WETLANDS: A FLOODING SOLUTION

by

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A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture/Regional and Community Planning
College of Architecture, Planning, and Design

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Approved by:

Major Professor
Dr. Tim Keane

Abstract

Wildcat Creek in Riley County, KS has repeatedly flooded in the past 5 years causing significant damage to the watershed, private property, and community livelihood. Strategically placing wetlands throughout the watershed can help reduce stormwater runoff, increase infiltration, and increase wildlife habitat. A watershed assessment was completed to determine the best location for wetlands in the Wildcat Creek Basin. Two watershed-scale plans for wetlands were derived and evaluated based upon estimation of stormwater runoff and quality of wildlife habitat.

Wetlands were then examined and incorporated into existing land cover and land uses at the site-scale for an existing golf course. Three proposals for the nine hole course (for best golf experience, wildlife habitat, and wetland creation) were developed to reflect expansion options from a Par 30 to a Par 34 or 35 course. Each proposal was evaluated based on wetland capacity from estimated stormwater runoff, quality of wildlife habitat, playability of the golf course for all skill levels, and cost of implementation. After this evaluation, the wetland proposal was moved forward and further developed into a proposal that is best suited for the site. Following wetland implementation, stormwater runoff can be collected on-site to prevent runoff and flooding at the golf course and downstream.

In order to solve flooding problems in the Wildcat Creek watershed, a series of wetlands can be implemented at the smaller site scale, like the Wildcat Creek Golf Course site, throughout the watershed. Wetlands are one component of a larger stormwater management system that is needed to reduce flooding of the Wildcat Creek and the flood-prone area of Manhattan, KS.

Wetlands: A Flooding Solution

Using a watershed and golf course to show integration of wetlands with existing land and creation of wildlife habitat

Jennifer Engelke
Masters of Landscape Architecture
2012

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WETLANDS: A FLOODING SOLUTION

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Jennifer Engelke

A master's project and report

submitted in partial fulfillment of the requirements for the degree

Master of Landscape Architecture (MLA)

2012

Committee:

Dr. Tim Keane, Major

Professor Chip Winslow

Dr. Stacy Hutchinson

LAR 700 : Project Programming (Fall 2011)

LAR 705: Master's Project (Spring 2012)

LANDSCAPE ARCHITECTURE
/ REGIONAL & COMMUNITY PLANNING
THE COLLEGE of
ARCHITECTURE, PLANNING & DESIGN // K-STATE

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List of Abbreviations

WARSSS - Watershed Assessment of River Stability and Sediment Supply

RLA - Reconnaissance Level Assessment

RRISSC - Rapid Resource Inventory for Sediment and Stability Consequence

PLA - Prediction Level Assessment

Acknowledgements

Wetlands: A Flooding Solution has allowed me to further develop and expand my interests in landscape architecture, design, and natural systems. I would like to thank Dr. Tim Keane for his exceptional guidance, inspiration, and words of wisdom throughout the project and to recognize committee members Professor William 'Chip' Winslow and Dr. Stacy Hutchinson for their insights and expertise on the project. Also, a special thanks to Professor Stephanie Rolley for her continued support, guidance, and encouragement throughout my time at K-State.

I would like to thank the owner of Wildcat Creek Golf Course, Kevin Fateley, for his availability to meet with me and his help in supplying information about the flooding damage on the course. He provided a valuable historical perspective about the site and shared useful information about the goal and future of the course.

Throughout my education, I have learned a wide spectrum of design and would like to thank other professors who have provided inspiration, support, guidance, encourage, and knowledge: Professors Lorn Clement, Katie Kingery-Page, Tony Barnes, Eric Bernard, Tony Chelz, Melanie Klein, Lee Skabelund, Jessica Canfield, Jon Hunt, Jason Brody, Blake Belanger, and Howard Hahn. You all have taught me so much about the vast range of landscape architecture opportunities and all aspects of the profession. Thank you!

Lastly, I would like to thank my parents for their continued support and encouragement of me throughout my life. You have shown me leadership in your given professions and motivated me to work hard in pursuing my professional career. Your love and dedication have proven to me that life is about following your dreams and reaching for the stars.

Project Synopsis

Reduction of Flooding = Wetlands Restoration + Retrofitting Land Through Design

project overview

Dilemmas:

Wildcat Creek flooded in 2010 and 2011 resulting in significant property damage to residents of Riley County, Kansas. The creek, home to endangered species (e.g. Topeka Shiner, Whooping Crane) and other threatened wildlife, has vegetative, wildlife, aquatic, human, weather, and development systems that exist within its watershed. Many areas in the watershed have large areas of impermeable surface, causing high levels of stormwater runoff into Wildcat Creek. Considerable development, growth, and change in the Wildcat Creek watershed further affect the flooding dilemma. Site analysis was critical to selecting locations that caused the flooding and helping concerned citizens address the following issues: How has the watershed grown? How have these changes affected flooding? What areas of the watershed produced and continue to produce the most runoff? How can the watershed be modified to increase infiltration rates without taking away important aspects of the ecosystem? How can multiple systems effectively interrelate to solve the problem of significant flooding?

One location that has had significant flooding in the past is Wildcat Creek Golf Course. The flooding and runoff created by soils with low permeability levels and limited stormwater retention capacity on the golf course contributed to substantial damage on the property and throughout the creek corridor. Concerns to be addressed include: How has land use upstream impacted the Wildcat Creek Golf Course? How have the current golf course layout, topography, and vegetation influenced flooding on-site? How can Wildcat Creek Golf Course be redesigned to reduce flooding on-site and runoff which floods other areas?

Idea Development:

In past flooding events, large and small, across the United States, people looked for ways to control the property damage in future events. Wetlands such as freshwater swamps, freshwater marshes, and wet prairies absorbed water and created locations that handle flooding and excess water (Mitsch et al, 2009). The 1993 floods on the Mississippi River were thought to be magnified by development that contributed to the loss of wetlands. The wetlands acted as a natural area that can flood and were meant to hold water during high flow times. Hey and Philippi (1995) built a case for the need to restore wetlands along the Mississippi River after the 1993 flood and subsequently provide a place for water to naturally go without destroying urban and farming areas. Today, the Mississippi River wetlands also serve as critical habitats to waterfowl and other wildlife in the area. Hey (2011) argued that if we can restore areas back to wetlands, water quality would improve, flooding would occur naturally in areas intended to flood, and greater wildlife habitats in the region would enhance species biodiversity and increased landing areas for migratory birds. Wetlands are built around ecosystem construction or habitats that are all helping each other and creating stronger opportunities for the wildlife or humans. Wetlands serve as sustainable landscapes that help prevent flooding, are self-reliant, and continue to perform for years to come.

Wetlands are one long-term option that considers natural habitat, existing systems, and the impact of building (e.g., roads, buildings, and impervious surfaces) as essential elements in understanding design impact and generating lasting solutions to flooding (Chambers, 2011). Regenerative systems (Lyle, 1994) have the ecosystems that are self-reliant and help to reinvigorate the health of the ecosystem. A regenerative system is dependent on the formation and growth of the ecosystem. In wetlands, the species habitat growth and dependence were shown through their food sources, their ability to be food sources, and the environment they lived in. The connected habitat web, as identified by Eric Sanderson (2011), demonstrated the importance and dependence of species on one another. Designing of wetlands with future growth and regenerative strategies is vital to helping the design sustain, grow, and develop through time.

Open spaces, today, offer an opportunity for people to see and understand sustainable and regenerative landscapes. They create places that are beneficial to the environment and able to give resources to many different systems. Connecting humans to the landscape is important in the understanding of the landscape and natural ecosystems. Golf courses, parks, and wildlife corridors are all open spaces that connect the human system with the landscape. They are all defined in unique conditions creating opportunities for a different human experience at each location. Incorporating natural ecosystems, wetlands, and wildlife into the human experience creates sustainable landscapes that can still be enjoyed by many people.

Golf is a game that changes in each environment it is played. Unlike predefined football fields or basketball courts, golf courses are molded into the terrain creating variations in course type and challenge. Many courses today are designed with conservation areas that directly address environmental concerns and are viewed as a solution for the future (Martin & Schoeder, 2009).

Golf courses can be designed to hold water, reduce runoff, and encourage growth of healthy wildlife habitats in the surrounding area. Controlling the water quality and runoff through the use of wetlands on the course creates natural environments that interact with the golf course, provide opportunities to control flood water, and reduce runoff from the course.

Thesis:

A series of wetlands and wetland systems can be strategically placed along Wildcat Creek corridor and throughout the watershed to reduce stormwater runoff and increase infiltration. As a site specific example, in this project Wildcat Creek Golf Course will be redesigned to accommodate stormwater flow from upland and on-site through wetlands that establish healthy wildlife habitats and to help reduce damaging flooding downstream.

Studio Design Group Involvement:

A common dilemma of flooding exists in the Wildcat Creek watershed. As a studio design group, a variety of solutions for reducing flooding and damage in the watershed were hypothesized. Although everyone in the group had a different thesis, our collective aim was to generate a variety of solutions that could assist members of the community in problem-solving, reduce flooding and property damage, promote a sustainable environment and ecosystem, and ultimately benefit the community of Manhattan and Riley County, Kansas.

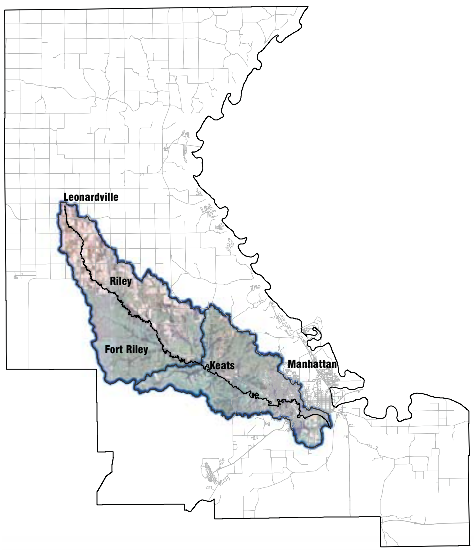
Wildcat Creek watershed runs from northern agricultural land and part of Leonardville, southward through Riley, part of Fort Riley, Keats and eventually into part of Manhattan, as seen in figure 1.01. The watershed begins in the north with a large amount of terraced and tilled agricultural land. There are many areas where the creek has been straightened or altered to gain more usable farmland. Many of the tributaries in the north are also ephemeral streams and only have water or a consistent flow of water during storms with heavy rainfall. As you proceed further downstream in the watershed, the creek runs through the town of Riley, and becomes the border of Fort Riley. The town of Riley offers a small amount of concentrated urban development that creates more impervious surface. Fort Riley was formerly agricultural land, but when the government bought the land they transformed the northern part of the land into tall-grass prairie and are currently using the southern portion for military training. The prairie was restored to the area due to the extensive topography that limited its training use. The training section of the watershed has areas that have severe erosion and significant

Context map

Figure 1.01 | (Produced by author, 2012)

Wildcat Creek is located in Riley County, Kansas and stretches from Leonardville through Riley, Fort Riley, and Manhattan.

amounts of sediment heading into the creek due to firing ranges and tank movement around the creek. Further downstream, the Flint Hills take over as the topographic landscape. This area has more topographical change and is mainly used as grazing land. There are some areas in this land that have channelization or reduced vegetation due to the grazing efforts of the land use. Next downstream, the city of Manhattan surrounds the creek with development and open space. There is significant urban development and impervious surface that increases the runoff and sediment that flows into Wildcat Creek. Lastly, south of the city of Manhattan and beyond the flood walls is farming land that floods easily and on a regularly basis. The land use is all tilled and non-terraced agriculture due to the flat terrain of the landscape. Wildcat Creek travels through a variety of landscapes within the watershed and has multiple components that contribute to the flooding in the Wildcat Creek watershed.



A watershed analysis, based on Dave Rosgen's WARSSS (Watershed Assessment of River Stability & Sediment Supply, 2007) criteria, was completed as a studio design group for the Wildcat Creek watershed. During the first step, RLA (Reconnaissance Level Assessment), the group identified areas of concern that contributed to the flooding based on creek channelization, erosion, historical change, land use, land cover, and vegetation patterns. Selected areas were applied to the individual site analysis in which locations that are best suited for wetlands were identified. The studio design group then proceeded with the WARSSS process and the RRISSC (Rapid Resource Inventory for Sediment and Stability Consequence) and considered the impact of the areas of concern to Wildcat Creek and the Wildcat Creek Watershed. In RRISSC, specific land uses and land covers were used to determine further erosion risks for the channel. Channel features and characteristics were then used to classify the streams and determine changes in the channel. At the end of the RRISSC process, streams were evaluated as to whether or not they should move forward to the PLA (Prediction Level Assessment) to be further analyzed. A portion of the WARSSS assessment can be found in Appendix C and D of this document. The full document can be found here: https://krex.k-state.edu/dspace/handle/2097/13605

Project Boundaries & End Product:

Wetlands: A Flooding Solution project included reducing flooding amounts and increasing the optimal wildlife habitat through creation of wetlands within the watershed scale and within the redesign of Wildcat Creek Golf Course, as the process diagramed in figure 1.02. The first phase of the project was focused on gaining an understanding of the watershed flooding and area wildlife patterns at a watershed scale. Literature on constructed wetlands, wetland ecosystems, and wetland habitats was reviewed. Studies on wetland ecosystems, including how wetlands can detain water and what elements of wetlands are critical to wildlife habitat, were used to determine where wetlands would be most effective within the Wildcat Creek watershed. A GIS document was developed to formulate a greater understanding of the watershed, areas that need help, and locations that were best suited for wetlands. The second phase of the project included a detailed analysis of how the wetlands would best fit into the Wildcat Creek Golf Course. Precedent studies and literature on golf course environments were reviewed and studied. The existing golf course was analyzed to further understand how flooding has historically damaged the property. The quantity of water that has flooded the site was calculated to determine what amount of water needs to be detained in the redesign of the golf course. Habitat qualities of endangered species and strategies for revitalization were also examined. Wildcat Creek Golf Course was then redesigned to incorporate wetlands that hold flood water and encourage wildlife renewal. The existing master plan of the course was generally preserved; however, the revisions allowed for an expansion from a par 30 to a par 36 nine-hole golf course. Wetlands were strategically placed within the course design and on the perimeter to encourage an even dispersion of water resources for flooding and wildlife across the site. The entire project combined watershed planning and golf course design to diminish flooding and grow the optimal wildlife habitat in the area.

The final design and drawings for this project were produced based on the two scales: the watershed scale and the Wildcat Creek Golf Course site scale. For the watershed scale, the end product included a watershed plan with suggested wetland locations, the effect that wetlands would have on the flooding, and the wildlife species that would be enhanced. The wetland locations throughout the watershed were determined based on the site analysis and the types of wetlands that are possible in the Wildcat Creek area. The capacity of the proposed wetlands quantified the effect that the wetlands have on the watershed. Comparisons between the holding capacity and the proposed wetlands provided estimates of the reduction of flooding provided by the wetlands that were placed in appropriate locations for collecting the water. Ecosystem palettes were created to show the relationships between wildlife and their habitats.

Finding wildlife and plant species native to Wildcat Creek that support birds using the area as a migratory stop was critical to defining ecosystem palettes. Information about what comprised the ecosystem and what the habitat (i.e. food, water, shelter, and reproduction) needed to sustain for the future was used to produce a plan for a regenerative environment. Each wetland type was a preferred habitat for specific wildlife species based on the water detention and plant species.

For the site scale at Wildcat Creek Golf Course, a retro-fitting of the course modified the course to control the location of flooding and encourage wildlife use of the area. The general layout of the golf course remained largely intact with a few additions and modifications, but the character and design of each hole was changed to include materials with greater permeability rates and areas planned to address flooding through water detention. The course was extended to a par 34, forcing additions and renovations of the general layout of the course. Wetlands were molded into the existing layout of the course, altering the design and strategy of the holes. The wetlands were connected to the surrounding areas, including Anneberg Park and the development around Little Kitten Creek, to create a system which integrates the collection of water to prevent the golf course from future flooding events. The end product included an overall master plan for Wildcat Creek Golf Course, 9 individual hole designs, grading and planting plans of the wetlands, and calculations for water quantity capacity of the site. The design and drawings at the watershed scale allowed the designer to make informed decisions at the site scale resulting in a broad wetland restoration plan for the watershed as well as a wetland implementation plan at the site scale.

Community Involvement & Stakeholders:

Stakeholders in this project included the Wildcat Creek Golf Course owner, Kevin Fateley, who provided the designer with firsthand memories and experiences of the flooding and how it has impacted the golf course. Hearing stories from those affected by the flooding at community meetings also helped to further develop a better understanding of the dilemma. Nearby residents are in serious need of help to protect their property from further destruction and erosion. Hearing their concerns and learning about the damage that they have suffered further highlights the need to think beyond previous solutions and use new strategies to diminish Wildcat Creek flooding and its damaging effects. In an introductory meeting, Fateley had requested information about how he can restore an area on-site and what the best solution was for the land.

The group's end product that was given to the community was a book of suggestions for resolving flooding issues surrounding Wildcat Creek. The chapter which this author produced included a plan of selected locations where wetlands were recommended and benefits for choosing wetlands beyond reducing flooding. Precedents of other places that have accomplished wetland development and quantities of water capture are critical to building an argument to choose wetlands as a solution. The golf course would be included as an example of how Manhattan stakeholders could merge wetlands with existing features.

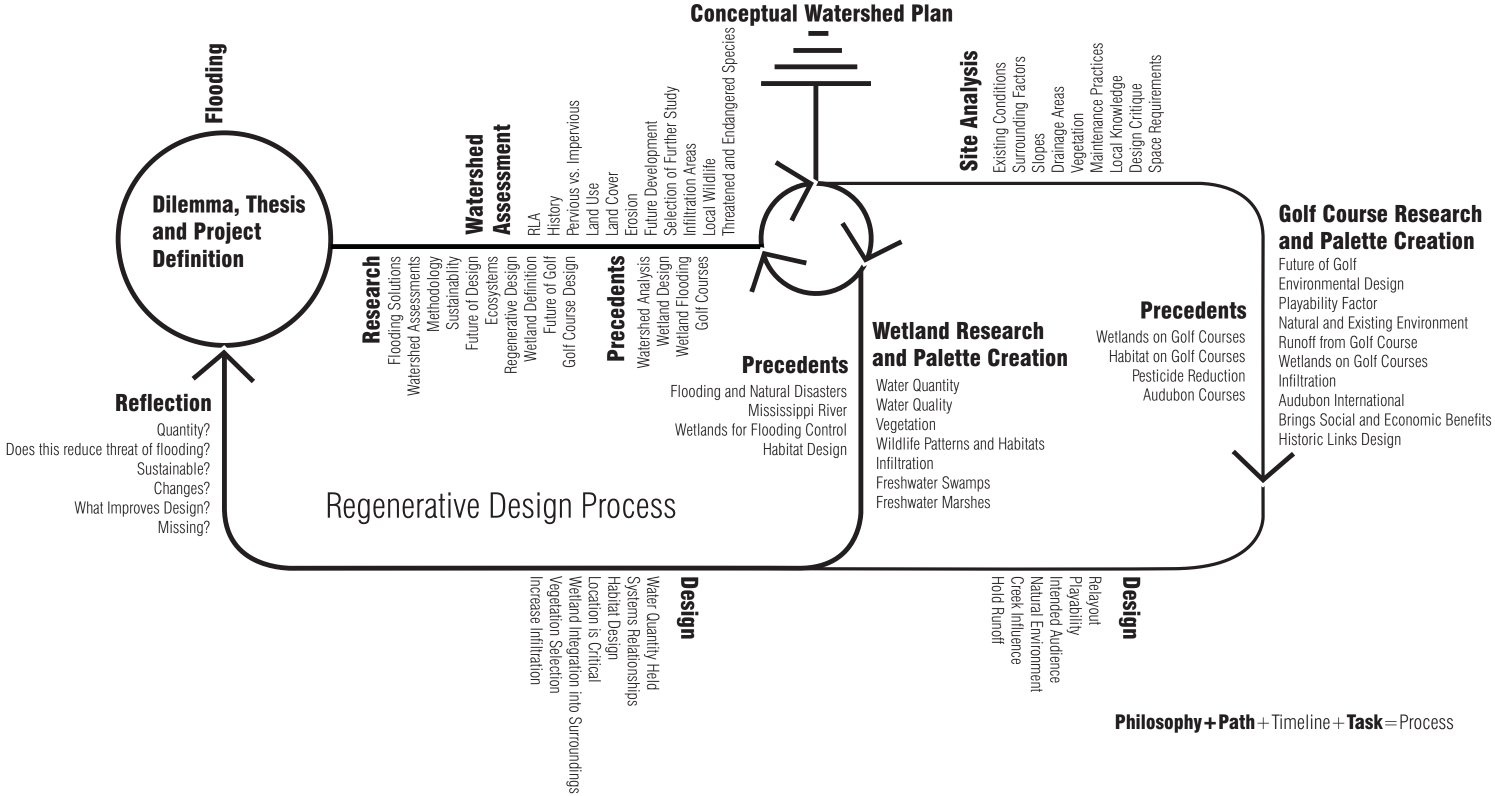
Conclusion:

The purpose of this project is to propose a watershed scale plan identifying where wetland systems would be best situated and redesign the Wildcat Creek Golf Course as one of the wetlands in the watershed using sustainable practices aimed to increase the infiltration rates and reduce flooding and runoff while retaining an eco-friendly environment for wildlife.

Regenerative design process

Figure 1.02 | (Diagram form adapted from John Lyle (1994) with graphic produced by author, 2012)

John Lyle has done considerable research and defining of regenerative systems, his design methodology. Not only was his logic incorporated into the design, but his methods of linking ideas, connecting through time and relying on components to be able to support other components, helps to support how the project process was planned. Each step along the way is influenced by a previous step that helps inform decisions made in the future. You cannot complete one step without going back to it after you understand how the layers fit together to better inform your decisions. It is a cyclical design process that is interconnected to produce a well informed design system.



Philosophy+Path+Timeline+**Task**=Process

Background

Literature and precedent studies were the foundation for the site analysis and design of the watershed and the golf course site.

- Literature
  - Summary
  - Annotated Bibliography
- Precedent Studies
  - Des Plains River Wetland
  - Kankakee Wetlands
  - The Glacier Club
  - Deer Creek Golf Club
  - Bandon Dunes Golf Resort
  - Mannahatta

Literature

Literature Summary + Annotated Bibliography

Common themes:
Wetlands
Ecosystems
Regenerative Thinking
Water Quality
Flooding
Watersheds
Habitat
Golf Design

literature summary

Flooding of Wildcat Creek is a dilemma that can be solved by combining multiple strategies to create a solution. Using a methodology and framework of theoretical thinking is important to bring support of potential solutions to the dilemmas. Lyle (1994) describes regenerative systems as "continuous replacement, through its own functional processes, of the energy and materials used in its operation. (pp. 10)" The stormwater infiltration, runoff, and flooding creates a hydrologic system that needs to be analyzed and synthesized in order to understand how the system can be modified to reduce flooding. The human systems, like development, infrastructure, and agriculture, need to be studied over time to determine what role they play in the change of the hydrologic system. Chambers (2011) explores the reaction, or domino effect, of one system changing all other systems in the area. For example, if you need to get wood to build something, you go back to where the forest was destroyed to get the wood and examine how the wood got to your location and what you are taking away from the environment that you are placing the wood. The wildlife system (ecosystem) of the area should be considered when proposing strategies to increase infiltration and reduce runoff in the hydrologic system. Wildlife species use vegetation as food and shelter. Choosing correct vegetation can help increase the infiltration rates and change the hydrologic system. Alterations in vegetation can also create different environments for wildlife that encourage more diversity and create a healthier home or migratory stop for the wildlife. All of these factors work together within one large system that should be regenerative and react within its systems to have stability rather than shift out of balance causing flooding throughout the region.

Hey and Philippi (1994) made concerted efforts to restore wetlands along the Mississippi River in order to prevent flooding in the future. Wetlands can be added into Lyle's theory of regenerative systems to balance the system and improve its components and layers. In *Wetland Ecosystems*, Mitsch, Gosselink, Anderson, and Zhang (2009) explain wetland systems as being comprised of water quality, water quantity, and vegetative/wildlife environments. The wetlands' ability to hold water and increase infiltration in their water quantity can significantly change the flooding system. Quality measures can be utilized to clean the water and reduce sediment and erosion flow from entering the river. Rosgen's (2006) WARSSS (Watershed Assessment of River Stability and Sediment Supply) process along with other watershed assessment strategies focus more on the cause of the erosion and sediment flow. Areas of higher erosion and sediment loss can be slowed by the placement of wetlands in that area. The environmental component of wetlands includes wildlife and human aspects. As mentioned above, vegetation choices can increase the infiltration and create a more dynamic area in which people can interact.

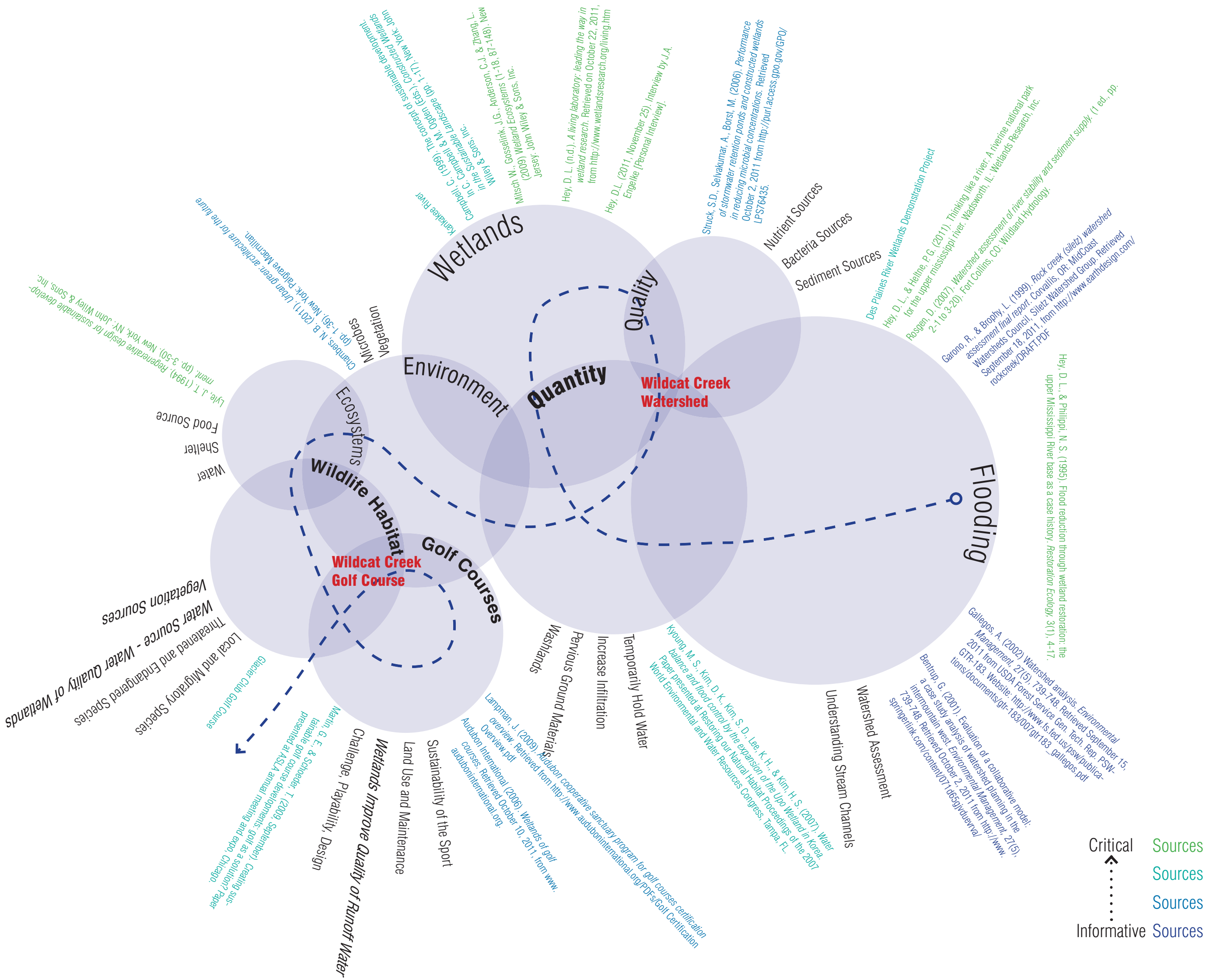
Mitsch et al. explains the vast numbers and types of wildlife that use wetlands as their homes. Mammals, birds, fish, and amphibians all play roles in having a healthy ecosystem. They are either providing food for other wildlife or eating the vegetation to keep the amount of vegetation in line or balanced. Vegetation types serve as shelter and food for the wildlife and as sources to absorb water instead of a source which increases runoff and sends water downstream. Hey (2011) begins by explaining how the systems have worked together in his experimental wetland in the Des Plaines River Wetland near Wadsworth, Illinois. Although the type of wetland varies from what would be found in Kansas, the wetland serves as a quantitative example of what wildlife use the wetland as home and how the systems come together to support each other and create a regenerative system.

One human system that could be meshed and molded into the solution for flooding is golf courses. Martin and Schoeder (2009) explored how to use the game of golf as a solution to the problem of unsustainable landscapes and as a means for improving the environment, economy, and social atmosphere. Golf needs to abandon its pictorial images and return to the flow of the course into the environment, similar to those that originated in Scotland with the links course style. The flowery, high maintenance golf courses (e.g. Augusta National) are not practical due to the high maintenance costs, high water usage, and low ecosystem development. Links style golf courses offer a natural aesthetic and design that is incorporated into the existing, natural landscape. Conservation areas are incorporated into other golf course designs to decrease the daily maintenance of a golf course and increase the wildlife habitat (Whitten, 2008). Audubon International uses wetlands, a type of conservation area, to evaluate golf courses and help landscape architects to enhance golf course designs by creating solutions to environmental problems (2006). Golf course architects are challenged by owners and critics to design courses that are viewed as a helpful component in the ecosystem instead of as a burden or detrimental factor.

Literature map

Figure 2.01 | (Produced by author, 2012)

The literature map shows the path research is taking within the project. Beginning at a large scale with the Wildcat Creek watershed, flooding, and wetland opportunities then narrowing the research to Wildcat Creek Golf Course, design, and wildlife. The path is looping and interconnected to bring all resources together.


Wetlands
Environment
Quantity
Quality
Ecosystems
Wildlife Habitat
Golf Courses
Flooding
Wildcat Creek Watershed
Wildcat Creek Golf Course
Nutrient Sources
Bacteria Sources
Sediment Sources
Vegetation
Microbes
Food Source
Shelter
Water
Vegetation Sources
Water Source - Water Quality of Wetlands
Threatened and Endangered Species
Local and Migratory Species
Challenge, Playability, Design
Wetlands Improve Quality of Runoff Water
Land Use and Maintenance
Sustainability of the Sport
Washlands
Pervious Ground Materials
Increase Infiltration
Temporarily Hold Water
Understanding Stream Channels
Watershed Assessment
Des Plaines River Wetlands Demonstration Project
Kankakee River
Glacier Club Golf Course
Critical Sources
Sources
Sources
Informative Sources

annotated bibliography

ASGCA. (2009). Golf and water. *By Design*, (1), 16-17. Retrieved from http://www.tudor-rose.co.uk/bydesign/By Design - Issue 1, Winter 2009.pdf

Golf is played in an outdoor environment, so water and rain is a part of the sport. Golf courses will also have an "effect of the environment (ASGCA, 2009)." The article talks about the golf architect's need to understand water and the environment, then plan the golf course within the existing, natural environment. Water can be involved in eight ways: water recycling, bio-filtering, irrigation technology, water harvesting, wetlands, naturalization, turf grass science, and drought ready areas.

This article suggests adding wetlands and naturalized areas to golf courses. Both do not require daily heavy maintenance while slowing and reducing runoff of stormwater. The wetlands and drought ready areas are able to be drought tolerant. Courses need the ability to be ready for heavy rains and drought periods to react to the weather conditions at that moment in time.

Audubon International (2006). *Wetlands on golf courses.* Retrieved October 10, 2011, from http://www.auduboninternational.org/PDFs/WQM-Wetlands%20on%20Golf%20Courses.pdf.

Audubon International published a Fact Sheet addressing questions about use of wetlands on golf courses. Wetlands are defined and evaluated by vegetation, soils, and hydrology. Observing these variables through on-site observation is critical to determining the health of the wetland. The wetland boundary is an important aspect of how the wetland fits into a golf course. Wetlands have restrictions and regulations that need to be maintained and that differ from typical golf courses. Wetlands offer opportunities for wildlife habitat, challenging course conditions, and, most importantly, water quality for the course and surrounding area.

This source provides basic information from Audubon International. It would be worth looking more at the criteria and policies that they specify to further identify the requirements of wetlands and the water quality requirements for sites.

Campbell, C. (1999). The concept of sustainable development. In C. Campbell & M. Ogden (Eds.), *Constructed Wetlands in the Sustainable Landscape* (pp. 1-17). New York: John Wiley & Sons, Inc.

Constructed wetlands are most effective if applied at the point source rather than in a traditional, centralized manner. A wetland's main priority is to remove chemicals from the water and clean the water. Wetlands can be very beneficial to sustainable landscapes. Initially, this book illustrates how wetlands can work with permaculture (i.e., permanent agriculture) to create healthy and vibrant crop land. It continues to examine measurable aspects of wetlands, and notes that the aesthetic value is important and constantly changing as time passes. In a discussion of current practices, authors such as McHarg, Tourbier, Lyle, and Thayer are suggested for further development of philosophy, methodology, and precedents about sustainable landscapes.

When studying wetlands, this source could be a very useful. The chapter outlines accurately describe the content covered within the book.

Chambers, N.B. (2011). *Urban green: architecture for the future* (pp. 1-36). New York: Palgrave MacMillan.

Chambers argues that any building (green or not) is destructing our environment. Everything that is a part of building, whether it is the iron needed to make nails or the forests being leveled to have wood, affects other things. Any building is defined as anything that destructs the natural ecosystem (e.g., buildings, roads, water pipelines, electricity circuits). Everything has a lifecycle and should be used to its fullest life cycle. Green building is currently being used to monitor energy and water, but Chambers suggests that it should be much greater than this. He believes current practices are hurting the greater ecosystem rather than helping. In addition, designers, contractors, and engineers are ruining the ecosystems, and it should be closely analyzed by conservation biologists as a way to save the land and prevent natural disasters and endangered species.

The beginning of the book may not be helpful to scientific research, but could help develop theory behind someone's project. The later chapters in the book give more examples and precedents that may be useful.

Forman, R.T.T. & Godron, M. (1986). Landscape ecology. New York: John Wiley & Sons, Inc.

Forman has done considerable research on wildlife habitat and ecosystems that are created in the landscape. Forman looked to patches, corridors, and networks as ways to demonstrate and categorize wildlife habitats. The closer the patches are in proxmity, the better the wildlife habitat. Creating corridors for wildlife helps to form long, continuous places for species to travel without breaks while networks create homes for wildlife to benefit from the assets of the habitat and ecosystems. Forman also states that more sinuosity of the edges creates more habitat and diversity for the species.

Forman's research and categories could be helpful in determining wildlife habitats and evaluating the habitats that are created from wetlands in Wildcat Creek.

Gillihan, S. W. (2000). *Bird conservations on golf courses: A design and management manual.* Chelsea, MI: Ann Arbor Press.

Birds and golf have benefits that help each other be the best they can be. In many urban environments and golf course developments, the golf course may be one of the only habitats left for the birds. If the land would have been developed into housing or other development potentials, the birds wouldn't have anywhere to go. Gillihan uses patches, edges, and corridors to demonstrate how habitats can be incorporated into the golf course design. By considering the type of development and initial routing of the course, golf architects can create larger habitats that benefit birds and other wildlife in natural areas. According to Gillihan, a bird habitat has four components: "food, water, shelter, and nest area (2000)."

The book offers benefits to golfers and birds for creating natural habitats on golf courses and gives a positive impact of golf courses

on the environment. There are examples of how patches, edges, and corridors can be incorporated into the design. Designing with these conditions is critical to creating a golf course that is beneficial to the environment and its surroundings. At the end of the book, there is an extensive list of birds that are compatible on golf courses. The list of birds gives their breeding habitat, territory requirements, food sources, and nesting habitat.

Hey, D. L. (n.d.). *A living laboratory: leading the way in wetland research.* Retrieved on October 22, 2011, from http://www.wetlandsresearch.org/living.htm

In 1979, Hey and other nationally-recognized experts formed the Des Plaines River Wetland Demonstration Project to facilitate quantitative research on wetlands. Today, their wetland serves as a study site for multiple researchers and has proven to be an effective habitat for many birds and wildlife. The wetland was initially created to test the idea that natural landscapes can be used to solve flooding and water-related problems, a concept supported by the Corps of Engineers and US EPA's Section 404 of the Clean Water Act. Over the years, the wetland has proven to not only be a water filter, but it has become a sanctuary for wildlife that has provided opportunities for experts to study the structure of the wildlife habitats.

This source will become an effective precedent study for me in the future. The wetland is established and has data to support the researcher's findings. The site also directs you to more articles on specific studies that have been conducted on the Des Plaines River Wetland.

Hey, D.L. (2011, November 25). Interview by J.A. Engelke [Personal Interview].

Dr. Hey provided an historical perspective of the Des Plaines River site describing how 100 acres of wetlands were added to 450 acres that were reconstructed. He emphasized that a system of wetlands is needed to allow for areas of flooding and natural changes. He stressed that lifecycle must be clearly understood to shrink or grow a species. For example, carp must be eliminated from the ecosystem in a natural way so as not to kill other fish.

Dr. Hey further discussed the financial challenges of wetlands. Dr. Hey explained his incentive for people to have wetlands (e.g. A Riverine National Park for the Upper Mississippi River). He made recommendations of different opportunities to explore and recommended the following resources and references.

