A total of 33 subwatersheds have been numbered in this manner. (See map on previous page.)

Examples:

1. Subwatershed 101 is within the Lower Walnut Creek area (100). This subwatershed would be the most downstream area which drains directly to the main stream segment (01—“0” for main stream, “1” for being the first numbered segment).
2. Subwatershed 112 is also within the Lower Walnut Creek area (100). This subwatershed is the area draining to a smaller tributary, the second small tributary encountered starting from the downstream end (12—“1” for tributary, “2” for being the second tributary designated).

Walnut Creek Watershed Identification System



The digits to the right of the decimal point designate smaller divisions called microwatersheds. In most cases, only two digits are used. If the one closest to the decimal point is a “0,” then this area drains directly to the main stream segment included within that subwatershed. Smaller tributaries are numbered in order (1,2,3,...). The second number identifies each microwatershed area, numbering them in order starting at “1,” from downstream to upstream. This numbering system is completed for both the main stream segments and each tributary microwatershed.

Examples:

1. Microwatershed 411.01 is within the Eastern Headwaters of Walnut Creek (400). This subwatershed is the area draining to a smaller tributary, the first small tributary encountered starting from the downstream end (11—“1” for tributary, “1” for being the first tributary designated). This specific microwatershed would be the first one draining to the main stream segment within this subwatershed (.01—“0” for draining to the main stream and “1” for being the most downstream area).
2. Microwatershed 411.12 is within the same subwatershed as the example above. This specific microwatershed would be along the first smaller tributary within this subwatershed and would be the second segment of that tributary encountered moving from downstream to upstream (.12—“1” for draining to the first tributary and “2” for being the second most downstream area).

Recent Land Use Changes by Watershed

Subwatershed ID	2001							2011						
	Open Water	Urban	Forest	Grassland/ Wetlands	Pastureland	Cropland	TOTAL	Open Water	Urban	Forest	Grassland/ Wetlands	Pastureland	Cropland	TOTAL
101	0.0	956.7	272.0	151.0	57.6	43.4	1480.6	3.1	966.0	264.0	177.5	49.4	20.6	1480.6
102	0.0	537.5	8.2	10.9	8.2	0.0	564.9	0.0	555.8	8.0	1.1	0.0	0.0	564.9
111	0.0	1196.2	26.7	3.1	0.0	0.0	1226.0	0.0	1201.5	21.3	3.1	0.0	0.0	1226.0
112	0.0	956.8	6.9	0.0	0.2	0.0	963.9	0.0	961.3	2.7	0.0	0.0	0.0	963.9
201	0.0	1180.7	36.6	94.5	10.0	0.0	1321.8	0.0	1196.9	30.6	88.9	5.3	0.0	1321.8
202	20.9	1455.3	84.0	145.1	243.6	102.0	2050.9	14.4	1625.3	57.2	132.8	152.4	68.8	2050.9
203	5.8	435.3	258.2	98.6	288.5	241.4	1327.8	5.8	832.5	213.4	93.0	144.5	38.7	1327.8
211	0.0	678.8	0.0	0.0	11.0	0.0	689.7	0.0	688.8	0.0	0.0	0.9	0.0	689.7
212	1.6	691.4	102.7	14.4	301.5	796.3	1907.9	3.1	1062.8	95.1	10.2	166.8	569.8	1907.9
213	63.1	1936.7	67.9	37.9	349.9	413.3	2868.8	60.2	2582.9	46.1	32.3	73.7	73.5	2868.8
214	1.3	81.1	136.7	5.7	41.0	401.8	667.6	1.3	171.7	130.9	5.7	35.9	322.1	667.6
301	5.1	126.2	125.4	140.5	440.7	1168.8	2006.7	4.2	608.4	106.7	100.3	264.8	922.3	2006.7
311	0.0	16.6	5.3	4.0	23.6	426.4	476.0	0.0	17.5	5.3	6.7	20.9	425.5	476.0
312	0.0	37.8	8.7	6.9	51.6	580.7	685.7	0.0	37.8	8.7	6.9	51.6	580.7	685.7
401	0.0	17.3	3.8	11.1	113.9	252.0	398.1	0.0	17.3	3.8	13.8	111.9	251.4	398.1
402	0.0	171.1	9.1	74.2	145.4	3382.0	3781.9	0.0	171.1	9.1	74.2	145.4	3382.0	3781.9
411	4.0	219.7	4.9	70.1	151.5	3701.8	4151.9	4.0	219.7	4.9	72.5	137.9	3712.9	4151.9
501	0.0	771.4	24.5	0.0	0.0	0.0	795.9	0.0	771.4	24.5	0.0	0.0	0.0	795.9
502	2.7	1117.5	12.0	18.2	0.0	0.0	1150.5	2.7	1117.5	12.0	18.2	0.0	0.0	1150.5
503	11.6	1475.9	34.9	46.7	145.4	527.7	2242.3	10.7	1762.7	28.9	42.3	54.1	343.6	2242.3
504	0.0	372.6	2.7	0.0	134.3	973.5	1483.0	6.0	662.9	2.7	0.0	67.8	743.6	1483.0
511	0.0	1333.4	0.0	0.0	2.9	0.0	1336.2	0.0	1333.4	0.0	0.0	2.9	0.0	1336.2
512	4.2	949.5	4.7	0.0	10.7	0.0	969.0	4.2	955.3	0.2	4.0	5.3	0.0	969.0
513	2.0	160.3	0.0	0.0	17.1	990.7	1170.1	4.7	497.6	0.0	0.0	0.7	667.2	1170.1
601	10.7	207.2	145.2	101.5	407.0	1601.9	2473.6	10.7	738.9	124.9	84.2	249.2	1265.8	2473.6
602	0.0	89.2	3.8	7.3	59.3	1542.1	1701.8	0.0	89.2	3.8	7.3	59.3	1542.1	1701.8
611	2.4	241.7	51.9	32.0	185.3	603.3	1116.6	1.1	727.6	28.9	14.0	61.3	283.8	1116.6
612	3.1	503.0	8.0	7.3	44.0	212.6	778.0	3.1	583.5	7.3	7.3	10.9	165.8	778.0
613	0.0	161.3	10.0	16.0	11.1	1511.4	1709.8	0.0	161.3	10.0	20.0	11.1	1507.4	1709.8
614	0.0	43.4	0.0	4.7	0.4	802.5	851.0	0.0	43.4	0.0	4.7	0.4	802.5	851.0
701	1.6	109.8	192.1	36.2	198.1	1988.2	2525.9	1.6	109.8	192.1	36.2	188.9	1997.3	2525.9
702	6.2	333.2	0.0	62.8	66.7	3511.6	3980.5	6.2	364.3	0.0	65.0	64.1	3480.9	3980.5
711	0.0	98.7	3.3	8.2	9.7	1850.3	1970.3	0.0	100.0	3.3	12.4	9.7	1844.7	1970.3
Totals	**146.2**	**18663.4**	**1649.9**	**1209.2**	**3530.3**	**27625.8**	**52824.8**	**147.1**	**22936.2**	**1446.4**	**1134.7**	**2147.3**	**25013.2**	**52824.8**
Change (in acres)								0.9	4272.8	-203.6	-74.5	-1383.0	-2612.6	
Change (% of watershed)								0.0%	8.1%	-0.4%	-0.1%	-2.6%	-4.9%	

CHAPTER 3

KEY CONCEPTS

1. Long-term trends

Average annual temperature and precipitation levels observed in this area have been increasing.

2. Small storms matter

Around 90% of all rainfall events in Central Iowa are equal to or less than 1.25 inches. Since most rainfall is generated by these smaller events, most pollutant loads are washed off surfaces and carried to streams by these storms.

3. Moderate storms matter too

In this watershed, storm events of greater than 2.67" in a 24-hour period occur about once a year. These storms which occur about once a year on average are larger than 98% of local rainfall events. These storms often cause local flash flooding and can destabilize streams due to erosion caused by the rapid "bounce" in stream flows following such storms.

4. Runoff is increasing

Average annual streamflow in Walnut Creek has increased 37% since 1981.

5. Seasonal flow patterns

Highest flow rates have been most commonly observed from late April through June. Some very significant flood events have also occurred in July and August.

6. Land use impacts stream flow

Streamflow has increased more intensely than precipitation, indicating that land use changes are influencing streamflow increases.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Climate factors such as temperature and precipitation ultimately impact pollutant loads. Certain pollutants are more likely to be present after storm events. Some are more common when temperatures are higher. Higher rainfall amounts could lead to increased flood risks. Such risks also are influenced by changes in land use.

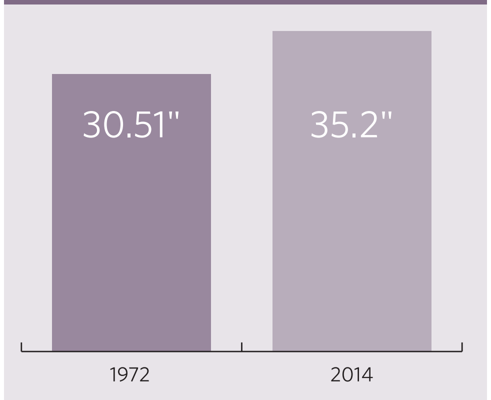
three

Climate and Streamflow

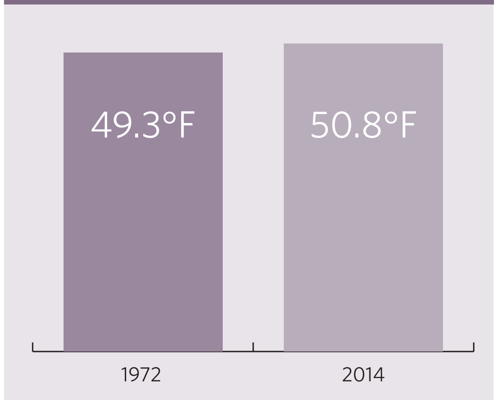
Climate - Recent Trends

NWS data collected at Des Moines Airport

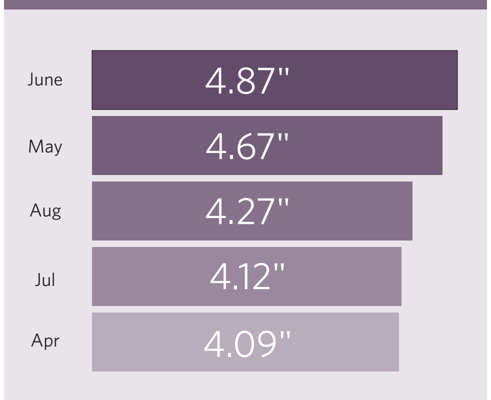
Normal Annual Precipitation



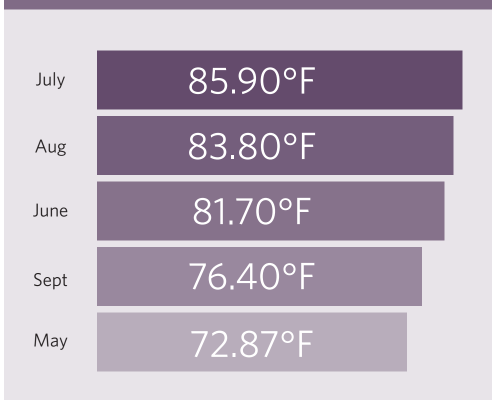
Normal Annual Temperature



Highest Monthly Precipitation*



Highest Monthly Temperatures*



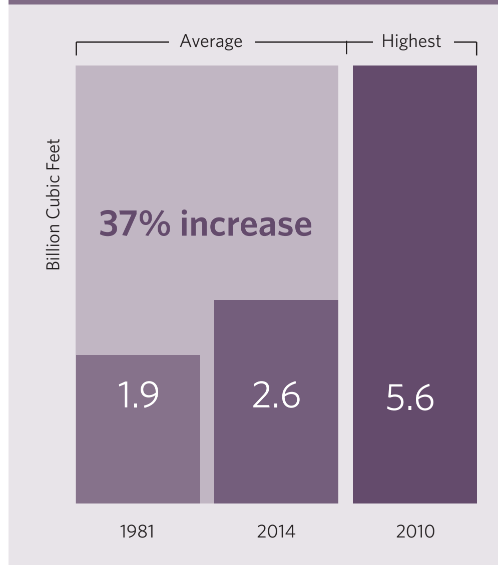
90% of all rainfall events in central Iowa are less than 1.25 inches in depth.

*1985-2014

Streamflow - Recent Trends

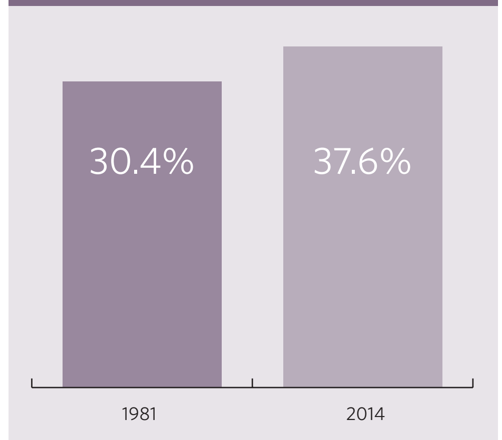
USGS stream gage data

Annual Flow



5.6 billion cubic feet of water would fill 21,000 water towers

The portion of rainfall converted to runoff has increased recently.

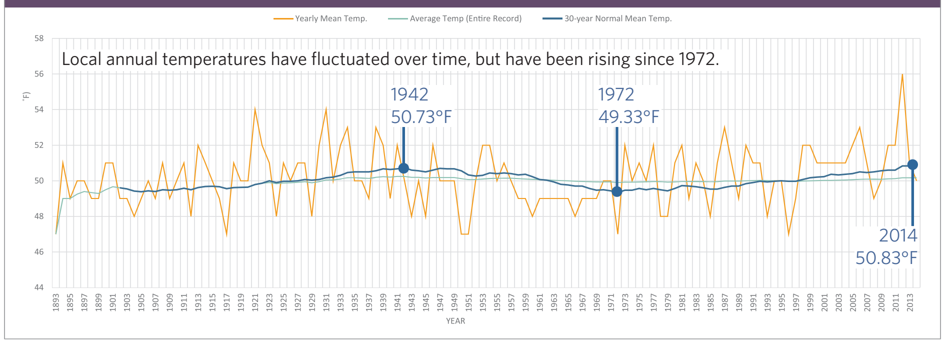


Some larger water towers = 2 million gallons

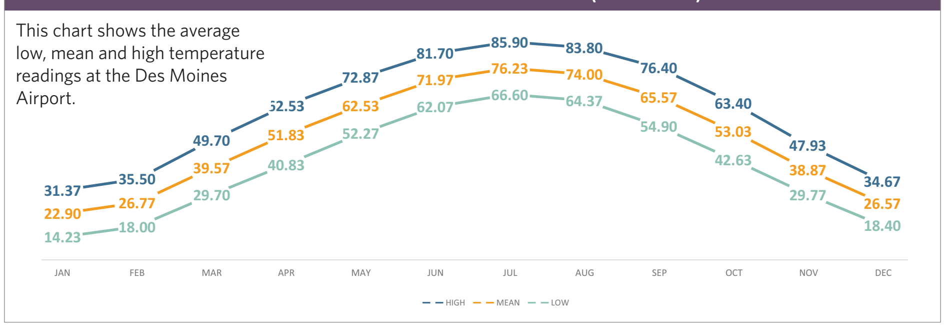
Highest flows typically from May - June

Historic climate data was obtained through the Iowa Environmental Mesonet (IEM) website, housed by Iowa State University. Since no weather stations fall directly within the footprint of the Walnut Creek watershed, data from the station located at the Des Moines International Airport (IA2203) was used. This site is located approximately 2 miles southwest of the boundary of the watershed. Its historic record extends from January 1, 1893 to the present.

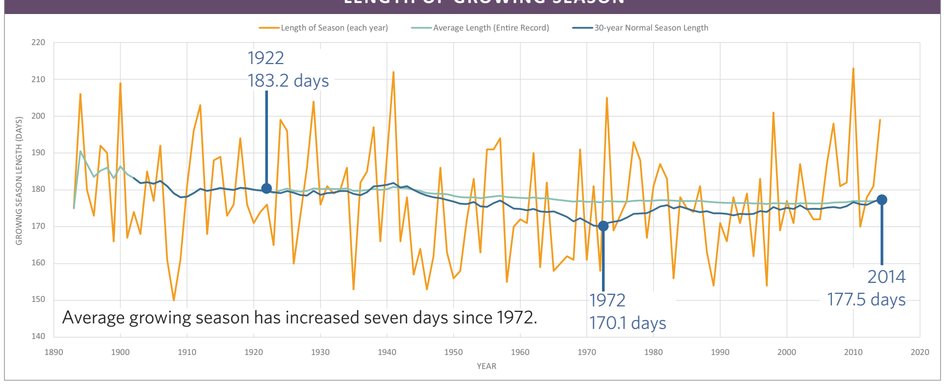
AVERAGE ANNUAL TEMPERATURE



MONTHLY AVERAGE TEMPERATURES (1985-2014)



LENGTH OF GROWING SEASON



Annual Temperature

Records were used to review cycles and trends in average annual temperature. A **normal annual mean** temperature was calculated using the average annual temperature readings over the previous 30 years for any given date through the period of record (1893-present).

Seasonal Temperature

Over the past 50 years, January has generally been the coldest month of the year, with a **mean** temperature of 22.90˚F. July has typically been the warmest month of the year. The highest temperature recorded at the Des Moines Airport was 110˚F on July 25, 1936 and August 4, 1918. The minimum temperature reading of -29˚F was registered on January 12, 1912.

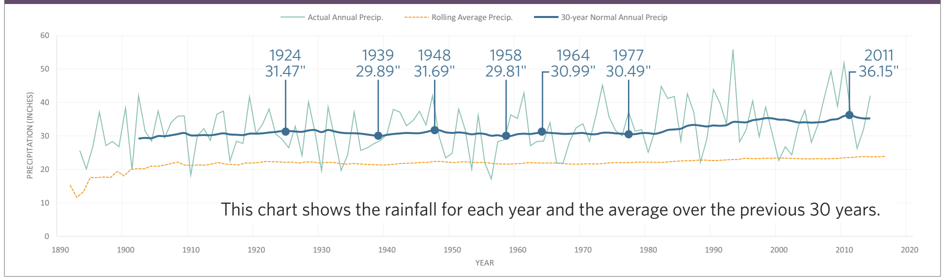
Growing Season

An analysis calculated a normal growing season length using the average length of season over the previous 30 years. Even though normal annual temperatures increased until 1942, the normal growing season length generally decreased until 1972. Since that date, the average growing season has generally been on the rise, although a downtrend did occur between 1982 and 1992. The normal growing season length in 2014 was calculated to be 177.5 days (based on period form 1985-2014).

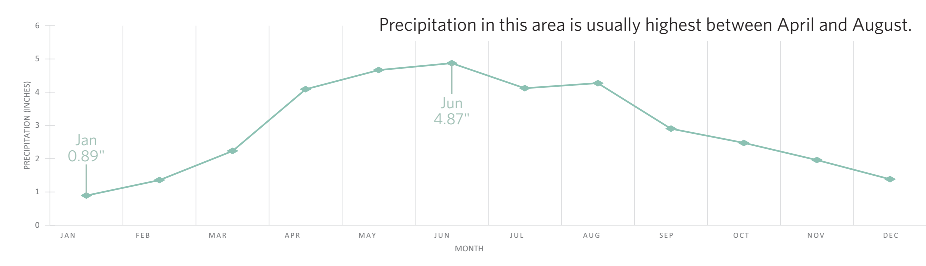
Annual Precipitation

Precipitation data was reviewed in a manner similar to temperature information. Annual precipitation totals observed at the Des Moines Airport over the period of record range from 17.08" (1956) to 55.89" (1993), with an average of 32.14" over the entire period of record. A **normal annual precipitation** depth was computed using the annual precipitation over the most recent 30 years through the period of record. Up until 1982, the annual normal precipitation generally remained within 0.5" of the average of the overall period of record. But since that time, annual rainfall has been trending upward. Normal precipitation values peaked in 2011 at 36.15." The normal value dropped slightly through 2014 to 35.23," as the three consecutive wet years of 1982-1984 dropped out of the computation of the 30-year normal. Even so, the normal annual precipitation remains more than three inches above the longer-term

ANNUAL PRECIPITATION



AVERAGE MONTHLY PRECIPITATION (1985-2014)



average. There appears to be a clear local trend of increased precipitation over the past three decades. Six of the top eight wettest years on record have occurred since 1982, while none of the driest years on record have occurred during that same period.

Monthly Precipitation

Normal precipitation levels are lowest in January, rising through the spring to highest levels during the month of June. Precipitation levels remain elevated through July and August, falling off significantly through the fall months.

Top/Bottom Precipitation Years				
	HIGH		LOW	
Rank	Year	Precipitation (in inches)	Year	Precipitation (in inches)
1	**1993**	**55.89**	1956	17.08
2	**2010**	**51.78**	1910	18.25
3	**2008**	**49.43**	1930	19.58
4	1973	45.19	1933	19.68
5	**1982**	**44.81**	1901	19.78
6	**1990**	**43.94**	1953	20.01
7	1961	42.88	1894	20.07
8	**1986**	**42.59**	1967	21.83
9	1947	42.08	1966	21.86
10	1902	42.02	1955	21.99

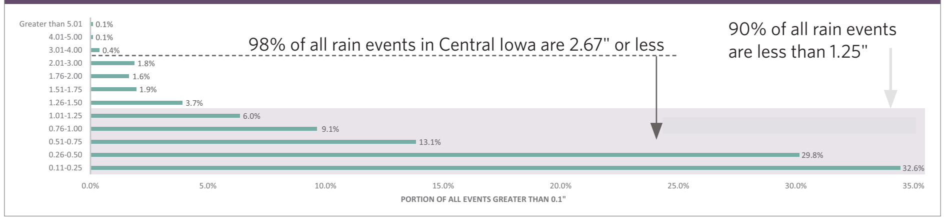
Six of the eight wettest years on record have occurred since 1980.
None of the 10 driest years have occurred over that same period.

Engineers use published studies on local rainfall rates in the design of storm sewers, culverts and storm water management practices. In the past, **local design standards** have used information from Technical Paper 40 [1] (1961) and Bulletin 71 [2] (1992) rainfall depths and rates for short-term events (time periods ranging from a few minutes to up to 10 days). Recently, **NOAA** issued their Atlas 14 [3] rainfall data set, which included more recent precipitation data to establish these rates. **SUDAS (Statewide Urban Design Standards and Specifications)** and **ISWMM (Iowa Stormwater Management Manual)** have adopted these values for use in design. Values listed in Atlas 14 are generally similar to or higher than those listed in previous studies, meaning that storm water facilities now are expected to be designed to handle runoff generated by more rainfall than expected in the past.

Changing Approaches: Water Quality and Channel Protection

Recently, more emphasis has been placed on addressing runoff created by smaller storms. These storms are much more common so overall they are responsible for carrying most pollution downstream. Some more modest events cause local flash flooding and streambank erosion. Designers are now encouraged to create practices that address these smaller storm events, which make up 98% of all rainfall in Central Iowa.

RAINFALL FREQUENCY AMES, IOWA (1964-2004)



Adapted from Iowa Stormwater Management Manual

Rainfall Depths (in inches) for Various Storm Event Durations—1-Year Return Period Storm

		TP-40	Bulletin 71	Atlas 14
Issue Date		1961	1992	2013
Storm Event Duration	30 minutes	1.1	0.88	0.99
	1 hour	1.3	1.12	1.29
	6 hours	2.0	1.79	2.05
	12 hours	2.3	2.07	2.34
	24 hours	2.7	2.38	2.67

Rainfall Depths (in inches) for Various Storm Event Durations—10-Year Return Period Storm

		TP-40	Bulletin 71	Atlas 14
Issue Date		1961	1992	2013
Storm Event Duration	30 minutes	1.9	1.58	1.70
	1 hour	2.4	2.01	2.23
	6 hours	3.6	3.20	3.61
	12 hours	4.2	3.71	4.07
	24 hours	4.7	4.27	4.46

Rainfall Depths (in inches) for Various Storm Event Durations—100-Year Return Period Storm

		TP-40	Bulletin 71	Atlas 14
Issue Date ->		1961	1992	2013
Storm Event Duration	30 minutes	2.7	2.45	2.63
	1 hour	3.4	3.11	3.55
	6 hours	5.1	4.96	5.98
	12 hours	6.0	5.75	6.62
	24 hours	6.7	6.61	7.12

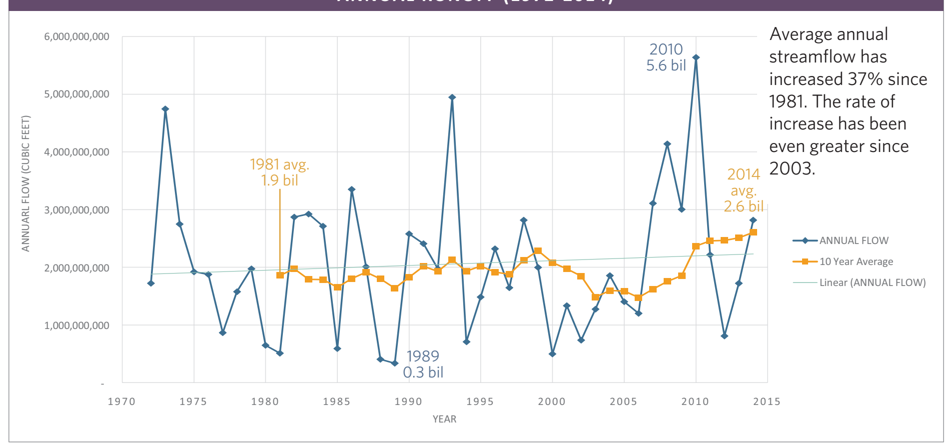
Available Streamflow Gage Data

Stream flow data has been collected at a **USGS** gaging station located near the 63rd Street Bridge on the border between Des Moines and West Des Moines (USGS 05484800). Data collection began in October of 1971 and continues through the present day. At this location, Walnut Creek is collecting runoff from an area of 78.3 square miles (95% of its entire watershed).

Annual Flows

Stream flow varies greatly from year to year. Since 1972, annual flow volumes have ranged from 334 million cubic feet in 1989 to 5.64 billion cubic feet in 2010. To put that in perspective, the annual volume of flow from 2010 would be enough to fill 21,000 large water towers (assuming each tower could hold 2 million gallons). A general upward trend can be observed in runoff volume. The value of **annual flow** based on an average over the previous 10-years has increased from 1.9 billion cubic feet in 1981 to a high value of 2.6 billion cubic feet in 2014, an increase of 37%.

ANNUAL RUNOFF (1972-2014)



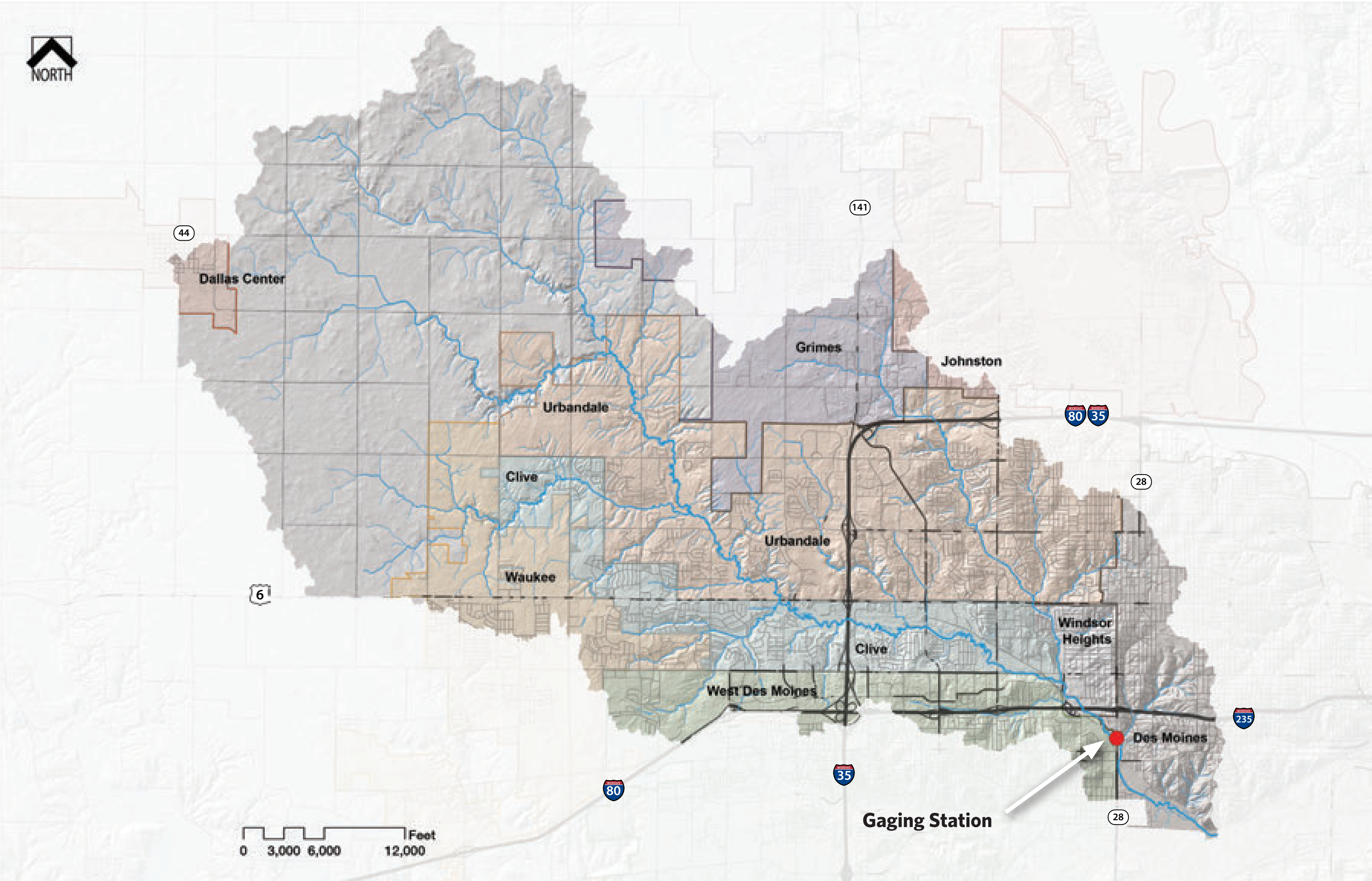
Data from USGS gaging station #05484800.

Sources:

1. Values for TP-40 interpreted from rainfall map data.
2. Rainfall Frequency Atlas of the Midwest; Huff,Floyd A. and Angel, James R.; Midwest Climate Center—NOAA, 1992.
3. Values for Atlas 14 taken from Iowa SUDAS Design Manual, interpreted from Atlas 14 map data.

Technical Paper No. 40—Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years; Hershfield, David M.; US Department of Agriculture, May 1961.

NOAA Atlas 14, Precipitation-Frequency Atlas of the United States (Volume 8, Version 2.0); Perica, Sanja, et al; US Department of Commerce, NOAA and NWS, 2013.

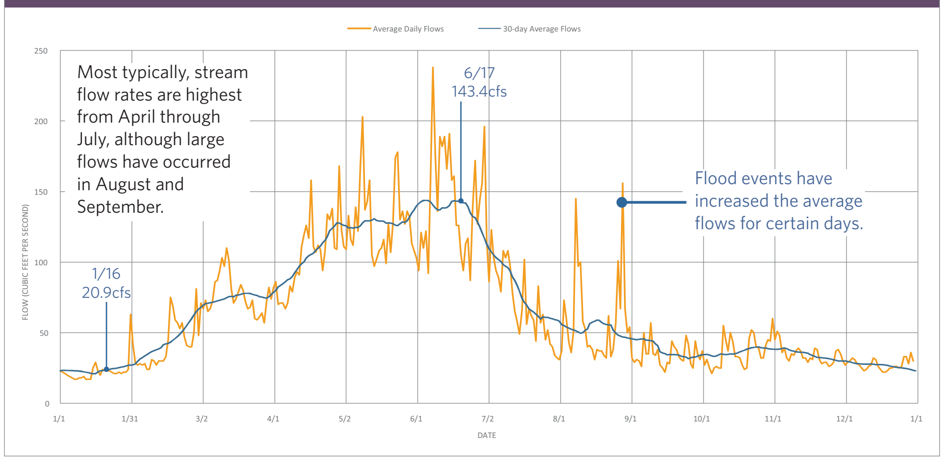


Gaging Station Location

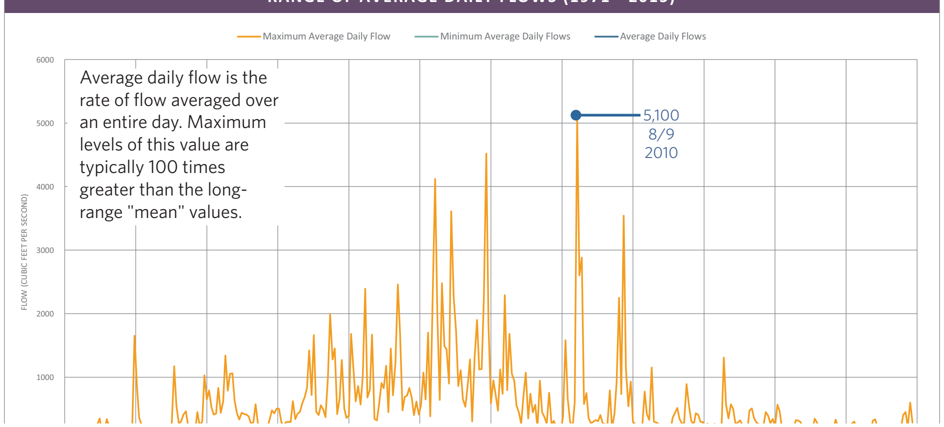
Flow Variation

Daily average flow rates in Walnut Creek have ranged from very little flow to 5,100 cubic feet per second on August 9, 2010. The total flow on that single day of 441 million cubic feet would have exceeded the flow for the entire year of 1989, and would have been equal in volume to more than 1,600 large water towers.* However, such large flows are uncommon. Average daily flow rates have exceeded 1,000 cubic feet per second for only 67 days over a period of more than 43 years (less than 0.5% of all days). The average daily flow rate over the entire period of record is 26 cubic feet per second, or a daily volume of 2.3 million cubic feet**.

AVERAGE DAILY FLOWS (1971 - 2015)



RANGE OF AVERAGE DAILY FLOWS (1971 - 2015)



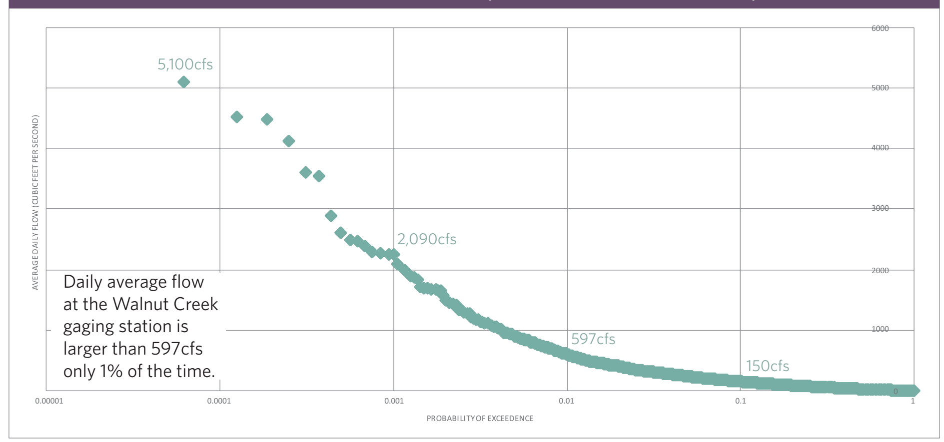
* Assuming 2 million gallons each

** 2.3 million cubic feet = 9 water towers

Seasonal Variation

A **typical flow curve** for Walnut Creek has been constructed by reviewing average daily flow data collected from October 1, 1971 to August 5, 2015. Over this period, highest flows are most often observed between late April and the end of June. Flows typically decline through July, although higher flows have sometimes occurred during periods in early and late August. The typical flow curve is constructed by using a 30-day average (looking 15 days before and after a given date). This has the effect of smoothing out the high and low values into a more regular pattern over the course of an "average" year.

OBSERVED AVERAGE DAILY FLOWS (OCTOBER 1971 - AUGUST 2015)



Source: Data from USGS gaging station #05484800.

Probability of Exceedance

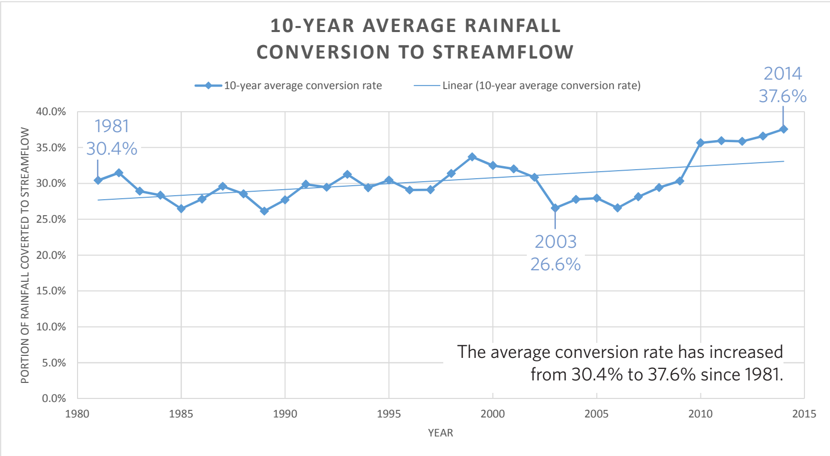
Charts that show probability of exceedance demonstrate how often streamflow rates exceed a certain value. A flowrate with a probability of exceedance of 10% would mean that over the entire measurement period, flowrates have been measured larger than that value only 10% of the time. As given flowrates increase, the probability they will be exceeded gets smaller.

Conversion of Precipitation to Streamflow

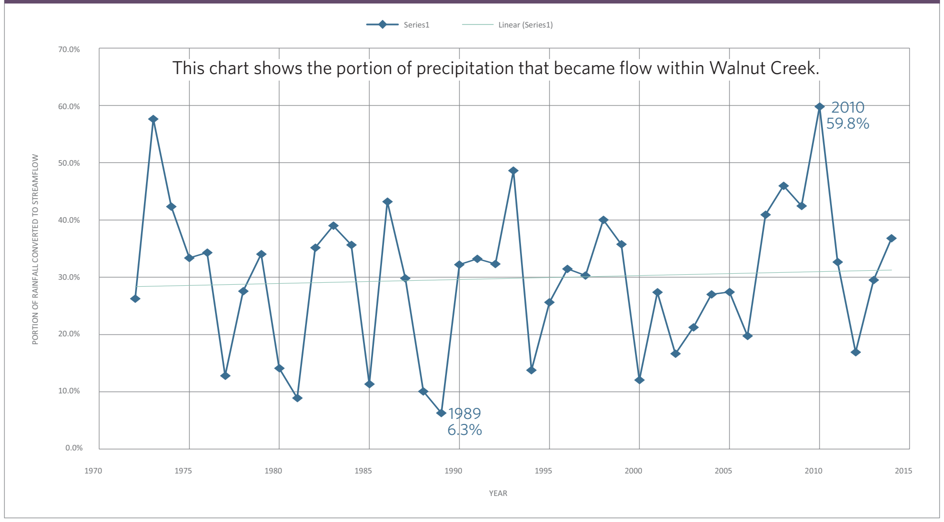
The amount of precipitation which is converted to streamflow has varied greatly. Comparing precipitation observed at the Des Moines Airport and data from the stream gage at Walnut Creek, we can find that in 1989, annual stream flow volume was only 7% of the volume of that year's precipitation. Contrast that with 2010, when stream flow equaled nearly 60% of annual precipitation.

Many factors appear to influence this value which are hard to separate at this level of study:

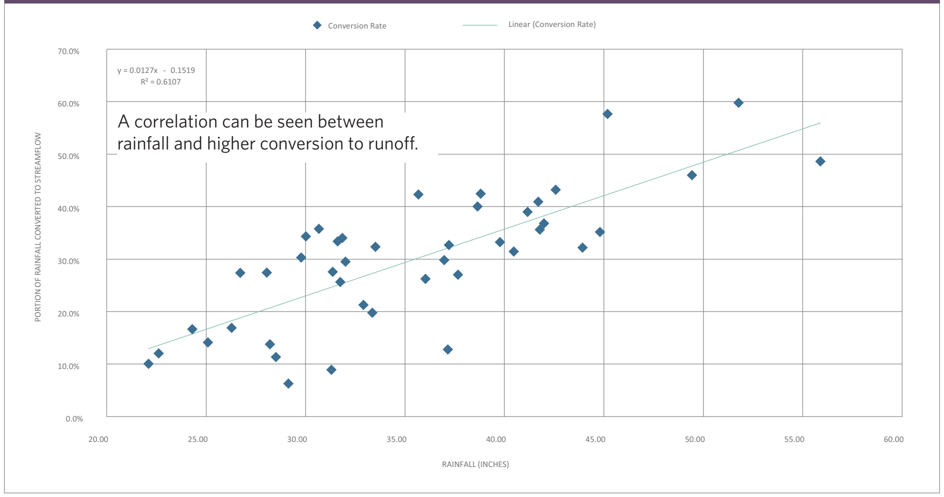
- *Was that year more wet or dry?* Streamflow percentages are higher in wet years than dry years.
- *Was the previous year wet or dry?* A previous dry year may have lowered groundwater and surface moisture levels, resulting in less runoff.
- *Did precipitation come in large storm events or more steady over time?* A higher percentage of runoff is expected during heavier rainfall.
- *How have land uses changed?* Development activities install **impervious** surfaces (hard/solid surfaces that won't slow or hold water like rooftops and driveways) and development compacts remaining open spaces through mass grading. These factors lead to higher levels of runoff.



PORTION OF PRECIPITATION TO STREAMFLOW (1972-2014)



CONVERSION OF RAINFALL TO STREAMFLOW (1972-2014)



Source: Data from USGS gaging station #05484800.

With the information that is available, it is difficult to draw conclusions on how each of the items above influences the percentage of precipitation that is converted into streamflow. From the information on hand, we can state the following:

1. The portion of streamflow that is converted to runoff increases with annual rainfall volume and increases in impervious land cover.
2. Reviewing averages over the previous 10-years from a given date, the proportion of precipitation converted to runoff has increased from an average of 30.4% in 1981 to 37.6% in 2014.
3. Normal annual precipitation has risen from 30.61 inches in 1981 to 35.23 inches in 2014 (based on the average precipitation of the previous 30 years from the given date).
4. Urban land cover has increased greatly, from 35% to 43% of the total watershed area (a change of 4,300 acres) between 2001 and 2011.

Flood Risk Potential

Flooding is a key concern within this watershed, frequently discussed at board meetings and open houses. A flood event that occurred during the planning process intensified the focus on this issue. Flooding occurred during the morning hours of June 25, 2015. This event occurred when more than five inches of rain fell over portions of the watershed beginning late in the evening of June 24. Most of the rain fell over a three to five hour period, depending on location.

Urban development has occurred within many flood prone areas. In some cases, structures have been located in areas where they are frequently flooded including residential, commercial, industrial and public buildings.

Flood risks in this area have been evaluated multiple times. Studies of flooding are developed into maps that demonstrate different levels of expected risk along major stream corridors (Flood Insurance Rate Maps issued by FEMA). These maps are intended to identify the need for flood insurance to be purchased by property owners.

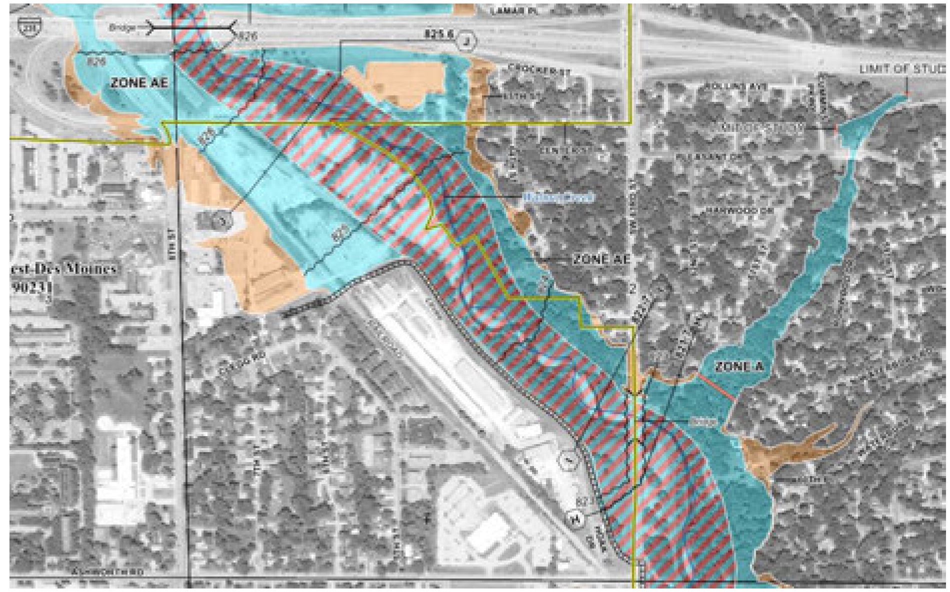
These maps typically identify key features of a flood plain:

- Base Flood Elevations—Detailed studies may identify expected high water elevations caused by a 1% **annual exceedance probability** flood. This is a flood event, expected to have a 1% chance of occurring in any given year, or over very long periods of time would be expected to happen once every 100 years on average. This has commonly been referred to as a "100-year **flood event,**" although the phrase "1% annual exceedance probability" is now the preferred terminology.

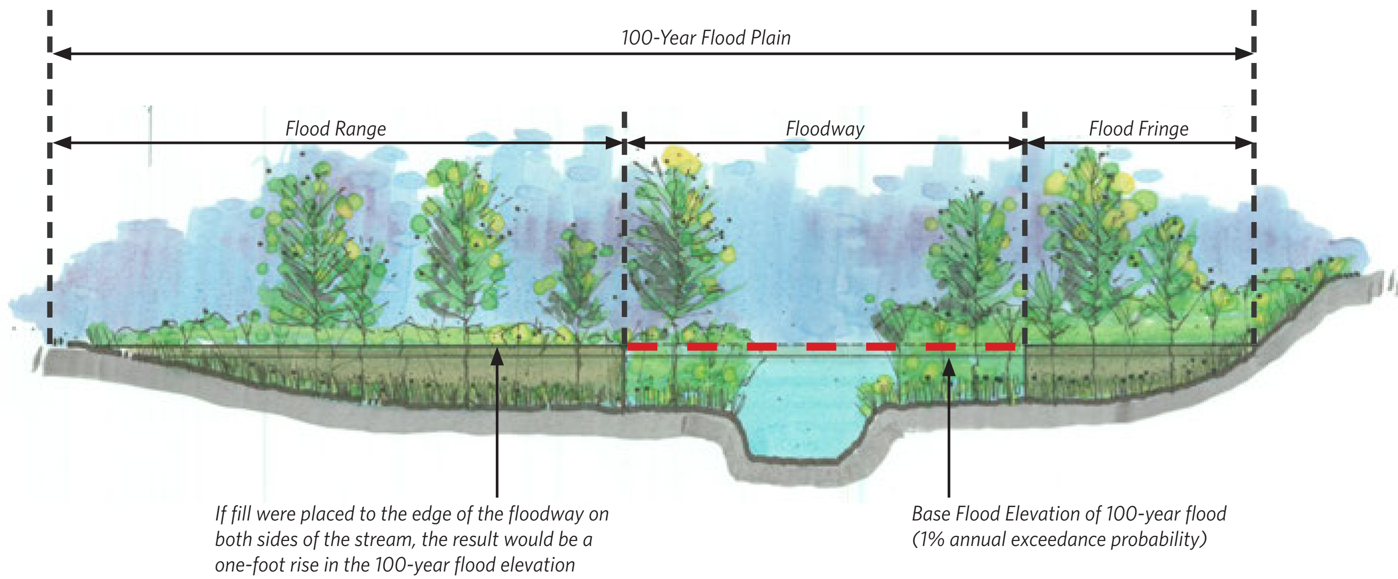
Aerial photos from flood event—June 25, 2015

- Floodway—A zone where grading or structure construction is most limited. This zone is intended to be kept clear of obstructions. In theory, the flood plain could be completely filled on either side of this zone and the expected result would be a one foot rise in base flood elevations. Not all maps identify the floodway for a given stream, but they are usually identified on larger streams or in areas where more detailed studies have been completed.
- Flood Fringe—Maps often identify areas outside of the floodway which show areas expected to be covered by the 1% or 0.2% annual exceedance probability flood events. The 0.2% probability event has commonly been called the "500-year flood event."

In some areas, these maps are associated with studies that provide detailed cross-sectional information of the flood plain. Such studies may include expected flood elevation profiles for other more commonly occurring storm events (i.e. 2%, 10% exceedance probability, etc.). *It is important to understand that localized flash flooding can occur outside of areas with mapped flood risk. This can be caused by clogged inlets or storm sewers and culverts; overloaded storm sewer systems, blocked overflow paths and urban small stream flooding.*



A flood risk map sample of a section of Walnut Creek



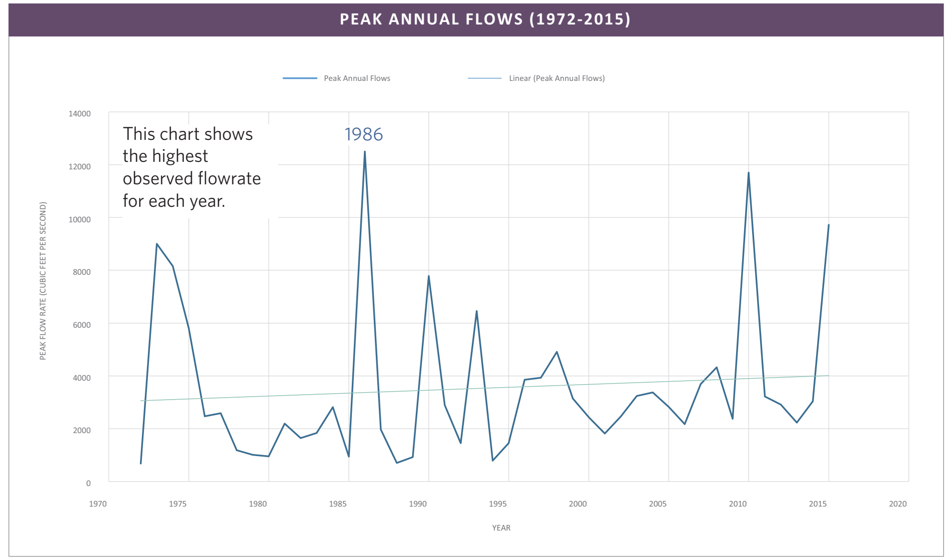
Flood History

At the USGS gaging station at the 63rd Street Bridge, minor flooding impacts are expected at a **gage height** of 14 feet. At this location, major impacts due to flooding are expected when water exceeds a gage height of 17 feet. Gage height data has been collected every year since 1972. Over that 44 year period, there have been 14 years (31.8%) where a gage height above 14 was recorded. Water levels have exceeded a gage height of 17 feet in eight (18.1%) of the years on record. This indicates that a flooding to a gage height of 17 feet may be expected once every five years on average.

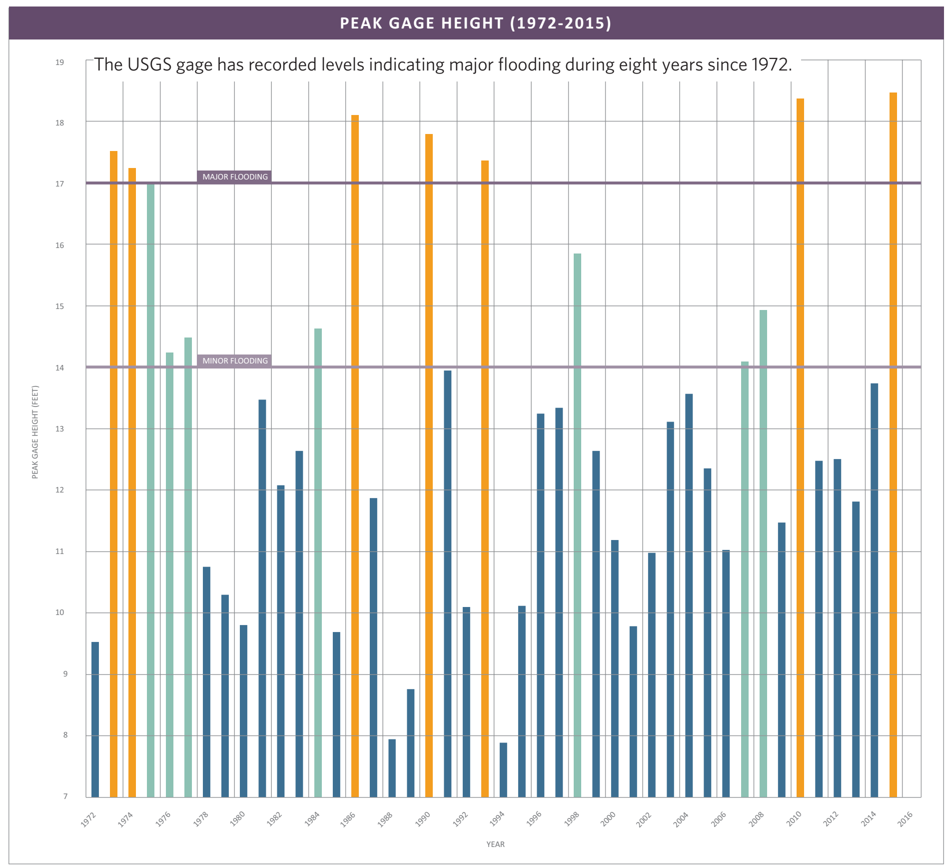
Hydraulic Modeling and Flood Inundation Mapping

To begin the hydraulic and floodplain mapping investigation for the Walnut Creek Watershed Management Plan, data and models from three previous studies were reviewed. These previous studies included **hydraulic and hydrologic analyses** for the North Walnut Creek watershed, hydraulic and hydrologic analyses for the Walnut Creek watershed, and updated **FEMA** floodplain mapping for North Walnut Creek and Walnut Creek. These studies and models were produced using rainfall data published in 1992 (Bulletin 71), which was the most recent rainfall data available at the time these studies were completed. These studies were eventually incorporated into a FEMA floodplain mapping update that was published as a preliminary study in June 2015. After a public commend period, they are scheduled to become effective in the winter of 2016.

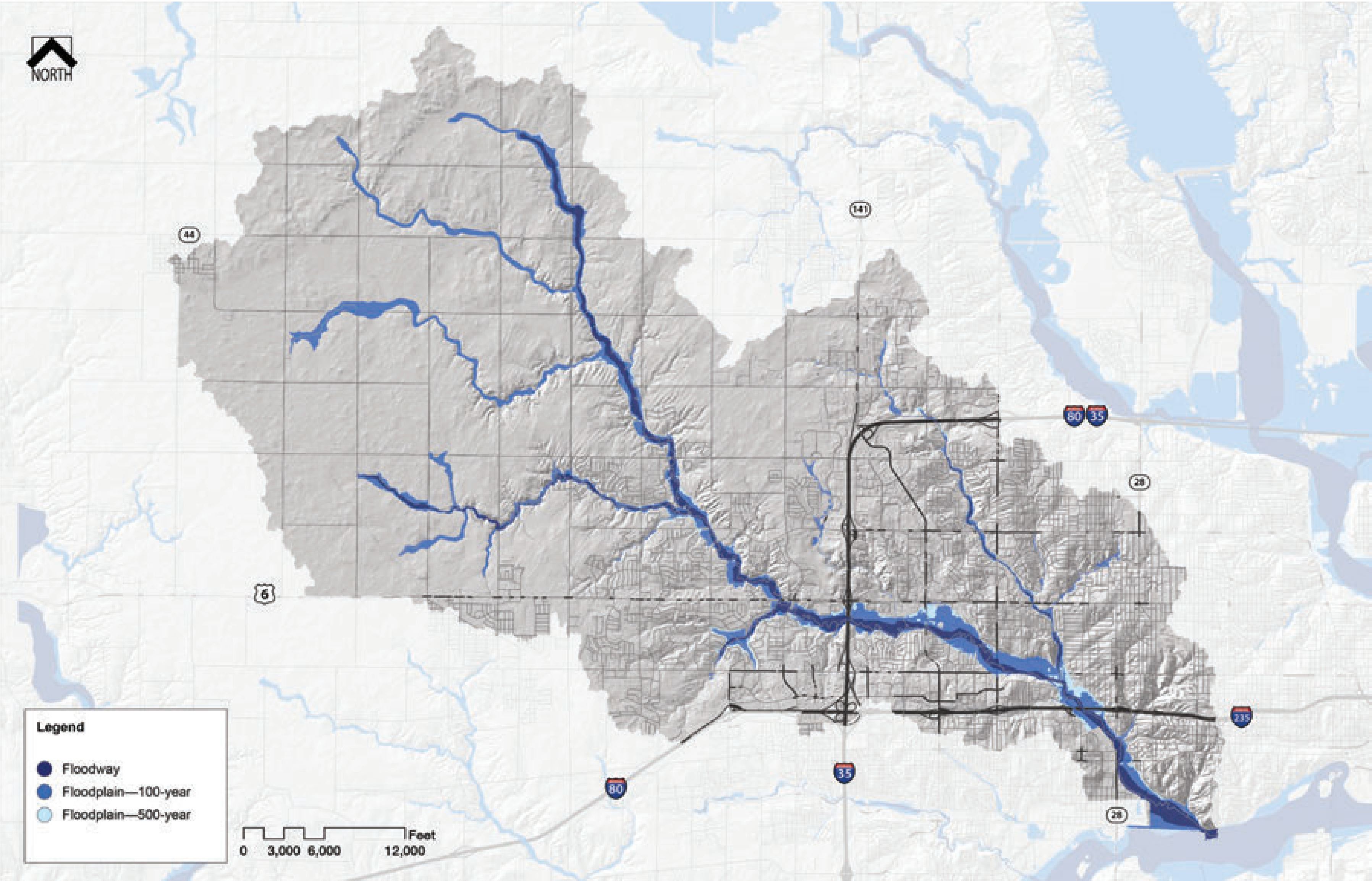
This study further updates hydrologic and hydraulic models as well as **inundation mapping** for Walnut Creek and North Walnut Creek using more recent rainfall estimates. This plan uses NOAA Atlas 14 data. The Atlas 14 rainfall estimates take into account a longer period of statistical data than Bulletin 71 and include rainfall data through the 2013 water year. In general, in Iowa, the rainfall estimates for NOAA Atlas 14 have increased when compared to Bulletin 71. This is also the case for the Walnut Creek and North Walnut Creek watersheds. This increase in rainfall estimates, in turn, increased the peak flow estimates, water surface elevations, and floodplain extents.



Source: Data from USGS gaging station #05484800.



Source: Data from USGS gaging station #05484800.


NORTH
44
141
6
80
35
28
235
Legend
Floodway
Floodplain—100-year
Floodplain—500-year
0
3,000
6,000
12,000
Feet

Flood Risk

The results of the analyses using the Bulletin 71 estimates and the NOAA Atlas 14 estimates were compared. Points of interest are outlined for each flooding source below.

Walnut Creek 1% Annual Exceedance Probability:

- 73 acres greater floodplain area for the Atlas 14 based mapping over 18 miles of stream length
- An average of 34 feet wider than the preliminary mapping or 17 feet on either side of the stream
- Smaller in some areas due to some of the additional area being within backwater fingers

North Walnut Creek 1% Annual Exceedance Probability:

- 16 acres greater floodplain area for the Atlas 14 based mapping
- An average of 24 feet wider than the preliminary mapping or 12 feet on either side of the stream
- Smaller in some areas due to some of the additional area being within backwater fingers

The differences highlighted above are a direct result of increased rainfall estimates with the updated statistical data. However, as land use and management changes within the watershed, these increases in peak flow estimates could worsen over time. Since future meteorological changes are unknown, to mitigate risk and future losses, watershed and floodplain management becomes paramount.

Flow Increases			
	Effective Flows [1] (CFS)	**Preliminary Flows [2] (CFS)**	**Atlas 14 Flows [3] (CFS)**
	1% Annual Exceedance Probability Flows		
Above RT Bank Tributary	5,480	5,415	6,137
Above Little Walnut Creek	10,280	10,875	12,368
At NW 142nd Street	14,410	14,715	16,734
At NW 100th Street	14,950	16,570	18,858

Source: Analysis completed by Snyder & Associates, comparing to current effective models and new model under consideration by FEMA.

Notes:

1. Effective flows are the flowrates used to develop the flood maps (FIRMs) currently used to establish flood insurance rates.
2. Preliminary flows are the flowrates used to develop the revised FIRMs which are currently going through a review process and will likely become effective sometime late in 2016. Neither the effective nor the preliminary flows were calculated using recently available Atlas 14 rainfall data.
3. Atlas 14 flows are flowrates which have been adjusted as part of this study to reflect newer rainfall data.

Aerial photos from flood event—June 25, 2015 *Source: RDG*

CHAPTER 4

KEY CONCEPTS

1. **Walnut Creek is impaired by pollutants**
   Recreational uses involving direct human contact with Walnut Creek water are currently *not supported* because of high measured levels of E.coli bacteria. These levels have routinely been higher than the state's water quality standards and are the reason why the stream is listed as an impaired waterbody.

2. **The Raccoon River and Des Moines Water Works are impacted too**
   The Raccoon River is also listed as impaired due to high bacteria levels. The river is also identified as being impaired due to high levels of nitrates, which risk safe drinking water supplies. During periods of high nitrate levels, Des Moines Water Works has to activate special treatment systems which reduce nitrate levels in the treated water supply.

3. **Nutrient pollution is not just a local problem**
   Compounds containing nitrogen and phosphorus are carried downstream from the Mississippi River watershed to the Gulf of Mexico. Chemical and biological reactions increased by high levels of these nutrients can lower oxygen levels in the water to the point where fish and other animals cannot survive. This process has caused a "dead zone" to be formed in the Gulf which is over 5,800 square miles in area.

4. **Past work provides insight**
   Several past studies offer important analyses and recommendations related to the Walnut Creek Watershed.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Previous studies have identified potential risks to human health and the environment. These studies identify likely sources of pollution and the reduction of pollutant loads necessary for streams to fully support their designated uses. Strategies and best management practices are identified to address these concerns, some of which may be applicable within this plan.

Four

Background

Downstream waterbodies are:

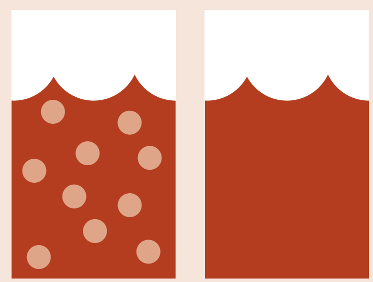
1. Des Moines River
2. Lake Red Rock
3. Mississippi River
4. Gulf of Mexico

Elevated levels of nutrients such as nitrogen and phosphorus have created a 5,500-square-mile hypoxic "*dead zone*" in the Gulf of Mexico (10% of the size of the entire State of Iowa) *

* The size of the dead zone is the five-year average size of the hypoxic zone, based on data collected by NOAA from 2011–2015.

Walnut Creek

- Currently considered an impaired waterbody due to high levels of bacteria.
- Flows into the Raccoon River which is impaired due to high levels of bacteria and nitrate.



Des Moines Water Works collects water from the Raccoon River for drinking water use. This water must be disinfected and nitrates removed through a special process when concentrations are above a certain level.

Iowa's Nutrient Reduction Strategy

Created to reduce the amount of nutrient load sent from Iowa to the Gulf of Mexico.

Past studies have been completed that broaden the understanding of Walnut Creek and where it fits within larger watersheds. The maximum allowable concentrations of certain pollutants are based on the designated uses of the stream. This influences if the stream is considered to be impaired, and the required reductions in pollutants that are needed in order to fully support the stream's desired public uses.

Designated Uses

Streams have specific designation classifications based on their use. Uses such as swimming, fishing, drinking water or maintaining aquatic life fall into different classifications. Each class has a series of rules that applies to it, known as the **IDNR water quality standards**.

The listed **designated uses** for Walnut Creek
(Waterbody ID Code: IA 04-RAC-0020_1) are below:

- *Class A1 (Primary contact recreational use):* The recreation uses involve full body immersion with prolonged and direct contact with the water.
- *Class B (WW-2):* Typically smaller, perennially flowing streams capable of supporting and maintaining a resident aquatic community, but lacking the flow and habitat necessary to fully support and sustain game fish populations.

Sources:
IDNR website *"What does 'Designated Use' mean?"*
http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WaterQualityStandards/DesignatedUses.aspx
Iowa DNR 305(b) Water Quality Assessment Database – 2014 Water Quality Assessment.
Iowa Surface Water Classifications (567 Iowa Administrative Code 61.3).

Impaired Waters Status

The lowest 7.6 miles of Walnut Creek are listed on the State of Iowa's 305(b) list as an impaired waterway. Streams are added to the **impaired waters** list if conditions exist that have a negative impact on one or more of the streams' designated uses. For each stream studied, each use is categorized as being fully, partially or not supported.

Portions of Walnut Creek are listed as Category 4a , meaning that it is impaired or a downward water quality trend is evident, and a TMDL (Total Maximum Daily Load report) has been prepared.

Primary contact recreation uses (Class A1) are listed as "not supported" based on data from Iowa Geological Survey snapshot monitoring from 2004 through 2008. The levels of indicator bacteria (E.coli) at multiple sampling points were far in excess of the water quality criterion established by the State of Iowa. (These criteria for E.coli are a *geometric mean* for all samples of 126 organisms per 100 milliliters (mL) and a single sample maximum of 235 orgs/100 mL)

Aquatic life support is listed as "fully supported" based on data collected in the 1998 IDNR/UHL stream biocriteria project (Class B).

The lower Raccoon River (Waterbody ID Code: IA 04-RAC-0010_1) is listed as impaired by bacteria and nitrates. Elevated bacteria levels are the reason it is listed as "not supporting" primary contact recreation.

In addition to the uses established for Walnut Creek, the Raccoon River has the following designated uses:

Class C (Drinking water supply): Water is used as a raw water source of potable water supply.

Class HH (Human health): Waters where fish are routinely harvested for human consumption or where water is used as a drinking water supply and where fish are routinely harvested for consumption.

Source: Iowa DNR 305(b) Water Quality Assessment Database – 2014 Water Quality Assessment.

The river is also listed by the state of Iowa as a **high-quality resource**, or a water "of substantial recreational or ecological significance which possesses unusual, outstanding or unique physical, chemical or biological characteristics."

Applicable Water Quality Standards

The TMDL established for the Raccoon River set **maximum contaminant levels** (MCLs) for both nitrate and bacteria.

The Raccoon River is listed as "fully supporting" fish consumption. However, nitrate levels frequently exceeded the maximum contaminate level for nitrate of 10 mg/L, leading to this stream segment being categorized as "not supporting" use for drinking water.

Source: IDNR 305(b) Water Quality Assessment Database
https://programs.iowadnr.gov/adbnet/assessment.aspx?aid=12318

The Raccoon River TMDL report set the MCL for nitrate for single samples at 9.5 mg/L (which includes a factor of safety below the acceptable limit established by the state (10.0 mg/L)). The MCL for bacteria for single samples was established to be 200 organisms / 100 mL, which also includes a factor of safety below the state water quality standard (235 org./100mL). These standards are to be applied to major tributaries of the river (such as Walnut Creek) which have been designated as impaired by these pollutants of concern.

Previous Studies

Water Quality Improvement Plan for Raccoon River (TMDL)—2008

The federal **Clean Water Act** required the Iowa Department of Natural Resources (IDNR) to develop a Watershed Improvement Plan, also known as a Total Maximum Daily Load (TMDL), for waters that have been identified on the state's 303(d) list as impaired by a pollutant. These plans determine current pollutant loads and determine the required reductions needed to bring levels back below the desired standard. Three segments of the Raccoon River have been identified as impaired by nitrate and five segments by the **pathogen indicator bacteria** (E.coli TMDL, p.12). The segment of Walnut Creek in Polk County, downstream of I-80/35 is one of several Class A1 streams within the Raccoon River watershed which were within the report prepared for the overall Raccoon River TMDL.

Surface water from the Raccoon River is used as a drinking water source for the Cities of Des Moines and Panora. Because of this, the Class C water quality standard applies to the Raccoon River at these two locations. Between 1996 and 2005, nitrate concentrations at the Des Moines Water Works (DMWW) exceeded state water quality standards 24.0% of the time. Higher concentrations were observed during April, May and June as well as November and December. Nitrate concentrations were highest during higher flows, with an average concentration of 10.0 mg/L when flow rates were in the highest 25% of recorded levels (TMDL, p 12).

E. coli is used as the indicator bacteria for Class A waters (waters with a recreational use where human contact is likely to occur). Sampling data suggests that all Class A1 waters in the Raccoon River watershed could be considered as "not supporting" their designated uses. Therefore, the conclusion of the Raccoon River TMDL report was to assign a maximum contaminate level (MCL) to all of these streams within the watershed which had not been previously classified (TMDL, p 14).

Highest concentrations were observed during May, June and July, although concentrations above 10,000 organisms/100mL were observed in some samples collected at DMWW in all months except February and December. Highest concentrations were observed when flows were highest, with the median concentration being 665 organisms/100mL in the highest upper 25% flow range (TMDL, p 14). **Non-point sources** were expected to contribute up to 99% of the total loading, on days when observed concentrations were higher than the established standards (TMDL, p 15).

The TMDL report projects that reductions of nitrate loading of 48% would be required to reduce nitrate concentrations to 9.5 mg/L for all storm events. Loading of E.coli is projected to require more than 95% reduction to reduce levels to 200 org./100mL for all ranges of flow, with more than 99% reductions required when flows are in the upper 70% of observed levels.