Hey, D. L. *A riverine national park for the upper mississippi.* Wadsworth, IL: Wetlands Research, Inc.

Hey, D. L. (2011). *Des plaines river wetlands demonstration project* 1983-2011 progress report. Wadsworth, IL: Wetlands Research, Inc.

Hey, D. L., & Heltne, P. G. (2011). *Thinking like a river: A riverine national park for the upper mississippi river.* Wadsworth, IL: Wetlands Research, Inc.

Hey, D., Kostel, J., & Montgomery, D. (2009). An ecological solution the the flood damage problem. In Criss & Kusky (Eds.), *Finding the Balance between Floods, Flood Protection, and River Navigation* (pp. 73-79). Saint Louis, MO: Center for Environmental Sciences at Saint Louis University.

Tandarich, J. P., & Vepraskas, M. J. *Changes in soil properties of created wetlands used for stormwater retention.* River Grove, IL: Wetlands Research, Inc.

Wetlands Research, Inc. (Director), & Ceisel & Associates, Inc., (Producer) (n.d.). *Growing wetlands for clean water* [DVD].

Hey, D., & Philippi, N.S. (1995). Flood reduction through wetland restoration: the upper Mississippi river base as a case history. *Restoration ecology*, 3(1), 4-17. Retrieved on September 18, 2011, from http://www.springerlink.com/content/071d65gjvduevrva/.

The history of controlling river flooding can teach us a great deal about how we should handle flooding in the future. The authors used the Mississippi River as an example of how flooding was viewed at the time, noting when settlers first arrived on the land they found many similar conditions. Levees were put in place years ago, but they can only grow to a limited extent, so our challenge today is to learn how to deal with the water where it lands and try to manage the water in those locations to minimize large scale flooding. When levees were first put in place, the beaver habitat was destroyed causing beavers to become endangered in Illinois. (Although if you were Chambers, that would be a good thing.) At present, soil types can help determine where water will be held and which locations are appropriate for wetlands. Analyzing existing conditions and practices can help avoid major damages and flooding in the future.

This article is calling for change. The authors make some valid points about how to improve wildlife habitats, restore wetlands, and reduce flooding. A next step would be to propose and implement the suggested changes to existing infrastructure to study their actual influence on reducing flooding.

Korfmacher, C. V. (2011, November 23). Interview by J.A. Engelke [Personal Interview].

Korfmacher described science and design are incorporated to complete AES projects throughout the country. He highlighted work related to restoration, habitat and ecosystems, flooding projects, and flooding problems. Precedent studies were also discussed. Korfmacher described a few of the projects AES has done that involved river and wetland restoration. There were different ways and types of restoration that he recommended. He also suggested not forgetting the social/human aspect of wetlands and the project. Not a lot can get done without hearing and understanding the community to gain support. Projects he recommended were:

Seneca Meadows Landfill, Upstate New York

Kankakee River, Indiana

Shorewood Hills, Wisconsin

Kenosha, Wisconsin

Kyoung, M. S., Kim, D. K., Kim, S. D., Lee, K. H., & Kim, H. S. (2007). *Water balance and flood control by the expansion of the Upo Wetland in Korea.* Paper presented at Restoring our Natural Habitat Proceedings of the 2007 World Environmental and Water Resources Congress, Tampa, FL.

The article refers to a model built to study the Upo Wetland in Korea, an actual region comprised of 4 separate wetlands that merge during flood season. The article examines adding washlands to wetlands as a way to control flooding. Washlands are open spaces that are created for habitat and can be used for flood overflow, like an undeveloped floodplain. The results revealed that individual washlands were not effective, but by combining multiple wetlands the flood control effect was increased and helpful in the 100 year flood level. The washlands minimized downstream effects and created ecological connections for habitat development. The washlands were connected to wetlands and the rivers by weirs (i.e., small overflow dams). The weir height can be helpful in determining how much water ends up in the wetland and eventually the river.

Washlands are one solution that could be incorporated into the flooding solutions. Finding locations for washlands and what impact they might have would be important. Also, taking a look at how the researchers conducted these studies and constructed their models would be beneficial to future models we apply to Wildcat Creek.

Lampman, J. (2009). *Audubon cooperative sanctuary program for golf courses certification overview.* Retrieved from http://www.auduboninternational.org/PDFs/Golf Certification Overview.pdf

The ACSP (Audubon Cooperative Sanctuary Program) creates a way to quantify and encourage improving environmental aspects on golf courses. ACSP focuses their efforts on "Environmental Planning, Wildlife and Habitat Management, Chemical Use Reduction and Safety, Water Conservation, Water Quality Management, and Outreach and Education (pp. 1)." This is the golf version of Sustainable Sites Initiative (SSI) or LEED accreditation.

From my own observation of some Audubon certified courses, I would question how they are truly adding positive environmental elements to the course and not just counting the birds they find on the course. I think it would be easier to quantify and encourage improvements with courses that were designed with the environmental aspects in mind rather than to reclassify a course that didn't have sustainable practices originally incorporated into its design. It is a start to having some attempts to improve the environment, but as LEED and the SSI have gotten more sophisticated over time, there will also need to be modifications made in the future in the ACSP plan.

Lawrence, A. (2010). Weathering the storm. *By Design,* (4), 14-15. Retrieved from http://asgca.org/images/stories/by-design/By-Design-Fall-2010.pdf

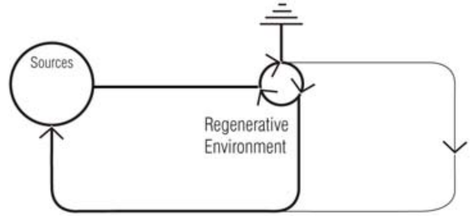
Golf courses offer an opportunity for a place for water to go in urban environments. There is potential for golf courses to be used as reservoirs in time of need. "If a golf course floods, it's bad news for golfers – but if a town centre floods, it is bad news for all inhabitants! (Lawrence, 2010)" The golf course offers a place for the water to go and the course can be designed to accommodate the water as necessary in flooding events. Natural stormwater drainage is key to the design and consideration of a golf course, especially in an urban environment.

This article offers a few precedent study options, like Dubsdread municipal course in Orlando, FL and Deerpath golf course in Lake Forest, IL, that were redesigned to accommodate flooding from surrounding development. The article gives support to allowing flooding on golf courses and designing the golf courses to control where the water is trapped and traveled across the course. The commentary talks about other water issues golf courses have and how wetlands are often solutions to the problems.

Regenerative systems

Figure 2.02 | (Lyle, 1994)

Lyle based all processes on the regenerative system. He had a diagram that demonstrated his definition of a regenerative environment.



Lyle, J. T. (1994). *Regenerative design for sustainable development* (pp. 3-50). New York, NY: John Wiley & Sons, Inc.

"A regenerative system provides for continuous replacement, through its own functional processes, of the energy and materials used in its operation" (p. 10). When everything functions like an ecosystem, an ecosystem has all the requirements needed to survive and thrive in the environment. The same is true with the regenerative system. It is a way of feeding itself and eventually giving back to the original sources.

Lyle discusses the role science plays in designing and gives suggestions to how we can produce regenerative designs. His initial suggestions include "letting nature do the work" and seeing how nature can be a support system as well as the subject you are studying.

Lyle gives a great perspective and definition of design theories to be thinking of and considering. Although his book was published in 1994, I believe the information is still relevant to ecosystem design and could be used as a framework for the project.

Martin, G. E., & Schoeder, T. (2009, September). Creating sustainable golf course developments: golf as a solution? Paper presented at ASLA annual meeting and expo, Chicago.

Golf courses began in Scotland as something that fit into the environment. As they shifted to the U.S., we became more concerned with what the course looked like, making it green, creating challenges, and developing photographic masterpieces. Golf can be viewed as an economic, cultural, environmental, and aesthetic solution. Skillful golf course design practices have the potential to bring generations together, create an open environmental space that protects habitats, utilize science-based best management practices, and serve as means of controlling flooding in the surrounding area. Golf course design can be the solution to the problem and not a limiting destroyer of the environment.

The author did not see the presentation at the conference, but the information and way they told their story in the power point helps to formulate a problem and shape ideas in ways that create a solution. The manner in which they constructed their argument could be helpful in creating a convincing argument of the project. They also provide some good precedent studies for flooding solutions.

Mitsch W., Gosselink, J.G., Anderson, C.J. & Zhang, L. (2009). *Wetland Ecosystems* (pp. 1-18, 87-148). New Jersey: John Wiley & Sons, Inc.

Mitsch et al. gives an excellent introduction and explanation to wetlands. They are comprised of a physiochemical environment (e.g., soil, chemistry and water quality), hydrology (e.g., water level flow, frequency and water quantity), and biota (e.g., vegetation, animals, and microbes). All of these elements work together to form a wetland ecosystem. Within the wetland typology, the freshwater swamp and marsh would be the most applicable to Kansas. These wetlands are non-tidal systems with low sediment build up. Wetland ecosystems include plant species that do well in aquatic environments as well as keystone species that are common in wetlands. Specific wildlife that typically exist in a wetland ecosystem are listed. The book provides a great basis for wetland formation and components within a wetland system. The authors also reference another book, Wetlands, which would give more technical and advanced information.

Phillips, K. (2012, February 3). Interview by J.A. Engelke [Personal Interview].

Phillips was the golf course architect of Deer Creek Golf Course in Overland Park, Kansas. Phillips explained the design thought process that went into designing Deer Creek Golf Course and Prairie View Golf Course. The courses were designed around a creek or river and are intended to create more stormwater storage capacity for the creeks. Small parts of the creek were re-naturalized while building the course, yet larger manicured areas still remained on the golf course. The valleys were used to develop the course, preserve the creek, and keep housing away from the floodplain. The course and naturalized areas were used to define edges and minimize the impact of flooding. The housing was intended to be kept on ridgelines and away from any flooding potential. Deer Creek Golf Course was designed without changing the main flow of the creek and while utilizing the topography to maximum potential.

Deer Creek Golf Club is a precedent study and can be comparable to Wildcat Creek Golf Course in Manhattan, Kansas. The courses both have creeks that are integral to the design of the course. Phillips is the source of information about the creek, since he designed the course. There is not extensive literature on Deer Creek Golf Club, so the designer is the source of information on history and design methodology.

Rosgen, D. (2007). *Watershed assessment of river stability and sediment supply.* (1 ed., pp. 1-1 to 4-74). Fort Collins, CO: Wildland Hydrology.

Rosgen developed the Watershed Assessment of River Stability and Sediment Supply, or WARSSS series, to "(quantify) the effects of lands uses on sediment relations and channel stability (1-1)." This process will be used to analysis the Wildcat Creek watershed and pinpoint concerns within the watershed. The Reconnaissance Level Assessment (RLA) and Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC) of the assessment was completed to examine the erosion processes and effects of "land and river management changes" (3-1) as well as locates problem areas for further evaluation and recognition of fixing in the future.

Understanding the steps of the RLA process is critical to completing an analysis of the watershed, the initial phase of understanding Wildcat Creek. Learning how the history has affected the watershed and what role it may have played to the flooding is essential to finding solutions and fixing the dilemma.

Whitten, R. (2008, November). Big mac, little greens and wide-open spaces: The shape of course to come. *Golf Digest*, 130-146.

The future of golf course design involves reflecting on the history of what the greats, like C.B. MacDonald, did in the initial courses that were designed. MacDonald's theory was "Rake ideas from great old golf holes – a bunker from one course, a green complex from another, a tee-shot configuration from a third – and put your spin on them (Whitten, 2008)." The style is much closer to a links style and finding the land is the most important part of building a course. The courses are looking for low maintenance, less manicured areas and more natural appearances. The courses are not clearing trees to build the courses but finding holes within the land that already exists. The Augusta National style courses are no longer popular due to the maintenance, cost, tree dominance, and artificial look that was created. During America's golf boom, courses were built to increase tourism and housing prices. Today, the goal of a golf course is not the land value, but the experience the golfer has on the course. The golfer looking for strategy and a variety of ways to play a hole will bring someone back to keep trying it different ways until they find the best way to play the hole.

The article talks a lot about the future of design and different strategies that are used to design courses. The common trends are talked about and historic, classic holes are demonstrated to give you an idea of what is considered extremely good by other people. The article does not talk specifically about wetlands, but it does talk about design and designing with the environment.

Precedent Studies

Places across the county had flooding issues in the past and used wetlands at a large scale for a flooding solution. The studies are compared to Wildcat Creek in Manhattan, KS. There are also studies that look to the methodology used to complete the study.

Des Plaines River Wetlands Demonstration Project
Kankakee River Marsh
The Glacier Club
Deer Creek Golf Club
Bandon Dunes Resort
Mannahatta

des plaines river wetlands demonstration project

Date: 1970's – 1989 with research continuing today

Location: Des Plaines River, City of Wadsworth, Lake County, Illinois (Northeastern Illinois)

Reason to Choose the Precedent: The study was designed to provide quantifiable evidence as to the effects of a wetland. Researchers (university scientists) are continually using the site as a foundation/springboard for more research and published papers.

Context (Relation to River and Surrounding Open Space): The wetlands are adjacent to the river and appear to be a part of a greater open space plan for the Des Plaines River. There are preserves and adjacent forests from the Wisconsin boarder down to Interstate 55, south of the city, as shown in figure 2.03.

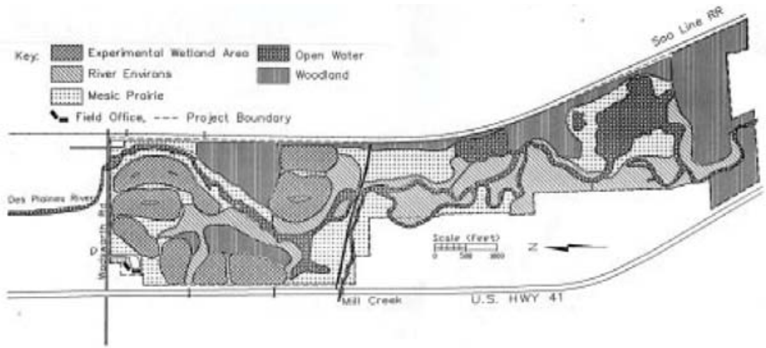
History: Lake County faced serious flooding damage, "$40 million in 1986 (Hey, n.d.)", and used the wetland restoration as a way to measure if flooding has changed. The restoration process began in 1986 completing 22 acres by 1989, followed not long after by an additional 28 acres. The land was originally farm land, but deemed unworthy to continue as such.

Methodology: The process of implementing the research wetland began with a feasibility study. After a few years, public funds and federal grants allowed the researchers to begin the implementation phase. In 1991, they added 28 acres of habitats which helped them to establish a "vigorous research program" (Hey, n.d.). Through the wetlands, researchers have learned that the water and sediment levels were "below the threshold of the assimilative capacity of the wetlands" (Sather, 1992). The sediment levels of the water were compared in different areas and determined that they were worst in open water area. Vegetation is being studied in a variety of ways, and it has been determined that water quality appears to be better controlled with higher flood amounts. The vegetation choices do not seem to affect the amount of infiltration in this study.

Successful? Why? How?: The goal of the demonstration project was designed to provide quantifiable research. Scientists have been able to study the wildlife habitats and increase the habitat for 5 endangered species in Illinois and up to 16 endangered species from surrounding states and on a federal level (Hey, n.d.). Researchers continue to study the effects of wildlife habitat and water quality in the wetland and the region. Wetlands appear to have helped when flooding occurred this past summer in the surrounding area of Wadsworth. Although there is no scientific data to support this claim, images from the flooding coverage suggest that the presence of wetlands were a reason that flooding wasn't prevalent in Wadsworth, but still very prevalent downstream, closer to Chicago.

Improvements, Suggestions, and Questions: Can numbers be put to the flooding (or lack of flooding) to quantify the help of wetlands in the area? The official boundaries of the wetland seem unclear due to a large string of preserves that begin in Wisconsin and extend down to Interstate 55. What size wetlands hold the most water while having a high infiltration rate? All wetlands, preserves, and research appear to be adjacent to the river. Are there other areas within the watershed that could be restored to wetlands that would create more wildlife habitat and help to reduce flooding? It is interesting how much of the wetlands are in the floodplain. There is not much floodplain beyond the wetland locations. This allows the property damage to private structures caused by flooding to be greatly reduced.

Conclusions and Relationship to Wildcat Creek and Manhattan: The Des Plaines River Wetlands Demonstration Project is a long-term example of how wetlands can provide habitat and increase the diversity of species found in the area. The wetlands prevented damaging flooding to the immediate area this past summer. If we could implement a wetland system similar to that in Wadsworth, we could potentially eliminate some of the flooding that is seen along Wildcat Creek. Keeping a stream and system in multiple areas within the watershed should reduce runoff from many areas. A watershed comparison between the precedent and Wildcat Creek is shown in figures 2.08-2.11.



Wetlands site map

Figure 2.03 | (Hey, 2011)

The location of the research wetlands are concentrated just north of Wadsworth, Illinois. Part of the research wetlands component is that there are 5 different types of wetlands that are being studied and monitored. The different types are dispersed across the land. Image: Not To Scale

grand kankakee wetlands project

Date: Currently on going restoration project

Location: The portion of the Grand Kankakee River that the marsh refers to is between South Bend, IN and the Illinois/Indiana State Line. The width varies between 1 to 15 miles along the river.

Reason to Choose the Precedent: The precedent talks about the development and other conditions that damaged the wet prairie environment initially. Here in Manhattan, we have had similar issues with building of infrastructure that has reduced the prairie habitat. The environmental conditions and type of wetland are also similar to what could be proposed for the Wildcat Creek and its surroundings.

Context (Relation to River and Surrounding Open Space): The marsh is adjacent to the river and is used as a flooding overflow. The width of marsh varies along the river. It is never less than 1 mile wide.

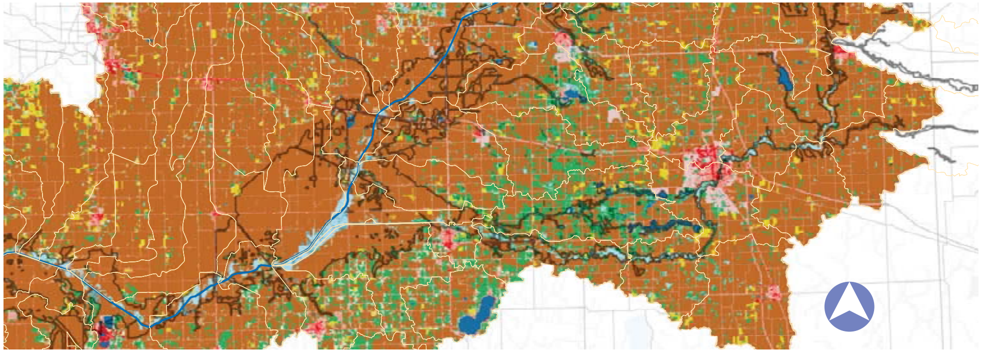
History: The marsh began as 500,000 acres of pristine marshland in the 1800's. It initially "supported a local economy that was built around water flowing and fur trade ('Indiana grand kankakee')." In Ira Fry's historical essay, The Kankakee, there is mention of "deer, buffalo, partridge, grouse, prairie chicken, passenger pigeons…ducks, geese…pike, bass, channel and bank catfish, many varieties of panfish, the American or native carp, also dogfish" and other wildlife. During the 1880's-early 1900's, infrastructure and development began causing the marsh to be dug up, drenched and ditched and subsequently eliminating the ecosystem and habitat homes in the area. A majority of the land had been used for agriculture, as shown in figure 2.04. In recent years, The Indiana Grand Kankakee Marsh Restoration Project have worked to restore part of the marsh and declared 30,000 acres a National Wildlife Refuge to help preserve the wetland and prairie habitat in the future. There are many plant and wildlife species that are reliant on the marsh as a home. (Sweeney, 2001)

Methodology: The restoration project is buying land from willing sellers or collecting donations of land in order to restore the land to its "original, natural wetland and upland conditions to the extent practical ('Indiana grand kankakee')." The land becomes federal or non-profit agency land and will be preserved in future years. It became important to have habitat serve as the driver of the conservation efforts to bring back waterfowl and other wildlife to the area.

Successful? Why? How?: The restoration project is getting wildlife back to the area and re-establishing a healthy ecosystem. Area is being set aside and preserved to insure that the land will remain in its restored state. The landscape cannot be overtaken in the future, and there are barriers set up to insure that development and infrastructure will not impede the ecosystem growth.

Improvements, suggestions, and questions: There is not much documentation on the scientific changes to this area. Also, it is hard to match dates to when the restoration occurred. It appears that many of the smaller restoration efforts were within the last couple of years due to significant flooding in 2008 and 2009, and today the project continues to expand the restoration efforts.

Conclusions and Relationship to Wildcat Creek and Manhattan: The marsh has a vast landscape acreage that far exceeds the size of Wildcat Creek, but it is the large scale and different locations that prompt the precedent study. A comparable sized river would be the Kansas River, which would put Wildcat Creek comparable to a main tributary of this river. The ecosystem as a wet prairie and marshland could be applicable in areas of Manhattan, especially with the prairie being a major part of the landscape and ecosystem that already exists in the watershed. The way that they went about buying out people or accepting donations for land that would be preserved by non-profit organizations or the federal government shows one way that the structural damage of buildings could be altered. A watershed comparison between the precedent and Wildcat Creek is shown in figures 2.08-2.11.



Land use map

Figure 2.04 | (USDA NRCS, 2011)

The land use of the northwestern portion of Indiana shows the amount of agricultural land that inhabits the area. The land use shows possibility for restoration in the area. The land use also shows the amount of potential sediment caused from agriculture and tillage. The upper portion of Wildcat Creek watershed has a significant amount of agriculture that create a correlation between the Kankakee River and Wildcat Creek. Image: Not to Scale

the glacier club

Date: Opened July 2004

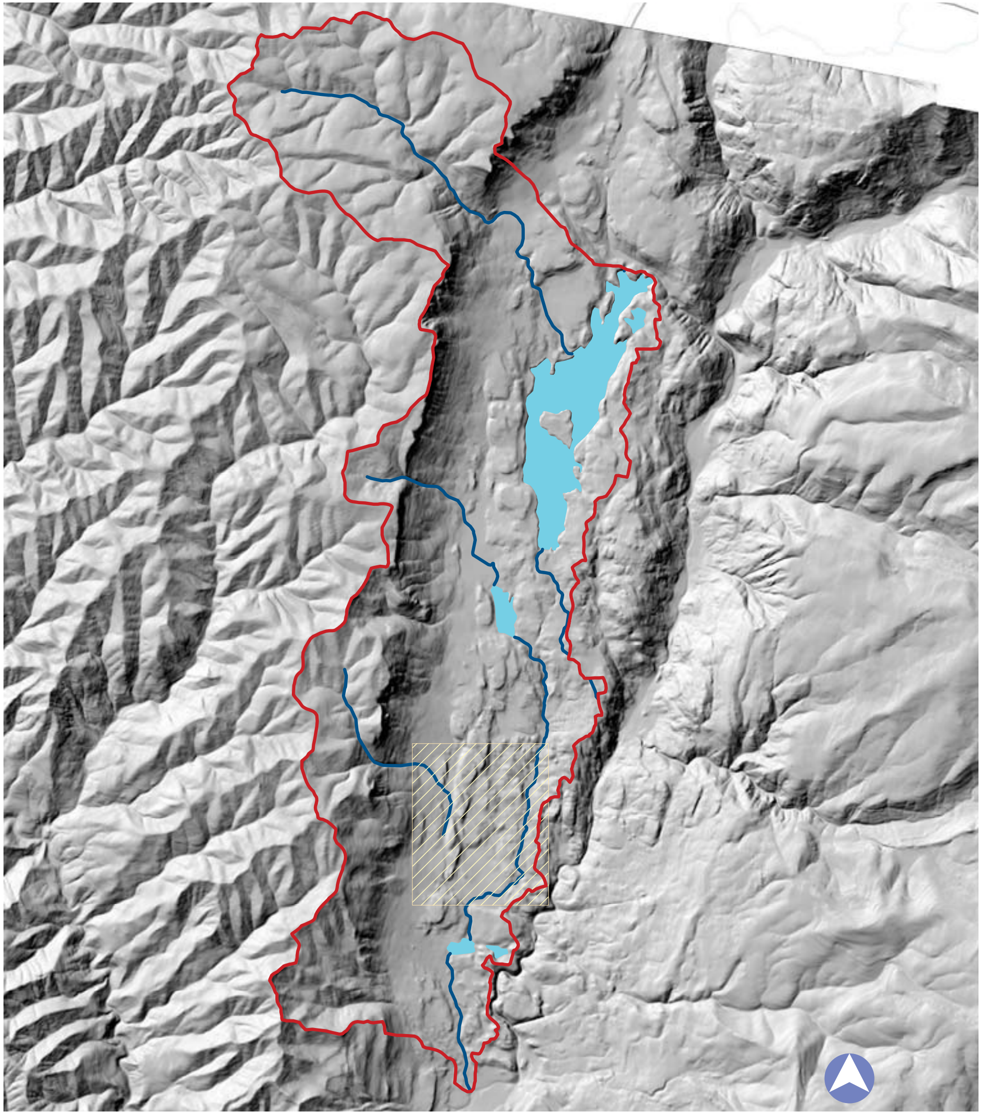
Location: 20 miles north of Downtown Durango, CO within the San Juan National Forest in Southwestern Colorado

Reason to Choose the Precedent: The golf course has been admired by many for how the designers considered the environment when remodeling and adding to the course. The course master plan was considered in 5 classifications: wetlands, forest, uplands, golf course, and residential. The course is considerate of the wildlife in the area and has specific practices in place to retain the pristine habitats that were created.

Context (Relation to River and Surrounding Open Space): A small creek does go through the golf course, as seen in figure 2.05, and has wetlands that are attached to the river, but it is not the highlight of the course or the reason the course was chosen.

History: The course was originally designed in 1975 by Arthur Hills. The course and grounds went through many ownership changes which resulted in the care lacking and people not keeping up with the course condition. In 2001, the property was once again sold to a new owner, and they decided to remodel the course, add a new 9 holes, new clubhouse, and other resort features. Based on the designer they choose, there were sustainable water principles, wildlife habitat consideration, and environmental connections across scales that were implemented and used to drive the design of the course. (Design Workshop, 2007)

Methodology: The designers thoroughly considered the environmental and aesthetic concerns of the golf course. The firm that worked on the project is founded on four pillars: social, economic, environmental, and artistic needs. Some people feared that by adding another nine holes to an already existing true 18-hole mountain course it may “soften the dramatic experience of the site too deeply.” (Design Workshop, 2007). The design was guided by the terrain and ecosystem of the site. As the design progressed, a series of a variety of types of bmp’s were implemented into the course to address stormwater issues. Those bmp’s were helped by “(structuring) the entire course with an underlayment of 8 inches of sand.” (Design Workshop, 2007) The “course drainage sand” increases infiltration levels and reduces the everyday runoff from the golf course.



The glacier club hillshade

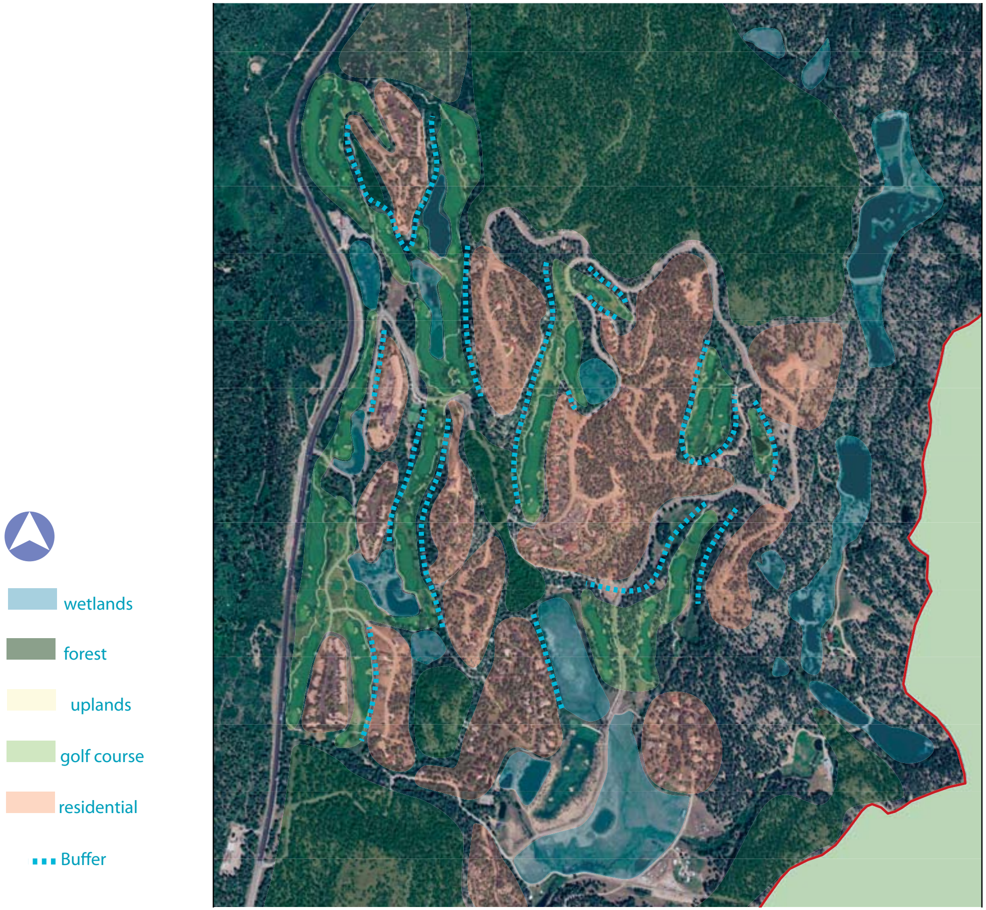
Figure 2.05 | (Produced by author, 2012):

The hillshade of the watershed that the Glacier Club resides in shows the topography and mountain conditions that are found in Durango, Colorado. The site of the golf course is outlined in yellow. The hillshade shows the significant topography difference compared to the Wildcat Creek watershed. The corridor and watershed are still used as wildlife connectors in the area.
Image: Not To Scale

Successful? Why? How?: They were successful in considering how the site fits into the existing conditions and were able to preserve as much forest as possible, ultimately creating fire breaks, that could help slow the spread if a forest fire were ever to occur, by "clearing out underbrush that would fuel the fire" (Design Workshop, 2007). The course also allowed migration corridors to be opened for wildlife. There were over "43 acres of wetlands" on the original site that they worked hard to save. Only, under 1/3 of an acre of wetlands was actually disturbed and 8 acres of wetlands were constructed to increase the total wetland capacity. The course appears to have hired a superintendent who is concerned about the environment, creating habitat and maintaining the course in good condition for everyone (Rodebaugh, 2011).

Improvements, Suggestions, and Questions: The course and environment appear to be making a great impact on the environment, but I would wonder what effect or requirements are in place for the residential housing that is planned, as seen in figure 2.06. What impact has the golf course had on separating the wildlife habitats? Is there a concern about the human interaction with the environment they set up?

Conclusions and Relationship to Wildcat Creek and Manhattan: The terrain and topography of the site is vastly different from Wildcat Creek Golf Course. The Glacier Club is located in the San Juan National Forest, has existing wetlands on site, and is a true mountain course. Although Wildcat Creek Golf Course does not have any of the same characteristics, the methodology and goals of the project are similar. The ability to design with the environmental concerns in mind is critical to redesigning the golf course. Constructing new wetlands on the site and habitat considerations are important elements to be mindful of on Wildcat Creek Golf Course. Glacier Club Golf Course fits into the landscape and was developed without ruining what was there first by creating habitat locations and buffers between the human and wildlife areas. The course is not built around flooding or a prominent river, but does have two smaller creeks that run through the property that connect into a larger river. It is similar to Wildcat Creek Golf Course being along Little Kitten Creek. Although, in Manhattan, the course is at the mouth of Little Kitten Creek and in Durango, it is upstream from the major creek intersection. The wetlands that previously existed on site are critical to the water control and the wildlife in Colorado, so disturbing that would have taken away from the aesthetics of the area. Blending into the aesthetics and bringing that aesthetic into the golf course was critical in connecting the golf course to the surrounding environment. The need to connect the golf course to an aesthetic and environmental element (the wetlands) in Wildcat Creek golf course is significant in the design and solution to flooding. A watershed comparison between the precedent and Wildcat Creek is shown in figures 2.08-2.11.



The glacier club layout

Figure 2.06 | (Produced by author, 2012)

The golf course is supposed to be reflected in five different experiences. There are buffer zones between these systems that allow for an edge condition and intersection between concepts. Areas were created through five categories of the design intent. Image: Not To Scale

deer creek golf club

Date: Opened 1989

Location: Overland Park, Johnson County, Kansas

Reason to Choose the Precedent: The golf course was designed and laid around Tomahawk Creek in Kansas City. The course has had concerns about flooding after the course was built and greens were redone to try to correct some of the problems. Native vegetative areas were preserved and restored to give the creek a natural setting in which to flow. The precedent site is geographically closest and gives a similar regional context to Wildcat Creek in Manhattan, Kansas.

Context (Relation to River and Surrounding Open Space): The golf course is intertwined around the creek and was chosen for that reason. The adjacency between the Deer Creek Golf Course and Tomahawk Creek is similar to the relationship between Wildcat Creek Golf Course and Wildcat Creek.

History: The course was originally designed by Kyle Phillips when he worked for Robert Trent Jones II, LLC. When the course was built, the creek was preserved despite concerns of flooding. Development was in the area prior to the course development, but nothing was developed within the block of the course. The development of the block occurred with the master planning of the golf course. When redoing the greens in the Fall of 2010, the contours and elevations were moved back to the same point that were originally specified to address issues of flooding.

Methodology: During the initial development of the course, the designer was very conscientious of the 100 year floodplain. Keeping housing out of the floodplain was essential and using the valleys that were already on the site for golf made the routing of the course set naturally into the land. The ultimate goal in any golf course development around a river or creek would be to increase the storage capacity of the creek. Phillips used limestone to elevate, define edges, and add stability to the course. Limited natural land was able to be maintained, but re-naturalization was allowed and the creek gained a buffer between the maintained area and the channel area. The course has sizable areas that are highly manicured and require maintenance. A great deal of that may have to do with the time and era in which the course was built.

Successful? Why? How?: The course is successful in allowing the creek to have naturalized areas and areas which allow for flooding but do not interfere with the housing and development in the area as shown in figure 2.07. The houses are set on ridgelines that overlook the golf course but are away from the course in most locations. Another positive is that the course did not change the route of the creek to build the course.

Improvements, Suggestions, and Questions: More space could have been left to re-naturalize; as a result, there is considerable manicured land. The creek and tributaries flow through the course, but there is not a strong reason as to why or how the course is incorporated around the creek. If they were having trouble with flooding at the current elevation of the course, it may not have been useful to reconstruct the greens to the exact same elevations. The flooding issues can still occur at that point, so raising the green elevations and regrading around the green complexes would have helped to reduce the flooding and damage to the green complex.

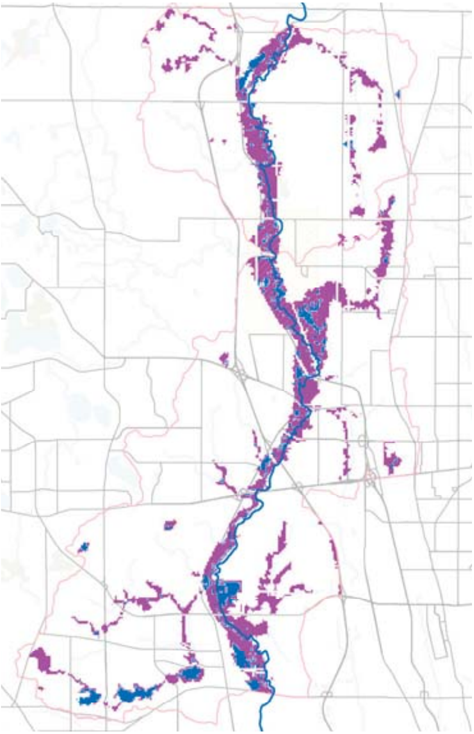
Conclusions and Relationship to Wildcat Creek and Manhattan: Deer creek as a golf course is similar to Wildcat Creek golf course. The size of the river that flows through the course is comparable to Little Kitten Creek in Manhattan. There is more development around Deer Creek Golf Club than there is around Wildcat Creek Golf Course resulting in the Tomahawk Creek watershed having a greater amount of pervious pavement without the influence of agricultural land. As Manhattan grows further, the watershed composition could become more like the Tomahawk Creek. A watershed comparison between the precedent and Wildcat Creek is shown in figures 2.08-2.11.

Deer creek golf club layout

Figure 2.07 | (Produced by author, 2012)

The course uses vegetation as the buffer between the course and the residential and works to incorporate the holes into the surrounding land cover. Image: Not To Scale

100 year FEMA floodplain

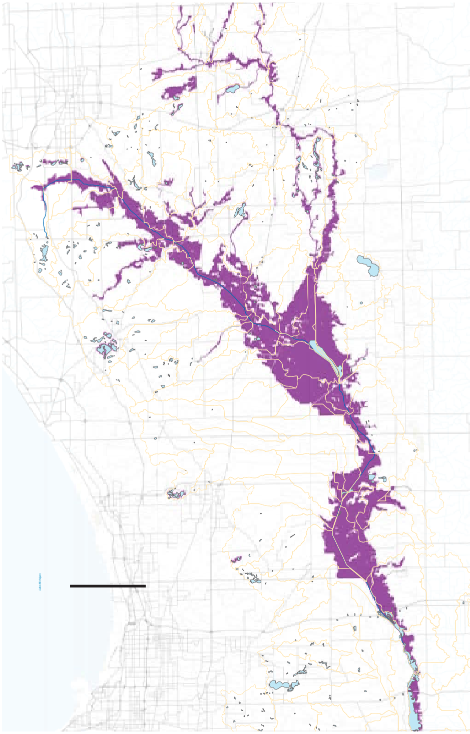


Des Plaines River: Wetland Restoration

26.3% floodplain

Scale: 1" = 4.5 miles

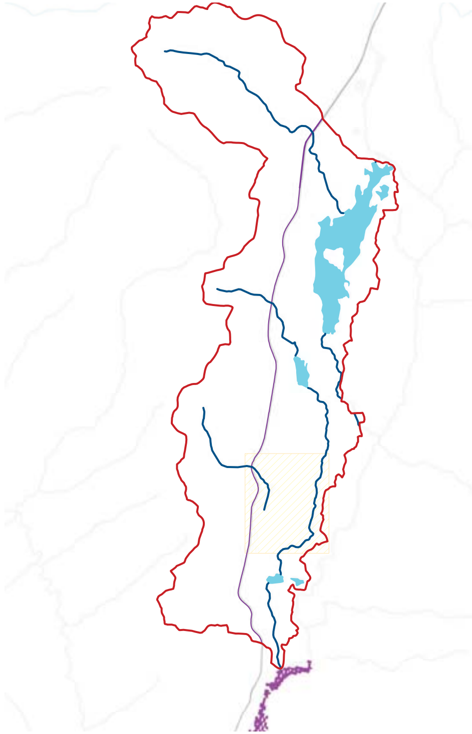
0 2.25 4.5 miles



Grand Kankakee Restoration

Scale: 1" = 25 miles

0 12.5 25 miles

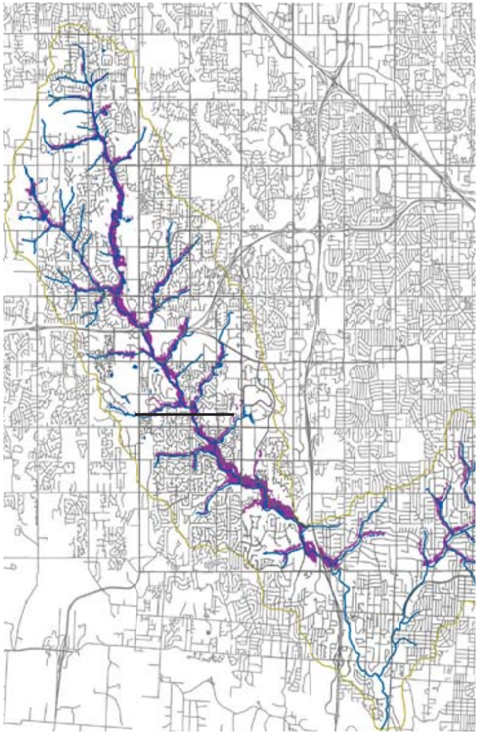


The Glacier Club

0% floodplain (Floodplain begins at mouth of watershed

Scale: 1" = 2 miles

0 1 2 miles

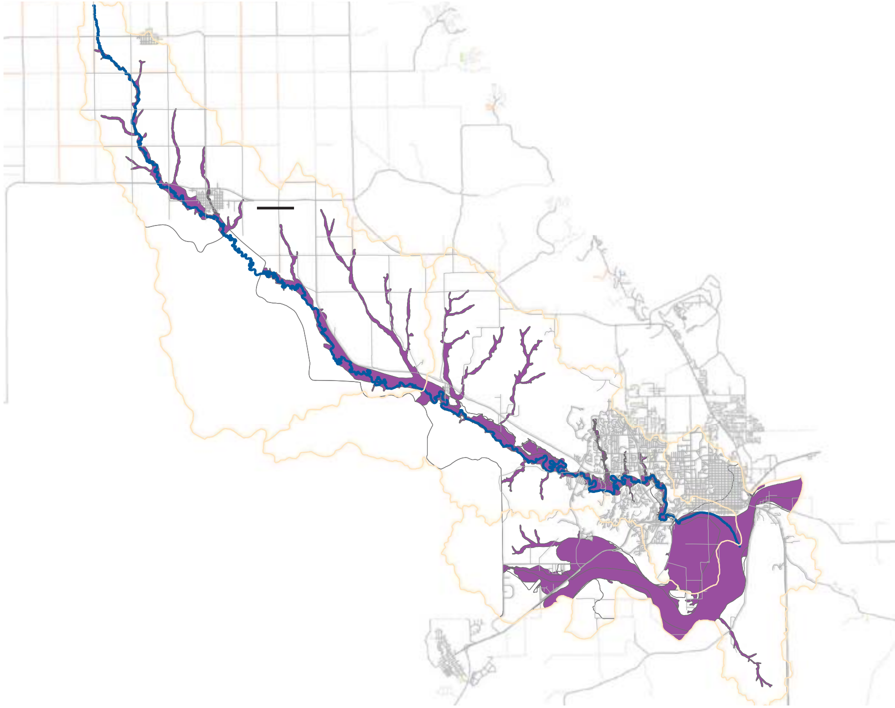


Deer Creek Golf Club

26.6% floodplain

Scale: 1" = .5 miles

0 .25 .5 mile



Wildcat Creek Watershed

5.7% floodplain

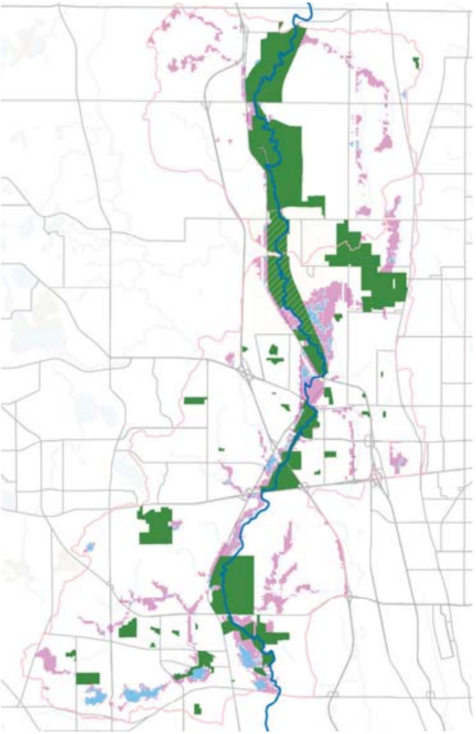
Scale: 1" = 5 miles

0 2.5 5 miles

Figure 2.08 | (Produced by author, 2012)

The 100 year FEMA floodplain is what is used to consider where the flooding occurs in these sites. The sites all in some way use wetlands or stormwater management tools to help prevent flooding.

floodplain + parks and open space

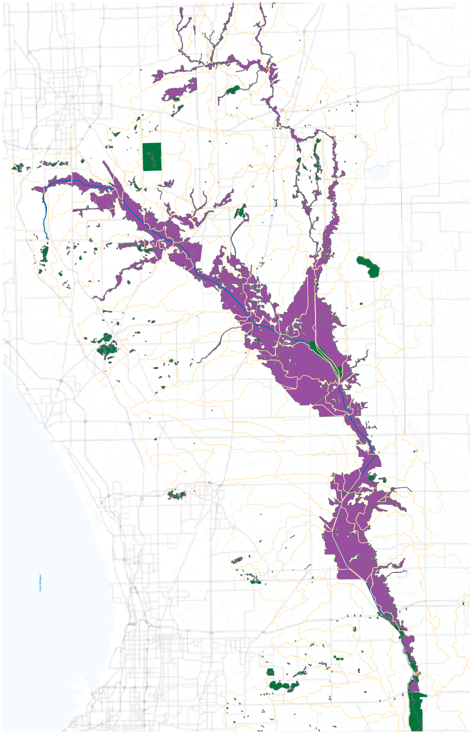


Des Plaines River: Wetland Restoration

13.8% parkland

Scale: 1” = 4.5 miles

0 2.25 4.5 miles

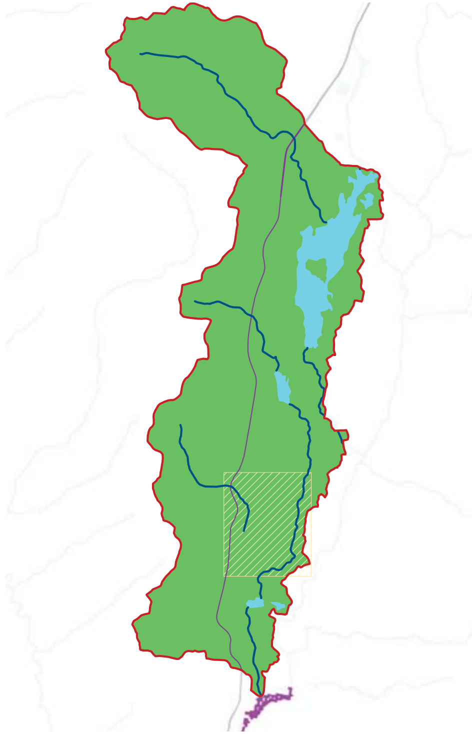


Grand Kankakee Restoration

0.7% parkland

Scale: 1” = 25 miles

0 12.5 25 miles

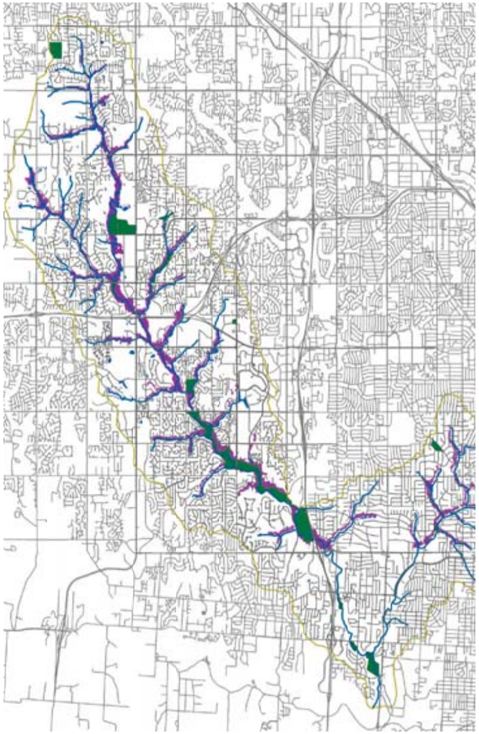


The Glacier Club

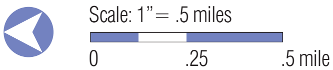
100% parkland

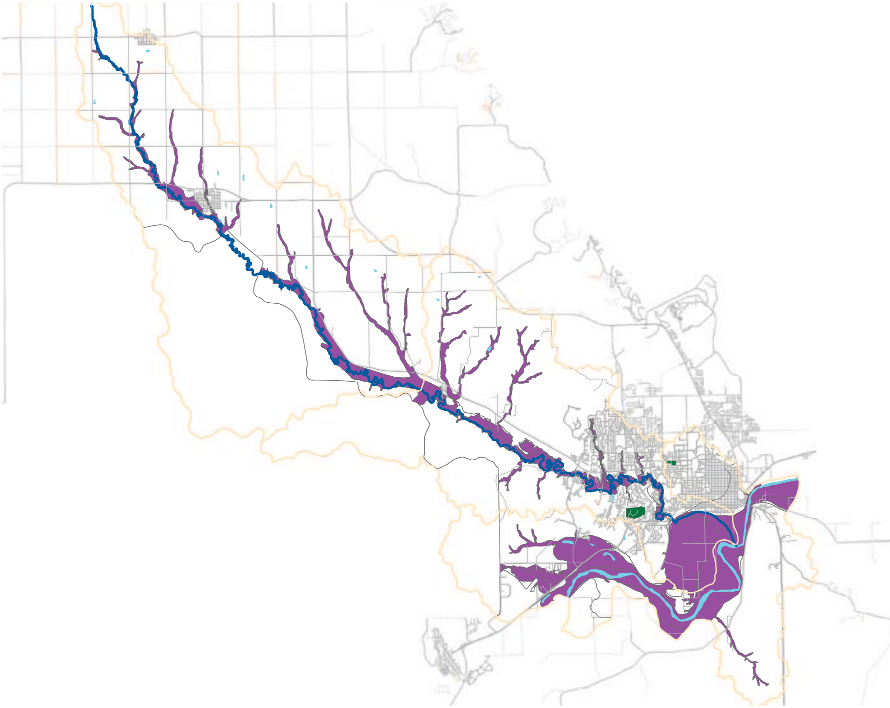
Scale: 1” = 2 miles

0 1 2 miles



Deer Creek Golf Club





Wildcat Creek Watershed

0.12% parkland

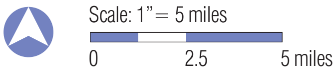
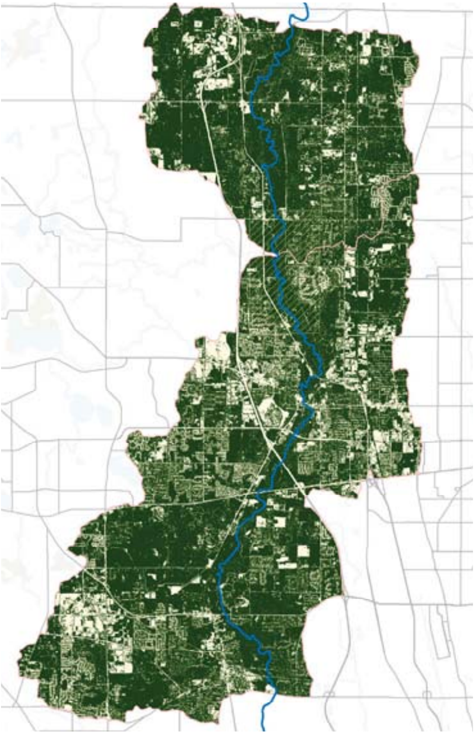


Figure 2.09 | (Produced by author, 2012)

The parks offer open space areas that can serve as flooding grounds in times of need. The more parks that are within the Floodplain, the better and more natural the creek can flow.

impervious surface



Des Plaines River: Wetland Restoration

24.59% impervious surface

Scale: 1" = 4.5 miles

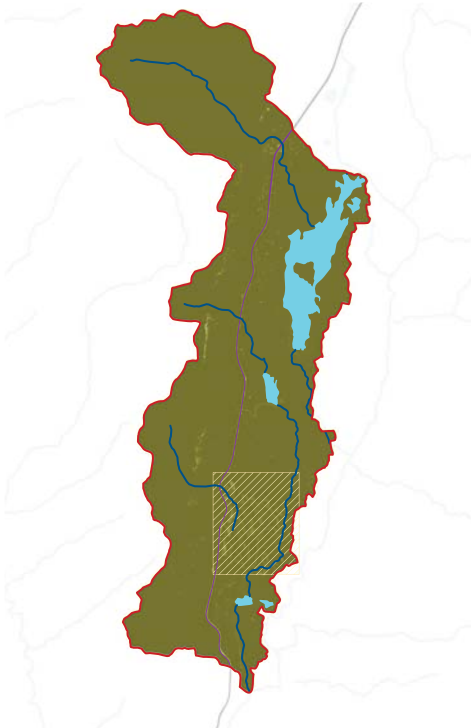
0 2.25 4.5 miles

Grand Kankakee Restoration

1.56% impervious surface

Scale: 1" = 25 miles

0 12.5 25 miles

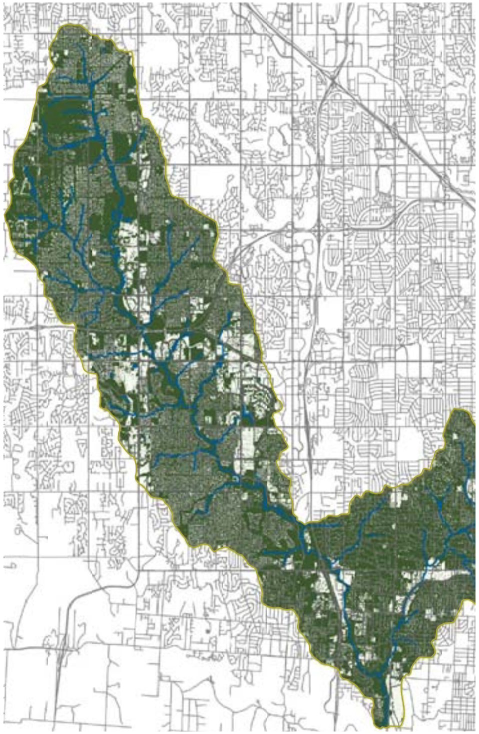


The Glacier Club

1.26% impervious surface

Scale: 1" = 2 miles

0 1 2 miles

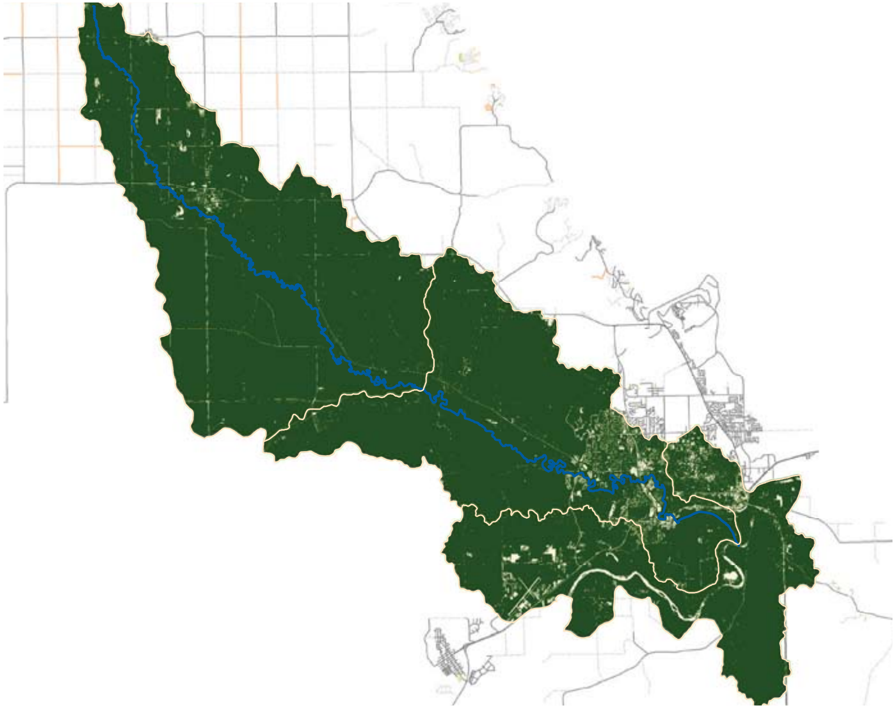


Deer Creek Golf Club

2.5% impervious surface

Scale: 1"= .5 miles

0 .25 .5 mile



Wildcat Creek Watershed

.3% impervious surface

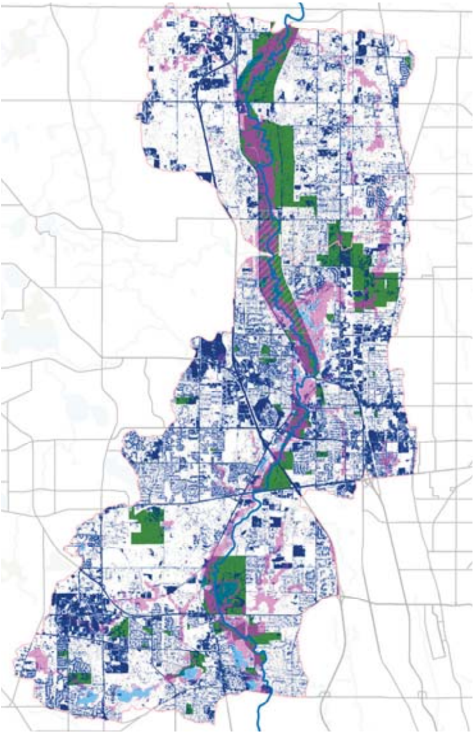
Scale: 1"= 5 miles

0 2.5 5 miles

Figure 2.10 | (Produced by author, 2012)

Impervious surfaces create greater runoff and areas in areas that often see areas of concern in flooding. Impervious surfaces also create more sediment that contributes to flooding.

floodplain + parks + impervious



Des Plaines River: Wetland Restoration

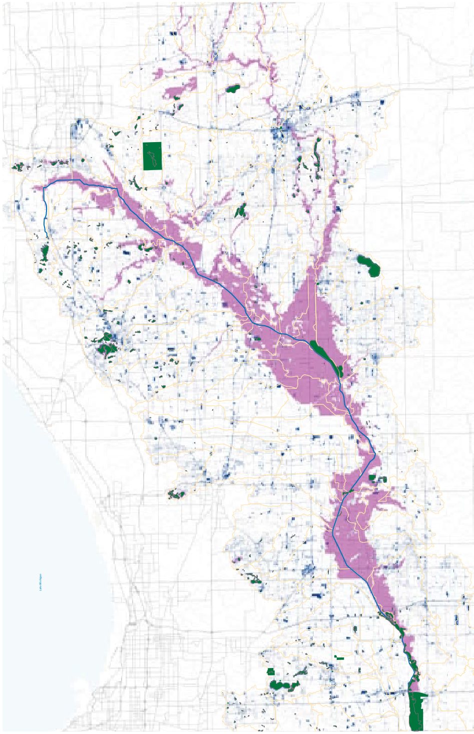
47,217 acre watershed

460.276 feet of river within watershed study

1.25% (5,888 acres) Wetland or National Forest

Scale: 1" = 4.5 miles

0 2.25 4.5 miles



Grand Kankakee Restoration

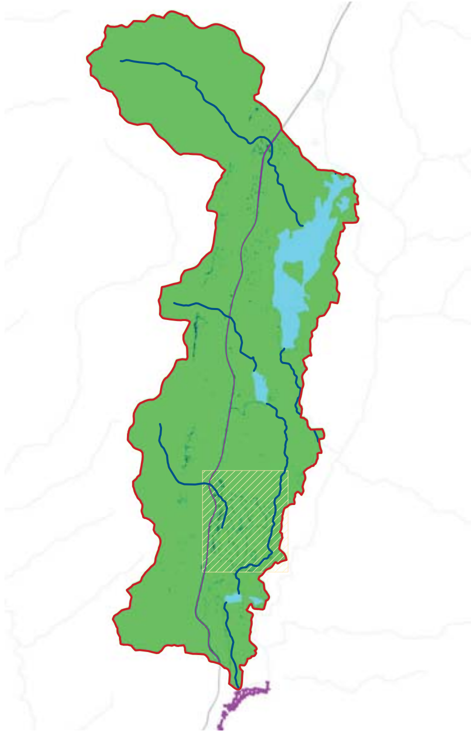
1, 427, 295 acre watershed

472,709 feet feet of river within watershed study (state line)

1.6% (22,310.4 acres) Wetland or National Forest

Scale: 1" = 25 miles

0 12.5 25 miles



The Glacier Club

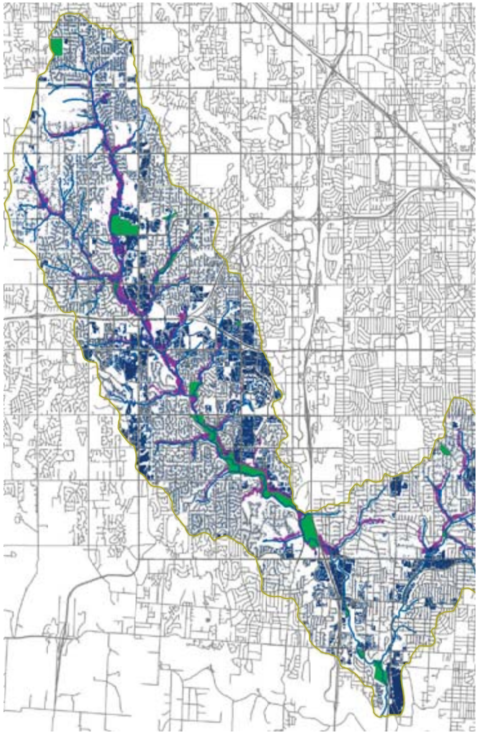
16,366 acre watershed

40,733 feet of river in Elbert Creek + 12,973 feet of river in Goulding Creek

100% (16,366 acres) of National Forest (San Juan National Forest)

Scale: 1" = 2 miles

0 1 2 miles



Deer Creek Golf Club

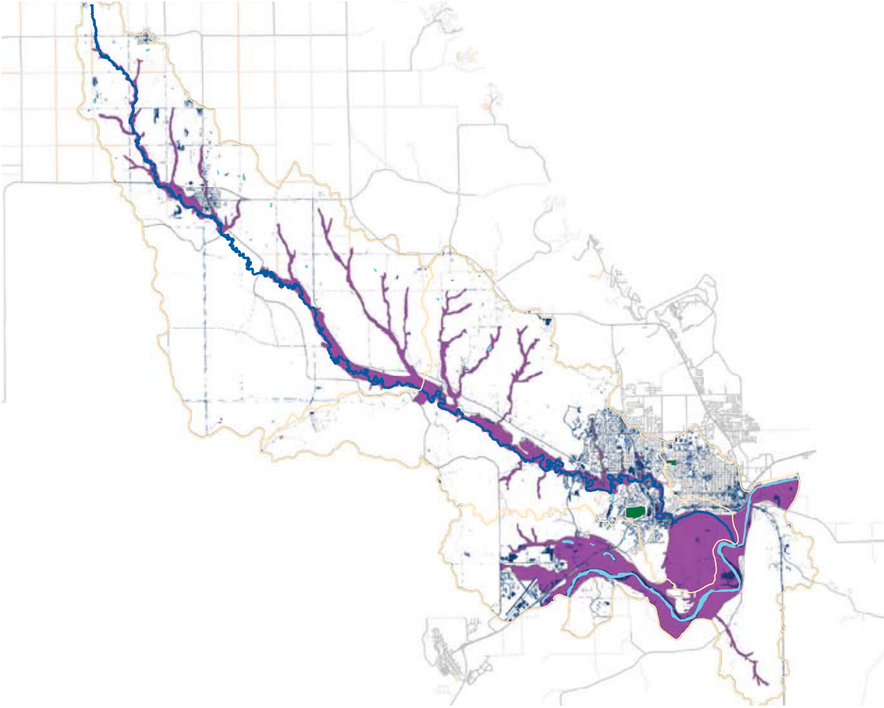
23,516 acre watershed

29,523 feet of river within watershed study

0% Wetland or National Forest

Scale: 1" = .5 miles

0 .25 .5 mile



Wildcat Creek Watershed

82,919 acre watershed

241,640.4 feet of river within watershed study

0% Wetland or National Forest

Scale: 1" = 5 miles

0 2.5 5 miles

Figure 2.11 | (Produced by author, 2012)

Each of these studies look at the health of the creek. Creating areas and open spaces that allow for flooding when needed. The summary looks to what areas are lacking open space and pervious surface and may be creating more flooding issues.

bandon dunes golf resort

Date: Bandon Dunes opened in 1999, Pacific Dunes opened in 2001, Bandon Trails opened in 2005, and Old Macdonald opened in 2010.

Location: 5 minutes north from Bandon, Oregon, along the Pacific Coast and within natural sand dunes.

Reason to Choose the Precedent: Bandon Dunes was chosen to examine how the course fits into the surrounding land and how it has drawn character from the surrounding land. There is not a predominant river or creek that feeds into the design, but the designer was able to take the original gorse sand dunes and create four distinct courses that are inspiring for people to play. There was also quite a bit of concern from the local, county and state when trying to get permits to build the original course.

Context (Relation to River and Surrounding Open Space): The course was discovered in the natural terrain. The sand dunes are a remarkable natural feature in the area with two state parks in close proximity that allow for large surrounding open spaces. The courses are developed with the incorporation of the terrain changes, natural vegetation, and surrounding open spaces (especially the ocean) into the course and highlight the views that surrounding areas bring to the site.

History: The land was originally part of sand dunes that were covered in gorse. The land is fully sand and has great access to Cliffside real estate on the Pacific Ocean. Before Mike Keiser bought the property, two different companies had bought the land with intentions of building golf resorts. When Keiser bought the land, his goal was to build "dream golf" not "commercial golf." (Goodwin, 2006, pp 94) Keiser did not want to develop a resort with the land, but instead have golf courses that were the land. On the Pacific Dunes course, the thick gorse had caught fire just before clearing was going to begin. As a result, the gorse fire allowed the designer to see the existing land for what the topography offered. The fire created opportunities to use the land and create "dream golf." (Goodwin, 2006, pp 94)

Methodology: Each course was designed differently with a different methodology and mindset.

Bandon Dunes

Bandon Dunes was designed by David McLay Kidd and was a "restoration course (Goodwin, 2006).” The course land was restored to grasses and forbs that reflect the feel of a Scottish course. The natural features of the land (e.g. sand, grasses, and the ocean) are the critical factors to make the course what it is today. The course is built on sand making it one of the true links courses in the United States while emphasizing ledges and cliff tops. It was not about shaping a course, but it is about finding the course within the site. “Golf begins with dirt” (Goodwin, 2006) which equates to the difficulty, options, and fun that is created through terrain on a golf course. The course was found in the land, then the terrain was molded to create the dream golf course.

Pacific Dunes

Tom Doak designed the Pacific Dunes course with the idea of preserving the land. The routing of the golf course uses the dominant features that already existed on site. As the routing plan was being discovered, the designers cleared just the gorse that needed to be cleared. There was a goal of incorporating the gorse into the site design. The holes were naturally in the land, and they did not need to be shaped. Since the designers did not change the topography drastically, the course is not extraordinarily long. Typical seaside golf courses would have two loops which both end on the water. Doak did not want the course to be too cliché. So, he brought the course to the ocean at different times and did not end either nine on the water. The course is meant as a classic design that emphasizes strategy that is designed for all levels of golf. The course characteristic takes after the gorse and the Pacific winds by having a “rugged nature” (Goodwin, 2006, pp 225) and windy bunkers.

Old Macdonald

The Old Macdonald course was inspired by Charles Blair (C.B) Macdonald. The designers, Tom Doak and Jim Urbina, channeled their inner Macdonald and tried to envision what he would do with the site. The course was not a copy of holes that MacDonald had done, but instead considered characteristics that Macdonald would have used including “vast greens, myriad angles of play, and … fierce (deep) bunkers. (www.bandondunesgolf.com)”.

Successful? Why? How?: The Bandon Golf complex is successful in its ability to design with the terrain in mind. It was not high design, but a classic links style golf. The preserving and restoring of the environment was critical to building the courses (shown in figure 2.12). Passing the permits to get the course built was one huge consideration. The course was not about commercial golf to make money, but has been very economically successful. The complex was a dream that has taken off to become the next Pebble Beach and golf mecca in the United States.

Improvements, Suggestions, and Questions: When the course was built, were patches or corridors considered in the layout of the course? What habitats were involved in the course, and how has this affected the course design? With the intensity of sand dunes on the course, how was stabilization planned and what methods were put in place to keep the site stable for the future? Since the region is known for its rain, was there any consideration of stormwater in the design?

Conclusions and Relationship to Wildcat Creek and Manhattan: The context of the site is much different from Manhattan, Kansas. The biggest thing to learn from the courses was the methodology of how they were built. The discovery of the holes may not be possible with the terrain of Wildcat Creek Golf Course. With the wetlands going into the course, it is about carving out a course from the wetlands, incorporating the course into the land, and creating natural holes that blend the course into the wetlands.

Bandon dunes golf resort layout

Figure 2.12 | (Produced by author, 2012)

The Bandon Dunes Resort Complex has a distinct, rugged character that helps the sand dunes be incorporated into the design. The light grey areas show the amount of daily maintained land. As a result, a smaller amount of land is maintained on a daily basis allows for the grasses and other vegetation to creep into the design and strategy. The areas of black show the ability to weave the course through larger areas of environmental land. Piecing the larger areas together helps create higher levels of connections, patches, and interesting edge conditions. Image: Not to Scale

mannahatta

Date: 1609-2409

Location: Manhattan, New York

Reason to Choose the Precedent: Mannahatta was a project designed to examine the historical conditions that previously existed in current day Manhattan, New York. Attention to Mannahatta came from the extensive research and ecosystem classification that was done. The process researchers took to explain specific habitats and ecosystems, as demonstrated in figure 2.13, is something that was considered when looking at the wildlife habitats in the Wildcat Creek watershed.

Context (Relation to River and Surrounding Open Space): Mannahatta is not about a river or fixing a flooding issue, but instead it is dealing with the process and methodology that Eric Sanderson used to discern the historical state of present day Manhattan, New York.

History: Mannahatta was established by European settlers in 1609. Prior to settling, Mannahatta at one point in time could have had "55 different ecological community types" (Sanderson, 2008). The island once held rivers, wetlands, mountains, forests, and swamps. Communities began to form after the last glacier melted, laying the framework of soils, rivers, cliffs, mountains, and sand piles for the ecological communities creation. The communities were not just habitats but part of an estuary that brought and continues to bring great biodiversity to the area. "The estuary is the motor, the connector, the driver, the great winding way, the central place that gathers all the old neighborhoods together and makes the rest possible." (Sanderson, 2009, pp. 143)

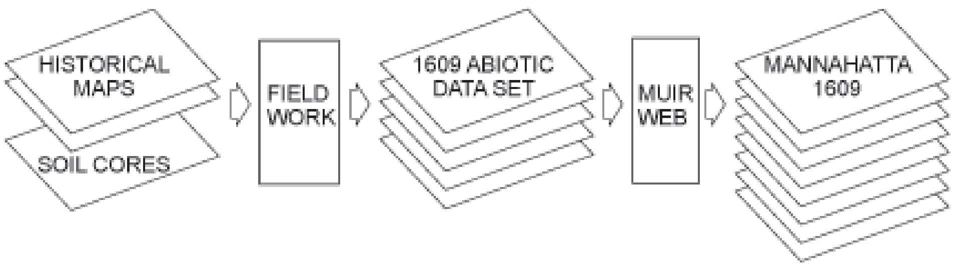
The first known disturbance to the land was the Lenape community. Although there were hunters and gatherers, they still tried to be good stewards to the land. The European settlement began in 1609 near the southern tip of the land. The land was slowly developed by the shoreline, eventually adding John Randel Jr.'s grid system that is currently in place. Many of the neighborhoods in present day Manhattan are named for the original landscape (e.g., Washington Heights, Harlem Hill, and Morningside Heights).

Future: Sanderson, a landscape ecologist, views New York City as an ecosystem. The buildings are cliffy hills, traffic is a flowing river, and the city is a "mosaic of ecosystems" (Sanderson, 2011). Today, there is still an ecological community and habitat in Manhattan.

The definition of habitat has changed slightly. Human habitat adds an element of meaning and a sense of reason to do something to the definition that originally included food, shelter, water, and reproductive resources, as seen in figure 2.14. The city has a future of human habitat along with bringing the wildlife back to the area. The density of Manhattan is needed to accommodate the number of people in the world and eventually the nation. Sanderson shows the future of Manhattan to have the density of present day Manhattan in more places and the restoration, green space, and decamping of areas that show the landscape of Mannahatta.

Methodology: Discovering the historical data of Manhattan involved an extensive, multi-year approach and team process. Ecologists used the original maps that laid out lower Manhattan and soil maps to begin to decipher the original landscape. Holes were dug to determine what soils previously existed on sight. The original maps had different levels of shading that showed a variety of levels of elevation. Unfortunately, the levels of elevation were not noted, so the amount of elevation change couldn't be determined. They were able to measure the elevation levels on the cliffs that still remain in Manhattan to determine what the level of the elevation maps were allowing the data to be put into GIS.

The species currently in the area were surveyed by a group of local amateurs and professionals that had passions for natural history in Manhattan. From that survey, the species were tested on 3 components: the species could not have been introduced from somewhere else in North America or the world; the species could not have expanded its home into



Mannahatta process map

Figure 2.13 | (Sanderson, 2009)

The process to create the vision of Mannahatta has a detailed analysis that helps set the foundation for the project. Sanderson set up a methodical process to figure out what Mannahatta looked like in 1609.

Manhattan within the last 400 years; and the habitat for the species must have been found in one of the 55 ecological communities (pp. 174, Sanderson, 2009). Once a list of species was established, they looked at the habitat and fauna of these species. There were records from the Europeans that identified some of the fauna and helped to establish what species were found in Mannahatta in 1609.

Each species has invisible connections to other species, prey, food sources, predators, shelters, and more that tell you more about what the ecological community was like. There connections from “Muir webs” (figure 2.15) are based on John Muir’s explanation of the ecological connections (Sanderson, 2009, pp. 190) Sanderson considers habitat to have 4 components: food, shelter, water, and reproductive resources (Sanderson, 2011). With these connections, the habitats were able to be mapped and the invisible strings of Muir’s were able to become visible to the history of Mannahatta.

Successful? Why? How?: The project has been able to interpret the landscape of what currently exists in a dense, urban environment. The project’s methodology was able to create an environment that has little connection to what is there today. The visual depiction of the Muir webs shows the relationship between wildlife, vegetation, soils, and other environmental conditions. Sanderson was able to take his research and historical perspective of Mannahatta and apply it to what the future would look it. The maps that he made may be representational of his densification locations and the decamping areas, yet they provide a vision for the future. The project was woven together with a solid methodology and research that was supported by historical, quantitative and qualitative research.

Improvements, Suggestions, and Questions: The Muir maps were done for the past relationships, but what would the maps look like for Mannahatta 2409? How would a human involvement and interaction change the Muir web? Could humans be added to that web?

Conclusions and Relationship to Wildcat Creek and Manhattan: The project’s methodology is an approach that brings to light ideas of how to consider habitat and the future of Wildcat Creek. First, John Muir’s web connections allow one to visually show the invisible lines that form habitats. The habitats begin to overlap and eventually form ecosystems that overlap each other. The overlap of ecosystems begins to create buffer and interconnecting webs. The webs make up systems that make up the world as we know it today. The

Ecosystem web

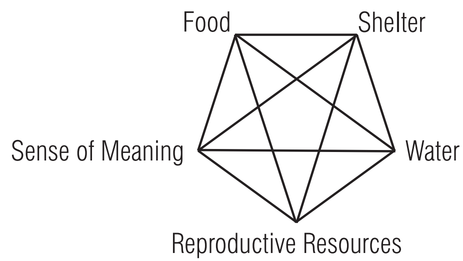
Figure 2.15 | (Sanderson, 2008)

Sanderson created ecosystem webs to show all components and relationship between elements. There are words with lines showing connections and the relationship between elements.