For a more detailed summary about the TMDL report for the Raccoon River, refer to the technical memo on this topic included in the appendix of this management plan.

Five load reduction strategies were analyzed by computer modeling as part of the TMDL report:

1. Reducing the rate of ammonia fertilizer application.
2. Remove all cattle from the streams.
3. Remove all human waste from the watershed.
4. Convert all row crop lands located on slopes greater than 9% slopes to CRP grassland.
5. Convert all row crop lands located on floodplain soils to CRP.

Several other strategies were also listed to address nitrate and bacteria pollution:

- Strategically construct new wetlands near tile outlets.
- Implement urban stormwater **best management practices** (BMPs).
- Changing fall applications of fertilizer to spring.
- Changing fertilizer application method.
- Use **nitrification inhibitors**.
- Improved **manure management**.
- Adopt comprehensive farm **nutrient management plans** using NRCS Conservation Practice Standard 590.
- Adopt **conservation tillage**.
- **Contour planting and terracing**.
- Use **cover crops**.

Raccoon River Watershed Water Quality Master Plan—2011

This plan was prepared by Agren, Inc., funded by a grant from the Iowa Department of Natural Resources (DNR) to the Missouri and Mississippi Divide RC & D. The plan states that it "does not define specific outcome targets for water quality, nor does it prescribe a specific vision of what constitutes an environmentally and economically prosperous Raccoon River basin. Rather, it focuses on common needs that have been identified by, and are broadly supported by, multi-disciplinary experts and watershed stakeholders." (p 3-4)

The plan organized identified priorities into nine recommendations (p 5):

1. Develop a regional planning organization to guide implementation of the Raccoon River Watershed Water Quality Master Plan.
2. Conduct public education to improve awareness of water quality and instill a personal commitment to water quality improvement among all watershed residents.
3. Focus outreach and education efforts to farm operators and agricultural landowners on nutrient and drainage management strategies.
4. Aggressively pursue opportunities to facilitate private-sector conservation planning services.
5. Take full advantage of emerging technologies and LiDAR elevation data to identify areas of concern and target practices based on landscape characteristics at the field level.
6. Target implementation of agricultural best management practices to priority **subwatersheds** and **priority impairments**.
7. Enhance effectiveness of nutrient control and removal practices by encouraging a "stacked" approach to nutrient management such as reduce, trap, and treat.
8. **Monitor** water quality at the subwatershed scale to characterize existing conditions and evaluate effectiveness of watershed projects and conservation practices.
9. Continue to assess long-term water quality status and trends in the Raccoon River and enhance these efforts as resources allow.

The plan discussed the topic of **subsurface tile** drainage. "Although subsurface tile decreases runoff from the surface of a field, subsurface flow and leaching losses of nitrate are increased. This is due mostly to an increase in flow volume and the 'short-circuiting' of subsurface flow, but also in part to the increased mineralization and formation of nitrate in the soil profile (Randall, Goss, and Fausey 2010). Subsurface tile drainage provides a direct channel from farm fields into adjacent surface water streams." (page 21)

Other findings listed were as follows:

- An organization is needed to carry out a strategic mission for the entire Raccoon River watershed, however to be effective, projects would need to target smaller geographic areas (p 25).
- The Iowa Stormwater Management Manual was identified as an under-used resource for educating communities on the issue of stormwater management and low-impact development (p 31).
- Recent surveys identified a lack of awareness among agricultural landowners regarding the impact of row crop production in tile drained landscapes (p 33).
- Proper messaging regarding the priority problem and the need for action needs to be developed. The absentee landowner needs to be successfully engaged (p 36).
- Creating an effective payment or incentive program to engage agronomists is important (p 41).
- A table of agricultural best management practices that were evaluated is included (p 50).
- The Walnut Creek watershed was listed as very low priority for nitrate reduction (p 55).
- The plan also listed the Walnut Creek watershed as very low priority for pathogen reduction (p 59). (This seems to be contradicted by available monitoring data which shows extremely high pathogen levels, especially in the urbanized area of the watershed).
- Phosphorus reduction was listed as a higher priority in areas outside the Walnut Creek watershed (p 64).
- Sediment reduction within the Walnut Creek watershed was listed as a medium priority (p 66).

A nutrient reduction strategy is described on page 73 of the Raccoon River plan, stating "adequate control of nutrients will require a combination of best management practices that 1) reduce the source of nutrients; 2) trap nutrients before they enter water sources; and 3) treat tile drainage water or surface runoff to reduce nutrients." A table of nutrient BMPs categorized by source reduction, trapping and treatment is included on that same page.

Iowa Nutrient Reduction Strategy—Updated 2014

The subtitle of this report is "a science and technology based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico." It was prepared by the Iowa Department of Agriculture and Land Stewardship (IDALS) along with the IDNR and Iowa State University's College of Agriculture and Life Sciences.

It was developed following the creation of the 2008 Gulf Hypoxia Action Plan that calls for states to create strategies to reduce pollutant loadings to the Gulf of Mexico. The Action Plan set a goal of at least 45% reduction in total nitrogen and total phosphorus loads. The Iowa Nutrient Reduction Strategy outlines steps to prioritize watersheds and resources, improve current state programs and increase voluntary efforts to reduce nutrient loadings (Executive Summary).

The Nutrient Strategy assigns pollutant loadings to both **point** and **non-point sources**. It assumes that a 4% reduction in nitrogen and 16% reduction in phosphorus can be accomplished by point source reductions such as improvements at wastewater treatment plants. The remaining 41% of nitrogen and 29% of phosphorus reductions are identified as being accomplished through non-point source reductions (page 3).

The Strategy projects that nitrogen losses are a greater concern in tile drained landscapes. The largest losses are expected to occur with sustained flows occurring in the spring and at times with little evapotranspiration and nutrient uptake. In steeper, hilly areas, phosphorus losses can be greater. Surface runoff and transported sediment are common carriers of phosphorus. The largest losses can occur after rainfall events (page 9). Streambank erosion is also identified as potentially significant source of phosphorus loading (page 10).

The Strategy includes the Iowa Nonpoint Source Nutrient Reduction Science Assessment. This is based on **peer-reviewed studies** of **in-field, edge-of-field** and **watershed scale practices** and treatments to determine potential reductions in total nitrogen and phosphorus.

The framework for the Nutrient Reduction Strategy includes several major points (pages 18-26). <u>Key items relatable to the Walnut Creek watershed are underlined.</u>

1. Prioritization of Watersheds. In 2013, the Water Resources Coordinating Council (**WRCC**) selected nine priority watersheds to focus targeted conservation and water quality efforts. The North Raccoon River was listed as one of these nine priority watersheds.
2. Determine Watershed Goals. The WRCC is tasked with coordination of indicators to provide stakeholders with information to establish baselines and report progress.
3. Ensure Effectiveness of Point Source Permits. The goal is to have major **Publicly Owned Treatment Works** (POTWs) install improvements to reduce nutrient outflow. <u>Permitted animal feeding operations will continue to be monitored</u>. Iowa point sources, IDNR, IDALS and WRCC will work to develop a nutrient trading credit program, based on 2003 EPA guidance.
4. Agricultural Areas. <u>Setting priorities includes a focus on conservation, in- and off-field practices, pilot projects and implementation of nutrient trading.</u> Research and Technology will continue to identify new technologies and solutions, develop private and public support for more research and continue to gain a better understanding of the Gulf Hypoxia Zone. <u>An approach to improved outreach, education and collaboration is outlined</u>. Programs for farmer recognition and a statewide education and marketing campaign is identified as a need. Sources of potential funding are briefly described.
5. Storm Water, Septic Systems, Minor POTWs and Source Water Protection. No specific nutrient reductions are identified for urban stormwater runoff. <u>However, a focus is given to infiltration of the water quality volume (runoff from a 1.25" rainfall event). By managing this volume, reductions of 80-85% of annual runoff volumes could be achieved. Septic systems are proposed to be addressed through time of sale inspections to identify and correct leaky systems</u>. The Iowa Source Water Protection Program educates the public and local officials on the importance of protecting groundwater drinking water resources. A link to potential funding sources is provided.
6. Accountability and Verification Measures. A technical work group will define the process for providing a regular nutrient load estimate. The IDNR will track progress of implementing the reduction strategy for permitted point sources. A system for tracking non-point sources and improvements is outlined.
7. Public Reporting. WRCC will develop public annual reports. <u>Watershed management plans are expected to include strategies to assess and demonstrate progress in achieving load reductions.</u>
8. Nutrient Criteria Development. IDNR continues to review and assess water quality, with development of a suitable nutrient criteria as a long-term goal.

Section 2 of the Nutrient Reduction Strategy contains the science assessment. Some key findings of note, as related to the development of a plan for the Walnut Creek watershed:

- Key practices for nitrogen removal:
  - Nitrogen management practices, **cover crops** and **living mulches**.
  - Land use changes to energy crops, **perennial vegetation** or **extended rotations**.
  - Wetlands, drainage water management, **buffers** and **bioreactors** are edge-of-field practices with greatest potential for nitrogen reduction.
- Key practices for phosphorus removal:
  - Reducing tillage and cover crops can significantly reduce phosphorus loss.
  - Land use changes from corn-soybeans to energy crops, perennial vegetation or extended rotations.
  - Edge of field practices that settle sediment such as ponds and stream buffers.
- The Science Team will publish an updated practice list as an addendum to the Reduction Strategy,
- Table 2 (p 6) and Table 3 (p 7) have details on expected load reductions for nitrogen and phosphorus for various practices and their expected impact on corn yield.

Source: USDA

Source: USDA

CHAPTER 5

KEY CONCEPTS

1. **The streams of this watershed currently are not "natural"**
   Most of the streams within the watershed have been altered by human activity. Most streams that were present naturally have been straightened and widened. Other streams have been created by grading or tiling. Some streams which did exist have been enclosed within pipes and culverts.

2. **Stream assessments identify problems**
   Nearly half of the significant streams in this watershed were reviewed in the field. Of these, 57% had signs of moderate to severe streambank erosion. Only 1% of streams in urban areas were considered to be stable.

3. **Increases in flow make small streams act like larger rivers**
   Streams throughout the watershed are often wider and lower than they were historically. They have formed wider and deeper channels to convey larger volumes of water.

4. **Buffers wanted**
   Buffer strips along streams were either absent or were not wide enough along almost half of the smaller streams across the watershed. This means nearly 100 miles of stream length could use better buffers.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Current levels of streambank erosion and management are far above historic levels. Private property and infrastructure near streams are put at great risk. Adequate stream buffers can reduce runoff, slow velocities, resist erosion, filter pollutants and provide important habitat.

Five

Character of Streams

57%

of all field assessed streams had moderate to severe erosion

Many streams are

4-10 times

wider now than they were prior to pioneer settlement. As they widen, streambanks are eroded, displacing trees and large amounts of soil; nearby property and infrastructure is often threatened.

239

miles of streams reviewed as part of the development of this plan

48%

of smaller streams *(0 or 1st order)* have no stream buffer or have a buffer that is less than 50 feet in total width

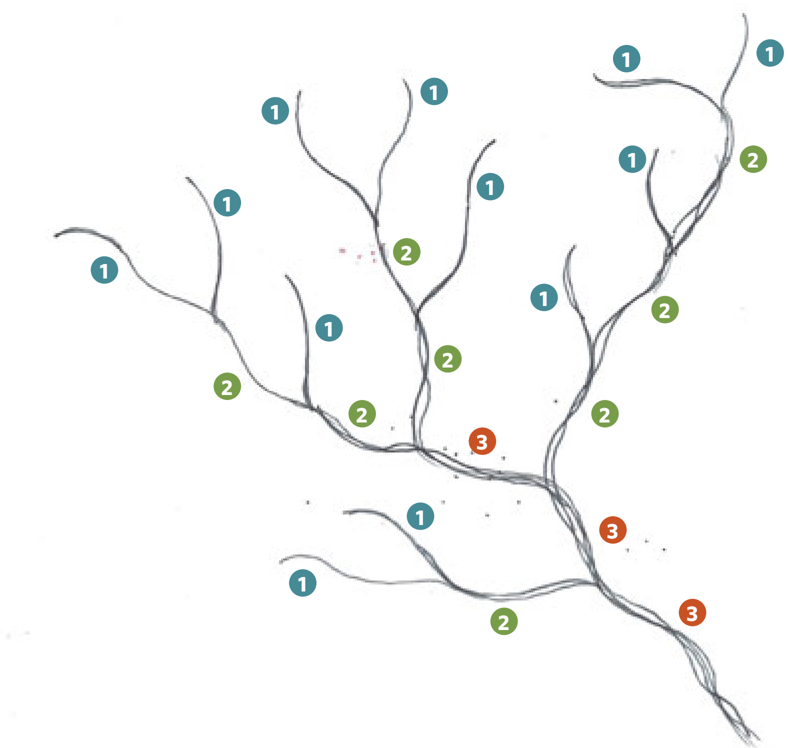
71%

of streams *(1st order and above)* are incised or deeply incised meaning they have downcut or become lower over time

What is a buffer? Buffers slow and filter runoff before it enters the stream.

Stream Order

Stream order is an important concept to understand in watershed planning. Streams of different sizes often have different challenges and opportunities for improvements. The IDNR has created maps of streams throughout the state. They group these streams into classes by stream order using the **Strahler method**. The headwaters of a given stream, where **perennial** flow is first observed are defined as first order steams. When two first order streams meet, they join to form a second order stream. When two second order streams meet, they join to form a third order stream. Two streams of the same order must meet in order to move up to the next order. For example, at the confluence of a first and second order stream, the downstream segment remains classified as a second order stream. The second order stream does not become a third order stream, until it meets another second order stream. [1]



Stream order classification

The Walnut Creek watershed includes first, second and third order streams. Most of the perennial streams in the watershed are of the first order. Lower sections of the Little Walnut, South Walnut and North Walnut Creek are second order streams. Walnut Creek is a third order stream downstream of its confluence with Little Walnut Creek.

Throughout the watershed, there are many swales, ditches, depressions and small streams that drain significant areas, yet do not have perennial flow and are not classified as first order streams. These drainage paths are clearly visible on LiDAR topographic imaging available through the State of Iowa. To better understand the properties of key flow paths throughout the watershed, many of these features have been mapped as "zero order" streams. As part of this effort, they were studied in similar detail to the more defined stream segments within the watershed.

Most of the streams reviewed in this plan are "zero order" and "first order" streams.

Streams that have year-round continuous flow during periods of normal rainfall are called "perennial streams." "Intermittent streams" normally stop flowing for extended periods each year. "Ephemeral streams or channels" usually only have surface flow right after rainfall events. (Adapted from Wikipedia definition of "perennial stream").

Stream Order	Length Within Watershed (miles)	Proportion of All Streams
0	143	60%
1	58	24%
2	21	9%
3	17	7%

Source: Stream order 1-3 data: IDNR Natural Resources GIS Library website. Stream order "zero" data as mapped by RDG Planning & Design, using information from Iowa Geographic Map Server website.

Source:

1. State University of New York; http://www.fgmorph.com/fg_4_8.php

USGS website; http://usgs-mrs.cr.usgs.gov/NHDHelp/WebHelp/NHD_Help/Introduction_to_the_NHD/Feature_Attribution/Stream_Order.htm

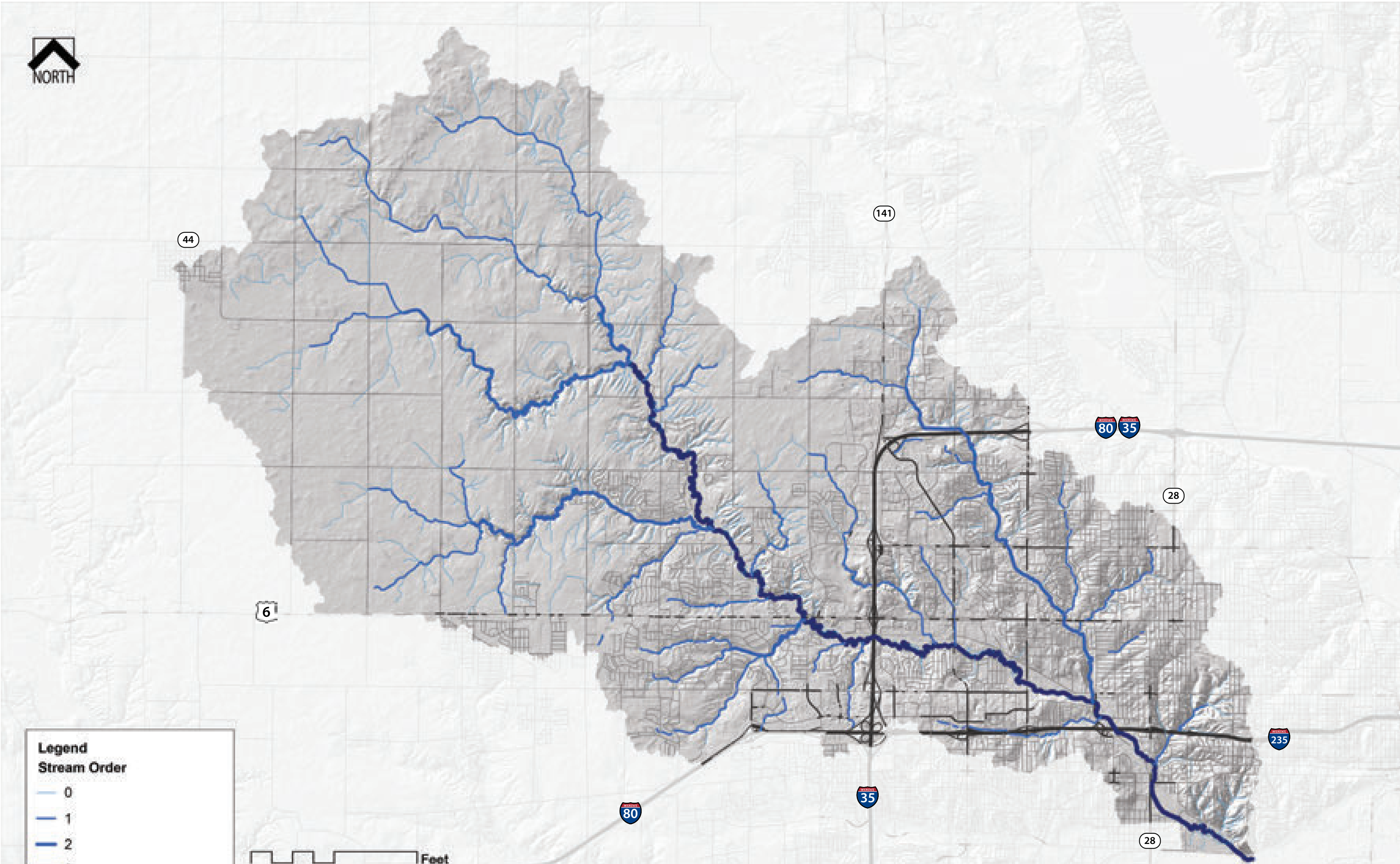
ZERO ORDER STREAM: A small "zero order" stream passes through a grass buffer in this photo.

FIRST ORDER STREAM: "First order" streams are often more defined and have constant flow.

SECOND ORDER STREAM: A "second order" stream pass through a treed buffer.

THIRD ORDER STREAM: A lower section of Walnut Creek is a "third order" stream

Source (all): RDG



Source: Stream order 1-3 data: IDNR Natural Resources GIS Library website. Stream order "zero" data as mapped by RDG Planning & Design, using information from Iowa Geographic Map Server website.

Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.

Stream Order

Vertical Stream Character

These basic categories were used to describe the general types of stream cross-sections that have been observed during field assessments and desktop GIS information review. They are used to evaluate the relationship of a stream to the surrounding areas and the severity of past erosion.

Larger streams are more likely to be incised or deeply incised. Ravines most commonly appear on smaller streams with steep slopes.

Vertical Stream Character by Stream Order

Stream Order	P	U	D	I	DI	R	G	V
0	3%	11%	55%	9%	8%	10%	2%	2%
1	8%	2%	28%	11%	45%	6%	0%	0%
2	4%	0%	2%	14%	73%	2%	5%	0%
3	0%	0%	0%	0%	100%	0%	0%	0%

Source: Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.


Pond

Vertical Stream Characteristics

Character Type		Description
P	**Pond**	Wet ponds, usually located on zero to second order streams and usually created by an artificial dam.
U	**Undefined**	These are parts of zero and first order streams in agricultural lands in the flat, upper areas of the watershed. Paths of **concentrated flow** are difficult to discern from topographic information. Sometimes these paths can be determined by wet areas observed in aerial photographs. There is little or no daily flow observed between rainfall events.
D	**Defined**	Sections of zero to second order streams where the flow path can be seen using **LiDAR** topographic maps. Road ditches, swales and more concentrated flow paths in farm fields fall into this category.
V	**Valley**	Similar to a ravine, but with more gentle side slopes and with minimal active erosion. Flow passes through a narrow point. The top of the valley is most often more than 100 feet wide.
I	**Incised**	Erosion is visible on some portions of zero to second order streams where the stream is beginning to downcut into the soil. This "incision" usually begins on streams with moderate to higher slopes with a narrow cut of one to five feet in width and one to two feet in depth. In this condition, normal stream flow is beginning to be separated from the rest of the natural flood plain.
DI	**Deeply Incised**	Where downcutting has progressed past a small incision, erosion can range from three to fifteen feet (or more) in depth, at widths from 5 to more than 50 feet. The cross-section of the stream is actively deepening and/or widening to convey additional flow. Most of the higher order stream segments within the watershed fall into this category. At this stage, normal stream flow is disconnected from the surrounding flood plain.
R	**Ravine**	Ravines (or gullies) were considered to be smaller order stream segments, usually with steeper slopes. Active downcutting is often visible in these segments. The rate of erosion is moderate, with the stream channel cross-section forming a "V" shape with a narrow bottom and steep sides. The top of the ravine is usually 20 to 100 feet wide.
G	**Gorge**	Similar to a ravine, but with more rapid erosion. The channel cross-section has a wider bottom, forming a shape more similar to a "U." Depths of erosion can exceed 20 feet and the top of the gorge can be 40 to 60 feet in width.


Undefined
Source: RDG


Deeply Incised
Source: RDG


Defined
Source: RDG


Ravine
Source: RDG


Incised
Source: RDG


Gorge
Source: Greg Pierce

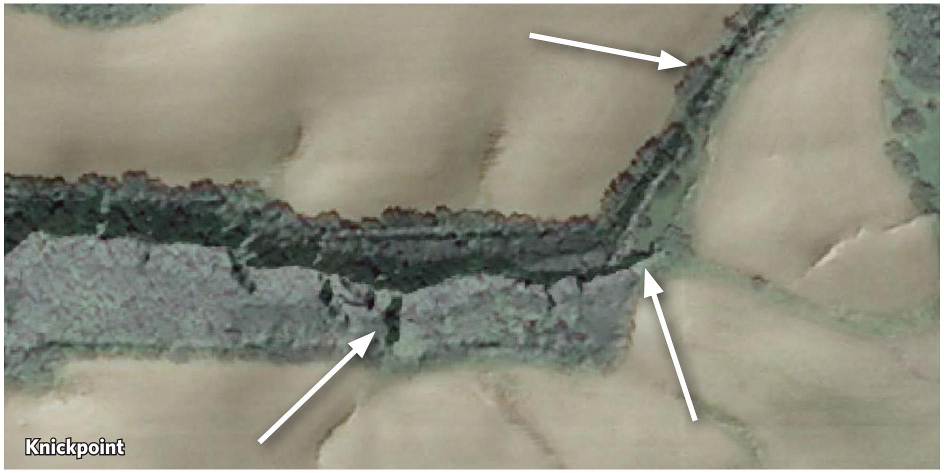
Horizontal Stream Character

These basic categories were used to describe the general types of stream alignments that have been observed during field assessments and desktop GIS information review. They are used to evaluate the relationship of a stream to the surrounding areas and the potential for movement of the stream.

Horizontal Stream Characteristics		
Character Type		Description
B	Braided	This is where the stream is divided into multiple paths, separated by islands or where multiple points of erosion have occurred.
M	Meandering	The stream weaves back and forth through a series of tight curves.
O	Oxbow	These are remnants of past channel locations. As the stream moves and meanders, low spots are left in the landscape where the stream channel used to be. They are often filled with sediment during large flood events, becoming much more subtle features over time. Since these are no longer the primary path of flow of the stream, they were catalogued as "zero order" streams, even though they usually were found alongside higher order streams.
K	Knickpoint	These are segments where a sudden drop or waterfall occurs. Below the drop, the stream is actively incising (downcutting). These knickpoints tend to work their way upstream over time, as erosion grows more significant. The downstream channel is left wider and flatter than before, able to convey larger flows at lower velocities than the stream above. These are usually located on smaller order streams. Often, the downstream alignment follows a straightened path. The knickpoint is usually at a defined point, but for the purpose of this analysis, longer segments were defined as this feature type when the knickpoint existed within them.
S	Straightened	Almost all segments have been altered, straightened or restricted from movement in the past. For this analysis, the stream was defined as straightened if it was a stream with constant flow where the alignment and general character of the original drainage ditch construction was clearly evident.
N/A	No Definition	The location and character of most of these segments have been significantly altered by human activity, but they don't clearly fall within any of the definitions above.

Horizontal Stream Character by Stream Order						
Stream Order	B	M	O	K	S	N/A
0	<0.1%	3%	3%	6%	7%	81%
1	0%	30%	0%	1%	28%	42%
2	0%	61%	0%	0%	30%	9%
3	0%	70%	0%	0%	25%	5%

Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.



Source (all): Iowa Geographic Map Server website.


Straightened
Source: RDG


Straightened Aerial
Source: Iowa Geographic Map Server website

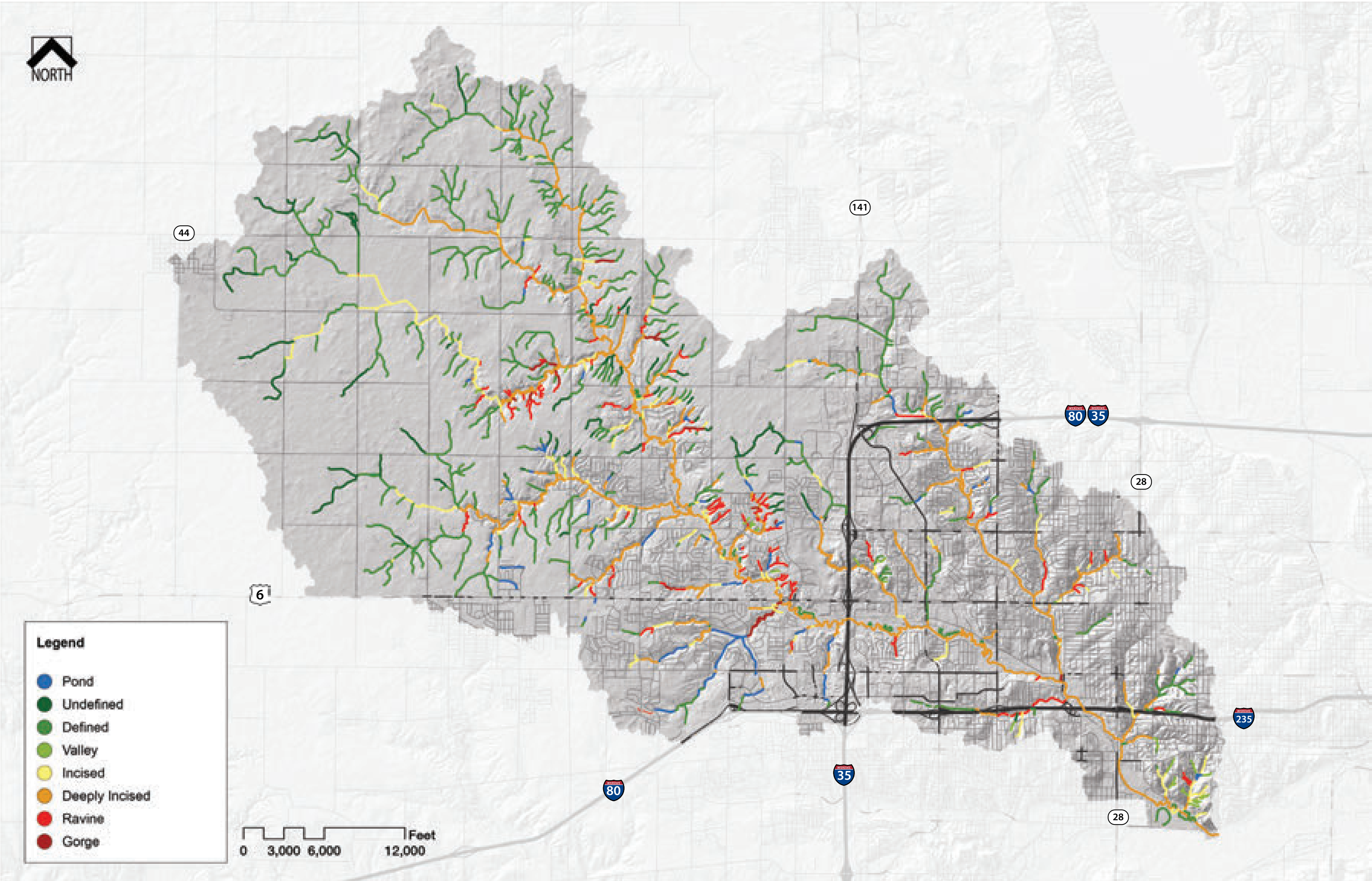

Tiled
Source: RDG

Why are the horizontal characteristics of a stream important?

These characteristics tell much about the history of a stream and how it is expected to behave in the future.

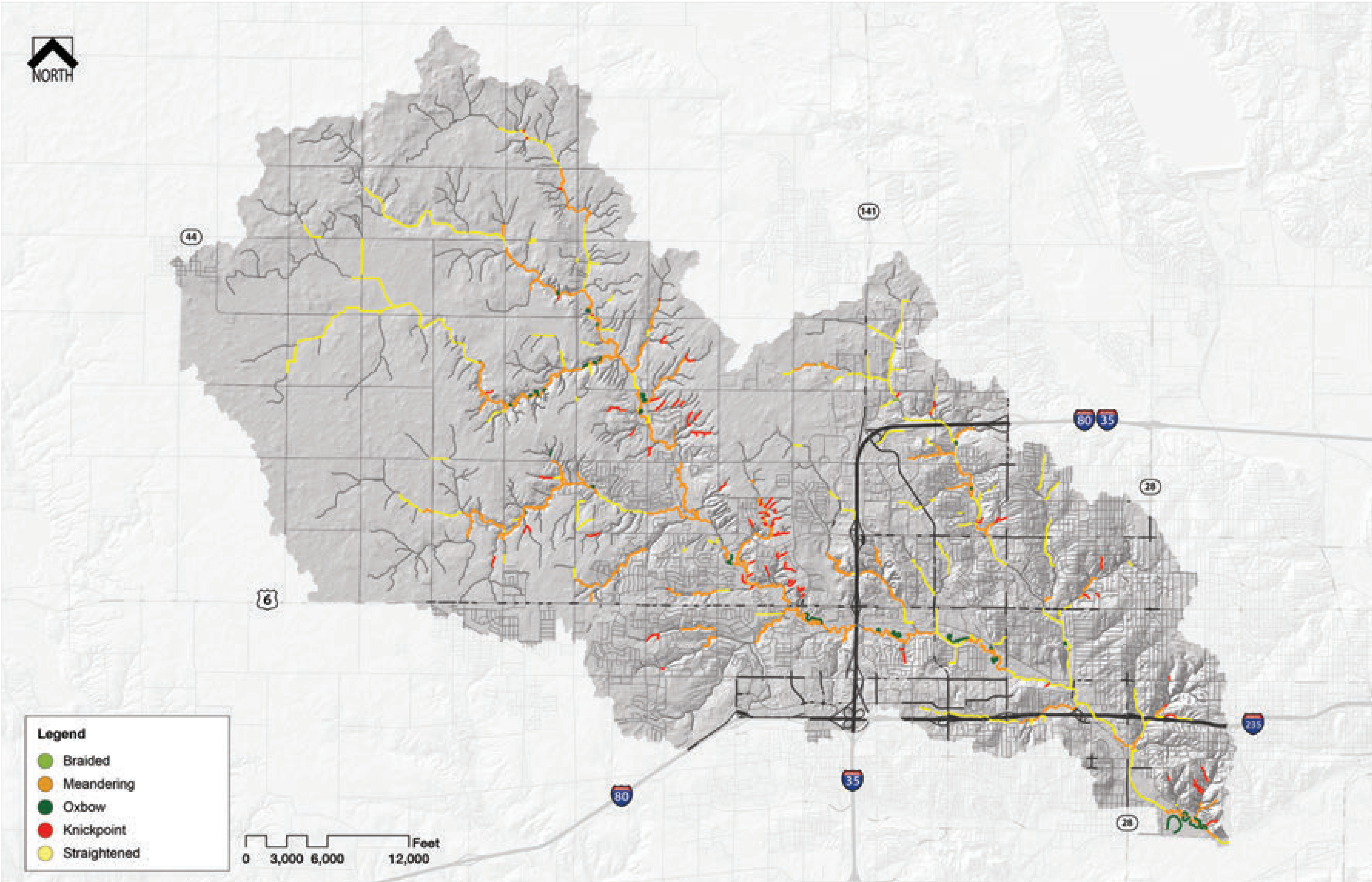
- Meandering streams are changing paths over time. The rate of change may be more rapid in areas with higher flow.
- Oxbows are past stream channels, where the main path has moved a different direction, leaving a depression or pond where the old channel used to be.
- Knickpoints indicate that there may be active erosion (downcutting) which will move upstream over time.
- Straightened streams have had their paths altered by construction of ditches, dikes or levees. They usually will push water downstream at an accelerated speed, which could lead to more significant erosion downstream.
- Some drainage paths with relatively large drainage areas (more than a square mile in some cases) may not show signs of being a stream at all. In agricultural areas, this is usually due to the installation of subsurface tile drainage lines.

Larger streams develop meanders more frequently. Stream meandering is a natural process; however, increases in streamflow and sediment load can accelerate that process far beyond natural levels.



Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.

Vertical Stream Characteristics



Source: Analysis by RDG Planning & Design, using field observations and information from Iowa Geographic Map Server website.

Horizontal Stream Characteristics

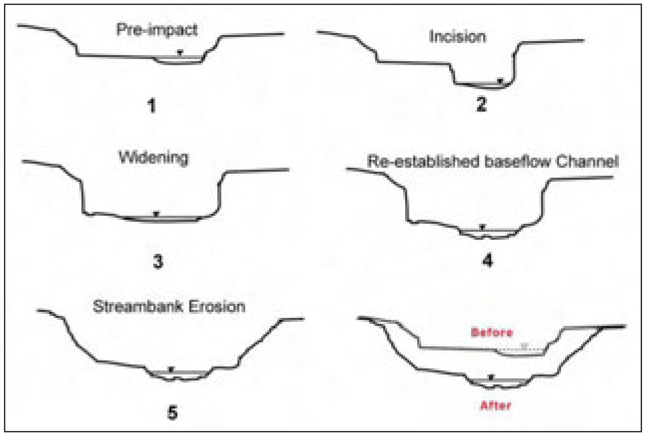
Stream Evolution

The study of stream evolution is called **fluvial geomorphology**.

One method of stream path change involves sediment settling out of flow in areas where velocity is reduced (i.e. inside curve of stream bends, downstream of obstructions like downed trees or debris piles). As sediment collects, it piles up and can change the normal path of flow, often forcing it toward the outer banks of the stream. As this happens, stream velocity increases along the edges of the stream, leading to more streambank erosion. The sediment lost from the streambank is carried downstream until it reaches a place where velocities slow to a point where sediment can settle out. This is a cycle of erosion and deposition which repeats over time. The stream meanders, and flow paths form and disappear. In some areas along Walnut Creek, there is evidence of past meanders that are more than 500 feet from the current stream.

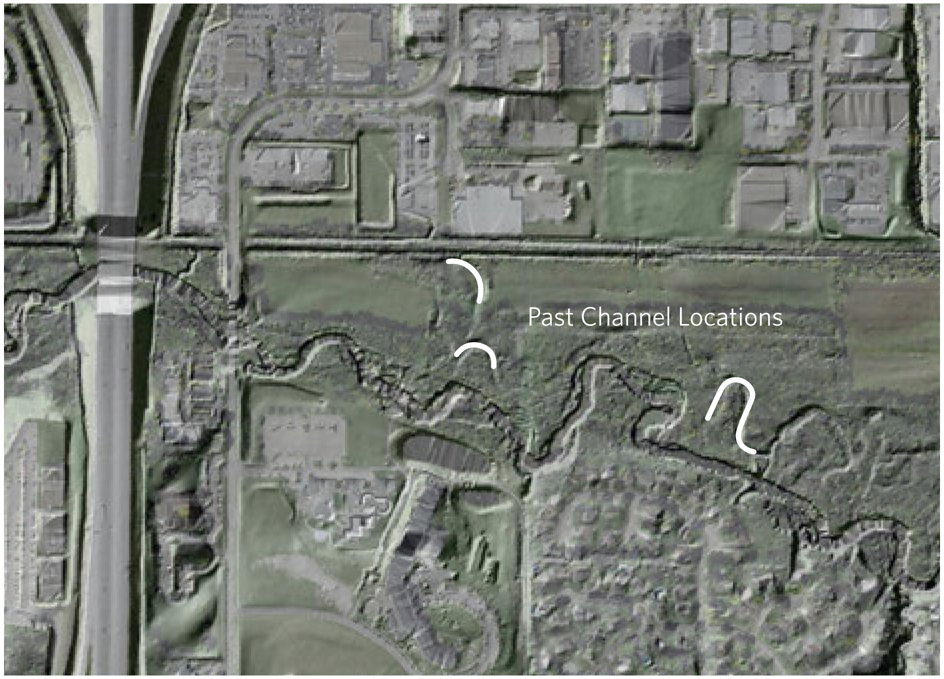
Changes in land use can magnify this effect to levels not seen within the native landscape. Increases in the rate and volume of runoff result in faster and deeper streamflows. These effects increase the erosive force on the bed and banks of the stream. This shear force cuts against stream banks, widening the stream. The bed of the stream begins to be incised, or downcut.

Sources of increased sediment loads, such as cropland, gullies and construction sites with insufficient controls can accelerate the cycle of stream evolution. Over a long period of time, a wider and flatter stream is created, capable of conveying higher flow volumes. The new channel is often several feet lower than the natural stream bed. This results in a stream that is disconnected from the flood plain above. When streams are disconnected from their floodplain, it is more difficult for water to spread out across the floodplain where it can flow more slowly allowing for absorption and filtration. Disconnection also changes the habitat conditions for a variety of plants, insects and animals which rely on having access to a stable boundary between stream and floodplain.



Channel Evolution: Progressive Stages of Channel Incision
Source: Schumm, 1999


Areas where sediment has deposited

Evidence of past channel locations seen in LiDAR topography


Streambank Stability Analyses

Two separate stability studies were reviewed as part of development of this plan. The first was completed within the scope of this planning process by staff from the Polk County Soil and Water Conservation District. Their efforts completed a RASCAL (Rapid Assessment of Stream Conditions Along Length) survey of more than 28 miles of streams, primarily in the rural areas of this watershed. This assessment was completed in the field during the summer months of 2015, walking along each segment using a GPS data collector equipped with the RASCAL software to gather information about a variety of characteristics of the stream.

The second was the 2014 Clive Stream Assessment Report Update. This study reviewed the stability conditions of streambanks of more than 13 miles of streams within the City of Clive. Most of these assessments were completed within the publicly owned Clive Greenbelt. This report was an update to assessments completed in 2009, which was conducted using the RASCAL protocol.

Collectively, these two studies evaluated streambank stability for nearly 42 stream miles within this watershed. This represents a current evaluation of 44% of the total length of first through third order streams in this area. Other studies have also been completed in the past by other cities, which were reviewed as part of development of this plan. In some cases, specific GIS data from these other studies was not available for analysis. In other cases, the data provided was from before 2014, so it was not considered a current evaluation of stream conditions and was not included in the statistical analysis for this plan.

	2015 RASCAL Survey		2014 Clive Assessment		Combined	
Bank Stability	**miles**		**miles**		**miles**	
Stable	5.89	20.8%	0.10	0.7%	5.99	14.4%
Minor Erosion	7.72	27.3%	4.24	31.6%	11.97	28.7%
Moderate Erosion	7.41	26.2%	5.83	43.4%	13.24	31.7%
Severe Erosion	7.26	25.7%	3.26	24.3%	10.52	25.2%
Total	28.29		13.43		41.72	

Less than 1% of urban streams assessed were categorized as stable. 68% of urban streams were seen to have moderate or severe erosion.

Source: Includes analyses by Polk County SWCD (2015) and Clive Stream Assessment Report Update (2014).

These assessments generally grouped streambank conditions into four categories:

- *Stable*—Banks were protected by natural vegetation and were not showing signs of lateral erosion.
- *Minor erosion (or moderately stable)*—Banks were mostly protected by natural vegetation, but the banks were showing signs of minor erosion.
- *Moderate erosion (or moderately unstable)*—Natural vegetation was not protecting major portions of the stream. Outer banks were often showing signs of erosion. Often there were some signs of trees and/or other vegetation falling into the stream within these segments.
- *Severe erosion (or unstable)*—Some straight reaches and inside bends were actively eroding, as well as almost all of the outer bends. Trees and vegetation were frequently falling into the stream. Little or no natural vegetation was protecting the banks of the stream.

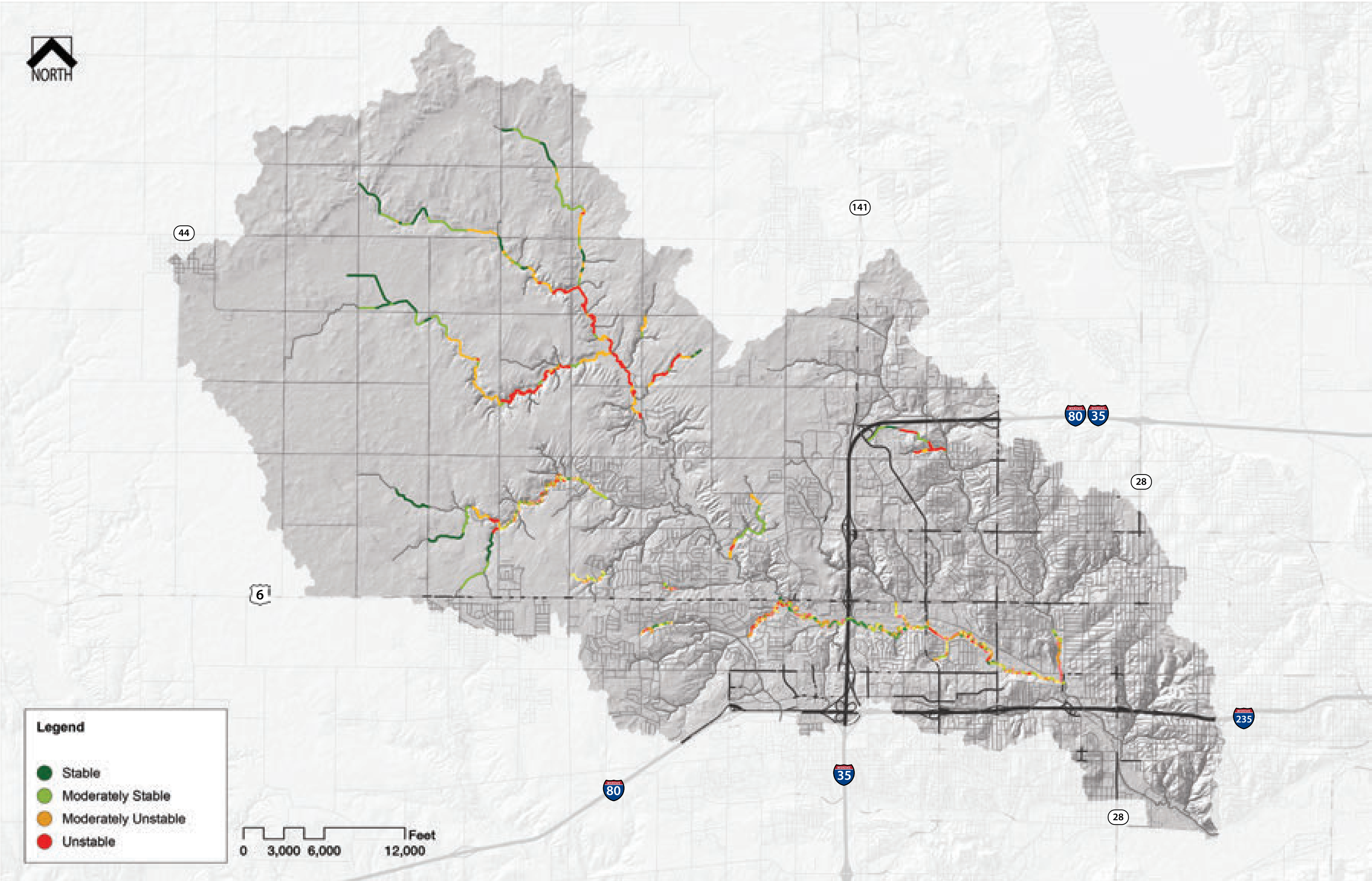
Definitions above were adapted from IDNR RASCAL protocol instructions.

What is notable from these studies is that streambanks appear to be more unstable in urban areas. Less than 1% of streams in urban areas were categorized as "stable," with 21% in this condition in the rural assessments. Moderate erosion is also much more noticeable in urban areas than in rural areas.

It is estimated that 11,300 tons of sediment loading per year may be caused by streambank erosion. Primary sources of this erosion are the 88.7 miles of stream segments that were categorized as "incised" or "deeply incised." The methods of water quality modeling that generated these estimates are explained in greater detail in Chapter 6 and in the appendices of this plan.

Sediment Load: How is it estimated?

To calculate sediment loads generated by streambank erosion, erosion rates were established for each of these four conditions. To account for loadings where streams were not assessed, the ratios above were applied to all streams which were noted as having a vertical condition as "incised" or "deeply incised," as described earlier within this plan. Ratios from the 2015 RASCAL survey were applied to non-assessed streams in rural areas. Ratios from the 2014 Clive Assessment were applied to those streams in urban areas.



Source: Includes analyses by Polk County SWCD (2015) and Clive Stream Assessment Report Update (2014).

Rascal Streambank Stability

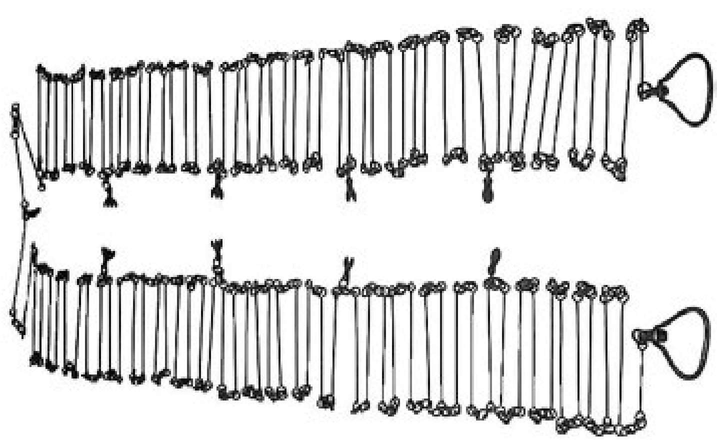
Stream Width

Streams throughout the watershed have changed significantly since pioneer settlement. The early surveyors measured the width of streams as they surveyed each section line (or the edge of each square mile of land). They would measure the width of streams by the numbers of links on their surveyor chains. Each chain had 100 links and the chain was 66 feet long. So each link in the chain was eight inches in length. By reviewing the original survey maps of this area, we can determine the width of the stream in their time (mid 1800s) and compare it today's conditions.

Two conclusions can be reached:

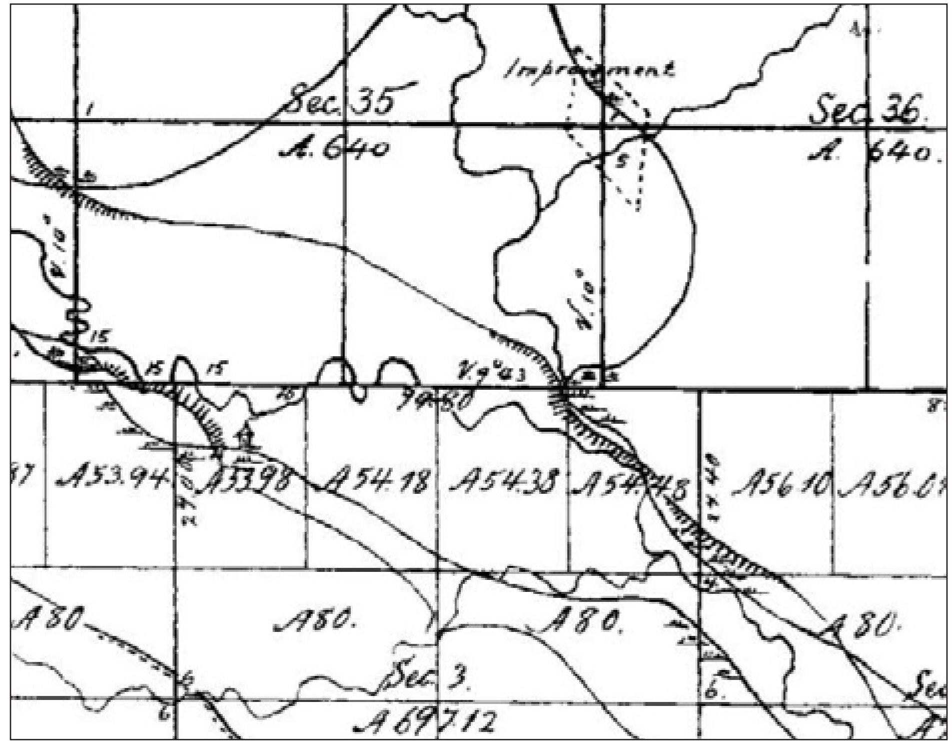
1. Fewer streams existed prior to settlement. The surveyors recorded streams as small as one foot in width. Many of the "zero" and some of the first order streams that exist today were not drawn on their survey maps and no measurement for stream width was recorded. As agricultural and urban uses have increased the portion of precipitation that is converted to surface runoff, new streams have been created. New streams were also created by draining the landscape to support agriculture during the late 1800's and early 1900's through installation of tiles and ditches.

2. The streams that did exist prior to settlement were much narrower than those we see today. The table on the following page notes changes in stream width between what was recorded by the original surveyors and what can be measured from the LiDAR survey of the state that was completed in 2007-2008.

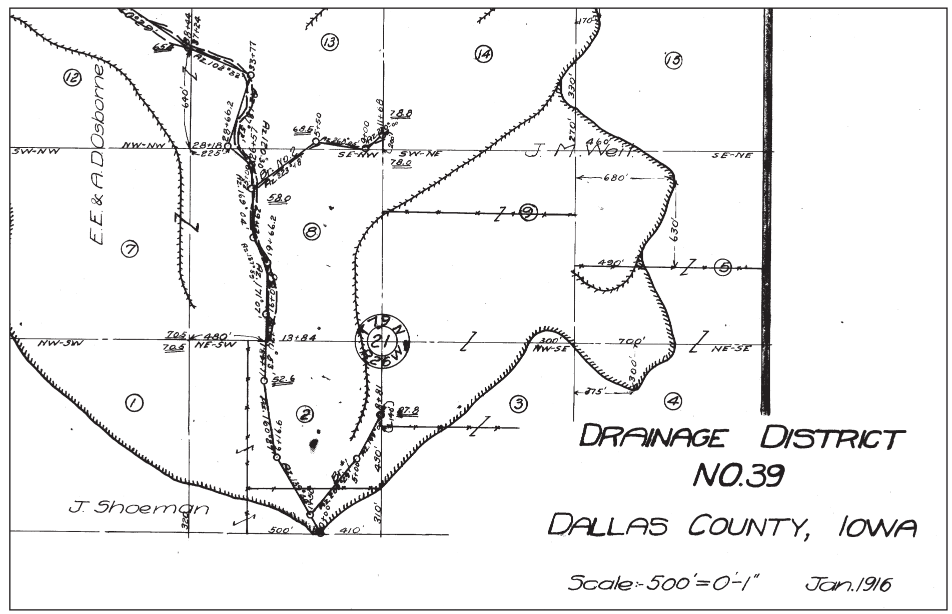


Survey Chain

Source: Williams Computer Science http://eventfuljava.cs.williams.edu/s04/labs/links/



1800s Land Survey Map

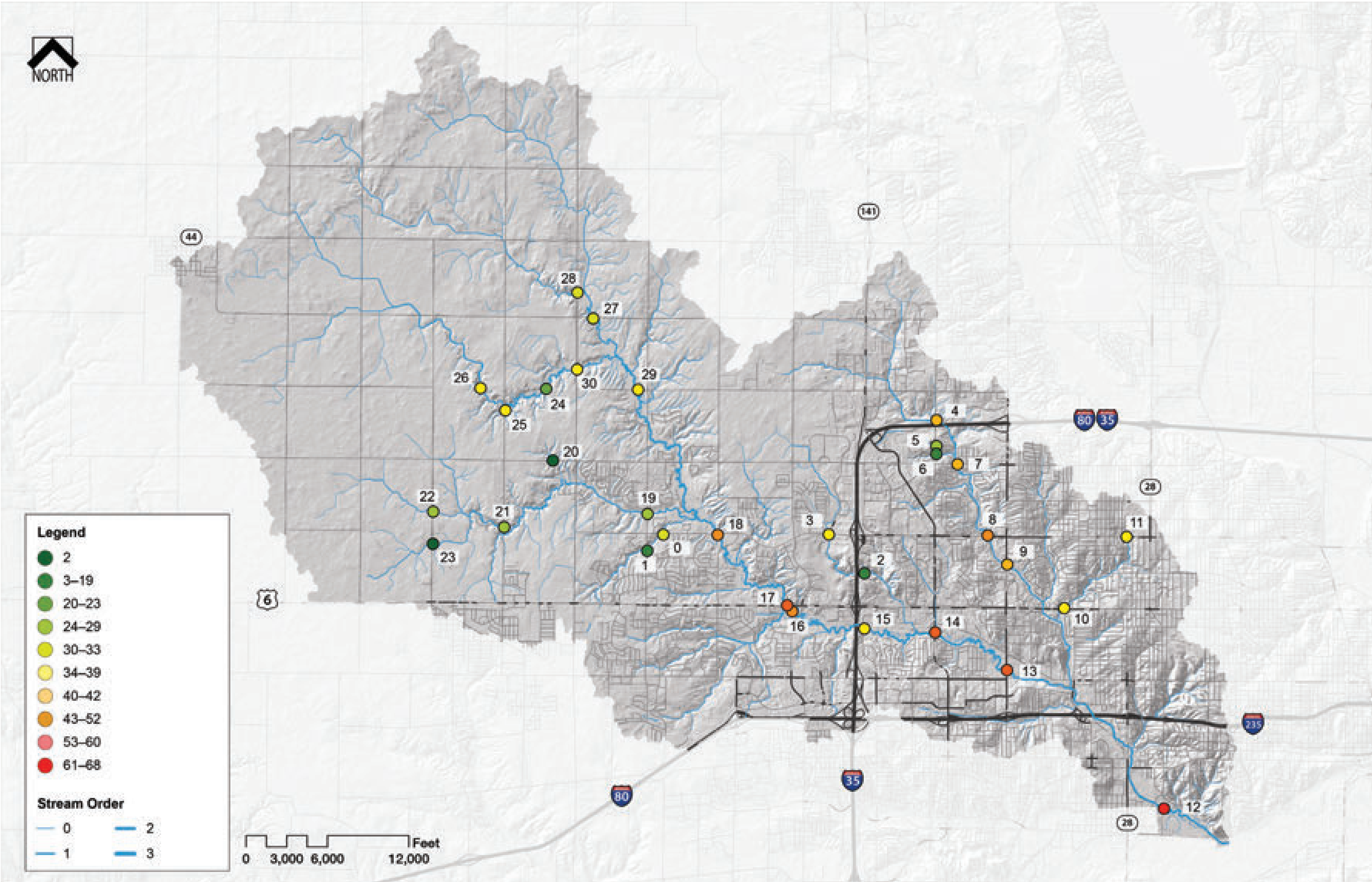


1916 Drainage District Map

ID #	Location	Microwatershed	Stream Bottom Width (in feet)		Change (in feet)	% Change
			Mid-1800's	Recent (LiDAR)		
0	Tributary to Little Walnut at Douglas Avenue	611.01	3	35	32	1067%
1	Tributary to Little Walnut at 156th Street	611.01	3	20	17	567%
2	Living History Creek at Projection of 114th Street	212.01	4	20	16	400%
3	Living History Creek at Douglas Avenue	212.01	4	40	36	900%
4	North Walnut Creek at 100th Street (Just North of I-35/80)	503.02	3	45	42	1400%
5	Tributary to North Walnut at Projection of 100th (S of Brookview)	503.22	1	30	29	2900%
6	Small Tributary to N. Walnut at Projection of 100th (N of Oakwood)	503.23	1	20	19	1900%
7	North Walnut Creek at Meredith Drive	503.01	3	45	42	1400%
8	North Walnut Creek at Douglas Avenue	502.02	4	55	51	1275%
9	North Walnut Creek at 86th Street	502.02	4	45	41	1025%
10	Rocklyn Creek at Hickman Avenue	511.01	4	40	36	900%
11	Rocklyn Creek at Douglas Avenue	511.03	1	40	39	3900%
12	Walnut Creek at Projection of 55th Street (DSM)	101.02	12	80	68	567%
13	Walnut Creek at 86th Street	201.01	10	65	55	550%
14	Walnut Creek at 100th Street	201.01	8	65	57	713%
15	Walnut Creek at 114th Street	202.01	10	45	35	350%
16	Walnut Creek at Old Alignment of 128th Street	202.02	10	60	50	500%
17	Walnut Creek at Hickman Road	203.01	10	70	60	600%
18	Walnut Creek at Douglas Avenue	203.03	8	60	52	650%
19	Little Walnut Creek at 156th Street	601.02	7	35	28	400%
20	Small Tributary to Little Walnut Creek at Meredith Dr.	601.31	4	6	2	50%
21	Little Walnut Creek at Warrior Lane	601.03	4	30	26	650%
22	Little Walnut Creek at U Avenue	602.01	3	30	27	900%
23	Tributary to Little Walnut at U Avenue	613.01	4	6	2	50%
24	Tributary to Walnut Creek at Projection of 260th (East)	701.01	7	30	23	329%
25	Tributary to Walnut Creek at V Avenue	701.01	4	40	36	900%
26	Tributary to Walnut Creek at Projection of 260th (West)	701.01	3	40	37	1233%
27	Walnut Creek at 250th Street	401.01	7	40	33	471%
28	Tributary to Walnut Creek at W Avenue	411.01	2	35	33	1650%
29	Walnut Creek at 260th Street	301.02	7	45	38	543%
30	Tributary to Walnut Creek at W Avenue	701.01	7	45	38	543%

These are 31 locations where mid-1800's surveys located and measured stream width. All are significantly wider today. Refer to Chapter 2 for more information on watershed ID numbering.

Source: Pre-settlement data from General Land Office Survey Maps from Iowa Geographic Map Server website. Recent data based on RDG measurements from LiDAR data available from Iowa Geographic Map Server website.



Stream Width

Stream Buffers

Variety of Buffer Types

Stream conditions throughout the watershed were observed and were grouped into seven general buffer descriptions, defined on the following page. The length of each type of buffer for each stream order for the entire watershed was calculated.

Several observations can be made from this analysis.

- Nearly 50% of all "zero order" streams pass through agricultural and urban landscapes without any noticeable buffer.
- Grass buffers were most common on smaller first order streams.
- Buffers along larger streams are more likely to include overstory trees, either from historically forested areas or locations where grass buffers have been allowed to evolve into a young forest.

Current Stream Buffer Widths

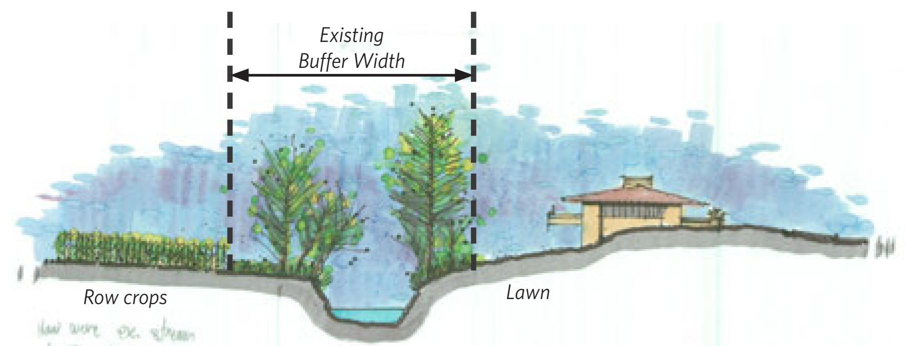
Existing buffers can generally be grouped into grass and tree buffers. Knowing the width of these buffers is important in understanding how effective each buffer will be in filtering runoff and providing important habitat. Buffer width for this study is defined as the total width measured across both sides of the stream.

Developing Overstory Aerial *Source: Iowa Geographic Map Server website*

Where they exist, grass buffers are often wider than 50 feet. However, 33% of "zero order" streams had grass buffers that are less than this width. Combining these lengths with those sections that were observed to have no buffer at all, means that 57% of all "zero order" streams in the watershed have either no buffer or grass buffers which are less than 50 feet in width. Grass buffers can be very effective in smaller order streams in capturing sediments, reducing pollutant loads and slowing runoff velocities. Their notable absence in large portions of the watershed is a concern.

Most treed buffers exceed 100 feet in width. These buffers tend to get wider along larger streams. Many of these higher order streams pass through urban areas. Their larger drainage areas lead to wider floodplains, limiting other development opportunities. Over time, many of these open spaces have developed into wider buffers of overstory trees. These areas need to be maintained through selective clearing to prevent overgrowth or development of **invasive species**.

Example of Buffer Width Measurement



For this study, stream buffers were measured from the edges of adjacent urban or agricultural uses.

Source: RDG


Grass Swale
Source: RDG


Range
Source: RDG


Overstory Aerial
Source: Iowa Geographic Map Server website


Tilled
Source: RDG


Partial Over Aerial
Source: Iowa Geographic Map Server website


Urban
Source: RDG

Generic Buffer Descriptions			
	Buffer Type		Description
No Buffer	T	Tilled	Water flows directly through row crop agricultural lands without any type of buffer.
	R	Range	Streams pass through pastures used to support livestock operations, where they have direct access to the stream and no fencing or other buffer is present.
	U	Urban	Streams pass adjacent to residential, commercial or other urban land uses without a discernible buffer between the land use and the stream. Manicured lawns, paved surfaces or even structures are located directly adjacent to the top of bank of the steam.
	G	Grass	A buffer of tall grasses or native vegetation (primarily without trees or shrubs) located along the stream.
Trees	D	Developing Overstory	Overstory trees are starting to establish within what was previously a grass buffer.
	P	Partial Overstory	The canopy cover of trees within the buffer is generally between 40 and 70%.
	O	Overstory	The buffer along the stream is more than 70% covered by a tree canopy.

Generic Buffer Types by Stream Order							
Stream Order	**T**	**R**	**U**	**G**	**D**	**P**	**O**
0	42%	2%	5%	17%	4%	4%	26%
1	6%	1%	15%	35%	2%	7%	33%
2	0%	8%	6%	12%	5%	11%	58%
3	0%	0%	0%	4%	15%	26%	55%

About 50% of zero order streams pass through a tilled field, pasture or urban area without a buffer.
Larger streams are more likely to have treed buffers.

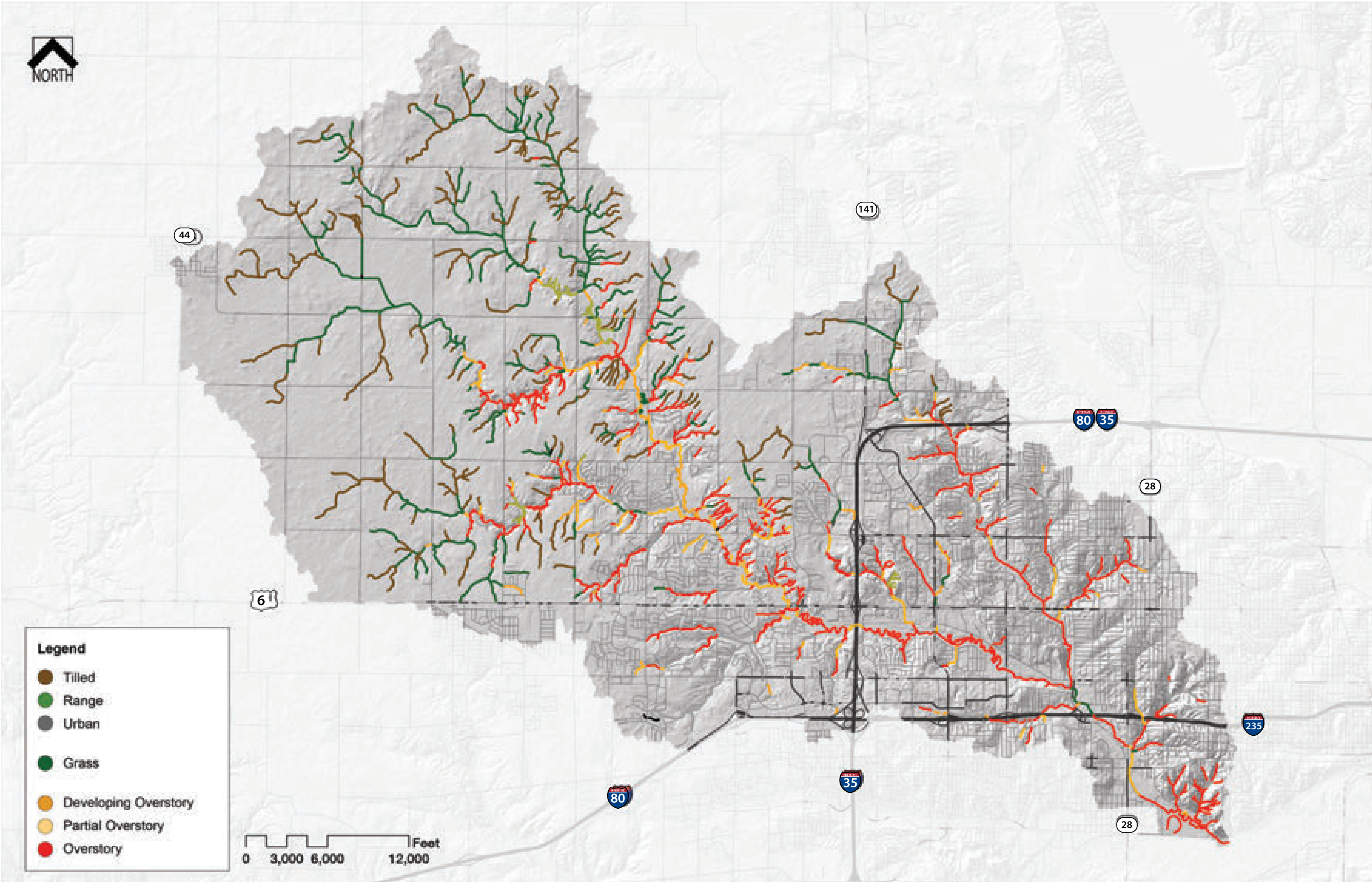
Grass Buffers					
	Buffer Width (feet)				
Stream Order	**< 10**	**11-49**	**50-99**	**100-199**	**> 200**
0	7%	26%	48%	15%	4%
1	0%	14%	16%	43%	27%
2	0%	0%	32%	12%	56%
3	0%	0%	0%	31%	69%

By combining areas with grass buffers of less than 50 feet in width with areas with no buffer, it is found that 48% of zero and first order streams have inadequate buffers.