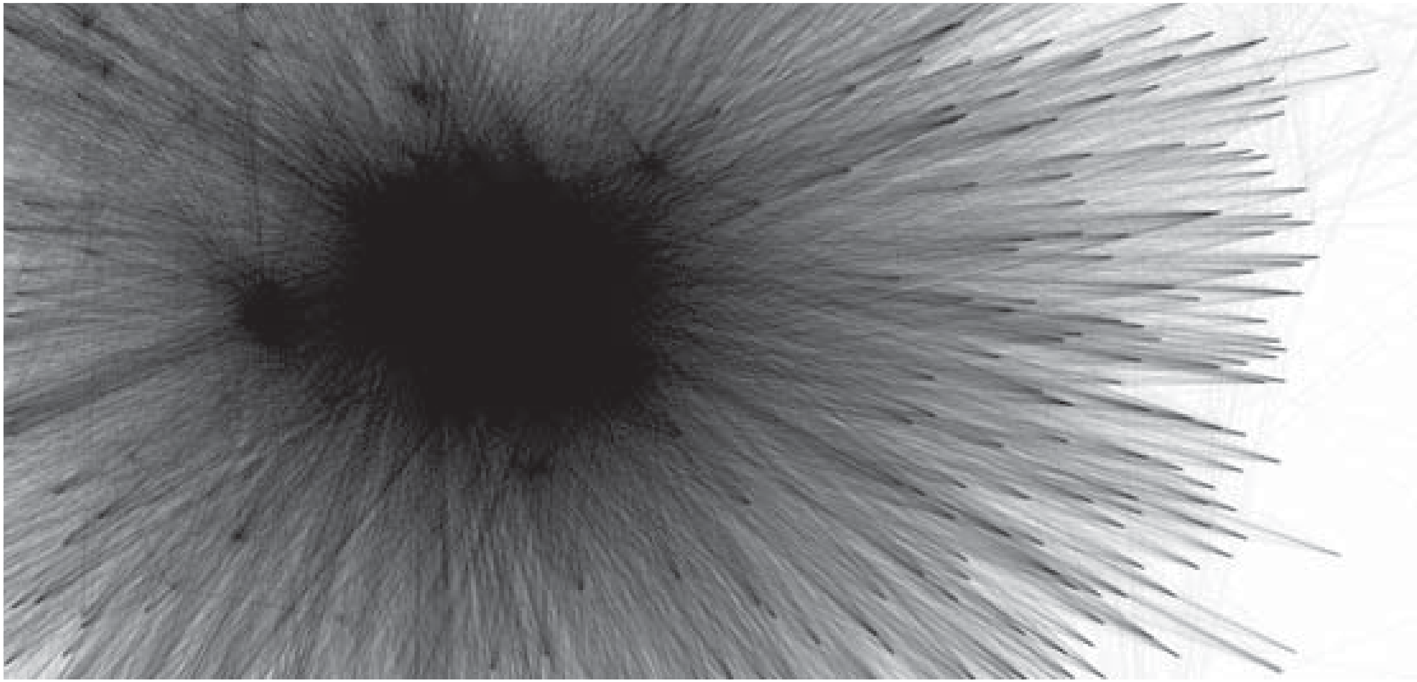
Human habitat definition

Figure 2.14 | (Produced by Author, 2012)

Sanderson defines human habitat as a combination of Food, Shelter, Water, Reproductive Resources, and Sense of Meaning are all needed and combined to serve as a human habitat.



connections define systems and relationships of habitat. The overlap of systems is something that is being looked at in the Wildcat Creek watershed. The habitats of wildlife in this area need to be able to overlap and use resources that are beneficial to increase infiltration rates. The vegetation has to have soils that it can grow in, surrounding vegetation that creates the shade/sun components and grow well with, and proper level of water saturation that it can grow in. The cycles of vegetation, wildlife, habitat, and rainfall are all interrelated and essential aspects that need to be depicted for Wildcat Creek. The Mannahatta project has depicted these elements and was able to predict the future based on the research of the systems. The future prediction for Wildcat Creek is the location of wetlands that mix into the existing environment and serve as a component to solving the flooding downstream.



Watershed + Wetlands

The watershed scale looks at the region and solutions at a large scale to encourage flood reduction across the watershed

Assessment
- WARSSS
- Wetland Analysis
- Wildlife

Planning | Design
- Watershed Plan

Evaluation
- Runoff Evaluation
- Forman's Evaluation

Assessment

An analysis is essential to the future of the watershed and finding a solution. The wetlands are best created in specific conditions and areas of the watershed.

WARSSS
On-Channel Wetland Analysis
Off-Channel Wetland Analysis
Wildlife Habitats
- Whooping Crane
- Topeka Shiner
- Sandhill Crane
- Golden Eagle
- Henslow's Sparrow

wetland assessment

Goals of a watershed scale plan

- Create a series of wetlands across the watershed that collect flood water and reduce the demand on Wildcat Creek.
- Increase the biodiversity of wildlife species through habitat production within Wildcat Creek Watershed.
- Redesign Wildcat Creek Golf Course to include wetlands that collect and hold water during flood times, subsequently reduce its impact on Wildcat Creek, and address existing water problems of the course that are unrelated to creek flooding.

Facts:

Wildcat Creek Watershed had at least 802.2 acres (26,996.7 acre feet volume of water) of flooding in 2011 which was documented through GIS and aerial photography from the City of Manhattan. Additional areas outside of the city limits were flooded, but location and scale of flooding was not documented. 111.3 acres of flooding was documented in Frank Anneberg Park, adjacent property that feeds into the flooding on Wildcat Creek Golf Course.

Wetlands are just one solution to a greater problem. Strategically placing the wetlands within the watershed can help reduce the flooding, disperse the water into other areas that are designed to hold water, and create regions that are intended to flood.

Concepts:

There are two types of wetlands that could be fed within the watershed: 1) those that would be supported by the flooding waters and placed as near to the creek, on-channel, and flooding locations as possible, and 2) those that are off-channel and collect or slow down runoff from higher elevation. Lowlands are best fit for on-channel wetlands, while middle grounds respond to off-channel wetlands because they do not get flood flow that high in elevation. Lastly, high ground areas associated with ridgelines are not set up for wetlands due to the energy it takes to pump water at large elevation changes and the limited water that would have a runoff through the area.

Wetlands should be incorporated into the existing surroundings. Wildcat Creek Golf Course in Manhattan, KS is at the intersection of Little Kitten Creek and Wildcat Creek, two waterways that produced significant flooding in June of 2010 and 2011. The adjacent land is suitable for on-channel wetlands that collect water to take pressure off of the water channels. Integrating the wetlands with the golf course creates solutions for the flooding without changing its original land use. Many elements that make up wetland ecosystems are critical to the design analysis and development, as shown in figure 3.01.

Site Selection Suitability.
Site Habitats Suitability.
Site Ecosystem Suitability.
Species Suitability.

	soil conditions	Hydric levels of soils	Nutrient Groups (Carbon, phosphorus…)	Amount of water holding (volume)	Proximity to River	Shelter	Reproduction	Food Sources	Prey sources	Water	Meaning/Reason	Birth	growth	death (reason)	decomposition	grass species	wildlife species	waterfowl species (migration birds)	wooded species
soil conditions	■	x		x					x	x			x			x		x	x
Hydric levels of soils		■		x					x	x	x		x			x		x	x
Nutrient Groups (Carbon, phosphorus…)			■	x			x				x			x	x	x			x
Amount of water holding (Volume)				■	x			x		x	x		x			x			x
Proximity to River					■			x	x	x		x	x			x			x
Shelter						■					x	x	x			x	x	x	x
Reproduction							■	x	x		x	x	x			x	x	x	x
Food Sources								■	x				x			x	x	x	x
Prey sources (species that use it as a food source)									■				x	x		x	x	x	x
Water										■			x	x		x	x	x	x
Meaning/Reason											■	x	x			x	x	x	x
Birth												■	x	x	x	x	x	x	x
growth													■	x		x	x	x	x
death (reason)														■	x	x	x	x	x
decomposition															■	x			
grass species																■	x	x	
wildlife species																	■	x	x
waterfowl species (migration birds)																		■	x
wooded species																			■

Elements of suitability matrix

Figure 3.01 | (Produced by author, 2012)

The matrix considers the what overlapping elements are needed to create wetlands. Wetland ecosystems have a variety of components that all form a web.

WARSSS – RLA:

The Wildcat Creek group applied Dave Rosgen's Watershed Assessment of River Stability and Sediment Supply (WARSSS, 2006) process to the Wildcat Creek Watershed. WARSSS is split into 3 sections: RLA (Reconnaissance Level Assessment), RRISSC (Rapid Resource Inventory for Sediment and Stability), and PLA (Prediction Level Assessment). The watershed assessment, as a whole, identified areas that have contributed to flooding in the watershed. Flooding areas were further researched to identify their significance to the watershed. The final step included examining potential solutions for each identified areas. Rosgen's WARSSS process served as a base for the group dilemma and has been incorporated into each individual project. The full report can be found here: https://krex.k-state.edu/dspace/handle/2097/13605.

During the Fall semester, RLA was completed and used to provide a quick introduction to the entire watershed, identify areas and conditions that should be examined further, and eliminate areas that appeared to be in good condition. In order to study the 90+ square miles, the watershed was split into six types of land based on geography, topography, and land use. Each type was further divided into sub-watersheds to break down areas and conditions so they could be examined in greater detail. Within each sub-watershed, small areas (i.e., hotspots) were selected based on noticeable surface and mass erosion, topography, woody vegetation, channelization, channel history, and impervious surfaces. After hotspots were delineated, each of the six types were studied and classified on a generalized scale. Following a field visit to study hotspots in question, each hotspot and watershed was reviewed to determine whether or not further study is needed. Results of the RLA process can be found in Appendix C.

RRISSC was completed in the spring to further identify areas of concern to the health of the creek. The criteria needed to make that assessment were studied through a road assessment, surface disturbance, agricultural analysis, and an urban development analysis. Each assessment was used to consider the hillslope, hydrologic, and channel processes assessment for the watershed. The watershed was first evaluated by geographic location section which fits with mass erosion, roads, surface erosion, and streamflow change. Second, the stream type location section was used in analysis of streambank erosion, direct channel impacts, channel enlargement, aggradation of excess sediment, channel evolution, and degradation. Each assessment rated the sub-watershed as very low, low, moderate, high, and very high to determine whether it moves forward to the PLA phase. Results of the RRISSC can be found in Appendix D

In the author's individual project, hotspots generated from the RLA process were used as identification of areas which caused problems in the watershed and were in need of change. Wetlands were considered as one strategy for correcting damage that resulted from flooding of the creek. Locations of the hotspots were placed into a weighted analysis that was set up to determine the best placement of wetlands. Site selection criteria for wetlands included analysis elements were used to identify conditions contributing to the flooding, places that flooded, places with proper elevation and topographic conditions and soil conditions that already were appropriate for wetlands. The hotspots determined from the group WARSSS assessment were considered when determining wetland locations.

on-channel wetlands

See weighted overlay map in Figure 3.02

- Hotspot locations (10% in location selection weighted overlay)

  Hotspots were determined by the lack of forested vegetation, devegetation, channelization, non-terraced agriculture, surface erosion, urban development, and historical change. The hotspots create specific areas throughout the watershed that contribute to the flooding issue. See Figure 3.03.

- Proximity to 100 year FEMA floodplain boundary (10%)

  Ideally, the on-channel wetlands would be located within the 100 year floodplain as identified by FEMA because it is within an area that has high flooding potential. The more flooding potential, the more conducive the area is to on-channel wetlands. See Figure 3.04.

- % Impervious surface (6%)

  Areas of impervious surface cannot maintain their current land use if converted into a wetland, although the areas with high levels of impervious surface could use wetlands due to the increase of runoff caused by the impervious surfaces. See Figure 3.05.

- Soil permeability level (6%)

  On-Channel wetlands are best found in areas that will already flood. The areas with poor soil permeability are best suited for wetlands that are intended to hold at least a minimal amount of water. If a soil has high levels of the permeability, it could be used as a wetland that does not hold water and would have a much greater increase of base flow. See Figure 3.06.

- Hydric soil rating (30%)

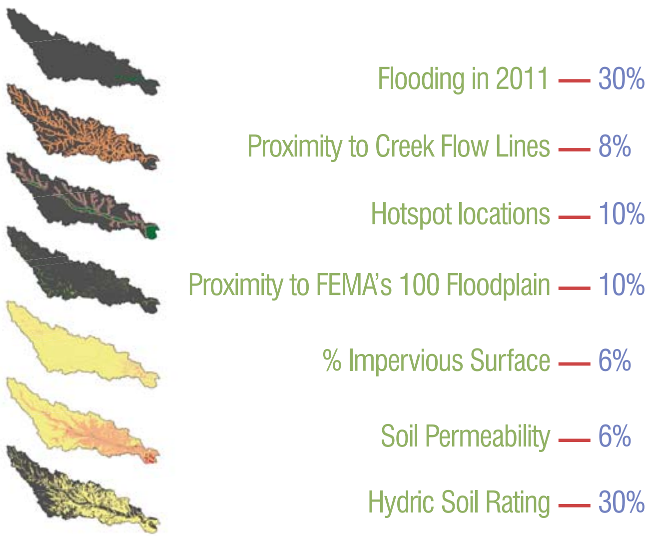
  Hydric soils are areas that were formerly wetlands and places that have historical value to wetlands. See Figure 3.07.

- o Flooding in 2011 (30%)

  The locations that flooded in 2011 are areas that will continue to flood if nothing is done. These areas are also places where water naturally travels. Having the water naturally flood or flow into the wetlands is important to maintaining the same creek patterns. See Figure 3.08.

- o Proximity to creek channel (8%)

  The closer the wetland is to the river, the more water that has the opportunity to flood into the wetland. Water is likely to be picked up from upstream if the wetland is adjacent to the creek channel. See Figure 3.09.



On-channel wetland suitability

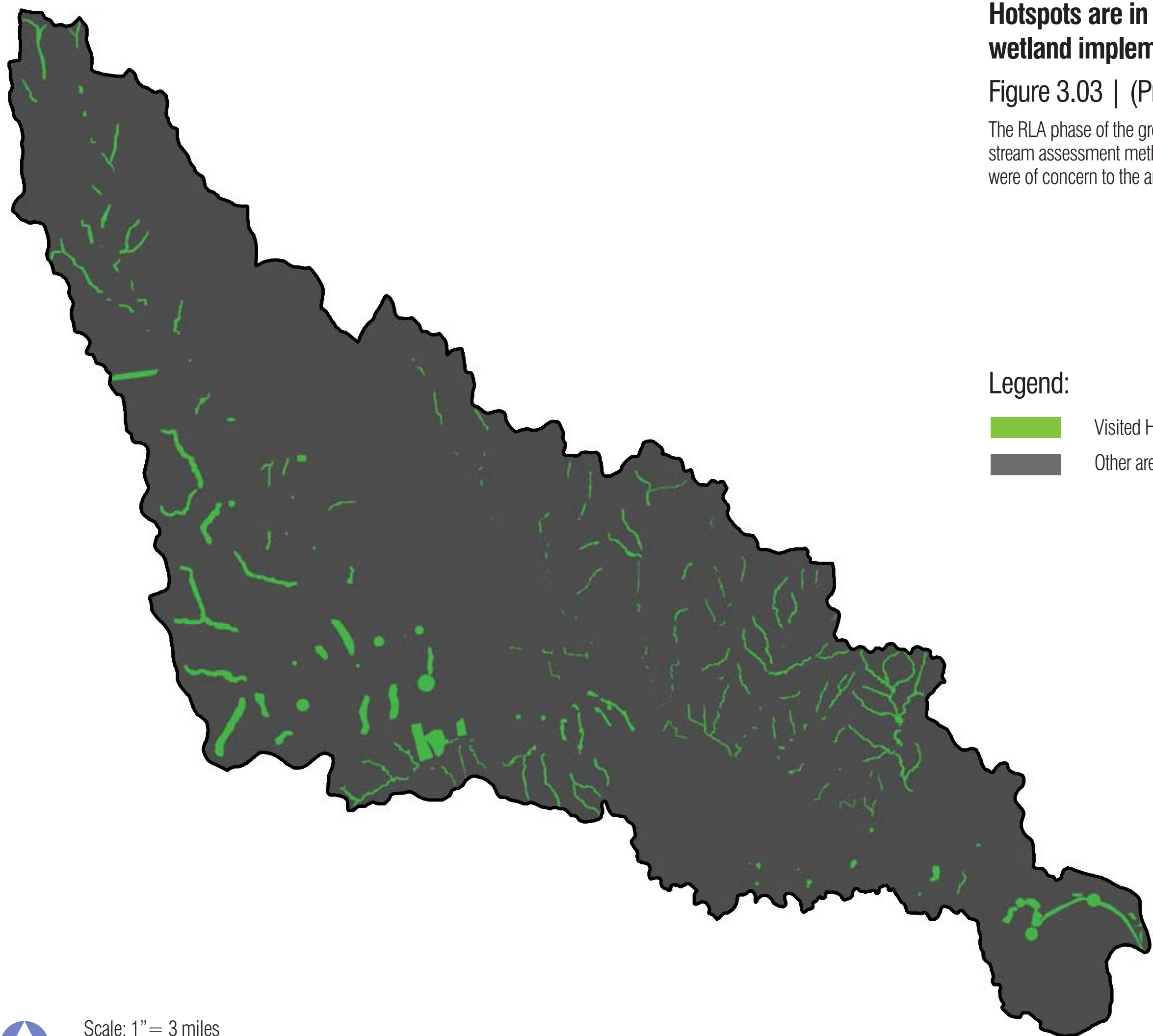
Figure 3.02 | (Produced by author, 2012)

Each layer in the suitability analysis is weighted based on the importance of the layer.

Hotspots are in need of repair through wetland implementation

Figure 3.03 | (Produced by author, 2012)

The RLA phase of the group assessment, Rosgen's WARSSS stream assessment method, used hotspots to identify areas that were of concern to the area.



Legend:

Visited Hotspots

Other areas in the watershed

Value in suitability analysis

High → Low

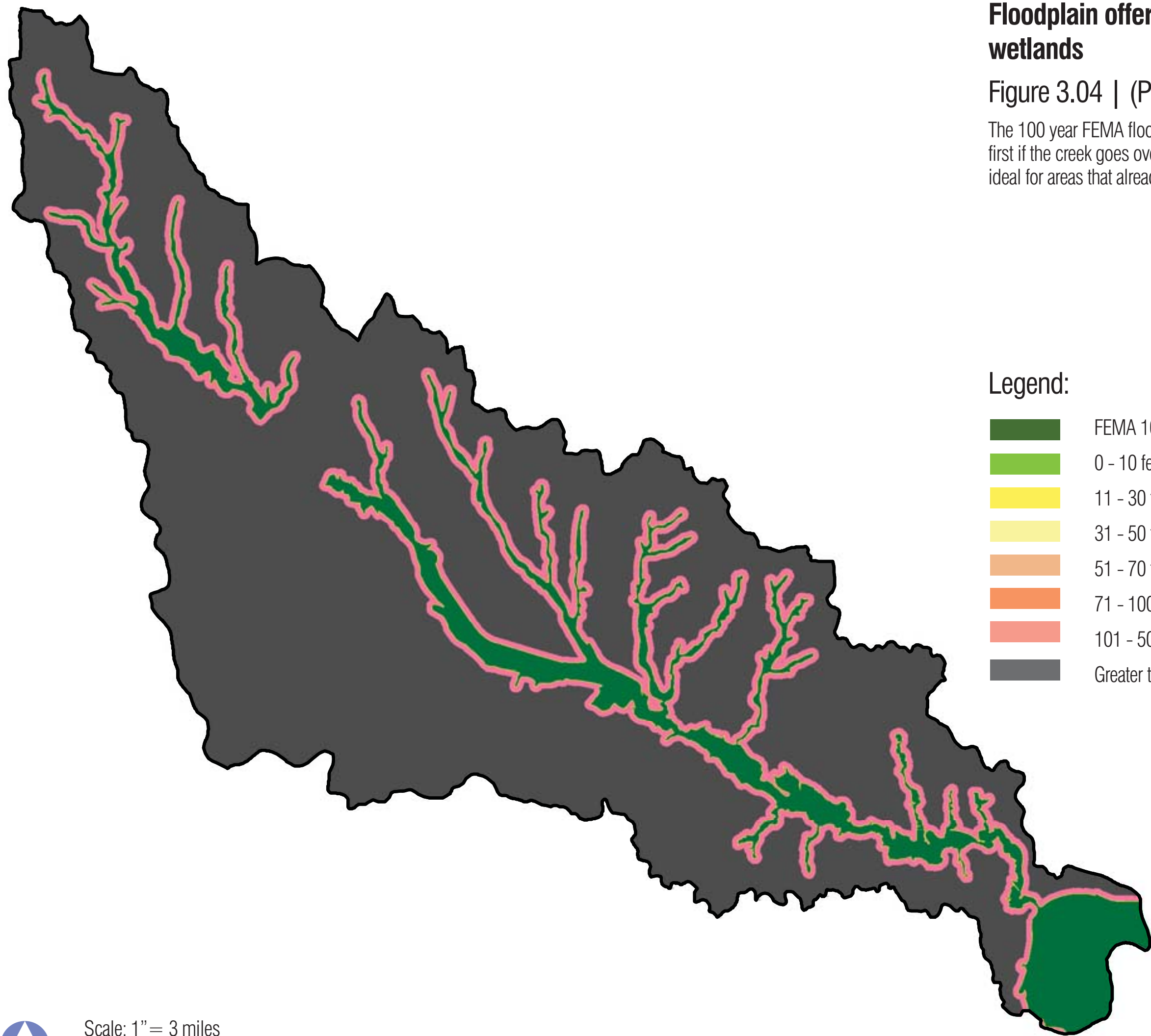
Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

Floodplain offers excellent opportunities for wetlands

Figure 3.04 | (Produced by author, 2012)

The 100 year FEMA floodplain shows areas that are likely to flood first if the creek goes over capacity. The on-channel wetlands are ideal for areas that already are likely to flood.



Legend:

- FEMA 100 year floodplain
- 0 - 10 feet from floodplain
- 11 - 30 feet
- 31 - 50 feet
- 51 - 70 feet
- 71 - 100 feet
- 101 - 500 feet
- Greater than 500 feet

Value in suitability analysis

High → Low

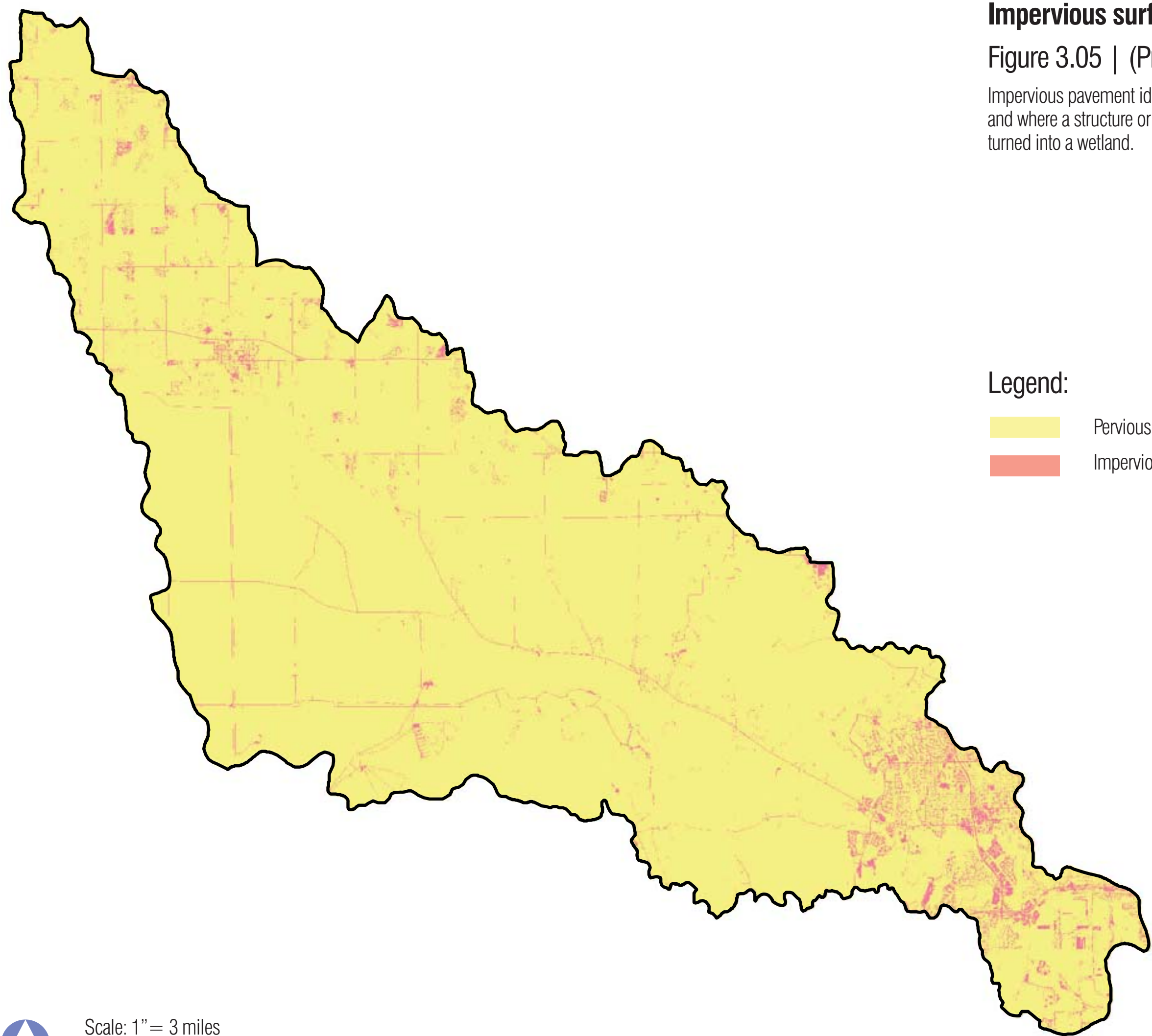
Scale: 1”= 3 miles

0 1.5 3.0 6.0 miles

Impervious surface is not ideal for wetlands

Figure 3.05 | (Produced by author, 2012)

Impervious pavement identifies where development has occurred and where a structure or pavement would need to be torn up to be turned into a wetland.



Legend:

Pervious surface

Impervious surface

Value in suitability analysis

High → Low

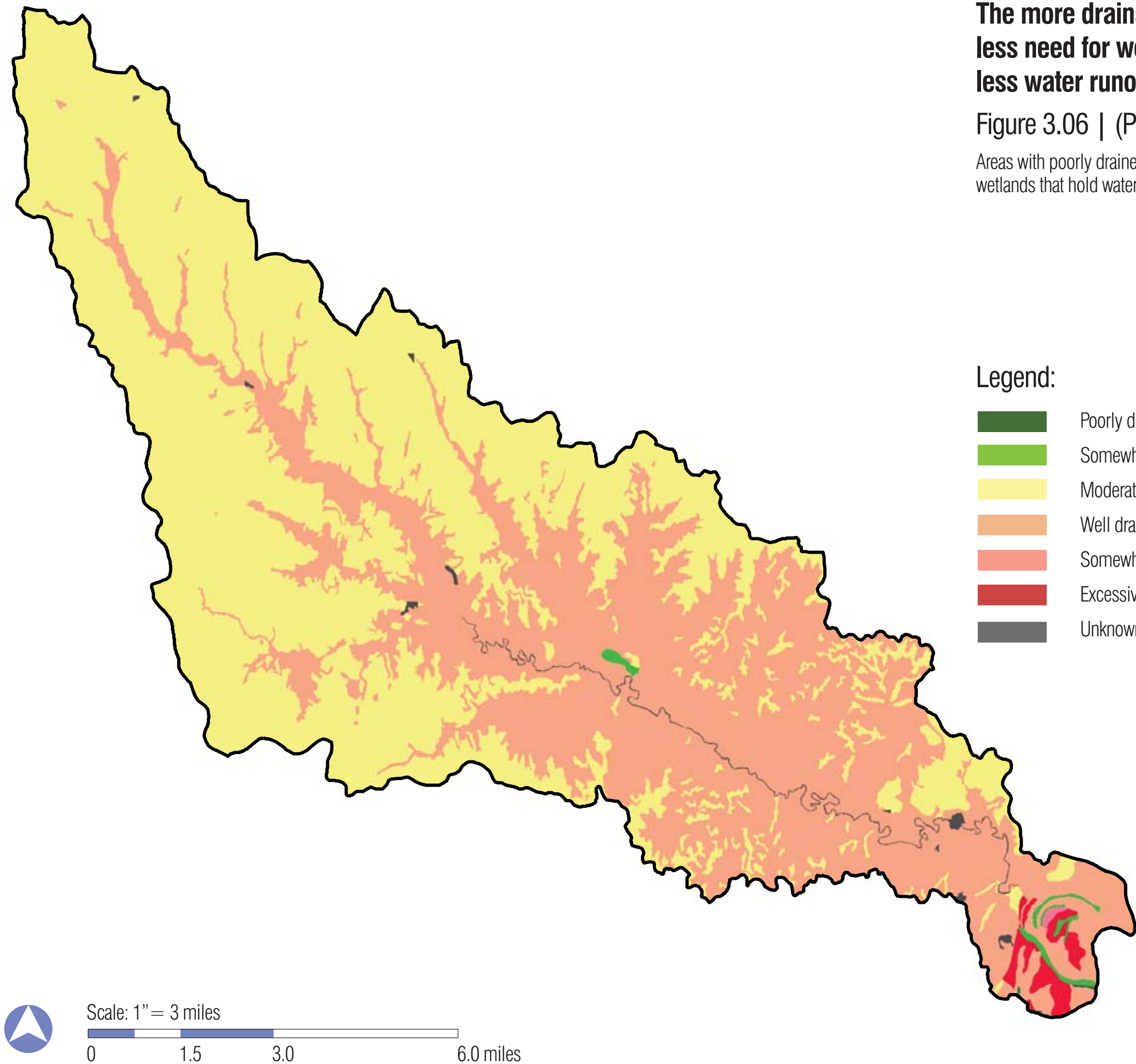
Scale: 1"= 3 miles

0 1.5 3.0 6.0 miles

The more drainage ability of the soil, the less need for wetlands because there is less water runoff

Figure 3.06 | (Produced by author, 2012)

Areas with poorly drained soil would be good areas to have wetlands that hold water.



Legend:

- Poorly drained soil
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained
- Unknown

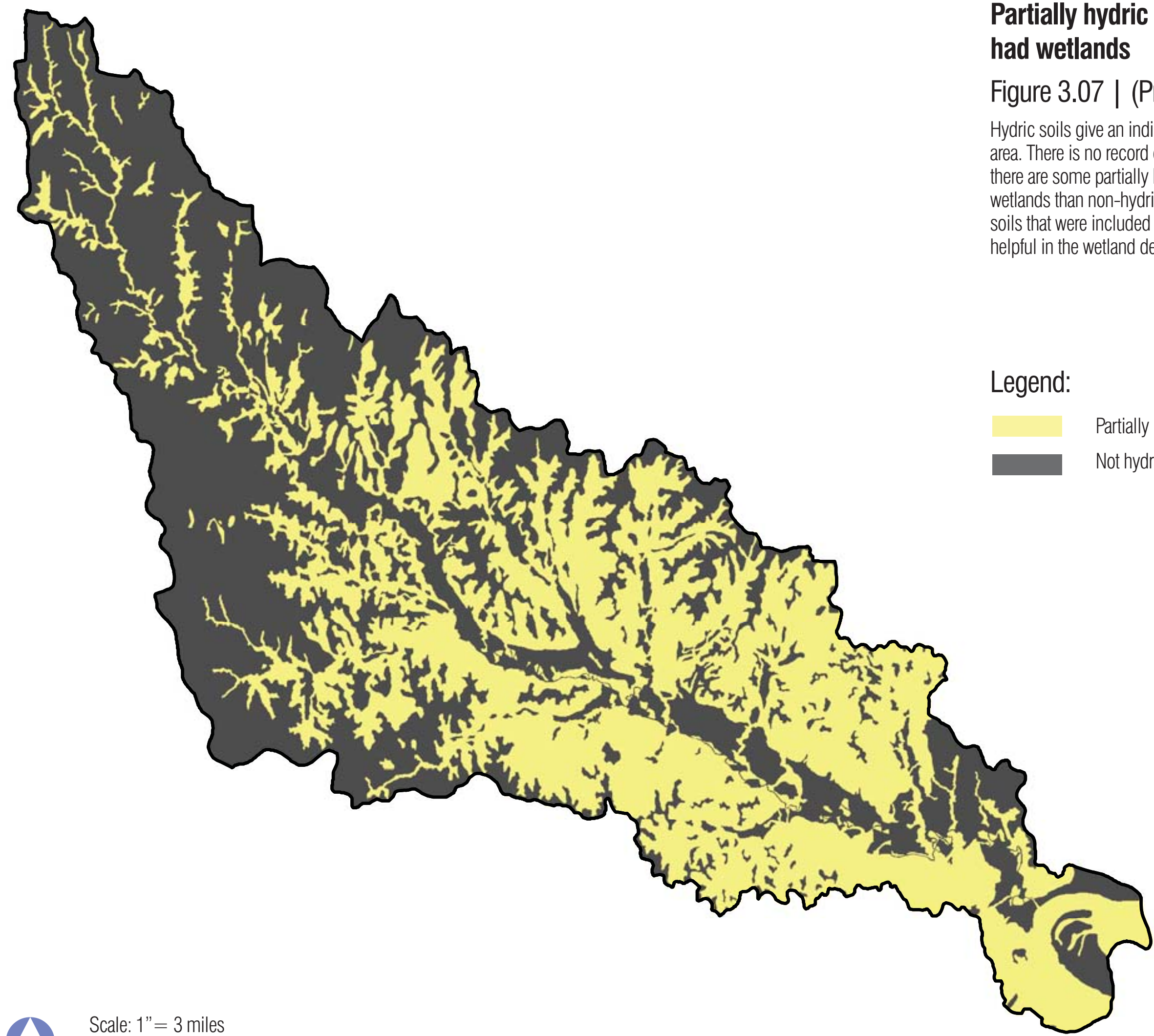
Value in suitability analysis

High → Low

Partially hydric soils historically may have had wetlands

Figure 3.07 | (Produced by author, 2012)

Hydric soils give an indication that a wetland formally existed at that area. There is no record of true hydric soils in the area, although there are some partially hydric soils that would be better suited for wetlands than non-hydric soils. There were some unknown hydric soils that were included with the non-hydric to assume they are not helpful in the wetland determination.



Legend:

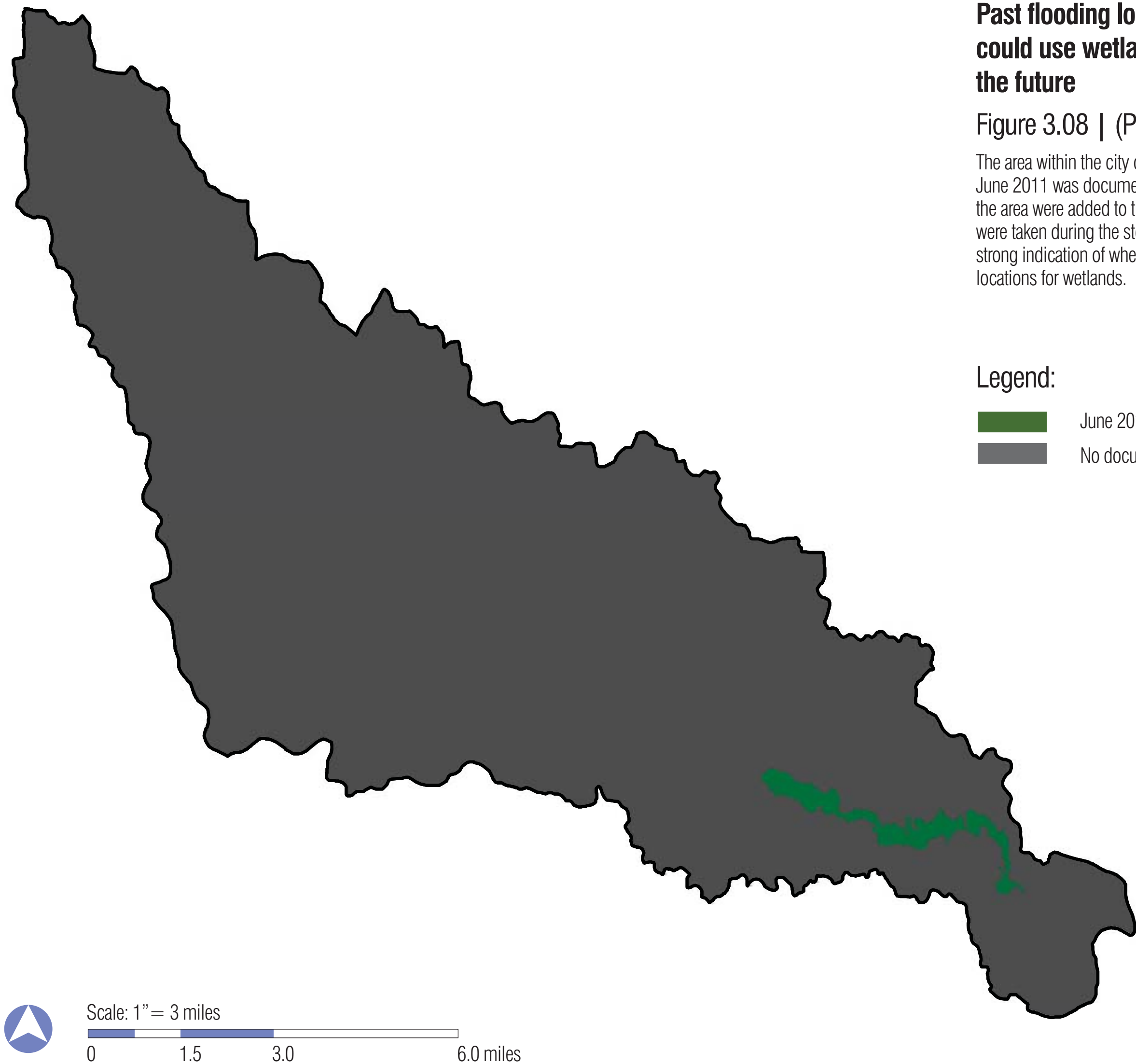
- Partially hydric soils
- Not hydric soil or unknown

Value in suitability analysis

High → Low

Scale: 1” = 3 miles

0 1.5 3.0 6.0 miles



Past flooding locations show areas that could use wetlands to prevent flooding in the future

Figure 3.08 | (Produced by author, 2012)

The area within the city of Manhattan boundary that flooded in the June 2011 was documented by the city. Additional areas outside of the area were added to the flooding map based on photographs that were taken during the storm. The area that flooded in 2011 shows strong indication of where it will flood again and would be ideal locations for wetlands.