Treed Buffers					
	Buffer Width (feet)				
Stream Order	**< 10**	**11-49**	**50-99**	**100-199**	**> 200**
0	0%	3%	20%	44%	33%
1	0%	1%	22%	36%	41%
2	0%	0%	12%	14%	74%
3	0%	0%	0%	15%	85%

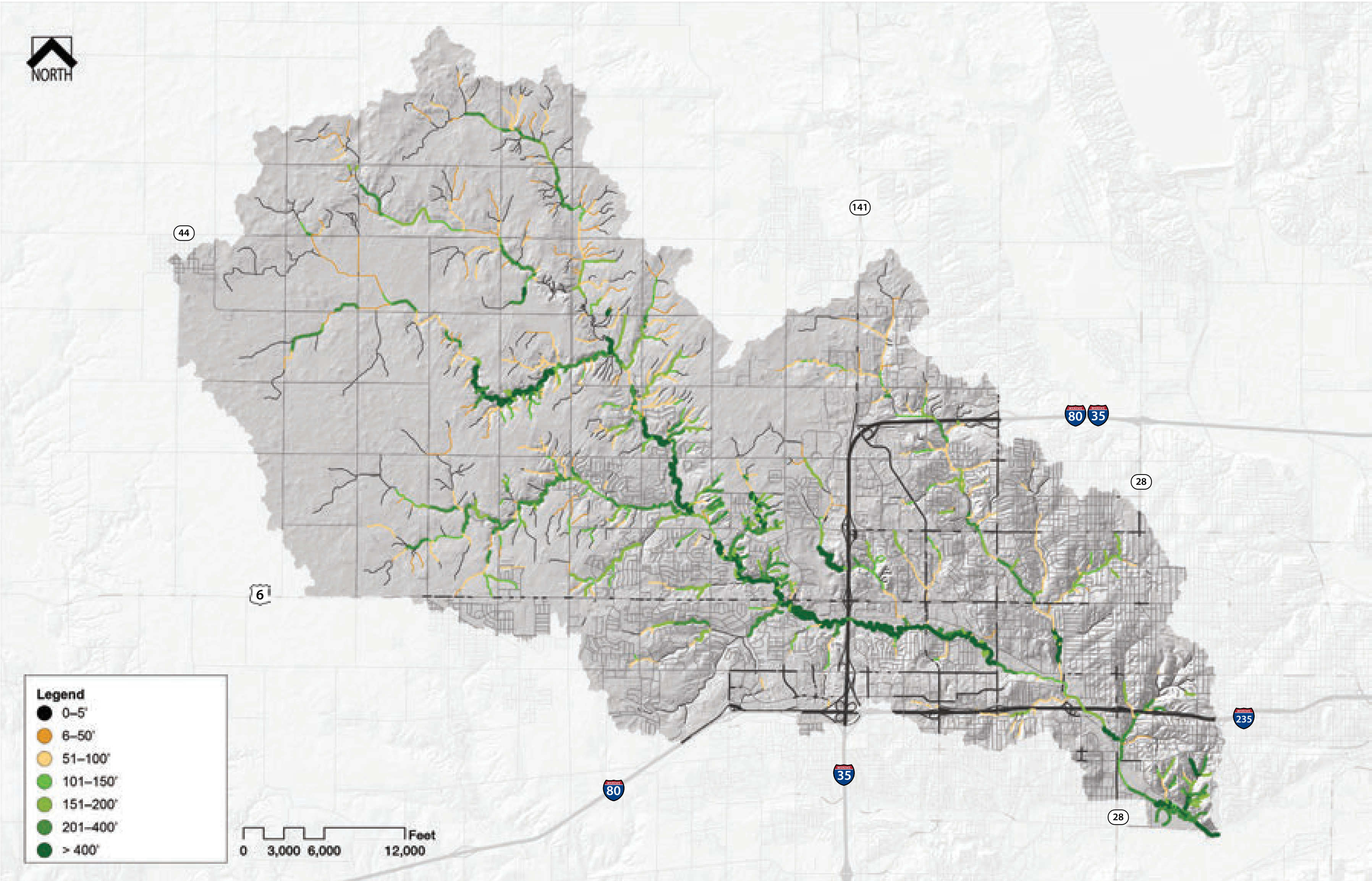
The majority of treed buffers are at least 100 feet in width.

Source (all): Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.



Source: Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.

Stream Buffer Types



Source: Analysis by RDG Planning and Design based on data from Iowa Geographic Map Server website.

Stream Buffer Widths

CHAPTER 6

KEY CONCEPTS

1. **Key pollutants of concern have been identified**
   Nitrogen, phosphorus, sediment and pathogens have been identified as the most important pollutants to address with this plan. These pollutants pose risks to human health and the environment, which are outlined within this chapter in greater detail. Strategies to prevent increases in stormwater rates and volumes also need to be considered, as stormwater tile flow and runoff are the largest carriers of these pollutants to the receiving streams. Local flooding has also caused damage to private property and infrastructure.

2. **Water quality monitoring data is valuable**
   Data collected by the Iowa Soybean Association / Agriculture's Clean Water Alliance (ISA/CWA) and the IOWATER volunteer monitoring program has been valuable to identify pollutant loads and their potential sources.

3. **Nutrient levels appear higher in rural areas**
   Monitoring data has demonstrated that levels of nitrogen and phosphorus compounds are usually seen at higher levels in the rural areas within this watershed.

4. **Bacteria levels appear higher in urban areas**
   Observed levels of E.coli bacteria have been much higher within the urban landscape, although levels all across the watershed were consistently above the state's water quality standard.

5. **Key sources of sediment loading**
   Streambank erosion, construction sites and gully erosion are projected to be the leading current sources of sediment loading to Walnut Creek. Almost 30,000 tons of sediment per year are estimated to be delivered from the Walnut Creek watershed to the Raccoon River.

6. **Small footprint, big impact**
   Construction sites make up only 0.1% of the watershed on average each year, but contribute significantly to the overall sediment load.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

To develop targeted, effective solutions, the key pollutants posing the greatest risk need to be identified. The likely sources of these pollutants need to be identified so that effective practices can be implemented to achieve the desired load reductions.

six

Key Pollutants and Sources

Water Quality Monitoring Samples

- Collected by Iowa Soybean Association/Agriculture's Clean Water Alliance and IOWATER volunteers
- Collected at two sites along Walnut Creek, every other week, throughout spring and summer
- IOWATER completed sampling at over 30 locations within the watershed, but more infrequently

Key Pollutants of Concern

- Nitrogen
- Phosphorus
- Sediment
- Pathogens *(bacteria and viruses)*
- Runoff rates and volumes

Agricultural Areas
Nitrogen and phosphorus compounds have been measured at higher levels.

Urban Areas
Levels of bacteria have been at higher concentrations.

Pollutant Sources By Land Use

	N	P	Sediment
Urban	14%	26%	7%
Cropland	81%	49%	10%
Pastureland	2%	2%	0%
Forest	0%	1%	0%
Grasslands	0%	0%	0%
Gully	1%	5%	19%
Streambank	2%	10%	38%
Construction Site	1%	8%	25%

Source: Results of STEPL modeling performed by RDG

8 loading reduction goals are outlined within this chapter.

Nitrates

Highest measured concentration

22.9 mg/L

More than twice the Raccoon River Total Maximum Daily Load (TMDL) standard of 9.5 mg/L.

(from Iowa Soybean Association monitoring data)

77,010 orgs./100mL was observed to be the maximum level of E.coli (indicator bacteria), which is more than 330 times the state's allowable average concentration of 235 orgs./100mL.

Available monitoring data within the Walnut Creek watershed was reviewed to aid in the identification of pollutants of concern, potential sources of pollution and to help inform and calibrate watershed water quality models. Several sources of information were reviewed.

Pollutants of Concern

Key **pollutants of concern** within the Walnut Creek watershed have been defined by considering the following information gathered through development of this plan:

1. Review of past studies, including the Water Quality Improvement Plan for the Raccoon River (TMDL), the Raccoon River Water Quality Master Plan and Iowa's Nutrient Reduction Strategy.
2. Review of past local and municipal watershed assessments and storm water infrastructure studies.
3. Collection of stakeholder input at WMA meetings, open houses and individual conversations.
4. An overview of the available water quality monitoring information collected from sites within the watershed.

Potential Impacts of the Identified Pollutants of Concern

This document identifies **key sources of pollution** and determines methods to reduce their impacts, both in this watershed and the downstream receiving waters. Reducing pollutant loads will require policy changes and implementation of practices requiring significant investment. To understand why such investments are necessary, it is important to realize the impact these pollutants have on health, the environment and local economic interests.[1]

Nutrients (Nitrogen and Phosphorus)

Nutrients like nitrogen and phosphorus exist in both surface and ground water under natural conditions. Their presence supports the growth of **algae** and aquatic plants, providing food and habitat for fish and other aquatic life within streams and lakes. Excessive algal growth can occur when the levels of these nutrients are too high. **Algal blooms** can block sunlight below the surface, clog fish gills, reduce habitat quality and diminish habitat. The death and decay of algae can lead to diminished oxygen levels, known as **hypoxia**. Oxygen levels can fall to a range where fish and other wildlife may be sickened or killed. As of 2013, there were 166 of these hypoxic "dead zones" that had been identified in and around the United States. The largest

Source:
1. http://www2.epa.gov/nutrientpollution/problem

Pollutant of Concern	Reasons
Nitrate (Nitrogen)	• The Raccoon River is listed as impaired by high nitrate levels, one of the reasons for development of the Raccoon River TMDL. • Nitrogen is one of the two key pollutants of concern listed within Iowa's Nutrient Reduction Strategy. • Levels of nitrate have routinely been observed at monitoring sites within the watershed above the State's water quality standard for the streams intended uses and above those levels established within the Raccoon River TMDL.
Phosphorus	• Phosphorus is one of the two key pollutants of concern listed within Iowa's Nutrient Reduction Strategy. • Levels of phosphorus have occasionally been observed at monitoring sites within the watershed above the State's water quality standard for the streams intended uses and above those levels established within the Raccoon River TMDL.
Sediment	• Insufficient construction site erosion control has been observed to be a significant source of sediment loading in certain locations. • Significant sediment deposition has been observed within channel areas of Walnut Creek and its tributaries. • Sediment loading has impacted the water quality and storage capacity of many ponds and lakes throughout the watershed, including Country Club Lake and Southfork Pond. • Depositing sediment has deflected and narrowed low flow paths, accelerating the horizontal movement of streams. This is leading to more significant streambank erosion, generating even higher sediment loads.
Pathogens	• The Raccoon River and lower Walnut Creek are listed as impaired by high bacteria levels, one of the reasons for development of the Raccoon River TMDL. • Levels of indicator bacteria at monitoring sites within the watershed have almost always been observed above the State's water quality standard for the stream's intended uses and above those levels established within the Raccoon River TMDL. In many cases, these levels have been well above the established standards, indicating a potential risk to public health.
Stormwater Quantity (Runoff Volume)	• While not considered a pollutant directly, volumes and rates of stormwater runoff are observed to be well above those which would have been expected prior to agricultural and urban development. These changes to the hydrology of the watershed increase the risk of flooding, streambank erosion and act as a carrier for larger pollutant loads being delivered through and out of the watershed.

of these areas was a 5,840 square mile area (approximately 10% of the size of the entire state of Iowa) in the Gulf of Mexico, largely attributed to nutrient polluted runoff received from the Mississippi River watershed (which includes the entire state of Iowa).

Excessive algal growth can also increase growth of bacteria and other human **pathogens**. In some cases, algae can form toxins which can cause rashes, stomach/liver illness, **respiratory** and **neurological** effects in humans. Direct exposure to this algae affects fish and other wildlife, with the toxic impacts being carried up the food chain if they are consumed by other animals. If toxic algae enter into the water supply stream, they can be converted into **dioxins** through the use of chemical disinfectants in the water treatment process. Risks to human health from dioxins include cancers, reproductive and developmental issues. (1)

Nitrate has been observed at elevated levels in stream flows within the Walnut Creek watershed. Des Moines Water Works' main intake point for surface water from the Raccoon River is located just downstream of where Walnut Creek flows into that river. Nitrates have been known to cause illness and death of human infants when at high levels.

Blue baby syndrome can affect the elderly and bottle-fed infants, with those younger than three months being most at risk. High nitrate levels in drinking water supplies can be converted by the human body into nitrite. These react with red blood cells, reducing their ability to carry enough oxygen throughout the body. The mouth, hands or feet of the affected person may appear blue. Complications can include trouble breathing, diarrhea, vomiting, lethargy, loss of consciousness and seizures. Extreme cases may be fatal. (2)

For this reason, Water Works employs a state of the art nitrate removal system, which is used when elevated levels of nitrate are detected in the source water. This system is expensive to operate and maintain, costing $7,000 per day to operate. From December 2014 to July of 2015, **DMWW** spent more than $1,500,000 to remove nitrate from the water. The cost of this operation is being transferred to residents and local businesses through annual water use rate increases.

Sources:
1. *World Health Organization (www.who.int/water_sanitation_health/diseases/cyanobacteria/en/)*
2. *Adapted from World Health Organization website: http://www.who.int/water_sanitation_health/diseases/methaemoglob/en/*

Possible Sources of Nutrient Pollution	
Wastewater Treatment Plant	Dallas Center's wastewater treatment facility is located within this watershed. Point sources such as these are permitted through the Iowa Department of Natural Resources and are required to provide treatment of wastewater to lower pollutant loads to acceptable levels.
Leaking Sanitary Sewer Systems	Untreated wastewater can exfiltrate, or leak out from gaps or cracks in sanitary sewer mains, structures and connection points. This most commonly occurs in older systems, if they are not regularly inspected or maintained. Communities often have a program of regular inspections to address this issue.
Septic Systems	System failures related to improper design, age or lack of maintenance can lead to overflows or leakage into shallow groundwater layers.
Confined Animal Feeding Operations	These are **point sources** and require operation permits by the State. Wastewater is collected in lagoons and applied in the surrounding area following a manure management plan.
Pastures	Loading can be higher where livestock has direct access to streams, or there is little buffer between the pastureland and the stream.
Fertilizer and Manure Applications	Pollutant loadings can be affected by application rates, season, timing of rainfall events and application close to streams where adequate buffers are absent.
Legume Fixation	Process where crops such as soybeans convert nitrogen in the atmosphere to nitrogen compounds. A portion of the amount converted often remains in the soil and can be transported into groundwater or tile drainage.
Tile Drainage	More efficiently drains shallow groundwater from agricultural fields. This groundwater often contains elevated levels of nutrients.
Lawn Fertilizer Applications	Nutrient content, irrigation, overspray onto paved surfaces or streams and rainfall events following application can influence the amount of nutrient loading from this source.
Pet and Yard Waste	Fecal matter from pets and decomposing yard waste such as lawn clippings, leaves and garden waste. These materials are sometimes not collected appropriately, or in some cases are dumped directly into the storm sewer system or streams.
Wildlife	Sources include fecal matter from ducks, geese, other birds, deer, raccoons, other rodents, feral cats and dogs.
Car wash detergents	Car wash detergents contain high levels of phosphates. Most commercial car washes have systems which collect polluted wash water, however washing of vehicles in parking lots and driveways could allow these detergents to be washed into the storm sewer system.
Atmospheric deposition	Nitrogen gas is the most common compound in our atmosphere. Deposition of nitrogen can be increased by elevated levels of air pollution, usually attributed to the burning of fossil fuels.

Source:
1. *Adapted with information from http://www2.epa.gov/nutrientpollution/problem.*

With information adapted from Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008).

Pathogens

Pathogens are the most common cause for **water quality impairment** in the United States, with nearly 11,000 waterbodies listed as impaired for this cause in 2014. Pathogens are microscopic organisms which can cause disease in humans or animals. These include viruses, bacteria, protozoa and parasitic worms. The likely presence of pathogens is typically identified by measuring levels of **fecal indicator bacteria** (FIB) such as **Escherichia coli** (E. coli) or **fecal coliform**. Elevated levels of these indicator species demonstrate that conditions are favorable for pathogens at a level which could impact human health when exposures occur.

The primary concern is incidental human ingestion during recreational contact, resulting in illness. In addition, respiratory, skin, ear and eye infections are also possible. Those most at risk are the very young, those with compromised immune systems and those with no prior exposure to the pathogen. The level of exposure required to cause illness varies with each type of pathogen.

Pathogen	Symptoms
Viruses	Main symptoms from most common viruses may include diarrhea, vomiting, headache, fever and abdominal cramps.
Bacteria Salmonella	May cause diarrhea in humans.
Bacteria Campylobacter	Known to cause diarrhea, abdominal cramping, pain, fever, nausea and vomiting.
Bacteria E. coli	Most strains are harmless. A few specific strains can result in hemorrhagic colitis. Approximately 10% of cases of this disease lead to hemolytic uremic syndrome, a leading cause of kidney failure in children.
Other Bacteria	Other water related bacterial diseases include pneumonia, kidney infections and skin / wound infections.
Protozoa Cryptosporidium	This is one of the most significant causes of waterborne illness today, able to persist in the environment for months at a time in some cases. The dose required to cause infection is small. The disease is usually self-limiting, however it can be chronic and life threatening for those with compromised immune systems.
Protozoa Giardia	The dose required to cause infection is small. The disease is usually self-limiting, however it can be chronic and debilitating for those with compromised immune systems.

Source: Adapted from "Pathogens in Urban Stormwater Systems," Urban Water Resources Research Council, August 2014

Possible Sources of Pathogens	
Wastewater Treatment Plant	Dallas Center's wastewater treatment facility is located within this watershed. Point sources such as this, are permitted through the Iowa Department of Natural Resources and are required to provide treatment of wastewater to lower pollutant loads to acceptable levels.
Leaking Sanitary Sewer Systems	Untreated wastewater can exfiltrate, or leak out from gaps or cracks in sanitary sewer mains, structures and connection points. This most commonly occurs in older systems, if they are not regularly inspected or maintained. Communities often have a program of regular inspections to address this issue.
Septic Systems	System failures related to improper design, age or lack of maintenance can lead to overflows or leakage into shallow groundwater layers.
Confined Animal Feeding Operations	These are point sources and require operation permits by the State. Wastewater is collected in lagoons and applied in the surrounding area following a manure management plan.
Pastures	Loading can be higher where livestock has direct access to streams, or there is little buffer between the pastureland and the stream.
Manure Applications	Pollutant loadings can be affected by application rates, season, timing of rainfall events and application close to streams where adequate buffers are absent.
Pet and Yard Waste	Fecal matter from pets and decomposing yard waste such as lawn clippings, leaves and garden waste. These materials are sometimes not collected appropriately, or in some cases are dumped directly into the storm sewer system or streams.
Wildlife	Sources include fecal matter from ducks, geese, other birds, deer, raccoons, other rodents, feral cats and dogs.

Source:
1. Adapted with information from http://www2.epa.gov/nutrientpollution/problem

Adapted from "Pathogens in Urban Stormwater Systems," Urban Water Resources Research Council, August 2014, with information adapted from Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008).

Sediment

A certain amount of sediment is naturally present and transported in streams. However, the excessive loadings observed within this watershed can have significant impacts on water quality and stream structure.

High sediment loads directly impact watershed ecology through habitat loss, reduced wetland functions and impaired water quality in ponds and lakes. Sediment impacts the physical characteristics of waterbodies through decreased floodplain volumes (increases flood risk), higher stream velocities, accelerated streambank erosion, and reduced storage in ponds and lakes. Water quality is also directly affected, as some pollutants are able to bind to sediment particles and be carried downstream.

Possible Sources of Sediment	
Tilled Agricultural Landscapes	During periods of heavy rain, wind or during the spring freeze thaw cycle, soils can be eroded from the surface of the land and transported to streams.
Paved Surfaces	Since paved surfaces absorb no rainfall, they add to the amount of water that flows to our stormwater system and increase the speed and force of the water that reaches our creeks/streams through that system. These paved surfaces often are catch-alls for a variety of pollutants including oils, fuels, other chemical mixtures and trash/litter. Minimizing paved surfaces and buffering those that do exist, can reap meaningful results in preventing erosion, other forms of pollution and in some instances, assist with flood mitigation.
Construction Sites	Surfaces that are disturbed by construction can be significant sources of sediment loading, with erosion rates commonly ranging from 35-45 tons per exposed acre.[1] Effectively installed and maintained, erosion and sediment controls are necessary to prevent the movement of soil particles or to trap displaced sediment particles if erosion does occur.
Gully and Ravine Formation	Erosion rates can be dramatic within steep, narrow stream corridors. Rates of erosion can be highest where the surface has little erosion resistant vegetation or where flow rates or volumes have been altered by land development activities.
Streambank Erosion	When stream channels widen, downcut or move laterally, the soil eroded from the bottom or the bank of the stream is directly input into the flow of the stream.
Wind Erosion	Wind erosion can remove soil from various landscapes and deposit it in other surfaces where it can be washed away during rainfall events.

Source:

1. *Developing Your Stormwater Pollution Prevention Plan; A Guide for Construction Sites—US EPA, May 2007*

Problem	Effect
Habitat Loss	• In-stream structures, such as pools and gravel beds (which are important habitat for fish and other aquatic life) can be lost when filled with sediment. • Sediment laden waters can keep fish from finding food and can interrupt spawning.
Deposition	• Sediment is more quickly deposited in lower velocity flow zones, such as inside bends of streams or near bridge columns. As sediment builds up in these areas, it can push more water outward in higher velocity zones toward banks of the stream, accelerating bank erosion and creating even higher sediment loads. • In some locations sediment deposition can reduce channel flood plain storage and clog stormwater infrastructure such as inlets, pipes and culverts. • Deposited sediment can fill wetlands, ponds and lakes; diminishing their storage depth, affecting habitat and impacting water quality within and downstream of these waterbodies.
Other Pollutants	• Sediment particles act as transport vehicles for certain pollutants, such as phosphorus and metals. • Sediments can provide refuge for pathogens from sunlight and predators, extending their lifespan and in some cases creating a medium for their reproduction.
Drinking Water	• Taste and odor problems can be developed in drinking water sources.

Source:

1. *Adapted from Handbook for Developing Watershed Plans to Restore and Protect Our Waters (March 2008).*

Runoff Rates and Volume

Hydrology is the study of how water moves through and over the landscape. Stormwater runoff caused by rain, snowmelt and groundwater movement are the main ways that pollutants are carried from the landscape to receiving waters. As volumes of surface and subsurface runoff increase, a larger load of nutrients, pathogens and sediments are likely to be driven to the stream. Understanding the activities that increase the rates and flows of runoff can help us identify potential sources of such increases to address.

Activities that reduce the soil's ability to soak up water **(infiltration)** or restrict its ability to move through the soil **(percolation)** lead to increases in stormwater runoff volume. Both infiltration and percolation are decreased when soils are compacted. In rural areas, compaction can occur when large equipment is driven over or through the soil during agricultural activities. Tilling, fertilizing, harvesting and tile installations are all activities which can compact soils. In urban areas, soil compaction primarily occurs by use of heavy equipment during grading and construction operations as part of land development. Installation of impervious surfaces such as roofs, driveways, parking lots and streets can virtually eliminate infiltration which increases runoff volume.

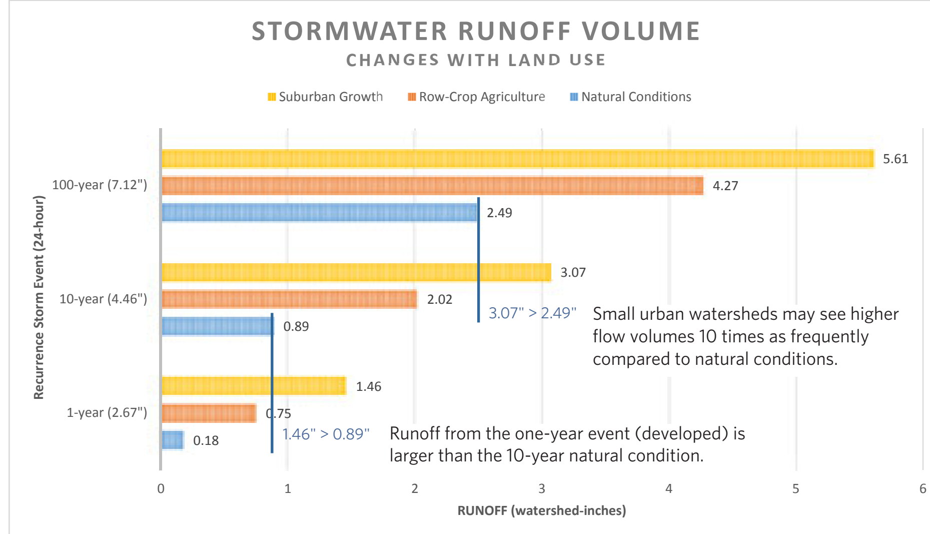
Runoff volume is also increased when native plants, trees and other vegetation are removed. Plants use water in **photosynthesis**, changing air and water into sugars for growth. They also distribute water to their leaves and release it back into the atmosphere using a process called **transpiration**. Their root structures dig deep into the soil, helping to keep it loose and porous. They provide habitat for worms, insects and burrowing animals which also increase void spaces within the soil.

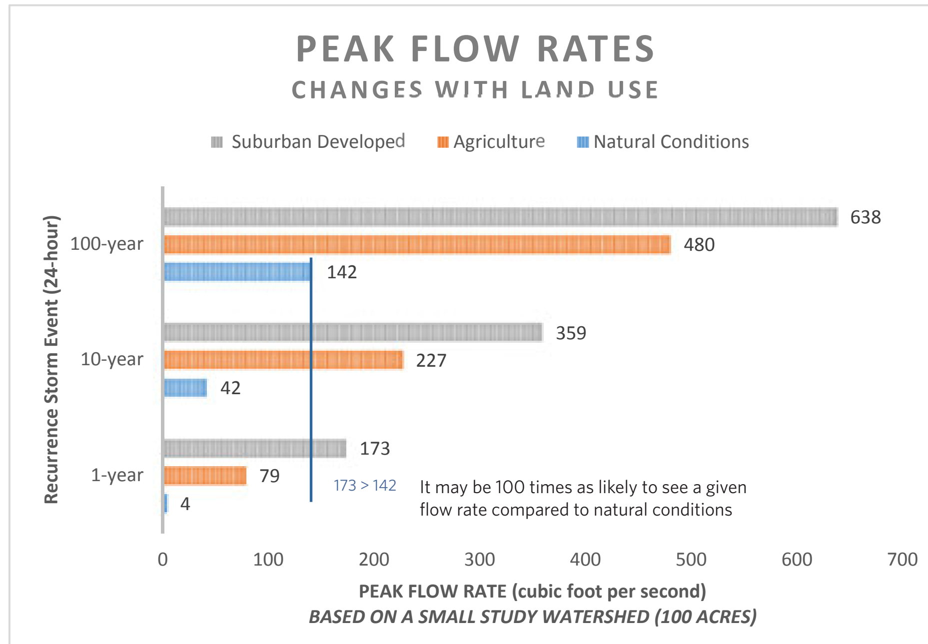
As landscapes are developed, many changes also effect the speed at which runoff is funneled to streams. This decreases the **time of concentration**, or the longest time it takes for runoff to reach the most downstream point from the extents of a given area. In agricultural areas, many ditches and tiles were constructed to drain wetlands and low lying areas. In some areas, the alignments of larger streams were straightened. Roads were installed with ditches and culverts. In urban areas, impervious areas collect runoff and quickly funnel it into gutters and storm sewers. The pipe network very quickly routes this runoff to the nearest pond or stream.

The combination of these effects results in a system which has been significantly altered from natural conditions. By modeling a case study of a developing area, the effects of these changes can be seen. Runoff volumes in both the agricultural watershed and suburban environments are likely to be several times higher than pre-settlement conditions. The proportion of increases are highest during the smaller, most frequently occurring storms. It should be noted that this comparison is based on suburban conditions (primarily single-family with some commercial growth, with a total of 40-45% impervious cover). More intense development scenarios would be expected to generate even higher runoff volumes.

Shortened time of concentrations magnify the effects of increased runoff volume. In rural areas, peak rates of flow may be nearly 20 times higher than pre-settlement levels during the most frequently occurring storms. In the suburban environment, peak rates for these events are expected to be 20-45 times more than the natural conditions. These drastic changes demonstrate how storm events of less than three inches of rain can cause rapid rises in stream levels and flash flooding. These effects are likely most dramatic in smaller streams in urban developed areas. These quick bounces account for a significant amount of streambank erosion on an annual basis, leaving the streambanks weakened and vulnerable for more significant impacts from the more rarely occurring larger events.

URBAN SMALL WATERSHED STUDY





Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see Chapter 8 and appendix resources).

Overview of Available Monitoring Data

Iowa Soybean Association / Agrculture's Clean Water Alliance (ISA/ACWA)

The **Iowa Soybean Association** in collaboration with **Agriculture's Clean Water Alliance** and the Des Moines Water Works has collected data at four separate locations along the main stem of Walnut Creek. Regular **sampling** at these sites offers the ability to evaluate conditions during a variety of flow conditions through most of the year. The limitations of this data are the small number of sites (no more than two for each year) and a lack of data during the winter, early spring and fall months of the year.

Site 40—Located near Valley Drive Bridge over Walnut Creek (Des Moines)

Data collection at this site began in April 1999 with weekly sampling through mid-November of that year. Beginning in 2000, sampling was usually conducted every other week from April through August. Data through 2014 was reviewed with the development of this plan.

This location is located less than one mile downstream of the USGS gaging station referred to in Chapter 2. Walnut Creek has received runoff from over 98% of its watershed at this location. The combination of these two factors makes this location valuable in estimating overall watershed loading and watershed scale model calibration.

Note: Water Quality data provided by the Iowa Soybean Association, the Agriculture's Clean Water Alliance and the Des Moines Water Works, supported by various grants and contracts assisting watershed management implementation in Iowa. For more information contact Roger Wolf, Director of Environmental Programs; Executive Director, Agriculture's Clean Water Alliance; Iowa Soybean Association; 1255 SW Prairie Trail Parkway; Ankeny, Iowa 50023; Tel: 515-251-8640 Fax: 515-251-8657

Information about eleven parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Discharge
- E.coli
- pH
- Fluoride
- Nitrate as N
- Nitrite as N
- Turbidity
- Orthophosphate as P
- Sulfate
- Total Coliform

Site 70.0—Located near 156th Street Bridge over Walnut Creek (Urbandale)

Data collection at this site began in April 2005 with sampling occurring every other week, usually during the spring and summer months. Data through 2014 was reviewed with the development of this plan.

This location, in concert with sites 70.1 and 70.2 provide valuable information about water quality as the stream leaves the agricultural landscape in rural Dallas County and enters the developing urban area.

Information about ten parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Nitrate as N
- Nitrite as N
- Turbidity
- Fluoride
- Sulfate
- Total Coliform
- Orthophosphate as P
- Ecoli
- pH

Site 70.1—Located near Douglas Parkway Bridge over Walnut Creek (Urbandale)

Data collection at this site began in April 2002 with sampling occurring every other week through August of 2003. Both years, sampling ended in late August.

Information about nine parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Nitrate as N
- Total Phosphorus
- Fluoride
- Sulfate
- Conductivity
- Orthophosphate as P
- Nitrite as N
- Turbidity

Site 70.2—Located near Meredith Drive Bridge over Walnut Creek (Urbandale)

Data collection at this site began in April 2004 with sampling occurring every other week through August of that same year.

Information about four parameters was collected at this location. Not all parameters were measured during each sampling.

- Chloride
- Nitrite as N
- Nitrate as N
- Orthophosphate as P

Snapshot Monitoring Data

Water quality data was collected at 31 sites across the Walnut Creek watershed through the Polk County, Raccoon River Watershed and Walnut Creek **snapshot monitoring** events. These events were typically conducted twice annually (a spring and fall date each year) by volunteers using IDNR **IOWATER** field test kits. These kits contain test strips and other measurement methods of making a quick evaluation of water quality conditions in the field. During these events, some samples were also taken for laboratory testing. The laboratory samples measure pollutants more precisely than the test kits, which only indicate the likely concentration range for a given pollutant. Data collected and reviewed as part of this study extends from June 2004 through October 2014.

Data gathered using field test kits included the following parameters:

- Chloride
- Dissolved Oxygen
- Nitrate as N
- Nitrite as N
- pH
- Phosphate
- Water Temperature
- Transparency
- Secchi Depth (measures turbidity)

Laboratory analysis included the following parameters:

- Bromide
- Chloride
- Chlorophyll
- Nitrate + Nitrite
- Nitrite
- Nitrogen, Ammonia
- Solids, Total Suspended (TSS)
- Solids, Total Volatile Susp. (TVSS)
- Specific Conductance

- E. Coli
- Fluoride
- Nitrate
- Nitrogen, Kjeldahl
- Orthophosphate
- Solids, Dissolved
- Sulfate
- Total Coliform
- Turbidity

Data was not collected at every site during each snapshot event. Also, not all of the parameters above were analyzed for each sample collected. Since sampling was conducted less frequently, this data is less effective at measuring the patterns of pollutant loading on a monthly or seasonal basis. It is also more difficult to evaluate the effects of different flow conditions on these pollutant levels, as detailed flow data is not recorded when samples are taken. However, this data is beneficial because it has been collected over a broader area than that collected by the Iowa Soybean Association, with a greater number of pollutants measured. More data was also collected in the later months of the year than at the ISA sites. Using this information with that collected by ISA/ACWA, allows a broader evaluation into the possible sources of certain types of pollution. This provides opportunities to validate outcomes from **water quality modeling** at a subwatershed level.

USGS Water Quality Data

Water quality data was collected at USGS gaging station 05484800 located near the 1st Street / 63rd Street Bridge over Walnut Creek on the border between Des Moines and West Des Moines (same location referred to in Chapter 3). Data was collected on roughly a monthly basis between December 1971 and August 1975; October 1983 and January 2002. *Over these periods, data on the following parameters was collected:*

- Discharge
- Gage Height
- Temperature, Water
- Suspended Sediment Discharge
- Suspended Sediment Conc.
- Specific Conductance
- pH
- Temperature, Air

Des Moines Water Works

Des Moines Water Works collects nearly continuous water quality information from their intake site on the Raccoon River. This site is located less than one mile downstream of the confluence of Walnut Creek with the Raccoon River. The continuous nature of the data available makes it a valuable resource to review. However at the point of measurement, streamflow from Walnut Creek has mixed with flow from the much larger Raccoon River watershed. Given the other data sources available, it can be difficult to separate out the influence of the Walnut Creek watershed from water samples collected at this location.

Water Quality Monitoring

Water quality monitoring allows the presence of pollutants in streams to be evaluated. However, results can be effected by collection methods, timing, weather conditions, flow levels, sampling, testing methods and sampler training. Monitoring efforts rely on developing and following quality assurance plans to reduce these factors which can skew data collection. To improve the quality of collected data submitted to the state for recording, volunteer efforts must comply with requirements of Iowa Administrative Code Section 567.61.

Review of Existing Monitoring Data for Key Pollutants

Now that we have identified the key pollutants of concern, it is important to review the available **monitoring data** for these pollutants in greater detail.

Data collected by the ISA/ACWA offers the highest number of samples, typically collected every other week. Site 40 is also located just downstream of a USGS gaging station, and is less than two miles from the weather station located at the Des Moines Airport. Collectively, this information offers opportunities to understand how pollutant concentrations vary with time, streamflow and climate patterns.

IOWATER data collection does not have as many samples at each site, but has more sites distributed throughout the watershed. This data can be used in determining where higher pollutant concentrations are most likely located.

Nitrate (Nitrogen)

ISA/ACWA Monitoring

A total of 168 samples were collected and analyzed for nitrate from the ISA/ACWA site 40 between 1999 and 2014. At sites 70.0, 70.1 and 70.2; a total of 131 samples were collected between 2002 and 2014. Reviewing this data indicates that nitrate concentrations appear to be significantly higher in streams within the rural landscapes. (The site 70 locations were positioned in a primarily rural watershed, whereas site 40 received runoff from both urban and rural sources.) It appears that nitrate concentrations in urban runoff is lower, diluting nitrate concentrations as those flows enter the stream.

At both sites, concentrations were highest during the months of April through July, with peak levels occurring in May and June. This trend seems to follow the times after spring fertilization has occurred and when rainfall patterns are near their highest levels. It should be noted that concentration levels were noted to drop significantly in August, although average precipitation remains high during this month. Concentrations remained

ISA/ACWA Monitoring

	Site 40	Site 70
Average Nitrate Concentration	5.83 mg/L	9.95 mg/L
% Above Water Quality Standard	26%	49%
Maximum Recorded Level	17.6 mg/L	22.9 mg/L
Date of Maximum Recorded Level	5/20/2004	5/16/2013

Nitrate concentrations were 78% higher on average in rural areas; 49% of all samples taken at the rural ISA/ACWA site were above the state's water quality standard.

IOWATER Average Nitrate Concentrations (Laboratory)

SPRING			SUMMER			FALL		
SITE	COUNT	AVG	SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L		#	mg/L
LWC1A*	5	14.9	-	-	-	LWC1A*	4	5.6
WC1	3	13.1	-	-	-	WCTrib*	4	4.7
WCTrib*	6	11.3	-	-	-	WC1	5	4.5
WC8*	6	11.0	-	-	-	WC8*	4	3.9
WC3	3	10.7	-	-	-	WC5	5	3.3

* No Nitrate + Nitrite laboratory samples taken at this site during this season

Several IOWATER sites had average lab results for nitrate concentrations which exceeded the state standard.

IOWATER Average Nitrate+Nitrite Concentration (Laboratory)

SPRING			SUMMER			FALL		
SITE	COUNT	AVG	SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L		#	mg/L
LWC2*	2	17.5	NWC1*	2	2.9	LWC2	1	11.0
WCTrib2*	2	14.0	D11*	2	2.2	LWC1	1	7.1
LWC1*	2	13.5	POL2*	2	1.0	WCTrib2	1	6.3
WC1	6	13.1	WAVE*	2	0.5	WCTrib1	1	5.7
D11*	2	12.5	-	-	-	WC7	1	5.4

* No Nitrate laboratory samples taken at this site during this season
** Only eight total samples taken in summer months throughout the entire watershed

Several IOWATER sites had average lab results for nitrate concentrations which exceeded the state standard.

IOWATER Average Nitrate Concentrations (IOWATER test kits)

SPRING			SUMMER			FALL		
SITE	COUNT	AVG	SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L		#	mg/L
LWC1A	6	11.2	WC4	4	7.5	LWC1	3	5.3
D11	6	8.7	D11	4	7.3	WCTrib2	2	5.0
WCTrib	6	8.7	NWC6	6	4.8	LWC2	3	3.3
WC8	6	8.7	NWC2	2	3.5	WCTrib	5	2.4
WC1	13	8.4	WC3	2	3.5	WC7	3	2.3

Test kit data also indicated elevated nitrate concentrations in rural areas.

The maximum lab value of 31.8 mg/L is three times higher than the state water quality standard.

IOWATER Maximum Nitrate Concentrations (Laboratory)								
SPRING			SUMMER			FALL		
SITE	DATE	MAX	SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L			mg/L
LWC1A*	5/8/13	31.8	-	-	-	LWC1	-	14.3
WC8*	5/8/13	21.0	-	-	-	WCTrib	-	9.8
WCTrib*	5/8/13	18.9	-	-	-	WC8	-	9.4
WC2	5/8/13	17.4	-	-	-	WC2	-	8.4
WC1	5/23/07	16.2	-	-	-	WC1	-	7.9

* No Nitrate + Nitrite laboratory samples taken at this site during this season

Some IOWATER samples indicate a fall spike in nitrate levels.

IOWATER Maximum Nitrate+Nitrite Concentration (Laboratory)								
SPRING			SUMMER			FALL		
SITE	DATE	MAX	SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L			mg/L
LWC2*	4/28/07	20.0	NWC1*	7/21/07	3.9	LWC2*	9/22/07	11.0
WC1	6/2/04	18.0	D11*	7/21/07	2.3	WC1	10/16/07	8.4
NWC1	6/2/04	17.0	D11*	7/22/06	2.0	WC2	10/16/07	7.7
WC2	6/2/04	17.0	NWC1*	7/22/06	1.9	WC3	10/16/07	7.6
LWC1*	4/28/07	17.0	POL2*	7/21/07	1.8	WC4	10/16/07	7.5

* No Nitrate laboratory samples taken at this site during this season
** Only eight total samples taken in summer months throughout the entire watershed

Twenty test kit samples registered as 20mg/L.

IOWATER Maximum Nitrate Concentrations (IOWATER test kits)								
SPRING			SUMMER			FALL		
SITE	DATE	MAX	SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L			mg/L
NWC1	5/8/13	20	WC4	5/8/13	20	WC8	5/8/13	20
NWC2	5/8/13	20	WC4	5/24/13	20	LWC1A	5/8/13	20
WC1	6/2/04	20	WC5	5/8/13	20	LWC1A	5/7/14	20
WC1	5/8/13	20	WC6	6/2/04	20	D11	7/4/08	20
WC2	6/2/04	20	WC6	5/9/12	20	NWC6	7/8/13	20
WC2	5/8/13	20	WC6	5/8/13	20	WC4	7/8/13	20
WC3	5/8/13	20	WCTrib	5/8/13	20			

low from September to November, although very few samples were collected during each of these months (only 5 total samples were collected in the months of Sept-Oct-Nov at site 40, and only 2 samples during those months at site 70).

At site 40, nitrate concentrations appear to be lowest during low flows, noticeably so when streamflows are in the lowest 20% of observed flow rates. They appear highest when flows are in the highest 10–50% of observed flowrates. This distribution pattern indicates that nitrate loading is most likely from non-point sources, being moved off the landscape or out of tile flows primarily during and after measurable rainfall events. In contrast, if concentrations remained high at low flow, or had spikes that appeared outside of larger rainfall events, that would indicate that the source of the pollutant was from one or more point sources, which have more constant outflows between rainfall events.

Snapshot Monitoring (Lab Samples)

IOWATER has collected data from 31 separate **sampling sites** in the Walnut Creek watershed. Nitrate was measured by 233 laboratory samples from these sites. Laboratory samples were also collected for Nitrate + Nitrite, with 189 collected for that parameter (nitrite levels when measured alone were typically low, so nitrate + nitrite may still be a good measure to approximate and compare nitrate levels).

Since significant seasonal patterns were seen at the ISA/ACWA sites, analysis of IOWATER samples has been divided into three periods: spring (April-June), summer (July-August) and fall (September-November). The sites with the highest average levels of nitrates are listed below.

Since there are fewer data points at each site, it is difficult to draw specific conclusions about each location. However, this data seems to follow the pattern of the ISA/ACWA monitoring, indicating elevated levels of nitrate in the spring months, especially where runoff is being received from rural landscapes.

The IOWATER data does seem to lend some support to possibilities of spikes in nitrate concentrations in the fall. Some higher concentrations were noted on a few dates. In reviewing USGS streamflow data, it appears that these elevated values may coincide with above average flow rates. Regularly occurring late season monitoring would be needed to determine if elevated nitrate levels in the fall are a normal pattern or caused by more unique sets of circumstances.

Snapshot Monitoring (Test Kits)

IOWATER test kits use strips that read nitrate levels by changes in color. This means that readings are estimates of concentration within a given range around that number. Of the 521 samples taken, no reading above 20 mg/L was recorded. This measurement on the strip is intended to represent a range between 20 and 50 mg/L. The table on the previous page notes the different locations and dates where readings of 20 were recorded. Most of these dates coincide with elevated flow volumes measured at the USGS gaging station within the Walnut Creek watershed.

Phosphorus

ISA/ACWA Monitoring

A total of 136 samples were collected and analyzed for phosphorus from the ISA/ ACWA site 40 between 2001 and 2014. At sites 70.0, 70.1 and 70.2; a total of 127 samples were collected between 2002 and 2014. This indicates that phosphorus concentrations may be higher in streams within the rural landscapes.

At site 70, average concentrations were elevated above 0.12 mg/L during all months sampled, except for August, with peak levels occurring in May and June. At site 40, highest concentrations were observed in April, with concentrations wavering after that. Seasonal trendlines are present, but do not appear as strong as those seen for nitrate concentrations. Also in contrast to nitrate levels, there appears to be much less correlation between high flow levels and elevated phosphorus concentrations. This appears to indicate that phosphorus concentrations may be more influenced by individual site actions, such as fertilizer applied soon before a storm event, which could lead to a sudden spike in phosphorus concentrations.

ISA/ACWA Monitoring		
	Site 40	Site 70
Average Phosphorus Concentration	0.083 mg/L	0.134 mg/L
Maximum Recorded Level	1.5 mg/L	0.68 mg/L
Date of Maximum Recorded Level	4/17/2004	4/18/2013
At Site 40, 110 samples were below the concentration levels which could be detected by the test. At site 70, 73 samples were below this threshold. To calculate average concentrations, tests that indicated concentrations were below the detection limit were assumed to have a value of one half of the detection limit.		

Phosphorus levels were 61% higher on average at the rural location (site 70).

IOWATER Monitoring

Average Phosphorus and Orthophosphate Concentrations (Laboratory)					
PHOSPHORUS			ORTHOPHOSPHATE		
SITE	COUNT	AVG	SITE	COUNT	AVG
	#	mg/L		#	mg/L
WAVELAND GC	2	0.45	LWC1(A)	9	0.16
WC1	8	0.45	WAVELAND	7	0.14
D11	1	0.36	WCTrib	10	0.14
WCTrib1	1	0.36	WC8	10	0.12
WAVELAND	9	0.36	WAVELAND GC	3	0.11

IOWATER Monitoring

Maximum Phosphorus and Orthophosphate Concentrations (Laboratory)					
PHOSPHORUS			ORTHOPHOSPHATE		
SITE	DATE	MAX	SITE	DATE	MAX
		mg/L			mg/L
WC1	5/18/05	2.5	NWC1	10/15/14	0.69
WAVELAND	5/18/05	1.0	WCTrib	10/15/14	0.66
WAVELAND	10/12/05	1.0	WAVELAND	10/12/05	0.64
WAVELAND GC	5/24/06	0.68	LWC1	10/15/14	0.57
WAVELAND	5/14/06	0.54	LWC1	5/8/13	0.52

Some snapshot readings indicate that runoff from Waveland Golf Course could contain elevated phosphorus levels.

Snapshot Monitoring

IOWATER has collected data from 31 separate sampling sites in the Walnut Creek watershed. Phosphorus was measured by 136 laboratory samples from these sites. Laboratory samples were also collected for Orthophospate, with 217 collected for that parameter.

Since there are fewer data points at each site, it is difficult to draw specific conclusions about each location. However, this data seems to indicate elevated levels of phosphorus may be present at various locations in both rural and urban areas.

A review of maximum phosphorus concentrations also seems to indicate that the areas near Waveland Golf Course may have significant spikes in loadings. Perhaps these are associated with fertilization coinciding with certain rainfall events. It is also worthy of note, that certain dates resulted in maximum values at multiple sites. This indicates that runoff or streamflow patterns likely do influence concentrations, but it is difficult to interpret how much with the limited data available.

Bacteria (E. coli)

Iowa Soybean Association / ACWA Monitoring

A total of 62 samples were collected and analyzed for E. coli at the ISA/ACWA site 40 between 2005 and 2011. At site 70.0, a total of 46 samples were collected between 2006 and 2011. The overall average concentration for all samples at site 40 was 3126 MPN (most probable number of organisms)/100 mL, with 73% exceeding the State of Iowa's single sample water quality criterion of 235 MPN/100mL. The average concentration for samples collected at site 70 locations was 1333 MPN/100mL, with 66% of the samples exceeding the single sample criterion. Average values at site 40 were 135% higher than those observed at site 70. This indicates pathogens may be much more present in streams which receive more urban runoff.

At both sites, average concentrations over this period peaked in June, with average levels during that month at 8,122 orgs./100mL at site 40 and 1,602 at site 70. Average values showed a very high peak in June at site 40, where values were more consistent through all months at site 70.

At site 40, there appears to be a connection between high flow levels and elevated bacteria concentrations. Most of the highest concentrations were observed during the highest 30% of all flow conditions. At site 70, this connection was much less defined.

This data provides strong evidence that there is a connection between high runoff events from urban environments and high concentrations of indicator bacteria. Other seasonal factors, such as elevated temperatures may provide better environments for these bacteria and allow them to survive and multiply.

ISA/ACWA Monitoring		
	Site 40	Site 70
Average E. coli Concentration	3,126 orgs./100mL	1,333 orgs./100mL
Maximum Recorded Level	54,700 orgs./100mL	14,670 orgs./100mL
Percentage of samples exceeding water quality standard	73%	66%
Date of Maximum Recorded Level	6/26/2008	7/24/2008

Levels of E. coli were much higher at the site receiving urban runoff.

Average and Maximum E. coli Concentrations (Laboratory)					
AVERAGE			MAXIMUM		
SITE	COUNT	AVG	SITE	DATE	AVG
	#	orgs./100ML			orgs./100mL
NWCTrib1	12	9,165	NWCTrib1	10/12/2005	77,010
WC3Trib	2	7,875	WC6	5/8/2005	61,310
NWC5A	2	8,585	WAVELAND	10/12/2005	30,760
WAVELAND	10	8,585	NWCTrib2	10/18/2006	30,760
WC6	19	5,332	NWC5A	10/18/2006	16,070

The state's water quality standard for E. coli is 235 orgs./100mL for a single sample.
The maximum level observed was **more than 300 times** that level.

Snapshot Monitoring

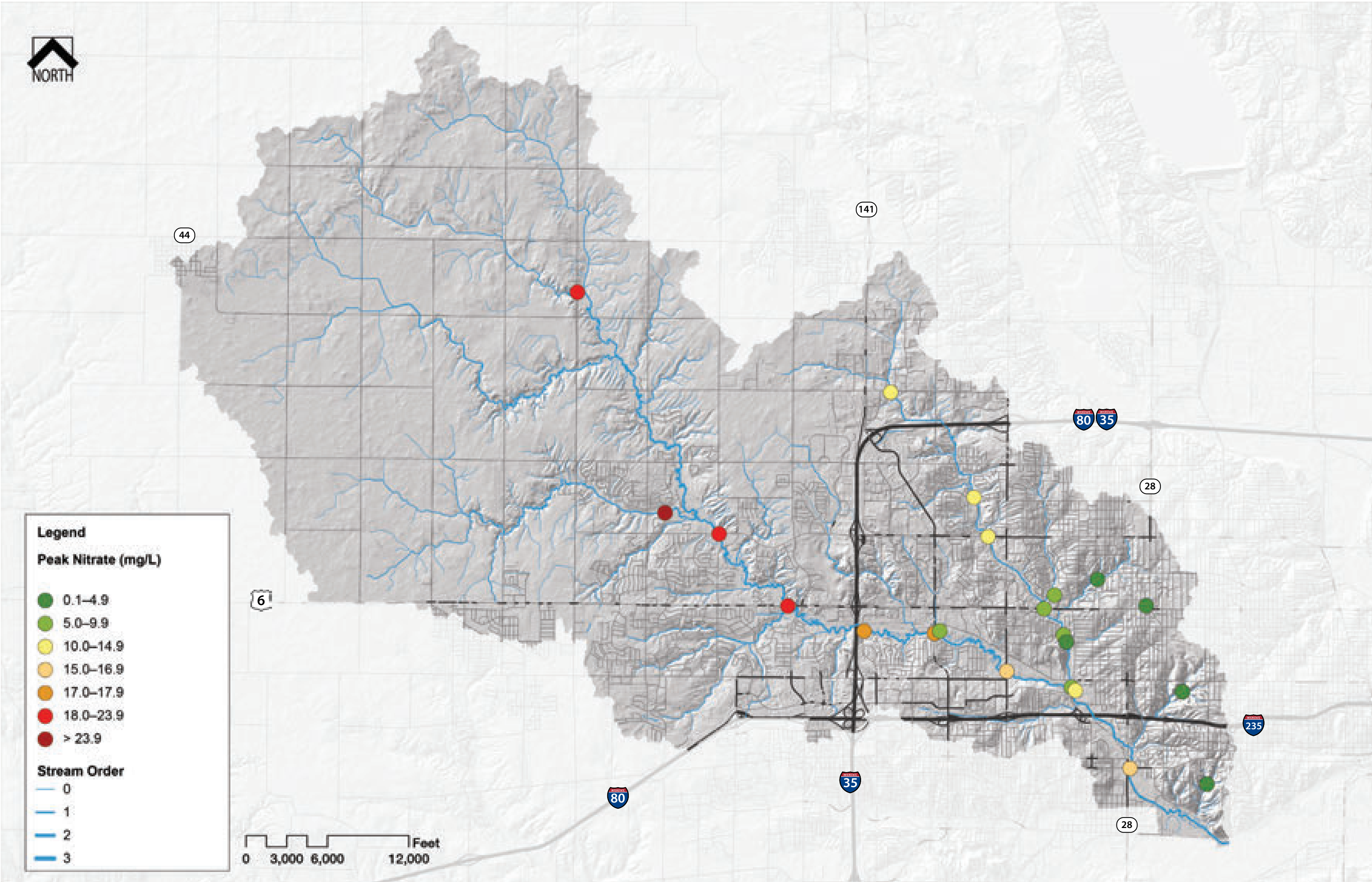
IOWATER has collected data from 31 separate sampling sites in the Walnut Creek watershed. E. coli was measured by 298 laboratory samples from these sites.

Since there are fewer data points at each site, it is difficult to draw specific conclusions about each location. However, this data seems to follow the pattern of the ISA/ACWA monitoring, indicating elevated levels of indicator bacteria where runoff is being received from urbanized areas.

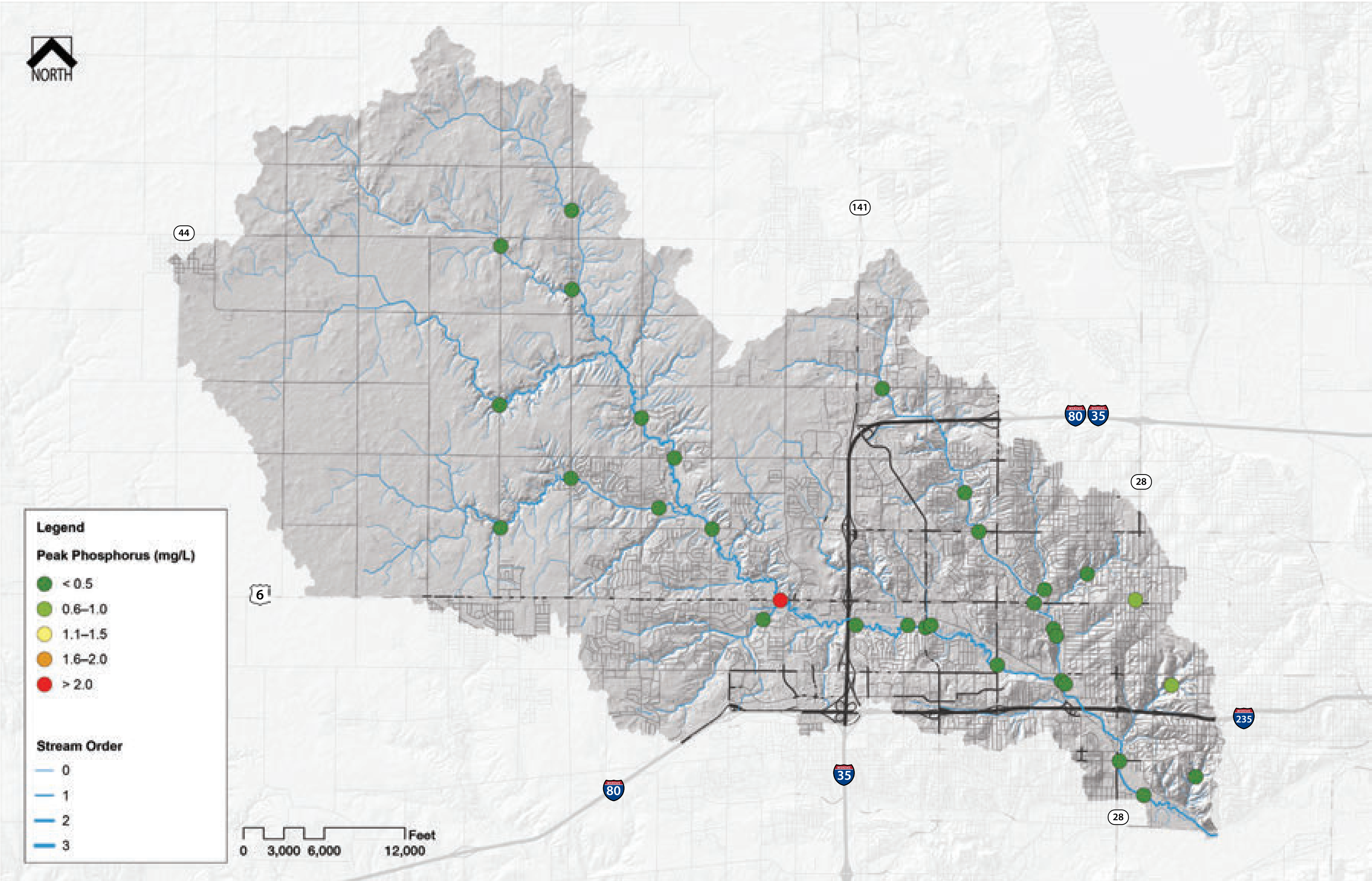
Highest concentrations appear to be in the older developed areas, lying east of I-35/80. Highest concentrations often appear in tributary streams, however high averages and maximums were noted at sites NWC5A (North Walnut Creek) and WC6 (Walnut Creek). Samples at both of these sites were collected from second or third order stream channels.

Did you know...?

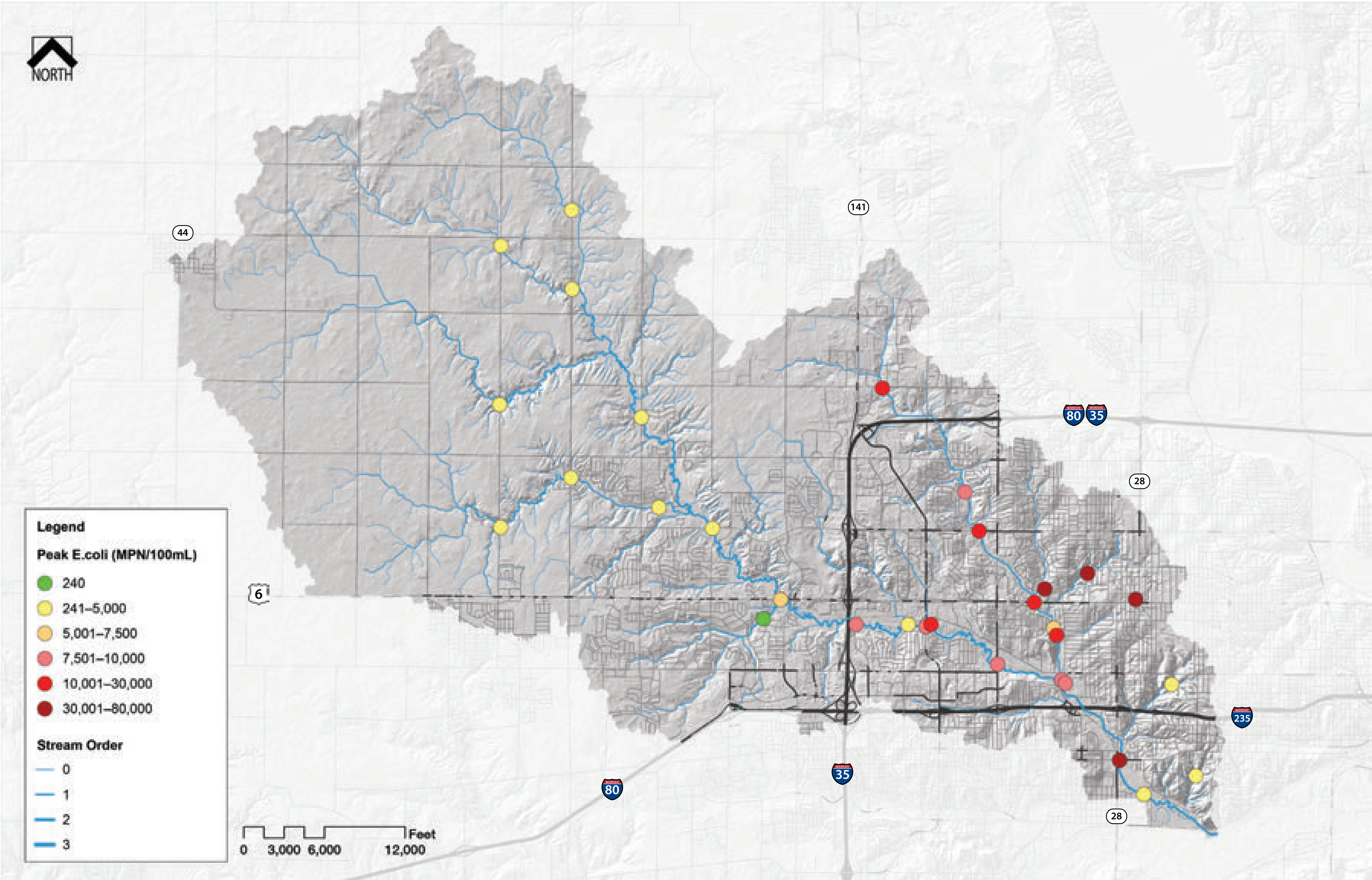
E. coli levels are usually measured by finding the most probable number (MPN) of bacteria organisms (orgs.) that are present in 100mL of water.



Nitrogen Monitoring



Phosphorus Monitoring



Bacteria Monitoring

Watershed Loading—Key Pollutants

Water quality modeling system software was used to determine the most likely sources of the key pollutants of concern. A more detailed description of this modeling effort is included as an appendix to this plan. Available **GIS land use dataset** information was used to determine the amount of different land uses in each of 33 subwatershed areas within the Walnut Creek watershed. The model accounts for other factors including local rainfall patterns, soil types, terrain, livestock, wildlife and management practices. Gully and streambank stability characteristics were also input into the modeling. The modeling software used did not account for construction site runoff. To account for this, separate calculations were completed to determine the amount of development that occurred on an annual basis over a recent ten year period. Modeling results were developed for each subarea, considering scenarios with and without this construction site loading.

Estimated Average Watershed Loading		
Pollutant	**Total Load (pounds)**	**Total Load (tons)**
Nitrogen	941,600	471
Phosphorus	61,500	31
Sediment	59,360,000	29,700

Estimated pollutant levels delivered from Walnut Creek to the Raccoon River.

Pollutant Sources By Land Use			
	N	**P**	**Sediment**
Urban	14%	26%	7%
Cropland	81%	49%	10%
Pastureland	2%	2%	0%
Forest	0%	1%	0%
Grasslands	0%	0%	0%
Gully	1%	5%	19%
Streambank	2%	10%	38%
Construction Site	1%	8%	25%

Projected source location of each pollutant.

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Existing monitoring data at Iowa Soybean Association Site 40 and streamflow data from the USGS gage located nearby were used to evaluate preliminary results. The monitoring and streamflow data was used to calculate approximations of loading rates based on the data available. The water quality model was then calibrated using this information, to bring it into better agreement with real world observations.

Expected Pollutant Sources by Land Use

Modeling results demonstrate that cropland is likely the largest source of nitrogen and phosphorus loadings. This is consistent with observations from monitoring sites, which demonstrated higher phosphorus and much higher nitrate concentrations in rural areas. Over 80% of the sediment loading in the watershed is expected from three sources—streambank, construction site and gully erosion.

Pollutant Sources by Subarea

The water quality modeling completed identifies potential sources of key pollutants at a subwatershed level. For each of these areas, the expected annual load of nitrogen, phosphorus and sediment has been calculated. These loading rates were divided by the acres of land within each subwatershed to determine the annual loading rate per acre, in order to compare loading rates of subwatershed that are different in size.

Loading rates have been calculated both with and without the expected effects of construction site sediment loads. Construction site loadings were calculated based on land development patterns that occurred between 2001 and 2011. The modeling provides a good estimate of average annual construction site loadings from each subarea which would have occurred during that period of time. As development patterns change over time, the location of these sources will be different in the years ahead. Therefore, the maps included within this chapter show the expected loading rates without construction site effects. This allows non-construction site sources to be evaluated and targeted separately. Construction site sources are best addressed with site level management techniques.

Nitrogen

Sources of nitrogen are expected to be highest in the agricultural lands that make up the headwaters of Walnut Creek. Areas west of Waukee and those between Dallas Center and Grimes appear to be the largest sources for nitrogen on a per acre basis. Elevated levels are also indicated to be present in the upper reaches of the North Walnut Creek subwatershed. These results appear to be consistent with available monitoring data.

Phosphorus

Like nitrogen, sources of phosphorus are expected to be highest in the agricultural lands in the upland areas of the watershed. However, there is less variation in phosphorus loading between the various subareas. Twenty-eight of the thirty-three subwatersheds are expected to have loading rates between 0.8-1.3 pounds per acre per year. Levels are expected to be below this range in two subwatersheds and above this range in three others. These results appear to be in agreement with available monitoring data.

Pathogens

This modeling software did not include detailed modeling of bacteria sources. Bacteria loading can be difficult to estimate, as they are driven by a variety of factors such as animal sources, temperature, precipitation, growth and lifespan. Available monitoring data for bacteria indicates levels are most elevated in the urban environment.

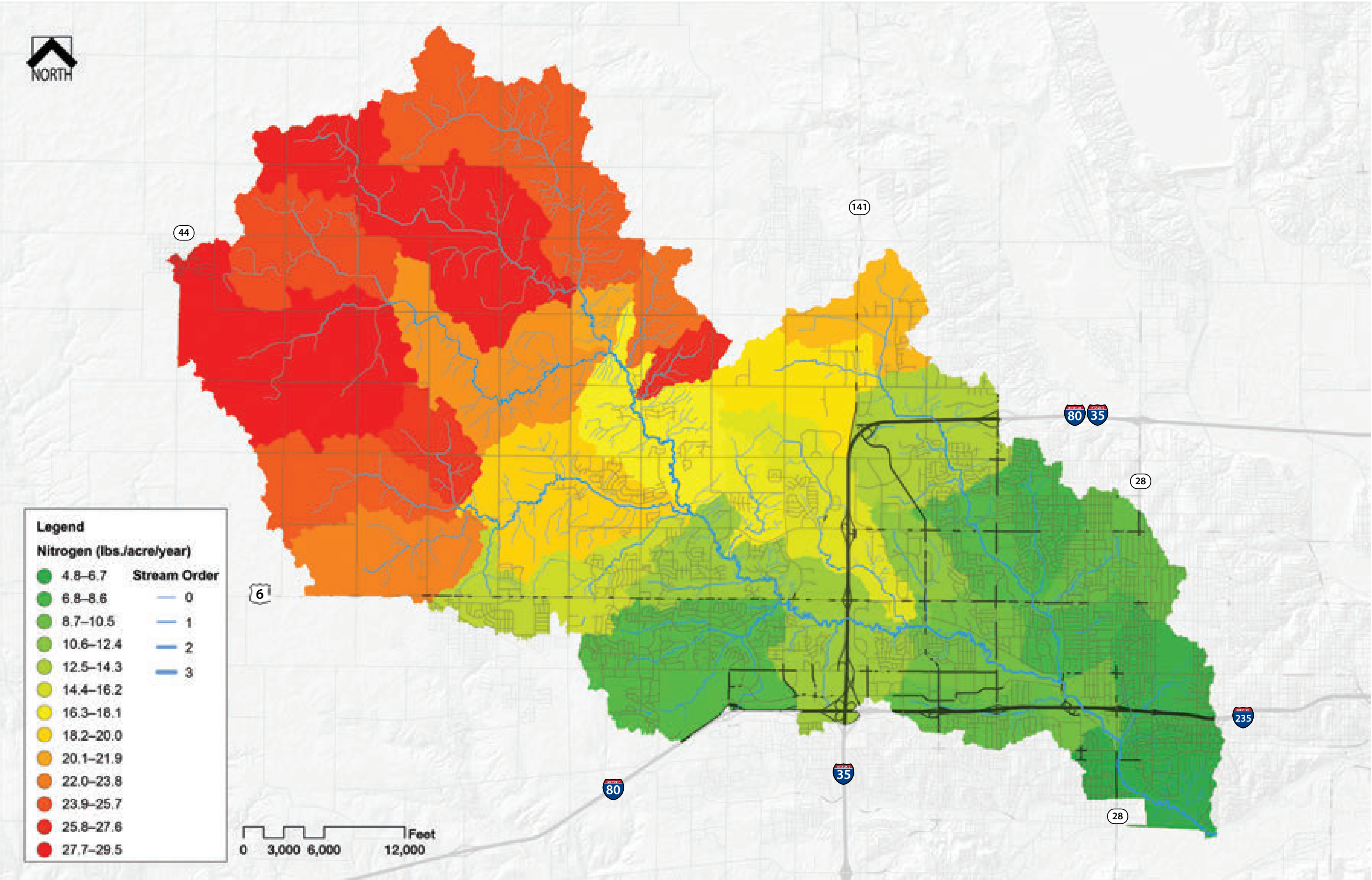
Sediment

Source loadings of sediment are expected to be highest in areas of steeper slopes and where more streambank and gully erosion has been observed. Highest levels are expected along lower Little Walnut Creek and along Walnut Creek upstream of its confluence with South Walnut Creek. There are many ravines, gullies and streams with significant slope in these areas. Please remember construction site loadings are not reflected in the maps included within this chapter.

Average Loading per Acre by Subwatershed Without Construction Site Runoff

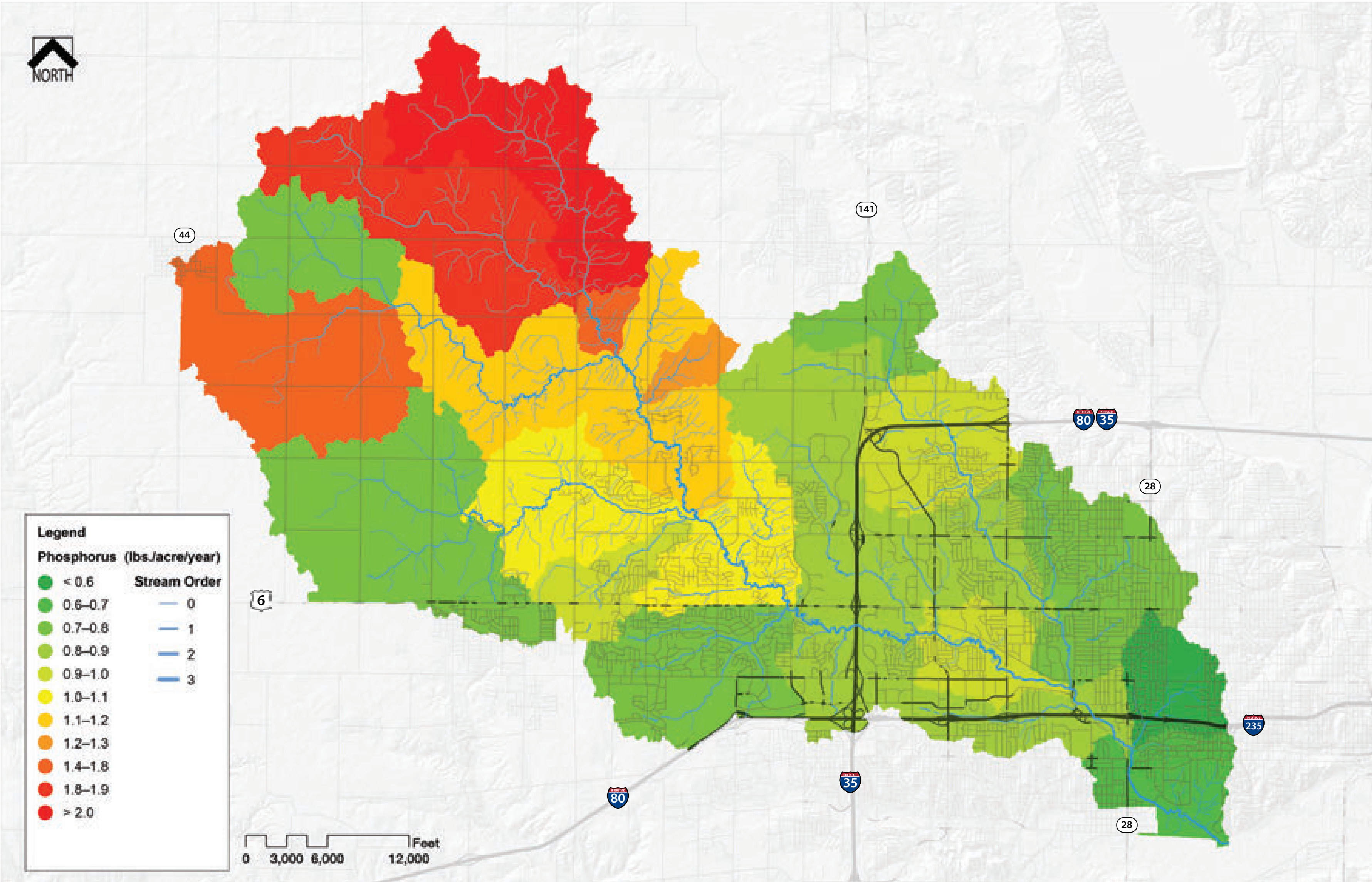
Subwatershed Site	N lb/ac/yr	P lb/ac/yr	Sediment lb/ac/yr
101	4.8	0.7	967.2
102	6.1	0.9	895.3
111	5.1	0.6	489.1
112	6.0	0.9	729.5
201	6.1	1.0	1034.2
202	6.7	0.9	911.9
203	6.7	1.1	2198.1
211	6.4	0.9	761.7
212	13.3	0.9	737.5
213	6.3	0.8	919.7
214	17.3	1.1	1810.8
301	17.7	1.2	1923.3
311	28.3	1.3	1862.8
312	27.0	1.2	1513.8
401	24.0	1.8	3823.2
402	27.4	1.0	568.4
411	28.7	1.9	520.7
501	5.5	0.8	855.7
502	5.8	0.9	1081.4
503	9.8	1.0	1001.6
504	18.0	0.9	335.7
511	6.0	0.8	799.4
512	5.5	0.8	605.6
513	19.3	0.8	201.0
601	18.6	1.1	1311.7
602	27.4	0.8	195.6
611	12.3	1.0	1051.1
612	10.8	0.8	389.6
613	26.7	0.8	254.3
614	28.2	0.8	182.5
701	25.5	1.2	1757.9
702	29.5	1.8	153.8
711	28.0	0.8	184.2
Watershed Avg.	**17.6**	**1.1**	**840.8**

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.



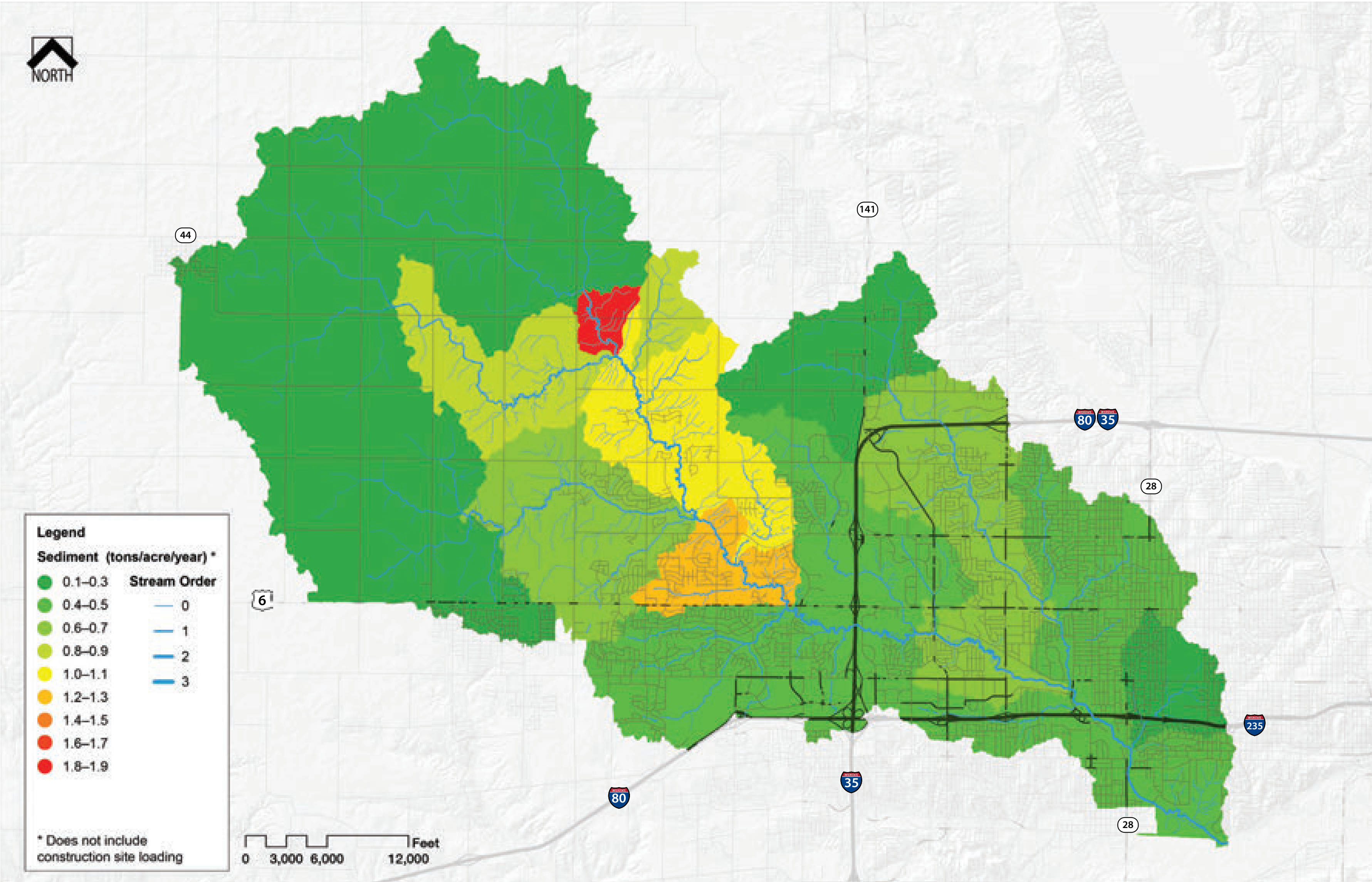
Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Nitrogen Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Phosphorus Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Sediment Loading

Projected Reduction Targets

The reduction targets within this section are intended to be long-term goals which will likely take many decades to achieve. The Watershed Action Plan (Chapters 7–10) and Implementation Plan included (Chapters 11–14) within this document will identify how to begin progress toward these goals over the next decade.

Iowa's Nutrient Reduction Strategy calls for reductions in nutrient loading from **non-point sources** in agricultural areas. These loading reductions are 41% for nitrogen and 29% for phosphorus. Using past monitoring data from the ISA/ACWA sites, loading reductions of this amount for nitrogen would be expected to limit violations of the Raccoon River watershed TMDL standard for nitrate to less than 1% of all samples collected at site 40. Many management practices which target phosphorus are also effective at reducing erosion or trapping sediment loads. Based on this, it seems reasonable to expect that sediment loadings from the agricultural areas could be reduced by a similar amount by implementing practices which aim to reduce phosphorus loading.

Did you know...?

Phosphorus is a pollutant that often binds with sediment particles.

Did you know...?

This plan estimates that 25% of the sediment load from this watershed could be attributed to construction sites. These sites cover only 0.1% of the entire watershed in a typical year. Those statistics may be difficult to imagine, however the average sediment loss estimated for construction sites is equal to only about 1/8 inch of soil across the surface of all construction sites. A more detailed discussion of how construction site loadings were calculated is included within an appendix to this plan.

The Nutrient Reduction Strategy does not establish reduction goals for nutrients within urban areas. The analysis within this plan identifies that pathogens, sediment loadings and runoff volumes and rates are more critical pollutants to address within the urban environment.

Loading Reduction Goal #1:

Reduce nitrogen loading from non-point sources within rural areas by at least 41%.

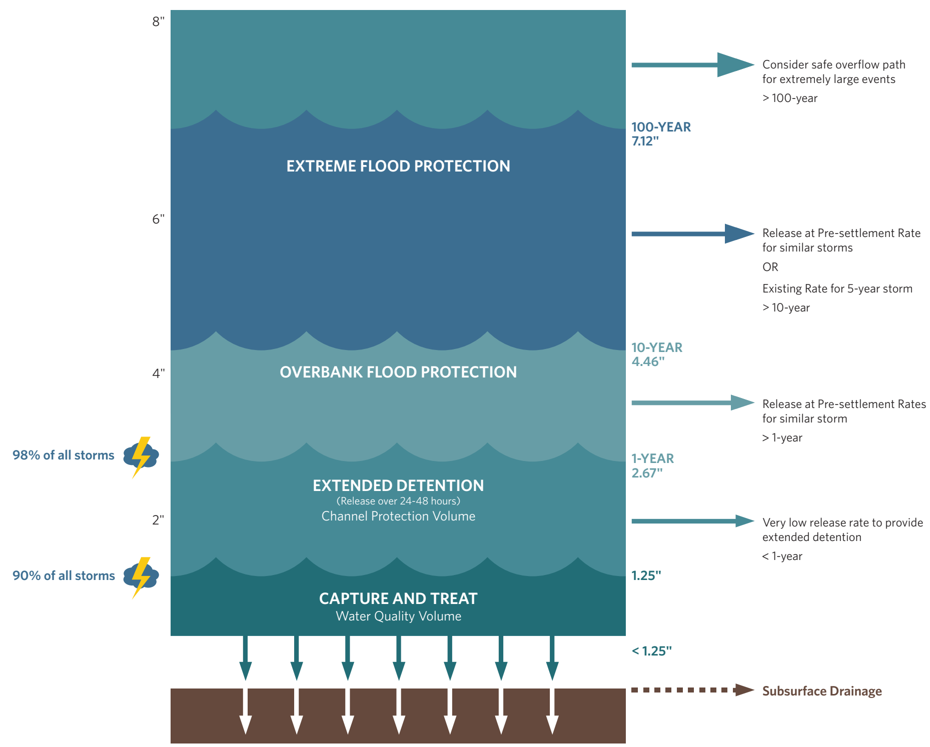
Loading Reduction Goal #2:

Reduce phosphorus loading from non-point sources within rural areas by at least 29%.

Loading Reduction Goal #3:

Reduce sediment loading from non-point sources within rural areas by at least 29%.

Levels of Stormwater Management Using ISWMM's Unified Sizing Criteria



Source: RDG

The Raccoon River TMDL established a target single sample maximum concentration of E.coli bacteria at 200 MPN/100mL. Based on monitoring sites, load reductions of more than 99% would be necessary to meet this criterion. This appears to be an impractical goal, given the level of existing urban development throughout the watershed and the amount of retrofits that would be necessary to meet this standard. For this reason, the following load reduction goals are proposed:

Loading Reduction Goal #4:

In newly developing areas, employ **best management practices** (BMPs) to capture and treat runoff from the 1.25" rainfall event (**Water Quality event**). Select practices such as **bioretention, wet detention ponds** and **constructed wetlands** which have been demonstrated to be most effective at reducing bacteria loading. (1) Refer to the International Stormwater BMP Database (bmpdatabase.org) for updated information.

Loading Reduction Goal #5:

In existing developed areas, develop a program to employ stormwater retrofits where practical to reduce pathogen loading to the maximum extent possible.

There is no established statewide criteria governing sediment loadings or water quantity volumes. This plan has identified that these items have a significant impact related to both water quality and stream corridor stability. Therefore, the following goals related to sediment and runoff water quantity are proposed:

SEDIMENT

Loading Reduction Goal #6:

Implement and/or enforce effective construction site pollution prevention management practices in developing areas. Controls should reduce total suspended solids (TSS) from site runoff by 80% (as compared to no controls). (2) Could reduce watershed sediment load by 15%.

Loading Reduction Goal #7:

Complete streambank stabilization and restoration projects as needed to reduce sediment loading attributed to streambank erosion by 50% by 2040.

RATES AND VOLUMES

Loading Reduction Goal #8:

In developing areas, provide stormwater management practices which achieve the following:

- Capture and treat runoff from the Water Quality Event (treat 100% of runoff from precipitation events of less than 1.25 inches). 90% of all rainfall events in Central Iowa fall into this category. (2)
- Provide extended detention of the 24-year, 1-year return period event; with slow release over a period of not less than 24 hours. This should reduce peak runoff rates from newly developing areas by more than 95% for these types of storm events. (3)
- Limit runoff rates for events equal to or smaller than the 24-hour, 1% annual exceedance probability (100-year return period storm) to levels similar to natural (pre-settlement) conditions.

Loading Reduction Goal #9:

In developed areas, evaluate opportunities and implement practices to reduce runoff rates and volumes by the maximum extent possible.

- Develop education and outreach incentives to increase use of best management practices on existing developed areas.
- Install practices that are intended to maximize reduction in rates and volumes from a one-year storm event.

Source:
1. *Iowa Stormwater Management Manual*
2. *Iowa's NPDES General Permit Number 2*
3. *Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see Chapter 8 and appendix resources)*

VISION: Engaged residents working across political and property boundaries to create and sustain a healthy watershed.

MISSION: Through collaboration, education and research, implement science-based policies and practices for flood mitigation, water quality improvements, natural resources protection and improved recreation while maintaining economic health.

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Strategic Framework

ONE

Reduce flooding through improved stormwater management and soil health.

TWO

Improve water quality, with an emphasis on sediment, nitrate, phosphorus and E.coli reductions.

THREE

Enhance recreation and public health through improved water quality, habitat restoration, stream accesses, improved connectivity to parks/trails and cultural opportunities.

FOUR

Deliver enriched conservation education and programming with emphasis on water quality/quantity management, wildlife/habitat, urban and agricultural needs within the watershed.

FIVE

Support community vitality and maintain economic health through implementing multi-purpose projects producing benefits in public, natural resources and economic health that can be documented.

SIX

Develop ongoing means for collaboration and implementation of effective policies and practices, taking a consistent watershed and/or regional scale approach as much as practical.

GOALS

1. Reduce flooding.
   a. Implement urban and rural best management practices (BMPs) to:
      i. Mitigate increases in runoff volumes and peak rates of flow caused by man-made alterations to the landscape
      ii. Reconnect Walnut Creek and tributaries with their adjacent flood plains
      iii. Reduce streambank and channel erosion
      iv. Improve physical habitat within the stream and adjacent flood plains and stream buffers
      v. Reduce flood damage overall and protect municipal infrastructure
   b. Promote policies and practices which lead to soil quality restoration on both urban and rural landscapes

> Refer to the BMP Matrix to see which practices address these goals and the pollutants of concern.

2. Improve water quality, with an emphasis on sediment, nitrate, phosphorus and E.coli reductions.
   a. Improve effectiveness and consistency of enforcement of Stormwater Pollution Protection Plans
   b. Develop and implement a monitoring program to measure results and identify additional pollutants of concern
   c. Implement urban and rural BMPs to meet water quality standards, reduce sediment and allow water contact recreation

3. Enhance recreation and public health.
   a. Phase improved stream accesses to coordinate with water quality and safety improvements
   b. Improve watershed-wide volunteer coordination/opportunities for habitat improvement projects
   c. Incorporate purposeful community arts initiatives for improved public engagement and education, as well as enhanced aesthetics
   d. Enhance/improve greenway development within the watershed (e.g., See upcoming Clive Greenbelt Master Plan for example)
   e. Use buffering to expand the watershed's greenways network and connectivity of waterways and trails
   f. Implement BMPs to:
      i. Restore wetlands/natural areas
      ii. Expand native landscape cover and riparian areas
      iii. Improve wildlife habitat and remove invasive species
      iv. Promote healthy soils

4. Deliver enriched conservation education and programming with emphasis on water quality/quantity management, wildlife/habitat, urban and agricultural needs within the watershed.
   a. Implement the Education and Collaboration Plan included within this Watershed Plan (Chapter 11)

5. Support community vitality and maintain economic health through implementing multi-purpose projects producing benefits in public, natural resources and economic health that can be documented.
   a. Establish metrics for projects that identify appropriate scales to measure social, economic, and environmental costs and benefits for projects
   b. Identify BMPs with multiple benefits through use of this Watershed Plan's BMP Matrix, particularly employing use of the Community Section where multi-purpose projects, citizen awareness and regional connections are emphasized

6. Develop ongoing means for collaboration and implementation of effective policies and practices, taking a consistent watershed and/or regional scale approach as much as practical. (Also see Chapter 11: Collaboration and Education Plan, and Chapter 9: Policy Recommendations).
   a. Priority policies for watershed-wide (and/or metro-wide) adoption include:
      i. Unified sizing criteria as described within the Iowa Stormwater Management Manual (ISWMM)

ii. Protected stream buffers, protecting the five-year flood plain in rural areas and following guidance within this plan for urban areas (see Chapter 9)
iii. Construction site pollution prevention improvements (see Goal 2a above) to address both erosion and sediment control practices that are currently falling short
iv. Ordinances to protect or restore healthy soils, referencing ISWMM for recommendations
v. Flood plain protection standards designed to reduce structural/property losses, maintain flood storage capacity, identify areas of active stream movement (for preservation) and provide flood "head room" (set building protection elevation three feet above regulatory 100-year flooding elevations).

b. Advocate for expanded regional/watershed resources for planning and practice implementation at the county, state and federal level
c. Collectively pursue resources for plan implementation, recognizing projects often have benefits beyond the jurisdiction/property boundaries in which they are implemented
d. Recognizing upstream partner costs and downstream partner benefits, explore creative funding options (e.g., a water fund or nutrient trading, whereby downstream partners support upstream practices)
e. Similarly, pursue incorporation of regional-scale practices with associated cost-benefits, e.g., wetland mitigation banks

Legend
P = Primary benefit
C = Complementary benefit

	Best Management Practices													
	Urban													
Restoration Objectives (below)	Better Site Design / Source Reduction	Construction Site Erosion Controls	Construction Site Sediment Controls	Soil Quality Management / Restoration	Pre-treatment Practices	Parking Lot Retrofits	Bioretention	Bioswales	Constructed Wetlands	Wet Detention Pond	Extended Dry Detention Pond	Increase Flood Plain Storage	WQ Outlet Modifications	Stream Corridor Restoration
Water Quality														
Reduce pollutants of concern														
Nitrates	P			P		P	P	P	P	P			C	
Bacteria	P			P		P	P	P	P	P	C	C	P	
Sediment	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Phosphorus	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Meet water quality standards	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Reduce sediment contamination	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Allow water contact recreation	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Water Quantity / Flooding														
Retain more runoff higher in the watershed	P			P		P	P	P	P	P	P		P	
"Lengthen the watershed" (longer flowpath, slower velocities, etc.)	P			P		P	P	P	P	P	P	P	P	C
Reduce Directly Connected Impervious Areas (DCIAs)	P					P	P	P	P	P	P			
Increase floodplain capacity												P		P
Promote / sustain compatible land uses within the flood plain	P								P	P		P		P
Reduce flood damage	P			P		P	C	C	P	P	P	P	P	P
Biological														
Restore wetlands/natural areas	C				C				P	P		C	C	P
Expand native landscape cover							P	P	P	P	P	C		P
Enhance wildlife habitat				P	P		P	P	P	P	C	P	C	P
Remove invasive species	C								C	C		P		P
Enhance riparian areas	P			P	P				P	P	C	C		P
Promote healthy soils	P	P		P										P
Physical														
Reduce channel erosion	P	P	P	P		P	P	P	P	P	P	P	P	P
Reconnect with floodplain												P	P	P
Restore physical habitat				P	P		P	P	P	P	P	P	P	P
Protect municipal infrastructure	P			P	P	P	C	C	C	C	C	P	P	P
Social and Economic														
Eliminate trash/debris		P	P		P								P	P
Create greenways / waterfront access / open space	P								P	P	P	P		P
Revitalize neighborhoods	P			P	P	P	P	P	P	P				P
Improve aesthetics beautification	P	P	P	P	P	P	P	P	P	P	P	P		P
Increase citizen awareness	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Improve recreation	P	C	C	P	P	C	C	C	P	P	C	P	C	P
Multi-purpose projects	P			P	P	P	P	P	P	P	P	P	P	P
Regional connections	P								C	C				C

Legend

P = Primary benefit

C = Complementary benefit

							Best Management Practices																							
							Rural																							
	Relationship to Goals						Nutrient Management						Land Use Change					Erosion Control / Edge of Field								Stream Improvements				
Restoration Objectives (below)	1 - Reduce Flooding	2 - Improve Water Quality	3 - Enhance Recreation	4 - Conservation Education / Programming	5 - Community Vitality / Economic Health	6 - Collaboration / Implementation	Nitrogen Application Rate (N)	Cover Crops (N and P)	Living Mulches (N)	Phosphorus Source (P)	Placement of Phosphorus (P)	Tillage (P)	Energy Crops	Land Retirement (CRP) - Target Steep Slopes	Land Retirement (CRP) - Target Flood Plain	Extended Crop Rotations	Grazed Pastures	Drainage Water Management (N)	Shallow Drainage (N)	Wetlands (N)	Bioreactors (N)	Adequate Stream Buffer Widths (N and P)	Saturated Buffers (N)	Terraces (P)	Sediment Basins or Ponds (P)	Road Crossing Outlet Modifications	Grass Swale	Two-Stage Ditches	Restrict Cattle Access to Streams	Streambank Repairs
Water Quality																														
Reduce pollutants of concern		P	C	C	C	C																								
Nitrates							P	P	P				P	P	P	P	P	P	P	P	P	P	P			C	P	P	P	
Bacteria													P	P	P	P	P			P		P		P	P	C	P	P	P	C
Sediment								P	P			P	P	P	P	P	P					P		P	P	C	P	P	P	P
Phosphorus								P	C	P	P	P	P	P	P	P	P					P		P	P	C	P	P	P	P
Meet water quality standards		P	C	C	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Reduce sediment contamination		P	C	C	C	C						P	P	P	P	P	P			C		P	C	P	P	P	P	C	C	P
Allow water contact recreation		P	C	C	C	C		P	P			P	P	P	P	P	P					P		P	P	C	P	P	P	P
Water Quantity / Flooding																														
Retain more runoff higher in the watershed	P	P	C	C	C	P							P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C		
"Lengthen the watershed" (longer flowpath, slower velocities, etc.)	P	P	C	C	C	C							C	C	C	C	C	P	P	P	C	C	C	P	P	P	P	P		C
Reduce Directly Connected Impervious Areas (DCIAs)	P	P	C	C	C	C																								
Increase floodplain capacity	P	C	C	C	C	C																C		C	P	P	C	P		P
Promote / sustain compatible land uses within the flood plain	P	C	C	C	C	C									P		P	P		P	C	P	P		P	P	P	P	P	
Reduce flood damage	P			C	P	P							P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	C	P
Biological																														
Restore wetlands/natural areas	P	P	C	C		C									P			P	P	P		P	P		C	C	P	P	C	P
Expand native landscape cover	C	P	P	P	C	C								P	P			P	P	P	C	P	P		C	C	P	P	C	P
Enhance wildlife habitat		C	P	P	P	C							C	P	P	C	C	P	P	P	C	P	P	C	C		C	P	C	P
Remove invasive species		C	P	P	P	C								C	C			C	C	C		C	C				C	C	C	P
Enhance riparian areas		C	P	P	P	C									P			P	P	P		P	P		P	P	C	P	P	P
Promote healthy soils	P	P	C	P	C	C	P	P	P	P	P	P	P	P	P	P	P													
Physical																														
Reduce channel erosion	P	P	P	P	P	C							C	C	P	C	C	C	C	C		P	P	P	P	P	P	P	P	P
Reconnect with floodplain	P	C	P	P	P	C									P							P			P	P	P	P		P
Restore physical habitat		C	P	P	P	C		C	C			C	C	P	P	C	C	P	P	P		P	P		P	P	P	P	P	P
Protect municipal infrastructure	P	C		C	C	P							C	C	C	C	C	C	C	C		C	C	C	C	P	C	P		P
Social and Economic																														
Eliminate trash/debris		P	P	P	P	P																		C	C	C			C	P
Create greenways / waterfront access / open space	C	C	P	P	P	P							C	C	P					P		P	C		P	P	P	P	P	P
Revitalize neighborhoods	C		P	C	P	P																								
Improve aesthetics beautification		C	P	P	P	C								P	P	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P
Increase citizen awareness		C	C	P	P	P						C	C	P	P	P	C	P	P	P	P	P	P	P	P	P	P	P	P	P
Improve recreation		C	P	P	P	P	C	C	C	C	C	C	C	P	P	P	C	P	P	P	C	P	P	C	P	P	P	P	P	P
Multi-purpose projects	P	P	P	P	P	P		P				P	P	P	P	P	C	P	P	P	P	P	P	P	P	P	P	P	C	P
Regional connections						P							C							C		C						C		C

CHAPTER 8

KEY CONCEPTS

1. **The case for "case studies"**
   Focusing on improvements in smaller "case study" subwatersheds allows the results of improvements to be seen more quickly and at less cost than implementation at the full watershed scale.

2. **Rural case study model plan**
   A plan has been developed for a six-square-mile watershed in rural Dallas County which meets the loading reduction goals set forth in this plan. The nutrient reduction components of these goals are consistent with Iowa's Nutrient Reduction Strategy.

3. **Urban case study model plan**
   Some outlet structures at existing detention ponds can be modified to reduce storms from small and moderate storm events ("one-year" storms and smaller—2.67" or less). Runoff rates from smaller drainage areas where these ponds are located could be reduced by 40% during these types of storms. Such improvements would also reduce sediment and phosphorus pollution downstream.

4. **Developing case study model plan**
   Embracing use of the Iowa Stormwater Management Manual as a design standard for new stormwater management practices could reduce runoff rates for small and moderate storm events by 97% compared to traditional methods. Such reductions would help to maintain the stability of streams in developing areas as well as improve water quality by capturing and filtering out pollutants during the most commonly occurring storm events.

5. **Healthy topsoil is important**
   Topsoil is an essential component in increasing how much rainfall is absorbed where it falls.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Implementing model plans in "case study" subwatersheds will allow us to complete improvements for an area in a shorter period of time and review the effects by monitoring changes in water quality. The monitoring data will either validate the approach or highlight where changes are needed. The lessons learned can be applied to future improvements across the watershed.

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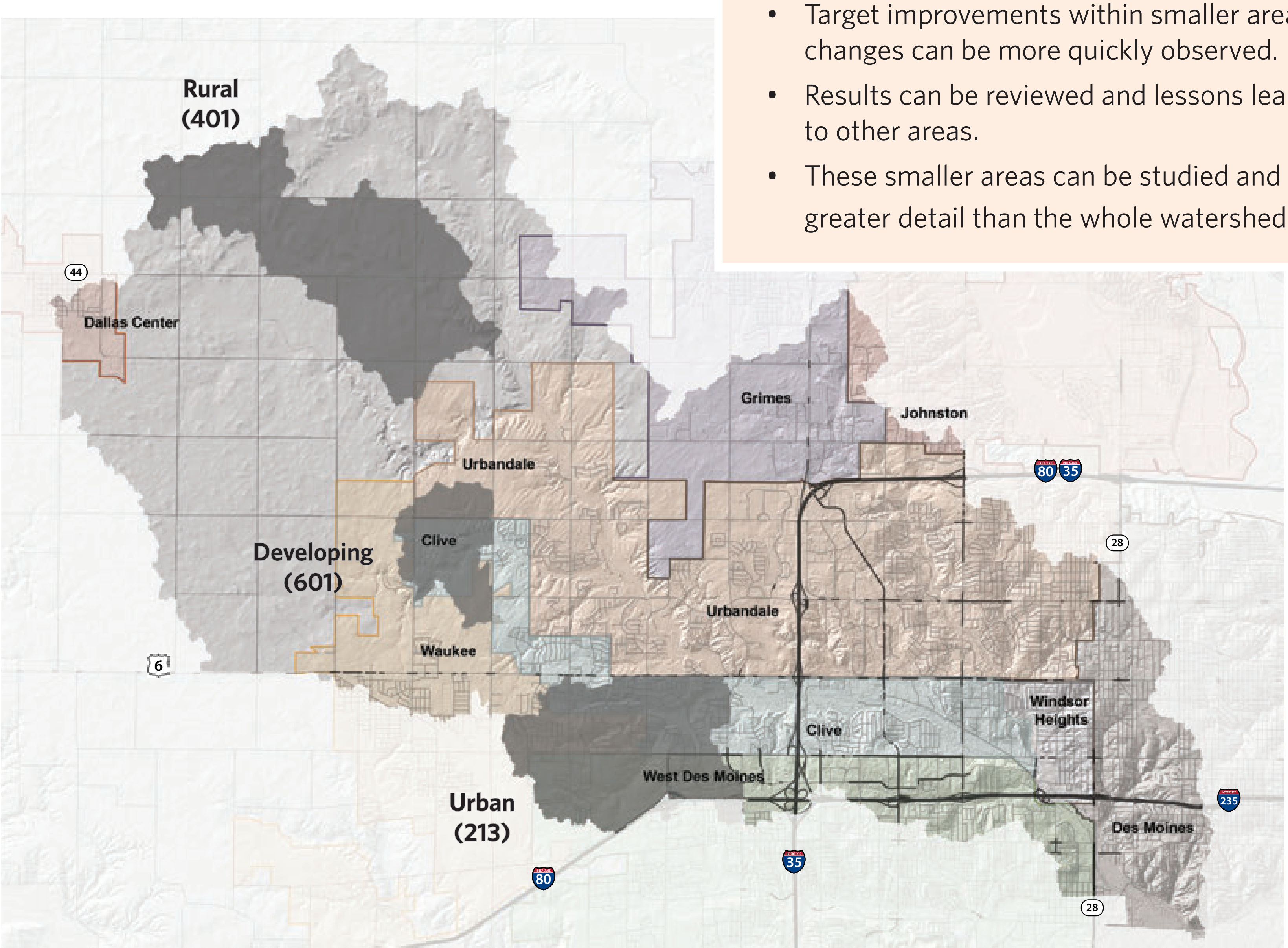
Case Study: Subwatershed Strategic Plan

Smaller subwatersheds are being used as case studies to:

- Target improvements within smaller areas where changes can be more quickly observed.
- Results can be reviewed and lessons learned applied to other areas.
- These smaller areas can be studied and modeled in greater detail than the whole watershed.



Key Lessons Learned

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.
Runoff analysis performed by RDG Planning and Design.

Rural (411)

- Cropland is expected to be the largest source of nitrogen and phosphorus loads.
- Gully and streambank erosion is expected to be a large source of sediment load.

Urban (213)

From 2001-2011, construction sites made up 2-3% of this subwatershed. This small portion of this landscape is estimated to contribute:

- 61% Sediment load
- 17% Nitrogen
- 26% Phosphorus

Developing (602)

7x

Runoff volume increase in suburban residential areas compared to pre-settlement conditions during a one-year storm event *(2.67" in 24 hrs)*

43x

Rate of flow increase for same conditions

97%

Reduction in peak outflow rates from developing areas for the one-year event, using new stormwater design methods outlined in the Iowa Stormwater Management Manual *(compared to current methods)*

1/2

Restoring healthy topsoil layers to open space areas can reduce stormwater runoff by 1/2.

25%

Construction sites likely contribute more than 25% of the total sediment load in the Walnut Creek watershed.

Modifying key pond outlet structures to manage small storms could reduce:

- One-year outflow rates for the area served by more than 40%
- Phosphorus and sediment loads downstream by 10%

Subwatershed Case Studies

The Walnut Creek watershed covers an area of nearly 83 square miles.

It would take significant investments within an area of this scale to notice measurable improvements in water quality. This is the primary reason that certain subwatersheds have been selected for more intense study. Focusing efforts in these "case study" areas allows monitoring to better measure changes in water quality that result from localized improvements. This provides the opportunity to review results and make strategic adjustments which can be applied to improvements in other subwatershed areas. A secondary benefit of this approach is more precise modeling of the subject area, using information about land use, streambank conditions, gully formation and existing management practices at a higher level of detail than is practical to collect at the larger watershed scale.

One subwatershed was selected to represent a typical rural setting, another in a developed area and one in an area which is expected to experience rapid urban growth in the next few years. Four candidate subareas of each of these types were presented to the Walnut Creek WMA board for review, to establish a consensus on which ones were to be designated as case study subwatersheds. For each selected subwatershed, a specific plan has been developed to target expected sources of key pollutants (see map on page 136).

A more detailed review of each case study is included within an appendix to this plan.

Rural Case Study—Subwatershed 411

Location

This area is located in the **headwaters** of Walnut Creek. This 6.5-square-mile area is generally located between Dallas Center and Grimes, with Highway 44 running east-west through the center of the area. This subwatershed has been divided into 18 smaller areas, or microwatersheds, for analysis.

Pollutant Sources

More than 80% of this subwatershed is used for **row-crop** agricultural production. Over the past two years, these areas were primarily farmed either in a rotation of corn and soybeans, or planted as corn in each year. Modeling results indicate that

Average Loading per Acre by Microwatershed

Microwatershed *		Area	N	P	Sediment
		(acres)	lb/ac/yr	lb/ac/yr	lb/ac/yr
411.01	W1	138.1	17.8	2.5	4,884
411.02	W2	165.5	15.0	1.1	1,111
411.03	W3	32.4	14.6	1.4	375
411.04	W4	102.7	31.5	2.6	2,079
411.05	W5	1116.3	27.7	1.9	624
411.06	W6	297.9	32.2	2.1	322
411.11	W7	224.7	22.7	1.8	1,463
411.12	W8	257.8	31.4	2.1	423
411.21	W9	174.7	27.5	1.8	348
411.31	W10	222.1	29.8	1.8	392
411.32	W11	151.2	29.3	1.9	338
411.33	W12	202.6	31.5	2.0	361
411.41	W13	39.0	27.9	2.0	454
411.42	W14	299.8	30.8	2.1	472
411.51	W15	72.8	27.6	1.5	370
411.52	W16	299.1	30.6	1.9	389
411.61	W17	157.1	32.5	2.2	546
411.71	W18	198.1	30.5	2.1	574

* Refer to Chapter 2 (page 54) for explanation of watershed numbering.

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

cropland areas are the most significant sources of nutrient loadings. Row-crop areas also produce the majority of the sediment loading from this subwatershed, although streambank and gully erosion are also significant contributors of this pollutant. There are several areas within this subwatershed with pollutant loadings that are expected to be much higher than the Walnut Creek Watershed averages, based on completed modeling.

Current Land Uses—Subwatershed 411		
	Area (acres)	**%**
Cropland	3,422.9	82.4%
Urban	376.0	9.1%
Grasslands	277.3	6.7%
Pastureland	69.0	1.7%
Forest	6.7	0.2%
Total	**4,151.9**	

Estimated Pollutant Sources—Subwatershed 411			
	N	**P**	**Sediment**
Cropland	95.4%	87.2%	53.0%
Urban	3.1%	7.1%	5.2%
Pastureland	0.6%	0.8%	1.3%
Streambank	0.5%	3.0%	29.5%
Gully	0.3%	1.4%	10.6%
Grasslands	0.1%	0.5%	0.4%
Forest	0.0%	0.0%	0.0%

Estimated Pollutant Loading—Subwatershed 411 *			
	N	**P**	**Sediment**
	tn/yr	tn/yr	tn/yr
All Sources	59	4	1,540
% of Watershed Total	12%	13%	5%
* Note that pollutant loading is the estimated pollutant load delivery to the outlet point from this subwatershed area.			

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

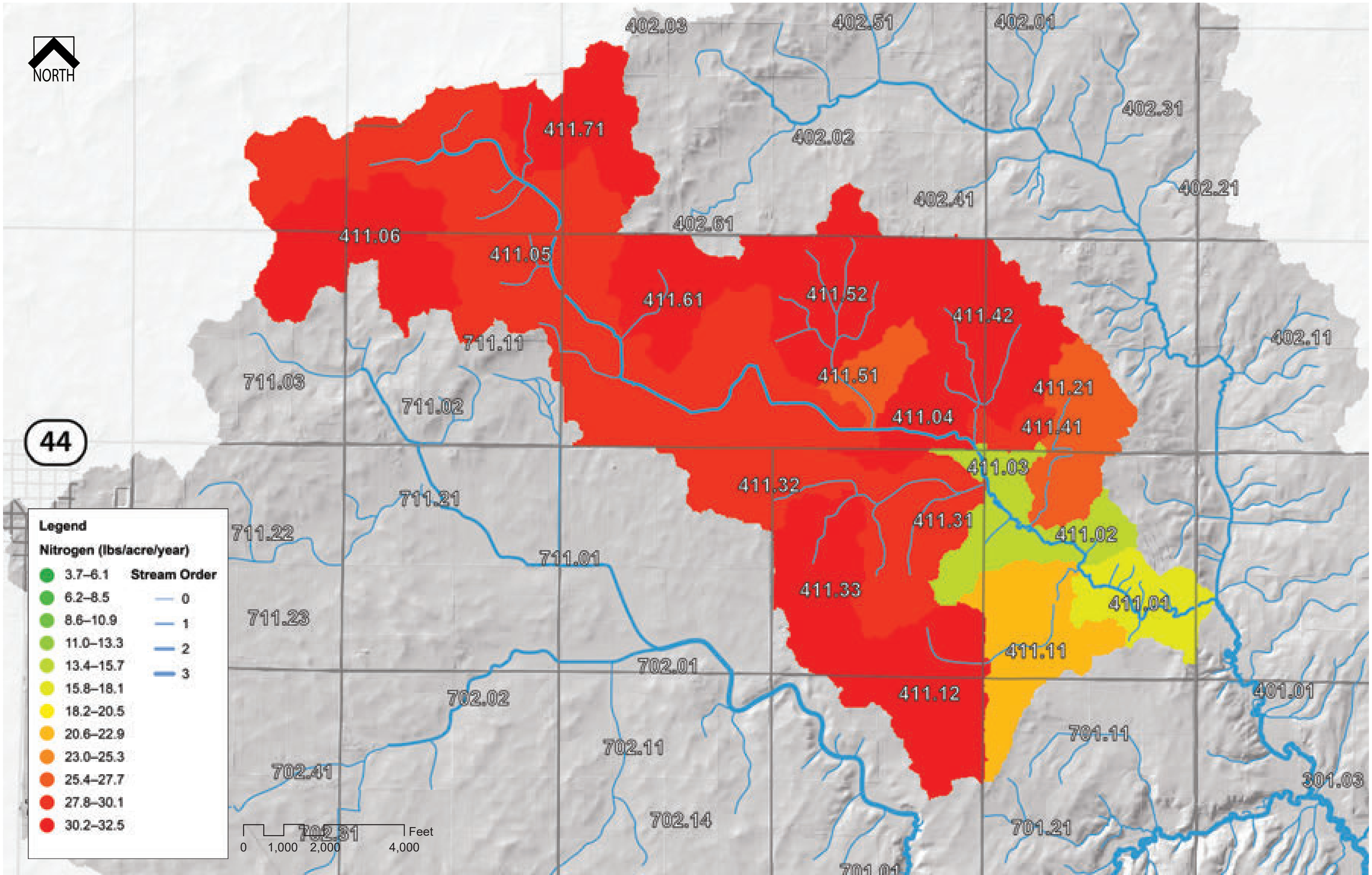
Water Quality Improvement Plan

The following strategies are recommended to improve water quality within this subwatershed area and develop and evaluate a template for future action within other rural agricultural areas.

Subwatershed Strategy #1—*Employ best management practices (BMPs) which are identified in the Nutrient Reduction Strategy document or other resources, with a goal of reducing nutrient loads from this subwatershed area.* Loading reduction targets are 41% for nitrogen and 29% for phosphorus by 2025.

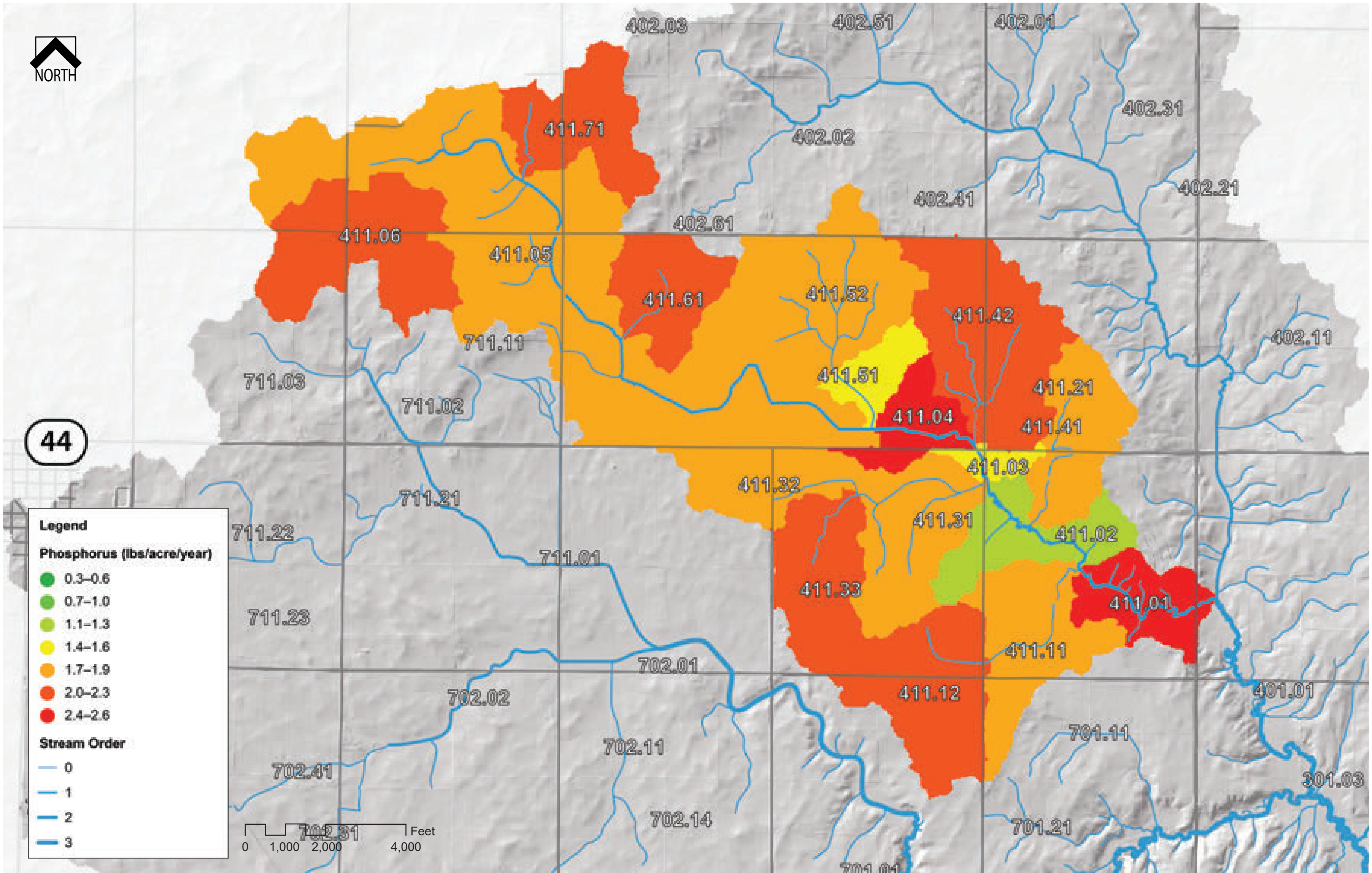
- This chapter outlines a “model plan,” which is one possible set of improvements that collectively would reach these goals. Many other combinations are possible.
- Staff and resources from local and regional groups such as the Heartland Co-op, County Soil and Water Conservation Districts (SWCDs), IDNR, **NRCS** and Iowa Soybean Association should work with local farmers and landowners to expand knowledge about these practices and find the right fit for practices throughout the landscape.

Erosion along an outer bend in subwatershed 411



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Nitrogen Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Phosphorus Loading

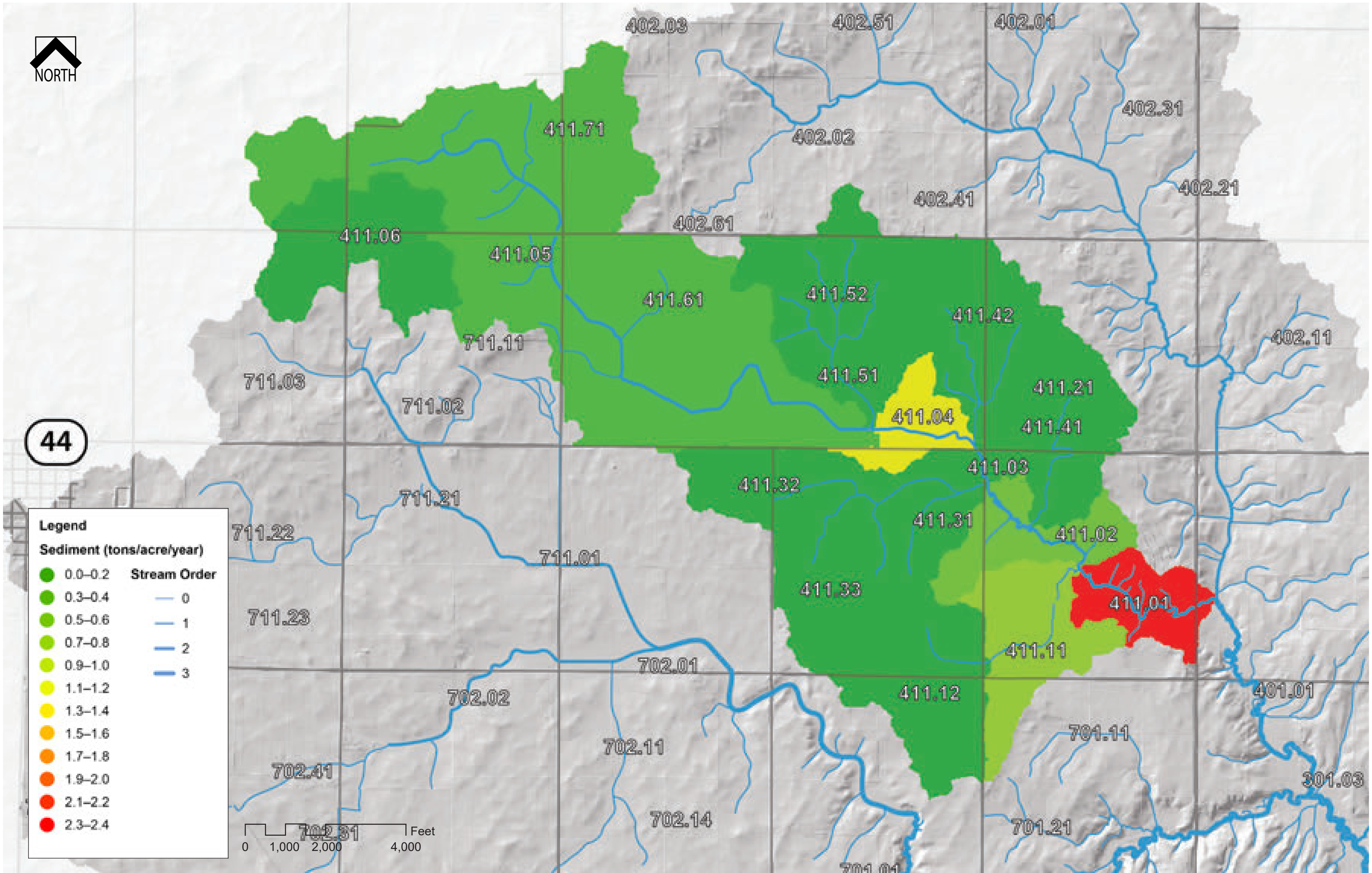
Model Plan—Practices to be Applied Broadly Across Case Study Area				
Practice	Acres to be Applied	Portion of Subwatershed to be Applied	Expected Load Reduction (Where Applied) (1)	
			Nitrogen	Phosphorus
Extended Crop Rotations	415	10%	42%	NA*
Split Seasonal N Applications	830	20%	5%	NA
Cover Crops	1,040	25%	28%	29%
Increased Use of Nitrification Inhibitors	1,040	25%	9%	NA
Increased Use of "No-Till" Practices	1,455	35%	NA	90%
Adjust N Application Rates	2,075	50%	10%	NA
* The nutrient reduction strategy does not list reductions for phosphorus from extended crop rotations. However, some reductions are expected, although not included in the model.				

The model plan focuses on several key practices to meet the desired load reductions. Brief descriptions of these practices are included in Chapter 15 of this plan. Six of these practices were projected to be applied broadly across this subwatershed area. Expected load reductions are typically based on values from the 2014 edition of the Nutrient Reduction Strategy.

The "model plan" also identifies practices recommended to be installed within certain smaller microwatershed areas.

- *Land Retirement to CRP*—Convert some steep-slope (slopes > 5%) cropland areas to grasslands through use of CRP or by dedication to permanent conservation easements. The model assumes that 5% of the cropland in area 411.01, 2% of the cropland in 411.04 and 1% of the cropland in 411.05 would be converted in this way. (The Raccoon River Water Quality Improvement Plan identified this as a strategy to address nutrient losses on steeper, more erodible lands.)
  - Total land affected = 20 acres.
  - Expected reductions of 85% nitrogen and 75% phosphorus loading from groundwater and surface runoff from the affected areas.
- *Saturated Buffers*—Intercept tile drainage systems and divert most subsurface drainage through a saturated buffer strip adjacent to the stream. The model included 50% of the land area within subarea 411.04 and 35% of the land area within subarea 411.05 being managed using this method.
  - Total land area treated = 442 acres.
  - Expected reduction of 33% nitrogen loading from groundwater from the treated area.
- *Bioreactors*—Intercept tile drainage systems for smaller areas (less than 100 acres) and divert most subsurface drainage through a bioreactor system. The model included 30% of the land area within subareas 411.02, 411.03, 411.11, 411.31, 411.32, 411.33 and 411.41 being treated in this manner.
  - Total land area treated = 311 acres.
  - Expected reduction of 43% nitrogen loading from groundwater from the treated area.
- *Grass waterways*—Create or enhance grass waterways to maintain a minimum 33-foot width, or wider as dictated by current design guidelines or as needed to protect the five-year flood plain. The model included installing such waterways (where they don't yet exist) along 90% of the "zero order" streams mapped as part of this plan located within subareas 411.12, 411.21, 411.32, 411.33, 411.42, 411.51, 411.52, 411.61 and 411.71. Installing such waterways would impact 26 acres of cropland area.
  - Total land area treated = 1,632 acres. Length = 34,200 feet.
  - Expected reduction of 50% phosphorus loading from surface runoff from the treated area.

Source:
1. *Reduction rates adapted from Section 2.1-2.3 of the Iowa Nutrient Reduction Strategy (May 2013).*



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Sediment Loading

- Wetlands—Construct wetland features in areas where productivity is most commonly lost due to standing water. Flow paths immediately upstream of road crossings are also good candidate locations. Wetlands should be designed with multi-stage outlet structures to maximize reduction of peak flow rates from small and moderate storm events. (Provide drawdown of a one-year return period storm over a period of 24–48 hours). Such outlet modifications would allow the wetlands to serve two key purposes: nutrient reduction and stormwater peak flow reduction for storms of approximately 3" or less. For this model, it is assumed that wetlands could intercept runoff from 30% of subarea 411.05 and 100% of subarea 411.06. Total wetland new area expected to be 30 acres in size.
    - Total land area treated = 633 acres.
    - Expected reduction of 52% phosphorus loading from surface runoff from the treated area.
- Two-Stage Ditch—Although these features have not been included in the Nutrient Reduction Strategy, several studies have demonstrated that these features have been very effective at removing nitrogen and phosphorus from streams with larger drainage areas. They are best implemented in areas without adequate buffer widths, where the stream is narrow or where the streambanks or channel bottom are unstable. This practice allows for expansion of the channel cross-section, slowing flow velocities and allowing for increased filtration of runoff. One key section of channel extending through parts of subarea 411.04 and 411.05 appears best suited for this practice. It would treat not only runoff from this subarea, but all areas located upstream. Installation of this practice would likely affect only two acres of current row-crop production.
    - Total land area treated = 2,244 acres.
    - Expected reduction of 10% nitrogen and 15% of phosphorus loading from both surface and groundwater runoff from the upstream treated area.

Subwatershed Strategy #2—*Address key areas of gully and streambank erosion.*

- *Streambank stabilization and restoration*—Target efforts to a one-mile stretch of stream within subarea 411.01 and a half-mile segment within subarea 411.02. These improvements have the potential to reduce the annual rate of erosion by 265 tons.
- *Two-stage ditch*—Conversion of a section of stream within parts of subareas 411.04 and 411.05 to a two-stage ditch would also reduce the annual rate of erosion by up to 52 tons.

The "model plan" includes the two improvements listed above. There are also some other gully areas in subareas 411.01 and 411.11 which could be addressed that could reduce annual erosion rates by up to 170 tons. Such repairs have not been included in the model calculations.

Subwatershed Strategy #3—*Look for opportunities to reduce the peak rates of flow caused by small to moderate storm events.*

Where practices are constructed that detain or retain water (i.e. wetlands, sediment basins, ponds, etc.) use multi-stage outlet designs that provide temporary stormwater storage for extended detention of small and moderate storm events. A one-year return period, 24-hour storm event in this area is 2.67" of rainfall. Such controls could reduce runoff peak rates by over 95%. The multi-stage design would not necessarily be designed to fully detain runoff from larger storms; however, the runoff from the one-year event is approximately 40% of the flow volume of a 100-year return period event. This would be captured and slowly released by managing runoff from the more commonly occurring smaller storms. Therefore, such outlet structures would provide downstream benefits during both small and large storm events.

Expected Load Reductions

The projected load reductions included in this table are based only on the practices and strategies listed previously as included in the "model plan" for this case study area. The simulation indicates that this plan meets the goal for nitrogen loading reduction, and exceeds the goals for phosphorus and sediment loading reductions.

Projected Pollutant Loading—Subwatershed 411 *

	N	P	Sediment
	tn/yr	tn/yr	tn/yr
All Sources	33	2	582
Model Plan Projected Reductions	42%	62%	65%

* Note that pollutant loading is the estimated pollutant load delivery to the outlet point from this subwatershed area.

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Urban Case Study—Subwatershed 213

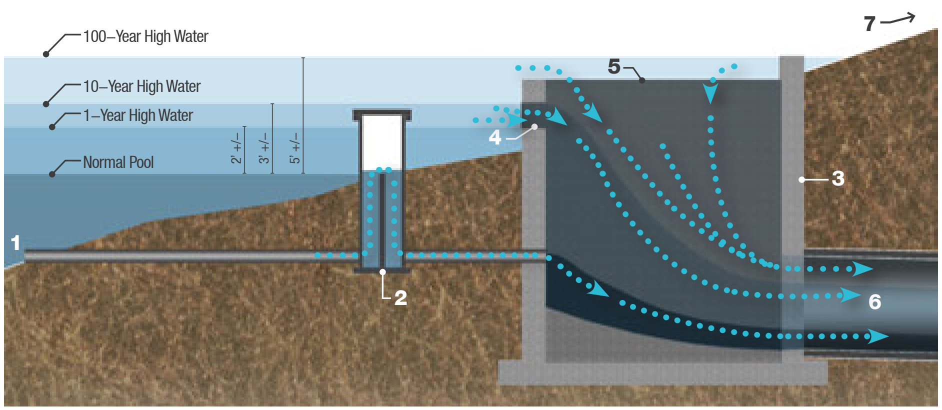
Location

This subwatershed includes areas which are **tributary** to South Walnut Creek, which flows into Walnut Creek just south of Hickman Road, west of 128th Street in Clive. Most of this area drains through Country Club Lake in Clive. This 4.5-square-mile area is almost completely developed at this point.

Pollutant Sources

More than 80% of this subwatershed is now developed into suburban land uses, and as such modeling indicates that a majority of nutrient loadings are expected to be sourced from these land uses. Cropland makes up less than 3% of the watershed, but is expected to be the source of over 13% of nitrogen and 7% of phosphorus loading. As these areas continue to be developed, the loading attributed to cropland is expected to decrease. Overall, nutrient loading from this subarea is expected to be generally lower than the Walnut Creek Watershed averages. However, within this subwatershed there are several areas with pollutant loadings that are expected to be much higher than the watershed average, based on completed modeling.

Example of a multi-stage outlet



Source: RDG

1. 1st Stage: Small Diameter Inlet - Low Flow Control (Below Surface)
2. Water Level Control Structure
3. Main Outlet Structure
4. 2nd Stage: Notch Weir or Medium Size Opening (Controls 2-25 Year Storms)
5. 3rd Stage: Longer Overflow Weir (50-100 Year Storms)
6. Pipe Outlet (Likely Controls 50-100 Year Storms)
7. 4th Stage: Emergency Spillway (For Storms Larger Than 100-Year)

Current Land Uses—Subwatershed 213

	Land Use	%
Urban *	2643.1	92.1%
Cropland	73.5	2.6%
Pastureland	0.0	0.0%
Forest	46.1	1.6%
Grasslands	106.1	3.7%
Total	2868.8	

* Includes Des Moines Golf and Country Club (470 acres)

Source: National Landcover Dataset (USGS)—2001 and 2011.

Estimated Pollutant Sources (Without Construction Site Runoff)—Subwatershed 213

	N	P	Sediment
Urban	82.0%	72.0%	18.8%
Cropland	13.5%	7.1%	6.0%
Pastureland	0.0%	0.0%	0.0%
Forest	0.1%	0.4%	0.1%
Grasslands	1.2%	5.8%	9.1%
Gully	0.2%	1.2%	5.2%
Streambank	2.9%	13.5%	60.9%

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Estimated Pollutant Sources (Including Construction Site Runoff)—Subwatershed 213

	N	P	Sediment
Urban	67.8%	53.6%	7.3%
Cropland	11.2%	5.3%	2.3%
Pastureland	0.0%	0.0%	0.0%
Forest	0.1%	0.3%	0.0%
Grasslands	1.0%	4.3%	3.5%
Gully	0.2%	0.9%	2.0%
Streambank	2.4%	10.1%	23.7%
Construction Site	17.3%	25.5%	61.0%

These modeling results represent pollutant loads expected at the downstream end of this subwatershed, where it enters Walnut Creek. Loadings of phosphorus and sediment might be significantly higher if they were measured upstream of one of the many wet ponds located in this area. Many of these ponds are projected to trap about half of the sediment and phosphorus loadings that pass through them, based on their current design. Identifying opportunities to address these pollutants in upstream areas would likely result in water quality improvements within the ponds themselves.

Sediment loading from the subwatershed over the recent past is expected to be primarily attributed to construction site and streambank erosion. Between 2001 and 2011, about 650 acres within this area was converted from agricultural to suburban land uses. If each construction site takes one to two years to construct (from initial construction to final home site development), then at any given time between 65 to 130 acres of land may have been in some stage of site construction. From modeling results, these sites, making up only 2-5% of the area within this subwatershed, may have generated more than 60% of the sediment load.

Streambank erosion is the next largest generator at nearly 24% of the expected load. A large share of loading due to streambank erosion is expected to come from microwatershed 213.01. This area is located downstream of Country Club Lake and features a heavily eroded segment of South Walnut Creek. This area bypasses all the ponds and other features within the subwatershed, so there is little opportunity to capture generated sediment before it enters Walnut Creek.

Estimated Pollutant Loading—Subwatershed 213 *

	N	P	Sediment
	tn/yr	tn/yr	tn/yr
All Sources Except Construction Sites	8.2	0.7	580
All Sources	10.0	0.9	1,490

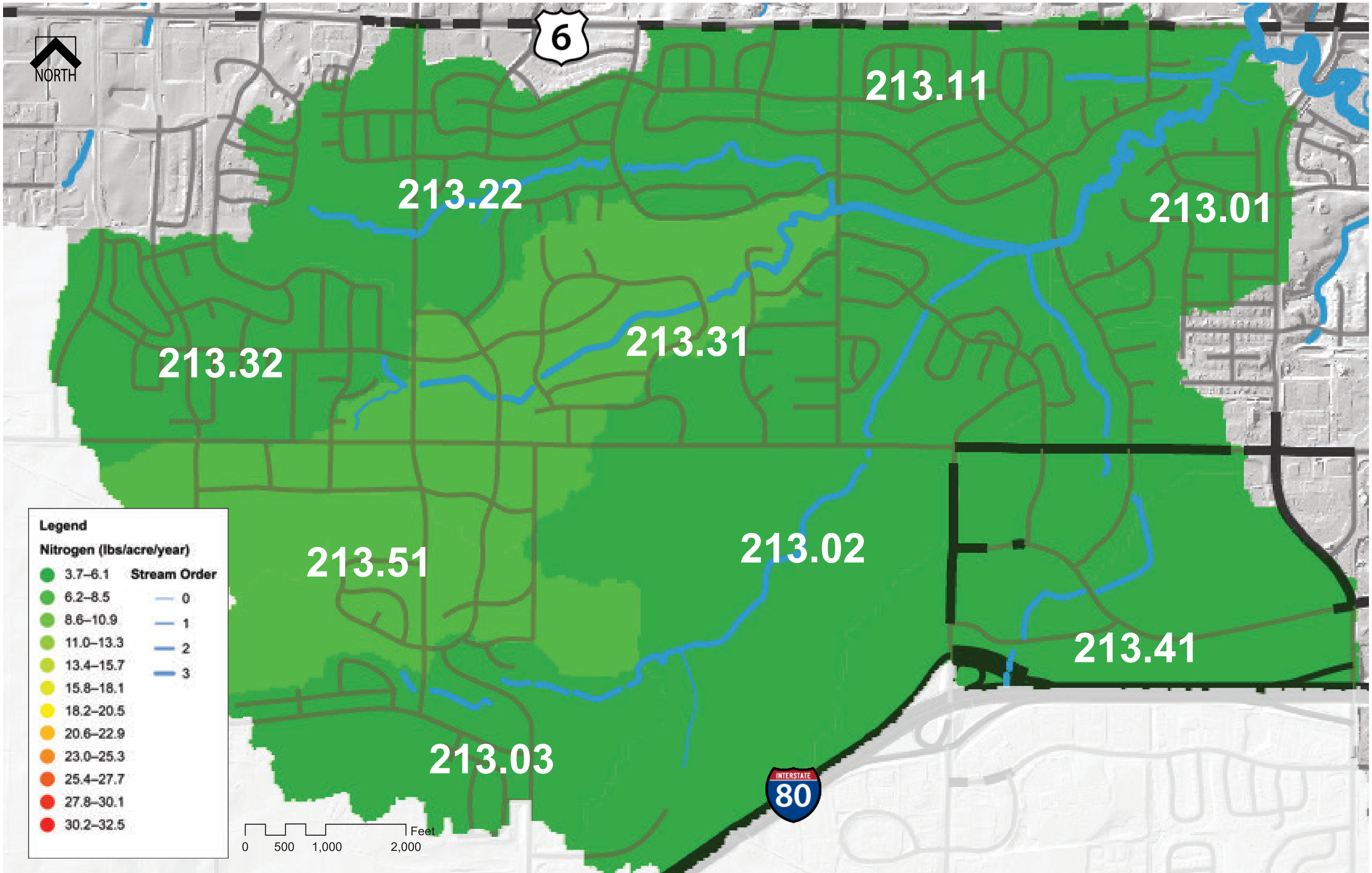
* Note that pollutant loading is the estimated pollutant load delivery to the outlet point from this subwatershed area.

Average Loading per Acre by Microwatershed (w/o Construction Site Loads) *

Microwatershed **		Area (acres)	N lb/ac/yr	P lb/ac/yr	BOD lb/ac/yr	Sediment lb/ac/yr
213.01	W1	181.0	5.5	1.2	12.4	2,827
213.02	W2	869.6	5.1	0.4	3.0	97
213.03	W3	208.2	5.5	0.3	2.7	83
213.11	W4	190.9	5.3	0.7	14.1	599
213.21	W5	43.8	3.7	0.3	2.3	91
213.22	W6	298.5	4.9	0.5	4.1	602
213.31	W7	402.7	8.5	0.4	3.2	335
213.32	W8	219.2	5.3	0.3	3.0	180
213.41	W9	285.8	5.3	0.3	2.6	87
213.51	W10	169.1	6.9	0.5	3.4	306

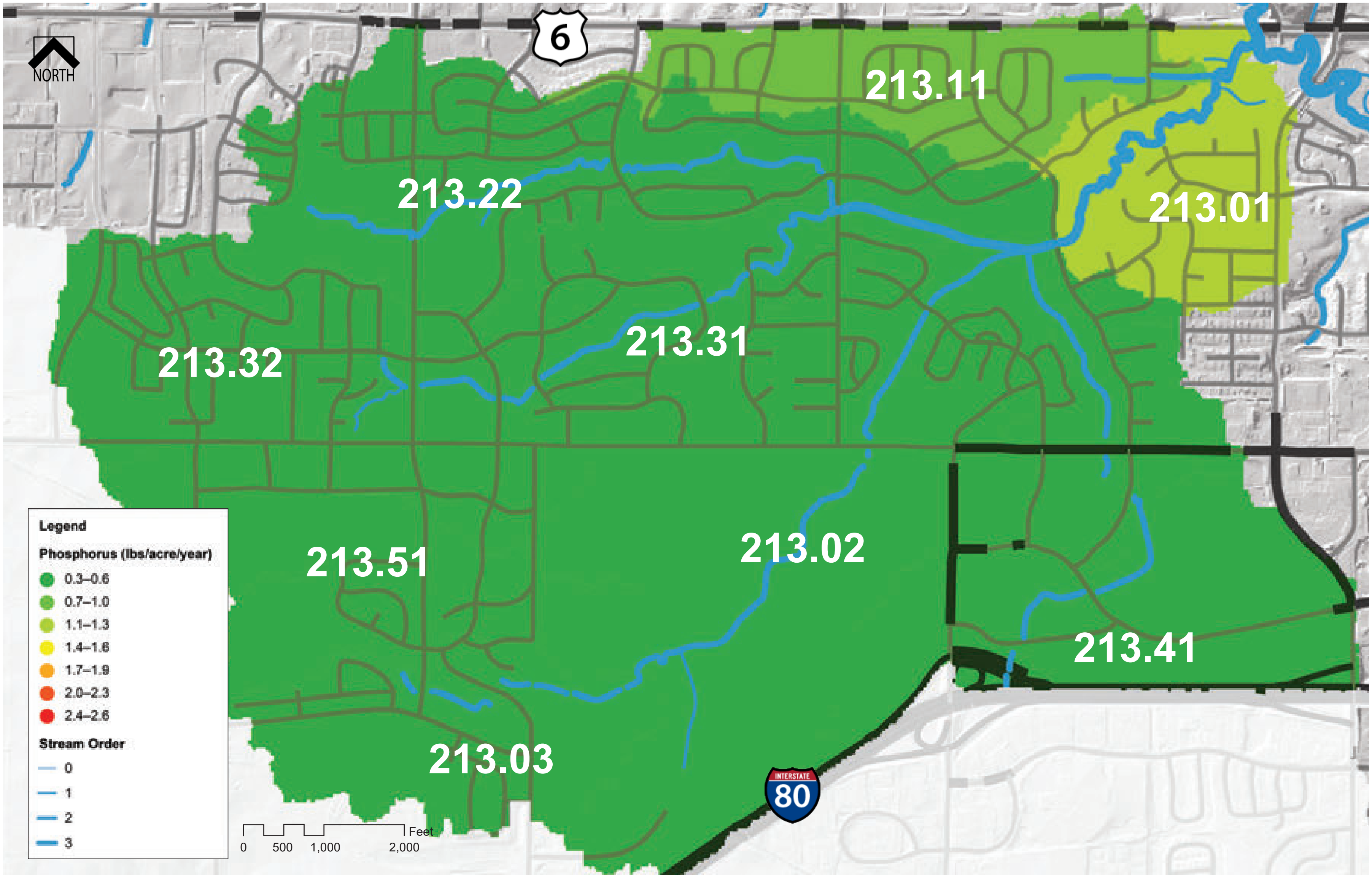
* Note that pollutant loading is the estimated pollutant load delivery to the outlet point from this subwatershed area.
** Refer to Chapter 2 (page 54) for explanation of watershed numbering

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.