Legend:

June 2011 documented flooding

No documented flooding

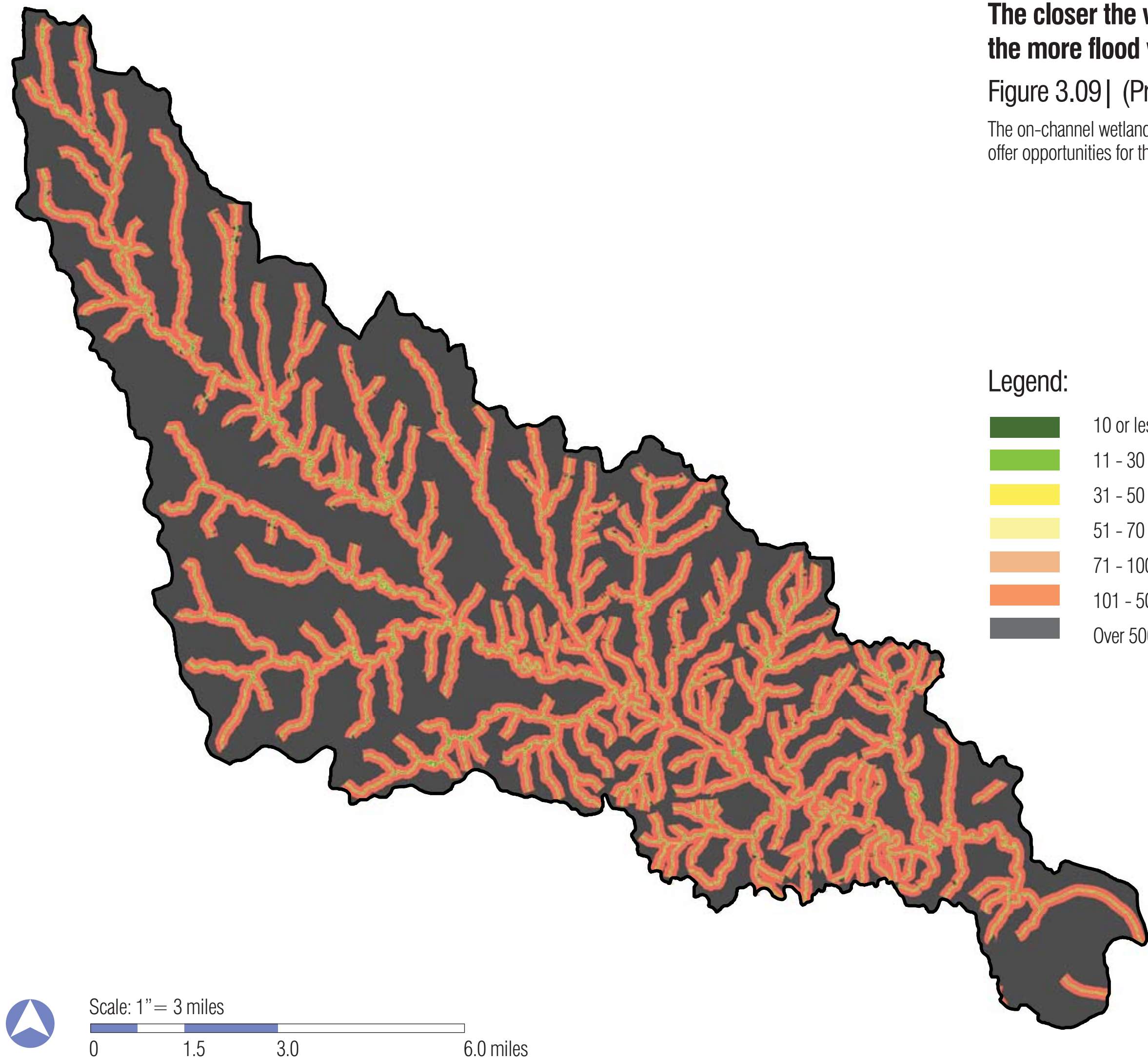
Value in suitability analysis

High → Low

The closer the wetlands are to the creek, the more flood water they can capture

Figure 3.09| (Produced by author, 2012)

The on-channel wetlands need to be adjacent to the stream and offer opportunities for the water to naturally flood into the wetland.



Legend:

- 10 or less feet to the center of the stream channel
- 11 - 30 feet
- 31 - 50 feet
- 51 - 70 feet
- 71 - 100 feet
- 101 - 500 feet
- Over 500 feet

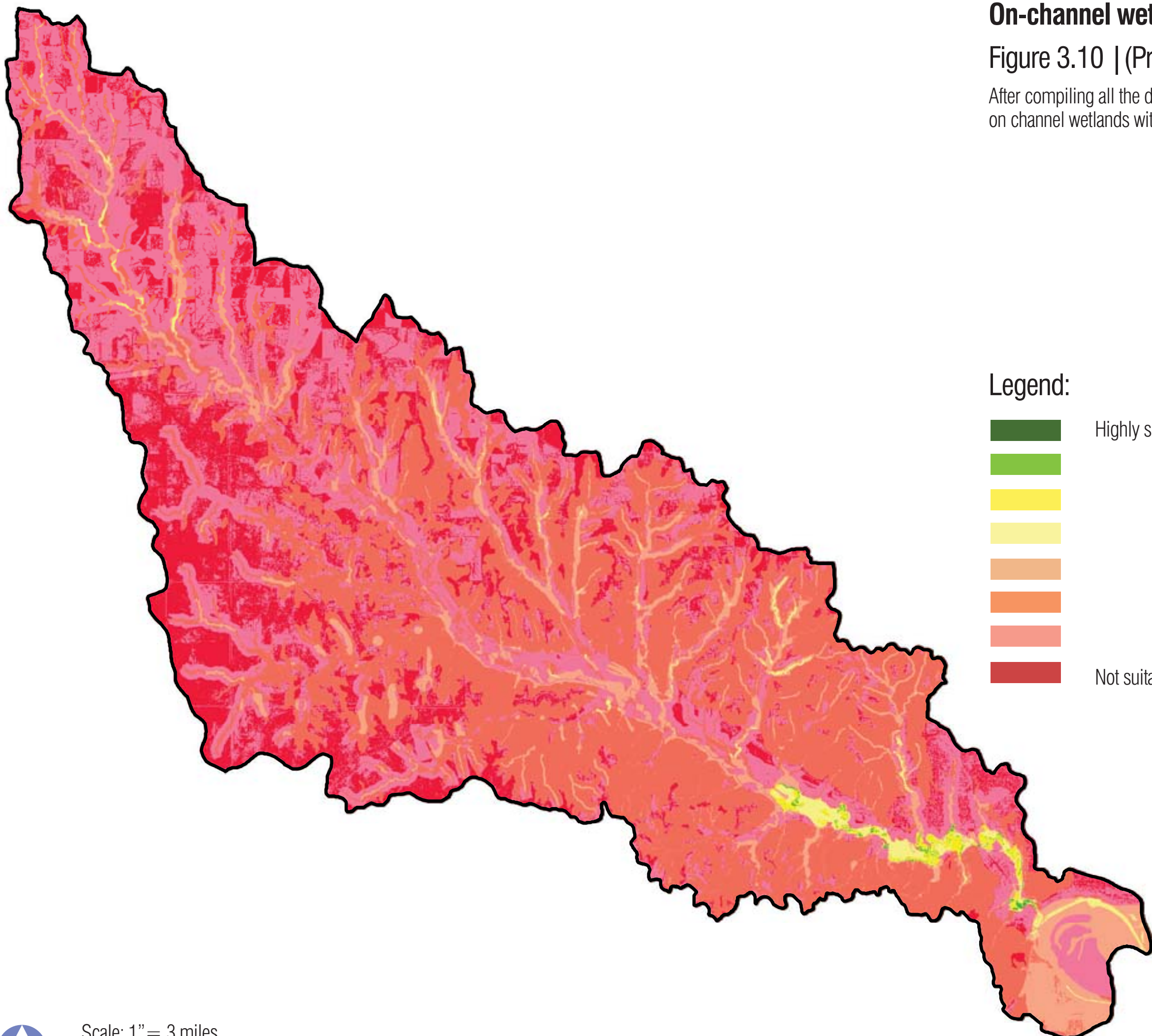
Value in suitability analysis

High → Low

On-channel wetland suitability

Figure 3.10 | (Produced by author, 2012)

After compiling all the data, there are areas that are very suitable for on channel wetlands within the Wildcat Creek watershed



Legend:

Highly suitable for wetlands

Not suitable for wetlands

Value in suitability analysis

High → Low

Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

off-channel wetlands

See weighted overlay map in Figure 3.12

- o City stormwater exit points (15%)

  Handling water at the point of contact is the best way to prevent runoff that causes flooding. Using city stormwater exit points help delineate points that can have high levels of water reaching pervious surface. The midlevel wetlands would be fed through the city stormwater system. The points of interest were determined by the storage tank, pump station, and flushing assembly locations. See Figure 3.13.

- o Flooding of creeks (10%)

  The off-channel wetlands are intended to collect runoff and reduce further runoff prior to reaching any creek level, not to consistently hold water year round. As a result, they are not found in locations where flooding has occurred in the past. See Figure 3.14.

- o % Impervious surface (5%)

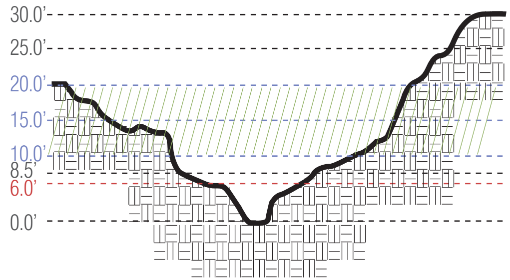
  Areas of impervious surface cannot maintain their current land use if converted into a wetland, although the areas with high levels of impervious surface need wetlands due to the increased runoff caused by the impervious surfaces. See Figure 3.15.

- o Ground elevation compared to channel elevation (elevation classification) (25%)

  The off-channel wetlands are intended to be in middle ground. Low grounds are much closer to the on-channel wetland options, while pumping water to significantly high grounds or ridgelines is not as beneficial due to the high cost of pumping water and the land does not receive enough runoff to make it a valuable location for a off-channel wetland. The ideal location is between the 20 and 30 feet above the creek elevation. See figure 3.11. For the watershed map, see Figure 3.16.

- o Hotspots

  Specific locations were chosen based on channelization, oxbows, and locations were the old creek can be used for wetlands. See figure 3.17



- WARSSS hotspot locations (5%)

  Hotspots were determined by the lack of forested vegetation, devegetation, channelization, non-terraced agriculture, surface erosion, urban development, and historical change. The hotspots create specific areas throughout the watershed that contribute to the flooding issue. The hotspots are areas that could use wetlands to help counter the increase of flow and sediment that the hotspots produce. Many, but not all, wetlands are adjacent to the creek channel. See Figure 3.18.

- Proximity to 100 year FEMA floodplain boundary (5%)

  The off-channel wetlands are not intended to be in areas that are prone to flooding. They are intended to collect runoff and reduce further runoff prior to reaching any area that has high potential for flooding. See Figure 3.19

- Distance to creek (5%)

  The off-channel wetlands are not intended to be adjacent to the creek or fed by the flooding of the creek, so being further from the creek channel is helpful to solving the problem throughout the watershed and collecting water at the point of contact. See Figure 3.20.

- Soil permeability level (20%)

  The areas with poor soil permeability are best suited for wetlands that hold minimal water. If a soil has high levels of the permeability, it could be used as a wetland that does not hold water. The areas could be used to increase wildlife habitat and as areas with increased infiltration. In upland conditions, it would be good for the soil to have some level of infiltration that reduces the flooding levels of the wetland. See Figure 3.21.

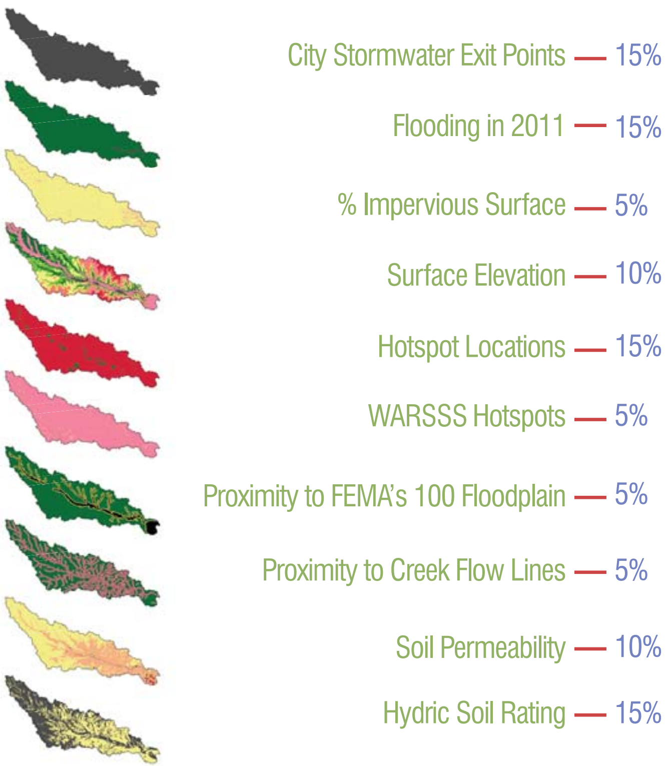
- Hydric levels (10%)

  Hydric soils are areas that were formerly wetlands and regions that have historical value to wetlands. See Figure 3.22.

Off-channel elevation of stream channel

Figure 3.11 | (Produced by author, 2012)

The off-channel wetlands are best found in a middle ground to catch stormwater from higher lands before it reaches the creek.



Off-channel wetland suitability

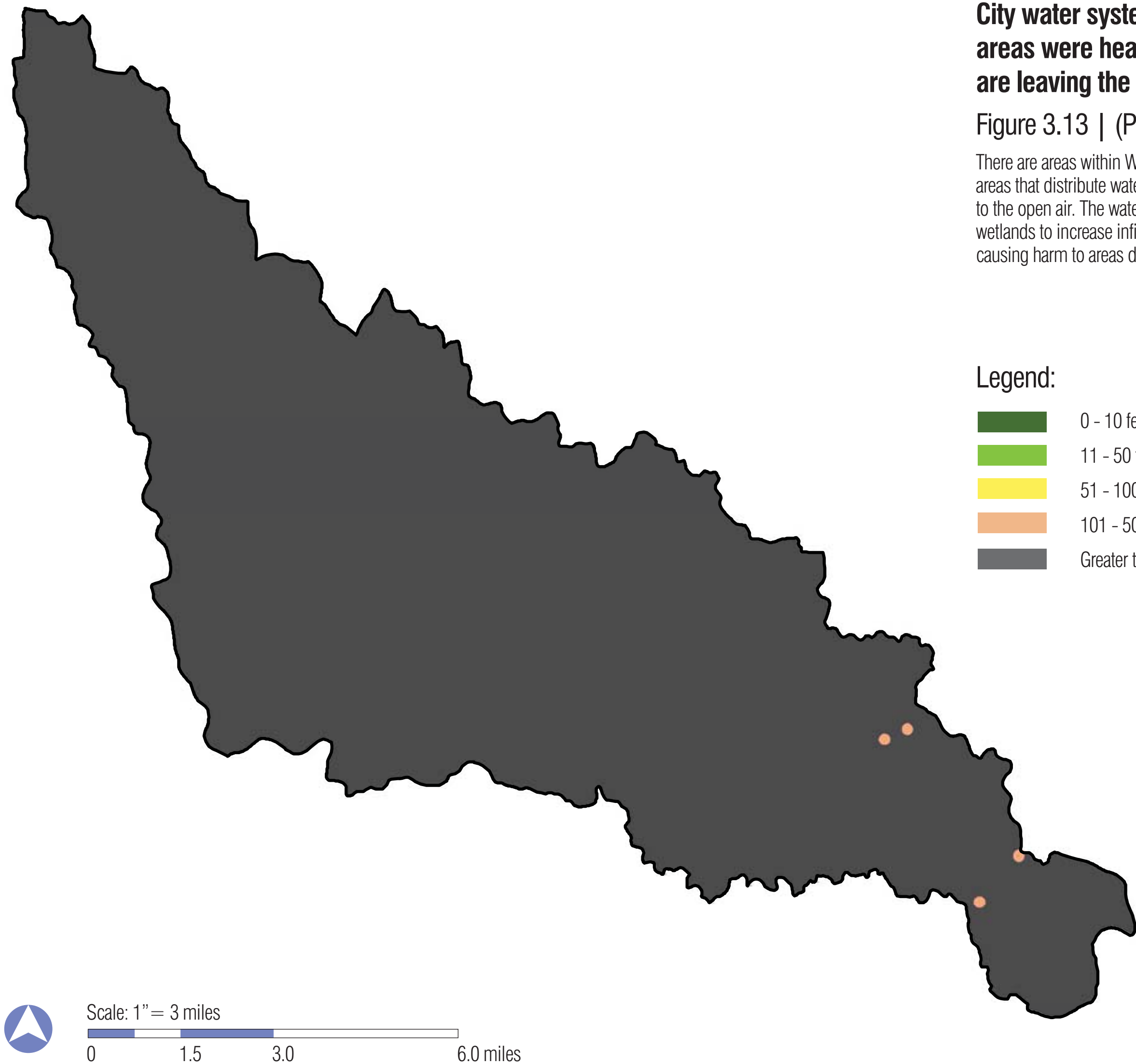
Figure 3.12 | (Produced by author, 2012)

Each layer in the suitability analysis is weighted based on the importance of the layer.

City water system daylight points show areas were heavy flows of concentration are leaving the system

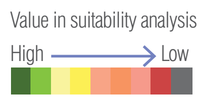
Figure 3.13 | (Produced by author, 2012)

There are areas within Wildcat Creek Watershed that appear to have areas that distribute water from an urban stormwater piping system to the open air. The water would be best distributed into off-channel wetlands to increase infiltration areas and reduce the possibility for causing harm to areas downstream.



Legend:

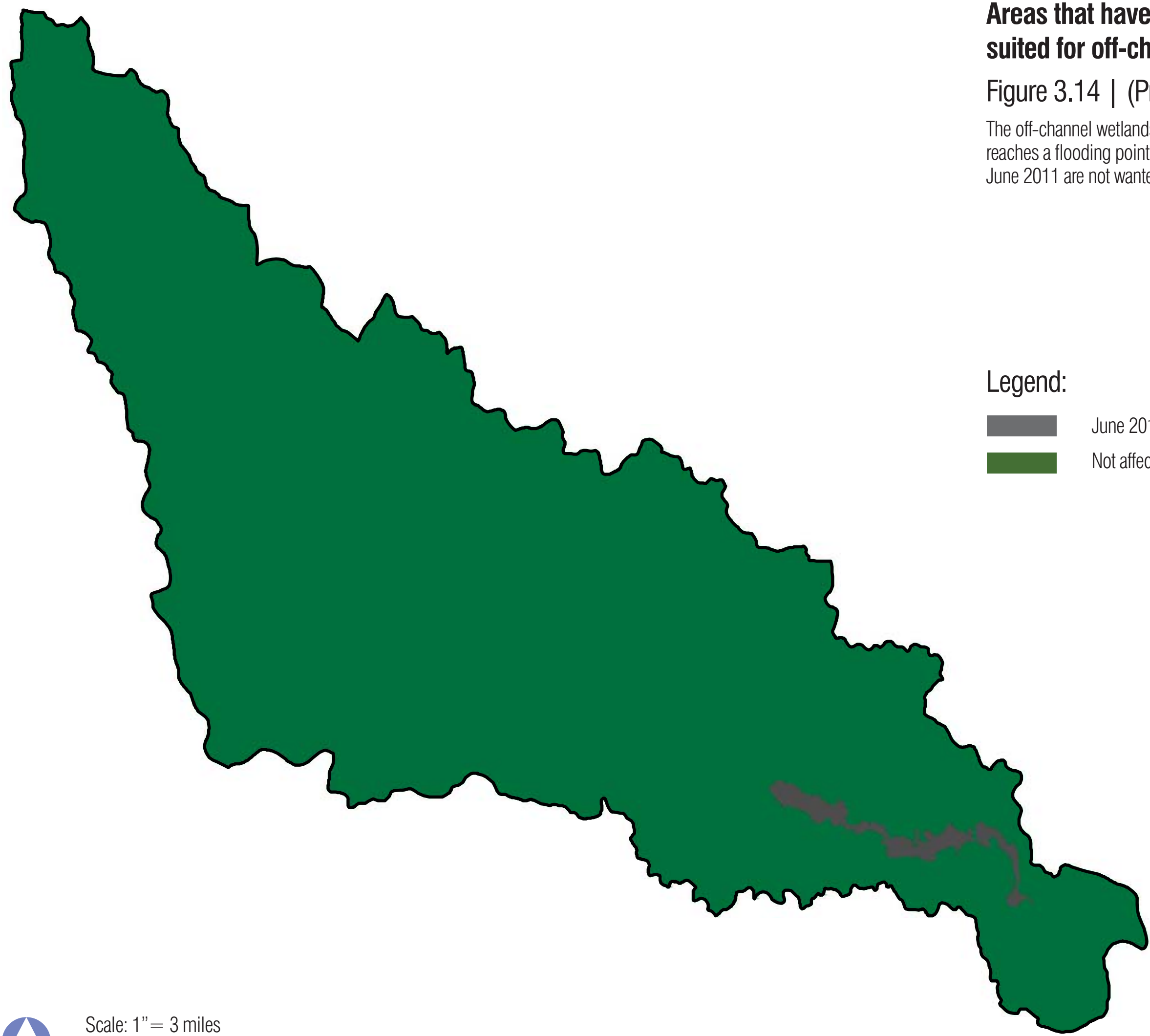
- 0 - 10 feet around daylight point
- 11 - 50 feet
- 51 - 100 feet
- 101 - 500 feet
- Greater than 500 feet



Areas that have prior flooding are not suited for off-channel wetland suitability

Figure 3.14 | (Produced by author, 2012)

The off-channel wetlands are intended to handle water before it reaches a flooding point. Therefore, the flooding locations from June 2011 are not wanted for off-channel wetlands.



Legend:

- June 2011 flooding
- Not affected by 2011 flooding

Value in suitability analysis

High → Low

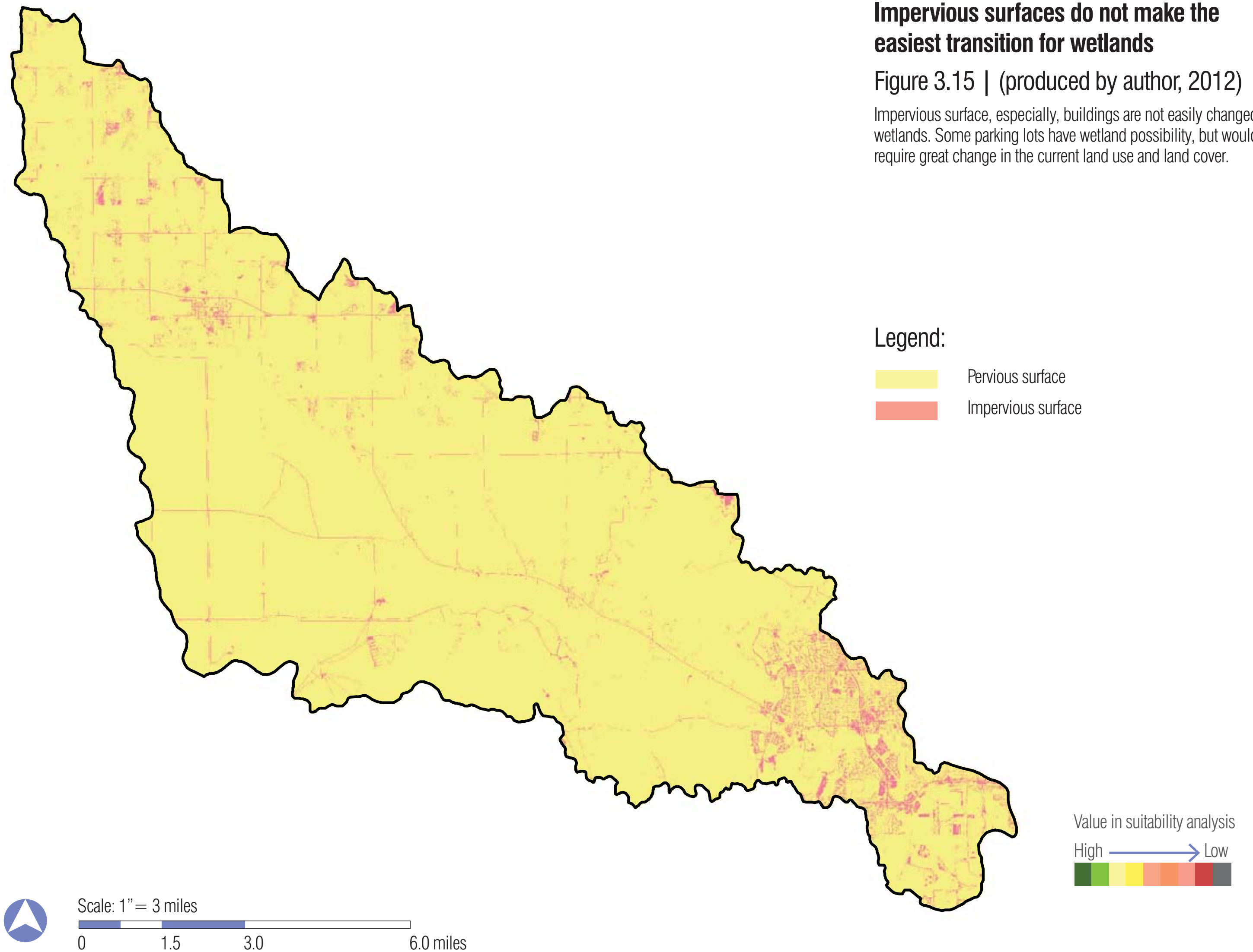
Scale: 1"= 3 miles

0 1.5 3.0 6.0 miles

Impervious surfaces do not make the easiest transition for wetlands

Figure 3.15 | (produced by author, 2012)

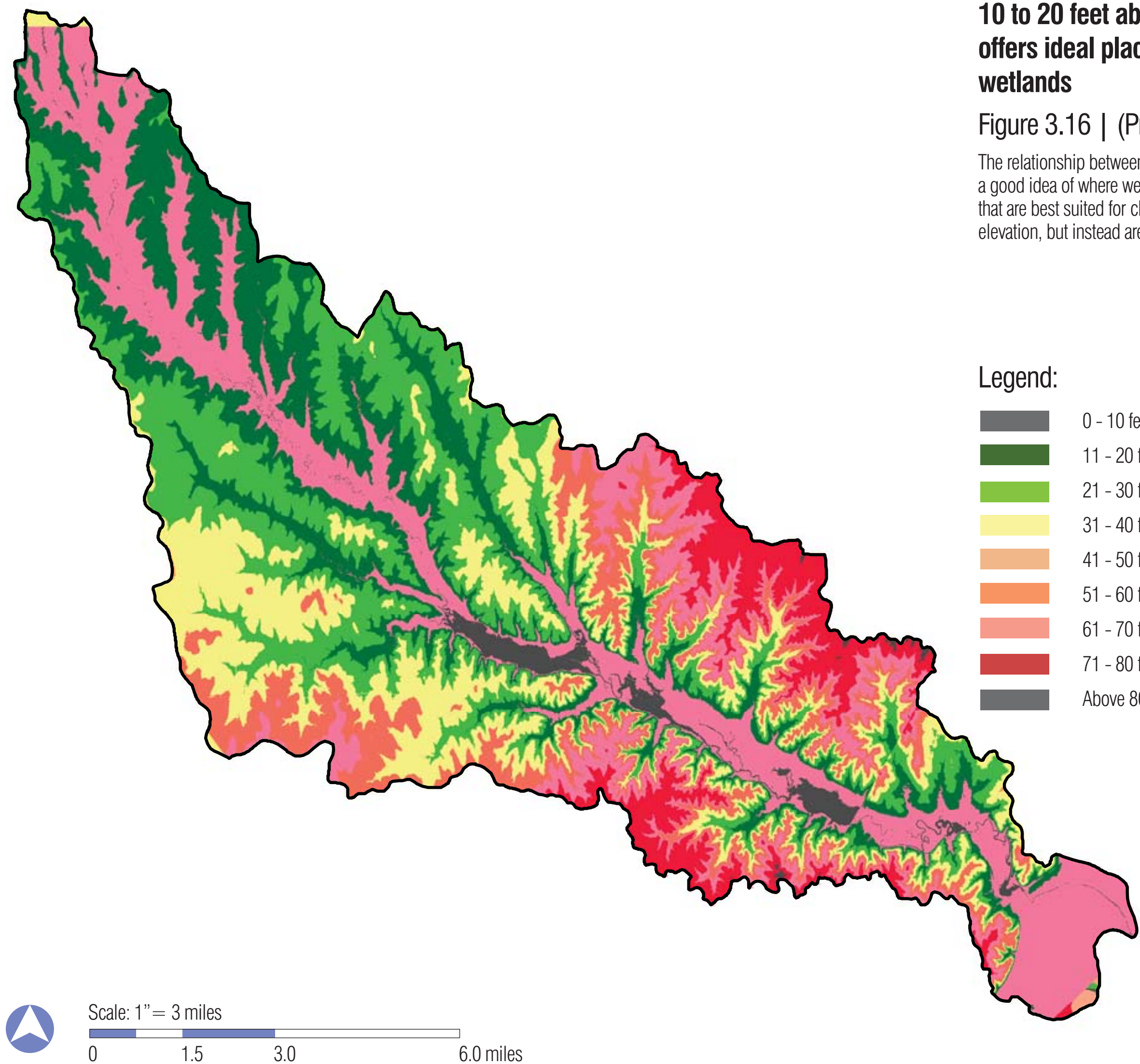
Impervious surface, especially, buildings are not easily changed to wetlands. Some parking lots have wetland possibility, but would require great change in the current land use and land cover.



10 to 20 feet above the stream elevation offers ideal placement for off-channel wetlands

Figure 3.16 | (Produced by author, 2012)

The relationship between the land and the creek channel helps give a good idea of where wetlands could be established. The locations that are best suited for channel wetlands are not at the stream elevation, but instead are in the first class up from the area.



Legend:

- 0 - 10 feet above creek elevation
- 11 - 20 feet
- 21 - 30 feet
- 31 - 40 feet
- 41 - 50 feet
- 51 - 60 feet
- 61 - 70 feet
- 71 - 80 feet
- Above 80 feet

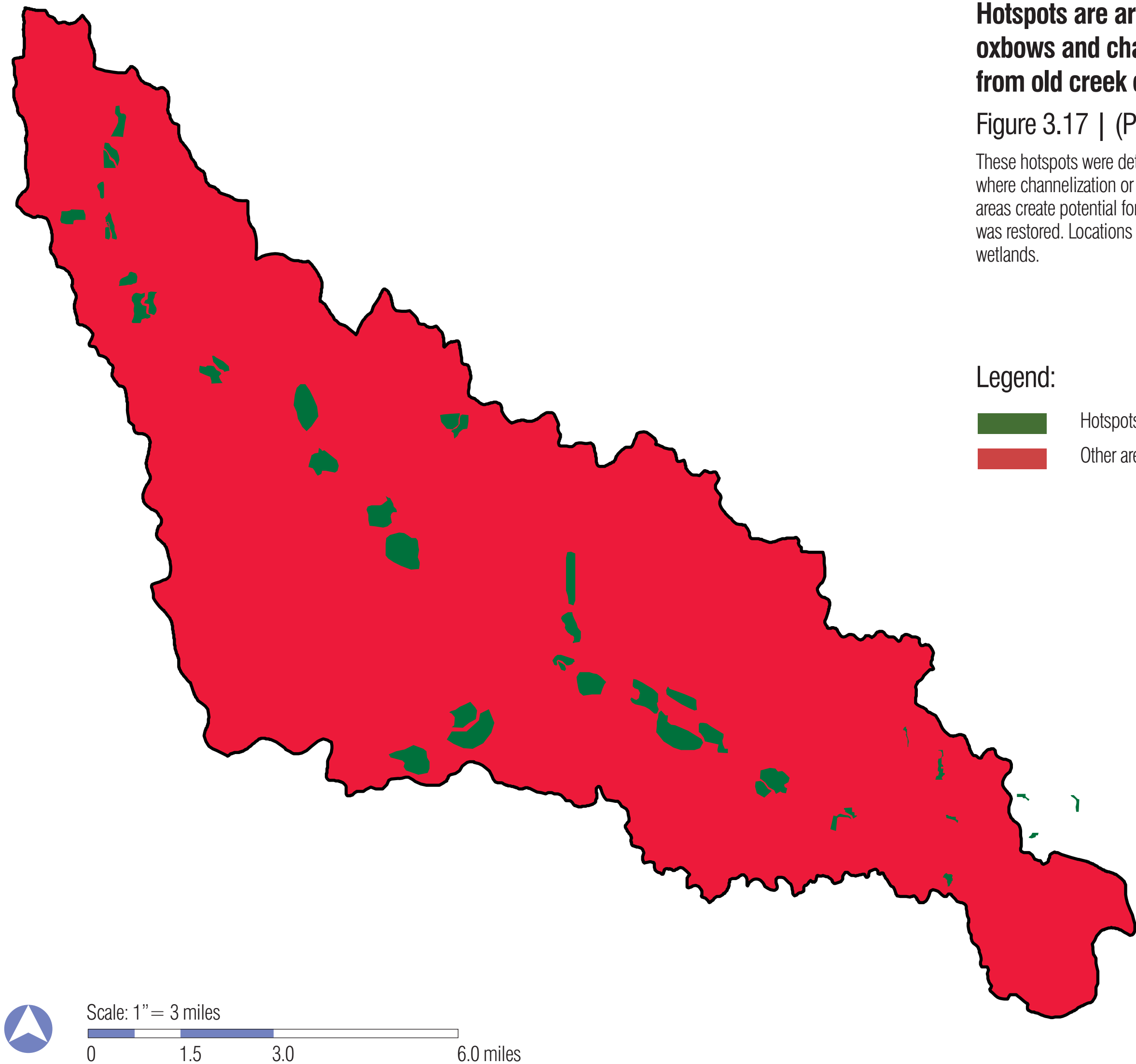
Value in suitability analysis

High → Low

Hotspots are areas that need change from oxbows and channelization where wetlands from old creek channels are ideal

Figure 3.17 | (Produced by author, 2012)

These hotspots were determined base on locations along the creek where channelization or change of stream has occurred. Those areas create potential for off-channel wetlands if the creek channel was restored. Locations of the old channel could be turned into wetlands.