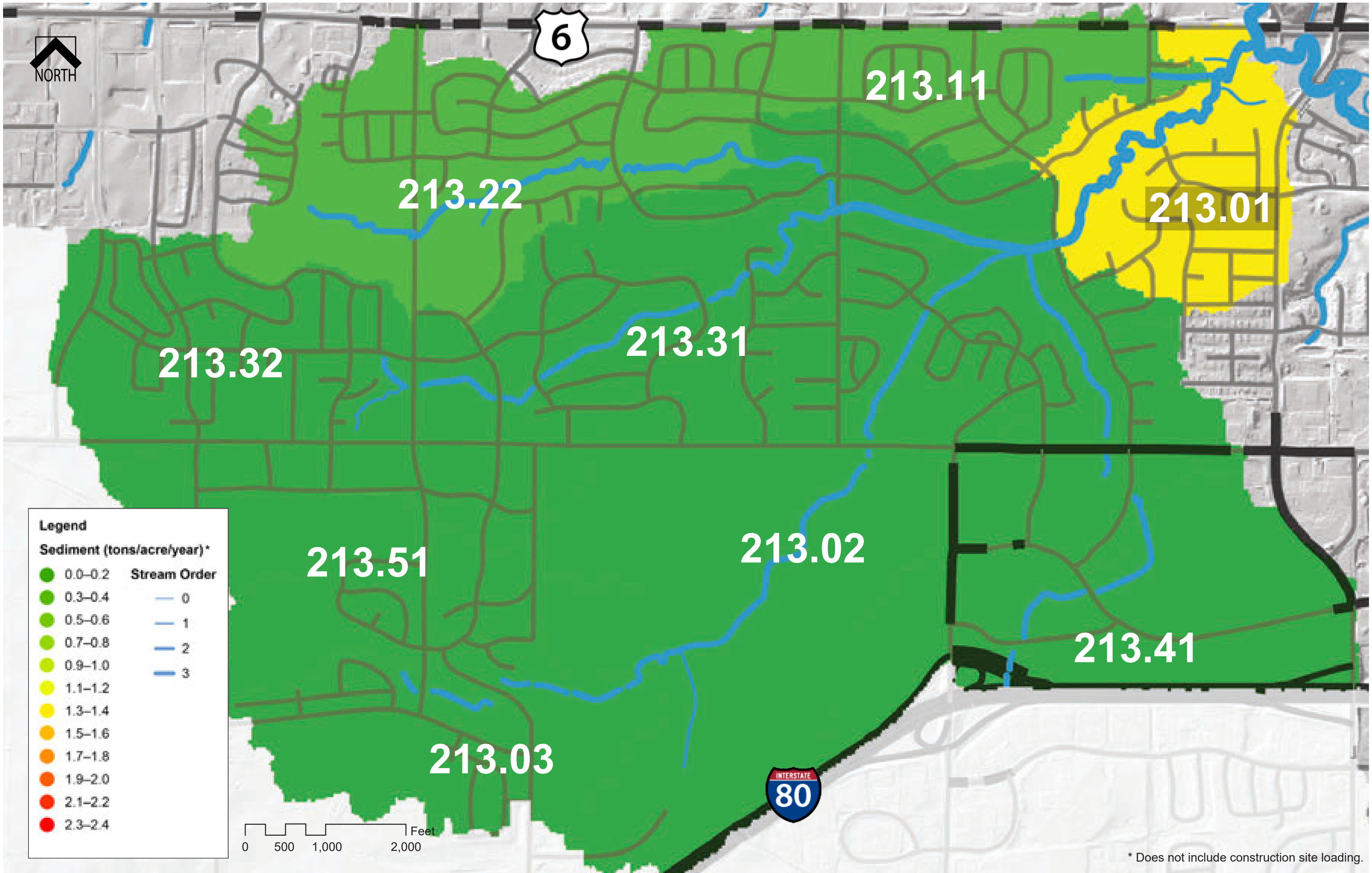
Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Nitrogen Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Phosphorus Loading



Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Sediment Loading

Water Quality Improvement Plan—Subwatershed 213

The following strategies are recommended to improve water quality within this subwatershed area and develop and evaluate a template for future action within other urban developed areas.

Subwatershed Strategy #1—*Review opportunities to develop public-private partnerships to modify outlets of existing ponds or entrances to existing culverts to provide better management of small storm events. Primary and secondary opportunities for these improvements are noted on the improvement plan map for this subwatershed. Other locations for such modifications may need to be evaluated.*

- Perform a more detailed study of selected candidate locations to determine if modifications can be made that result in significant reduction in the peak outflow rate for the 1-year return period, 24-hour storm event. The study should evaluate the improvement's potential impact on high water levels for storm events up to the 100-year return period, 24-hour storm event, to make sure that such changes will not have a negative impact on surrounding buildings or other infrastructure.
- Complete such improvements where they are determined to be feasible.

Other sections of this plan have demonstrated how land use changes have altered the volumes and flow rates of stormwater runoff. These changes have intensified streambank and gully erosion. Much of this erosion is caused by the types of events that occur most frequently. Ponds designed primarily to prevent flooding during large storms often lack controls to slow runoff from smaller, more common events. Modifying outlets to include multiple stages can limit peak rates of flow during small events, while still managing the risk of local flooding during larger storms.

Subwatershed Strategy #2—*Complete streambank stabilization and restoration projects in key identified areas, as identified on the improvement plan map for this subwatershed.*

- Perform a more detailed study of selected candidate locations to better define potential scope of work and project costs.
- Complete final design and construction of improvements.
- Perform **short-term maintenance** to establish desired vegetation and address minor erosion repairs which are most likely to occur before vegetation is well established.
- Schedule and perform **long-term maintenance** and repairs as needed to prevent re-emergence of invasive species, support desired vegetation and prevent larger erosion issues from developing.

These streambank improvements are proposed primarily on publicly owned land, but similar projects may be completed within privately owned common spaces or within private properties through private investments or where easements are provided by the owner.

Subwatershed Strategy #3—*For developing and redeveloping areas, require compliance with policy initiatives as identified within Chapter 9 of this plan.*

Iowa's Nutrient Reduction Strategy does not assign reductions of nitrogen or phosphorus to urban landscapes. Modeling results and monitoring data indicate that concentrations of nutrients within this subwatershed is likely lower than allowable **water quality standards**. However, addressing nutrient loadings would likely benefit the water quality within the individual ponds and water features within the interior of this subwatershed. Adoption of these policies would result in additional reductions of nitrogen and phosphorus loadings.

Expected Load Reductions

Modeling simulations have been completed to evaluate the effectiveness of the proposed strategies for this subwatershed. **These calculations are based on the following assumptions:**

1. *M*odify outlets at the following primary locations (strategy #1):
    - West Lakes Office Park Plat 3, **Outlot** Z
    - 6400 Westown Parkway
    - South of 1801 68th Street
2. *Modify* outlets at the following secondary locations (strategy #2):
    - Largest Pond within Southfork Development (upstream of Southfork Drive)
    - Country Club Lake
    - Ponds within Des Moines Golf and Country Club, immediately downstream of the South Maple Grove and Country Club Ridge developments

Complete Strategy #2 (streambank stabilization/restoration) at the following locations:

- Microshed—213.01: South Walnut Creek between Country Club Lake and Walnut Creek.
- Microshed—213.22: Between 156th Street and recreational trail crossing located 1,100 feet downstream in Clive.

Other strategy applications listed within Chapters 10 and 12 of this plan have not been included within modeling calculations.

Estimated Pollutant Loading (Without Construction Site Runoff)—Subwatershed 213 *			
	N	**P**	**Sediment**
	lb/yr	**lb/yr**	**tn/yr**
Current	16,500	1,370	580
Future	16,100	1,140	330
Rate Reduction	400	230	250
% Reduction	2%	17%	43%
* Note that pollutant loading is the estimated pollutant load delivery to the outlet point from this subwatershed area.			

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Developing Case Study—Subwatershed 601

Location

This area is located within the watershed of Little Walnut Creek and is expected to see rapid urban growth over the next decade. This 960-acre area is generally located on both sides of Little Walnut Creek between Warrior Lane and NW 170th Street. This subwatershed has been divided into 12 smaller microsheds for analysis.

Purpose

This case study is different from the rural and urban subwatersheds, in that the land uses of concern do not yet exist. The purpose of this analysis is to evaluate stormwater management techniques to prepare a plan for management which **mitigates** the impact to receiving streams caused by increased runoff rates and volumes as land uses change within this area. Nutrient, pathogen and sediment loading reductions are expected to be **complementary benefits** to this approach.

Expected Outcomes

To establish management strategies and to better explain their reasoning, the following outcomes need to be achieved by this study:

1. Understand predicted runoff volumes and rates within this area for four conditions:
    a. **Pre-settlement** *conditions:* Primarily tallgrass prairie prior to pioneer settlement.
    b. *Existing conditions:* Primarily agricultural row-crop uses with some areas reserved within a flood plain buffer.
    c. *Future conditions:* Mainly **low- to medium-density** residential growth with some commercial development. This case assumes that normal mass grading practices are used for development construction and minimal topsoil is replaced on the disturbed landscape.
    d. *Future condition with* **soil quality restoration***:* Similar to the conditions described in "c," except that it is assumed that techniques such as topsoil respreads or soil amendments are used to create a healthy layer of topsoil on the disturbed landscape.

2. Locate and size potential **"regional" stormwater management practices** (wet detention ponds). Determine the storage volume and outflow rates for these systems for the following conditions:

   a. Traditional stormwater management, with principal focus on management of larger storm events (5-year storms or larger).

   b. Use of the **Unified Sizing Criteria** from the Iowa Stormwater Management Manual to manage both small and large storm events. For this case, assume no soil quality restoration is completed.

   c. Use the Unified Sizing Criteria and implement soil quality restoration throughout this area.

Predict pollutant loads under existing and future conditions.

3. Determine expected load reductions that could be provided by regional stormwater management practices for conditions listed under "2a" through "2c" above.

Summary of Methods

An area within subwatershed 601 was defined where smaller **microwatersheds** exist that are largely free of urban development. Boundaries of twelve microwatersheds were drawn based on available **LiDAR topographic** information. Ten of these areas have separate outlet points, draining either to Little Walnut Creek, or to storm sewers, culverts or ditches which also drain to that stream. The other two areas drain in a series with one common outlet point to the creek.

For this study, it is assumed that each of these microsheds will include one stormwater management area, likely a wet pond, constructed wetland or other large "regional" basin for detention and retention of stormwater. These features could be incorporated into a public park or private common space featuring trails, fishing piers, etc. to make these management areas a public resource, rather than a liability. These ponds would retain water by holding it in a permanent pool. They would detain water by temporarily holding runoff from storm events in the additional storage space occupied as water levels rise above the normal pool. *For consistency of comparison, it was decided that the basin footprints would be adjusted as needed so that the water level rise caused by various storms would be as follows:*

Storm Event Return Period (24-hour duration)	Temporary Water Level Rise
1-year	2 feet
10-year	3 feet
100-year	5 feet

Runoff rates and volumes were calculated for each microshed for each of the conditions listed under item 1 of the "Expected Outcomes" listed on the previous page. Methods listed within the Iowa Stormwater Management Manual were used to develop a preliminary sizing of the storage required for each basin, based on each condition listed under item 2 of "Expected Outcomes." A more refined design was developed by creating **stage-storage relationships** and an initial outlet design for each pond. Calculated stormwater flows were then **routed** using computer modeling software through each basin and the outflow rates were reviewed to determine if the design requirements were met. The results were reviewed and the basin designs were adjusted to attempt to design a basin with the smallest footprint which restricts flow for each storm event below the required limits.

Overview of Results

Stormwater Runoff Volume from Land Uses

Changes in land uses have fundamentally altered the way runoff is generated by rainfall events. These effects are expected to be most dramatic in the most commonly occurring storms, such as those that are less intense than the 1-year return period storm (2.67" in a 24-hour period). Volume increases of over 7x from natural conditions may be expected during the most commonly occurring events. Conversion ratios of rainfall to runoff during these common events may change from under 7% for pre-development conditions to above 50% for developed suburban conditions (assuming that little or no topsoil is placed uniformly over the landscape). Runoff volume increases for larger storms are less dramatic by proportion, but represent a larger change in total volume (see tables on page 151).

Volume Generated in Inches *					
		Runoff Volume (inches x watershed area)			
Storm Return Period	Rainfall	Pre-settlement	Existing	Future w/no SQR	Future w/ SQR
1-year	2.67	0.18	0.75	1.46	0.81
10-year	4.46	0.89	2.02	3.07	2.11
100-year	7.12	2.49	4.27	5.61	4.38

* Runoff volumes from urban landscapes may exceed levels seen under natural conditions from storms that are ten times less likely to occur.

Conversion of Rainfall to Runoff *					
Storm Return Period	Rainfall	Pre-settlement	Existing	Future w/no SQR	Future w/ SQR
1-year	2.67	6.6%	28.2%	54.7%	30.3%
10-year	4.46	19.9%	45.4%	68.8%	47.4%
100-year	7.12	35.0%	59.9%	78.7%	61.6%

* Land use changes dramatically increase the portion of rainfall connected to runoff.

Increase in Runoff Volume from Pre-settlement Levels *					
Storm Return Period	Rainfall	Pre-settlement	Existing	Future w/no SQR	Future w/ SQR
1-year	2.67		327%	727%	358%
10-year	4.46		129%	247%	138%
100-year	7.12		71%	125%	76%

* Runoff volumes in suburban areas are likely to be seven times higher than natural levels during a storm event expected about once a year on average. SQR techniques can reduce this effect by about half.

Average Unit Peak Rates of Flow for 12 Microwatersheds in Area 601 (cfs per 100 acres drained) *				
Storm Return Period	Pre-settlement	Existing	Future w/no SQR	Future w/ SQR
1-year	4	79	173	91
10-year	42	227	359	250
100-year	142	480	638	518

* Peak rates in small suburban watersheds during a one-year event may exceed levels expected from a 100-year-event under natural conditions.

Increase in Peak Rates of Flow from Pre-settlement Level *				
Storm Return Period	Pre-settlement	Existing	Future w/no SQR	Future w/ SQR
1-year		1,912%	4,332%	2,216%
10-year		442%	459%	498%
100-year		230%	349%	265%

* Peak rates may be more than 40 times higher than natural conditions during common storm events.
SQR techniques can cut this effect roughly in half.

Source (all): Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).

Wet detention pond within city park in Ankeny, Iowa.

Stormwater Runoff Rates from Land Uses

Stormwater runoff rate increases are more dramatic than those for volume. As runoff is funneled quickly down roofs, driveways, gutters and storm sewers; a larger portion of runoff arrives at nearly the same time. This multiplies the effects of additional runoff volume. Again, these changes are largest in proportion during the more commonly occurring events. During the 1-year return period storm, runoff rates for fully developed conditions are likely 20x–40x higher than pre-settlement conditions. Lower increases are expected if sufficient topsoil is placed back on the landscape after development to absorb rainfall and support healthy vegetation.

What is Stormwater Detention?

Over the past few decades, stormwater has typically been managed by capturing runoff in a basin or pond, holding it for a period of time and releasing it more slowly. This is referred to as "detention" as water is temporarily held (or detained) and released at a more controlled rate. A detention basin can be thought of like a large bathtub, with a bigger pipe entering the tub and a smaller one draining it out. Water enters the basin faster than it can leave, which causes the basin to fill up.

Where do typical methods of detention design fall short?

Most detention basins have been designed to address very large rainfall events. Outlets designed to control runoff during very large events are often too big to effectively slow down runoff from the most commonly occurring small storm events. A more detailed description of these issues is included within an appendix to this plan.

The analysis completed as part of this plan indicates that if applied properly, traditional methods may provide adequate management of very large storm events. However, basins that are solely designed to manage runoff rates from large storm events may lack effective controls to adequately reduce runoff rates from the more frequently occurring storm events. Modeling results indicated these "traditional" basins may reduce peak flows from the 1-year return period event by less than 35%.

The Iowa Stormwater Management Manual (ISWMM) offers a different approach, which includes a tiered structure to manage both small and large storm events. This structure is called the Unified Sizing Criteria.

Comparing Basin Design Using Traditional Methods vs. ISWMM's Unified Sizing Criteria

In recent years, stormwater management has primarily been provided by installing **detention basins**, either as a regional practice or at an **individual development scale**. Typically, these facilities have been designed to prevent local flooding caused by large storm events. A common standard has been to design the basin to limit runoff from under developed conditions from very large events (such as the 100-year return period storm), to a rate similar to a smaller event under existing agricultural conditions (often the peak rate generated by the 5-year return period under the conditions existing immediately prior to development).

What is the Unified Sizing Criteria (and what is it supposed to do)?

The Unified Sizing Criteria are different stages of stormwater management included in the Iowa Stormwater Management Manual. The goal is to better control runoff from both smaller storms (which occur more frequently) and larger events (which are more rare) and maintain more natural flow patterns in streams. There are four key criteria that are to be met:

1. **Water Quality Volume—Storms that are 1.25" or less.**

Capture and hold this runoff, using water quality best management practices (BMPs) to filter, absorb and break down pollutants.

2. **Channel Protection Volume—Storms up to a 1-year, 24-hour event (2.67" in Central Iowa)**

Runoff from these events is detained for extended periods of time. Where traditional detention methods may detain runoff for an hour or two, this "extended detention" slowly releases runoff over a period of more than 24 hours. This slow release protects downstream channels during these commonly occurring storms which would normally have enough flow and force to cause significant erosion.

3. **Overbank flow protection—Storms up to a 10-year, 24-hour event (4.46" in Central Iowa)**

Management of these storms is intended to prevent flash flooding and overloading of the downstream storm sewer system. Runoff from these events is detained and released at rates similar to pre-settlement conditions. Pre-settlement conditions would be conditions that existing prior to the mid-1800s, when tallgrass prairies would have absorbed most of the rain that fell on the landscape.

4. **Extreme Flood Protection—Storms up to a 100-year, 24-hour event (7.12" in Central Iowa)**

Management of these storms is intended to reduce the impact of larger scale flood events. Runoff from these events is detained and released at rates similar to pre-settlement conditions.

To achieve all of these goals, storm outlets will usually need to feature a "multi-stage design" which is discussed in greater detail in Chapter 9.

Modeling results of the 12 microsheds in this case study area indicate that sizing stormwater management areas using the Unified Sizing Criteria outflow rates from basins during the 1-year return period storm event would be 97% lower than basins designed using traditional methods. These basins would also have better management of the larger storm events. To accomplish these additional rate reductions, more storage volume is required. However, it has been calculated that the overall footprint would increase by only 1.8% of the size of the drainage area to each basin. Furthermore, this increase in size can be effectively mitigated by requiring soil quality restoration or topsoil replacement to establish an 8" layer of healthy soil across open spaces post-construction within developed areas.

Average Expected Unit Peak Release Rates of Flow for 12 Microwatersheds in Area 601 (cfs per 100 acres)			
Storm Return Period	Traditional	Unified Sizing Criteria	Reduction
1-year	126	4	97%
10-year	158	43	73%
100-year	186	144	23%

Rate Reduction compared to Traditional			
Storm Return Period	Traditional	Unified Sizing Criteria	Unified Sizing Criteria w/SQR
1-year		97%	97%
10-year		73%	80%
100-year		23%	29%

Projected Detention Footprint Area of 100-year High Water Elevation (as % of watershed area drained)			
Storm Return Period	Traditional	Unified Sizing Criteria	Unified Sizing Criteria w/SQR
100-year	4.61%	6.41%	4.60%
SQR = Soil Quality Restoration techniques applied to restore healthy topsoil layers to open spaces			

Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).

Comparing Pollutant Reduction Using Traditional Methods vs. ISWMM's Unified Sizing Criteria

Designing stormwater detention areas using the Unified Sizing Criteria is expected to result in better pollutant removal rates. The WinSLAMM program was used to model pollutant loadings and removal rates. Systems designed with the Unified Sizing Criteria are expected to significantly reduce loadings from sediment (solids) and phosphorus. Data from the International BMP Database indicates that such regional detention facilities would also likely provide better pathogen removal rates. Modeling indicates that nitrogen removals may not be influenced as much by basin design. Other best management practices such as bioretention cells and bioswales may need to be included upstream of regional detention facilities to treat runoff from the Water Quality event, likely resulting in better removal of nitrogen from the system.

Projected Loading from Developing Case Study Area to Walnut Creek (in tons per year) *			
Pollutant	Traditional	Unified Sizing Criteria	Reduction
Particulate Solids	28	8	71%
Total Solids	86	64	24%
Phosphorus	0.21	0.14	34%
Nitrate	0.30	0.30	0.2%
* Note that pollutant loading is the estimated pollutant load delivery to the outlet point from this subwatershed area.			

Source: Results of STEPL pollutant load modeling performed by RDG Planning and Design.

Comparing Outcomes With and Without Topsoil Replacement or Soil Quality Restoration

Topsoil is the first link in the chain of stormwater infrastructure. It is the first point where water can be absorbed into the landscape, thereby reducing runoff volume. Volume can be captured both by intercepting direct rainfall onto open spaces with healthy topsoil layer, or by diverting runoff from impervious surfaces onto such areas. Stormwater modeling can account for the presence or absence of topsoil, by adjusting factors that indicate how much runoff the landscape will absorb (curve numbers or runoff coefficients).

Modeling results from this case study indicate that runoff volumes for the one-year storm return period, 24-hour event are expected to be 80% larger [(1)] in areas with minimal topsoil re-spread (sod over compacted soils), as compared to areas where 8" of healthy topsoil is provided. Such topsoil can be provided by respread of topsoil material or by using compost and other materials to restore soil function. (ISWMM includes a chapter that details the variety of methods which can be used). Runoff volumes are also increased for larger storms without soil retention, nearly 30% for a 100-year return period storm event. While the proportional increase is less for large storms, the actual runoff volume increase is greater.

Stormwater reduction due to topsoil restoration is measurable and significant. It has a direct impact on the required size of management practices, as well as the depth and duration of flows that urban streams will receive. Modeling results indicate that management practices will need to have 48% more volume and be 40% larger [(2)] in the footprint area, if adequate topsoil is not provided within open spaces throughout the watershed. This increases costs associated with land dedication, construction and maintenance of these systems. Even if basins are constructed larger to accommodate the additional volume of runoff, these larger flows will eventually be passed downstream. Since the peak discharge rates from each basin are fixed, larger runoff volumes mean that drawdown times from each basin would be extended.

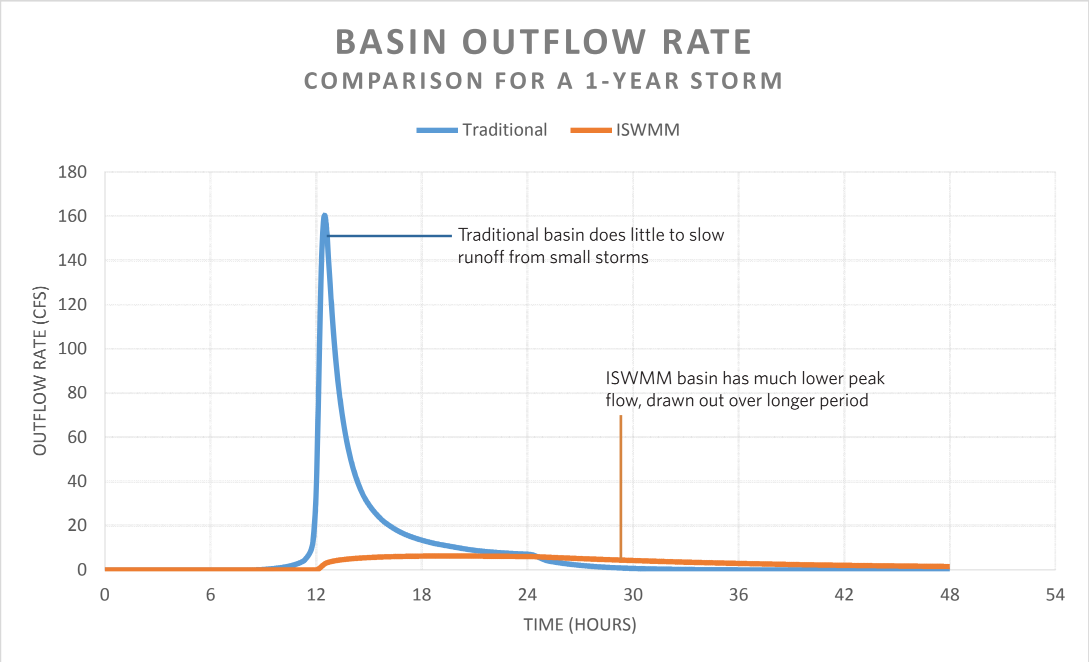
Receiving streams would see higher flow levels over a longer period of time. Higher flows and velocities would exist for extended periods, increasing the potential for streambank and gully erosion to occur.

Therefore, soil quality restoration in developing areas is viewed as a critical "first line of defense" against stormwater runoff increases.

Example of hydrographs for outflow for a traditional basin and one designed using ISWMM Unified Sizing Criteria.

Release rates would be comparable to natural stream baseflow.

Much less channel erosion could be expected downstream.



Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).

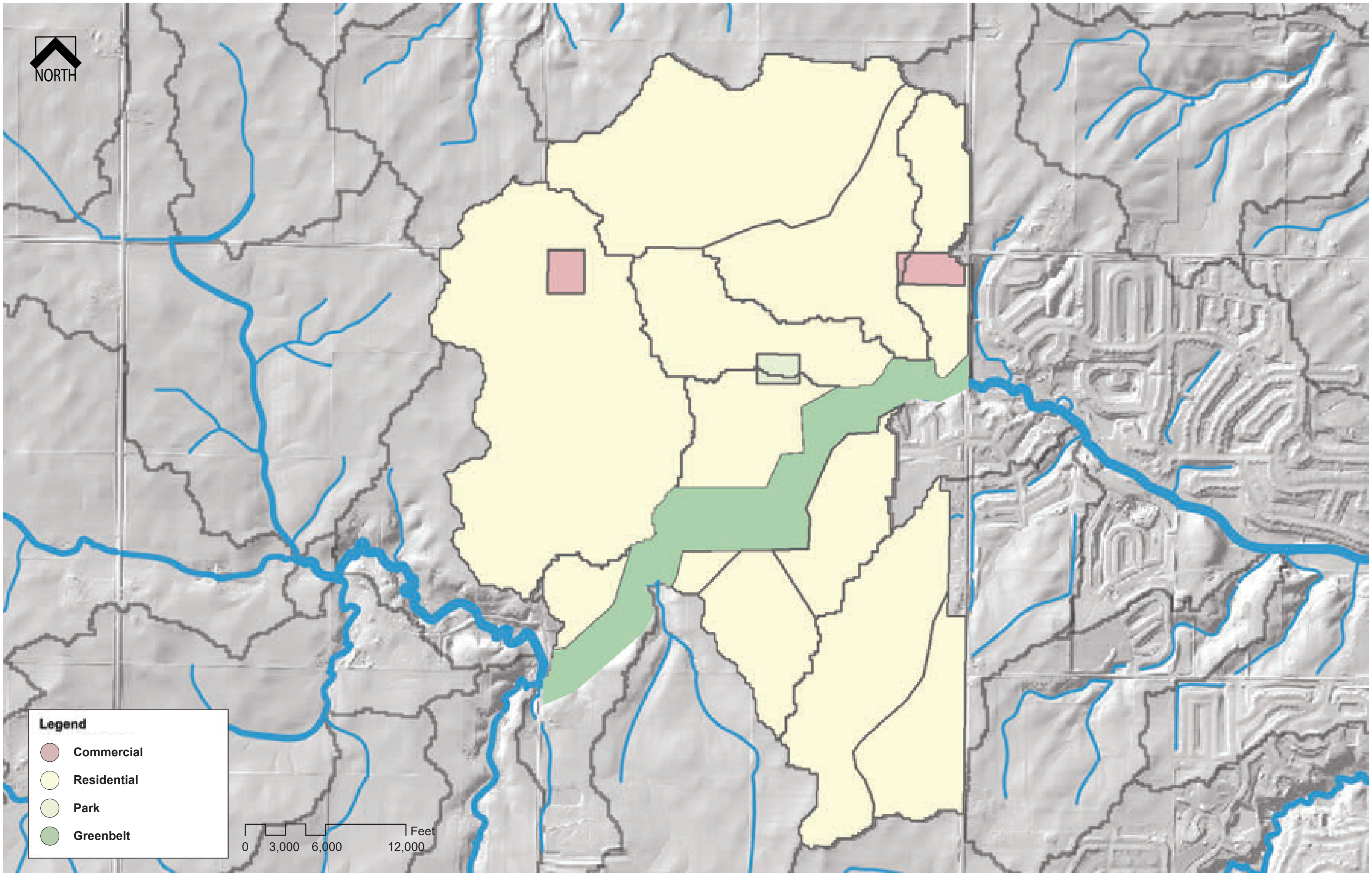
Notes:

1. *Runoff from a 1-year, 24-hour storm event (2.67" of rainfall) is expected to be 1.46" with typical construction methods leading to open space compaction, or 0.81" if soil quality restoration techniques are employed. See tables on previous pages.*
2. *The average top surface area of management facilities within this subwatershed is projected to be 6.4% of the watershed area served if typical construction methods are used, compared to 4.6% of the watershed area served if soil quality restoration techniques are employed. See tables on previous pages.*

Comparison of Values (With and Without Soil Quality Restoration)				
Unit	**Value**	**Without SQR**	**With SQR**	**Reduction with SQR**
Watershed Inches	1-year Runoff Volume	1.46	0.81	45%
	10-year Runoff Volume	3.07	2.11	31%
	100-year Runoff Volume	5.61	4.38	22%
Cubic Feet per Second	1-year Peak Inflow Rate	173	91	48%
	10-year Peak Inflow Rate	359	250	30%
	100-year Peak Inflow Rate	638	518	19%
Cubic Feet per Acre Drained	1-year Required Storage	3899	1806	54%
	10-year Required Storage	6579	3979	40%
	100-year Required Storage	11160	7502	33%

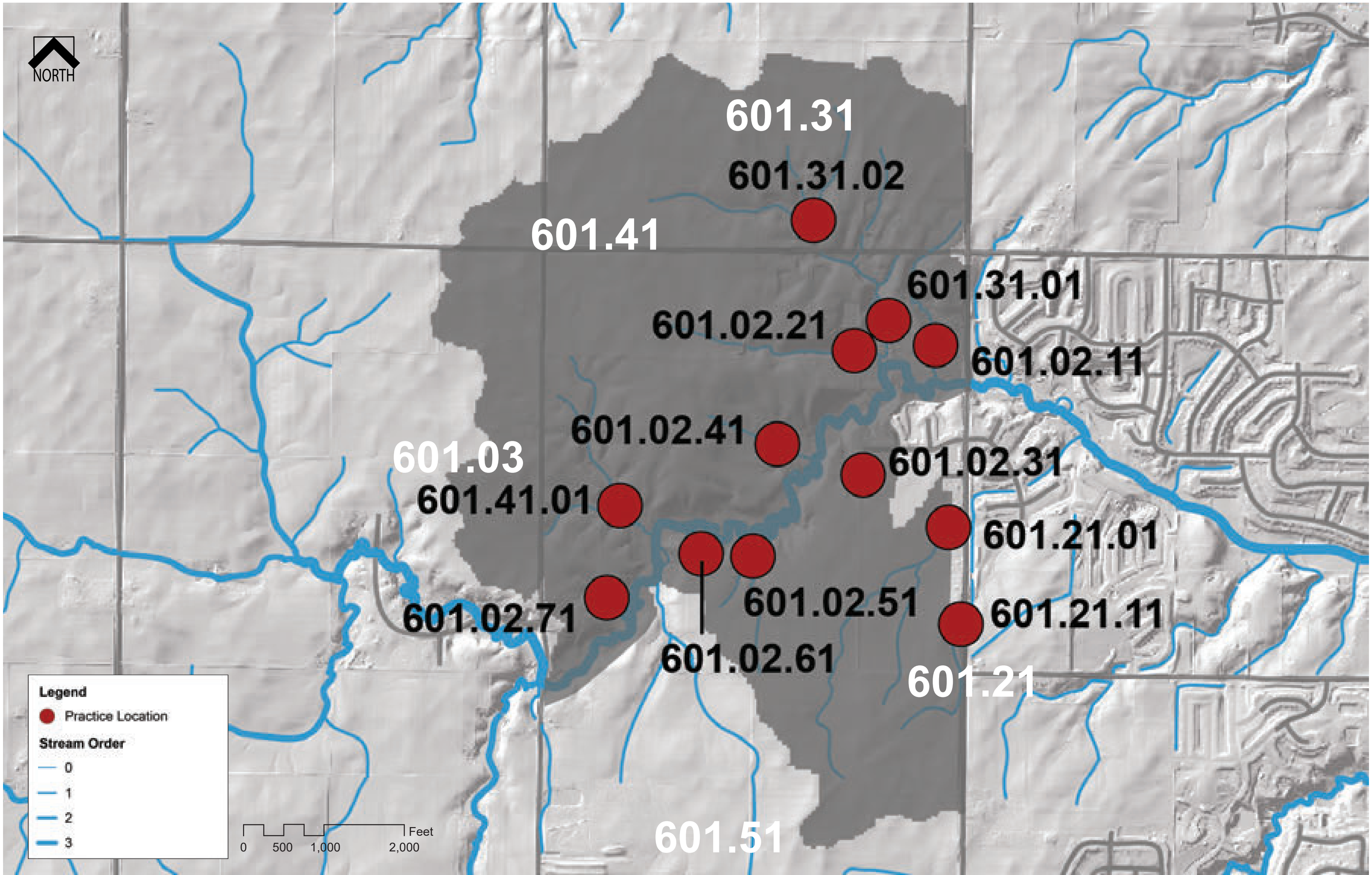
Drawdown Comparison—1-year return storm event (average of basin results)				
	With SQR	**Without SQR**	**Increase Due to Increased Volume Without SQR**	
	Time (in hours)		**(in hours)**	**(by %)**
Time from peak of rain event to high water level	5.8	8.3	2.6	45.0%
Drawdown time from high water to 1' above normal pool	8.9	24.0	15.1	169.0%

Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).



Source: Land Use projections from the Tomorrow Plan.

Projected Land Use



Potential Practice Locations

Projected Sizes and Locations of Regional Stormwater Management Practices in the Developing Case Study Subwatershed								
		Storm Event Return Period						
		1-year		10-year		100-year		
Microshed	**Area (acres)**	**Storage (cubic feet)**	**Peak Release Rate (cubic feet per sec.)**	**Storage (cubic feet)**	**Peak Release Rate (cubic feet per sec.)**	**Storage (cubic feet)**	**Peak Release Rate (cubic feet per sec.)**	**Surface Area * (acres)**
601.41.01	259	510,000	6.3	1,082,000	51	2,075,000	210	10.6
601.31.02	168	301,000	5.5	677,000	41	1,325,000	158	7.2
601.31.01	92	225,000	7.5	404,000	57	684,000	267	4.1
601.21.11	52	102,000	1.3	215,000	12	412,000	52	2.5
601.21.01	103	202,000	2.5	464,000	15	863,000	69	4.6
601.02.71	18	26,000	1.1	66,000	8	118,000	41	0.9
601.02.61	7	10,000	0.5	22,000	6	43,000	17	0.3
601.02.51	47	82,000	1.5	185,000	13	358,000	54	2.3
601.02.41	45	70,000	2.0	161,000	18	309,000	81	1.9
601.02.31	45	70,000	2.0	170,000	14	330,000	57	2.0
601.02.21	71	127,000	2.3	286,000	18	550,000	77	3.3
601.02.11	52	108,000	1.7	229,000	14	424,000	66	2.5

* Surface area assumes that temporary storage depth of the 100-year return storm event does not exceed 5 feet above normal pool
Results shown assume that soil quality restoration has been applied to open spaces within these microwatersheds
Outflow from basin 601.31.02 drains into basin 601.31.01
These design criteria assume that one larger regional stormwater practice is applied in each of these microwatersheds.

Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).

The storage volumes, release rates and surface area projections listed in the table above are based on the following:

- Expected impervious cover based on the land uses shown in this Chapter
- An expectation that soil quality restoration techniques will be employed within developing areas
- An assumption that extended detention of small storms and control of release rates from large events will be incorporated into a single stormwater management area at the downstream end of each microshed

Such regional practices may be constructed as features that address both water quality and quantity, such as wet ponds or wetlands. Otherwise, they may be paired with upstream practices (bioswales, etc.) which can improve water quality while conveying runoff to the larger detention practices. Incorporation with upstream water quality practices would be the recommended approach, as it would provide for improved water quality within the ponds and wetlands, especially if public use and access is proposed.

As development occurs, it may be decided that stormwater management is to be implemented by smaller-scale practices on a site-by-site basis. In that case, the table values could be divided proportionally into each drainage area served to get an initial estimate of the required storage volume (recommend adding a factor of safety of 15% for initial estimation). As design proceeds beyond a concept level, more detailed calculations using the methods described within ISWMM for preliminary and final design should be performed to validate site-by-site volume and area requirements.

A more detailed review of the benefits and challenges of managing runoff at a smaller or regional scale is included in Chapter 10.

CHAPTER 9

KEY CONCEPTS

1. **Policies supported by observations**
   This plan has identified the key pollutants of concern and their most probable sources. The policies outlined within this chapter are intended to support the water quality objectives required to meet the overall goals of this plan.

2. **Urban policy recommendations**
   To support implementation of this plan, local ordinances, policies and enforcement procedures should be reviewed. Existing rules may need to be modified or new ordinances created to address these key areas:

   a. **Stormwater Management**—Adopt the Iowa Stormwater Management Manual as a design resource using its Unified Sizing Criteria to establish requirements to manage runoff from storm events, large and small.

   b. **Flood Plain Protection**—Develop policies that limit construction of new structures or placement of fill within flood prone areas.

   c. **Stream Buffer Protection**—Provide adequate open space near streams to convey storm events as well as allow for access for maintenance, repairs, public use and environmental improvements.

   d. **Construction Site Pollution Prevention**—Refer to highlighted “points of emphasis” so that current rules, regulations and best management practices are being effectively implemented and enforced.

   e. **Topsoil management and restoration**—Consider how topsoil is to be managed during the design process with the goal of providing healthy topsoil to the greatest degree possible across open space areas after development has been completed.

3. **Rural policy recommendations**
   This plan identifies the need for connecting land owners and producers with financial and educational resources to more broadly implement conservation practices. Benefits of some practices related to soil health and subsurface water management have benefits beyond water quality.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Implementation of these policies would not only improve water quality but could reduce damages or costs related to streambank erosion, sediment excavation and dredging, private property losses and damage to public infrastructure (roads, bridges, utilities).

nine

Policy Recommendations

Concerns

- Elevated pollutant concentrations
- Long-term cost to repair eroded stream corridors ($2-3 million/mile)
- 25% of sediment load to Walnut Creek may be attributed to construction site runoff
- Flood damage to buildings and structures
- Lack of access for maintenance or repairs
- Damage to habitat and loss of resources

Policies

- Use new stormwater management guidelines in developing areas
- Reserve open spaces for flood plains and stream buffers
- Make improvements on points of emphasis for sediment and erosion control practices
- Protect or restore healthy topsoil layers on open spaces in developing areas
- Rural management strategies

Outcomes

- Where implemented, runoff is captured, filtered and reduced for more than 90% of all storm events
- Reduction in rapid bounce in water levels in small tributaries
- Establish a more natural pattern of flow in developing areas
- Lower the potential for costly stream bank and channel erosion
- Sediment loading related to construction sites and streambank erosion minimized
- Reserved spaces for access and improvements
- Limit placement of new structures or restrictions within the flood plain

Draft Recommendations—Policy

1 Stormwater Management

Adopt policies such as the Unified Sizing Criteria with the Iowa Stormwater Management Manual which call for management of both small and large storm events:

- Water Quality Volume: Capture and treat runoff expected to be generated by a 24-hour, 1.25" event. Over 90% of all precipitation in Central Iowa can be attributed to these types of events.
- Channel Protection Volume: Provide extended detention of the 1-year storm, with slow release over a period of between 24 and 48 hours.
- For larger storm events: Release runoff at rates similar to what would have existed prior to pioneer settlement.

2 Flood Plain Protection

Local policies and ordinances should be adopted or amended to protect flood plains in the following ways:

- Reduce property losses during major flood events by preventing construction of new privately owned building structures within the limits of the 100-year flood plain.
- Maintain flood storage capacity by limiting grading or placement of fill materials within the flood plain.
- Identify areas of active stream movement and reserve areas as open space where future stream movement or flood plain inundation is expected.
- Consider higher rainfall rates from NOAA Atlas 14 data when establishing flood protection elevations.

3 Stream Buffer Protection

Stream buffers should be established—either by public land acquisition or through preservation as permanent easements—as public or private open space. Local policies and ordinances should be adopted or amended to establish protected stream buffers. Stream buffers should be wide enough to serve the following functions:

- Include the entirety of the regulatory 100-year flood plain or areas expected to be inundated by a 24-hour, 100-year storm event.
- Allow for expected stream migration, based on recent movement patterns or historic stream channel locations.
- Provide enough width for future streambank improvements.
- Include room for reserved paths for maintenance or permanent multipurpose trails that can be used for access.
- Include a minimum building setback standard from all streambanks, trails and access paths.

4 Construction Site Pollution Prevention

Construction site runoff has been identified as one of the largest sources of sediment loading within the urban environment. Key improvements to address this include:

- Consider stormwater management early in the site design process, look for ways to minimize the footprint of disturbed areas, lessen grading volumes and reduce impervious surfaces.
- Develop and implement a Soil Management Plan (SMP), with the goal of providing healthy soils across all open-space areas on developed landscapes before construction has been completed.
- Increase the use of temporary seeding, mulches, rolled erosion control products (RECPs) and turf reinforcement mats (TRMs).
- Prior to commencing land-disturbing activities, install perimeter site controls.
- Don't overload controls. Refer to design guidelines for sizing and design.
- Check all site controls on a weekly basis and before rainfall is expected to make sure they are in good working order.
- Routinely check sites to assure that construction sites are in compliance with state and local standards.
- Inspection personnel should respond promptly when polluted site runoff or off-site tracking is observed, or citizen complaints are received.
- When necessary, "stop-work orders" or other methods should be used to force sites back into compliance before work on other construction items can proceed.

WALNUT CREEK WATERSHED RDG PLANNING • DESIGN DES MOINES AREA MPO SNYDER & ASSOCIATES Engineers and Planners Polk Soil & Water CONSERVATION DISTRICT

Policy recommendations shared at October 2015 open house event.

Introduction—Urban Areas

To address concerns highlighted within this plan, changes are necessary to methods of stormwater management, flood plain and stream buffer protection, construction site pollution prevention and soil quality management / restoration. Within developing areas, it is unlikely that required changes can be fully implemented on a voluntary basis. This chapter outlines policies and ordinances which are recommended to be adopted by municipalities within this watershed and enforced in order to achieve the desired results.

Policies for Urban Areas

Stormwater Management

Analysis in Chapter 8 of this plan has demonstrated that **traditional stormwater detention practices** have limited ability to control runoff for the most commonly occurring, small storm events. Rainfalls of 2.5" or less make up more than 98% of the precipitation volume in Central Iowa. Most streambank erosion occurs during the rapid rise and fall of streams during these types of events. To stabilize flowrates in urban tributaries, adopting policies that address these events is critical. Therefore, this plan recommends all communities within the watershed adopt the **Unified Sizing Criteria**, as described within the Iowa Stormwater Management Manual (ISWMM).

This standard would provide for the following:

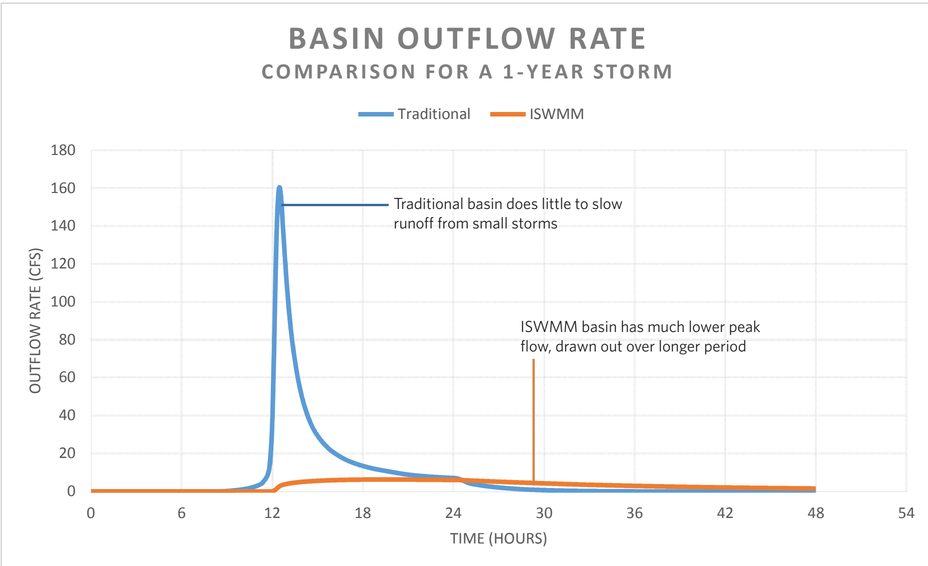
- Water Quality Volume: Capture and treat runoff expected to be generated by a 24-hour, 1.25" event. Over 90% of all precipitation in Central Iowa can be attributed to these types of events.
- Channel Protection Volume: Provide extended detention of the 1-year return period storm, with slow release over a period of between 24 and 48 hours.
- Overbank Flood Protection: Limit peak runoff rates for the 2-, 5- and 10-year return period events to **pre-settlement** levels. Pre-settlement levels should be determined by calculating the time of concentration (use the NRCS lag equation based on pre-settlement conditions) and selecting Curve Numbers (use a CN of 58 based on meadow in good condition) in order to model such conditions. Refer to the ISWMM manual for additional information.
- Extreme Flood Protection: Limit peak runoff rates for the 25-, 50- and 100-year return period events to the lesser of pre-settlement values for the same storm event OR the values calculated for the 5-year return period event under existing (agricultural) conditions.

Application

This plan recommends ordinance and policies be implemented to apply these standards to all new developments. Each community should identify how these standards will be applied to redevelopment sites. This may involve allowing past calculation methods to be amended to reflect proposed changes where new impervious areas are below a set threshold (perhaps 10,000 SF of new impervious area). Above such a threshold, stormwater management practices would be required to meet the new recommended standards.

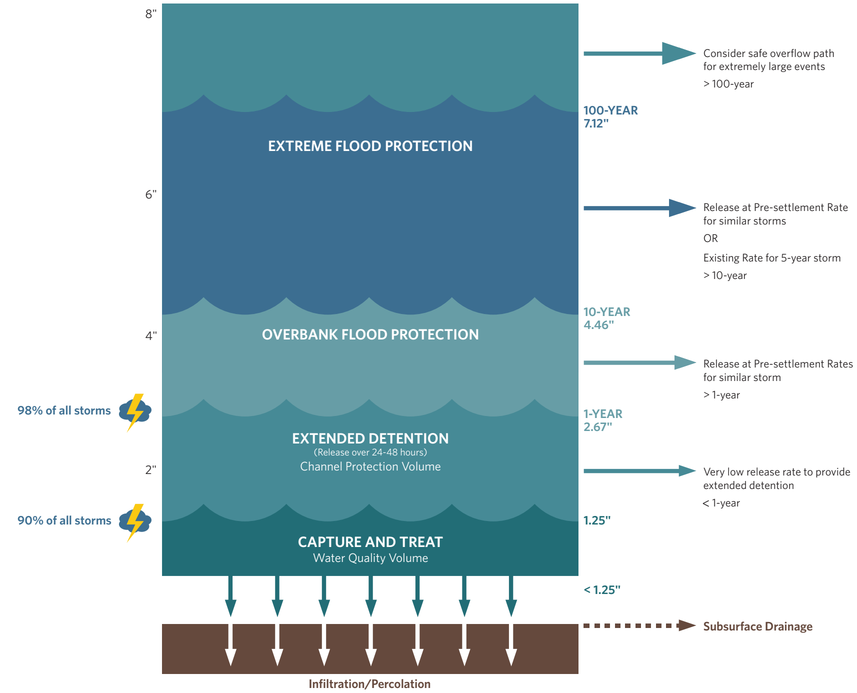
Expected Impacts (Where Applied)

- Little or no **direct surface runoff** during rainfall events that are equal to or less than 1.25" in depth.
- Over 95% reduction in peak flow rates for the 1-year return period storm event (less flashy streams).
- Approximately 70% reduction in peak flow rates for the 10-year return period storm event.
- Approximately 20% reduction in peak flow rates for the 100-year return period storm event.
- If topsoil or soil quality restoration policies are not implemented, total area devoted to stormwater detention features may increase approximately 1.8 acres per 100 acres developed.
- Measurable reductions in nutrient, pathogen and sediment pollution are expected.
- Streambank and gully erosion rates should be reduced due to lower stream flow rates and velocities.
- Potential long-term costs for stream repairs should be reduced.
- Reduced risk to infrastructure/streambank erosion.
- Implementation either regionally or within each individual development. However, regional basins may require less total area dedication and provide for more certain execution of long-term maintenance, Public-private partnerships to dedicate land and build such regional infrastructure will be necessary. Site by site implementation will likely better reduce sizes of downstream storm infrastructure.



Source: Results from runoff analysis completed as part of Developing Case Study completed by RDG as part of this plan (see appendix resources).

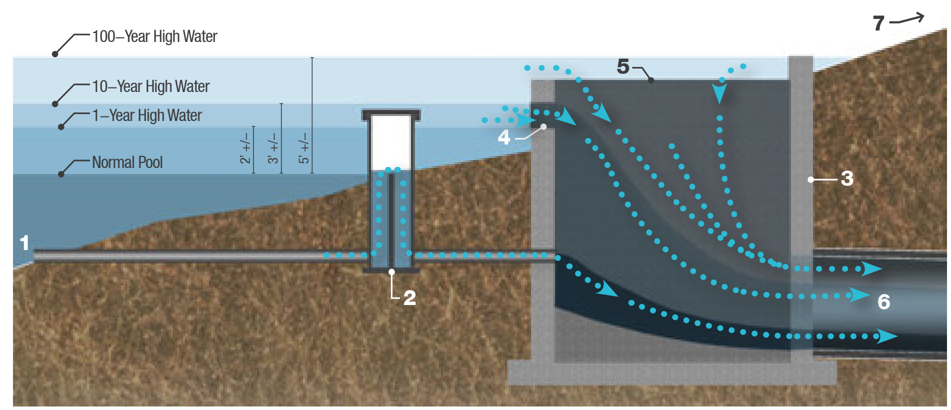
Levels of Stormwater Management Using ISWMM's Unified Sizing Criteria



Larger-scale multi-stage outlet structure in Ankeny, Iowa

Source: Greg Pierce

Example of a multi-stage outlet



Source: RDG

1. 1st Stage: Small Diameter Inlet - Low Flow Control (Below Surface)
2. Water Level Control Structure
3. Main Outlet Structure
4. 2nd Stage: Notch Weir or Medium Size Opening (Controls 2-25 Year Storms)
5. 3rd Stage: Longer Overflow Weir (50-100 Year Storms)
6. Pipe Outlet (Likely Controls 50-100 Year Storms)
7. 4th Stage: Emergency Spillway (For Storms Larger Than 100-Year)

Flood Plain Protection

Local policies and ordinances should be adopted or amended to protect flood plains in the following ways:

- Reduce structural and property losses during major flood events by preventing construction of new structures within the limits of the 100-year flood plain (1% annual exceedance probability).
- Maintain **flood storage capacity** by limiting grading or placement of fill materials within the 100-year flood plain.
- To the greatest extent possible, locate public infrastructure outside of the limits of the 100-year floodplain. When it can't be avoided, provide additional flood plain storage nearby through excavation or make other improvements to maintain projected highwater elevations.
- Identify areas of active stream movement and reserve areas as open space where future stream movement or flood inundation is expected.
- When establishing **flood protection elevations**, provide three feet of vertical separation between regulatory 100-year flood elevations and required building protection elevations to account for flow increases predicted by use of **NOAA Atlas 14** data.

Application

This plan recommends implementing ordinances and policies to apply these standards to all new developments and where new **land subdivisions** are planned to occur adjacent to streams where flood risk has been defined by FEMA Flood Insurance Rate Maps. Redevelopment within existing built parcels within the floodplain should be done in a manner to cause no net increase in flood elevations. The potential for recurring losses on such properties or need for flood protection techniques should be evaluated by local jurisdictions when site plans for redevelopment are considered. Existing structures which fall within these protection zones should be identified. Past known damages to such structures may be reason to pursue opportunities to acquire and remove such structures to avoid recurrent damages.

Expected Impacts (Where Applied)

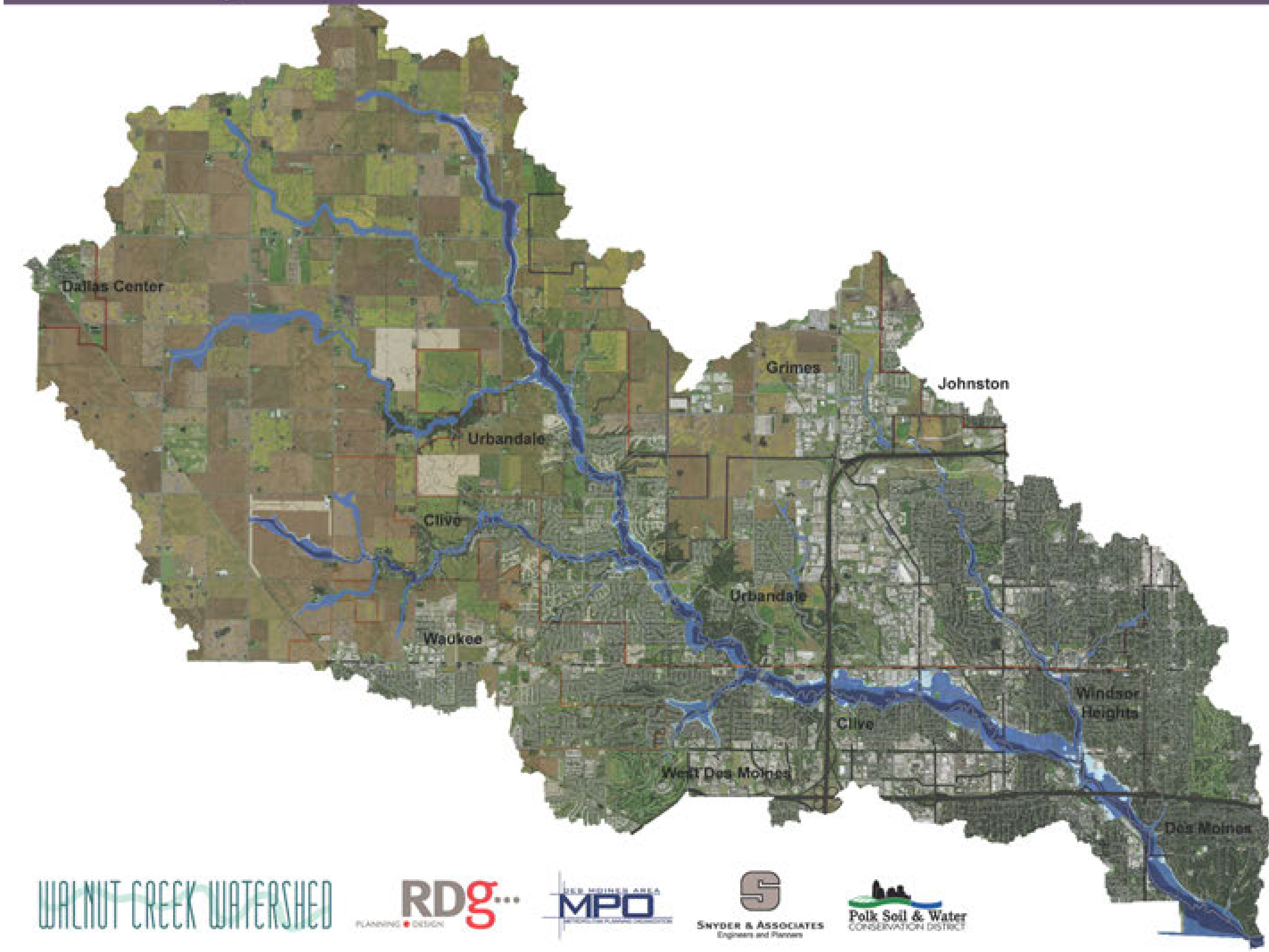
- Reduced potential for damages to buildings, property and other infrastructure during flood events.
- Maximized capacity for storage and conveyance of large flood events.

Source: RDG—June, 2015

Source: RDG—June, 2015

- Reduced risk of higher velocity flows or reduced **travel times** being caused by narrowing of the flood plain.
- Larger factor of safety above projected flood elevations.

Floodplain



LEGEND
Floodway
Floodplain - 100 year
Floodplain - 500 year
Feet
0 3,000 6,000 12,000

WALNUT CREEK WATERSHED
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DES MOINES AREA MPO METROPOLITAN PLANNING ORGANIZATION
SNYDER & ASSOCIATES Engineers and Planners
Polk Soil & Water CONSERVATION DISTRICT

Stream Buffer Protection

Stream buffers should be established, either by public land acquisition or through reservation as permanent **easements** as public or private open space. These buffers should be created along all first, second and third order streams, as well as any existing or created open drainage course with a drainage area that is larger than 40 acres. Local policies and ordinances should be adopted or amended to establish protected stream buffers.

Stream buffers should be wide enough to serve the following functions:

- Include the entirety of the **regulatory 100-year** (1% exceedance probability) **flood plain** OR where regulatory flood plains do not exist, include areas expected to be inundated by a 24-hour, 100-year return period storm event (flows calculated using the NRCS TR-55 method for fully developed conditions). Consider inclusion of the regulatory 500-year (0.2% exceedance probability) flood plain within the protected buffer.
- Allow for expected **stream migration**, based on recent movement patterns or **historic stream channel locations**.
- Provide enough width for future streambank improvements. This plan recommends setting a line based on the existing streambank toe locations, or a line that accounts for expected future movement of the streambank toe. From that line, the buffer should include all land which falls between the stream and a projected slope line from the established toe baseline to the surface of the surrounding area. The slope line should not be steeper than a rate of 4 (horizontal) to 1 (vertical).
- Allow width within the stream buffer for a minimum 15' cleared maintenance path on at least one side of the stream, with a cross slope not to exceed 5%, to allow for access by trucks, tractors and other maintenance equipment. Along streams of first order or higher, these maintenance paths should be provided on both sides of the stream. These paths may be either undeveloped paths (kept clear of trees and brush by annual mowing) or paths which are surfaced with pavement or gravel.
- Provide a minimum five-foot **setback** outside of the maintenance path to the edge of the reserved buffer, on the side opposite the stream from the path.
- For engineered channels in developing areas, construct channels as **bioswales** where feasible to improved volume reduction and water quality treatment. Refer to the ISWMM for feasibility review and design procedures.
- Program annual maintenance to remove invasive species and improve establishment of erosion resistant surface vegetation within protected buffer zones.
- In all cases, provide a minimum 50 foot building setback from the existing top of bank for a first order stream. Provide a minimum 100 foot building setback from the existing top of bank for second and third order streams.

Application

This plan recommends applying these standards to all new developments and where land subdivisions are planned to occur adjacent to streams subject to these provisions. Existing structures which fall within these protection zones should be identified. Past known damages to such structures may be reason to pursue opportunities to acquire and remove such structures to avoid recurrent damages.

Expected Impacts (Where Applied)

- Reduced potential for damages to buildings, property and other infrastructure during flood events
- Maximized capacity for storage and conveyance of large flood events
- Improved access for maintenance and ability to complete any necessary repairs
- Improved filtration of stormwater runoff through properly designed channels
- Opportunities for trails and other park features to be located along streams for public use

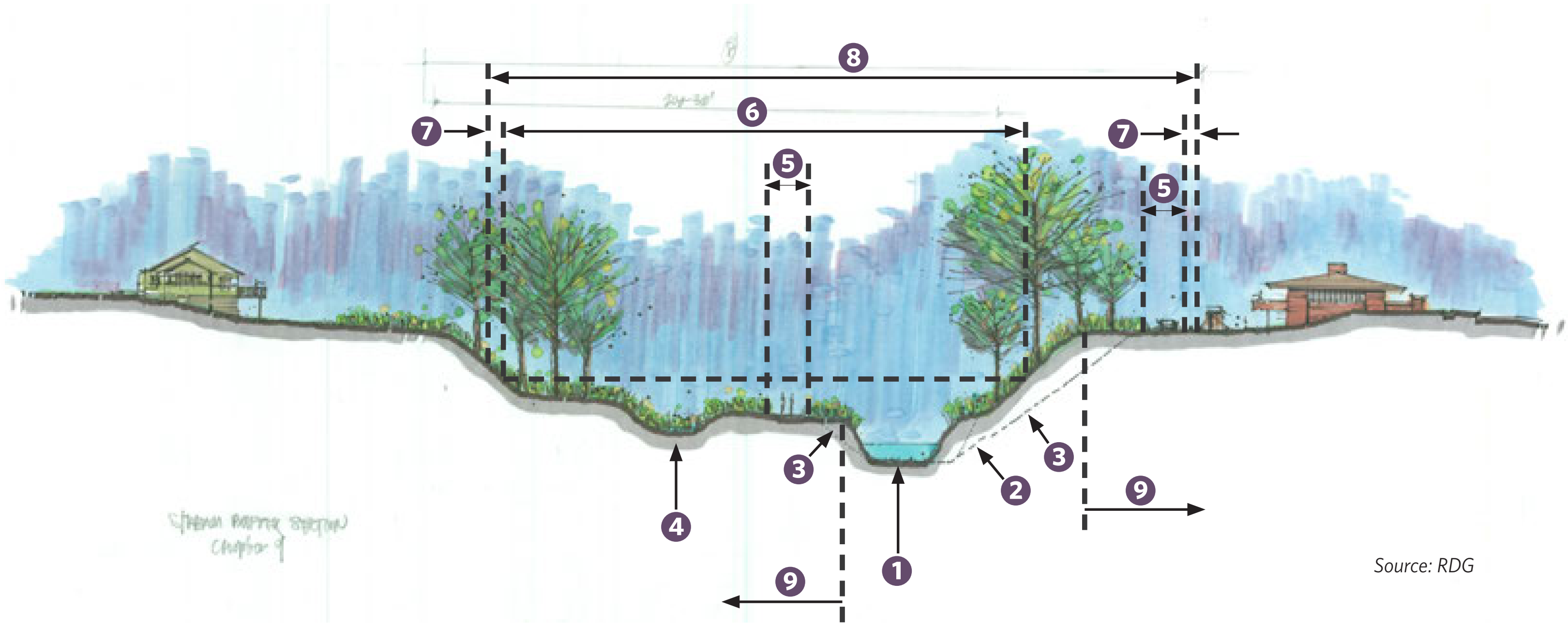
Stream buffer with trail access in Ankeny, Iowa


Source: Greg Pierce

Stream Buffer Width Guidance

Buffer widths need to vary in width from location to location. The width of the buffer to be acquired or protected by easement should include considerations for items 1 through 7 below. Recommended building setbacks may extend beyond the limit of the reserved buffer.

The orientation of these features within the buffer will vary based on local conditions. In some areas the width of the flood plain may include nearly all of these elements. In others, the projection of a stable slope, or provision for access, may extend beyond the limits of the flood plain. Ordinances can describe these features, which can then be applied to each location on a case-by-case basis.



Source: RDG

1. *Stream*
2. *Expected stream movement*
3. *4-to-1 (horizontal to vertical) projection from lowest creek elevation to surface*
4. *Past stream location (oxbow)*
5. *Trail of reserved access path (location within buffer may vary)*
6. *Area inundated by 100-year (or 500-year) storm*
7. *5-foot setback zone*
8. *Recommended buffer width*
9. *Recommended minimum building setback*

Construction Site Pollution Prevention

Construction site runoff has been identified as a significant source of sediment loading within the urban environment. Many strides have been made over the past two decades in the development and implementation of **stormwater pollution prevention plans** (SWPPPs). While most sites are applying for required permits and preparing SWPPPs, there appears to be room for improvement in installation and maintenance of adequate **erosion and sediment best management practices** (BMPs).

What is the Difference Between Erosion and Sediment Control?

Erosion control practices protect the surface of the ground from being displaced by the force of falling precipitation or flowing water. Sediment control practices are intended to collect polluted runoff for a period of time, allowing suspended pollutants to settle out of runoff before it is allowed to leave a construction site.

The following are generally not new requirements. Rather, they are points of emphasis to increase compliance with existing regulations. Improvements are recommended in implementation of erosion control practices:

- Consider stormwater management early in the site design process. Look for ways to minimize the footprint of **disturbed areas**, lessen grading volumes and reduce **impervious** surfaces.
- Develop and implement a **Soil Management Plan** (SMP), with the goal of providing healthy soils across all open space areas on developed landscapes before construction has been completed.
- Where upstream areas drain through a construction site, stage construction to avoid disturbance to the flow path or provide stabilized methods to divert stormwater around or through site construction.
- Increase the use of **temporary seeding and mulches**. Use of adequate temporary mulch has been shown to reduce surface erosion by up to 98% compared to sites with no erosion controls.[1] State law currently requires that disturbed areas where grading activities cease for a period of longer than 21

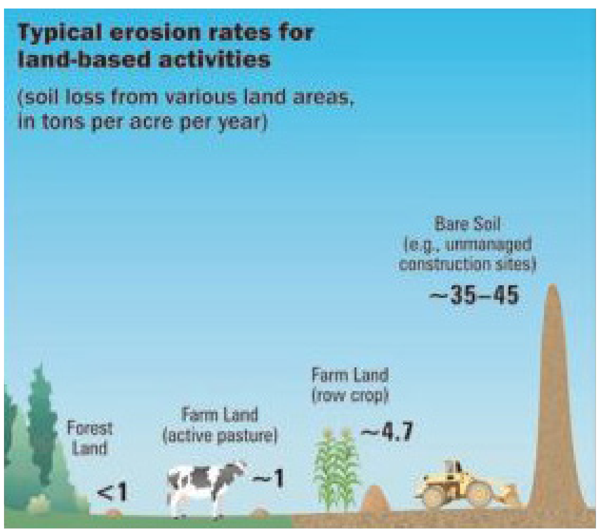
Source:
1. CPESC Exam Review Workbook. October 2002

Why is Pollution from Construction Sites a Problem?

Construction activities create new development from farmland or other open spaces. These activities strip off any vegetation that is reducing the potential for surface erosion. Once this vegetation is gone, the surface of the soil is easily washed away by rainfall and flowing water. Soil can also be tracked onto roads and highways or dumped into waterways. All of these actions make it likely that soil will be carried off site and washed into downstream storm sewers, creeks and rivers. This eroded soil (sediment) can plug up storm sewers and fill in waterways, affecting their ability to convey runoff. Other impacts of sediment are listed in detail in Chapter 6 of this plan.

Without effective controls, sediment discharge from construction sites often will range between 35–45 tons per acre.[1] Compare this with farmland areas which usually have loading rates of less than two tons per acre. Lawns and other stabilized areas have far lower erosion rates.

Construction sites can also be sources of other pollutants such as fuels, oils, paints, concrete washout, construction debris and human waste (collected in temporary toilet facilities from workers).



Source: Dunne, T. and L. Leopold, 1978; NRCS, 2000; NRCS, 2006; ASCE and WEF, 1992

days shall have temporary stabilization (such as mulch with seed) applied within 14 days after the last grading activity. Many sites are currently not providing adequate temporary stabilization measures to comply with this requirement.

- On steeper slope areas or in areas of concentrated flow, increase the use of **rolled erosion control products** (RECPs) and **turf reinforcement mats** (TRMs) where temporary mulch may be insufficient to prevent erosion.

Recommended improvements for sediment control practices:

- Prior to commencing land disturbing activities, install **perimeter site controls** (such as silt fences, filter socks, wattles and sediment basins), **stabilized construction entrances**, trash collection areas and **temporary sanitary facilities** for site workers
- Install interior site controls as soon as allowed by grading or utility construction
- **Don't overload controls**. Refer to design guidelines for sizing and design. For example, where silt fence is installed, provide at least 100 feet of silt fence length for each quarter acre drained.
- **Silt fences** should feature **"J-hooks"** or other methods to increase their storage capacity and prevent **concentrated flow** from larger areas being directed to a single low point in a long fence. Silt fences often fail when they "blow out" from collecting too much runoff or sediment, because the area they collect runoff from is too large. Silt fences should have these features placed at intervals of no greater than 200 feet.
- Use **soil logs or wattles** to break up the length of steeper slopes. Reducing the flow length along steep slopes can significantly reduce surface erosion.
- State law requires **sediment basins** to be installed where attainable, when runoff from more than 10 disturbed acres is routed to a common outlet. These basins are to be designed with floating outlets or devices that collect water from the surface of ponded water. As pollutants settle out by gravity, the surface of the ponded water tends to be less polluted than that discharged from the bottom of the basin. Few of these types of outlets are being utilized currently. Also, as properly sized basins are often most effective at removal of suspended sediment from constructed runoff, it is recommended that new local policies be implemented to require their use in smaller disturbed areas.

Source:
1. Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites, page 2; USEPA, May 2007

- All site controls should be checked on a weekly basis and before rainfall is expected to make sure they are in good working order. Controls should be maintained and repaired promptly as needed. Trash and sanitary collection facilities need to be emptied routinely and collected materials disposed of properly. Stabilized entrances may need new surface aggregate provided is they are failing to prevent off-site tracking from occurring.
- When **dewatering** excavations, divert **discharge** to a sediment basin or other collection area on-site. Do not directly discharge such water to the storm sewer system without treatment or filtration. Avoid releasing concentrated flows at the top of steep slopes where gully erosion may be caused.
- Immediately following full establishment of permanent vegetation, all temporary controls such as silt fences, soil logs, **inlet protection devices** should be removed. Accumulated sediment should be properly disposed.

Recommended improvements to SWPPPs:

- The plan should be a "living document." The plan should be amended in some fashion so that the site map reflects current site conditions. Inspection records and changes to the sequence of construction events should be made part of the SWPPP document.
- The SWPPP and all site controls are to be maintained as necessary until **full establishment of vegetation** across all disturbed areas. Site inspections and maintenance of controls should continue until all areas are stabilized with permanent vegetation and the **Notice of Discontinuation** (NOD) has been filed with the Iowa Department of Natural Resources.

Weeds can be seen growing in this area, indicating it was graded at least a few weetks ago. No temporary mulch or seeding is present.

Recommended improvements to municipal inspections:

- Routinely check sites to assure that construction sites are in compliance with state and local standards.
- Respond promptly when polluted site runoff or **off-site tracking** is observed, or citizen complaints are received.
- When necessary, use **"stop work orders"** and other methods to bring sites back into compliance before work on other construction items can proceed.

Application

The plan recommends ordinances and internal policies be implemented and enforced that would apply these standards to all sites requiring either a local grading permit or authorization under the State of Iowa's NPDES General Permit No.2 (construction sites or **common plans of development** which will disturb at least one acre).