Legend:

Hotspots

Other area

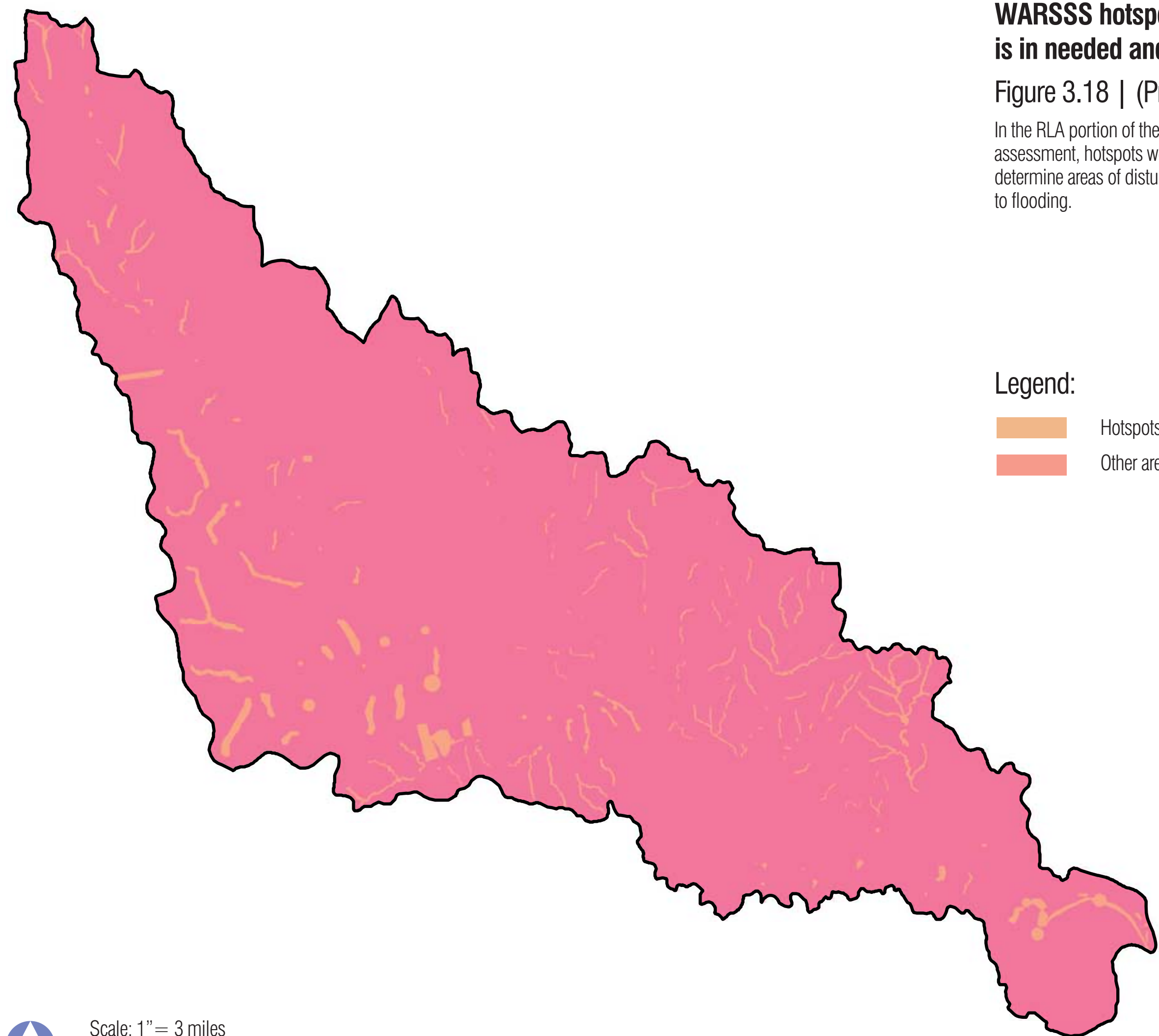
Value in suitability analysis

High → Low

WARSSS hotspots are areas where change is in needed and wetlands can be beneficial

Figure 3.18 | (Produced by author, 2012)

In the RLA portion of the group assessment, Rosgen's WARSSS assessment, hotspots were determined throughout the watershed to determine areas of disturbance and problems that have contributed to flooding.



Legend:

Hotspots

Other area

Value in suitability analysis

High → Low

Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

Floodplains are areas that are prone to flooding caused by the backing up from the creek; off-channel wetlands are not ideal in that area

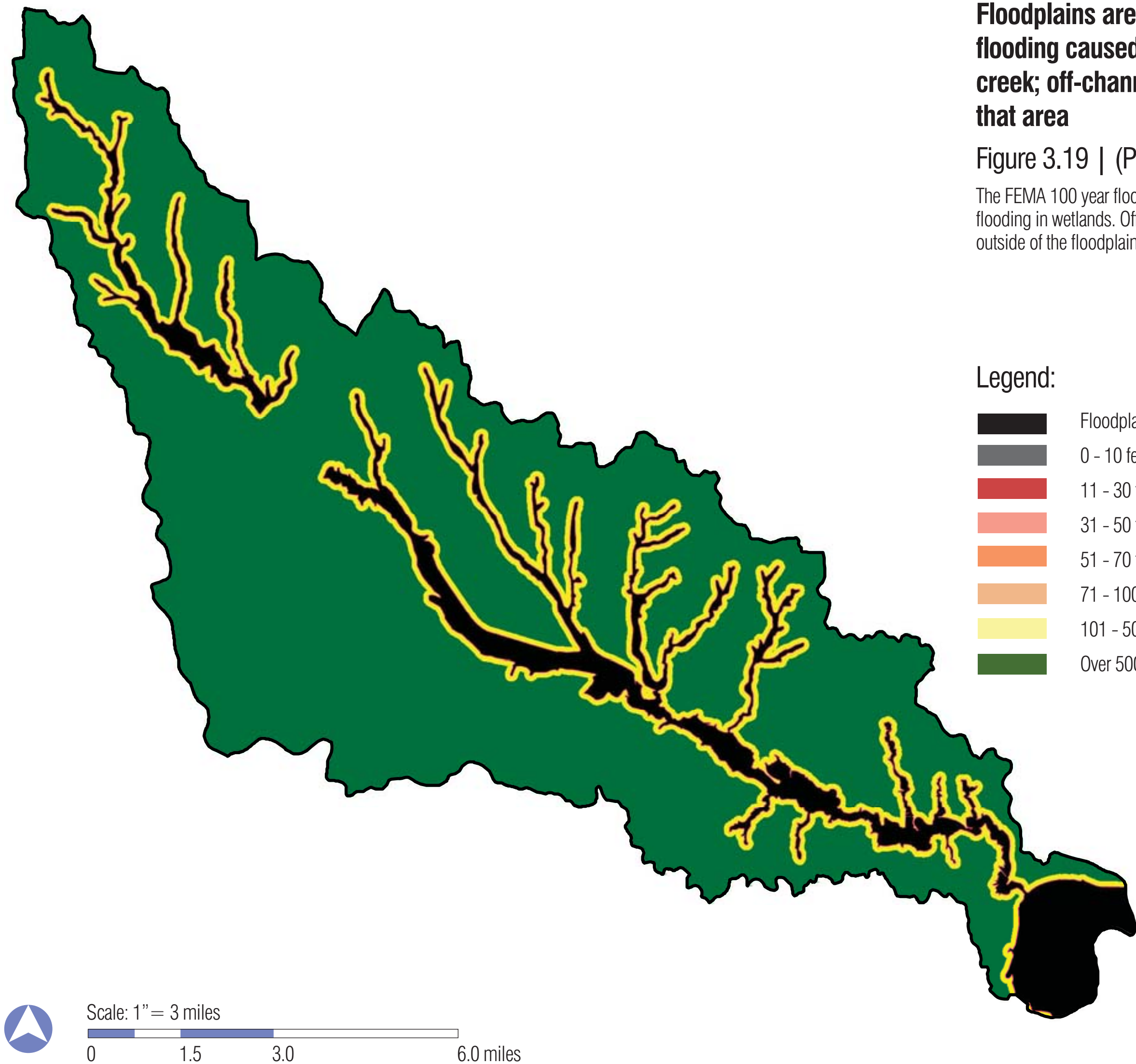
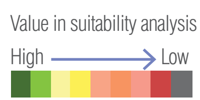


Figure 3.19 | (Produced by author, 2012)

The FEMA 100 year floodplain is an area that is best suited for flooding in wetlands. Off-channel wetlands are best suited in areas outside of the floodplain.

Legend:

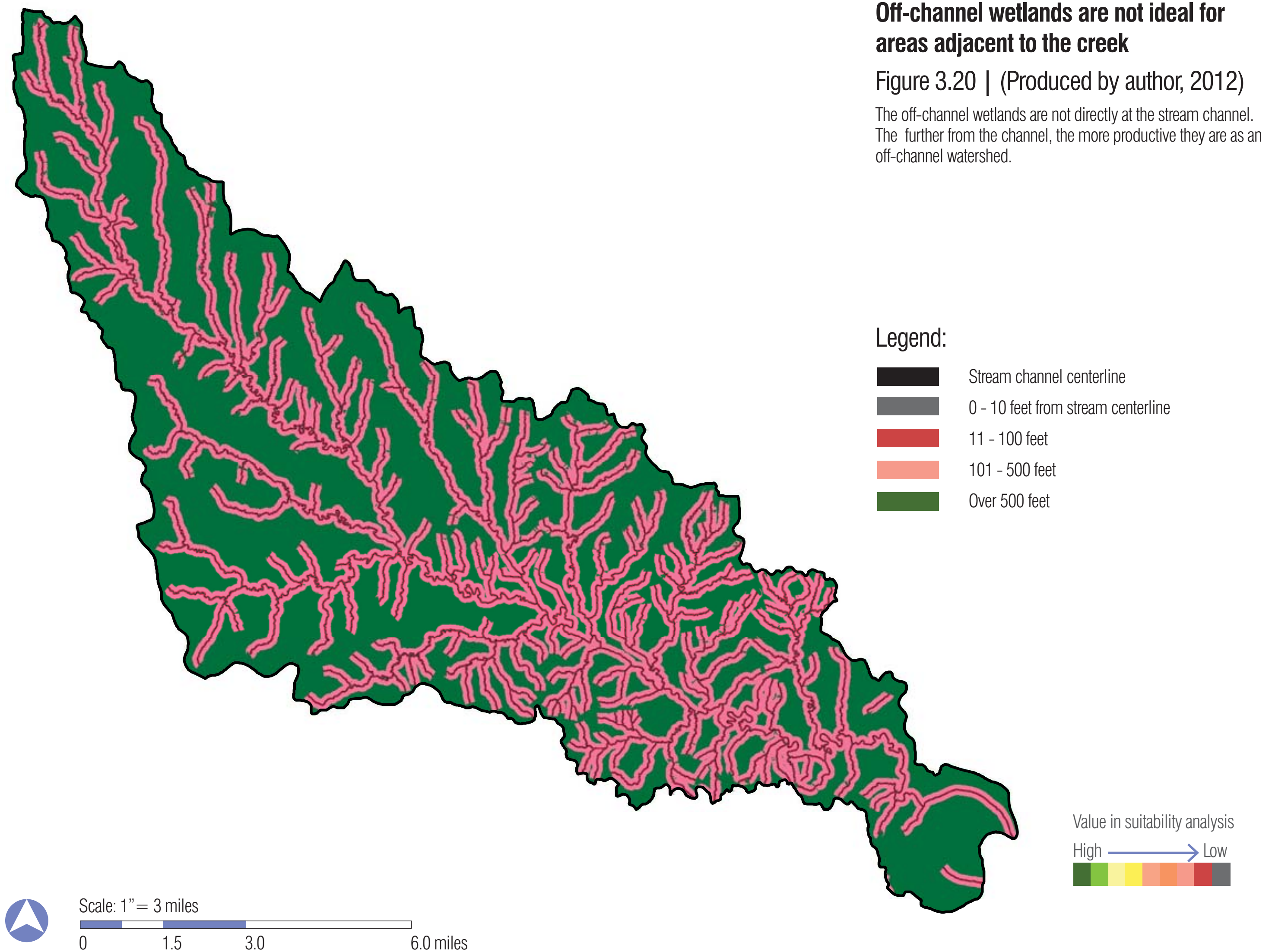
- Floodplain
- 0 - 10 feet from floodplain
- 11 - 30 feet
- 31 - 50 feet
- 51 - 70 feet
- 71 - 100 feet
- 101 - 500 feet
- Over 500 feet from floodplain

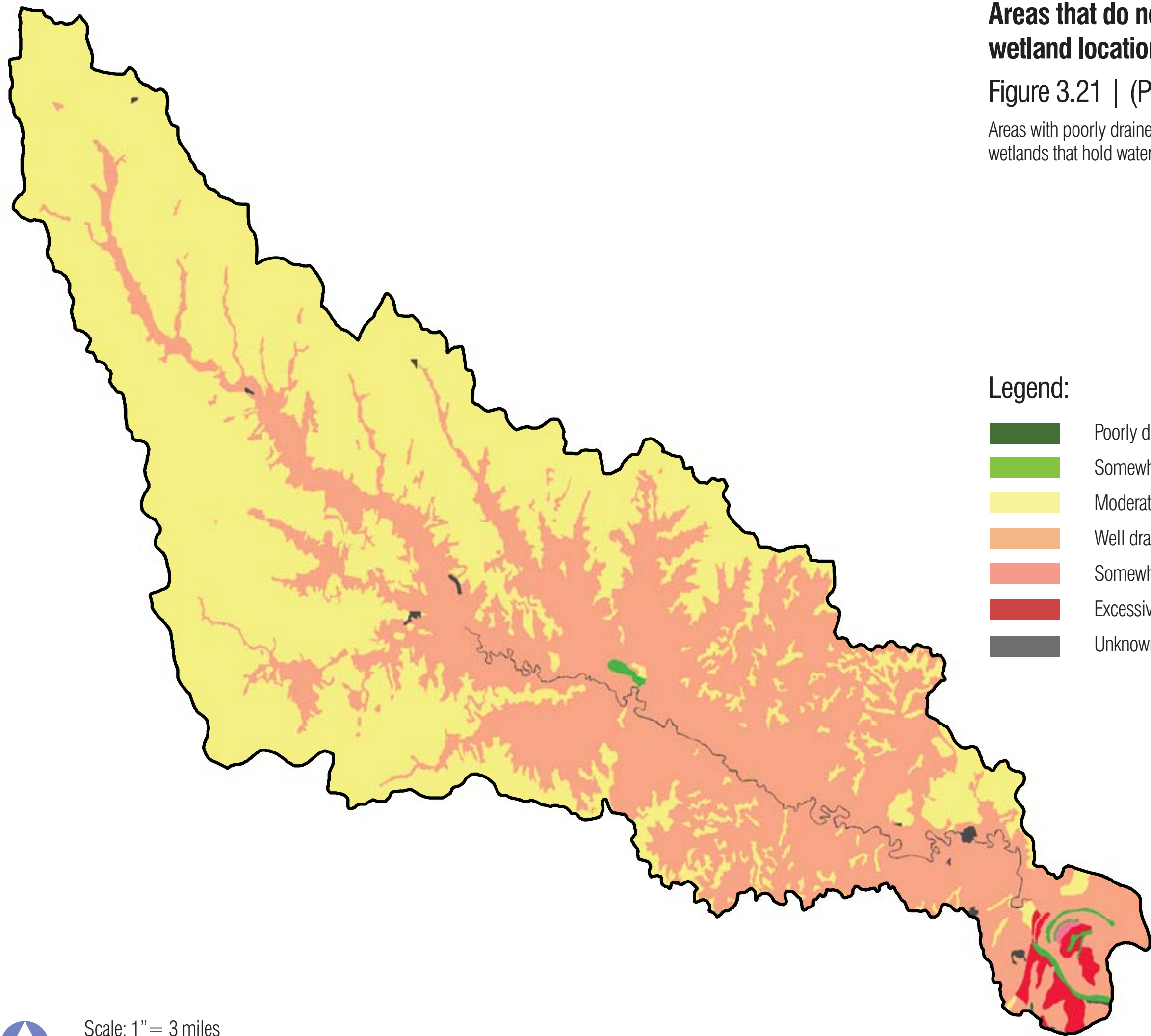


Off-channel wetlands are not ideal for areas adjacent to the creek

Figure 3.20 | (Produced by author, 2012)

The off-channel wetlands are not directly at the stream channel. The further from the channel, the more productive they are as an off-channel watershed.





Areas that do not drain well are ideal for wetland locations

Figure 3.21 | (Produced by author, 2012)

Areas with poorly drained soil would be good areas to have wetlands that hold water.

Legend:

- Poorly drained soil
- Somewhat poorly drained
- Moderately well drained
- Well drained
- Somewhat excessively drained
- Excessively drained
- Unknown

Value in suitability analysis

High → Low

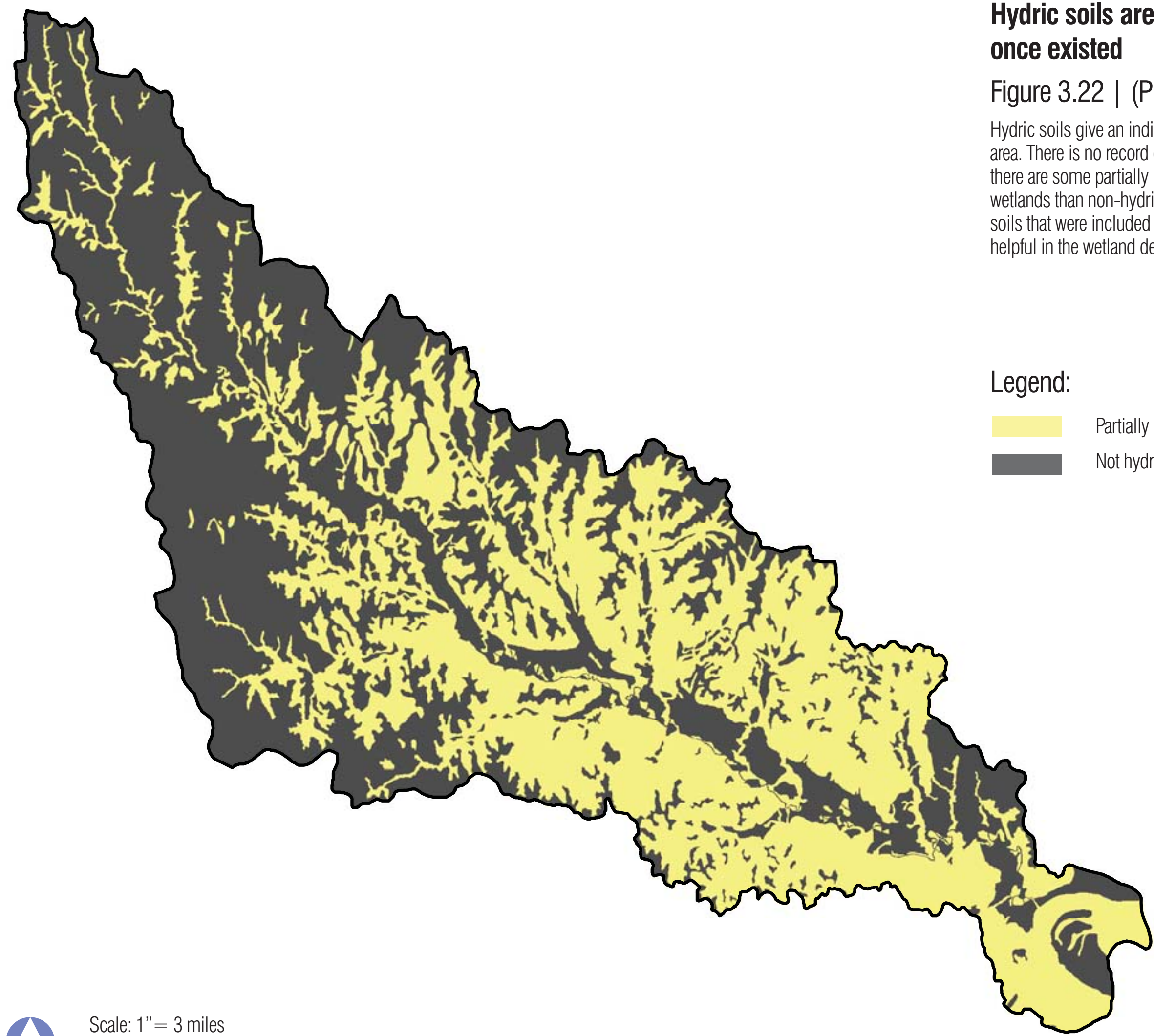
Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

Hydric soils are historically areas wetlands once existed

Figure 3.22 | (Produced by author, 2012)

Hydric soils give an indication that a wetland formally existed at that area. There is no record of true hydric soils in the area. Although there are some partially hydric soils that would be better suited for wetlands than non-hydric soils. There were some unknown hydric soils that were included with the non-hydric to assume they are not helpful in the wetland determination.



Legend:

Partially hydric soils

Not hydric soil or unknown

Value in suitability analysis

High → Low

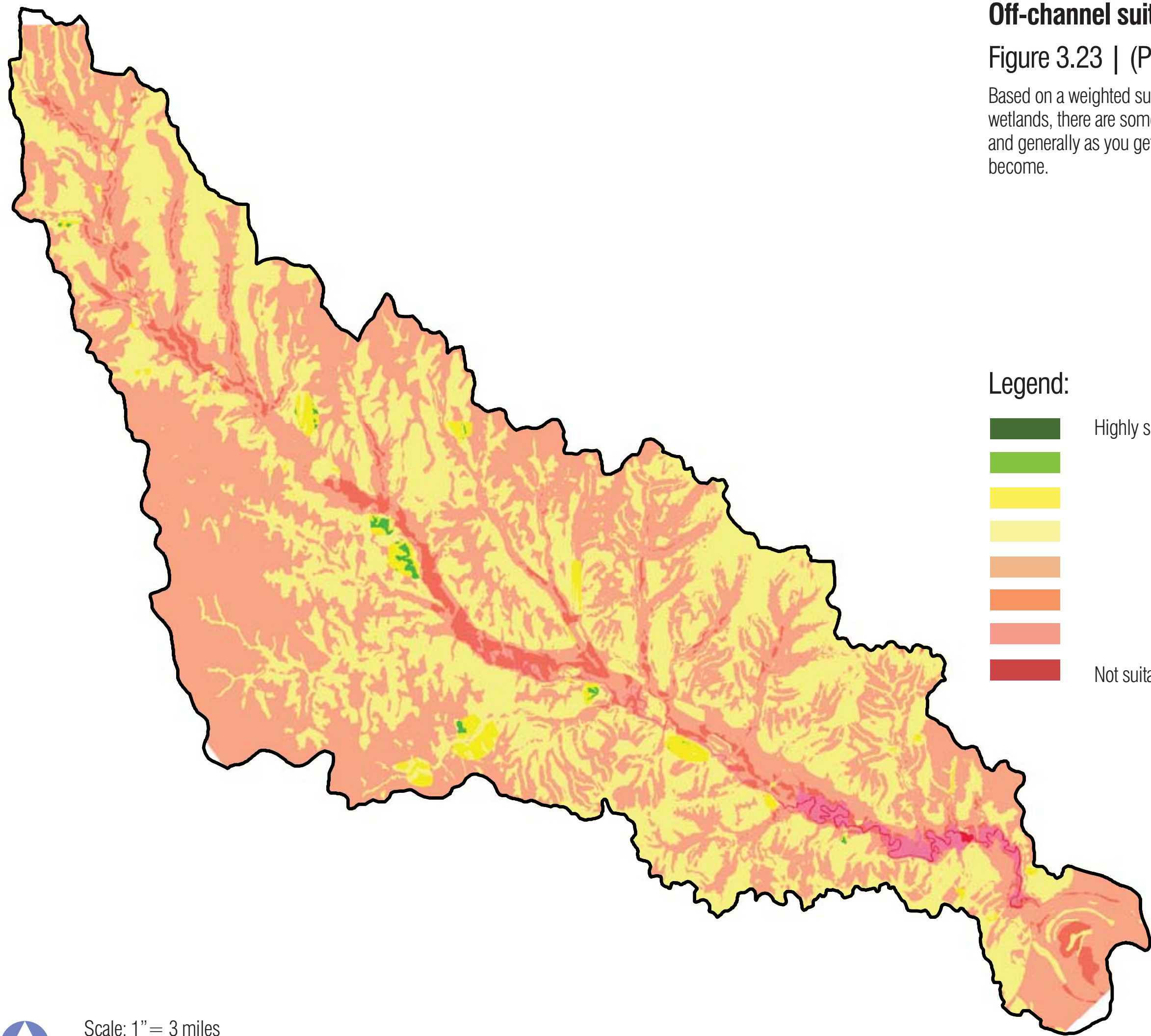
Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

Off-channel suitability

Figure 3.23 | (Produced by author, 2012)

Based on a weighted suitability for the best location of off-channel wetlands, there are some areas that are more receptive than others and generally as you get further northwest, the more receptive they become.



Legend:

- Highly suitable for wetlands
- Not suitable for wetlands

Value in suitability analysis

High → Low

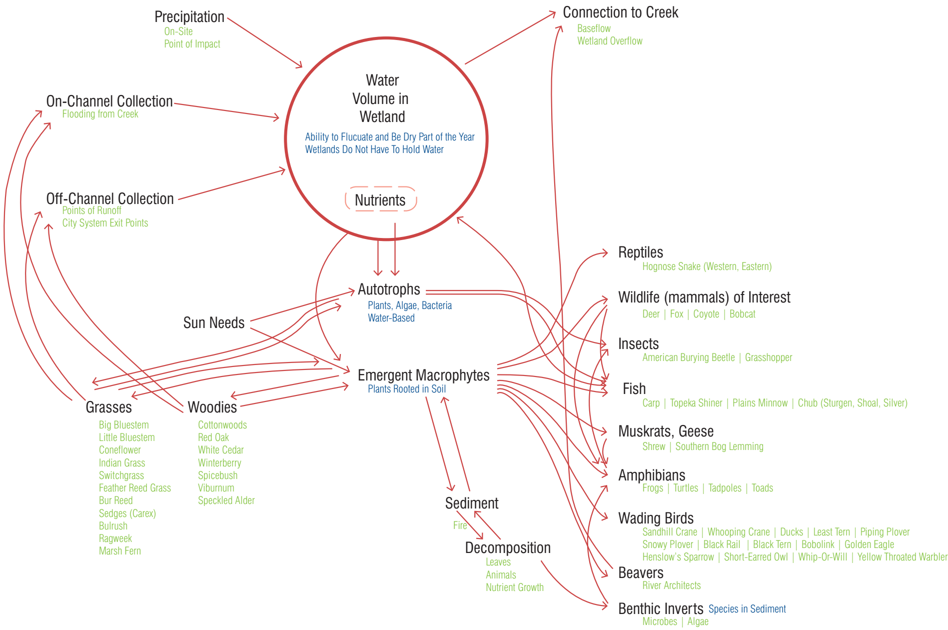
Scale: 1"= 3 miles

0 1.5 3.0 6.0 miles

wildlife habitats

Wildcat Creek is home to many threatened and endangered species listed by the state of Kansas including Topeka Shiner and Whooping Crane. Other species, including Golden Eagles and Henslow's Sparrow, are on a list of species that need to be watched. The Sandhill Crane has a limited habitat zone that includes migration patterns from common breeding ground of the Platte River in Nebraska through Kansas to Texas. Each of these species has habitat needs served by wet prairies (off-channel wetlands) or wetlands (on-channel wetlands).

The species need support across their habitat web to maintain strength and find a home in the region. The habitat web includes food, shelter, water, and reproduction resources. If it were a human habitat, the meaning or reason to do something is a fifth element in the habitat web (figure 2.14). An ecosystem is a more complex version of a habitat web. Mitsch et al defines an ecosystem as "a complex of ecological communities and their environment, forming a functioning whole in nature (2009, pp 1)", and uses ecological diagrams to describe each type of wetland in their typology for the nation. The "freshwater swamp" or "freshwater marsh" (2009, pp 87) are the only applicable wetlands to Wildcat Creek and Riley County Kansas. The ecosystem diagram, figure 3.24, shows the complex relationships that are needed in wetlands through plant selection, material choices, soil types, and many other components. It has been modified by the author to relate the five (5) species of interest to the diagram and the proposed wetlands in the Wildcat Creek watershed.



whooping crane

Grus americana (Threatened and endangered species)

> "The only remaining natural, self-sustaining flock of Whooping Cranes breeds in Wood Buffalo Nation Park in the Northwest Territories, Canada and winters in Aransas National Wildlife Refuge (Texas)." (International Crane Foundation)

The Whooping Crane species has significantly decreased in numbers. According to the International Crane Foundation (n.d.), attempts to revitalize the species have not been successful. Scientists tried to have a Sandhill Crane flock hatch and raise the eggs, but the Whooping Cranes were not able to reproduce with each other to create a greater flock. They have started a migratory path from Wisconsin to Alabama to Florida, but the flock is led by an ultralight aircraft and not self-supported. There is one flock of Whooping Cranes that represents the only self-sustaining flock to fly from the Platte River in Nebraska, through Kansas, and down to Texas. The species has limited places that they stop but migrate through the area twice annually. The more places there are to rest, eat, and find as their natural habitat, the more the Whooping Cranes are able to travel and grow.

The Whooping Crane species is accustom to a habitat of the "northern tallgrass prairie" that is found in the northern states and "wetland ecosystems" as a wintering habitat in the southern states, according to the International Crane Foundation (n.d.). The Kansas Flint Hills are known for their tallgrass prairie and with the addition of wetlands for flooding control in the Wildcat Creek Watershed, the Whooping Crane species has an expanded habitat on its migratory route between climates.

The Whooping Cranes are omnivorous. Their main food sources include "mollusks and crustaceans, insects, minnows, frogs, and snakes" (International Crane Foundation). Little is known about what the cranes naturally eat in the Midwest due to their rapid extinction before studies were completed. In the south, other food sources include "acorns, snails, insects, and rodents (International Crane Foundation)." In order for the cranes to have a healthy amount of food sources, the area must be equipped to support insects, minnows, frogs, snakes, acorns, and rodents. Frogs need a wetland or steady water source to lay eggs and allow the tadpoles to grow. Frog types in Kansas could include American Toads, Great Plains Toads, Bullfrogs, Spring Peepers, Chorus Frogs, and Leopard Frogs, according the Robert F. Clarke (1984). Many frogs prefer habitats with vegetation six to twelve inches. Much of the wetlands and riverside marshes are ideal for frogs. The Leopard Frog has a diet of spiders, snails,

Ecosystem diagram

Figure 3.24 | (Produced by Author based on Mitsch et al (2009) ecosystem definition, 2012)

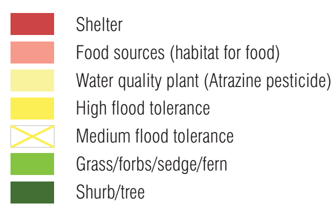
Wetlands have complex ecosystems with a variety of components to be considered and make the cycle possible and insects including “moth and butterfly larvae, grasshoppers and crickets, bees, wasps and ants,” according to the Environmental Protection Agency (EPA, n.d.). One grasshopper species that is already found on Konza Prairie is the toothpick grasshopper (White & Salsbury, 2000). The grasshopper feeds on grasses, including “western wheatgrass, bluegrass, neeleandthread, blue grama, sand dropseed, threeawn, sunsedge, Indian ricegrass, big bluestem, and little bluestem” (Brust, 2007). These grasses and other grasses found on Konza Prairie are home to many grasshoppers and insects that may interest the cranes, but also the snakes, frogs, and rodents that serve as food sources for the Whooping Crane.

In Wildcat Creek, prairie and wet prairie/wetlands need to be integrated into the landscape to broaden the range for the Whooping Cranes, as shown in figure 3.25. The species needs to continue the growth of their migratory patterns to enable the cranes to continue migrating. If the stopping grounds for the species disappear, the last remaining self-supporting Whooping Crane flock in the country will be lost.

Whooping crane habitat

Figure 3.25 | (Produced by author, 2012)

Habitat is comprised of shelter, food, water, and reproduction. Each element has plant species that are critical to individual parts of the habitat. Each plant also has certain water tolerances that make the plants better in certain locations over other locations.



topeka shiner

Nortropis topeka (Threatened and endangered species)

The Topeka shiner is an endangered species that is native to Wildcat Creek and parts of the Kansas River. The species survives best in continuous streams that flow in environments that are or were prairie ecosystems.

Topeka shiners have lost a majority of their habitat across South Dakota, Minnesota, Nebraska, Iowa, Kansas, and Missouri. The species diminished due to “sedimentation, increased nutrient loading, decreased stream flow, and increased water temperature” (“5-year review: Summary,” 2009, pg 11). The habitat of the Topeka shiner has shown to be impacted by row crop production. Decreasing the prairie habitat to create crop production has shown to increase sedimentation and change the river characteristic. Physical changes in the river allow for more land to produce crops and the ability to pump water out the creek which allows for greater income to the farmers and a less expensive water bill. Subsequently, a decrease in native, stable vegetation, increase of the loose sediment that flows into the creek, increased stream bank erosion, and a change in water levels occurs in the creek channel if the creek is channelized. If levees and other ponding mechanisms that stop the creek from flowing naturally are implemented, the species’ ability to swim and live becomes very limited. With the channelization of the creek, pumping of water, and increase of sediment, the creek fluctuates and does not allow for a stable environment for the fish.

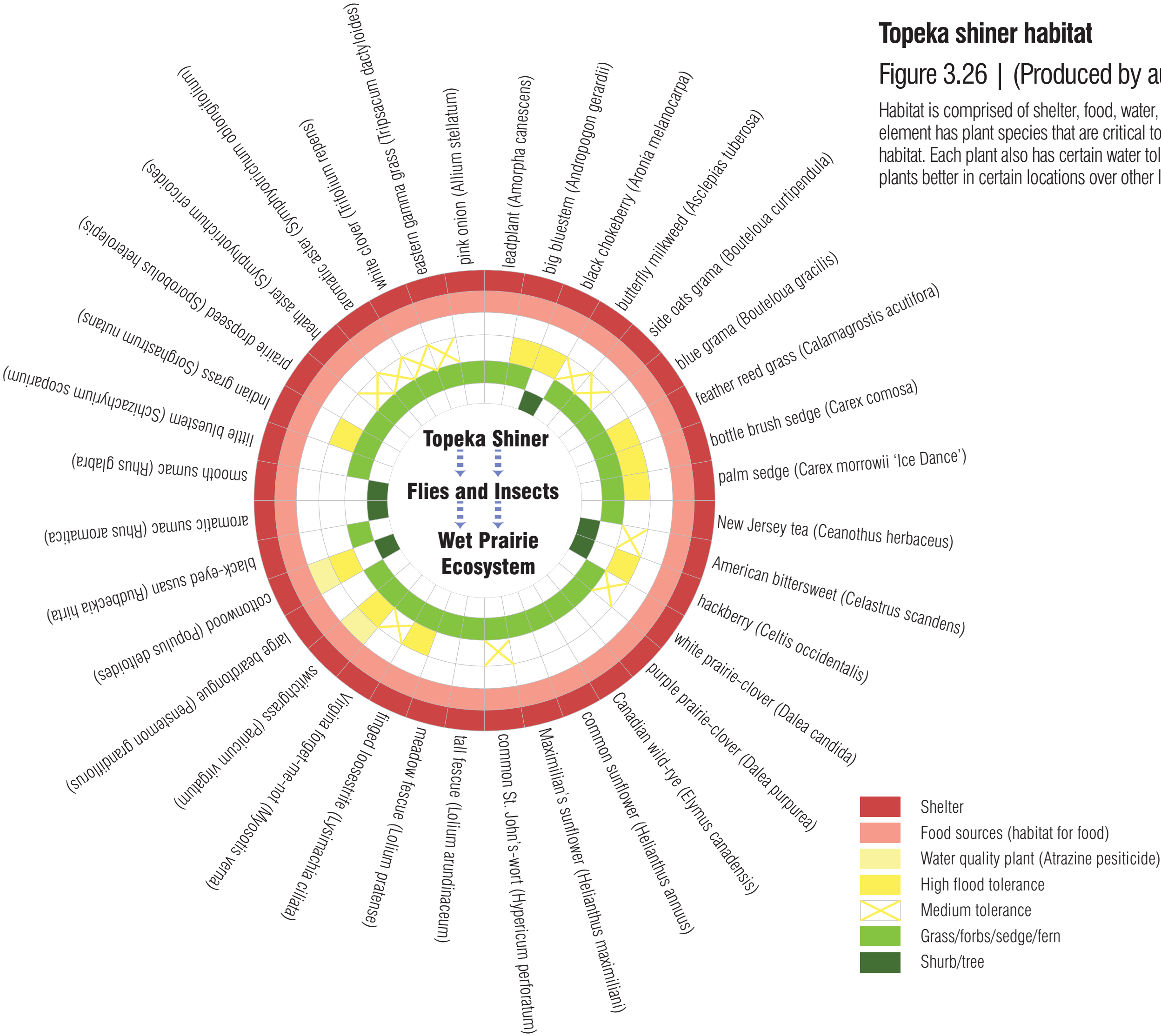
In order to keep the fish species intact and within Wildcat Creek, the creek needs to stabilize, maintain limited sediment run off, and maintain an even, steady stream of water throughout the creek. The creek cannot be dug into or pumped from to maintain even water levels and sediment levels. The surrounding land needs to be carefully considered in terms of how it is used to decrease the amount of sediment that runs off into the creek. Non-terraced farming, heavily traveled dirt roads, and tank paths are major contributors to the sediment buildup in the creek. A stable creek that has limited runoff and an even flow level is the best way to maintain the Topeka shiner species in Wildcat Creek.

The Topeka shiner inhabits “small prairie streams with good water quality and cool temperatures.” (Suckling, n.d.) Much of Wildcat Creek is adjacent to developed and agricultural land. Restoring a corridor of prairie around parts of the stream will help to re-establish proper habitat for the species. Wetland plants help clean the runoff and would be beneficial to increasing the water quality as well as slowing the sediment flow into the river. Restoring the land to prairie and wetland plants, as shown in figure 3.26, promotes good water quality and familiar habitat for the Topeka shiner.

Topeka shiner habitat

Figure 3.26 | (Produced by author, 2012)

Habitat is comprised of shelter, food, water, and reproduction. Each element has plant species that are critical to individual parts of the habitat. Each plant also has certain water tolerances that make the plants better in certain locations over other locations.



sandhill crane

Grus canadensis

> "Spring staging areas along the Platte River in Nebraska are of special concern because of their importance to the migratory subspecies and the development pressures facing this region. Approximately 80% of all Sandhill Cranes utilize a 75-mile stretch of the Platte River in spring migration." (International Crane Foundation)

The Sandhill Crane species is not as endangered as the other species are, but are found in a critical habitat just to the north of the Nebraska-Kansas boarder near the Platte River. The species summers in Canada, Alaska and the Northern States. The species then migrates down to Mexico, Texas and Florida. The flocks that fly through Kansas are typically headed to Texas or Mexico. (International Crane Foundation)

Throughout the flock's journey, the Sandhill Crane find "bogs, sedge meadows, and fens to open grasslands, pine savannas, and cultivated lands" as their habitat, according to the International Crane Foundation (n.d.). There is concern of losing the wetlands to development and not having enough habitats to support all of the flocks. The additional wetlands for flooding purposes in the Wildcat Creek Watershed also share a critical habitat for the Sandhill Crane species' migration routes.