Expected Impacts:

- Successful implementation of these policies would significantly reduce sediment loadings from construction sites and annual sediment loadings within the Walnut Creek watershed.
- Reduced sediment loading will slow the rate of deposition within the flood plain. This maintains the flood plain's ability to convey and store runoff. This reduces the potential for increases in flood elevations and flow velocities.
- Reduced deposition also lowers the potential for streambank erosion due to deposited soil pushing flows toward the outside bends of streams.

Soil Quality Management and Restoration

Recently, requirements within the State of Iowa's NPDES General Permit #2 for construction sites were amended. These changes removed a requirement to restore four inches of topsoil across disturbed open spaces. The permit now requires that topsoil be preserved on site where feasible, but does not specify where and how that topsoil is to be placed or preserved. During the discussions leading up to these changes, many concerns were raised by development and real estate interests about the cost and timing of restoring topsoil, especially on finished lawn spaces within **single-family land developments**. Conceivably, the changes in permit language allow topsoil to be preserved within berms or other confined areas and may not be placed uniformly across the landscape. This means that many open spaces may lack the healthy soil material needed to support the growth of lawns and landscaping. Should this occur, the soil will have limited ability to absorb runoff during rainfall events (runoff volumes may be increased by more than 80% during the most commonly occurring storm events) [(1)]. Higher levels of watering and fertilization will be necessary to support desired plant materials. All of these factors have the potential to increase stormwater runoff volume and pollutant loads.

For this reason, it is recommended that communities implement local ordinances to protect or restore healthy soils in open space areas within new development sites. The Iowa Stormwater Management Manual has an entire chapter devoted to the topic of maintaining and restoring healthy soil profiles. Options include limiting the footprint of land disturbance, topsoil stripping/replacing or using soil amendments like compost and sand to rebuild a healthy surface topsoil layer.

To fully realize the benefits of soil quality restoration, the methods within ISWMM manual list various ways to maintain or create eight inches of a healthy soil profile across the surface. Requirements to achieve this standard can be incorporated into other ordinances, or implemented as a stand-alone ordinance.

Such requirements should include the following elements:

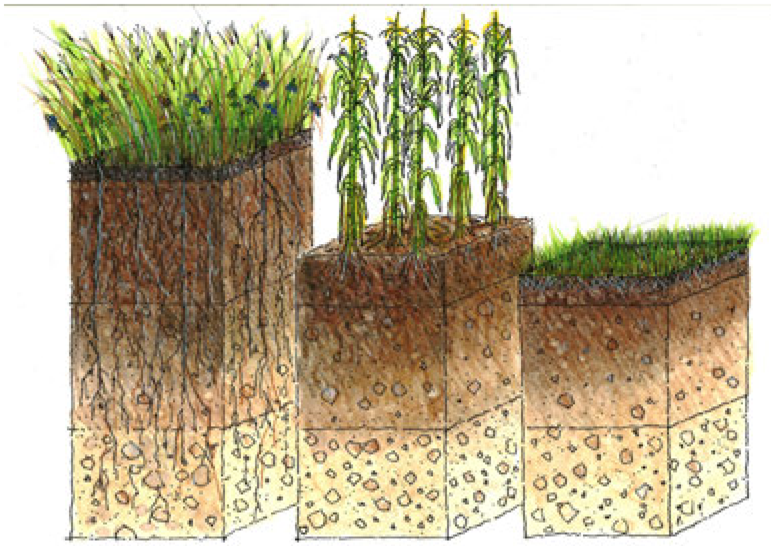
- All construction sites which are subject to local grading permit or State NPDES permit requirements should develop and maintain a Soil Management Plan (SMP) which becomes a part of the SWPPP document when one is created for a given site.
- The SMP shall review soils information from county maps, geotechnical studies or other sources to identify where higher quality soils may exist. When possible, the organic content of onsite topsoil material should be determined by testing.
- To the extent possible, site improvements should be oriented to minimize disturbance of high quality soils. Site grading should be planned to avoid compacting, filling or tilling under the drip line of trees which are identified as being intended to be preserved through construction.
- Identify where topsoil will be stripped, stockpiled and replaced. The quantity of stockpiled material should be estimated.
- Where grading is necessary, show the location and type of method of Soil Quality Restoration (SQR) to be applied (reference ISWMM chapter to see the available methods and how they are achieved).
- In some locations, it is possible to use SQR techniques to partially or totally address the Water Quality Volume. If this is proposed, identify locations where SQR techniques are intended to be used to meet such requirements. Include relevant calculations to demonstrate compliance with requirements listed in the ISWMM manual within a stormwater management report submitted to the local jurisdiction for review.
- If SQR techniques are not proposed, or not applied, appropriate adjustments to runoff coefficients and curve numbers within stormwater design calculations should be made to account for the effects of soil compaction and poor establishment of vegetation. The ISWMM manual includes recommendations on how to account for these effects.

Application

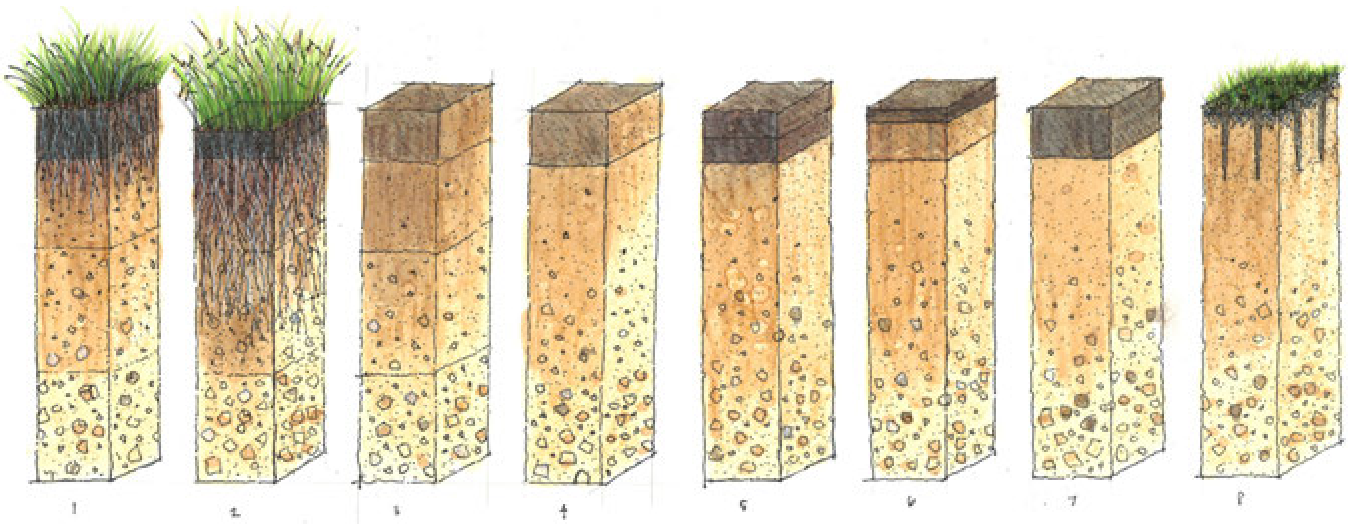
It is recommended that ordinance and policies be implemented that would apply these standards to all sites requiring either a local grading permit or authorization under the State of Iowa's NPDES General Permit No.2 (construction sites or common plans of development which will disturb at least one acre).

Note:

1. Refer to analysis in Chapter 8.



Historic topsoil depth and organic matter levels have been reduced in agricultural areas. The remaining topsoil is often stripped off or compacted during grading and construction of new land developments.



The Iowa Stormwater Management Manual contains a section on Soil Management and Restoration. It designates eight different methods that can be used to protect or restore a healthy topsoil layer during the construction process. Designers can use this information to develop a Soil Management Plan, which outlines how developers or contractors can use one or more of these eight methods to leave lawn and landscaping areas with adequate topsoil to support vegetation and reduce stormwater runoff.

Expected Impacts (Where Applied)

- It is expected that successful implementation of these policies could reduce runoff volumes from suburban development areas by approximately 45% during a 1-year return period storm event (2.67" in 24 hours). This would be a volume reduction of 17,600 gallons per acre drained for that event.
- Runoff reduction from areas developed using these policies during the 100-year return period storm event (7.12" in 24-hours) would be expected to be approximately 20%, compared to sites without soil quality restoration. This would be a volume reduction of 33,400 gallons per acre drained for that event.
- Total pollutant loading would be expected to be reduced by at least an amount similar to runoff volume reductions.
- Reduced need for irrigation and fertilization could lead to additional reductions.
- Stormwater detention areas and other management practices can be reduced in storage volume and footprint area. Modeling results from the developing case study area indicate that stormwater management areas in areas without soil quality restoration would need to have 48% more volume and be 40% larger in area to limit runoff rates to desired levels.

Policies for Developed Areas

While many of the policies in urban areas are focused on new or redeveloping areas, it is important to look for opportunities to make improvements within the 43% of the watershed that is already developed. Cities can require updated stormwater practices to be installed on properties where site improvements or re-development is proposed to a level where a new site plan must be approved. Other than these situations, cities usually do not have the ability to force private property owners to make improvements to their sites. For this reason, communities may decide to provide incentives (such as cost share programs, grants, utility fee reductions) to promote installation of new stormwater practices. Cities may also look to identify critical areas where stormwater retrofits could lessen the potential for flash flooding or streambank erosion along small urban tributaries. Education and outreach efforts can also broaden use of practices such as rainbarrels and raingardens in residential areas.

Policies for Rural Areas

Rural Policy Recommendations

Over the next decade, it is expected that most water quality improvements will rely on voluntary actions taken by individual farmers and landowners. To support and accelerate the implementation of this plan, a series of policies and action items has been identified.

1. New sources of financial support are needed to support water quality improvements in rural areas. Many practices known to be effective at reducing pollutant loads and/or runoff volumes, but several of these have costs associated with their installation or the lost potential for agricultural production. There are many economic factors which may make it more difficult for farmers and land owners to commit to investing in these practices. Low crop prices may leave little room above the "bottom line" to devote to water quality initiatives. With higher prices, there is incentive to maximize productive land, potentially reducing available for buffers and other practices. Federal, state and local resources can be used to bridge this gap and provide water quality and quantity benefits that are important to the entire watershed.

   Some alternatives for funding are listed below:

   - Iowa Department of Agriculture and Land Stewardship provides grant opportunities for practices that support the Water Quality Initiative (WQI) Nutrient Reduction Strategy Practice Implementation and Demonstration Program. At the time of this plan's writing, Polk Soil and Water Conservation District received a grant from this source of nearly $200,000 to help implement best practices within the watershed.
   - The Iowa Soybean Association has recently proposed a series of tax credits for farmers who install selected best management practices. Within the last year, these credits were included in House Study Bill 251 which would place emphasis on practices that are expected to provide multiple benefits and yield the highest levels of nutrient reduction.
   - The Natural Resources and Outdoor Recreation Trust Fund (which was authorized by voters in 2010, but has not been funded as of this date) could be used to fund a variety of urban and rural water quality improvement. By law, money placed in the fund must be spent on a variety of conservation practices and improvements, many of which would have a direct benefit to water quality.

- The Iowa League of Cities has been working on a water quality offset exchange which would allow public water utilities or other municipalities to develop water quality projects in upstream areas that would have quantifiable nutrient reduction benefits. This or some other nutrient trading system could be used in the Walnut Creek watershed to develop rural-urban partnerships to creatively fund practices which address water quality and/or quantity.
- There are several other grants and cost sharing programs that are in place, some of which have funds targeted for use in the Walnut Creek watershed. However, with the projected cost to implement improvements broadly within this area, there is a need for additional programs to be implemented.

2. Develop private and public partnerships to develop precision business planning for agricultural areas, targeting those areas which currently farmed on an annual basis, but are routinely not profitable to the producer. These lands could potentially be set aside for water quality practices such as conservation easements, wetlands, buffers, etc.
3. Additional educational materials are needed that better explain the best management practices that are included in the nutrient reduction strategy: what they are, where they are best applied, how they work, their benefits and liabilities, and where interested groups can seek out more information for funding or constructing such practices. The need for such materials extends beyond the boundaries of this watershed.
4. More information on existing research needs to be accessible to explain to producers and landowners what would be considered "natural" levels of nutrient loadings and how current agricultural practices have been shown to impact these levels.
5. Develop a stream buffer policy for voluntary implementation of stream buffers and grass waterway improvements throughout the watershed. It would be recommended to provide a buffer of native vegetation, which protects areas expected to be inundated by a five-year flood event. Also, it is recommended that grass waterways or other buffers be provided along "zero order" streams so that they are protected for a width of one rod (16.5 feet) on either side of the stream.
6. Practices that improve soil health and address water management have benefits beyond water quality and quantity improvements that should be pursued.
    - Maintaining and improving the structure and organic material within the upper soil profile is key to sustaining agricultural production into the foreseeable future. Practices such as **extended crop rotations** may cause short term reductions in yield when fields are used for alfalfa production, but long-term benefits in soil depth and quality are likely to be realized.
    - Methods of **subsurface water control** also can offer reduce risk of crop losses. It has been identified that over the past sixty years, significant crop losses can be attributed to either excess or insufficient moisture. In the past, field moisture management has often been focused on drying fields out during wet years. The importance of having the ability to retain moisture during drought conditions should not be overlooked. Drought has historically been a larger cause of crop losses than either excess moisture or flooding.

Portion of All Crop Losses Reported that are Related to Drought, Excess Moisture or Flooding

Cause of Crop Loss	Iowa Corn (1948-2010)	Iowa Soy (1995-2010)
Drought	40%	28%
Excess Moisture	27%	27%
Flooding	6%	6%

Source: "Managing Risk in Agriculture;" Chad Hart; Presented at Ag Credit School; Ames, Iowa; June 2013.

Future Considerations

This plan focuses on voluntary efforts to implement measures to improve water quality. A wider establishment of adequate stream buffers and grass waterways is an essential component of this plan. Even if there was a desire to make stream buffer protection a requirement in rural areas, there is not currently a means at the city or county level to execute and enforce such requirements. Therefore, at this time it is essential that landowners, farmers, conservation and advocacy organizations work together to more broadly adopt these practices.

This plan includes a 10-year implementation period for its first phase. If at the end of this period there has been little progress adopting stream buffer improvements on a voluntary basis, then there may be a need to advocate for stronger regulatory policies that could be enforced on the state level. Recently, the State of Minnesota implemented a mandatory stream buffer protection and re-establishment policy which will be implemented over the next few years. Should that program be successful, it could serve as a model which could be tailored to address conditions in Iowa.

CHAPTER 10

KEY CONCEPTS

1. **A ten-year "to-do list"**
   This chapter outlines key improvement needs that have been recommended to meet the goals of this plan. Many of these projects have been identified during development of this plan. Some of the projects were already included within the Capital Improvement Plans (CIPs) of communities within the watershed. It is expected that the projects included on these lists would need to be completed within the next ten years (by the end of 2025) in order to achieve the desired water quality improvement objectives within the case study subwatersheds, and to make progress toward targets for the Walnut Creek Watershed as a whole. Separate lists are provided for:

   a. Case Study Subwatersheds (Rural, Urban, Developing)

   b. Other Recommended Projects throughout the Watershed

   c. Other Stormwater Projects already identified in local Capital Improvement Plans

2. **Implementation**
   The timeline for implementation of these projects is included in Chapter 12 of this plan.

3. **Other support**
   Other cost for staffing, maintenance and monitoring are outlined in Chapter 13 of this plan.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

The timing and costs of the projects recommended to implement as part of this plan need to be well defined so that communities can begin to budget for these expenses or seek other funding sources such as state or federal grant or loan programs. WMA support of community projects will likely be one key to success in securing funding.

ten

Projects and Priorities

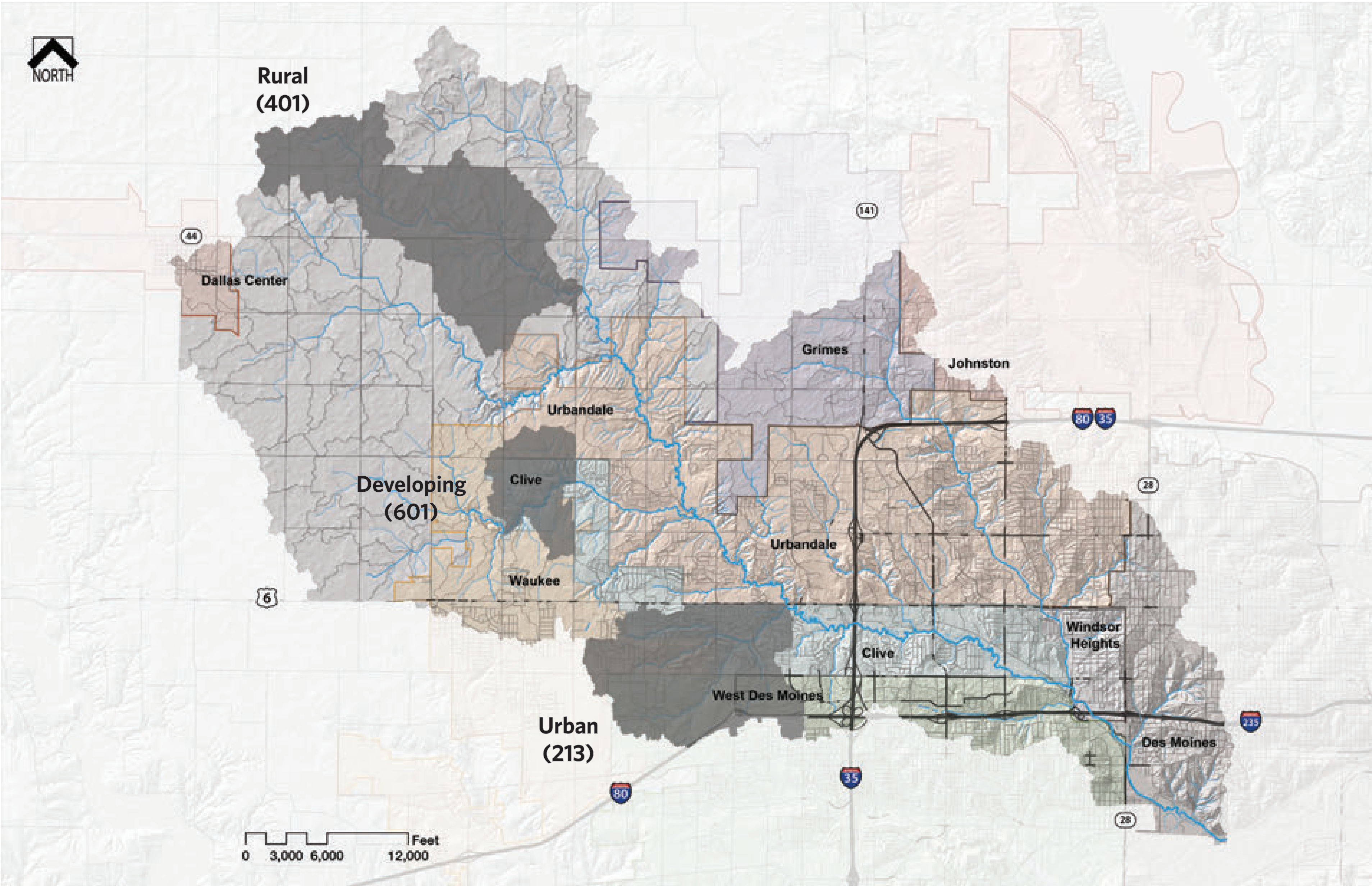
10-Year Implementation Plan

Case Study Subwatersheds

- Rural (411)
- Urban (213)
- Developing (602)

Scheduled Capital Improvement Projects

Other Recommended Projects Throughout the Watershed


NORTH
Rural
(401)
Developing
(601)
Urban
(213)
Dallas Center
Urbandale
Clive
Waukee
Grimes
Johnston
Urbandale
Clive
West Des Moines
Windsor
Heights
Des Moines
44
141
6
28
80
35
235
Feet
0
3,000
6,000
12,000

Developing Case Study Area (Subwatershed 601)

Chapter 8 of this plan outlines the overall scale of management practices that will be needed to reduce the rate at which runoff is directed to Little Walnut Creek. There is flexibility in how these practices can be constructed. The way these practices are implemented will affect the schedule of construction, the cost of improvements and who ultimately will be responsible for their construction.

Scale and Number or Practices

Small-Scale Practices

Stormwater is managed in multiple areas located at key points spread throughout each area.

Benefits:

- Stormwater is managed closest to the source.
- Each practice would be less expensive to construct.
- Practices could be built at the same time as surrounding development.
- It may be more effective to manage both water quality and quantity within smaller-scale practices.
- Practices would operate in series. If one practice is less effective than expected, there is opportunity for others to pick up the slack.

Challenges:

- The larger number of practices may increase the overall cost of managing stormwater within this subwatershed.
- Maintenance of multiple practices may be more costly and complicated to coordinate.
- Care must be taken in determining how off-site, upstream runoff is to be routed through each practice, so that ultimately all management requirements within the local watershed are achieved.

Regional Stormwater Practices

One or two larger practices could be constructed to control runoff from each microwatershed.

Benefits:

- Fewer practices would be required. Each practice would be larger, but the total cost of all practices would likely be less.
- A simpler maintenance program could be developed which could be carried out by private (homeowner's associations) or public (city resources, volunteer organizations) groups.
- Larger practices could likely be built as ponds, wetlands and other features which could be designed to be public amenities within open spaces accessible to the public. Such features could improve community health and increase surrounding property values.

Challenges:

- Larger practices may require cooperation between multiple developers or may need to be built as public (city) projects.
- For better removal of pollutants, other practices (such as bioswales) may be needed to address water quality before runoff enters the regional facility.

Construction, Ownership and Maintenance

Privately Built and/or Maintained

The responsible party would be a private developer or homeowner's association.

Benefits:

- The cost of stormwater management is most directly assessed to the development which increases runoff rates or volumes.
- Least direct cost to local governments.

Challenges:

- Less oversight and control of the staging and execution of construction.
- May be difficult to monitor maintenance and assure its proper execution.
- The general public's access to open spaces may be limited.
- Sometimes a larger private homeowner's association will not continue adequate investments in maintenance which seem to most directly impact homes nearest to the management area.

Publicly Built and/or Maintained

A community or other public agency would be responsible.

Benefits:

- City controls selection of contractors, staging requirements and methods of construction.
- City can directly execute required ongoing maintenance.
- Facilities are usually within open spaces that are accessible to the public.

Challenges:

- Cities need to program costs for staff, maintenance and repairs into their annual budgets.
- Cities may have to train staff or hire qualified contractors for some types of maintenance.
- Cities may incur higher potential liability
- May need to create public-private partnerships or develop new means to apply costs of construction to the developments which are served by them

Note: Private detention facilities have traditionally been built as "dry detention" basins. These facilities have been shown by several studies to offer limited pollutant reduction. The ISWMM manual recommends that such dry detention facilities not be intended for use as a practice to meet Water Quality Management requirements.

Developing Case Study

Type	Microwatershed	Sec-Twp-Range	Jurisdiction	Project Description	Cost (2016)	Note
Short-Term Projects (next five years)						
AQ	601	22-79-26	Clive/ Urbandale/ Waukee	Acquisition of property and/or conservation easements to protect first order streams and other critical wetlands and water bodies in the development case study area.	$200,000	
Medium-Term Projects (next ten years)						
SR	601.02	22-79-26	Clive	Streambank stabilization and buffer protection along Little Walnut Creek from Warrior Lane to Alice's Road.	$2,000,000	
SB	601.31		Urbandale/Clive	Bioretention features, stream buffer protection and enhancement along small tributary .	$300,000	2
SB	601.41		Waukee/Clive	Bioretention features, stream buffer protection and enhancement along small tributary .	$200,000	2
SB	601.51		Clive/Waukee	Bioretention features, stream buffer protection and enhancement along small tributary .	$400,000	2
O	601.51		Waukee	Outlet modifications at existing stormwater management facilities to provide better management of small storm events.	$150,000	2
Total Cost for Developing Short- and Medium-Term Projects:					**$3,250,000**	

Key

Type

ST	Study	WT	Wetlands
O	Outlet Modification	RT	Site retrofits (quality and/or quantity controls)
BR	Bioretention features (biocells, bioswales, raingardens)		
SR	Streambank repairs/restoration	$	Less than $250,000
DR	Detention/Retention Improvements	$$	$250,000–$1 million
SB	Stream Buffer Enhancements	$$$	$1 million–$2 million
AQ	Acquisition of Property or Easements	$$$$	More than $2 million

Notes

1. It is anticipated that studies identified would likely be initiated by local jurisdictions or an interested private party.
2. Projects which are located partially or fully within private property, will require private investments or some type of public / private partnership to complete. For stream restoration or stream buffer enhancement projects, the local jurisdiction may consider acquisition of property or easements for access, maintenance or public use.
3. Long term costs are based on current construction costs and conditions. Over time, project costs are expected to increase based on deteriorating conditions and inflation.

No Section-Township-Range is listed for projects which occur across multiple sections. Refer to microwatershed number and location description to identify.

The projects on this list define larger scale efforts to address existing conditions. In general, projects required to provide post-construction stormwater management for development sites are not identified and will be implemented as development occurs either through private investments at individual development scale or by public/private partnerships at a regional scale. There is also potential for many other small scale, site level retrofits which are too numerous to identify within this list.

Note: This key applies to multiple tables on the pages that follow; some abbreviations and notes may not appear.

Rural Case Study—Subwatershed 411

The following table lists practices that are included in the "model plan," one method to achieve the desired water quality improvements, as measured at the outlet point from this case study subwatershed. The cost of these practices includes the sum of all annual costs (including lost crop yields and the cost of implementing the practices) over the next ten year period (2016–2025). **Note that negative cost values indicate that the practice would produce an overall cost savings if implemented.**

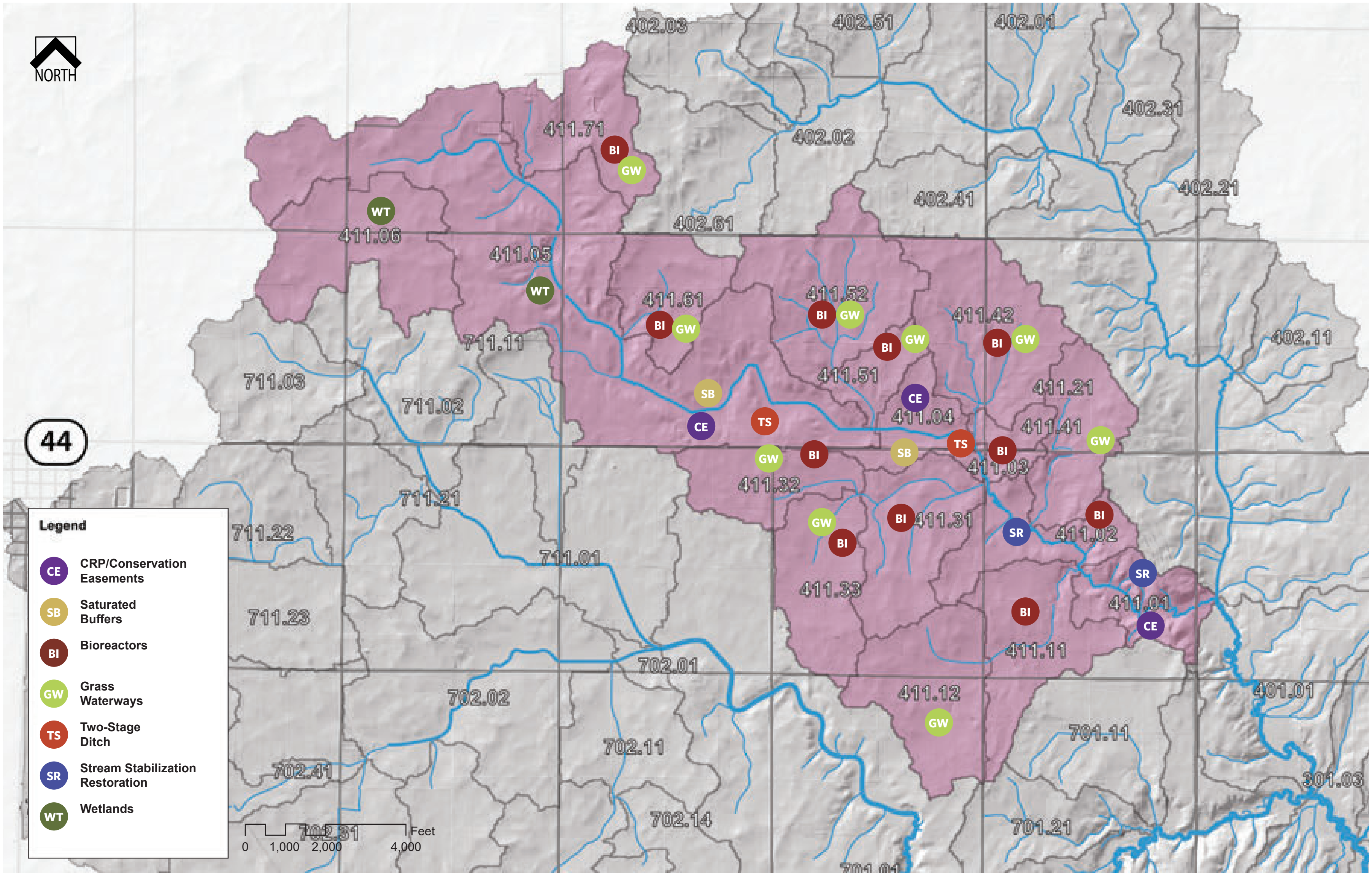
Rural Case Study—Subwatershed Scale Practices			
Portion of Subwatershed to be Applied	Acres to be Applied	Practice	Cost (2016)
10%	415	Extended crop rotations (include alfalfa in 2 years of a 5-year rotation)	$70,000
20%	830	Split seasonal N applications	- $40,000 *
25%	1,040	Cover crops (winter rye or oats)	$260,000
25%	1,040	Increased use of nitrification inhibitors	- $15,000 *
35%	1,455	Increased use of "no-till" practices	$100,000
50%	2,075	Adjust nitrogen application rates	- $20,000 *
		Subtotal	**$355,000**

* Net benefit due to cost savings or yield increase based on information from Section 2.2 of the Nutrient Reduction Strategy (May 2013)

Source: Polk County SWCD

Rural Case Study—Microwatershed Scale Practices		
Microwatersheds	Project Description	Cost (2016)
411.01, 411.04, 411.05	Convert 20 acres of steeper slope cropland into CRP or permanent conservation easement.	$55,000
411.04, 411.05	Install saturated buffers to treat runoff received from 442 acres of upslope areas.	$60,000
411.02, 411.03, 411.11, 411.31, 411.32, 411.33, 411.41	Install bioreactors to treat subsurface drainage received from 311 acres of upstream land area.	$140,000
411.12, 411.21, 411.32, 411.33, 411.42, 411.51, 411.52, 411.61, 411.71	Install grass waterways along 90% of the "zero order" streams within these areas. Estimated length required = 34,200 feet (6.5 miles)	$400,000
411.05, 411.06	Construct water quality wetlands on 30 acres to treat runoff from 633 acres of upstream land areas.	$180,000
	Subtotal	**$835,000**

Rural Case Study—Other Recommended Practices		
Microwatersheds	Project Description	Cost (2016)
411.04, 411.05	Modify an existing engineered stream channel to a two-stage ditch design to treat runoff along stream corridor receiving runoff from 2,244 acres of land.	$250,000
411.01, 411.02	Targeted streambank stabilization and restoration practices along a 1-1/2 mile of stretch of stream.	$950,000
All subwatershed areas	Install or modify outlets to include multi-stage design to more effectively manage the more commonly occurring rainfall events.	$225,000
	Subtotal	**$1,425,000**
	Subwatershed 411 Total 10-Year Cost	**$2,595,000**



Note: Icons designate which microwatershed practices are targeted for in the model plan. They do not represent specific project locations.

Rural Case Study Practice Locations

Urban Case Study—Subwatershed 213

The following table lists structural improvements that are recommended to achieve the desired water quality improvements, as measured at the outlet point from this case study subwatershed. Other site level water quality retrofits could help achieve the desired load reductions, however the cost of such improvements to private landowners may limit their implementation. Such practices should be encouraged, but are not relied upon for implementation of this plan.

The spillway at Country Club Lake currently has little ability to control runoff from small storms.

Urban Case Study				
Proj. # — Type	**Microwatershed / Sec-Twp-Range / Jurisdiction**	**Project Description**	**Cost (2016)**	**Note**
Short-Term Projects (next five years)				
1 — ST	213.41 / 1-78-26 / WDSM	Complete concept plan or more refined preliminary design for three pond outlet / culvert modifications discussed in case study modeling.	$15,000	1
2 — O	213.41 / 1-78-26 / WDSM	Modify pond outlet at West Lakes Office Park Plat 3, Outlot Z to feature multi-stage design for better management of 1-year return period storm event.	$40,000	2
3 — O	213.41 / 1-78-26 / WDSM	Modify pond outlet at 6400 Westown Parkway to feature multi-stage design for better management of 1-year return period event.	$40,000	2
4 — ST	213 / / Clive/WDM/ Waukee	Complete more detailed study or studies on feasibility of modifying existing ponds or stormwater management facilities to account for better management of small storms and reduction of peak discharges.	$180,000	1
5 — ST	213 / / Clive/WDSM/ Urbandale	Complete more detailed study or studies on opportunities to improve both water quality and quantity from neighborhood discharges	$150,000	1

Key

Type

ST	Study	WT	Wetlands
O	Outlet Modification	RT	Site retrofits (quality and/or quantity controls)
BR	Bioretention features (biocells, bioswales, raingardens)		
SR	Streambank repairs/restoration	$	Less than $250,000
DR	Detention/Retention Improvements	$$	$250,000–$1 million
SB	Stream Buffer Enhancements	$$$	$1 million–$2 million
AQ	Acquisition of Property or Easements	$$$$	More than $2 million

Notes

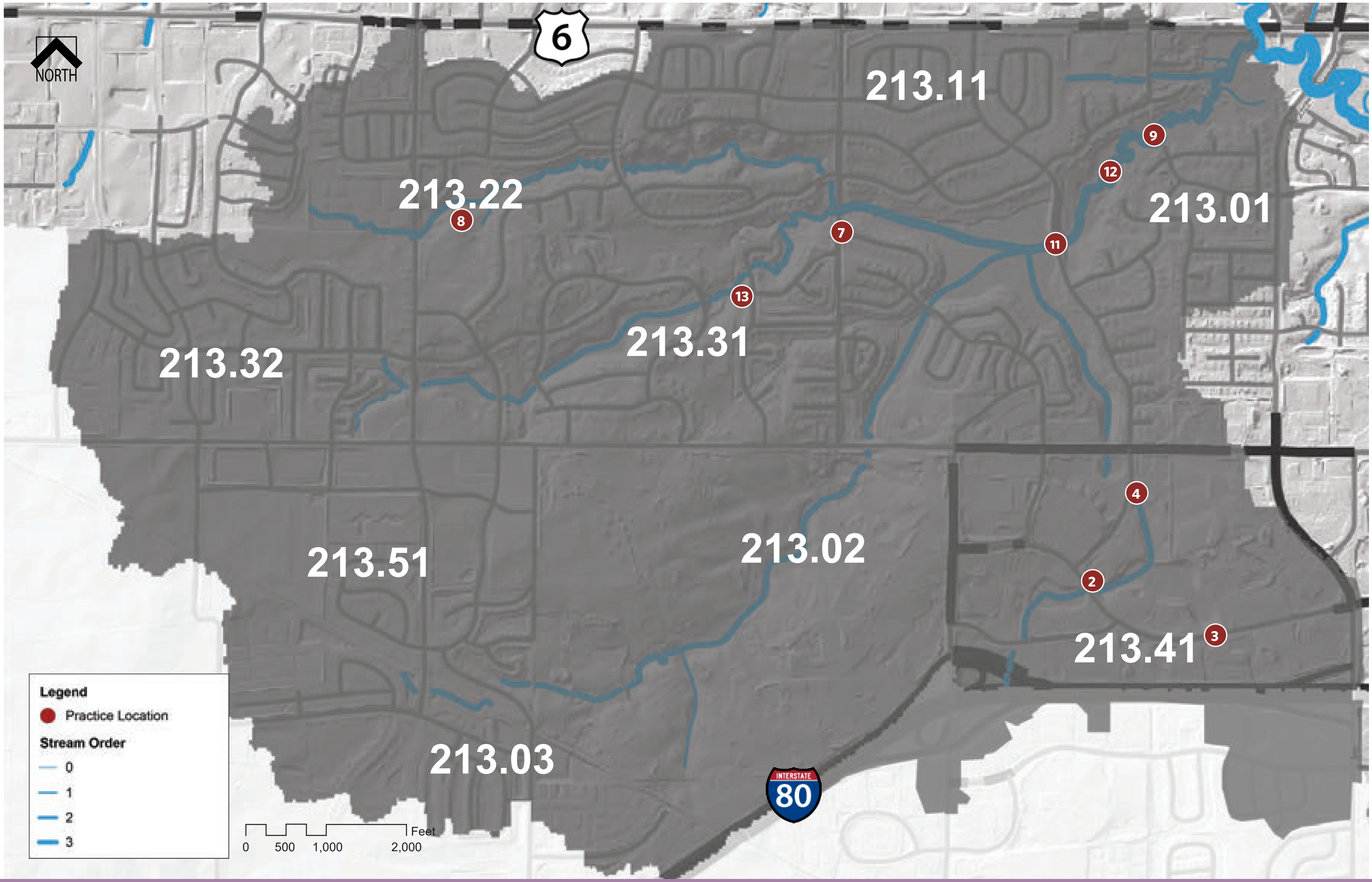
1. It is anticipated that studies identified would likely be initiated by local jurisdictions or an interested private party.
2. Projects which are located partially or fully within private property, will require private investments or some type of public / private partnership to complete. For stream restoration or stream buffer enhancement projects, the local jurisdiction may consider acquisition of property or easements for access, maintenance or public use.
3. Long term costs are based on current construction costs and conditions. Over time, project costs are expected to increase based on deteriorating conditions and inflation.

No Section-Township-Range is listed for projects which occur across multiple sections. Refer to microwatershed number and location description to identify.

The projects on this list define larger scale efforts to address existing conditions. In general, projects required to provide post-construction stormwater management for development sites are not identified and will be implemented as development occurs either through private investments at individual development scale or by public/private partnerships at a regional scale. There is also potential for many other small scale, site level retrofits which are too numerous to identify within this list.

Proj. # — Type	Microwatershed / Sec-Twp-Range / Jurisdiction	Project Description	Cost (2016)	Note
Medium-Term Projects (next ten years)				
6 — O	213.41 1-78-26 WDSM	Modify culvert inlet south of 1801 69th Street to feature multi-stage design. Add storage volume upstream of amended structure through grading.	$200,000	2
7 — BR	213.02/213.31 36-79-26 Clive	Construct bioretention features within NW 142nd Street ROW in order to minimize pollutant loads entering Country Club Lake.	$300,000	
8 — SR	213.22 36-79-26 Clive	Complete channel restoration, repairs and habitat improvements along urban small tributary from NW 156th Street to NW 149th Street.	$550,000	
9 — RT	213.22 36-79-26 Clive	Construction raingardens, bioretention features and/or other stormwater management facilities to reduce the peak flows entering into the urban small tributary at Wildwood Park	$300,000	
10 — O	213 Clive/WDSM/ Waukee	Initiate first phase of improvements to existing stormwater management facilities identified by previous studies.	$500,000	2
11 — O	213.02 31-79-25 Clive	If determined to be feasible by recommended studies, modify outlet structure of Country Club Lake to provide better management of small storms.	$350,000	2
12 — SR	213.01 31-79-25 Clive	Complete channel restoration and repairs to South Walnut Creek, downstream of Country Club Lake to its mouth, within the Clive Greenbelt (5,300 feet).	$2,750,000	
13 — SR	213.31 36-79-26 Waukee	Complete small tributary channel restoration and repair downstream of Southfork Pond to Brentwood Drive (600 feet).	$400,000	2
		Total Cost for Urban Short- and Medium-Term Projects:	**$5,775,000**	

Type	Microwatershed / Sec-Twp-Range / Jurisdiction	Project Description	Cost (2016)	Note
Long-Term Projects (beyond next ten years)				
RT	213 Clive/WDSM/ Waukee	Initiate phased implementation of improvements to improve water quality and quantity control from neighborhood discharges as identified by previous studies.	$$$$	2
O	213 Clive/WDSM/ Waukee	Initiate subsequent phases of improvements to existing stormwater management facilities identified by previous studies.	$$$$	2
WT	213.01 Clive	Construct a wetland bank within Clive Greenbelt upstream of the NW 128th Street bridge (projected area = 5 acres).	$	
BR	213.01 Clive	Construct bioretention demonstration project in abandoned right-of-way to improve water quality from neighborhood to South Walnut Creek (at Woodlands Parkway).	$	
DR	213.02 WDSM	Should the Des Moines Golf and Country Club redevelop, provide on-site stormwater management practices and stream restoration techniques as needed to comply with policy recommendations in Chapter 9.		2
SR	213.02 Clive	Shoreline improvements to provide more naturalized edge and enhanced buffer at Country Club Lake.	$$$	2
SR	213.22/213.21 Clive	Complete urban small tributary channel restoration and repair between NW 149th Street and Lakeview Drive (3,000 feet).	$$$	2



Urban Case Study Practice Locations

Walnut Creek Subwatersheds

Other Recommended Projects

The following table lists other key projects required to protect infrastructure or to address critical areas related to erosion reduction, streambank stability or water quality improvements.

Source: Polk County SWCD

Other						
Proj. # — Type	Microwatershed	Sec-Twp-Range	Jurisdiction	Project Description	Cost (2016)	Note
Short-Term Projects (next five years)						
1 — SR	201.01	35-79-25	Clive	Repairs and streambank improvements along Walnut Creek, west of railroad bridge where utility crossing and bridge have been affected by severe erosion.	$750,000	2
2 — SR	612.01	28-79-26	Waukee	Repairs and channel improvements to address severe erosion downstream of the dam for a private pond. Tributary to Little Walnut Creek, just west of Warrior Lane.	$400,000	2
3 — SR	611.21	26-79-26	Waukee/ Clive	Channel repairs and restoration to address severe bank erosion and downcutting close to sanitary lift station. Located west of Berkshire Parkway.	$600,000	2
4 — SR	701.01	11-79-26	Urbandale/ Dallas County	Repair major gully erosion in east right-of-way ditch, just south of major tributary (700).	$300,000	
5 — ST	511.01	25-79-25	Urbandale	Study to review the potential to construct water quality ponds to reduce bacteria and sediment loading along Rocklyn Creek on upstream side of 70th and 72nd Streets.	$30,000	1
6 — ST	201.11		Clive/ WDSM	Study feasibility of modifying stormwater management facilities to better manage small storms and reduce peak flows to Indian Hills Woods tributary.	$150,000	1
7 — ST	202.51/ 202.52		WDSM/Clive	Study to identify opportunities for water quantity and quality improvements within the Hickory Hills watershed.	$125,000	1
8 — ST	201.01	35-79-25	Clive	Study to identify opportunities to mitigate flooding impacts along the University Boulevard corridor along Walnut Creek.	$125,000	1
9 — ST			Clive	Study to identify opportunities to mitigate quantity and quality impacts from all publicly owned impervious surfaces.	$175,000	

Key

Type

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BR	Bioretention features (biocells, bioswales, raingardens)		
SR	Streambank repairs/restoration	$	Less than $250,000
DR	Detention/Retention Improvements	$$	$250,000–$1 million
SB	Stream Buffer Enhancements	$$$	$1 million–$2 million
AQ	Acquisition of Property or Easements	$$$$	More than $2 million

Notes

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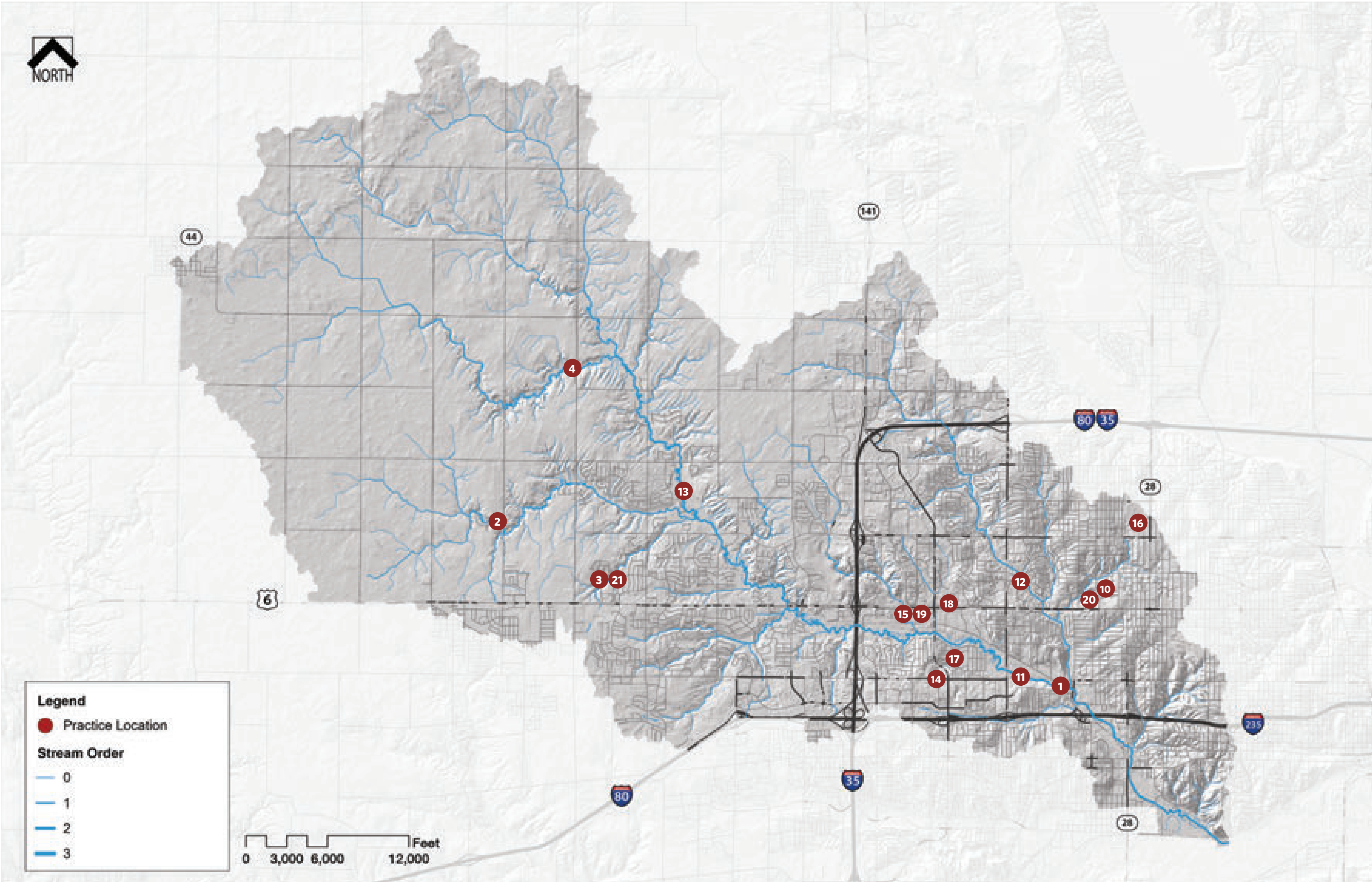
2. Projects which are located partially or fully within private property, will require private investments or some type of public / private partnership to complete. For stream restoration or stream buffer enhancement projects, the local jurisdiction may consider acquisition of property or easements for access, maintenance or public use.
3. Long term costs are based on current construction costs and conditions. Over time, project costs are expected to increase based on deteriorating conditions and inflation.

No Section-Township-Range is listed for projects which occur across multiple sections. Refer to microwatershed number and location description to identify.

The projects on this list define larger scale efforts to address existing conditions. In general, projects required to provide post-construction stormwater management for development sites are not identified and will be implemented as development occurs either through private investments at individual development scale or by public/private partnerships at a regional scale. There is also potential for many other small scale, site level retrofits which are too numerous to identify within this list.



Other Watershed Practice Locations

Proj. # — Type	Microwatershed / Sec-Twp-Range / Jurisdiction	Project Description	Cost (2016)	Note
Medium-Term Projects (next ten years)				
10 — DR	511.01 / 25-79-25 / Urbandale	Construct water quality pond along Rocklyn Creek on upstream side of 72nd Street (if feasible).	$800,000	2
11 — BR	201.01 / 35-79-25 / Clive	Install bioretention features within Buckeye Properties drainageway to repair erosion, address water quality impacts and reduce peak discharges to Walnut Creek.	$350,000	2
12 — SR	502.02 / 26-79-25 / Urbandale	Streambank restoration and improvements to address streambank erosion and incision within the greenbelt corridor along North Walnut Creek between 86th Street and Hickman Road.	$2,000,000	
13 — SR	301.01 / 24-79-25 / Urbandale	Streambank stability improvements along Walnut Creek within Walnut Creek regional park.	$1,500,000	
14 — RT	201.11 / / WDSM	Implement phased construction of improvements identified by prior study to improve water quality, reduce peak discharges to Indian Hills Woods tributary.	$1,500,000	2
15 — SR	212.01 / 33-79-26 / Clive	Channel repairs and improvements along Living History Creek, specifically along segment which parallels sanitary sewer alignment along north side of abandoned railroad grade.	$500,000	
16 — RT	511.02/ 511.03 / 24-79-25 / Urbandale	Stormwater management retrofits at Merle Hay Mall shopping center to improve water quality, reduce flow volumes and rates to Rocklyn Creek.	$1,500,000	2
17 — SR	201.11 / 34-79-25 / Clive	Channel improvements along the Indian Hills Creek corridor to address downcutting and streambank erosion.	$500,000	
18 — DR	211.01 / 34-79-25 / Clive	Retrofit the large drainage channel along the south side of Hickman Road and along the east side of 100th Street to provide extended detention of small storm events.	$350,000	2
19 — WT	212.01 / 33-79-25 / Clive	Construct a wetland bank within the Clive Greenbelt upstream of the mouth of Living History Creek. Projected area = 20 acres.	$300,000	
20 — DR	511.01 / 25-79-25 / Urbandale	Construct water quality pond along Rocklyn Creek on upstream side of 70th Street (if feasible).	$750,000	2
21 — DR	611.01 / 26-79-26 / Clive	Stream improvements, restoration and retrofit of stormwater management upstream of Boston Parkway to manage small storms.	$350,000	2
22 — BR	/ / Clive	Begin implementation of practices identified by previous study to manage water quality and quantity from city owned impervious surfaces.	$1,000,000	
23 — RT	/ / All	Phased implementation of opportunities to retrofit existing developed sites or stormwater management facilities to better manage small storms.	$1,500,000	2
		Total Cost for Other Short and Medium Projects:	**$15,555,000**	

See map on previous page.

Key

Type

ST	Study	WT	Wetlands
O	Outlet Modification	RT	Site retrofits (quality and/or quantity controls)
BR	Bioretention features (biocells, bioswales, raingardens)		
SR	Streambank repairs/restoration	$	Less than $250,000
DR	Detention/Retention Improvements	$$	$250,000–$1 million
SB	Stream Buffer Enhancements	$$$	$1 million–$2 million
AQ	Acquisition of Property or Easements	$$$$	More than $2 million

Notes

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3. Long term costs are based on current construction costs and conditions. Over time, project costs are expected to increase based on deteriorating conditions and inflation.

No Section-Township-Range is listed for projects which occur across multiple sections. Refer to microwatershed number and location description to identify.

The projects on this list define larger scale efforts to address existing conditions. In general, projects required to provide post-construction stormwater management for development sites are not identified and will be implemented as development occurs either through private investments at individual development scale or by public/private partnerships at a regional scale. There is also potential for many other small scale, site level retrofits which are too numerous to identify within this list.

Long-Term Projects (beyond ten years)—ordered by microshed number, not by priority						
Type	**Microwatershed**	**Sec-Twp-Range**	**Jurisdiction**	**Project Description**	**Cost (2016)**	**Note**
SR	101.01-101.03		Des Moines	Streambank restoration and improvements along Walnut Creek from 63rd Street to mouth	$$$$	
SR	101.11-101.12	12-78-25	Des Moines	Streambank restoration and improvements along Greenwood tributary	$$$	2
SR	102.01-102.02		Winds. Hts./ WDSM	Streambank restoration and improvements along Walnut Creek from 73rd Street to 63rd Street	$$$$	2
SR	111.01-111.03		Des Moines	Streambank restoration and improvements along Waveland Tributary	$$$$	2
SR	112.01-112.11		WDSM	Bioretention features, streambank restoration and improvements along I-235 corridor and adjacent urban tributary	$$$$	2
RT	112.02	4-78-25	WDSM	Stormwater retrofits at Valley West Mall	$$$	2
RT	201.01	34-79-25	Clive	Construct bioretention features and upgrade regional detention outlet structure at University Park Shopping Center for better management of small storms and reduction of peak discharges to Walnut Creek	$$	2
AQ	201.01	35-79-25	Clive	Acquisition of property and/or conservation easements to protect stream buffer and to mitigate repetitive loss properties along Walnut Creek from NW 86th Street to 73rd Street	$$	
SR	201.01	35-79-25	Clive/ WDSM	Streambank restoration, ox-bow reconnections and improvements along Walnut Creek from NW 86th Street to 73rd Street	$$$$	2
SR	201.01	34-79-25	Clive	Streambank restoration, ox-bow reconnections and improvements along Walnut Creek from NW 100th Street to NW 86th Street	$$$$	
SR	202.01/ 201.02	33-79-25	Clive	Streambank restoration, ox-bow reconnections and improvements along Walnut Creek from Interstate 35-80 to NW 100th Street	$$$$	
AQ	202.02	32-79-25	Clive	Acquisition of property and/or conservation easements to protect stream buffer and wetlands along Walnut Creek between NW 128th Street and Interstate 35-80	$$	
O	202.31	33-79-25	Clive	Outlet modifications at Clive Aquatic Center to provide better management of small storm events	$	
BR	202.41	32-79-25	Clive	Construct bioretention features within ditch near Pilot truck stop and I-80/35 to address water quality impacts from truck stop and interstate to Walnut Creek.	$$	2
O	202.51	6-78-25	WDSM	Outlet modifications at lake at Farm Bureau campus	$	2
BR	202.51/ 202.52		WDSM/ Clive	Implement phased construction of water quantity and quality improvements within the Hickory Hills watershed identified by previous study	$$$	2
SR	202.61	32-79-25	Clive	Stream channel improvements along urban tributary along Campbell Park	$$	
SR	203.01-203.03	30-79-25	Urbandale	Streambank restoration and improvements along Walnut Creek from Douglas Parkway to Hickman Road	$$$$	2
SR	203.11-203.12	25-79-26	Urbandale/Clive	Streambank restoration and improvements along urban tributary	$$$$	2
BR	203.12	25-79-26	Clive	Construct bioretention features and forebay within waterway leading into Woodcreek regional stormwater management facility	$	
BR	203.21	25-79-26	Clive	Construct bioretention elements and/or stormwater management facilities to reduce the peak flows entering the Deer Ridge West stormwater management facilities	$$	2
SR	211.02	28-79-25	Urbandale	Streambank restoration and improvements along Industrial Creek	$$$	2
SR	211.11	27-79-25	Urbandale	Streambank restoration and improvements along urban tributary to Industrial Creek	$$$	2
SR	212.01	28-79-25	Urbandale	Streambank restoration demonstration project within Living History Farms, along Living History Creek between I-80 and Hickman Road	$$$	2
DR	212.01	28-79-25	Urbandale	Regional stormwater management opportunity along Living History Creek just upstream of Hickman Road	$$$	2

Long-Term Projects (beyond ten years)—ordered by microshed number, not by priority (cont'd)						
Type	**Microwatershed**	**Sec-Twp-Range**	**Jurisdiction**	**Project Description**	**Cost (2016)**	**Note**
SR	212.01	29-79-25	Urbandale	Streambank restoration and improvements along Living History Creek between Douglas Parkway and I-80	$$$	2
O	214.01	30-79-25	Urbandale	Modify entrance to culvert along urban tributary at Douglas Parkway to provide better management of small storms and reduction of peak flow rates to Walnut Creek	$$	2
SR	214.01-214.02	19-79-25	Urbandale	Streambank restoration and improvements along urban tributary to Walnut Creek	$$$$	2
BR	301.01	24-79-26	Urbandale	Stormwater management demonstration projects within Walnut Creek Regional Park	$	
SR	301.01	13-79-26	Urbandale	Streambank restoration and improvements along Walnut Creek from 156th Street to Meredith Drive	$$$	2
SR	301.01	14-79-26	Urbandale	Streambank restoration and improvements along Walnut Creek from 260th Street to 156th Street	$$$	2
SR	301.03	11-79-26	Urbandale	Streambank restoration and improvements along Walnut Creek from confluence with major tributary (700) to 260th Street	$$$	2
SR	301.11	13-79-26	Urbandale	Small tributary streambank restoration and stream buffer protection	$$$	2
SR	301.21	14-79-26	Urbandale	Small tributary streambank restoration and stream buffer protection	$$$	2
SR	311.01-311.02		Urbandale	Small tributary streambank restoration and stream buffer protection	$$$	2
SR	312.01-312.02		Dallas County	Small tributary streambank restoration and stream buffer protection	$$	2
SR	401.01		Dallas County	Streambank restoration and improvements along Walnut Creek from confluence with major tributary (400) to confluence with major tributary (700)	$$$	2
SR	402.01		Dallas County	Streambank restoration and improvements along Walnut Creek from W Avenue to confluence with major tributary (400) - opportunity for two-stage ditch cross-section	$$$	2
WT	402.51-402.52		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
AQ	501.01	35-79-25	Clive / Winds. Hts.	Acquisition of property and/or conservation easements to protect stream buffer and wetlands along North Walnut Creek from Hickman Road to mouth	$$	
SR	501.01	35-79-25	Clive / Winds. Hts.	Streambank restoration and improvements along North Walnut Creek from Hickman Road to mouth	$$$$	
SR	502.02	27-79-25	Urbandale	Streambank restoration and improvements along North Walnut Creek from Douglas Avenue to NW 86th Street	$$	
SR	502.02	22-79-25	Urbandale	Streambank restoration and improvements along North Walnut Creek from confluence with tributary (503.1) to Douglas Avenue establishment of native buffer through Urbandale Golf & Country Club	$$	2
SR	503.01	22-79-25	Urbandale	Streambank restoration and improvements along North Walnut Creek from Meredith Drive to confluence with tributary (503.1)	$$$	2
SR	503.01	22-79-25	Urbandale	Streambank restoration and improvements along Cross Creek	$$$	2

Key

Type

ST	Study	WT	Wetlands
O	Outlet Modification	RT	Site retrofits (quality and/or quantity controls)
BR	Bioretention features (biocells, bioswales, raingardens)		
SR	Streambank repairs/restoration	$	Less than $250,000
DR	Detention/Retention Improvements	$$	$250,000–$1 million
SB	Stream Buffer Enhancements	$$$	$1 million–$2 million
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Long-Term Projects (beyond ten years)—ordered by microshed number, not by priority (cont'd)						
Type	Microwatershed	Sec-Twp-Range	Jurisdiction	Project Description	Cost (2016)	Note
SR	503.02	15-79-25	Urbandale	Streambank restoration and improvements along North Walnut Creek from I-80 to Meredith Drive	$$$	2
SR	503.02	16-79-25	Urbandale/ Grimes	Streambank restoration and improvements along North Walnut Creek from spillway dam to I-80	$$$	2
O	503.02	16-79-25	Grimes	Repairs to spillway at dam, immediately north of I-80 - modify structure to provide better management of small storm events	$$$	2
SR	503.22	16-79-25	Urbandale	Outlet modifications at existing stormwater management facilities to provide better management of small storm events	$$	2
SR	503.11-503.12		Urbandale	Streambank restoration and improvements along Golfview Creek	$$$$	2
SR	503.21-503.23		Urbandale	Streambank restoration and improvements along Crystal Creek	$$$$	2
SR	503.31-503.32	15-79-25	Urbandale	Streambank stabilization and buffer protection along urban tributary	$$$	2
SR	503.41		Urbandale/ Johnston	Streambank stabilization and buffer protection along urban tributary	$$	2
SR	504.01		Grimes	Streambank stabilization and buffer protection along North Walnut Creek	$$$$	2
SR	511.01-511.02	25-79-25	Urbandale	Streambank stabilization and grade controls along Rocklyn Creek from Douglas Avenue to 73rd Street	$$$$	2
SR	512.01-512.02	26-79-25	Urbandale	Streambank stabilization and grade controls along Karen Acres Creek from Douglas Avenue to mouth	$$$$	2
SR	512.01-512.02	23-79-25	Urbandale	Streambank stabilization and grade controls along Karen Acres Creek from Aurora Avenue to Douglas Avenue	$$$	2
SR	513.01-513.02	9-79-25	Grimes	Streambank stabilization and buffer protection along tributary to North Walnut Creek - consider two stage ditch cross-section	$$	2
SR	513.11-513.12		Grimes	Streambank stabilization and buffer protection along small tributary - consider two stage ditch cross-section	$$	2
WT	513.12	8-79-25	Grimes	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SR	601.01-601.02		Urbandale	Streambank stabilization and buffer protection along Little Walnut Creek from Urbandale / Clive boundary to mouth	$$$$	2
BR	601.02/601.21	23-79-26	Clive	Construct bioretention elements within Alice's Road right-of-way between Meredith Drive and Little Walnut Creek and upgrade existing stormwater management facilities	$$$	
SR	601.03	21-79-26	Waukee	Streambank stabilization and buffer protection along Little Walnut Creek from confluence with tributary (613.0) to Warrior Lane	$$$	2
SR	601.11		Clive/ Urbandale	Streambank stabilization and buffer protection along small tributary from Douglas Parkway to mouth	$$$	2
O	601.11		Clive	Outlet modifications at existing stormwater management facilities to provide better management of small storm events	$	2
BR	601.21	23-79-26	Clive	Construction bioretention features to reduce peak flows entering the Verona Hills Plat 1,2 and 3 stormwater management facilities.	$$	2
SR	601.21	23-79-26	Clive	Streambank stabilization and buffer protection along small tributary from Berkshire Parkway to mouth	$$$	2
SR	602.01		Dallas County/ Waukee	Streambank stabilization and buffer protection along Little Walnut Creek from T Avenue to confluence with tributary (613.0)	$$	2
WT	602.01	19-79-26	Dallas County	Construct water quality wetland with multi-stage outlet to manage small storm events and reduce peak flows to Little Walnut Creek	$$	2
WT	602.02-602.21		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SR	611.01	24-79-26	Urbandale	Streambank stabilization and buffer protection along small tributary from Douglas Parkway to mouth	$$$	2

Long-Term Projects (beyond ten years)—ordered by microshed number, not by priority (cont'd)						
Type	**Microwatershed**	**Sec-Twp-Range**	**Jurisdiction**	**Project Description**	**Cost (2016)**	**Note**
O	611.01	25-79-26	Urbandale	Outlet modifications at existing stormwater management facility just upstream of Douglas Parkway to provide better management of small storm events	$	2
SR	611.01	26-79-26	Clive	Channel repairs, habitat restoration and upgrade of outlet structure to account for better management of small storms and reduction of peak discharges to the Country Club Glen tributary	$$$	2
SR	611.01	26-79-26	Clive	Channel repairs and improvements along tributary within Country Club Glen Park	$$	2
SR	612.01	28-79-26	Waukee	Streambank stabilization and buffer protection along small tributary from Hickman Avenue to private pond	$$	2
SR	613.01	28-79-26	Dallas County	Streambank stabilization and buffer protection along small tributary from U Avenue to Little Walnut Creek	$$	2
SR	613.01-613.03	29-79-26	Dallas County	Streambank stabilization and buffer protection along small tributary from T Avenue to U Avenue	$$	2
WT	613.02-613.03		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	613.02-613-03		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	613.11	28-79-26	Dallas County	Buffer protection along small tributary	$	2
SB	613.21-613.22		Dallas County	Buffer protection along small tributary	$	2
WT	613.21-613.22		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	613.21-613.22		Dallas County	Install buffer near surface inlets to tiles	$	2
SR	614.01	21-79-26	Waukee	Streambank stabilization and buffer protection along small tributary from 270th Street to mouth	$$	2
SR	614.02		Dallas Cty/ Waukee	Buffer protection along small tributary	$	2
WT	614.02	17-79-26	Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	614.02	17-79-26	Dallas County	Install buffer near surface inlets to tiles	$	2
SB	614.11	16-79-26	Waukee	Buffer protection along small tributary from Waukee boundary to 270th Street	$	2
SR	701.01	11-79-26	Urbandale/ Dallas Cty	Streambank stabilization and buffer protection along tributary from W Avenue to mouth	$$	2
SR	701.01		Urbandale/ Dallas Cty	Grade controls and stabilization of small tributaries and ravines to larger tributary	$$	2
SR	701.01		Dallas Cty/ Urbandale	Streambank stabilization and buffer protection along tributary from V Avenue to W Avenue	$$	2
SR	701.01		Dallas County	Streambank stabilization and buffer protection along tributary from U Avenue to V Avenue - consider using two-stage ditch cross-section	$$$	2
SR	701.01		Dallas County	Streambank stabilization and buffer protection along tributary from confluence with tributary (711) to U Avenue - consider using two stage ditch cross-section	$$	2
SR	701.11		Dallas Cty/ Urbandale	Streambank stabilization and buffer protection along small tributary	$	2

Key

Type

ST	Study	WT	Wetlands
O	Outlet Modification	RT	Site retrofits (quality and/or quantity controls)
BR	Bioretention features (biocells, bioswales, raingardens)		
SR	Streambank repairs/restoration	$	Less than $250,000
DR	Detention/Retention Improvements	$$	$250,000–$1 million
SB	Stream Buffer Enhancements	$$$	$1 million–$2 million
AQ	Acquisition of Property or Easements	$$$$	More than $2 million

Notes

1. It is anticipated that studies identified would likely be initiated by local jurisdictions or an interested private party.
2. Projects which are located partially or fully within private property, will require private investments or some type of public / private partnership to complete. For stream restoration or stream buffer enhancement projects, the local jurisdiction may consider acquisition of property or easements for access, maintenance or public use.
3. Long term costs are based on current construction costs and conditions. Over time, project costs are expected to increase based on deteriorating conditions and inflation.

No Section-Township-Range is listed for projects which occur across multiple sections. Refer to microwatershed number and location description to identify.

The projects on this list define larger scale efforts to address existing conditions. In general, projects required to provide post-construction stormwater management for development sites are not identified and will be implemented as development occurs either through private investments at individual development scale or by public/private partnerships at a regional scale. There is also potential for many other small scale, site level retrofits which are too numerous to identify within this list.