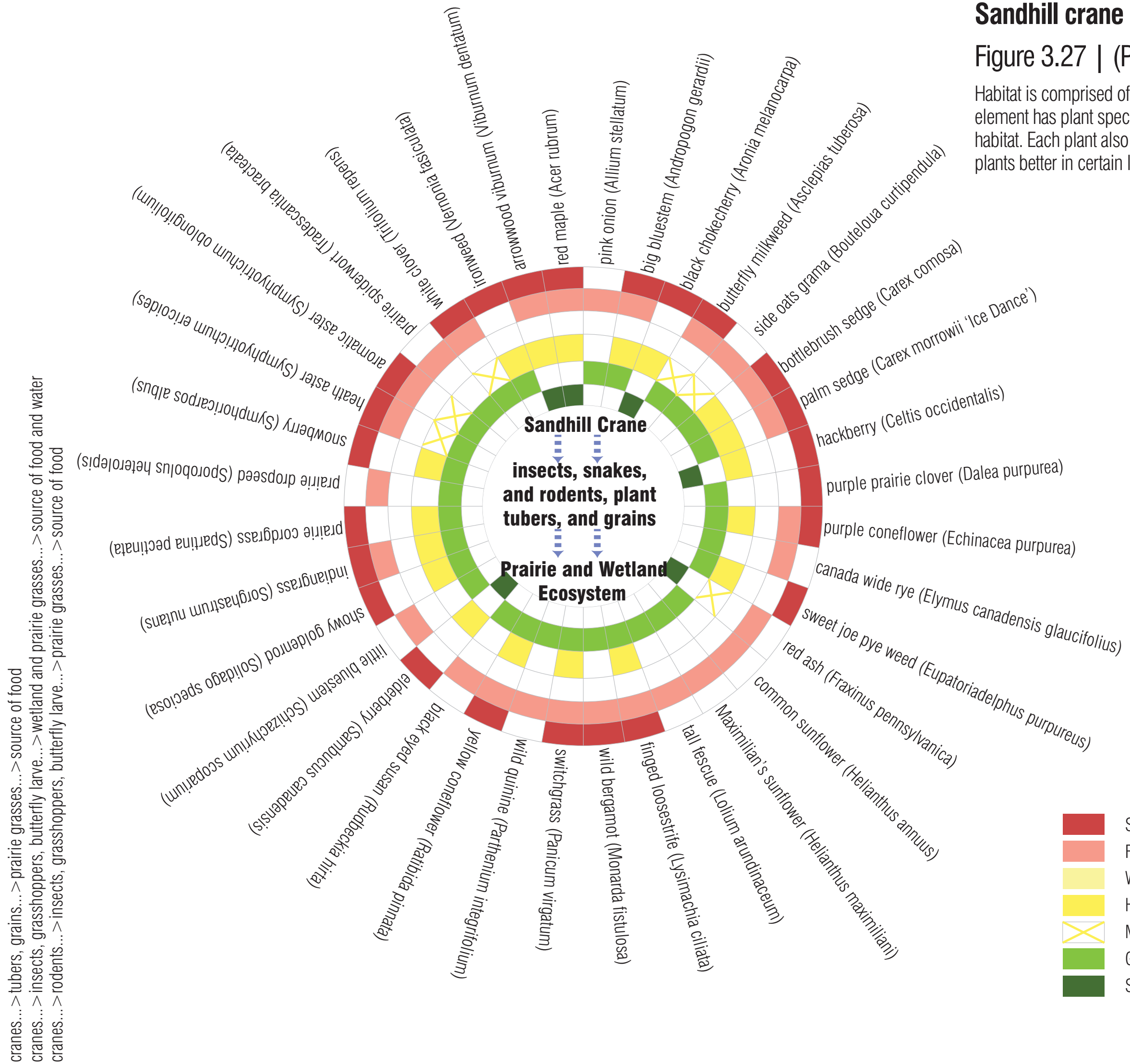
These birds are "generalists (International Crane Foundation)" and eat a wide range of food. The more common examples of their food sources include "plant tubers, grains, small vertebrates (e.g. mice and snakes), and invertebrates such as insects or worms (International Crane Foundation)." The food sources are typically found "in uplands and in shallow wetlands (International Crane Foundation)."

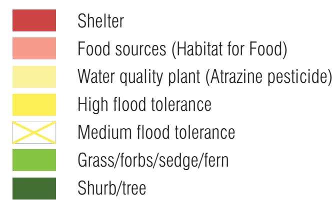
Using a variety of types of wetlands that includes the plant species found in figure 3.27 allows the species places that would be shallower to feed and areas with more substantial water sources for water and shelter. Having both types of wetlands available allows the cranes to expand their migration area and offers more habitat for them to safely reach their summer or winter breeding grounds.

Sandhill crane habitat

Figure 3.27 | (Produced by author, 2012)

Habitat is comprised of shelter, food, water, and reproduction. Each element has plant species that are critical to individual parts of the habitat. Each plant also has certain water tolerances that make the plants better in certain locations over other locations.





golden eagle

Aquila chrysaetos (Species in need of conservation)

The Golden Eagle will be added to the threatened and endangered species list in Riley County if the eagle population continues to decline. Currently, the Wildcat Creek Watershed is in the winter (non-breeding land), according to the Cornell Lab of Ornithology (2011). The year-round habitat for the animal begins on the western side of Kansas and continues westward.

The Golden Eagle is found on “cliffs and steep escarpments in grassland, chapparal, shrubland, forest and other vegetated areas (Golden eagle, 2011).” The species does not like developed areas. As a result, they may not be found near Manhattan, but could have a habitat home in the upper reaches of the watershed near Fort Riley, Riley, or Leonardville. The eagles are required to have trees, cliffs, or something to give them height allowing them to be far above ground to swoop down for prey.

The food source for the Golden Eagles is mainly small mammals. The most common food source is the Black-tailed jackrabbit. Other prey includes “hares, rabbits, ground squirrels, prairie dogs, and marmots (Golden eagle, 2011).” The black-tailed jackrabbits live in “meadows, prairies, desert scrubland and farmland (New Hampshire Public Television, 2012).” Kansas is on the eastern edge of the jackrabbit’s natural habitat, but still home to the animal. Jackrabbit’s feast on green plants in the summer and dormant and woody species during the winter. The jackrabbits sleep during the day and dine in the “late afternoon and the night (New Hampshire Public Television, 2012).”

In the Wildcat Creek watershed, meadows and prairies plant species, as shown in figure 3.28, would serve as a habitat and food source for the jackrabbit. To fit that into the Golden Eagle’s habitat, the prairies and meadows need to be restored on the upper reaches of the watershed, away from development. Jackrabbits can swim when needed to get out of harm’s way, so wet prairies could be a possibility. (Wet prairies would only flood when absolutely necessary to hold water and are not an initial holding device.)

Golden eagle habitat

Figure 3.28 | (Produced by author, 2012)

Habitat is comprised of shelter, food, water, and reproduction. Each element has plant species that are critical to individual parts of the habitat. Each plant also has certain water tolerances that make the plants better in certain locations over other locations.

henslow's sparrow

Ammodramus henslowii (Species in need of conservation)

The Henslow's Sparrow is on a list of concerned animals that may reach the Threatened and Endangered Species list in Riley County in the near future. The sparrow currently uses the eastern side of Kansas as part of their habitat for summer breeding season. Riley County appears to be near the edge of the zone to cause more concern as to the loss of the species (Henslow's Sparrow, 2011).

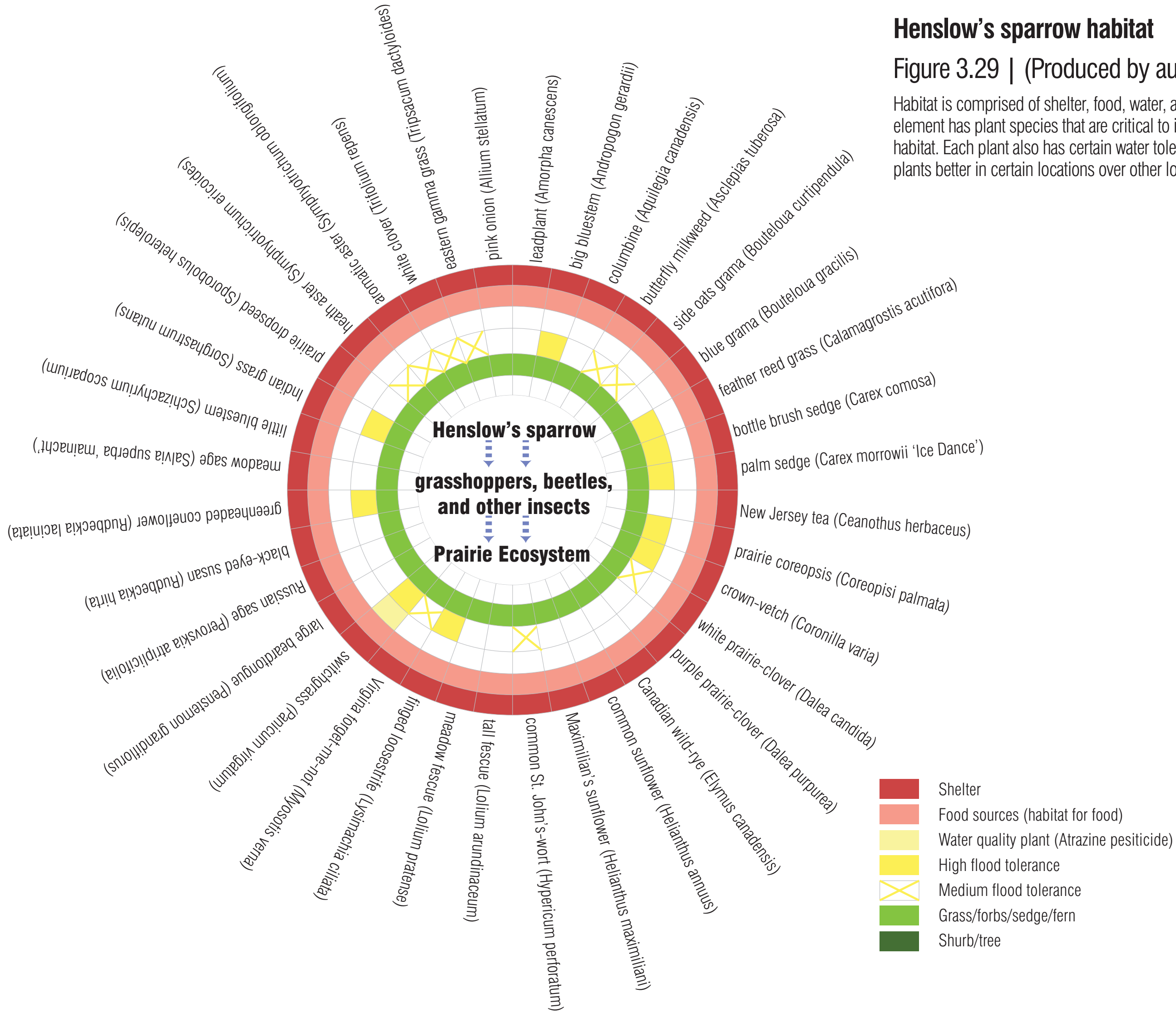
The sparrow habitat appears to be a dense prairie habitat. According to The Cornell Lab of Ornithology (2011), the Henslow's Sparrow lives in dense habitats to keep hidden. The species only flies when it has to and prefers to be on the ground and running when possible. Woody plants are not liked by the sparrow. Gillihan mentions the preferred breeding habitat as "open areas with tall grass and forbs, scattered shrubs (2000)". The Kansas tallgrass prairie appears to be a perfect habitat for the species. Having restored open spaces of dense prairie allow for the Henslow's Sparrow to have habitat in the Wildcat Creek Watershed.

The main food source for the sparrow is grasshoppers, beetles and other insects including caterpillars, ants, and spiders (Gillihan, 2000). These food sources are found in the prairie landscape and are accessible to the species in the Flint Hills and the Wildcat Creek Watershed. A plant palette for the Henslow's Sparrow is shown in figure 3.29.

Henslow's sparrow habitat

Figure 3.29 | (Produced by author, 2012)

Habitat is comprised of shelter, food, water, and reproduction. Each element has plant species that are critical to individual parts of the habitat. Each plant also has certain water tolerances that make the plants better in certain locations over other locations.



Planning and Design

A conceptual idea is developed for the watershed based on the watershed assessment. The broad idea was developed and specific ideas and design need to be done at a site scale.

Watershed Plan
- Spot Locations
- Corridor Plan

As flooding continues to be an issue in the Wildcat Creek watershed, wetlands can offer an opportunity for reduction in stormwater runoff and increase the infiltration of stormwater. Analyses of on-channel and off-channel wetlands were conducted to determine the most suitable locations for wetlands across the watershed. A combination of on-channel and off-channel wetlands is needed to help solve the dilemma. The most suitable areas for each type of wetland were combined to determine locations for the wetlands and create a conceptual design for the watershed.

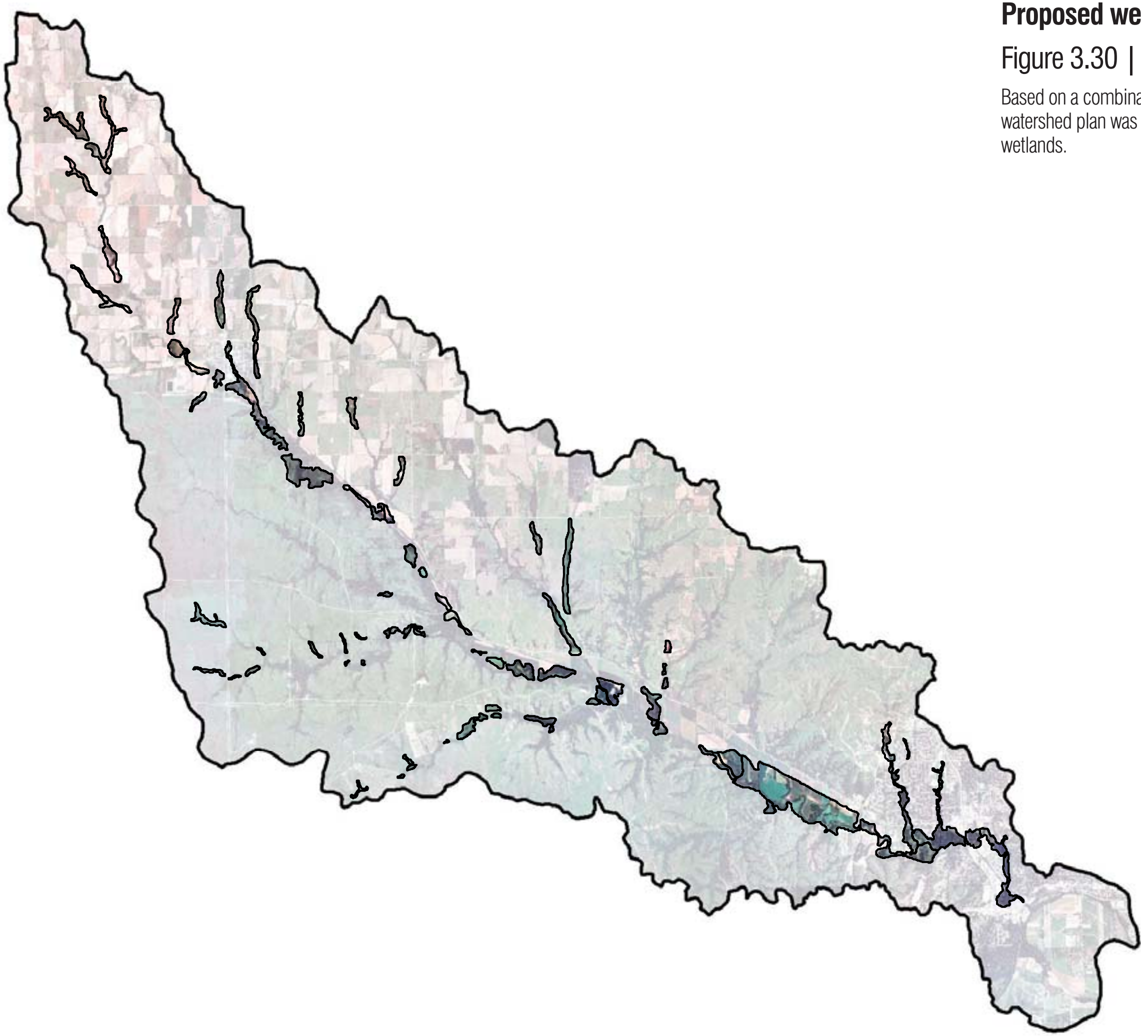
Wetlands also serve as critical habitats for wildlife in the region. There are five (5) species that are either on the threatened or endangered species list or are critical species to watch. The species that were considered for this project include Topeka Shiner, Whooping Crane, Sandhill Crane, Golden Eagle, or Henslow's Sparrow. The way a habitat is configured can determine the health and benefit that the wetland offers as habitat for wildlife. Richard T.T. Forman (1986) uses "networks" as vocabulary to explain a healthy wildlife habitat. Creating multiple corridors, connections, and options for the wildlife allows the species to roam, hide, and use the intricacies of the network.

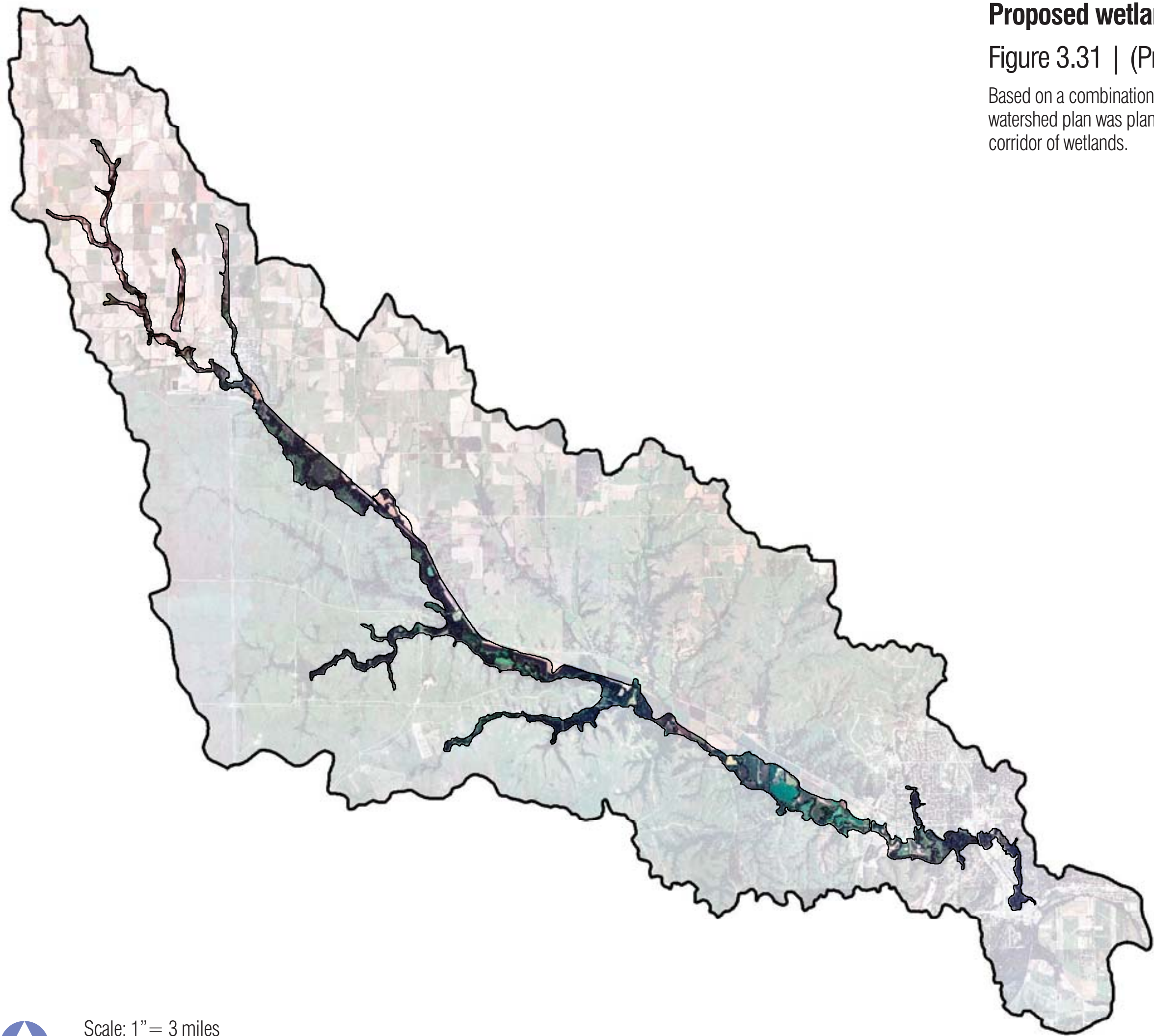
For the design of the watershed, the suitability analyses, 2010 orthographic imagery, and watershed contours were used to place wetlands in the watershed. There were two conceptual plans drawn to determine different strategies of the watershed. The first conceptual design (figure 3.30) looked directly at the spots or "patches" (Forman, 1986) that were deemed most suitable for wetlands. On- and off-channel wetlands were used across the watershed to reduce the stormwater runoff from reaching the creek and excess water from heading downstream. The second conceptual design (figure 3.31) looked at creating a wetland corridor across the watershed that served as a large connected habitat for wildlife. The watershed would still have on- and off-channel wetlands, but they would connect to form one large overall wetland within the watershed. Both designs were then evaluated for their ability to capture stormwater runoff and their ability to encourage wildlife habitat in the region.

Proposed wetland spot locations

Figure 3.30 | (Produced by author, 2012)

Based on a combination of the on- and off-channel wetlands, a watershed plan was planned to determine the best locations for wetlands.





Proposed wetland corridor

Figure 3.31 | (Produced by author, 2012)

Based on a combination of the on- and off-channel wetlands, a watershed plan was planned to determine the best location for a corridor of wetlands.

Evaluation

Each proposal was evaluated to determine what the best proposal for wetlands across the watershed.

Estimation of Runoff | TR-55
Quality of Wildlife Habitat

evaluation

Two conceptual watershed plans were prepared to place wetlands throughout the Wildcat Creek watershed to reduce runoff of stormwater and increase infiltration of stormwater. The plans were evaluated by sub-watershed to determine what impact they have on the stormwater runoff as well as the wildlife habitat configuration. The stormwater runoff is calculated through the TR-55 method of estimating runoff. The wildlife habitat is evaluated using on Forman's (1986) "patches, corridors, and networks" classification vocabulary to determine the ideal habitat configuration for wildlife.

TR-55 is a method for estimating the runoff through the process of determining the curve number from land cover and soil types, calculating the maximum retention after runoff begins, selecting a size of storm for the area being designed, and ultimately giving a runoff in inches. The process is intended to measure the amount of water produced in each sub-watershed which includes calculating the area by multiplying the runoff (in feet) by the acreage of the sub-watershed to determine the volume of stormwater. The volume was then compared with the volume of wetland proposed in the area. The goal of the wetlands would be to collect 50% of the runoff from leaving the sub-watershed and heading downstream.

The TR-55 produces a curve number (CN) that is used to complete the calculation of the runoff. The CN was determined based on land cover and soil hydrologic classes. Each sub-watershed was first split into agriculture and urban areas. The agricultural land was then split into terraced, non-terraced, or grazing land with a description of the amount of vegetation on each site. The urban areas were divided based on major roads, housing density (based on lot size), open space, parkland, and commercial/business area. The watershed layer of these polygons was then overlaid with the soil classification for the watershed. The soils are split into a, b, c, or d categories to determine their hydrologic permeability and infiltration rate. There were some areas that had an unknown soil classification. For the calculations, these were determined as a d classification or the class that creates the most runoff.

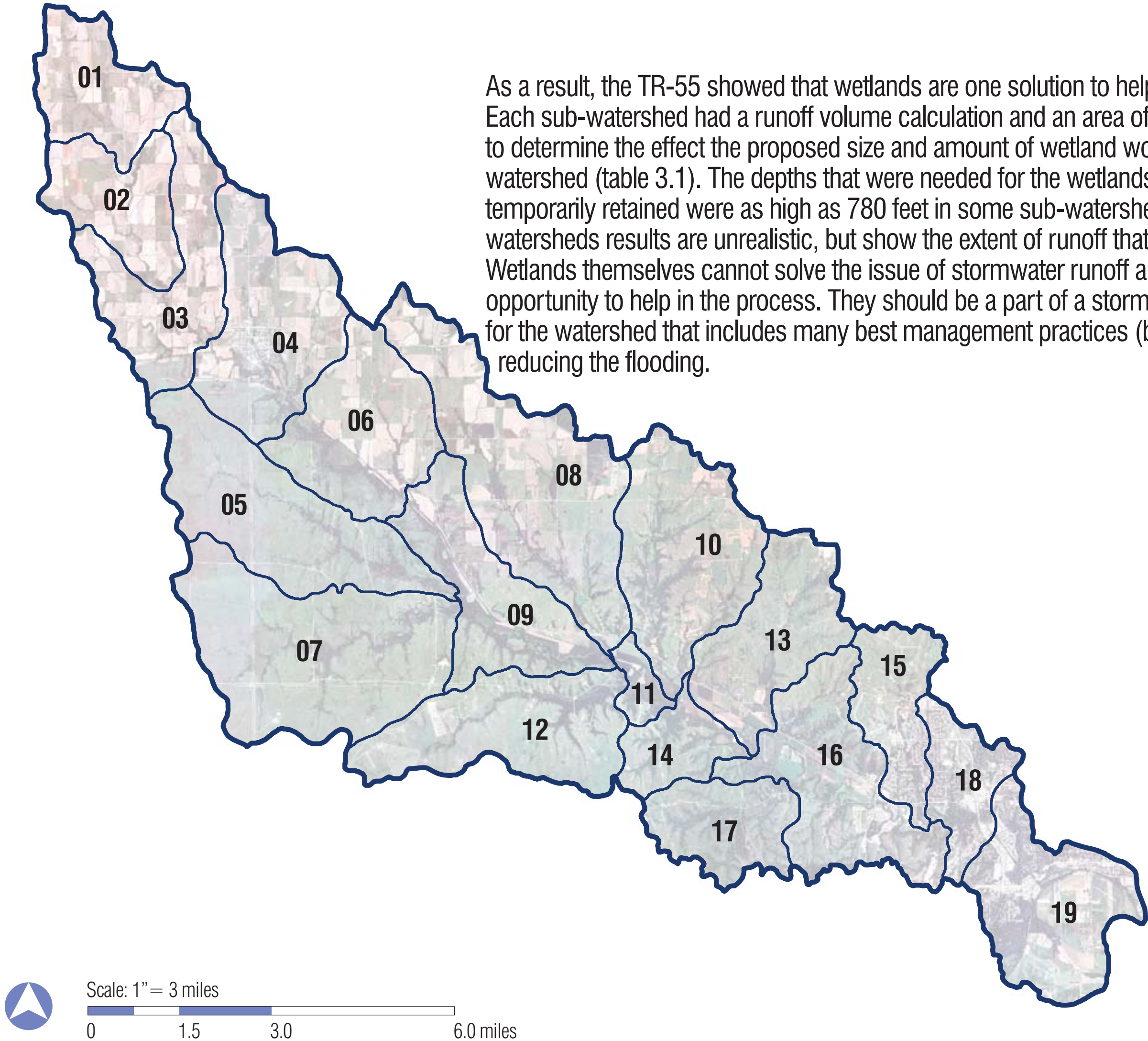
A 100 year, 24 - hour storm was used to determine the stormwater runoff for Manhattan, Kansas. The flash flooding in 1993, 2010, and 2011 came in short periods of time at a high intensity. The intensity of the storm was close to a 100 year storm in some locations of the watershed. The goal of the wetlands was to create an element that could handle storms of high intensity.

Sub-watersheds for Wildcat Creek

Figure 3.32 | (Produced by author)

Sub-watersheds were determined by land use, land cover, and topography to break the watershed up in calculations and assessment. The same sub-watersheds were used in the WARSSS assessment.

As a result, the TR-55 showed that wetlands are one solution to helping a greater problem. Each sub-watershed had a runoff volume calculation and an area of wetlands that were used to determine the effect the proposed size and amount of wetland would have for each sub-watershed (table 3.1). The depths that were needed for the wetlands to have 50% of the runoff temporarily retained were as high as 780 feet in some sub-watersheds. Some of the sub-watersheds results are unrealistic, but show the extent of runoff that occurs in those areas. Wetlands themselves cannot solve the issue of stormwater runoff and flooding, but can be one opportunity to help in the process. They should be a part of a stormwater management plan for the watershed that includes many best management practices (bmps) and methods of reducing the flooding.



Sub-Watershed	Area (square feet)	Area (acres)	Weighted CN Value	S Value	P Value	Q Value (inches)	Q Value (feet)	Runoff Volume (acrefeet)
1	104,294,669.93	2,394.28	80.09	2.49	7.50	5.17	0.43	1,031.07
2	101,748,970.02	2,335.83	81.42	2.28	7.50	5.32	0.44	1,035.59
3	143,897,436.90	3,303.43	81.35	2.29	7.50	5.31	0.44	1,462.37
4	179,451,538.86	4,119.64	84.57	1.82	7.50	5.68	0.47	1,950.56
5	203,159,140.54	4,663.89	78.52	2.74	7.50	4.99	0.42	1,939.32
6	160,020,018.82	3,673.55	81.67	2.24	7.50	5.35	0.45	1,637.52
7	277,315,116.48	6,366.28	82.34	2.14	7.50	5.43	0.45	2,878.56
8	267,951,521.03	6,151.32	83.99	1.91	7.50	5.62	0.47	2,878.64
9	149,903,742.95	3,441.32	79.80	2.53	7.50	5.14	0.43	1,472.68
10	190,599,101.59	4,375.55	85.75	1.66	7.50	5.82	0.48	2,121.72
11	22,564,135.04	518.00	80.46	2.43	7.50	5.21	0.43	224.92
12	173,478,687.62	3,982.52	77.57	2.89	7.50	4.88	0.41	1,620.31
13	140,018,724.55	3,214.39	75.17	3.30	7.50	4.61	0.38	1,235.39
14	58,861,631.67	1,351.28	75.04	3.33	7.50	4.60	0.38	517.67
15	87,878,402.66	2,017.41	79.02	2.66	7.50	5.05	0.42	848.33
16	181,604,723.28	4,169.07	75.42	3.26	7.50	4.64	0.39	1,612.03
17	92,218,055.79	2,117.04	74.46	3.43	7.50	4.53	0.38	799.62
18	72,691,596.93	1,668.77	81.88	2.21	7.50	5.37	0.45	747.13
19	165,358,835.00	3,796.12	81.23	2.31	7.50	5.30	0.44	1,676.04
Total	2,773,016,049.65	63,659.69						27,689.46

Watershed estimation of runoff

Table 3.01 | (Produced by author, 2012)

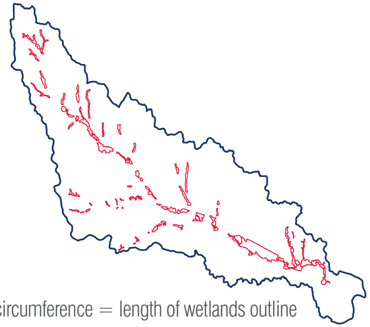
A TR-55 estimation of runoff was done for each sub-watershed. Each sub-watershed was broken down into small pieces and can be found in Appendix E.

Sub-Watershed	Corridor Plan Wetlands Area (feet)	Corridor Plan Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Spot Plan Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
1	1,054,308.00	24.20	515.53	21.30	5,799,027.78	133.13	515.53	3.87
2	9,149,717.65	210.05	517.80	2.47	4,014,629.39	92.16	517.80	5.62
3	8,666,549.67	198.96	731.18	3.68	4,306,741.37	98.87	731.18	7.40
4	14,150,860.37	324.86	975.28	3.00	11,922,303.40	273.70	975.28	3.56
5	724,028.13	16.62	969.66	58.34	258,898.82	5.94	969.66	163.15
6	23,932,850.55	549.42	818.76	1.49	12,062,674.69	276.92	818.76	2.96
7	9,658,300.69	221.72	1,439.28	6.49	4,932,942.78	113.24	1,439.28	12.71
8	80,462.09	1.85	1,439.32	779.21	7,093,776.52	162.85	1,439.32	8.84
9	32,712,497.80	750.98	736.34	0.98	9,136,122.29	209.74	736.34	3.51
10	306,605.20	7.04	1,060.86	150.72	2,932,875.33	67.33	1,060.86	15.76
11	7,256,773.41	166.59	112.46	0.68	2,729,234.85	62.65	112.46	1.79
12	11,583,670.17	265.92	810.15	3.05	6,044,299.94	138.76	810.15	5.84
13	2,674,554.90	61.40	617.69	10.06	2,957,555.02	67.90	617.69	9.10
14	5,267,487.71	120.92	258.83	2.14	2,214,029.25	50.83	258.83	5.09
15	4,116,155.70	94.49	424.17	4.49	5,128,091.55	117.72	424.17	3.60
16	30,438,682.07	698.78	806.02	1.15	30,678,839.89	704.29	806.02	1.14
17	492,618.24	11.31	399.81	35.35	613,352.00	14.08	399.81	28.39
18	7,077,233.64	162.47	373.57	2.30	7,625,879.99	175.07	373.57	2.13
19	5,314,399.93	122.00	838.02	6.87	4,465,668.63	102.52	838.02	8.17
Total	174,657,755.93	4,009.59	13,844.73	3.45	124,916,943.49	2,867.70	13,844.73	4.83

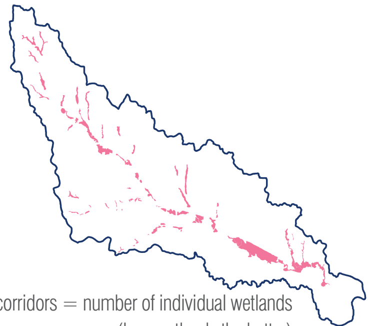
wildlife evaluation

The proposed conceptual designs were also evaluated based on the quality of the wildlife habitat (results in table 3.02). Richard T.T. Forman (1986) has researched wildlife habitats and found three characteristics to define the health of the habitat: patches, corridors, and networks. The wetlands serve as critical habitat for wildlife in the region. Habitat is ideally suited through series of patches and corridors that create a network to stretch across the watershed. The edge quality of the wetland can mean a lot to the habitat diversity for the species; more coves and movement in the edge condition creates better quality habitat. Each of these categories were measured by a set of criteria (figure 3.33) that the author developed to compare the proposals. The patches and edges were measured based on the circumference of the wetlands. The greater circumference meant a more quality habitat for the wildlife. The corridors offer opportunities for wildlife to have a wide range of area to in habitat and travel. The corridor health was measured through the number of individualized wetlands proposed within the watershed. The network of wetlands looked at the placement of wetlands in every sub-watershed. The network is focused on having a solid distribution in every sub-watershed. The network evaluation was done by comparing the percentages of wetlands in each sub-watershed. The difference in percentages was compared between proposals; the lower the difference, the more equal spread of wetlands across the watershed. The two proposals were compared in this set of criteria. Each category gave a 2 to the proposal that scored the highest and a 1 to the proposal that was lowest. The proposals ranking systems were then tallied and a total value was given resulting in the corridor plan to be best suited for wildlife habitat.

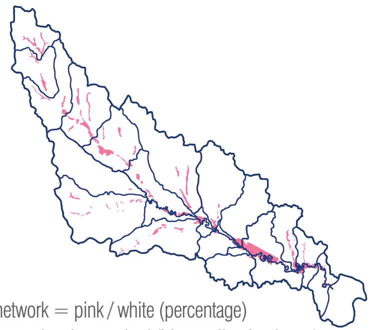
The watershed plan presents conceptual ideas that show what impact the proposed amount of wetland would have on the watershed. More specific designs and integration of the wetlands into existing site needs to be done at a site specific scale. At that scale, a more thorough understanding of stormwater runoff and wetland depth can be studied. Wetlands are not the only solution that should be used or considered for the reduction of flooding. It is one strategy that can be combined with other strategies to help reduce the future flooding events within the Wildcat Creek watershed.



circumference = length of wetlands outline



corridors = number of individual wetlands (less wetlands the better)



network = pink / white (percentage) for each subwatershed (blue outlined polygon)

Wildlife quality definition

Figure 3.33 | (Produced by author, 2012)

Wetlands were measured based on quality of wildlife habitat using the patches, corridors, and networks. Each category used the wetlands in a different way to compare the proposals. The diagram shows how each proposal was used.

Watershed wildlife evaluation

Table 3.02 | (Produced by author, 2012)

The wetland habitat quality of the proposals were evaluations based on the patches and edges of the wetlands, the corridors that are created, a network of wetlands, and species of habitat created.

	Patches and Edges	Corridors	Network of Subwatersheds		Habitat						**Total**
	Circumference (feet)	Number of Wetlands	Total	Difference	Topeka Shiner	Whooping Crane	Sandhill Crane	Golden Eagle	Henslow's Sparrow	Total	
Corridor	499,167.81	5.00	4,009.59	0.19							
			1.00		x	x	x	x	x		
	1	2	value	2					L	2H	7
Spot Locations	585,332.54	67.00	2,867.70	0.24							
			1.00		x	x	x	x	x		
	2	1	value	1			L			2	6

Network of Subwatersheds																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total	Difference
acres	24.20	210.05	198.96	324.86	16.62	549.42	221.72	1.85	750.98	7.04	166.59	265.92	61.40	120.92	94.49	698.78	11.31	162.47	122.00	4,009.59	0.19
percent	0.01	0.05	0.05	0.08	0.00	0.14	0.06	0.00	0.19	0.00	0.04	0.07	0.02	0.03	0.02	0.17	0.00	0.04	0.03	1.00	
value								L	H												2
acres	133.13	92.16	98.87	273.70	5.94	276.92	113.24	162.85	209.74	67.33	62.65	138.76	67.90	50.83	117.72	704.29	14.08	175.07	102.52	2,867.70	0.24
percent	0.05	0.03	0.03	0.10	0.00	0.10	0.04	0.06	0.07	0.02	0.02	0.05	0.02	0.02	0.04	0.25	0.00	0.06	0.04	1.00	
value					L											H					1

existing land use

A watershed scale design is predictive of how wetlands can impact the watershed and reduce flooding. The wetland proposals are examples of what land may be best suited for wetland development, although existing land use needs to be taken into account since the properties may affect landowners' livelihood.