Long-Term Projects (beyond ten years)—ordered by microshed number, not by priority (cont'd)						
Type	**Microwatershed**	**Sec-Twp-Range**	**Jurisdiction**	**Project Description**	**Cost (2016)**	**Note**
SR	701.21		Urbandale	Streambank stabilization and buffer protection along small tributary	$	2
SR	702.01-702.02		Dallas County	Streambank stabilization and buffer protection along small tributary - consider two stage ditch cross-section	$$	2
WT	702.02-702.03		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	702.02-702.03		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	702.11-702.15		Dallas County	Buffer protection along small tributaries	$	2
WT	702.13-702.15		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	702.13-702.15		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	702.21		Dallas County	Buffer protection along small tributary	$	2
WT	702.21		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$	2
SB	702.21		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	702.31-702.32		Dallas County	Buffer protection along small tributary	$	2
WT	702.31-702.32		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	702.31-702.32		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	702.41		Dallas County	Buffer protection along small tributary	$	2
WT	702.41		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$	2
SB	702.41		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	702.51		Dallas Cty/ Dallas Ctr	Buffer protection along small tributary	$	2
WT	702.51		Dallas Cty/ Dallas Ctr	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$	2
SB	702.51		Dallas Cty/ Dallas Ctr	Install buffer near surface inlets to tiles	$	2
SB	702.61		Dallas Ctr/ Dallas Cty	Buffer protection along small tributary	$	2
WT	702.61		Dallas Ctr/ Dallas Cty	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$	2
SB	702.61		Dallas Ctr/ Dallas Cty	Install buffer near surface inlets to tiles	$	2
SB	702.71		Dallas Cty/ Dallas Ctr	Buffer protection along small tributary	$	2
WT	702.71		Dallas Cty/ Dallas Ctr	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$	2
SB	702.71		Dallas Cty/ Dallas Ctr	Install buffer near surface inlets to tiles	$	2
SR	711.01-711.03		Dallas County	Streambank stabilization and buffer protection along small tributary - consider two stage ditch cross-section	$$	2
WT	711.01-711.03		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	711.01-711.03		Dallas County	Install buffer near surface inlets to tiles	$	2
SB	711.11		Dallas County	Buffer protection along small tributary	$	2
SB	711.21-711.23		Dallas County	Buffer protection along small tributary	$	2
WT	711.21-711.23		Dallas County	Restore pothole wetlands on less productive land - use multi-stage outlets to manage small storms	$$	2
SB	711.21-711.23		Dallas County	Install buffer near surface inlets to tiles	$	2

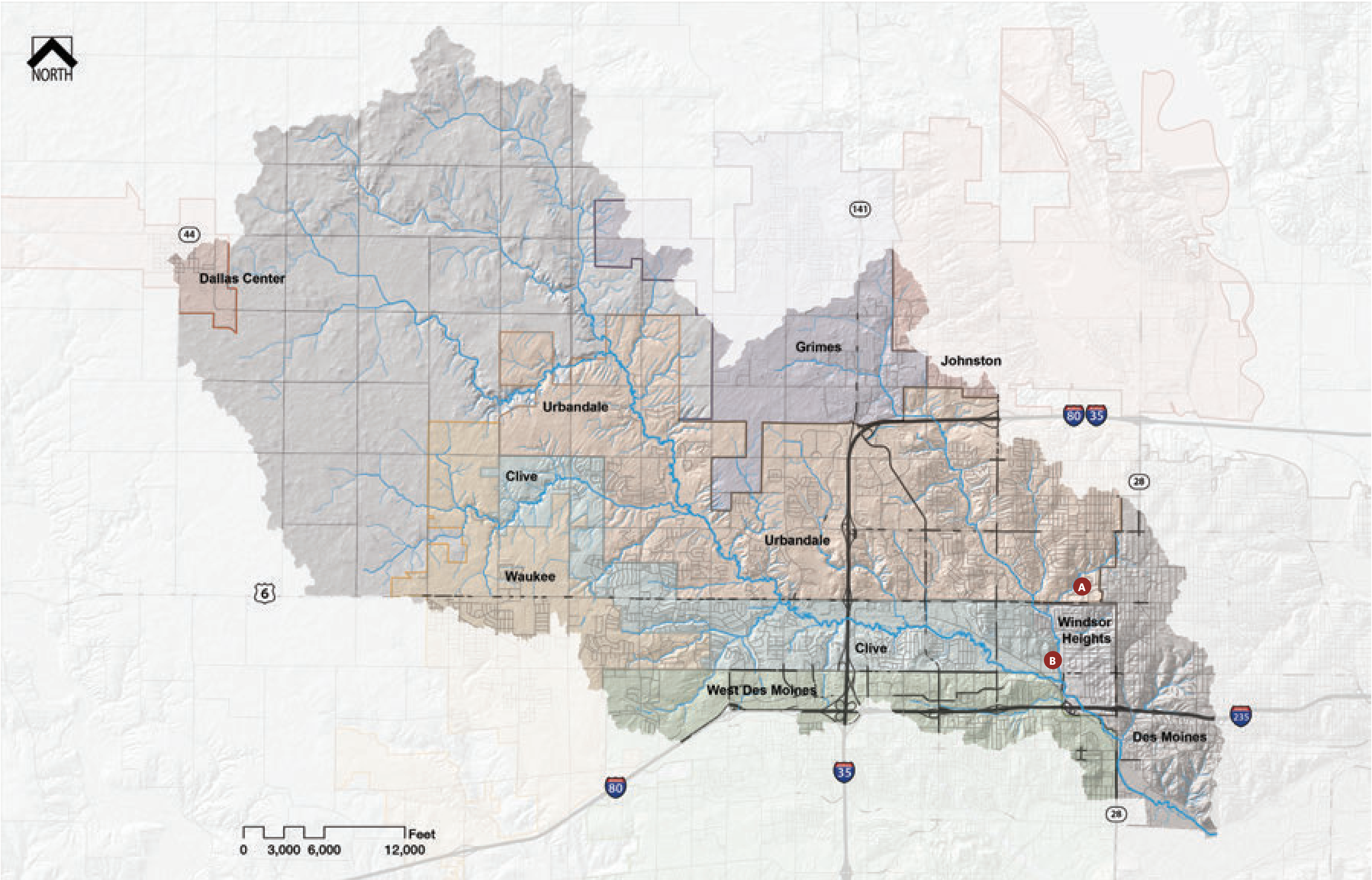
Erosion along North Walnut Creek between Clive and Windsor Heights.

Current Capital Improvement Projects

This table includes projects which have already been included by various communities within their Capital Improvement Plans. These projects are expected to be implemented over the next five to ten years and offer benefits related to the stated goals of this plan.

Watershed Level—Current Capital Improvement Plan Projects			
Schedule for Ch. 12	**Jurisdiction**	**Project Description**	**Cost (2016)**
Short-term *	Urbandale	Study to evaluate options to alleviate flooding along Rocklyn Creek A	$60,000
Short-/ Medium-Term **	Urbandale	Annual commitment for stormwater repairs	$125,000 per year
Short-Term	Windsor Heights	Stormwater management area near Clive Elementary School B	$175,000
Short-/ Medium-Term	West Des Moines	Annual commitment for stormwater repairs	$100,000 per year

** Within the next five years*
*** Within the next ten years*



Practice Locations

CHAPTER 11

KEY CONCEPTS

1. **Emphasis on Collaboration**
   This plan emphasizes collaboration and education among and between key audiences including policy-makers, developers, agricultural interests, the business community, and a "general public." Additionally, this plan emphasizes demonstration, broad engagement in research and interpretation, and ongoing idea and information exchanges.

2. **Key Messages**
   Key messages include paths to successful projects (financial resources and technical assistance), the importance of maintaining healthy top soil as the watershed develops, the impact of construction sites, the need for transparency and monitoring, the overall value of flood plain protection (in urban and rural areas) and the cost-benefit information of current BMPs.

3. **Individual Responsibility**
   The general public needs information to connect to their personal responsibility and specific tactics they can take as homeowners and/or consumers of waters, soils and natural resources.

4. **Education About WMAs**
   Ongoing education about Watershed Management Authorities and their role in sparking watershed results is also referenced here.

5. **Ongoing Information Sharing**
   Specific ongoing mechanisms for communication should be established.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

The plan proposes wide-ranging tools for exchange of information, depending on the audience(s) involved. Considering the variation in audiences, learning styles and the need for information, employing many of these tools simultaneously and on an ongoing basis is recommended.

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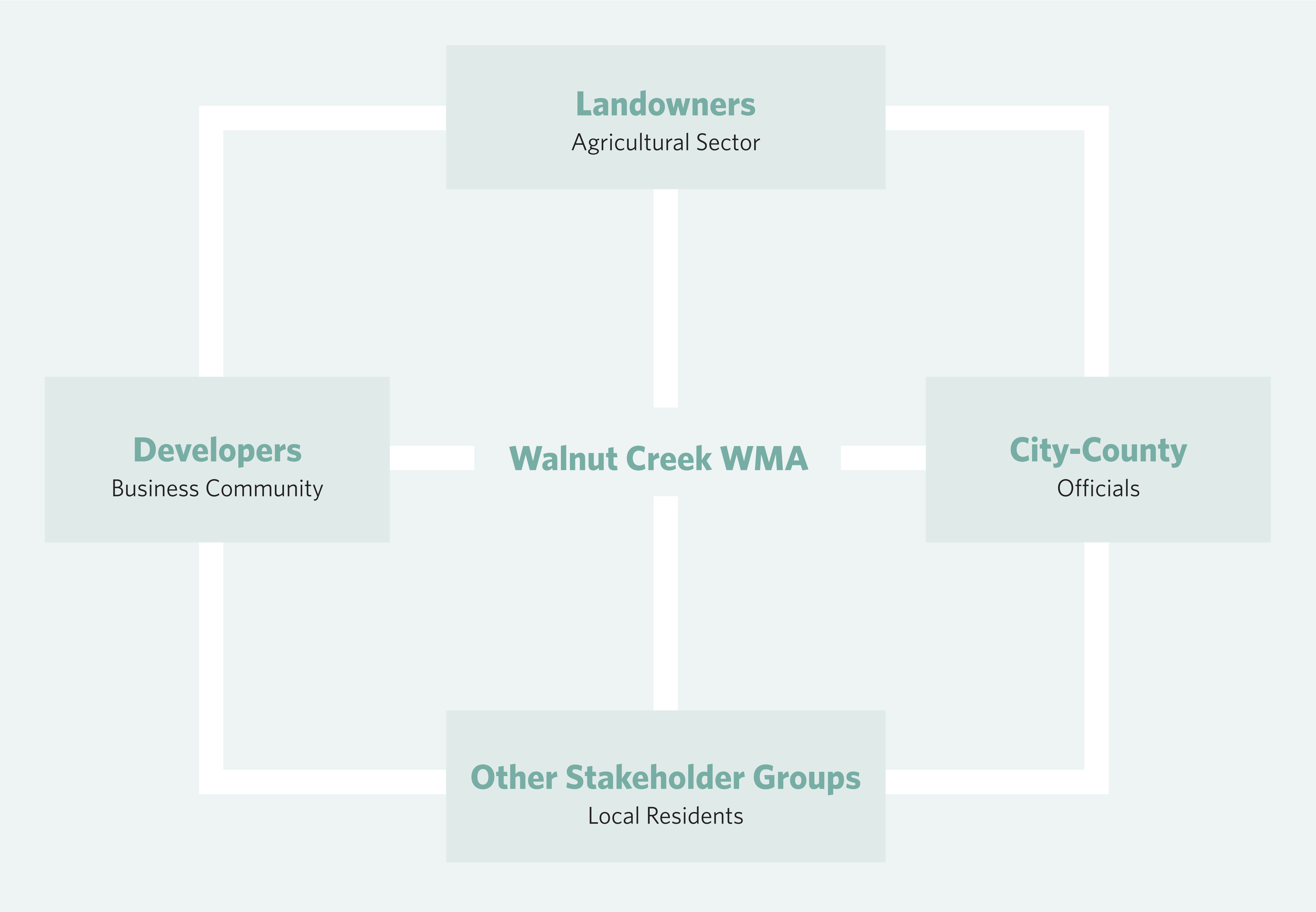
Education and Collaboration Plan


Landowners
Agricultural Sector
Developers
Business Community
Walnut Creek WMA
City-County
Officials
Other Stakeholder Groups
Local Residents

Walnut Creek WMA Watershed Plan

The following education and collaboration plan looks at five audiences with farmers, business/developers, staff and policy-makers (primarily council members, county supervisors, and SWCD commissioners) as the priority audiences. The "general public" is a catch-all for Walnut Creek watershed residents and students. Due to recent flooding, increasing erosion and news accounts of water quality problems in Iowa, a subset of residents will likely be particularly responsive to learning more about their role in the Walnut Creek watershed.

At the time of this plan development, a collaboration is forming among the metro area Watershed Management Authorities which will likely translate into some level of staff support for the various WMAs forming in the region. The specifics have been in discussion and a confirmed/documented collaboration has just recently transpired. This portion of the plan assumes staff time of a "watershed coordinator" will be available to the Walnut Creek WMA in partnership with other WMAs to support education/collaboration tactics such as:

1. Work Sessions
2. Field Days
3. "Speed Dating" Sessions with Farmers, Elected Officials, Developers, etc.
4. Developing Support from/through Current Staff
5. Incentives to Try Practices on Their Own
6. Engagement of Local Television/Media
7. Panel of Experts
8. Increased Engagement around Science and Research
9. Connection through Social Media

More general communications methods, and more specific "plan launch tactics" are described below for the primary audiences.

Landowners/Agricultural Sector

This chapter has been labeled an "education and collaboration" plan for a reason. Too many planning efforts have assumed that one sector of this planning group needs to "educate" another. That can be a patronizing and inaccurate way of addressing what needs to occur. Here, we propose that education is, in fact, an ongoing sharing of research, experience and ideas among all parties/stakeholders connected through the watershed.

Tactics and key messages include:

1. **Resources**—Extensive existing informational and teaching resources exist to ensure that practices are implemented correctly. There are also financial resources that can be used to address cost concerns. Those resources may also be on an upward trajectory. At the time of this report, new funding sources have been identified: grants through a multi-partner Regional Conservation Partnership Program (RCPP) and a grant awarded to Polk SWCD for specific practices. *Continue to improve connections between resources and on-the-ground actions/practices.*

2. **Concerns with Land**—The strategies targeted in this watershed management plan are intended to keep soil and nutrients in the upper watershed. This supports sustainable land use practices and agricultural yield potentials in the near term and for the following generations. *Share strategies, practices and associated benefits, particularly focusing on landowners/operators, where shifts in practice achieve the greatest overall benefit-to-cost ratio with respect to water management.*

3. **Partnerships & Collaboration**—Partnerships with other producers or land owners allow cost sharing and efficiency for the implementation of certain practices. Additionally, *landowners in this watershed have asked for bus tours/ information exchanges (urban/rural) and a seat at the research development and analysis table.*

4. **Range of Solutions**—There are a range of solutions available to mitigate certain concerns. While there may be room for some basic practices to be applied broadly (due to some level of guaranteed benefit), many practices are best established by each landowner/operator based on their particular situation and comfort level for implementation. *Information currently "buried" in the nutrient reduction strategy that pairs BMPs and their anticipated N/P reductions should be delivered to each landowner in the watershed. (See Tactics, next page).*

5. **Why Care?**—What is the *legacy we are leaving for the future generation* of producers? This message is best developed and understood as a collective understanding from all stakeholders in the watershed.

6. **Opportunities for Partnership Using Existing Entities**—Agencies, non-profits and trade groups, such as the NRCS, Polk Soil and Water Conservation District or the Iowa Soybean Association, already have the infrastructure for *building partnerships with individuals or groups of producers.*

Plan Launch Tactics

Early tactics for information distribution and primary information sources:

- A follow-up meeting at the Heartland Co-op to share the preliminary results of the plan and the early strategies for increased monitoring to get direct input into that aspect of the plan (thus providing an early "seat at the table"). Execute this in partnership with ISA, Heartland Co-op, Polk/Dallas SWCD. Begin with sharing "emerging themes" from the landowner meeting. (Note: At the time of publication of this report, this has been accomplished.)
- Through ISA/Co-op or other means, directly distribute highlighted pages of the Nutrient Reduction Strategy that feature BMPs and associated N/P reductions. Secure permission and post on-line. Distribute directly, by mail or other method as recommended by commodity group partners.
- Secure slot on Farm Bureau county meeting agenda(s) to present plan results.
- In partnership with ISA, Dallas/Polk SWCDs and the Heartland Co-op, identify a communications "task force" to develop (minimally) an annual bus tour.
- Identify (minimally) 3-5 area conservation farmers/landowners with best practices in place, and encourage their participation as watershed-educators through presentations, field days, and dialogue in their commodity group organizations. Research the viability of contracting with landowner-educators to secure ongoing participation.
- Additionally research the practicality of partnership through Iowa Flood Center, ISU and other entities to bring researchers to the watershed for interactive presentations about research methods and encourage mutual exchange.
- Work in partnership with the Greater Des Moines Partnership's Soil and Water Future Task Force ongoing dialogues to bring the Walnut Creek farm community to that table.
- Proactively connect to landowners-operators to share the benefits and achieve access to the new funding/granting opportunities as they arise.

Additional methods of ongoing communication include:

- Direct Mail
- Informational Meetings
- Focus Groups
- Outreach via Agricultural Retail—USDA, SWCD, etc.
- Field Days
- Surveys
- Website/Social Media
- Workshops
- Speaker Series
- On-Farm Learning Network

Developers and Business Community

Brief descriptions of the collaboration elements applicable to this group are presented below. In this instance, these elements present a mix of key messages and long-term strategies. These elements will assist in establishing greater consistency in the ordinances/guidelines throughout the WMA jurisdictions.

Tactics and key messages include:

1. **Resources**—There are extensive informational and teaching resources to ensure that practices are implemented correctly. Additionally, *once consistency in implementation throughout the watershed is achieved, developers will enjoy an increased efficiency* when navigating standards and requirements.
2. **Potential to Streamline the Review Process**—*Consistent standards* will assist with streamlining the review process.
3. **Review of Current Policies**—*Reviewing current policies while getting the business community involved* will connect and inform this group, as well as give ownership and involvement to the overall process.
4. **Public Health**—*Making a connection between the health of the waterways and overall public health* will help make a connection to the public, which builds advocacy. The developer and business community will have this information to take into consideration as they move forward with developments.
5. **Why Regulations Exist**—*Provide information regarding the negative effects* that would result if regulations did not exist.

6. **Demonstration Opportunities**—If practices are implemented within the property, it allows the owner to *demonstrate their practice and get recognition throughout the community.*
7. **Previous Studies**—*Educate regarding the positive outcomes of previous studies* performed with certain practices.
8. **Partnership Opportunities and Outreach to Clients**—This will allow *partnerships between businesses for shared costs* and provide another avenue to connect with potential clients and customers.
9. **Triple Bottom Line**—The triple bottom line consists of three P's: profit, people and planet. Sharing ideas for effective watershed management practices aims to demonstrate that the *financial, social and environmental performance of the corporation can improve* over a period of time.

Plan Launch Tactics

Early tactics for information distribution and primary information sources:

- In partnership with other jurisdiction(s)/organizations, or as a stand-alone task force, convene Walnut Creek area developers for a special interactive presentation on the existing-conditions findings and results of the Walnut Creek Watershed Plan. As part of this presentation/summit or short-term education series:
  - Include data on development growth and degradation in water management over time. Emphasize the need for new developments to achieve new results in stormwater management for prevention of additional flood damages and water quality degradation.
  - Place emphasis on the implications of topsoil loss and the engineering and water management impacts of failure to replace that topsoil.
  - Provide education on strengths and challenges of developing and applying Storm Water Pollution Prevention Plans (SWPPPs) and provide case studies of successful SWPPP applications and where SWPPPs have commonly "gone wrong." Acknowledge the ongoing concerns that have surfaced as part of this planning process related to potentially compliant, but perhaps ineffective, SWPPPs.
  - Present the vision of a healthy Walnut Creek watershed and the resulting growth in property values and desirability for residential and business/commercial interests.
  - Establish a dialogue about the necessity of low-impact development principles and associated ordinance/guidance options for implementation. Present local and regional case study examples, allowing for a healthy, collaborative assessment of same.
  - Jointly identify methods for government/community to support "new ways of doing business" on the part of the developers with the understanding that business-as-usual future development will fail the watershed and all those downstream.
- Encourage developer participation in bus tour and other landowner/farmer/policy maker interactions (see above).
- Establish ongoing and healthy means for dialogue/exchange on stormwater management and soil health issues within the region. Consider working with the Greater Des Moines Partnership's Soil and Water Future Task Force to potentially place greater emphasis on urban strategies and thereby maintain strong business-developer and urban-rural connections for ongoing strengthening of this plan.
- Additional methods of ongoing communication parallel those listed above under landowner/agricultural sector.

Decision- and Policy-Makers—City and County Officials

This group consists of city council members, county board members, and other civic and/or agency officials with a particular emphasis on elected officials.

Brief descriptions of the education messages for delivery to this group are presented below.

1. **Cost Savings with Potential Return on Investment**—If policy changes, or even dollar investments on certain practices, are made now, the *cost of future losses, maintenance, and repairs can be mitigated.*
2. **Impacts on Other Community Systems**—Recognition and mitigation of flood and water quality issues can reduce the resource commitment required to *address impacts to utility systems, transportation systems and public health.*
3. **Community Collaboration Opportunities**—*Some practices provide opportunities for collaboration* among different departments within a jurisdiction to ensure the most benefit for the community and its residents. There is also the possibility for talent collaboration with other jurisdictions on joint projects.
4. **What is in the Water = Public Health**—If the concentrations of contaminants entering Walnut Creek are reduced, the *public health of users of the creek and greenway system will be improved.*

5. **Cost Sharing and Grants**—Projects that may span *multiple jurisdictions* or are located at the border of more than one jurisdiction, *provide opportunities for cost sharing* and to implement a practice that may not otherwise be executed.
6. **WMA Education**—Despite the advent of Watershed Management Authorities within the state and region, *WMAs are still a new way for agencies to work together.* Provide information for elected officials and other decision-makers on the true workings and potential of WMAs. Ultimately, help leaders recognize the substantial benefits that can result through WMA efforts.

Plan Launch Tactics

The planning team has connected with decision-makers throughout the planning process (via WMA meetings, executive meetings, stakeholder meetings, public events and direct presentations to councils, boards of supervisors and SWCDs). This over-arching strategy of ongoing communication needs to continue. Specifically, a presentation on this plan as a work-in-progress was developed and delivered to each participating WMA jurisdiction.

Moving forward, plan implementation will also rely on gaining approval of the final plan from each of those jurisdictions. The following steps are proposed:

- After final changes are incorporated into the plan's final draft, craft a council/board resolution for plan approval and update an accompanying presentation and talking points as required. Urge WMA members to take the update/changes summary and resolution to their various jurisdictions for approval. The planning team will support these communications as much as possible.
- Publicize and post executive summary, final plan, and a checklist of early implementation steps including responsible parties and timelines as much as is practical.

Upon plan approval, the ongoing involvement of decision-makers requires ongoing communications similar to those listed above, but including:

- Quarterly updates via email newsletter with emphasis on:
  - Potential resources for plan implementation
  - Plan progress by partners, including measurable results
  - Project highlights and succinct success stories (from within and without the region)
- Quarterly updates at council/supervisor/SWCD meetings by WMA members
- Succinct, well-visualized annual "Reports to the WMA Communities" of plan progress and next steps

Government/Agency Staff—Day-to-day plan implementers

Primary messaging for this key audience focuses on understanding:

1. Cost-benefit of specific measures/practices
2. Impacts of traditional vs. low-impact development
3. Potential challenges and opportunities of various policies/ordinances
4. Technical requirements of successful projects and potential technical pitfalls
5. How to implement successful projects, including achieving positive impacts from guidelines and ordinances in play
6. How to measure success and achieve adaptive management
7. How to access/partner for resources

Plan Launch Tactics

- Convene a technical workshop (or workshops) for key implementers within agency staffs to address the priorities of the Walnut Creek Watershed Plan.
  - Partner with Fourmile Creek and Spring/Mud/Camp Creek Watershed plans, due to the overlap of key personnel involved.
  - Focus the workshop on identified outcomes, priority projects, enhanced technical understanding and purpose behind recommendations—why new methods of stormwater management are important.
  - Highlight stormwater management training including use of SWPPPs, the Iowa Stormwater Management Manual, low-impact design principles and strengths/challenges of proposed ordinances.
- Build awareness of other successful strategies/projects through case studies and partnerships.

Tools for this work parallel those identified in the Landowners/Agricultural Sector plus ongoing technical trainings and references/conferences related to updating available resources and securing grants.

The General Public

Among the general public, some residents have experienced direct effects of flood, silt or erosion damage. Others recognize they are at some risk for those impacts. A broader public has general interest in improved water quality and recreation and many value a broad range of education messages about water and natural resources reaching their school-age children. Some of the priority messages for the general public include:

1. Understanding flood mapping, flood insurance and associated risks and impacts
2. Creating a clearer understanding of source water, river/stream and drinking water standards and hazards
3. Knowing what clear, clean water in Iowa could/should look like
4. Effects of urbanization on soil erosion, water quality and flooding
5. Potential for low-impact development to shift impacts of urbanization
6. Agricultural impacts and potential for improvements through BMPs and other forms of stewardship
7. Recognizing homeowner responsibilities for water quality and flooding, along with homeowner actions (e.g., recognizing/appreciating green infrastructure; installing rain barrels, rain gardens, gray water systems). To this end, develop educational materials for residents that answer the question, "what can I do to help?"
8. The value of direct involvement of residents through volunteerism and citizen science
9. Ongoing education about the value of green spaces/greenways, habitat corridors, wetlands, fens and other natural features on overall quality of life, flood mitigation and water quality
10. Understanding of indicator species and basics of biological connections
11. Knowing the watershed in which they live, its associated partnerships and upstream/downstream implications
12. Celebrating/knowing the fun that can be had in clean water nearby

Plan Launch Tactics

- With homeowners in new flood zones and others needing to be aware of pending risks, the priority tactic here is getting information including maps, FAQs and public meeting notices to those affected homeowners. As of this writing, that work is in progress.
- Partner with the Walnut Creek Watershed Coalition for ongoing participation in this volunteer organization's many effective events that have included rain barrel making, public cleanups and celebrations. Consider supporting the work of this coalition to assist in expanding membership, the organization's physical reach within the watershed and ongoing education opportunities.
- Leverage the work of the Metropolitan Planning Organization's Water Trails Plan.
- Similarly, leverage the work of the Clive Greenbelt Master Planning efforts and associated expansion of education opportunities, facilities and associated programming.
- Support the water/watershed education work of the County Conservation naturalists, the Blank Park Zoo, the Science Center of Iowa and the many additional education arms (e.g., community naturalists, scouting groups, 4H and FFA) to enhance/expand watershed education within Polk and Dallas Counties.
- Employ education strategies of Soil and Water Conservation Districts, the Urban Conservationists, and/or the Iowa Stormwater Education Partnership (ISWEP).
- In partnership with the business community, launch improved realtor education and associated materials for distribution to potential home buyers.
- Through the schools, support the re-invigoration of the Project WET curriculum (an Iowa School curriculum, once more widely used than today, that offered broad-based, interactive learning about the science and uses of water).
- Develop public information, interpretation and signage components for bridges, benches, trails, trailheads and additional access points/gateways in/near Walnut Creek, North Walnut Creek and other streams/tributaries of the watershed.

Additional methods of ongoing communication parallel those listed above under the landowner/agricultural sector.

CHAPTER 12

KEY CONCEPTS

1. **Measures and Milestones**
   This chapter sets forth a timeline for implementing and meeting the objectives of this plan, which can be used to annually evaluate if progress is "on target."

2. **Urban Policy Adoption**
   As over 400 acres are projected to be developed each year, it is important to make ordinance and policy updates a priority for adoption. To see watershed scale results, communities are urged to complete these updates and amendments by the end of calendar year 2017.

3. **Monitoring**
   An effective monitoring program is necessary to better evaluate current conditions and to observe what changes occur as improvements are made and policies are adopted. This plan needs to be implemented as soon as possible so that data collection can begin. Monitoring should be coordinated with parallel efforts being completed by Polk County Conservation, IOWATER and the Iowa Soybean Association / Agriculture's Clean Water Alliance.

4. **Projects**
   Recommended timelines for completion of key projects are included within this chapter.

5. **Reporting Progress**
   An annual report should be presented to the members of the Walnut Creek WMA, which outlines collected water quality monitoring data and documents progress toward achieving expected outcomes of the plan.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

An effective plan addresses the questions: "Who, what, when, where and why?" Previous chapters are focused on answering the what, where and "why." This chapter focuses on the remaining questions. This chapter also outlines a means of evaluating and reporting progress. Such progress reports will be vital in determining how the plan needs to adapt in a changing environment. This plan needs to be a "living document," which may need to be changed based on what is learned through annual reports as well as the financial, technical and staffing resources that are available to carry out this plan.

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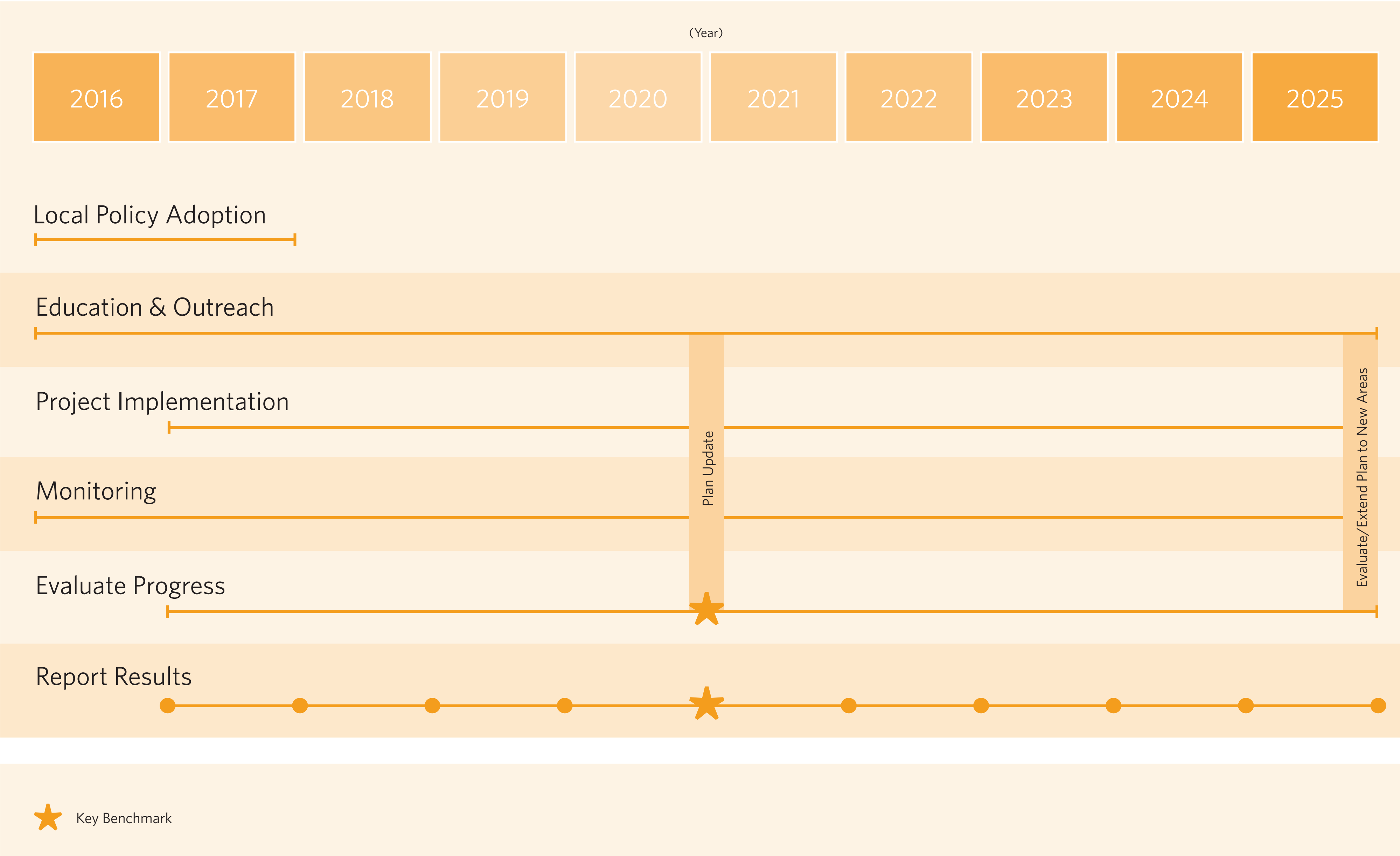
Measures and Milestones

Timeline


(Year)
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Local Policy Adoption
Education & Outreach
Project Implementation
Monitoring
Evaluate Progress
Report Results
Plan Update
Evaluate/Extend Plan to New Areas
Key Benchmark

Schedule

The following is a plan for the first ten years of implementation of policies, improvements within case study subwatersheds and other key improvements throughout the watershed.

Urban Policy Adoption

Changes in local ordinances and policies often requires extended interaction with the general public, local stakeholders and elected officials. Such changes often have an impact on costs at various stages of development and how private land can be altered for more intense uses. These factors often result in a resistance to change.

This plan has documented how aspects of erosion and sediment control, stormwater management and development within the flood plain have had a negative influence on water quality and stream corridor stability. It cannot be expected to see improved watershed conditions without alterations to the way policies are enacted and enforced. The potential impacts and benefits of these policies was outlined in previous chapters.

The timeline at right may be seen by some to be too rapid of a pace to make these changes. However, this study has identified that in an average year more than 400 acres are developed into urban land uses. As time passes, significant opportunities to reduce impacts related to stormwater runoff increases and pollutant loads will be lost. Also, uniform adoption of such policies will assure more widespread benefits throughout the watershed and reduce the perceptions that one community or municipality has standards which are more adverse towards development than the others. Such coordination and collaboration to set consistent policies across borders within the watershed has to be one of the key purposes of the existence of the Walnut Creek Watershed Management Authority.

Project Implementation

Chapter 10 contains lists for priority projects targeted within each of the case study watersheds as well as projects to be implemented throughout the entirety of the Walnut Creek watershed. Those projects identify larger-scale efforts to address currently observed conditions. The tables in Chapter 10 divide these projects into three categories:

- Short-term (within the next five years)
- Medium-term (within the next ten years)
- Long-term (likely to occur beyond the next ten years)

Implementation of Recommended Policies		
Policy	**Community**	**Adopt by End of Year**
Review existing construction site erosion control ordinances. Implement changes in enforcement to achieve the desired results as outlined in Chapter 9 of this plan. Amend ordinances as required to support such enforcement. Coordinate with IDNR storm water coordinator as necessary prior to amending ordinances. Use the local Council of WMAs as a means to reconcile any conflicts in recommended policy changes.	All communities	2016
Adopt or amend flood plain protection ordinances which include outlined recommendations as described in Chapter 9 of this plan.	All communities	2016
Adopt or amend stormwater management ordinances which reference ISWMM Unified Sizing Criteria as described in Chapter 9 of this plan.	All communities	2017
Adopt ordinances related to soil quality management and restoration or amend other ordinances to include requirements as described in Chapter 9 of this plan.	All communities	2017
Adopt or amend stream buffer protection ordinances which include outlined recommendations as described in Chapter 9 of this plan.	All communities	2017

Over time, conditions may change and priorities may shift based on new implementation opportunities. This list should be annually re-evaluated to review which practices have been completed and any need to move projects from one category to another.

These lists also do not identify the numerous opportunities to implement smaller-scale practices at the individual homeowner or development site scale. Also, they do not identify all of the stormwater management practices that will need to be implemented to manage runoff from new developments (regardless of whether they are proposed to be implemented on a site-by-site or regional basis).

Monitoring Plan

An expanded, ongoing **monitoring program** is required to better understand existing water quality conditions, better identify pollutant sources and evaluate the impact on installed practices on water quality. To more accurately define **pollutant loadings**, data needs to be collected more consistently from a broad number of locations and at dates spread throughout the year.

Data to be Collected

For each monitoring location that is maintained by the Walnut Creek WMA and its membership and partners, data should be collected on at least these key chemical or environmental parameters:

- Air temperature
- pH
- Dissolved Oxygen
- Water Temperature
- Level of Flow
- Recent precipitation (from NWS records)
- Nitrate
- Phosphate
- E. coli (lab)
- Transparency, Turbidity or TSS
- Nitrite
- Chloride
- Conductance (lab)

At least once annually, at each location collect information on the following physical site characteristics:

- Stream width (at toe and top of bank)
- Local biological assessment
- Local stream stability
- Stream depth (from baseflow)

Recommended Implementation Strategies

Strategy #1—*Coordinate and Build upon Existing Monitoring Efforts*

- There are several ongoing programs that are collecting water quality information within the Walnut Creek watershed. The purpose of this plan is to support these efforts, rather than supplanting or competing with them.
- Iowa Soybean Association / Agriculture's Clean Water Alliance
  These organizations continue to collect data at two separate locations along the main channel of Walnut Creek. Their data collection has occurred every other week, typically from April through late August or early September. We would recommend that they expand upon this work, to include year round sampling. Late season spikes in nutrient levels have been reported at the Des Moines Water Works intake site on the Raccoon River. Such a spike has also been observed at some IOWATER testing sites within the Walnut Creek watershed. Year round testing could determine if such a spike commonly occurs within this watershed and could provide a more accurate measurement of annual loadings of the pollutants of concern.
- Polk County Conservation
  This organization has just initiated a program to monitor select sites within the Fourmile, Beaver and Walnut Creek watersheds inside Polk County. They have selected four collection sites within the watershed (three on Walnut Creek and one on North Walnut Creek). They plan to collect data during the first and third calendar weeks of each month, on a given day between the hours of 10am and 2pm. During each sample they will assess chemical and physical conditions.
  IOWATER test kits will be used to evaluate the following parameters:
    - Transparency
    - pH
    - Dissolved Oxygen
    - Nitrate
    - Nitrite
    - Phosphate
    - Chloride
- *IOWATER volunteer monitoring*
  Volunteer monitoring data has been recorded from a total of 32 sites throughout the Walnut Creek watershed since 2004. Of these sites, data has been actively collected at 22 sites since 2012. At these ten sites, data has been collected twice each year (in May and October). Data has been collected both through the use of IOWATER test kits and by collection of samples for lab testing (lab testing completed at 10 of these sites since 2012). It is recommended that these volunteer efforts be continued and coordinated, so that data for the key parameters (noted under the heading "Data to be Collected" above) is collected at each site, either through IOWATER test kits or lab testing.

Recommended Real-Time Monitoring Station Locations		
Station #	Microwatershed Section-Township-Range Jurisdiction	Location Description
1	101.01 13-78-25 Des Moines	Downstream of railroad bridge, accessible by trail. Just upstream of mouth of Walnut Creek.
2	213.01 31-79-25 Clive	Just upstream of mouth of South Walnut Creek, accessible by trail. (Urban case study subwatershed monitoring station)
3	411.01 3-79-26 Dallas County	Upstream side of crossing at W Avenue along tributary to Walnut Creek. (Rural case study subwatershed monitoring station)
4	601.01 24-79-26 Urbandale	Upstream side of trail bridge, just upstream of mouth of Little Walnut Creek. (Developing case study subwatershed monitoring station)
5	501.01 3-78-25 Clive	Upstream side of trail bridge, just upstream of mouth of North Walnut Creek.
6	201.01 3-78-25 Clive	Station on Walnut Creek, just west of trail bridge over North Walnut Creek. Location nearby priority station 5.
7	301.02 11-79-26 Urbandale	Upstream side of bridge at 260th Street along Walnut Creek. (Monitor near current interface between rural and urban areas, downstream of where the three major headwater tributary streams converge)

Strategy #2—*Establish a Network of Real-Time Monitoring Stations within the Watershed*

This plan has noted how different pollutants originate from different sources. Some of these sources are less frequently occurring and some are larger sources during storm events. There are some questions that cannot be answered without constant collection of data. Real time data collection allows more rarely occurring sources of pollution to be identified (a one-time fertilizer application prior to a storm event, for example).

Ongoing data collection also makes it possible to understand how pollutant concentrations and loads are changing through the entire duration of a storm event. Higher concentrations are often observed during the "first flush" of storm events. It is challenging to grab samples during this period, as it would require collection of samples on random dates as rainfall occurs, samples would need to be collected within a short window after rainfall begins (often while it is still raining) and high flows could create dangerous conditions for sample collection.

For these reasons, a network of real-time monitoring stations is recommended as a key part of implementation of water quality improvements. As such stations come at an expense to install and maintain, this plan must be selective in the recommended initial locations for these stations. Over time, additional stations may be added to the network as dictated by the location of proposed improvements, changes in land use and available funding.

It is recommended that the initial network consist of seven stations located throughout the watershed. These locations have been selected to (1) help better define overall watershed pollutant loading rates, (2) differentiate pollutant concentrations and loadings within Walnut Creek and its principal tributaries, and (3) evaluate changes in conditions over time near the outlets of the case-study subwatershed areas.

The approximate cost for each station is expected to be $25,000 for the initial purchase of equipment and installation and average costs of $8,000 per year for ongoing operation and maintenance.

Strategy #3—*Establish Grab Sample Monitoring at Key Locations within the Case Study Subwatersheds*

To determine the effects of water quality improvements within each case study area, a more frequent and distributed pattern of monitoring is required. Monitoring sites should be located so that changes in outcomes over time can be evaluated. These sites should be established as soon as possible, so that a time record of water quality conditions prior to any improvements can be established. Over time, this monitoring should determine if measurable changes in water quality parameters can be observed. Trends in data can be reviewed to determine if the proposed implementation program is working as expected or if the plan needs to be reviewed and amended to improve results.

It is recommended that sampling be conducted using a similar collection schedule as that which has been developed by Polk County Conservation (year round, 1st and 3rd week of each month, collection between 10am and 2pm). This will improve the quality of collected data by collecting it under more uniform conditions. IOWATER test kits could be used for an initial site screening, however it is recommended that samples be collected during each site visit for lab analysis of key pollutants and lab analysis will be necessary to evaluate levels of indicator bacteria present.

Recommended Grab Sample Monitoring Sites in the Developing Case Study Subwatershed (601)

Station #	Microwatershed / Section-Township-Range / Jurisdiction	Location Description
D1	601.02 23-79-26 Urbandale	Upstream of crossing at NW 156th Street along Little Walnut Creek.
D2	601.02 22-79-26 Clive	Upstream of crossing of NW 170th Street (Alice's Road) along Little Walnut Creek.
D3	601.03 21-79-26 Waukee	Upstream of crossing of Warrior Lane along Little Walnut Creek.

* As development occurs, it is recommend to establish a sampling site at the inflow and outfall of each constructed detention facility.

Quality Control for Data Collection, Recording

The broad number of sites will likely require more than one person or party to complete the recommended sampling. Data needs to be collected in a consistent manner, to prevent results being influenced by how samples are collected or test kit results are interpreted at each site. The collected data needs to be collected and frequently uploaded into a database that is accessible to interested parties. For these reasons, the following methods are recommended by this plan:

1. Create a **Quality Assurance Project Plan** (QAPP) for all water quality monitoring activities. This document should be reviewed and approved by the Iowa Department of Natural Resources.
2. Maintain at least two databases of collected water quality data. Each database should be kept current with recorded results.
3. Collaborate with the ISA/ACWA, Polk County Conservation and IOWATER at the end of each quarter year, to share all collected water quality data within the Walnut Creek watershed.
4. Pursue means to use online resources to make collected water quality data available for public review.

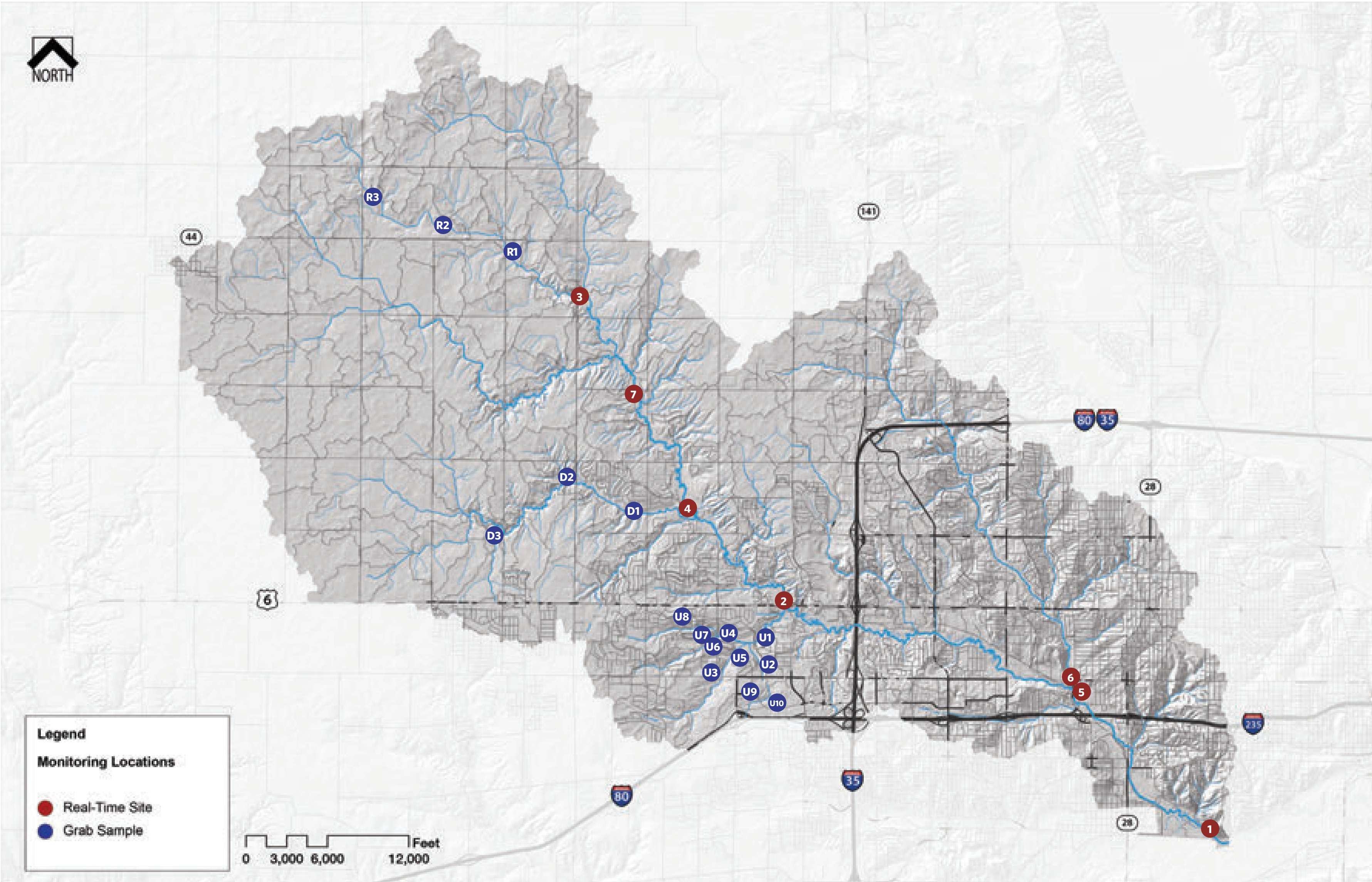
Reporting Progress toward Water Quality Standards

An annual monitoring report should be prepared and presented to the Walnut Creek WMA board, then made available for public review. The report should include the following information:

1. An overall map of the watershed showing monitoring locations, including those maintained by the Walnut Creek WMA (and its membership), ISA/ACWA, Polk County Conservation and IOWATER.
2. The average, maximum and minimum levels of each parameter at each monitoring location for the given year. Note the date when maximum and minimum levels were observed.
3. For each parameter, review changes in levels for each parameter on a month by month basis throughout the given calendar year.
4. Review data related to items #2 and #3 above for prior years, and provide a cumulative analysis for each that includes data collected for all calendar years to date.
5. Provide a brief review data from items #2-#4 above and determine if trends support that appropriate progress is being made toward the loading reduction goals at the end of Chapter 6 of this plan.

Recommended Grab Sample Monitoring Sites in the Rural Case Study Subwatershed (411)		
Station #	**Microwatershed** **Section-Township-Range** **Jurisdiction**	**Location Description**
R1	411.03 4-79-26 Dallas County	Upstream side of crossing at V Avenue, approximately 600 feet south of Highway 44.
R2	411.05 32-80-26 Dallas County	Upstream side of private farm crossing (north projection of U Avenue), approximately 1,100 feet north of Highway 44.
R3	411.05 32-80-26 Dallas County	Tile drainage outlet on east side of T Avenue, approximately 3,900 feet north of Highway 44.

Recommended Grab Sample Monitoring Sites in the Urban Case Study Subwatershed (213)		
Station #	**Microwatershed** **Section-Township-Range** **Jurisdiction**	**Location Description**
U1	213.01 31-79-25 Clive	Downstream of spillway from Country Club Lake, accessible by trail.
U2	213.02 31-79-25 Clive	Storm sewer outlets from University Avenue to east branch of Country Club Lake. Site is located approximately 300 feet west of Country Club Boulevard.
U3	213.02 31-79-25 Clive	Storm sewer outlets from University Avenue to central branch of Country Club Lake. Site is located approximately 400 feet east of NW 142nd Street.
U4	213.02 31-79-25 Clive	Box culvert outlet from NW 142nd Street to west branch of Country Club Lake. Site is located approximately 300 feet north of South Shore Drive.
U5	213.02 31-79-25 Clive	Box culvert outlet from Lake Point Drive into main body of Country Club Lake.
U6	213.31 36-79-26 Clive	Sample from tributary, draining from the west from Brentwood Drive. Sample to be collected just upstream of the confluence of this tributary with one that drains from the north from Lakeview Drive. This site is located just across NW 142nd Street from Urban Case Study Sampling Site #4.
U7	213.21 36-79-26 Clive	Sample from tributary, draining from the north from Lakeview Drive. Sample to be collected just upstream of the confluence of this tributary with one that drains from the west from Brentwood Drive. This is very close to Urban Site #7
U8	213.22 36-79-26 Clive	Storm outlet from NW 149th Street, approximately 150 feet north of Woodcrest Drive.
U9	213.41 1-78-26 West Des Moines	Storm sewer outlets from pond outlet structure at West Lakes Office Park Plat 3, Outlot Z. Site is located along the north side of Westown Parkway, approximately 400 feet northwest of Lake Drive.
U10	213.41 1-78-26 West Des Moines	Sample at outlet structure from pond at 6400 Westown Parkway. Take sample from flow entering outlet structure.



Monitoring Site Locations

Milestones—Criteria for Measuring Success

At the end of each year, progress towards meeting the goals of this plan need to be evaluated. These key milestones represent ways to measure if implementation of this plan is on schedule and that the expected results are being observed.

1. Document when communities adopt and begin enforcement of the various recommended policies.
    - Goal: A review of ordinances and adoption of recommended amendments or new ordinances by the dates listed earlier in this chapter (staggered adoption in 2016 and 2017).
    - If not achieved by the desired dates, what are the obstacles to adoption?
2. Document improved compliance with erosion and sediment control recommendations through photographs, reductions in enforcement actions or other annual reports. The report should provide the following information:
    - Are the concerns listed in Chapter 9 being addressed?
    - What are some areas that remain in need of improvement?
    - Coordinate with IDNR Field Office #5 to determine what are the most common local violations to address related to construction site pollution prevention. Ask field office staff the following questions:
        - In their view, have conditions throughout the watershed improved?
        - How many notices of violation were issued within the watershed during the past year?
3. Document when the recommended improvements are completed. Document any modifications to the implementation plan or additional practices which are constructed.
    - Review the schedule within this chapter and verify that this plan is on schedule.
    - If implementation is not on schedule, remark on expected changes to complete the overall project list by 2025.
    - Are there new challenges that have been identified that impede full completion of this list?
4. For the rural case study watershed, validate that desired pollutant loading reductions are being achieved by observing average annual (and seasonal) concentration reductions of 41% for nitrate + nitrite, 29% for phosphorus and 29% for TSS by the end of 2025.
5. For the urban case study watershed, validate that desired pollutant loading reductions are being achieved by observing average annual (and seasonal) concentration reductions of 2% for nitrate + nitrite, 17% for phosphorus and 43% for TSS by the end of 2025.
6. For the developing case study watershed, document the number and size of each management facility constructed in urbanizing areas. Validate that each basin is designed and constructed to meet ISWMM's Unified Sizing Criteria.

CHAPTER 13

KEY CONCEPTS

1. Financial Resources

Significant funds will be required to implement the first ten years of this effort. This chapter outlines the costs associated with this plan.

2. Staffing

Personnel will be required in order to coordinate ongoing projects, review ongoing monitoring, prepare or support grant applications and monitor overall execution of the plan.

3. Improvements

Total costs related to projects listed in Chapter 10 are summarized in this chapter.

4. Monitoring

The monitoring program outlined in Chapter 12 will require resources to install and maintain the system. Additional time will be required to complete grab sample monitoring, pay for lab testing and staff or consultant time to compile and analyze results.

5. Maintenance

Any physical improvement requires maintenance. But maintenance often fails to be completed if it is not properly accounted for in the budgeting process. It is important that local jurisdictions consider including such costs in their ongoing budgets.

6. Sources of financial support

A variety of grant sources are available at multiple scales of government as well as through not-for-profits and other private concerns. A general consensus across Iowa remains, however, that expanded resources will be needed to effectively address water quality and flood mitigation in this watershed and in most watersheds in the state.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

This plan will fail to be completed if appropriate funds are not set aside for implementation, or if qualified, motivated personnel are not used to coordinate efforts, evaluate progress and advise when amendments to the plan are necessary.

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Resource Requirements

Costs

Financial support will be key to successful implementation of this plan. Staff support activities, construction of improvements, monitoring water quality and maintenance activities cannot be completed without dedicated funding.

Staffing

Staff time will be required to monitor execution of the plan, review monitoring data, coordinate or complete grant applications, work with consultants and report results to the Walnut Creek WMA board and public. This can be achieved by using existing staff time from the various member communities or hiring a project coordinator (or additional staff) to be dedicated to directing execution of this plan on behalf of the WMA.

At the time of this writing, area WMAs intend to collaborate in securing support through Polk SWCD through a dedicated coordinator. This coordinator should fulfill at least the following duties:

Administrative

- Coordinate meetings, perform administrative duties, provide leadership and support

Monitoring

- Oversee the monitoring program and support collecting results
- Report and share data with other groups conducting monitoring within this watershed

Education and Outreach

- Provide resources and technical assistance to stakeholders
- Work with rural landowners and producers to identify candidate locations for practices and implement them
- Communicate with city and county officials regarding completion of watershed goals and objectives

Implementation

- Assist or coordinate during the design, layout and construction oversight of practices

Ordinance Changes

- Review draft ordinance changes prepared by local communities or regional entities to develop more consistent language across multiple jurisdictions
- Support ordinance adoption

Funding acquisition

- Pursue funding opportunities to execute this plan as well as other practices as deemed beneficial

Report Progress

- Prepare annual reports on plan achievements, ordinance adoption and monitoring results
- Make recommendations on any required changes based on available data

The initial cost of this coordinator position is expected to be $145,000/year. The cost for these services may be shared with other local WMAs.

Improvements

This plan has detailed dozens of priority projects within the watershed that are intended to achieve a set of short-term water quality goals. The table on the next page provides a summary of the overall infrastructure investments that have been recommended by this plan. For more specific information regarding these projects, refer to Chapter 10 of this plan.

Monitoring

Water quality monitoring will require resources to apply for grants and financial support, install monitoring stations, compensate for staff time and resources to collect samples and record results and pay for laboratory testing.

Maintenance

Several types of maintenance activities will be required to execute this plan and keep constructed improvements in good working order. Forested areas within stream buffers may need selective clearing of underbrush and invasive species to encourage establishment of more erosion resistant surface vegetation. Where new areas of native vegetation are established, short-term maintenance activities may include minor erosion repair and re-seeding, spot spraying of weeds. Long-term maintenance includes re-seeding, mowing and controlled burns. Streambank stabilization projects may require some repairs after major flood events. Other stormwater best management practices require removal of collected sediments, other debris and repairs to keep them operating as intended. These needed maintenance activities will likely not occur, if its cost is not identified and included in local budgets.

Category	Projected Cost (2016)
Rural Case Study Subwatershed	$2,595,000
Urban Case Study Subwatershed	$5,775,000
Developing Case Study Subwatershed	$3,250,000
Other Watershed Level Projects	$15,555,000
Current Capital Improvements Projects	$2,485,000

Year	Real-time Monitoring	Grab Sample Monitoring
2016	$ 5,000	$15,000
2017	$ 125,000	$15,000
2018	$ 90,000	$15,000
2019	$ 56,000	$15,000
2020	$ 56,000	$15,000
2021	$ 56,000	$15,000
2022	$ 56,000	$15,000
2023	$ 56,000	$15,000
2024	$ 56,000	$15,000
2025	$ 56,000	$15,000

Expected Cost of Maintenance (Urban Areas)	
Practice	Cost (in 2015 $)
Selective Clearing	$14,000 / acre
Re-seeding (native vegetation)	$6,000 / acre
Controlled Burns	$1,500-$2,000 / each
Repairs (restored streambank areas)	$12,000 / year / restored stream mile
Debris Removal	$10,000 / year / stream mile

Local Jurisdictions and Staff

To successfully implement this plan, city and county staff will need to cooperate. Key staff will need to review local ordinances and policies to identify current procedures that are in conflict with the recommendations of this plan. These staff should work with the project coordinator to draft language for ordinances and policy changes. They will also need to identify the financial needs expected for their jurisdiction based on this plan and determine how each area will be funded (capital improvement program, storm water utility, grant, etc.).

Any staff responsible for the review of storm water management plans and calculations should become familiar with the design and calculation methods set forth in the Iowa Stormwater Management Manual. The Iowa Stormwater Education Partnership has also developed other tools such as model ordinances and checklists which may be helpful to review staff when implementing the changes recommended in this plan.

Citizens and Businesses

Private organizations and individual citizens can make a difference. It is most effective to address stormwater as close to its sources as possible. Private homeowners can install rain barrels, rain gardens and direct downspouts away from driveways and other paved areas. Local businesses and agencies can use stormwater retrofits to address the quality and quantity of stormwater runoff from their properties. Refer to Chapter 11 for more information on how to engage these groups through educational efforts.

Sources of Financial Support

Stormwater Utility Funds

Many communities have established these funds. They collect fees from "users" of the utility (any property which generates runoff) which are usually added to City water bills. The fees are usually related to the amount of impervious area on a given property. These are funds which can be directly collected by the individual communities, but must be used to fund stormwater-related items.

Grant Opportunities

Sponsored Projects Program via State Revolving Fund

Municipalities that borrow funds to complete sanitary collection or treatment projects can piggyback a stormwater project through the Sponsored Projects Program. The state adjusts the interest rate on the project loan, allowing an extra 10% to be borrowed, but the repayment amount remains the same. Essentially, for every $1 million spent on a sanitary project, $100,000 can be borrowed toward construction of a stormwater quality project, at no additional cost to the municipality receiving the loan.

IDALS Urban Water Quality Initiative (WQI)

A program which takes annual requests to fund water quality improvement projects, with a maximum grant amount of $100,000.

Watershed Improvement Review Board

This program used to be a significant source of funding for stormwater improvement projects in both rural and urban areas. Projects were eligible for grants up to $500,000. However, in recent years the program has not been adequately funded at the State level. Watershed Management Authorities could work together to lobby for restored funding for this important program.

Polk County SWCD REAP funding for urban stormwater practices

Small amounts of funding ($10,000 / year) are available for small-scale stormwater (rainscaping) practices on private lands.

Environmental Quality Incentives Program (EQIP)

Funding from this program is available from county SWCD offices through IDALS and NRCS for conservation practices on private agricultural lands.

Resource Enhancement and Protection (REAP)

State of Iowa investments in the enhancement and protection of the state's natural and cultural resources. Funding is allocated to a variety of programs which may relate to projects included within this plan:

- City Parks and Open Space
- County Conservation
- Private / Public Open Space Acquisition
- Conservation Education
- Roadside Vegetation
- Soil and Water Enhancement

CHAPTER 14

KEY CONCEPTS

1. **Continued WMA Structure**
   This chapter offers recommendations on how the WMA should continue to operate and coordinate with other Central Iowa WMAs.

2. **Evaluation Framework**
   This plan needs to be evaluated at least annually, with more in-depth evaluations after year five.

3. **Amendment Timeline**
   After a ten-year period, the entire plan should be re-evaluated with the goal a developing a new ten-year implementation strategy.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

This plan needs to be a “living document,” which may need to be changed based on what is learned through annual reports as well as the financial, technical and staffing resources that are available to carry out this plan. Effective collaboration and communication between the various jurisdictions within this watershed will be vital to successful implementation of this plan.

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Evaluation and Amendments

Continued WMA Structure

The Walnut Creek WMA currently coordinates through an executive committee panel and a larger board with representatives from all the jurisdictions located within the Walnut Creek watershed. Other stakeholders and consultants frequently attend the WMA board meetings. It is recommended that both the executive committee and board continue to meet on at least a quarterly basis, to discuss plan progress and to coordinate implementation of the plan. Should a project coordinator be designated (refer to Chapter 13), this person would help to schedule meetings, develop agendas and minutes and prepare information for review by the board and committee.

Evaluation Framework

Implementing a ten-year plan requires regular review periods to determine if implementation is following the schedule set forth. It is also critical to review monitoring and other forms of measurement to ensure that the plan is achieving the desired results. By the end of June 2017, a status report should be prepared by the project coordinator (or other party designated by the board). This report should be repeated annually and contain the following information:

- Document which communities have enacted new ordinances related to the recommendations listed in Chapter 9.
- Include a brief update from each community related to erosion and sediment control enforcement and compliance.
- Itemize completed improvement projects related to water quality within each community.
- Summarize of monitoring results, including average, minimum and maximum pollutant concentrations and comparison of those values to those observed during Year 1 of the monitoring program.
- Detail progress on rural plan implementation including an update on the rural case study area and other conservation or storm water management practices applied throughout the watershed.

After Year 5 of monitoring, the annual report should include a more detailed review of monitoring results and determine if progress towards water quality goals (pollutant concentration reduction) is on pace, based on the level of improvements that have been implemented. If it is not, the implementation plan should be reviewed and adjustments considered, informed by local observations and updated study related to management practices.

Process / Timeline to Amend the Plan

This study has detailed how rapidly conditions within this watershed are changing. Based on past growth rates, it could be expected that within the next ten years an additional six to eight square miles of the watershed may be developed. At that point, urban development may cover between 50 and 55% of the overall land area. Over a similar period of time, it would be expected that stream conditions may be much different and the need for improvements could shift.

Over a decade, the other improvements within the case study areas and throughout the watershed should be implemented. Following Year 10 of the monitoring program, it is recommended to review and update many of the findings within this plan, and develop a new implementation and monitoring plan from those findings. New strategies should extend the plan for an additional 10 years.

CHAPTER 15

KEY CONCEPTS

1. **Rural Best Management Practices (BMPs)**
   Various practices to reduce runoff and pollution from rural landscapes are generally described in this chapter. A brief description of the practice is provided as well as a source for additional information.

2. **Urban Best Management Practices**
   Various practices to manage stormwater from developing and redeveloping urban areas are generally described in this chapter. Each practice listed is briefly described and includes a source for additional information.

HOW DO THESE CONCEPTS INFLUENCE DEVELOPMENT OF THE PLAN?

Land owners, farmers, suppliers, planners, designers and policy-makers need to understand the types of “tools” there are in the “toolbox” to address the water quality issues identified in this plan. Many people may not be familiar with these practices. This chapter is not intended to be a detailed design guide for such practices. It is intended as a resource to help people understand what each practice is, what it is intended to do, where they are most likely to be located and where to go for additional information.

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BMP Tool Kit

Rural Best Management Practices *		
	Practice	**Description**
Nitrogen Management Practices		
N	**Timing**	There are estimates that indicate over 3 million acres of cropland in Iowa have fertilizer applied in the fall. Research indicates that there could be an average reduction in nitrate-N concentrations in tile drainage water of 6% by moving fall applications of nitrogen fertilizer to spring, assuming the same application rate is used. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 4 and 24-25*
N	**Sidedress**	There are different techniques to apply fertilizer after corn emergence. The practice applies nitrogen during plant uptake, timing applications to reduce the risk of nutrient loss due to early spring rainfall / leaching events. Research indicates that there could be an average reduction in nitrate-N concentrations in tile drainage water of 5% by moving fall applications to spring/split-applications and 4-7% reduction with sidedress compared to spring pre-plant; considering the same application rate is used. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 4-5 and 28*
N	**Source**	Research indicates that a 4% reduction in nitrate-N concentrations may be expected when substituting liquid swine manure to fertilizer nitrogen, considering the same crop available application rate. Some manure sources high in solids content may also have a positive impact on soil organic carbon, soil structure and runoff. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 5*
N	**Application Rate**	Nitrogen rate varies based on a variety of factors including crop rotations and prices. The rate of application does have a predictable impact on nitrate-N concentrations leaving the root zone and entering tile flow. The online Corn Nitrogen Rate Calculator (Iowa State University Agronomy Extension) can be used to determine the Maximum Return to Nitrogen (MRTN) for corn or corn rotated with soybean acres. This practice involves reducing application rates to these values. The estimated load reductions from this practice range from 4-15%, depending on the MRTN value selected. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 5 and 27. and the Corn Nitrogen Rate Calculator—Iowa State University Agronomy Extension website*
N	**Nitrification Inhibitor**	Inhibitors slow the rate which microbes convert ammonium-nitrogen into nitrates. This allows more ammonium to remain present for crop use. This practice specifically uses Nitrapyrin applied with fall anhydrous ammonia, when soil temperatures were 50˚F and cooling. An average nitrate-N loading reduction of 9% is expected from this practice, with average crop yield increases of 6% currently observed in Iowa. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 5 and 28-30*

** Information adapted from the 2013 version of Iowa's Nutrient Reduction Strategy or other sources listed.*

N Nitrogen-Targeted Practice
P Phosphorus-Targeted Practice
NP Nitrogen- and Phosphorus-Targeted Practice

Fertilizer Application

Source: USDA

Phosphorus Management Practices		
P	**Soil Test P Level**	A large portion of phosphorus loss is associated with erosion, as phosphorus often binds to soil particles or becomes dissolved in surface runoff with suspended sediments. Phosphorus loss can be reduced by decreasing total soil P concentrations by limiting or stopping applications to soils when testing shows that the soil test levels are lowered to optimum conditions. This practice does not reduce erosion directly, but reduces the P loading that is within the eroded soil. On average, a 17% reduction in loading would be expected where this practice is implemented. *More info: Iowa Nutrient Reduction Strategy, Section 2.3—page 5 and 21-22*
P	**Source**	Research has provided little evidence of short-term reductions in P loading related to changing the source of this nutrient. However, long-term reductions have been observed when using manure (when compared to commercial fertilizers) by increasing soil organic carbon and improving soil structure. In addition, significantly less P loss has been observed on fields where beef or poultry manure was used as a source when runoff producing rainfall events occur immediately after P application. Research has indicated that long-term average loading reductions of 46% may be expected where manure is used in place of inorganic fertilizer sources. *More info: Iowa Nutrient Reduction Strategy, Section 2.3—page 6*
P	**Placement**	Subsurface banding of phosphorus or incorporation of surface-applied fertilizer or manure on sloping ground reduces P loss (when compared with traditional surface application) when runoff producing events occur within a few weeks of the application. Average loading reductions are expected to range between 24-36%, depending on the placement method used. *More info: Iowa Nutrient Reduction Strategy, Section 2.3—page 6 and 24-25*

Source: USDA

Land Use		
NP	**Cover Crops**	The intent of this practice is to reduce soil erosion and limit leaching of nitrate-N from the system. They can be seeded in the fall by a variety of methods. Research indicates that an average loading reduction of 31% of nitrate-N and 29% of P would be expected with use of a winter rye cover crop. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 6 and 30-32 and Section 2.3—page 6 and 27-29*
N	**Living Mulches**	These are permanent land cover that are grown within a primary row crop. This practice may have a steeper learning curve and can require a year or two to establish the living mulch before the desired row crop can be planted. However, the potential nitrate reduction is expected to be 41%. Reduced soil erosion and enhanced soil structure are other benefits of this practice. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 6*
NP	**Perennial (Energy) Crops**	These crops are grown for the use of biomass as fuel. As of 2014, there were few markets for these products. If these markets develop, the potential for nutrient reduction is high, with 72% N loading and 34% P loading reductions expected where row crop acres are converted to this practice. Increased habitat, reduced soil erosion and enhanced soil structure are expected additional benefits. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 6 and 37-38 and Section 2.3—page 7 and 30-31*

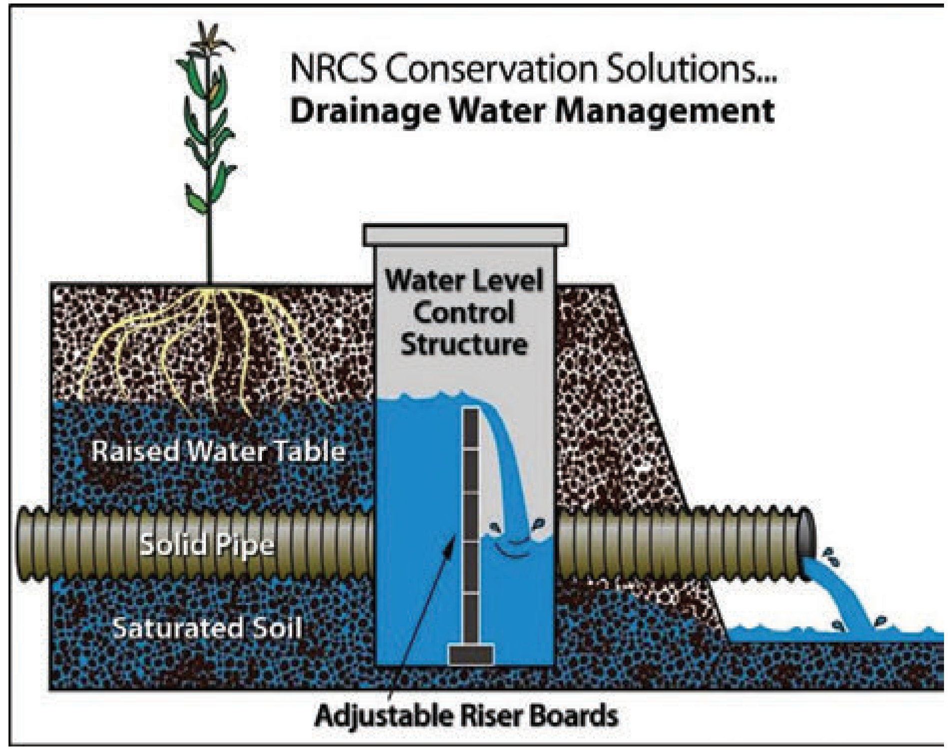
Source: USDA

NP	**Perennial Cover (CRP)**	The Conservation Reserve Program has already been used by many landowners to set aside land for long periods of time (10-15 years) into conservation plots similar to native prairie landscapes. Improved habitat and soil structure are expected in these areas. Research has indicated that an average reduction of 85% of nitrate and 75% of phosphorus loading is expected where row crop production is converted to CRP. Similar reductions are expected where permanent conservation easements are established as an alternative to CRP. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 7 and 36-37 and Section 2.3—page 7 and 31-33*
NP	**Extended Rotations**	This practice includes a primary row crop being rotated with at least two years of a forage legume crop such as alfalfa. Within the Nutrient Reduction Strategy, a corn-soybean-alfalfa-alfalfa rotation was assumed. Due to nitrogen fixing, very little if any nitrogen would typically need to be applied during the corn rotation. Improvements in soil structure and organic matter are expected benefits of this practice. This practice reduces P losses by reducing the potential for erosion of soils. Research indicates that an average nitrate loading reduction of 42% is expected in tile drainage water, with annual corn yields improved by 10%. Although significant phosphorus loading reductions are anticipated to be caused by this practice, there is little data available to evaluate what the specific load reductions would be. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 7 and 39-40 and Section 2.3—page 7 and 33-34*
NP	**Grazed Pastures**	No pertinent data is available for nitrogen leaching from pastureland systems in Iowa. Within the Nutrient Reduction Strategy, these systems are assumed to perform similar to the perennial crop (CRP) practice. Phosphorus loading reductions from this practice are expected to be 59% on average where row crop systems are converted to grazed pastures (assuming that the conversion is done in a way that provides no new direct animal access to streams). *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 7 and 36-37 and Section 2.3—page 7*
P	**Tillage**	Reduced tillage increases the ground cover provided by crop residue and exposes less soil to erosion. Research shows that both conservation tillage and no-till have substantial ability to reduce phosphorus losses, with expected average reductions ranging from 33-90% depending on which method is used. *More info: Iowa Nutrient Reduction Strategy, Section 2.3—page 6 and 26*

Source: USDA

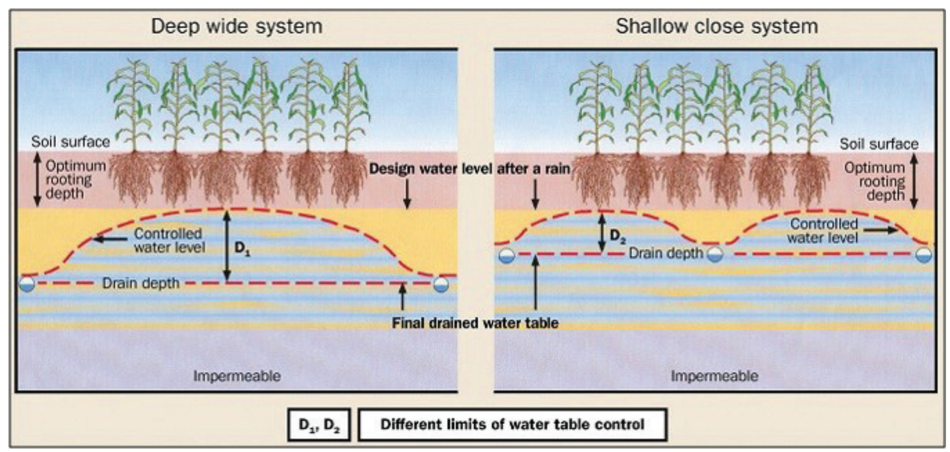
Source: USDA

Edge of Field		
P	**Drainage Water Mgmt.**	This practice involves installing control structures near tile outlets that allow the water table in a field to be raised or lowered. These systems reduce nitrate loadings by reducing the volume of tile drainage water by an average of 33%. Water is usually released before planting and harvest to allow for equipment traffic within the field. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 7 and 34-35*
P	**Shallow Drainage**	Tile drains can be installed more shallow (2.5 feet) and at closer spacing than traditional tile systems. Research has shown that tile drainage water volume is reduced by an average of 32%, which reduces nitrate loadings. This practice is most applicable where new tile drainage systems are being proposed or old systems need to be replaced. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 7 and 34-35*
NP	**Water Quality Wetlands**	The Conservation Reserve Enhancement Program (CREP) is the primary nitrate reduction wetland program in Iowa. These practices are designed to be installed where they can receive nitrates and they've been shown to reduce nitrate concentrations by 52% on average. Additional load reductions can be observed due to cropland being taken out of production. Wetlands can also help to trap sediments, reduce phosphorus loading and provide valuable habitat. The Nutrient Reduction Strategy does not project the expected phosphorus loading reduction due to wetlands. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 7-8 and 32 and Section 2.3—page 7*



Drainage Water Management System

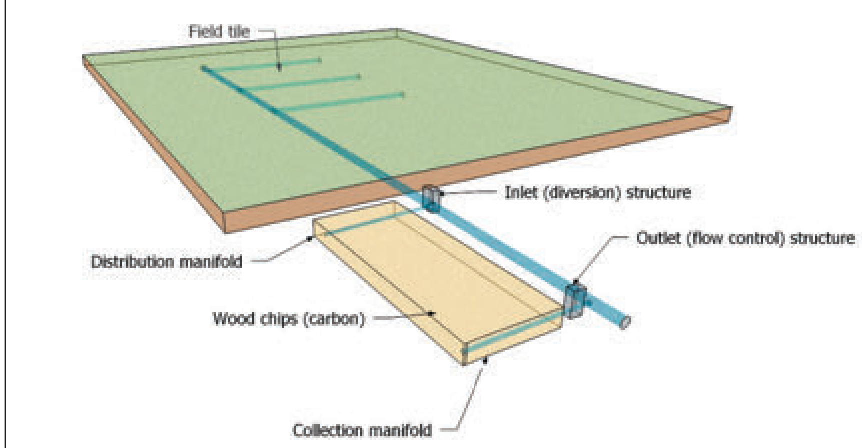
Source: USDA-NRCS



Shallow Drainage

Source: Ontario Ministry of Agriculture, Food and Rural Affairs

N	**Bioreactors**	These are excavated pits, filled with woodchips. Control structures are placed on tile drainage lines to divert water into these systems. These control structures allow larger flows to bypass the system and flow directly to the stream. Bacteria growing within the woodchip media convert nitrate into nitrogen gas. These practices can treat tile systems which receive runoff from up to 100 acres of land. Research indicates that these systems can reduce nitrate loading by 43%. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 8 and 33*
NP	**Buffers**	Located along streams, buffers offer the opportunity to remove nitrates in water flowing across the buffer or through its root zone. They also provide habitat, reduce sediment transport and help to stabilize streambanks. Their benefits for nitrate removal may be limited where drainage is diverted around or under the buffer by tile drainage. However, the nitrate concentrations in water contacting the root zone in the buffer is expected to be reduced by 91%. Nitrate removals have been shown to be high for a variety of buffer conditions. Average phosphorus reductions of 58% are expected from the area tributary to the buffer. *More info: Iowa Nutrient Reduction Strategy, Section 2.2—page 8 and 34 and Section 2.3,—page 8 and 29-30*
NP	**Saturated Buffers**	Tiles running toward a stream are intercepted into tiles running parallel to a stream and diverted to a control structure. This forces tile water to percolate through the soils under a buffer where it can be used by the roots of the native plants planted above.



Bioreactors

Source: Iowa Soybean Association

Buffers

Source: Minnesota Department of Agriculture

P	**Terraces**	Terraces have been used for many years as a method to prevent gully erosion within fields with steeper grades. They level steeper fields out using a set of stepped plateaus and/or dams. Runoff is captured at each level and drained through a system of subsurface tiles. As this is a well-established practice, little additional information is included in the Nutrient Reduction Strategy. Where applied, average phosphorus reductions of 77% are expected from the area served.
P	**Sediment Basins**	Basins can be constructed to capture sediment from fields prior to its entry into a stream or wetland. Where applied, average phosphorus loading reductions of 85% are expected from the area tributary to the practice. These basins could provide additional flood reduction and water quality benefits by being constructed with multi-stage outlets to provide extended detention of small storm events by slowly releasing runoff from a 1-year return period storm (2.67" in 24-hours) over a period of one to two days. *More info: Iowa Nutrient Reduction Strategy, Section 2.3,—page 7*

Source: USDA

Source: USDA

Other Practices		
NP	**Grass Waterways**	These are common practices used to prevent erosion through fields along paths of concentrated surface flow. The drainage path is shaped into a trapezoidal, triangular or parabolic cross-section and stabilized with perennial vegetation. Deeper rooted, native plants may be a good choice for vegetation of these areas, as their deeper root structures are more resistant to erosion and enhance the ability of the soil to absorb surface runoff. These structures do require maintenance, as sediment often builds up near the edges of the waterway, which may block runoff from entering the practice, leading to erosion as runoff follows a path parallel to the waterway. *More info: Part 650, Engineering Field Handbook—Chapter 7 (USDA / NRCS)*
NP	**Two-Stage Ditches**	Recently these practices have been implemented across several Midwestern states. They are most commonly used where an existing ditch is widened to include two bottom stages: (1) a narrow lower channel to convey baseflow and (2) a wider secondary flood-plain bench. This system offers many benefits over traditional narrow trapezoidal channels. Runoff has more area to spread out leading to slower flows, reducing peak flow rates downstream and less erosive force within the channel. Sediment is transported more effectively, leading to less long-term maintenance. The section also allows for improved habitat, by providing a more natural connection between the stream and the adjacent flood-plain. The flood plain bench also allows for better development of vegetation, leading to improved filtration potential of nutrients. These systems have been shown to reduce nitrogen, phosphorus and sediment loadings by significant amounts in various studies. *More info: Part 654, National Engineering Handbook—Chapter 10 (USDA / NRCS)*
P	**Culvert Modifications**	Entrances to existing culverts can be amended to include multi-stage outlet features. These modifications would allow runoff from small storms (those of a 1-year return period or less) to be captured and slowly released over a period of one to two days. These systems would reduce runoff rates from 98% of the rainfall events in Iowa to more natural rates. Such systems would also reduce flows during larger storms by capturing and holding a significant portion of the runoff volume. This offers multiple benefits including sediment capture and phosphorus load reduction from the served area, downstream flood peak flow reduction and reduced streambank erosion. These systems might be best located where crop losses due to excessive moisture are present, or where there is room for a constructed wetland or sediment basin immediately upstream of the candidate location. A system of these facilities distributed through a subwatershed could make a significant impact in reducing local flood risk by reducing both rates and volumes of flow during all rainfall events.


Grass Waterways

Source: RDG


Two-Stage Ditches

Source: RDG

NP	**Cattle Stream Access**	When cattle, sheep or other farm animals are allowed direct access to streams the direct manure input to the stream can have significant impacts. When given access, animals may spend around 90 minutes each day in the water (about 6% of the time). Direct access often leads to streambank instability and erosion due to overgrazing or soil exposure due to tracking up and down the steep slopes adjacent to the stream. Animal manure contains high levels of nitrogen, phosphorus and pathogens. Where feasible, direct access to the stream should be restricted by fencing or other means and other methods provided to get water from the stream (or other sources) to the animals for drinking. The Water Quality Improvement Plan for the Raccoon River (TMDL) identified this a key practice for both nitrate and bacteria load reductions. (That study did not analyze phosphorus reduction practices).
NP	**Streambank Stabilization**	Eroding streambanks and gullies have been shown to be significant sources of most of the key pollutants identified within this plan. Stabilization methods should be prioritized by the severity of erosion, potential impacts to property and infrastructure and available access to complete and maintain repairs. Stabilization techniques should include comprehensive techniques which use soils, plants and rock structures to secure the toes of slopes along outer bends, deflect the path of low flow toward the center of the stream and make the bank of the stream more resistant to erosion. These "bio-engineering" techniques should be employed in lieu of use of only stone or concrete materials to armor the surface of the streambank. Such traditional methods have been shown to offer more limited benefits and often have remained less stable over time. Widened cross-sections with better connection between the stream and flood plain should be created where feasible. Such sections would reduce flow velocities, lower erosion shear forces and provide for additional flood plain storage.


Cattle Stream Access

Source: USDA

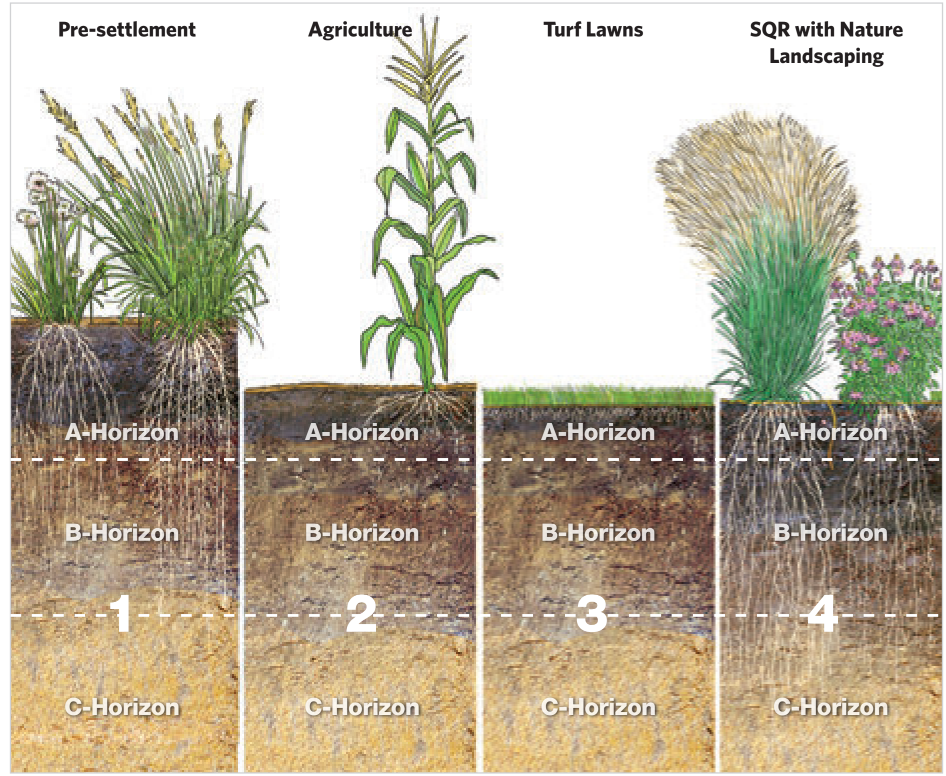

Streambank Stabilization

Source: Greg Pierce

Urban Best Management Practices	
Practice	**Description**
Better Site Design and Source Reduction	Far too often stormwater issues are first addressed late in the site design process, when many site layout decisions have already been made. At this point, there is often limited space to install the most effective management techniques. A better approach is to incorporate stormwater management very early in the planning process. Important features such as wetlands, streams, floodplains and high quality soils can be identified and protected. Alternative site layouts can be reviewed to orient site features in ways that reduce the amount of grading needed and the area to be covered by impervious surfaces (buildings, paving, etc.). Stormwater management features can be designed at multiple locations across sites, attempting to treat runoff as close to the source as possible. Preliminary estimates of required treatment volumes can be used to properly set aside space for the most efficient and cost effective water quality practices. *More info: Iowa Stormwater Management Manual, Section—"Planning and Design Principles"*
Construction Site Pollution Prevention—Erosion Controls	Erosion controls are measures that protect the surface of the soil from the erosive force of raindrops or running water. Mulches, compost blankets, seeding, sodding, rolled erosion control products (RECPs), turf reinforcement mats (TRMs) and flow diversions are all methods to reduce soil erosion. These measures are often overlooked, but it is more effective to prevent erosion than it is to try to trap sediment materials once they have been moved by water or wind. *More info: Iowa SUDAS Design Manual, Chapter—"Erosion and Sediment Control"* *Iowa Construction Site Erosion Control Manual (Iowa Department of Natural Resources)*
Construction Site Pollution Prevention—Sediment Controls	Sediment controls are practices that are intended to keep soil materials from being carried off site by running water or tracked by construction equipment. Stabilized construction entrances, silt fences, filter socks, wattles and sediment basins are examples of practices which serve these functions. Each of these practices have limitations that designers and installers should be familiar with. These practices much be properly located, sized, installed and maintained to work effectively. *More info: Iowa SUDAS Design Manual, Chapter—"Erosion and Sediment Control"* *Iowa Construction Site Erosion Control Manual (Iowa Department of Natural Resources)*
Construction Site Pollution Prevention—Other Features	Other forms of pollution prevention such as trash collection, concrete washout collection and spill prevention are also important to protecting downstream water quality. These features are also required to be identified and included in Storm Water Pollution Prevention Plans. *More info: Iowa SUDAS Design Manual, Chapter—"Erosion and Sediment Control"* *Iowa Construction Site Erosion Control Manual (Iowa Department of Natural Resources)*

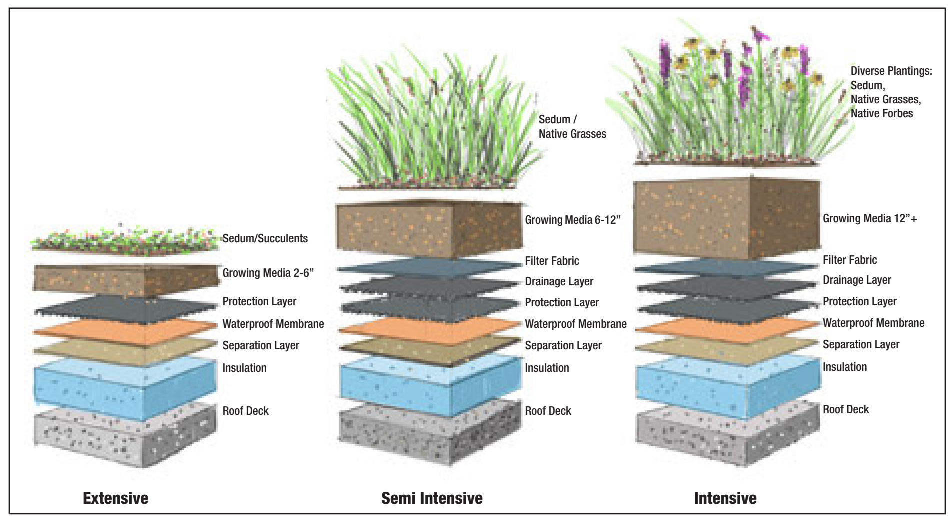
Source: Greg Pierce

Soil Quality Management and Restoration (SQM / SQR)	Preserving and restoring quality topsoil layers is the first line of defense in post-construction stormwater management. Open spaces that have healthy, porous surface are able to absorb and store more water. Organic material within these soils allows desired vegetation to be supported and provides habitat to worms, insects and burrowing animals which further increases soil water retention. Healthy soils are necessary to support desired landscaping and reduce the need for irrigation. A soil management plan (SMP) identifies the methods used at a given site to preserve or restore topsoil layers for open spaces. *More info: Iowa Stormwater Management Manual, Section—"Soil Quality Management and Restoration"*
Pretreatment Practices	Many different management practices can fail when they experience heavy sediment loads. Ponds can silt in, losing their storage volume and affecting fish habitat. Infiltration practices will not work if their surface layers become plugged with deposited sediment. There are several alternatives to intercept heavier sediment loads before they can impact downstream water quality management practices: • Concentrated flows can be directed through grass swales to filter runoff. • Where flow can be spread more evenly, it can be directed through vegetated filter strips. • Sediment forebays are depressions used to trap sediment at pipe outlets, curb cuts or other places where flow is near entry to a practice. These areas usually are a shallow pond or trap that can be cleaned out by a backhoe, skid loader or vacuum system. • Hydrodynamic devices are engineered systems installed underground that intercept runoff from storm sewer networks and divert it through a chamber where water is forced to swirl. This creates a low velocity zone in the center of the structure where sediments and debris can settle out and be removed. • Gravity separators and sumps are engineered systems within storm pipe networks which feature low sections or separator walls which force different pollutants or trash to fall out of suspension. • Catch basin sumps and inserts are methods to screen trash and debris or force sediment to settle in sections of storm sewer intakes that are set below the pipes that they are connected to. If these features are working properly, they will collect sediment and other debris which will need to be removed over time. It is essential that such maintenance is properly scheduled and budgeted for. Failure to do so may lead to more expensive repairs or sediment removal efforts downstream. *More info: Various sections within the Iowa Stormwater Management Manual*
Rainfall Collection and Reuse—Green Roofs	Green roof systems are beginning to be used more frequently in Iowa. They feature vegetation grown in layers of media or soil. Green roofs are an excellent way to address runoff at its source. Buildings featuring green roof systems will have runoff properties that are more similar to open spaces. In addition to addressing water quality, use of these systems can allow downstream water management practices to be downsized (refer to ISWMM for more details). *More info: Iowa Stormwater Management Manual, Section—"Green Roof Systems"*



Soil Quality Management and Restoration (SQM / SQR)

Source: RDG



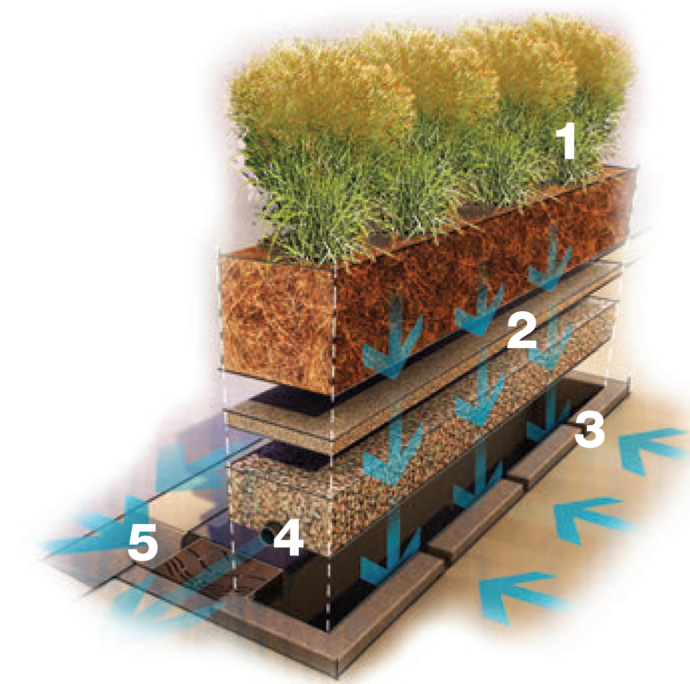
Rainfall Collection and Reuse—Green Roofs

Source: RDG

Rainfall Collection and Reuse—Rainwater Harvesting	Storm water can also be captured and reused for irrigation and non-potable uses (i.e. toilet flushing). This can be done by directing roof drains or other pipes to rain barrels, storage tanks or cisterns. This provides a double benefit of reducing both storm water runoff and the use of drinking water for irrigation and other uses.
Native Landscaping	Prior to pioneer settlement, Iowa's landscape was dominated by tall grass prairies and savannas. Native plants that lived within these systems are naturally tuned to our climate. Most of these plants can survive and thrive without becoming invasive or having other unanticipated negative effects on the environment. They also provide important habitat for pollinators (bees, butterflies), many of which have seen massive population losses. These systems developed deep root systems which extended many feet into the soil. Their root action combined with other biological activity to create the deep, rich topsoil which is the foundation for Iowa's agricultural economy. These roots also made these plant systems much more resistant to erosion than turf grass lawns. Using native landscaping in open spaces has great potential to reduce runoff volumes. It can also be incorporated within streambank restoration projects to create surfaces that are more resistant to streambank movement. *More info: Iowa Stormwater Management Manual, Section—"Native Landscaping"*
Infiltration-Based Practices—Tree Filter Systems	Tree filter systems are most often constructed within parking areas and along urban streetscapes. Planter boxes are created by building walls or fabricated vaults from concrete or other materials. These vaults are usually filled with an aggregate (small rock material free of small particles) layer set below engineered soils. Stormwater enters from adjacent streets, walks and other impervious areas through curb cuts, pipes or intakes. The runoff is used to support trees, shrubs or other landscape material that are planted on the surface of filter system. Sometimes a series of these systems can be connected by subsurface soil and aggregate layers to expand tree root growth zones and provide additional stormwater storage volume.
Infiltration-Based Practices—Infiltration Trenches	These systems are constructed by excavating an area and filling it with aggregate materials. The open space between the rocks allows water to infiltrate through the surface and be stored within the rock chamber. Stormwater can percolate out through subsoil layers or be drained out much more slowly by a subsurface drain system. Any water entering the drain system has been cooled and filtered, removing pollutant loads. *More info: Iowa Stormwater Management Manual, Section—"Infiltration Trenches"*

Native Landscaping

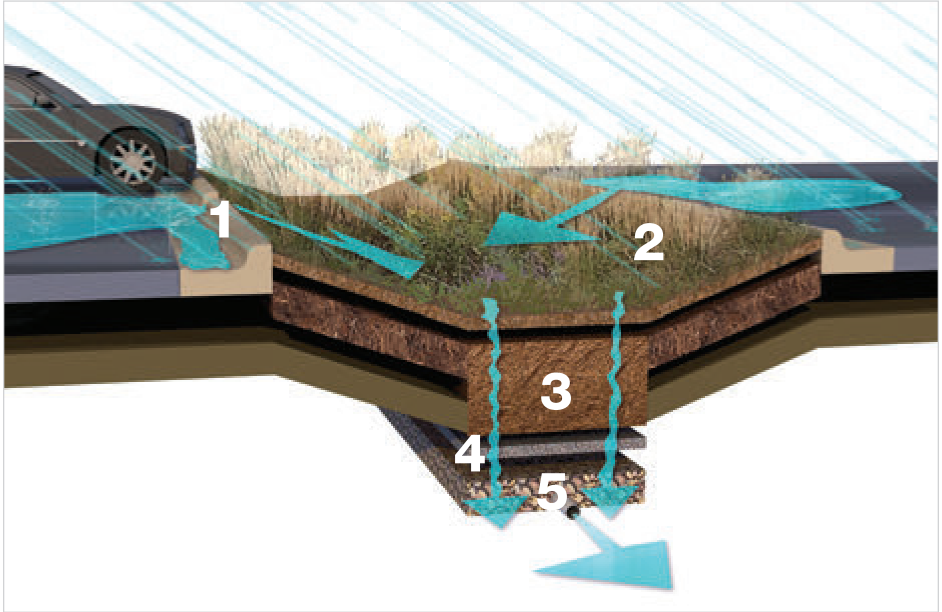
Source: Greg Pierce



Infiltration-Based Practices—Tree Filter Systems

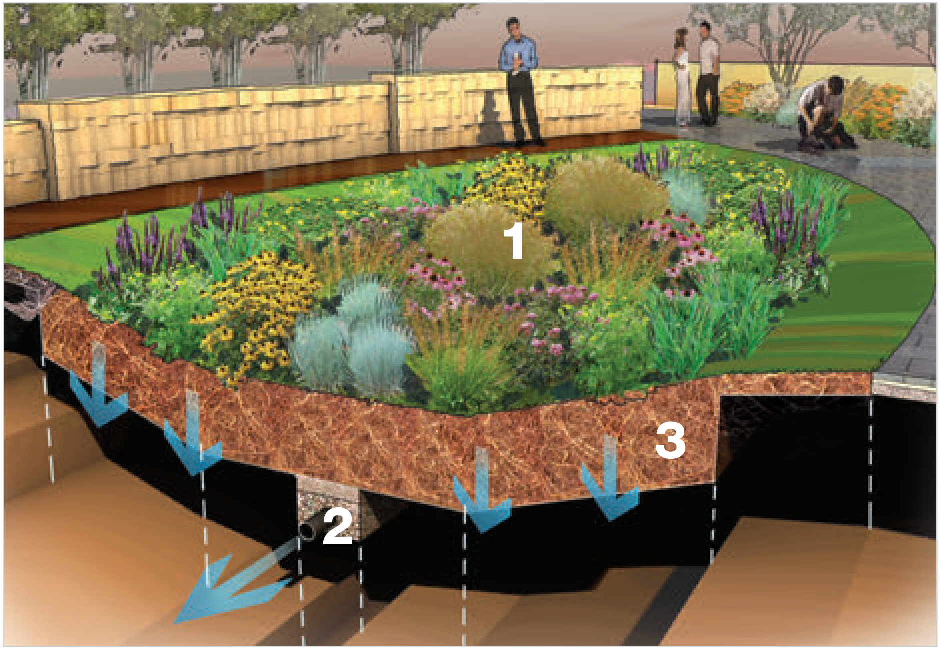
Source: RDG

Infiltration-Based Practices—Bioretention Systems	These features are constructed shallow depressions used to capture and filter runoff. An excavation is made and filled with a base layer of aggregate material, an engineered soil layer (a prescribed mix of compost, sand and topsoil) above and a mulch layer at the surface. The system is designed to have a surface that is level from end to end and side to side. The lowest surface drain outlet within the cell is set 6-9" above the level surface. Stormwater spreads across the level surface and, because of the elevated inlet, is forced to infiltrate into the soil. From there it will percolate through the soil and aggregate layers into subsoils. If water can't move quickly enough into the subsoils, it is able to be drained out through a subdrain system. The surface outlet is used to allow an overflow so that larger events don't overload the system. The outlet can be sized to control the rate of surface outflow to more natural levels. *More info: Iowa Stormwater Management Manual, Section—"Bioretention Systems"*
Infiltration-Based Practices—Bioswales	Bioswales are similar in construction to bioretention cells. The main difference between the two is that while bioretention cells are constructed level, bioswales are constructed with a slight grade from one end to the other. Water passes through the bioswales at low speeds, allowing pollutants to settle out, be filtered or absorbed by the native plant material within the swales. Check dams are also used to control runoff rates, and water ponded behind each dam is able to infiltrate into the soil layers below. Bioswales can treat runoff from larger drainage areas than bioretention cells. However, they need to have enough length to give water enough travel time to be treated. *More info: Iowa Stormwater Management Manual, Section—"Bioswales"*
Infiltration-Based Practices—Infiltration Basins	These large, flat basins use natural soil profiles to infiltrate runoff, so their application is usually limited to areas with soils with high percolation rates. They rely on creating a basin with a relatively flat bottom which allows captured runoff to be infiltrated into soils over a larger area. It can be difficult construct large basins with a level bottom (low areas tend to be created) or without compacting soils during construction (which reduces infiltration and percolation rates). For these reasons, bioretention systems or bioswales may be a more reliable option at many locations. Use of native landscaping in these areas can maintain or increase their ongoing ability to absorb runoff. *More info: Iowa Stormwater Management Manual, Section—"Infiltration Basins"*
Infiltration-Based Practices—Rain Gardens	These features are similar in shape to a bioretention cell. However, they do not include subsurface layers of engineered soils and aggregate and do not include a subdrain. They are most applicable on individual home or commercial sites where they serve small drainage areas. Subsoils must not have been disturbed extensively by construction and have adequate percolation rates for them to be able to absorb the water that they intercept. *More info: Iowa Rain Garden Design and Installation Manual*



Infiltration-Based Practices—Bioretention Systems

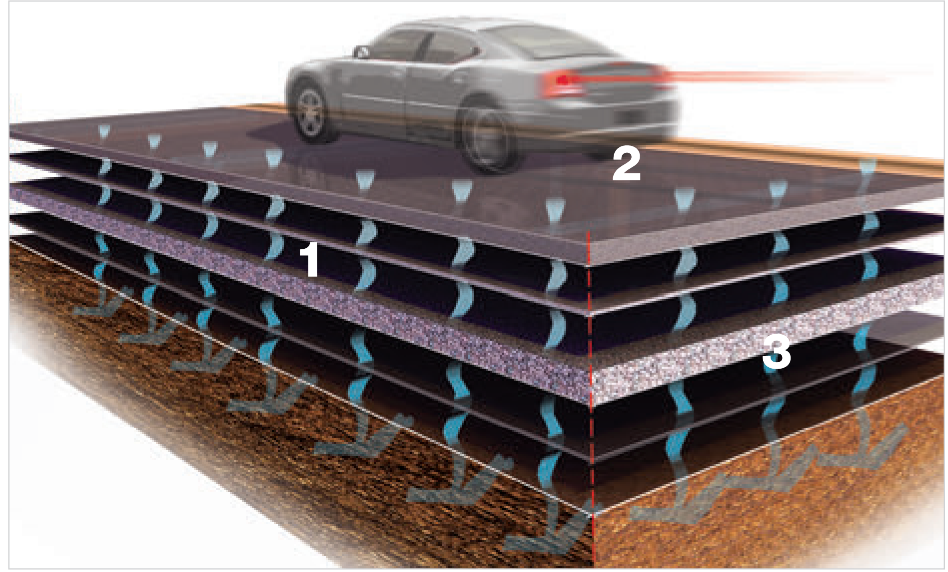
Source: RDG



Infiltration-Based Practices—Rain Gardens

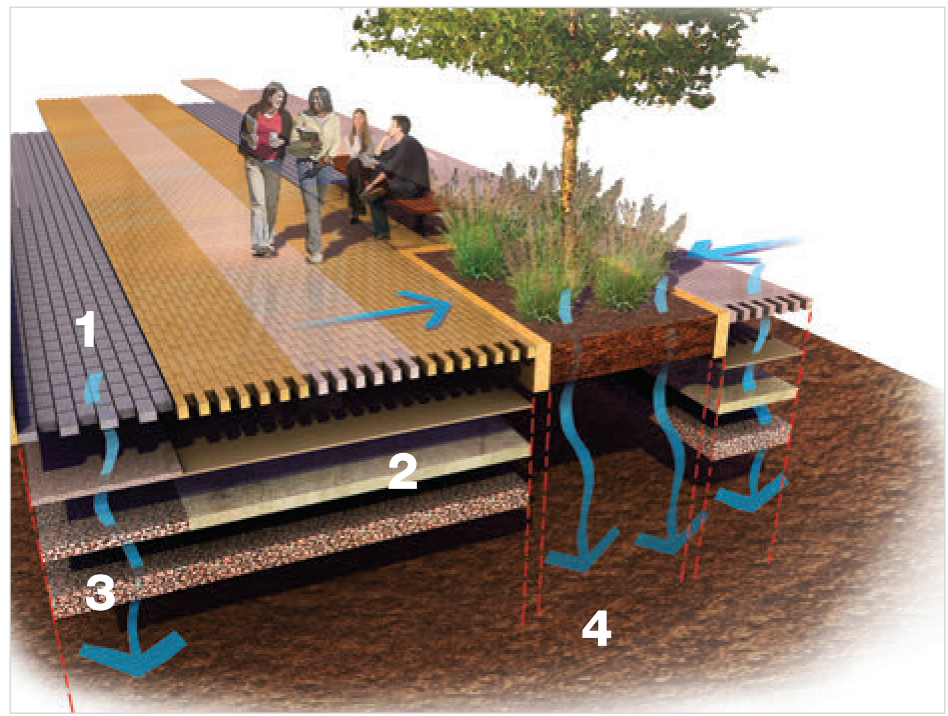
Source: RDG

Permeable Pavement Systems	Pavement systems are now available which allow water to pass through the surface. Runoff can be stored in a subsurface rock layer where it can be allowed to percolate through subsoil layers or released through a subdrain system at more modest rates. Permeable concrete, asphalt and pavers are available to be used for the surface of the pavement system. What makes these surfaces different from standard paving is that sands and other fine grained materials have either been left out of their mix design (concrete and asphalt) or not used as filler material between paver units. This allows water to flow more freely through the surface material into the rock storage below. Some of these systems have unique installation methods that installation contractors should be familiar with. These systems require routine maintenance by a vacuum truck or other methods to avoid clogging of the surface openings. It is very important that runoff from unprotected active construction sites or material storage areas not be allowed onto the pavement surface (this will quickly clog the pavement's ability to infiltrate water). *More info: Iowa Stormwater Management Manual, Sections—"General Information for Pavement Systems," "Pervious Concrete Pavement," "Porous Asphalt Pavement" and "Permeable Pavers"*
Stormwater Detention—Constructed Wetlands	Stormwater wetlands have been shown to be very effective at removal of bacteria, nutrients and sediments from storm water. A constructed wetland is basically a stormwater maze, forcing runoff to take a much longer path through a series of shallow depressions and pools of various depths. They can be used to address management needs for both small and large storm events. The proportion of shallow and deep water zones are set by different "recipes" for wetland designs set forth in ISWMM. These areas provide important habitat for many species including ducks, frogs, dragonflies and fish. *More info: Iowa Stormwater Management Manual, Sections—"General Information for Stormwater Wetlands" and "Design of Stormwater Wetlands"*
Stormwater Detention—Standard Dry Detention	Dry detention basins have historically been the most common form of stormwater management employed in Central Iowa. These areas are intended to be dry between rainfall events. Outlets are designed to limit the rate at which runoff can leave the basin. When larger storms occur, the rate of inflow is larger than the rate that water can get out of the basin. This causes water to back up within the basin or be "detained." Dry detention basins lack adequate methods such as infiltration, ponding or plant uptake to provide significant water quality benefits. For this reason, *standard dry basins are not usually considered water quality practices.* They need to be paired with other management practices located upstream to address water quality. *More info: Iowa Stormwater Management Manual, Sections—"General Information for Detention Practices" and "Dry Detention"*



Permeable Pavement Systems

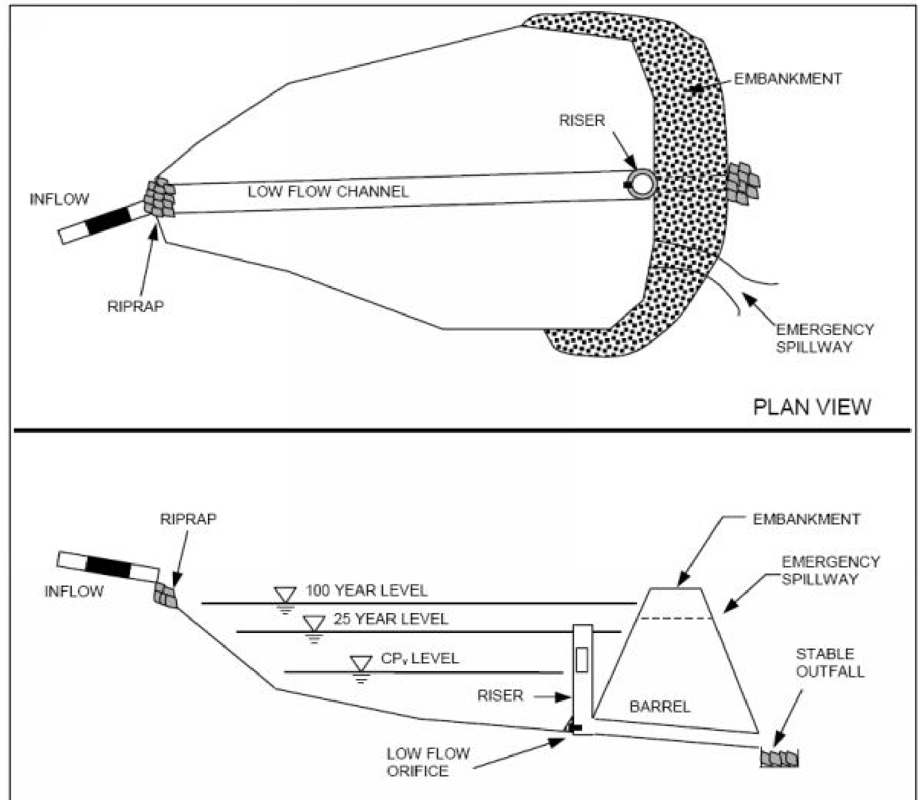
Source: RDG



Stormwater Detention—Constructed Wetlands

Source: RDG

Stormwater Detention—Extended Dry Detention	Dry detention basins can be designed or modified to provide for extended detention of small storm events. This involves designing outlets which are staged to release runoff during small storms much more slowly than was done in the past. Most standard dry detention basins release the runoff they receive in minutes or a few hours after a rain event. Extended detention basins capture and hold runoff longer, releasing it over a period of no less than 24 hours. Extended dry detention basins can be used to address the Channel Protection Volume (runoff caused by a 1-year, 24-hour event—2.67" in Central Iowa). Since water will be present more often in these basins, native plants chosen for wetter soil conditions are better suited than traditional turf grass lawns to provide permanent vegetation. *More info: Iowa Stormwater Management Manual, Sections—"General Information for Detention Practices" and "Dry Detention"*
Stormwater Detention—Wet Detention Ponds	Wet ponds are a feature that can provide aesthetic benefits, recreational opportunities, and improved habitat while meeting stormwater management goals. These systems retain a permanent pool of water which allows pollutants to drop out of solution, be absorbed by shoreline vegetation or broken down by other natural processes. Outlets can be designed to draw water out a few feet below the surface to keep the more oxygen rich water in the pond. Ponds can be designed to address water quality, provide extended detention and limit runoff for larger events to pre-settlement levels. Safety shelfs along the shoreline reduce drowning risk while provided better habitat for wetland vegetation. Maintenance access and pretreatment methods are important to consider in the design process. Outlets should feature a multi-stage design, to effectively manage runoff from both small and large storm events. *More info: Iowa Stormwater Management Manual, Sections—"General Information for Detention Practices" and "Wet Detention"*
Increase Flood Plain Storage	Grading can be completed along major streams to excavate collected sediments or other earth materials from within flood prone areas. This can increase the cross-sectional area of the stream or adjacent flood plain, which can reduce flow velocities. It also provides greater volume available for storage during larger flood events. These effects reduce flood hazard elevations and slow the downstream movement of flood waves. Such grading can often improve habitat by providing a more natural connection between the stream and the adjacent flood plain (often this connection is an abrupt slope due to years of downcutting or streambank erosion). There is a potential to reduce flow velocities to a level that would actually lead to higher levels of deposition, or create flow patterns that could be more erosive. Planning and design of such removals should be done by professionals familiar with patterns of stream movement (fluvial geomorphology). Environmental and flood plain construction permitting is usually required.



Stormwater Detention—Extended Dry Detention

Source: ISWMM manual

Stormwater Detention—Wet Detention Ponds

Source: Greg Pierce

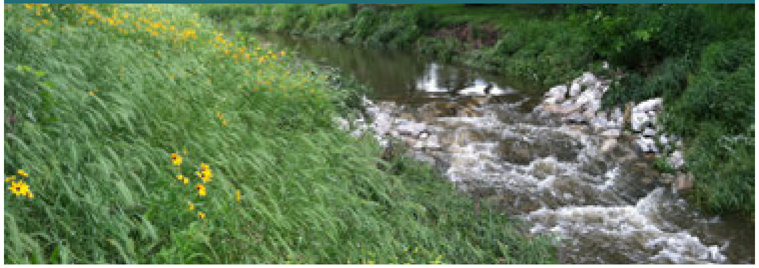
Water Quality Outlet Modifications	Larger ponds or detention facilities may offer opportunities to modify outlets to improve their capacity for extended detention. In some cases this could be as simple as changing the width or elevation of water entry points at the top of the outlet structure or adding a low flow pipe outlet. More detailed analysis of each basin could determine if such a modification could be made without significant additional risk to surrounding properties or structures during large storm events. Such modifications can usually be made with a smaller investment, yet could provide a measurable improvement in pollutant removal and downstream channel protection.
Stream Corridor Restorations	This plan has identified that very few urban small stream corridors are considered stable. Ongoing erosion can directly impact public infrastructure and private property. Streambank materials displaced by erosion is estimated to be the largest contributor of sediment to Walnut Creek. Stream corridor restorations can make streams able to withstand flow rates with less erosion. Rock riffles can be used to slow downcutting and mimic natural pool systems. Toe protection can reduce the potential for erosion along outer stream bends. Native vegetation improves aesthetics and provides more erosion resistant permanent vegetation. In addition to reduced channel erosion, stream corridor restoration improves water quality through filtration and deposition of pollutants. Habitat for a variety of wildlife is greatly improved. The final product is a stream system which is much healthier and accessible to the public.

Before

Source: Greg Pierce

Stream restoration techniques can be used to repair and restore eroded stream corridors.

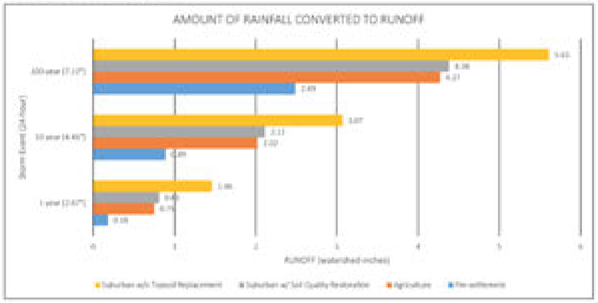
After



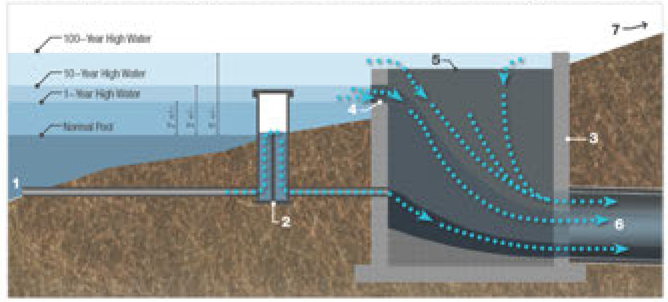
Source: Greg Pierce

Draft Recommendations—Best Practices

Preserve topsoil



Modify existing detention basins to manage 98% of all storm events



Staged Outlet

1. 1st Stage: Small Diameter Inlet - Low Flow Control (Below Surface)
2. Water Level Control Structure
3. Main Outlet Structure
4. 2nd Stage: Notch Weir or Medium Size Opening (Controls 2-25 Year Storms)
5. 3rd Stage: Longer Overflow Weir (50-100 Year Storms)
6. Pipe Outlet (Likely Controls 50-100 Year Storms)
7. 4th Stage: Emergency Spillway (For Storms Larger Than 100-Year)

Manage the water quality volume using green infrastructure

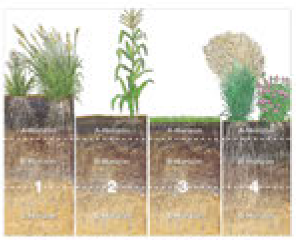
Storm Water Planters

Stormwater planters capture the street's stormwater runoff before it enters into the city's storm sewer. By promoting stormwater infiltration, the planters remove pollutants and debris that would otherwise be released directly into our waterways.

1. Salt tolerant native plants stabilize the soils and provide habitat for native organisms.
2. Plant growth and stormwater infiltration are enhanced by amended soil and layers of open graded washed rock.
3. Stormwater that collects on the sidewalk is directed to the planters through a series of curb cuts.
4. To help remove excess water from the stormwater planter, the underdrain ensures water will not pond on the surface for extended periods of time, creating an unhealthy soil for plants.
5. During times of heavy rain, water flows into the curb inlets and flows into the stormwater planter.

Soil Health

By supplementing existing urban soils with organic matter, soil health can be restored by increasing the pore space and water holding capacity.



1. Pre-Settlement Soil: Distinct A and B horizons; deep roots; well aerated soil; and up to 6% organic matter.
2. Agricultural Soil: Minimal A and B horizons; highly erodible B soils; and less than 2% organic matter.
3. Urban Soil: No A horizon; highly compacted soils; shallow roots and minimal aeration; and less than 1% organic matter.
4. Restored Soil: Increasing A horizon; increasing pore space; return of soil organisms; and more than 3% organic matter.

Permeable Pavers

Permeable pavers promote infiltration of stormwater through a series of small openings within the pavement surface. This reduces the amount of runoff that causes flooding and helps remove pollutants from stormwater.

1. Spaces between permeable pavers direct water to a series of layers below pavement subbase.
2. Layers of uniformly graded washed rock allows water to be temporarily stored below pavement surface before it infiltrates into existing soils.
3. Pollutants are removed from the stormwater by small beneficial bacteria that "digest" and breakdown complex metals and chemicals.
4. Sandy subsoil has a high infiltration rate allowing water to move through the soil at rates greater than 3" per hour.

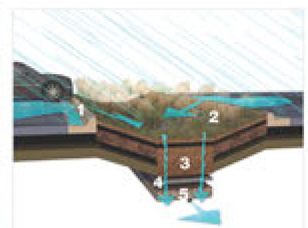
Rain Garden

Raingardens are an infiltrationbased stormwater management practice that work to clean water, reduce flooding and recharge the groundwater.

1. Native plants help manage stormwater runoff from buildings, landscapes and the surrounding watershed. Deep rooted native plants and grasses help build soil structure and allow water to infiltrate the ground better than traditional turf grass. Native plants also are low maintenance, adapt to the surrounding region, resist pests and diseases as well as provide habitat for local birds and butterflies.
2. To help remove excess water from the stormwater planter, the underdrain ensures that water will not pond on the surface for extended periods of time.
3. To support plant growth and promote infiltration, rain gardens are often supplemented with organic compost and sand. This amended soil removes pollutants from contributing waters and helps restore life within the soil.

Bioswale

Bioswales remove over 95% of the pollutants found within urban stormwater run off, including heavy metals, oil, leaking fuel and deicers.



1. A curb cut allows water to enter into the swale.
2. Water is infiltrated through the native plants and hardwood mulch. Native plants help aerate the ground, build soil structure and clean water as it moves into the subsoil. The hardwood mulch is an important system component, breaking down pollutants such as heavy metals, oils, leaking fuel and deicers.
3. Amended soil is used to promote infiltration and support plant diversity. The soils are a mixture of blended sand and compost.
4. Layers of washed rock help increase the soil's infiltration rate and remove harmful pollutants.
5. A subdrain is installed to help remove excess ponded water during times of heavy rain. Some bioswales do not need a subdrain if the soil contains a high percentage of sand.

Porous Asphalt

Porous asphalt is a flexible pavement that promotes the infiltration of stormwater through the pavement surface. Stormwater filters its way through a sequence of subbase layers filtering pollutants, heavy metals and other harmful chemicals.

1. Stormwater that moves through the pavement surface is captured and held in the pavement subbase and base course layers. Up to a 40% void space allows for water to be temporarily held before infiltrating into the ground, unlike traditional pavements where stormwater runs off.
2. Porous asphalt is composed of a highly permeable surface that does not have any fine sand or other small aggregates in the pavement. By using an evenly sized aggregate blend, a pavement surface with a void ratio of up to 16% significantly reduces the amount of stormwater runoff from vehicular service drives.
3. To prevent migration of the aggregates and stabilize the subbase layers, a geotextile (or permeable fabric) is placed between the rock and subsoil.

WALNUT CREEK WATERSHED   RDG PLANNING • DESIGN   DES MOINES AREA MPO   SNYDER & ASSOCIATES Engineers and Planners   Polk Soil & Water CONSERVATION DISTRICT

glossary

Glossary	
Abbreviation	
ACWA	**Agriculture's Clean Water Alliance**
BMP	**Best Management Practice**
CAFO	**Confined Animal Feeding Operation**
CWA	**Clean Water Act**
DMWW	**Des Moines Water Works**
FEMA	**Federal Emergency Management Agency**
FIB	**Fecal Indicator Bacteria**
FIRM	**Flood Rate Insurance Map**
GIS	**Geographic Information Systems**
IDALS	**Iowa Department of Agriculture and Land Stewardship**
IDNR	**Iowa Department of Natural Resources**
ISA	**Iowa Soybean Association**
ISWMM	**Iowa Stormwater Management Manual**
LiDAR	**Light Detection and Ranging**
MCL	**Maximum Contaminate Level**
MPN	**Most Probable Number of organisms**
NOAA	**National Oceanic and Atmospheric Administration**
NOD	**Notice of Discontinuation**
NRCS	**National Resources Conservation Service**
POTW	**Publicly Owned Treatment Works**
QAPP	**Quality Assurance Project Plan**
RC&D	**Resource Conservation and Development**
RECPs	**Rolled Erosion Control Products**
SMP	**Soil Management Plan**
SQR	**Soil Quality Restoration**
SUDAS	**Statewide Urban Design standards And Specifications**
SWPPPs	**Storm Water Pollution Prevention Plans**
TMDL	**Total Maximum Daily Load**
TRMs	**Turf Reinforcement Mats**
USGS	**United States Geological Survey**
WRCC	**Water Resources Coordinating Council**

Term	Definition as related to the context of this plan
absentee landlord	*A property owner who rents land for farming, but gives little or no oversight to the methods of farming or conservation practices used within their property.*
agronomist	*A person who studies properties of soils and/or plants and uses them to improve agricultural production.*
algae	*There are many types of algae, but those most common to this watershed are microogranisms that grow on the surface of freshwater ponds and streams.*
algal blooms	*When nutrient levels are high, growth of algae can be accelerated leading to algal blooms. These are large groups of algae which collect in a common area.*
annual	*The total or average value of something over a calendar year.*
annual exceedance probability	*The chance a storm event or flood of a certain depth will be equaled or exceeded in any given year.*
bioreactors	*Refer to Chapter 15 for details on rural best management practices.*
bioretention	*Refer to Chapter 15 for details on urban best management practices.*
bioswales	*Refer to Chapter 15 for details on urban best management practices.*
buffers	*A separation between a stream and adjacent land uses (either urban or agricultural) which feature grasses, forbs, trees and shrubs which filter and clean runoff before it can enter a stream. These areas usually provide important habitat to a variety of species.*
canopy	*An area under the expanse of branches and leaves from a tree or tree group.*
channel protection volume	*One element of the Unified Sizing Criteria within the Iowa Stormwater Management Manual. Practices designed to address this element will capture runoff from a 1-year storm (2.67" in 24-hours) and slowly release it over a period of 24-48 hours. Peak flows from such an event are typically reduced by more than 95% by these practices.*
Clean Water Act	*A federal law originally passed in 1972 which was intended to reduce surface water pollution. Most current federal regulations related to surface water quality are based on this law.*
common plan of development	*A term used in Iowa's NPDES General Permit No. 2 which governs pollution prevention and water quality protection from construction sites. It is usually a parcel or adjacent parcels of land which are planned to be developed in phases over a period of time. Permit coverage is required for common plans of development which will disturb more than one acre of land. This term is used in the permit requirements to prevent land from being developed in many smaller phases to avoid the requirement of a permit.*
complementary benefits	*Not the primary intended benefit of an improvement or practice, but a secondary benefit of value.*
concentrated flow	*Where runoff is funneled to flow more rapidly in a narrow path.*
conservation tillage	*Practices that reduce that reduce disturbance of the soil or leave additional crop residue in fields to resist erosion.*
constructed wetlands	*Refer to Chapter 15 for details on best management practices. There are varieties of these to treat runoff from both urban and rural land uses.*
contour planting	*Planting crops so that rows are placed "on contour" or across the slope. Runoff is forced to run perpendicular to the rows, reducing flow velocities and reducing erosion.*
cover crops	*Refer to Chapter 15 for details on rural best management practices.*
Des Moines Lobe	*A section of the Wisconsin Glacier which pushed into what is Central Iowa today.*
designated uses	*An official category of public uses of a stream, as defined by the State. These may include items such as public recreation, fishing and water supply.*

detention basins	*An urban BMP which reduces downstream runoff rates by having outlet controls which restrict flows to a certain level. The limited outflow rate forces water to build up within a depression or pond upstream, being stored or "detained" and released more slowly over and extended period of time.*
dewatering	*Removing water from a trench or other depression during construction, usually by pumping.*
dioxins	*A variety of highly toxic chemicals which is able to be absorbed by fatty tissue, able to remain present within the body of animals and humans for a long period of time.*
direct surface runoff	*Water that runs off the surface of the landscape without infiltrating into or percolating through soil or aggregate layers.*
discharge	*Stormwater that leaves a site and enters a pipe or surface water.*
disturbed areas	*An area of land where vegetation or other surface coverings are removed to accommodate grading or other construction related to urban land development.*
E.coli	*A species of bacteria that is commonly originates in the intestines of warm blooded animals. They may grow aggressively for a period of time in fecal matter, food or other media in the external environment. It is a fecal indictor bacteria currently used by the State to measure growth factors in the environment that would likely foster survival or growth of other pathogens (viruses and bacteria) which could pose risks to human health.*
easements	*A restriction placed on a piece of property which limits it use in favor of another purpose. For example, a drainage easement may restrict construction of structures, fences or other items which could prevent the safe flow of water through a drainage channel.*
edge of field	*A set of BMPs which are usually located along the boundaries between a field and a stream or other drainage outlet.*
ephemeral flow	*Channels or streams which only flow for hours or a few days after rainfall events or snowmelt.*
erodibility	*A soil property which indicates how likely a soil is to be eroded. Different soils have a coefficient assigned for this property that is used in the Revised Universal Soil Loss Equation to predict annual rates of soil erosion.*
erosion controls	*BMPs that are used to protect soil particles from being loosened from the surface of the ground by rainfall or concentrated flows.*
extended crop rotations OR extended rotations	*Adding alfalfa or other crops into a rotation of crops to rebuild organic matter in topsoil. Refer to Chapter 15 for rural best management practices.*
fecal coliform	*A species of bacteria that is commonly originates in the intestines of warm blooded animals. It is a fecal indictor bacteria which was formerly used by the State to measure growth factors in the environment that would likely foster survival or growth of other pathogens (viruses and bacteria) which could pose risks to human health.*
flood event	*A measure of stream flow related to a given level of rainfall, or a precipitation event which causes flow in a stream to exceed its banks and spread across into the adjacent low lying areas.*
flood protection elevations	*An established level where building structures must be placed above or have other protections in place to prevent damage from flooding.*
flood storage	*The volume available within a flood plain to temporarily store water.*
flow	*Water moving in a concentrated path.*
fluvial geomorphology	*The study of how stream conditions change over time.*
full establishment of vegetation	*A term used in Iowa's NPDES General Permit No. 2. When the desired permanent vegetation grows densely across all areas which were disturbed by construction, other than those areas covered by paving, structures or some other permanent stabilization technique.*
gage height	*The measured depth of flow above a set datum (base level) at a gaging station. At each station, the gage height at which flooding occurs is known.*

GIS databases	*Sets of information which include the location and properties of a variety of features which can be mapped using a given coordination system.*
GIS layers	*Groups of features of a similar type which can be mapped over each other on a similar coordinate system. Layers can be used to set how features such as parcels, land uses, utilities, roads, streams, etc. are displayed on maps.*
growing season	*The length of time where plants can grow, measured by consecutive frost-free days.*
headwaters	*The places where streams originate, or the furthest points from the mouth of the stream.*
high quality resource	*Waterbodies which have substantial recreational or ecological significance, requiring special protection.*
historic channel locations	*Places where streams used to flow, but have moved over time to flow along a parallel path.*
hydraulic	*Studies of the direction and velocity of moving water.*
hydric	*A soil that was historically saturated by water (either permanently or seasonally). These soils are used to determine where wetlands were most likely located in the past.*
hydrologic	*The study of the properties and movement of water across the surface of the earth.*
hydrologic soil group	*Soils are often grouped into four categories which measure the soils ability to infiltrate and percolate. Group A soils allow more free movement of water, while Group D soils offer more resistance to water movement.*
hypoxia	*A state of low dissolved oxygen levels in water, which can lead to the death of fish and other aquatic species.*
impaired waterway	*A waterbody which has poor water quality or other conditions which limits its ability to support its designated uses.*
impermeable	*A layer or feature that does not allow water to easily pass through it.*
impervious surface	*Buildings, pavement or other surface conditions which virtually eliminate water's ability to infiltrate into subsoil layers.*
individual development scale	*A stormwater BMP which is employed at a individual site or land development, usually having a smaller watershed area.*
in-field	*Rural BMPs which are applied within agricultural fields.*
infiltration	*Water entering the surface of the soil.*
inlet protection devices	*A BMP which is placed at the entrance to a culvert or storm sewer system to reduce the amount of sediment that is able to enter the pipe network.*
intermittent flow	*Streams which often have little or no flow for weeks or months at a time.*
inundation map	*A map that shows the area of land which will be covered by floodwaters for a given flood event.*
invasive species	*An animal or plant species with limited predators or other conditions that limit its reproduction. The species has the ability to grow rapidly to levels which negatively impact biodiversity by reducing habitat for other desirable species. Usually, invasive species are not native to the local environment.*
j-hooks	*Where sediment controls such as silt fences and wattles are turned upslope at the ends to increase the volume for water storage upstream of the control.*
key sources	*The primary land uses or areas where a type of pollution is expected to originate from.*
land subdivisions	*Areas of urban growth where larger parcels are subdivided into smaller parcels, usually involving the installation of streets and utilities to support construction of new buildings on the new parcels.*
living mulches	*Refer to Chapter 15 for details on rural best management practices.*

local design standards	*Requirements set by cities and counties to govern design of new developments.*
long term maintenance	*Maintenance requirements which are expected to occur at regular intervals for an indefinite period of time.*
low to medium density residential	*Single family homes or townhomes developments, usually less than 6 units per acre.*
manure management	*Plans required by the state to be developed for CAFOs for the storage, disposal or use of the manure wastes collected.*
maximum contaminate levels	*The highest concentration allowed of a certain pollutant to allow for a waterbody to support its designated uses.*
mean	*The average or the calculated middle value of a series of numbers.*
micro-watersheds	*The smallest divisions of drainage areas used by this plan, ranging from a few acres to about 250 acres in size.*
mitigate	*To offset the impact or effect of something. For example, wetland mitigation is done by creating additional new wetlands when others are lost.*
monitor OR monitoring	*Testing for water quality conditions by using test kits or by collecting samples for laboratory testing.*
monitoring program	*An detailed program to collect water quality data through monitoring and analyze the results. The program usually follows a QAPP to insure that data is collected accurately using consistent methods.*
neurological	*Related to the nervous system, including the brain, spine and the connecting nerves.*
nitrification inhibitors	*Chemicals that slow the conversion of fertilizer into nitrate.*
NOAA Atlas 14	*Updated tables of rainfall data that has been developed for most of the United States which was issued in 2013. Atlas 14, Volume 8 Version 2.0 includes data relevant to the State of Iowa.*
non-point source	*Pollutant sources that are distributed throughout the landscape, such as construction sites, most agricultural operations and urban developed areas.*
normal	*An average value over a more recent, defined period of time. For example, normal high temperatures are based on the average value for a given date or month over the most recent 30 years on record. Unless noted otherwise, the term normal used in this report refers to average values over the most recent 30-year period, ending in either 2014 or 2015.*
nutrient management plans	*A plan that defines how nutrient fertilizers are applied for agricultural operations. They include the location, schedule, application rate, chemical form and method of application.*
off-site tracking	*When sediments or other debris are carried by vehicle or equipment out of construction sites and are deposited on adjacent roadways or properties.*
outlot	*An open parcel of land that is not currently buildable, either reserved for future development or set aside as open space. Outlots are commonly used when a water feature or open space is held by either a public or private group to be used for the benefit of multiple land owners.*
pathogen indicator bacteria	*See FIB (fecal indicator bacteria).*
pathogens	*Items which can produce disease or infections such as various forms of viruses, bacteria, parasites and fungi.*
peer-reviewed	*Articles or studies which have been evaluated by experts in related fields for accuracy in the methods and procedures used to complete the work.*
percolation	*Water moving through void spaces in soils or other media.*
perennial flow	*Streams or rivers which will have continuous flow year round during periods of normal rainfall.*

perennial vegetation	*For the purposes of stormwater permitting, this refers to a desired mix of plant species which will grow back year after year. Temporary vegetation are grasses or other plants used for surface cover which typically only last one growing season.*
perimeter site controls	*Erosion or sediment controls placed near the boundaries of a construction site to prevent sediment from being washed or tracked onto adjacent properties or roadways.*
photosynthesis	*The process that plants use light to convert carbon dioxide and water into carbohydrates which they use to fuel their growth.*
point source	*A specific, individually regulated potential source of pollution, such as a wastewater treatment plant or confined animal feeding operation.*
pollutant concentration	*A measure of the amount of any pollutant present at any given time. Most chemical pollutants are measured by the weight present within a certain volume, such as milligrams per liter (mg/L). Biological concentrations may be in the most probable number of organisms (MPN) present in a certain volume, such as 100 milliliters (MPN / 100 mL).*
pollutant loading	*A total amount of a pollutant present in a stream over a set period of time, usually measured in units of weight (pounds, tons, etc.) Pollutant loading in streams is generally equal to pollutant concentration multiplied by the flow volume.*
pollutants of concern	*Chemicals, biological organisms, sediments or other factors that are known to be present at concentrations or volumes where they have a significant impact on stream functions, habitat, human health or the safety of people, private property or public infrastructure. Elements of this plan are specifically designed to address the pollutants of concern.*
pothole	*Shallow depressions located in flat areas below what was once covered by glaciers. These areas were most likely wetlands before they were drained by systems of tiles and ditches to improve agricultural production.*
precipitation	*Water falling from the sky in forms such as rain, snow, sleet or hail.*
pre-settlement	*Conditions that would have been expected prior to pioneer settlement which occurred in Iowa in the mid-1800s.*
priority impairments	*Impairments related to the largest sources of the key pollutants of concern identified within this study.*
publicly owned treatment works	*A facility owned by a city or other municipality for the treatment of wastewater (i.e. Dallas Center's Wastewater Treatment Plant).*
quality	*Managing for water quality means putting in place practices that reduce the presence of pollutants in any water discharged from a given site or area.*
quantity	*Managing for water quantity means using practices to reduce the volume or rate of flow being discharged from a given site or area.*
rate of runoff	*A measure of flow leaving a certain area, by volume over a certain period of time (such as cubic feet per second, or cfs).*
regional stormwater management	*Using larger scale practices to manage stormwater runoff for multiple properties or developments.*
regulatory 100-year flood plain	*Areas expected to be covered by floodwater during a 100-year flood (or a flood with 1% annual exceedance probability) as defined by flood rate insurance maps that are issued by FEMA.*
respiratory	*The system of organs in animals related to breathing.*
routed	*The method of passing larger flows through practices that have storage volume, such as ponds or detention basins. In analysis, comparison graphs are computed showing the inflow rate, outflow rate and the volume or depth of ponded (stored) water.*
row crop	*Agricultural products such as corn and soybean which are grown in rows.*
runoff volume	*The amount of runoff leaving a certain area measured in units of volume, such as cubic feet or acre-feet.*
sampling	*The process of testing for water quality by use of kits or collecting small volumes of water for laboratory testing.*

savanna	*An area where trees are present, but are spaced sufficiently so that light passes through the canopy to support grassland vegetation below.*
sediment basins	*In urban areas sediment basins are created by temporary excavations or dams which collect runoff form construction sites, allowing heavier suspended sediments to settle out of solution before the water is discharged. For rural settings, refer to Chapter 15 for details on rural best management practices.*
sediment controls	*BMPs that are used to capture soil particles which are suspended in stormwater runoff.*
setback	*A specified distance where structures or private property must be separated from a certain feature, such as a stream, utility, roadway or property line.*
short term maintenance	*Maintenance requirements which are expected to occur at regular or irregular intervals in the first few years after construction or establishment.*
silt fences	*A sediment control BMP which is an impermeable, synthetic fence stretched between metal posts used to capture runoff from construction sites so that sediment can settle out of solution upstream of the fence, preventing most of it from being washed off-site.*
single-family land development	*A subdivision of property into multiple parcels, each having only one dwelling unit which are not directly connected to any other dwelling unit.*
snapshot	*Water quality sampling events which are conducted only once or twice a year.*
soil logs	*A sediment control BMP which is a tube created by a netting or other synthetic material typically filled with compost, aggregate and seed. They are often installed along slopes to reduce the potential for erosion or with "J-hooks" to capture runoff and allow sediment to settle out on the upstream side. They can also be used along shoreline or edges of streams to establish vegetation and prevent erosion.*
source	*The area or land use where a key pollutant is expected to originate from.*
stabilized construction entrances	*A perimeter control where rock or gravel materials are used to remove sediment from the wheels of vehicles or equipment before they leave a construction site.*
stage-storage	*A graph, table or other relationship that shows the relationship between the water elevation in a practice and the volume of water that is being stored. These relationships are used in "routing" calculations.*
stop work orders	*A notice issued by a city or other enforcement agency used to stop any work on a construction site until proper pollution prevention best management practices are in place and in good working order.*
Strahler method	*A method of stream classification used to classify streams where headwater perennial stream are classified as first order. The confluence of two first order streams yields a second order stream. Where two second order streams meet, a third order stream is formed. Refer to Chapter 2 for more information.*
stream migration	*Patterns of stream movement over time.*
stream order	*A classification of streams into orders such as first, second, third, etc. based on the Strahler method. For this plan, significant paths of flow that were noted that have not been classified by the IDNR as first order or larger streams are referred to as "zero order" streams.*
subsurface tile drainage	*A system of perforated drains used to more rapidly drain groundwater from landscapes. Tile drainage systems have been used extensively in agricultural areas within the Walnut Creek Watershed as early as the late 1800s.*
subsurface water control	*Installing control structures that allow tile drainage flows to be stopped, released or diverted to another pipe.*
subwatersheds	*Larger divisions of drainage areas used by this plan. These areas vary greatly in size, but their average size is approximately 2.5 square miles (1600 acres).*
temporary sanitary facilities	*Portable restroom facilities used at construction sites or where more permanent restroom facilities are not available.*
temporary seeding and mulches	*An erosion control BMP where a fast growing temporary cover crop (such as rye or oats) or a mulch is used to reduce the potential for surface erosion.*
terracing	*Refer to Chapter 15 for details on rural best management practices.*
time of concentration	*The longest time it takes for runoff from a given area to travel from all the most distant points to the outlet (or another point of interest).*
topography	*The shape of the surface of the earth.*
TR-55	*A software program developed by the NRCS (originally as the Soil Conservation Service) that calculates the runoff volumes and rates of flow from small urban and rural watersheds.*
traditional stormwater management	*For the purpose of comparisons within this report, this term means management systems designed to capture runoff from a 100-year storm event and release it at peak rates that would be similar to those expected from a 5-year event under agricultural conditions. This assumes that such systems would be designed using techniques such as TR-55 and stage-storage routing.*
transpiration	*The process where water is moved from the roots, up through plants and evaporated into the air.*
travel times	*The time it takes surface runoff to pass from one point of interest to another.*
tributary	*A smaller stream which ultimately drains into a larger stream.*
typical flow curve	*For the purpose of this report, this term is defined as a graph of the normal stream flow expected for a given date, which has been calculated by finding the average flow for a 30-day period centered on a given date. For example, the average flow for January 15 is calculated by averaging flow observations that have been measured between January 1 and January 30. These values were calculated from flow observations at a USGS gaging station from October 1971 to August 2015.*
understory	*Smaller trees or shrubs which sometimes grow below the canopy of taller trees.*
water quality event	*A storm event of certain depth, where 90% of all events observed have been equal to or smaller. In Iowa, a water quality event has been established to be 1.25" in depth.*
water quality impairment	*When a pollutant is found to be in sufficient concentration through monitoring or other observations to have a significant negative effect on the designated uses of a waterbody.*
water quality modeling	*Computer calculations completed using software programs to predict pollutant loads and their sources.*
water quality standards	*Levels established by state or federal agencies that are allowed to be present in surface waters before the designated uses of waterbodies are negatively impacted.*
water quality volume	*One element of the Unified Sizing Criteria within the Iowa Stormwater Management Manual. Practices designed to address this element will capture runoff from a water quality event and use BMPs to treat this volume.*
watershed	*An area of land that drains to a common point of interest.*
watershed scale	*Practices that are applied across a broad area, or that are to be applied more broadly across all areas draining to Walnut Creek.*
wattles	*A sediment control BMP which is a tube created by a netting or other synthetic material filled with straw or mulch. They are typically installed along slopes to reduce the potential for erosion.*
wet detention ponds	*A pond which holds a permanent pool of water, which has space above to temporarily detain runoff after rainfall events.*
wetlands	*An area with hydric soils, which is permanently or seasonably saturated with water allowing the establishment of certain aquatic plants. Existing wetlands are protected by various environmental laws. Refer also to the definition of constructed wetlands.*
Wisconsin Glacier	*One of the most recent glaciers which extended across large parts of the upper Midwestern United States.*