Wetlands can be incorporated into existing and future land use and land cover. Parks are the first place in which wetlands can be integrated. Examining open spaces that are not programmed out in parks is an initial step in determining where wetlands can be implemented. Also, according to the analysis, considering the programmed elements, a redesign of the park would allow wetlands to be placed in areas best suited for wetlands. Golf courses are in a similar situation. Wetlands and golf courses can be merged to encourage continued use of the golf course and concurrently allow the property to be stormwater efficient and environmentally friendly, as seen in figure 3.34.

Agricultural land has several options in terms of how wetlands are best integrated. First, there are natural creek lines that could be restored to small on-channel wetlands. Some agricultural land may be lost, but the restoration of the creek and addition of wetlands could reduce flooding and result in more productive farmland. Secondly, the wetlands could be used for nutrient farming. Nitrogen and phosphorus are two nutrients that nutrient farming is built around. Donald Hey (2011) proposed a nutrient farming program for the upper Midwest that could be applied to future wetlands in Kansas. Hey's program showed that an increase in development has a significant increase in nutrient runoff. Harvesting the nutrients could increase the quality of the water and create better conditions for wildlife and humans.

After considering the land use of the locations that were selected for wetlands at the watershed scale design, a site scale design was completed to show the integration of wetlands into the existing site. Further calculations of estimate of runoff and the volume of proposed wetlands were done to prove what difference one site of wetlands has on the area. In *Wetlands: A Flooding Solution*, Wildcat Creek Golf Course was redesigned to show how wetlands are incorporated into a golf course.

Wetland incorporation

Figure 3.34 | (Produced by author, 2012)

Wetlands can be incorporated into the existing land use and land cover to increase habitat and reduce runoff.

Wetland incorporated into existing site

Wildcat Creek Golf Course already exists on site, but can be retro-fit to include wetlands

Wildcat Creek Golf Course + Wetlands

The site scale discovers how wetlands can be incorporated into the existing land. Wildcat Creek Golf Course is expanded to a Par 34 nine hole course that has wetlands integrated into the design.

Assessment
- Site Analysis

Design
- Master Plans
- Individual Hole Design
- Grading Plan
- Planting Plan

Evaluation
- Estimation of Runoff
- Evaluation for Wildlife Habitat
- Playability Assessment
- Feasibility Assessment

Assessment

The site assessment focuses on the placement of the wetlands on the existing Wildcat Creek Golf Course site.

Site Suitability
On-Channel Wetlands

site assessment

The watershed study showed a conceptual plan of implementing wetlands to help reduce the flooding of Wildcat Creek and increase the area for healthy wildlife habitat. The conceptual plans included on- and off-channel wetlands creating a variety of opportunities and possibilities throughout the watershed. The watershed plan needs to be further designed and implemented at a site scale to consider how wetlands are incorporated into existing conditions and land use. The analysis and work done at the watershed scale furthered the site scale (golf course) work by determining the type of wetlands (on- or off-channel) and locations that wetlands are best suited within the site.

Wildcat Creek Golf Couse is an excellent example of how a site can be redesigned to accommodate wetlands while still maintaining its existing land use. The watershed scale analysis indicates that the land is an excellent location for on-channel wetlands. Site wetlands can serve as a flood reduction from the site and the surrounding area. The location of Wildcat Creek Golf Course is at the confluence of Little Kitten Creek and Wildcat Creek, which has a number of proposed wetlands to collect runoff from the urban development, going into Wildcat Creek. The upstream runoff from agriculture land and recent urban development continues to produce high amounts of water that enter Wildcat Creek Golf Course.

In the process of looking at the site, three goals were generated to drive and influence the site scale design. First, the course was expanded to a par 34 or 35 course allowing for a variety of shots and practice for people of all ages and skill levels. Second, strategically incorporated wetlands, places for water to go in instead of increasing runoff downstream, provided further opportunity to reduce flooding on-site. The wetlands offered intrigue and challenge to the golf course strategy while promoting wildlife habitat that encouraged a safe and healthy environment for endangered species in the area.

The analysis for the site showed optimal locations for wetlands in Wildcat Creek Golf Course and the surrounding area. When looking for the on-channel wetland locations, additional factors were considered to further understand and develop the site. Wetland suitability was based on the following factors:

Channel evaluation and course location

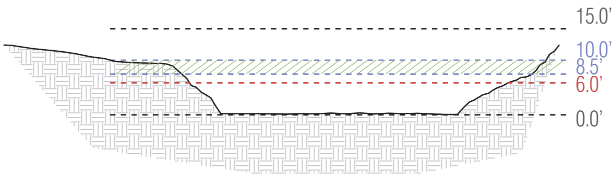
Figure 4.01 | (Produced by author, 2012)

150% of the cross-sectional area at bankful height begins at 8.5 feet. The distance between 8.5 and 10 feet is the ideal location for wetlands to create overflow from the flooding of the creek. That elevation is accounting for a two to five year storm. The cross section is taken from Wildcat Creek south of Anneberg Park.

Image is 1" = 40'.

The location of the cross-section is located on the watershed scale map in green. The map also shows the golf course being on the western edge of the City of Manhattan in the red box.

site on-channel wetlands



- o Proximity to the stream (10% in location selection weighted overlay)

  The closer the wetland is to the creek, the more the backflow from riffles is able to be held by the wetland in times of flooding and elevate flooding downstream. See Figure 4.02.

- o Elevation level of land compared to creek elevation (30%)

  The mean bankful depth for Wildcat Creek at Anneberg Park is 6.08 feet. With a bankful depth width of 65.6 feet, the creek has a bankful cross-sectional area of 364.8 feet. The wetlands cannot be below 150% volume of bankful cross-sectional area otherwise they interfere with the channel formation. As a result, a minimum bank height of 8.55 feet is needed before wetlands can be placed on site. Anything below the 8.55 feet is very low in the analysis, while 8.55 feet to10 feet is ideal and receiving the highest rating as shown in Figure 4.1. From the elevation of 10 feet and higher the rating gradually becomes worthless in the analysis. See Figure 4.03.

- o Hydric level of soils (15%)

  Hydric soils are areas that were historically wetlands and have high potential to be restored to wetlands. See Figure 4.04.

- o Material classification (30%)

  The area was split into land cover classes to distinguish locations that are most suitable for wetlands. Impervious surfaces were rated low. Maintained vegetation (the golf course, sports fields, residential lawns) were rated medium, and prairie, native, and riparian landscapes received a high rating. See Figure 4.05.

- o Slope percentage (15%)

  Areas with low slope percentages, or flatter regions, are more likely to hold more water than areas with high slope percentages where the water would drain off the site. See Figure 4.06.

The closer to the creek, the more flood water the wetlands can accumulate

Figure 4.02 | (Produced by author, 2012)

The overall watershed analysis showed that the golf course area would benefit most by on-channel wetlands that would help increase infiltration and reduce runoff. The on-channel wetlands are best situated outside of the channel, but within 500 feet of the stream.

Legend

- Stream center of flow
- 10 - 20 feet from center of flow
- 20 - 100 feet from center of flow
- 100 - 500 feet from center of flow
- Areas 500 or greater from center of flow
- Existing course
- Proposed boundary

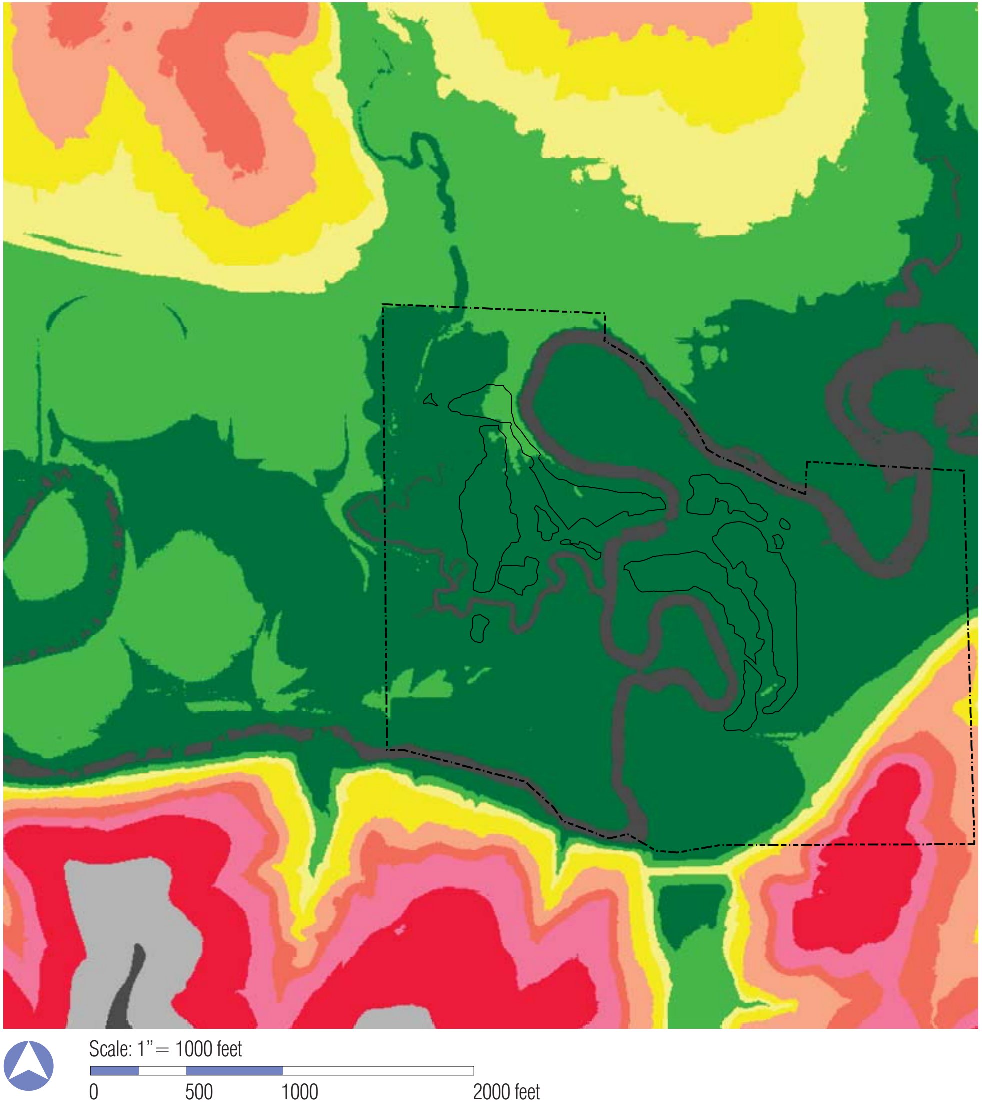
Value in suitability analysis

High → Low

150% of bankful area is ideal starting height of on-channel wetlands

Figure 4.03 | (Produced by author, 2012)

The elevation of the creek shows the areas that are similar to the creek and may not be a part of the creek, but could easily be areas that flood because of the creeks flow from upstream. The ideal elevation accounts for a the level of a two to five year storm.



Legend:

- 0 - 8.5 feet from stream channel elevation
- 8.5 - 10 feet from stream channel elevation
- 10 - 15 feet from stream channel elevation
- 15 - 20 feet from stream channel elevation
- 20 - 25 feet from stream channel elevation
- 25 - 30 feet from stream channel elevation
- 30 - 35 feet from stream channel elevation
- 35 - 40 feet from stream channel elevation
- 40 - 55 feet from stream channel elevation
- 55 - 70 feet from stream channel elevation
- above 70 feet from stream channel elevation
- Existing course
- Proposed boundary

Value in suitability analysis

High → Low

Partially hydric soils historically create better wetlands

Figure 4.04 | (Produced by author, 2012)

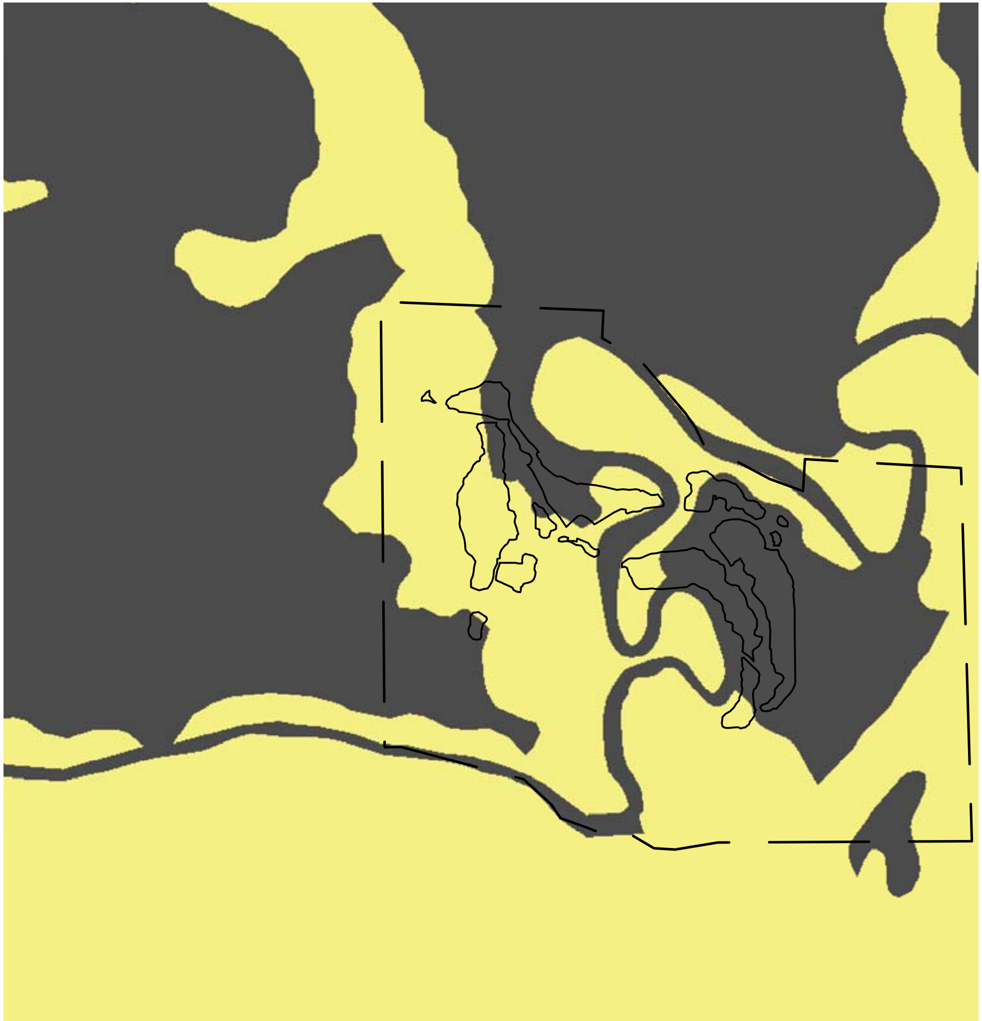
Hydric soil levels show locations where wetlands were formerly held. The watershed does not contain any hydric soils, but some of the areas are partially hydric and best suited for wetlands. There were some areas that have an unknown hydric soil that are placed with in the not hydric soil category to understand the least likely option of the soil.

Legend:

- Partially hydric soil
- Not hydric soil
- Existing course
- Proposed boundary

Value in suitability analysis

High → Low



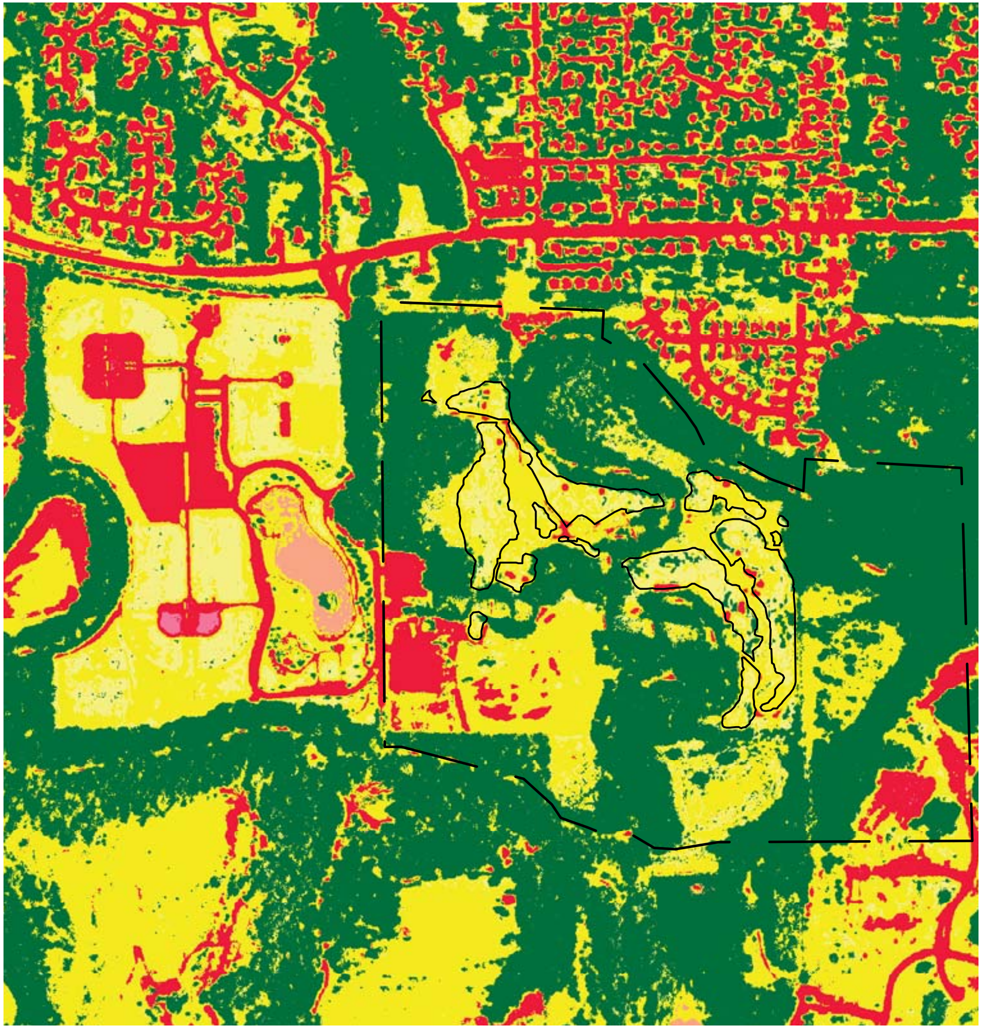
Scale: 1" = 1000 feet

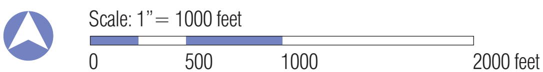
0 500 1000 2000 feet

Woody, marsh, and prairie vegetation make wetland implementation easier

Figure 4.05 | (Produced by author, 2012)

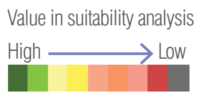
The type of material starts to tell what vegetation is best for the wetland, what areas are easy to turn into wetlands, and what areas are opposed to wetlands. The woody areas are stream stabilizers that could be turned into a wetland while marsh and prairie areas needing grading to become wetlands.





Legend:

- Trees and woody vegetation
- Marsh areas
- Prairie grasses
- Highly maintained land
- Standing water
- Impervious surface
- Existing course
- Proposed boundary



Lower slopes hold more water for wetlands

Figure 4.06 | (Produced by author, 2012)

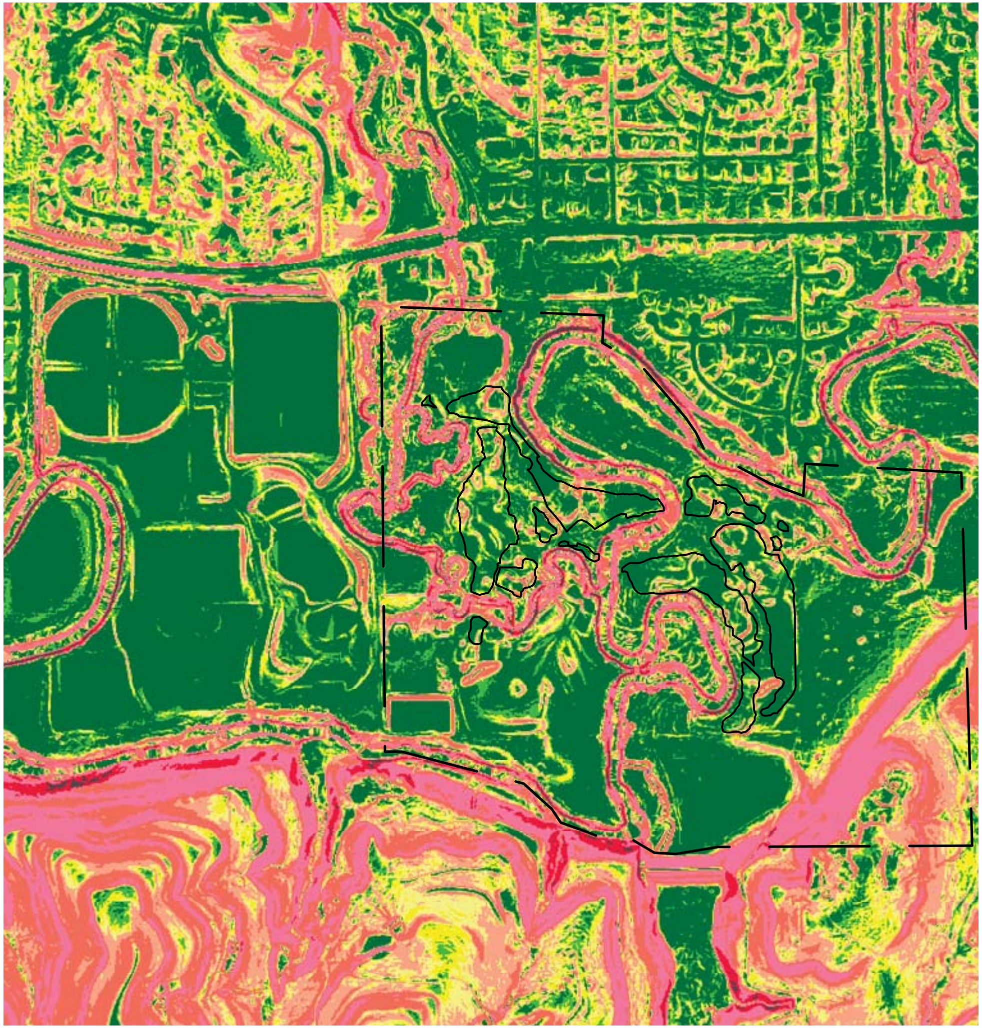
Areas with steep slopes would be more difficult to put wetlands on than areas with slight gradation. The high slope percentages show areas that are positive locations for the golf course. Some movement is desirable, so having some change in the movement can be beneficial to the golf course.

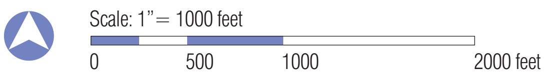
Legend:

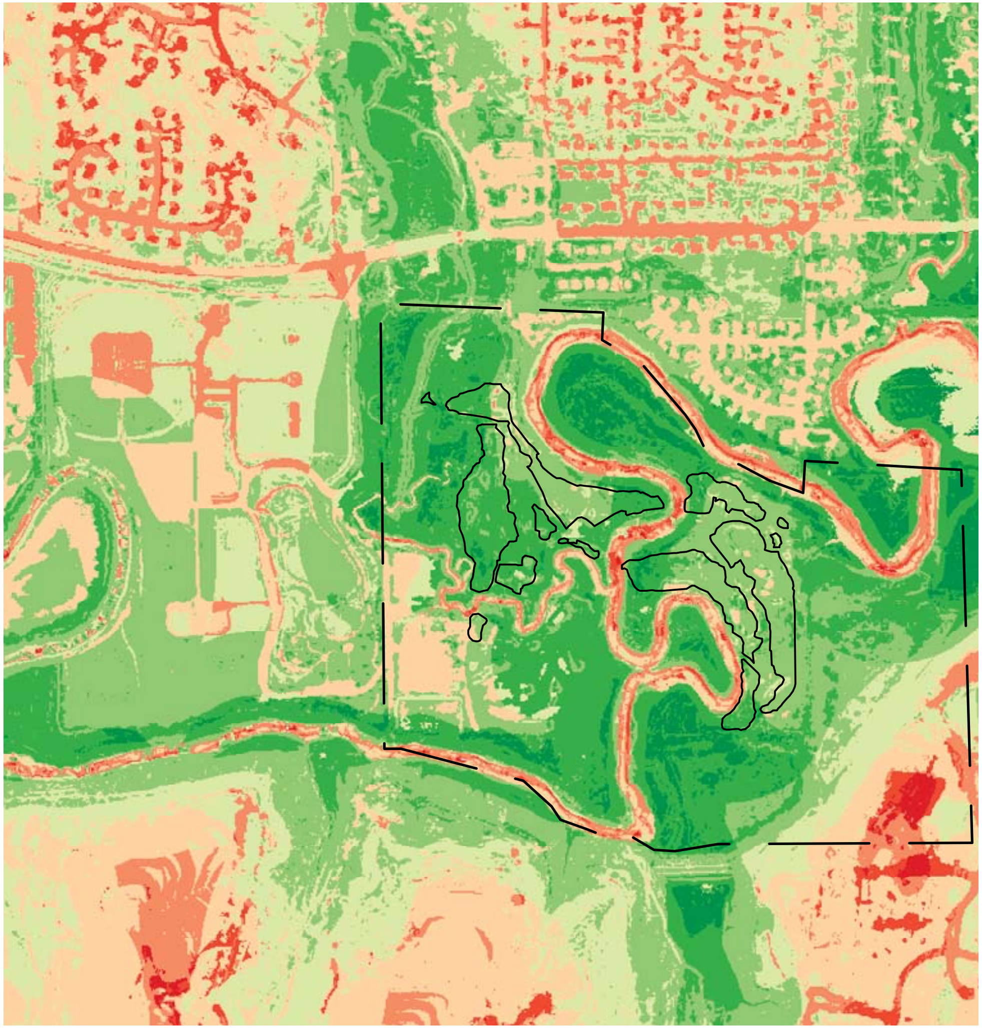
- 0-4 %
- 4-6%
- 6-8%
- 8-10%
- 10-15%
- 15-30%
- 30-60%
- 60-90%
- Greater than 90%
- Existing course
- Proposed boundary

Value in suitability analysis

High → Low







Wetland suitability for the golf course

Figure 4.07 | (Produced by author, 2012)

Wetlands are highly suitable in many areas of the site.

Legend:

- Ares most suitable for wetlands
- Least suitable areas for wetlands
- Existing course
- Proposed boundary

Scale: 1"= 1000 feet

0 500 1000 2000 feet

assessment + existing overlay

The wetland suitability was generated and used to determine optimal locations for wetlands. The wetland suitability was then overlaid with the existing fairways, greens, and tee complexes (diagramed in figure 4.08) to determine how the wetlands would fit into the existing land cover and land use.

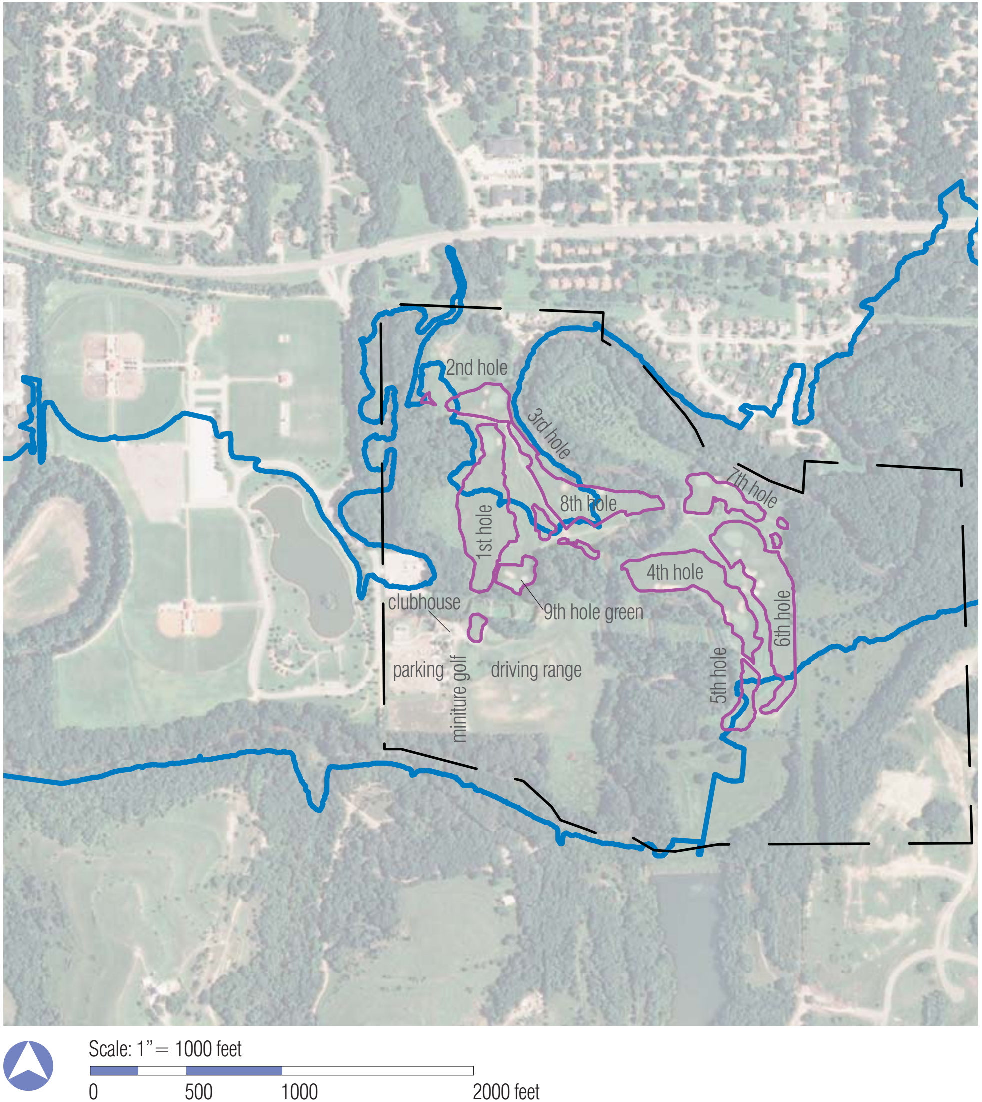
Tee and green complexes are an expensive part of the implementation process. The grow-in periods and maintenance needed to install the golf course are all part of the planning process. The existing tees, greens, and fairways were juxtaposed with the suitability to determine what components of the golf course could be reused.

Each proposal calls to expand the course from a Par 30 to a Par 34 or 35 course. In the expansion and addition of wetlands to the site, there will need to be a construction of new tees and greens. To make the project more feasible and practical to implement, considering the use of some existing tees and greens is important. Considering the best locations for wetlands and then looking to what existing features and strategies could be maintained and utilized went into the evaluation of the site for proposal designs.

Golf course and flooding conditions

Figure 4.08 | (Produced by author, 2012)

Flooding took over much of the golf course in June 2011 during the massive floodings. The past flooding gives an idea of where water migrates to in large intense storms. The current golf course has moved in and out of those areas with the large amount of maintained land that is required. This was not put into the suitability analysis but was used to examine the existing course conditions.



Legend:

- Area flooded during June 2011
- Potential boundaries for the golf course
- Current maintained areas on the golf course

Planning and Design

Wildcat Creek Golf Course is redesigned based on the assessment done at the watershed scale and the site scale. The design focuses on how flooding can decrease on the site and allow for additional areas that will naturally flood.

Master Plan
Site Grading
Wetland typology

master plan proposals

Site analysis of the golf course identified locations most suitable for on-channel wetlands. Wetlands were then juxtaposed with the existing golf course to determine which of three (3) proposals would be optimal for the site. The course had minimum criteria needed to maintain its existing land use: safety on the course, an increase of wetland capacity on site, and introduction of wildlife habitat. A visually interesting and challenging golf course was also required for all proposals. The existing site of the golf course barely fit the 9-hole design that currently exists. In the proposed master plans, a par of 30 was increased to a par 34 or 35 requiring that the property line be extended to property on the south and east of the site. The existing property is shown in white in figure 4.09 with the proposed change in red.

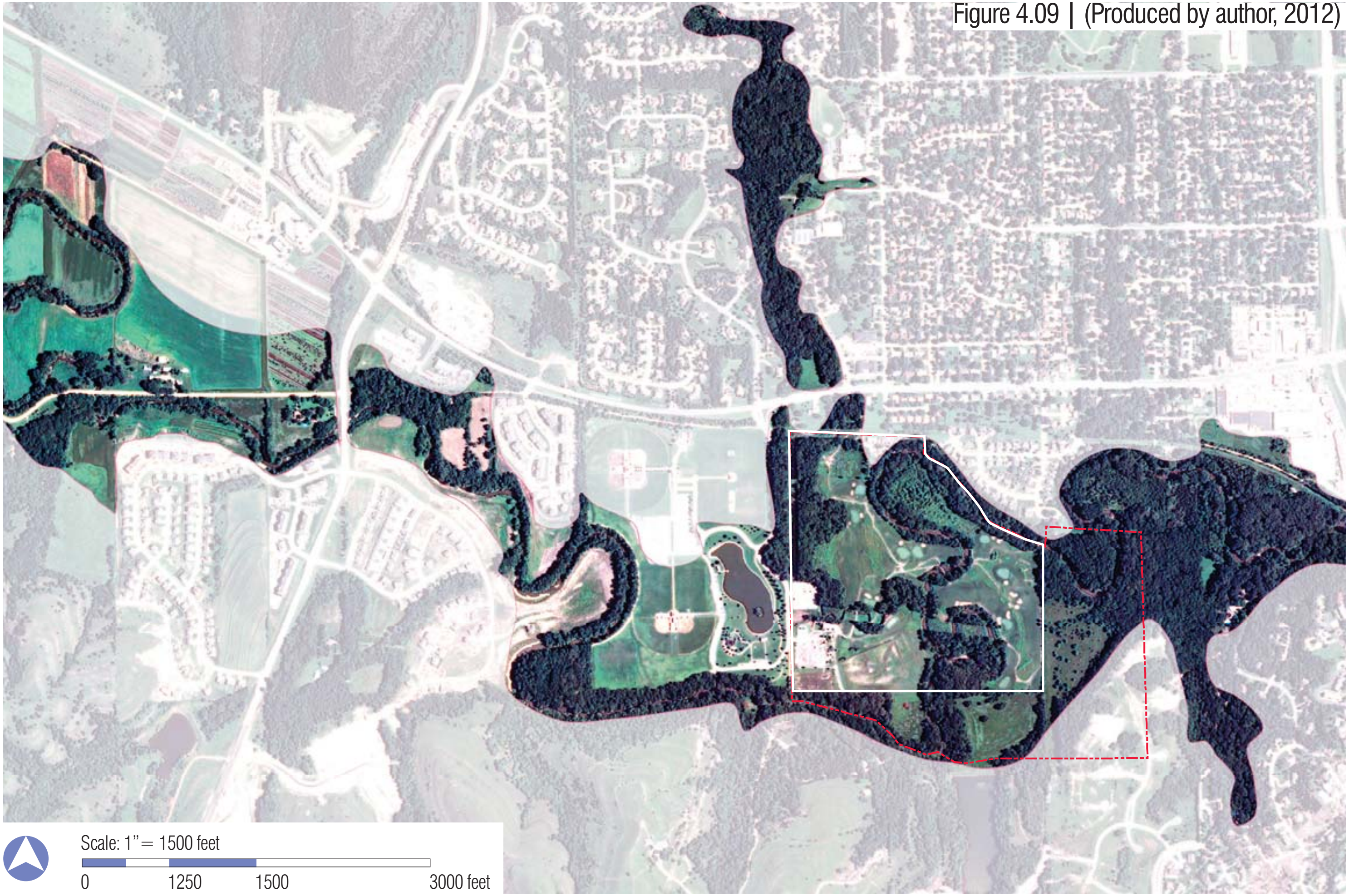
The golf course was designed with three pillars in mind: the golf experience, wildlife habitat, and wetlands. Master plan proposals were designed to incorporate all three pillars at some level. Three proposals were created, found in figures 4.10, 4.11, and 4.12; each one focused on a different pillar – golf, wildlife, or wetlands – as a major focal point of the design. One course was laid out with the thought of having the best golf course and golf experience possible; a course that was playable for all ages and skill levels and was fun and challenging. Promoting wildlife habitat was the focus of the second proposal. Creating corridors and networks for the wildlife with varying edges for an increase in the wildlife habitat and possibility for a variety of wildlife to find homes in the area. The third proposal emphasized adding wetlands to the site. The flood reduction and maximum wetland creation was first added then a 9-hole golf course was placed around and within the wetlands. Each proposal was generated with the base criteria in mind and a focus element; they were then compared based on water capacity, wildlife habitat, playability, and cost. The proposals had a combinations of wetland types including wetlands, wet meadows, and wet prairies as see in figures 4.13, 4.14, and 4.15.

The wetland locations in each proposal connect to wetlands that occur in surrounding areas, as seen in figure 4.09. Wetlands placed within Anneberg Park and along Little Kitten Creek feed into the wetlands on the golf course. The surrounding area creates runoff from urban development and other impervious surfaces in the area. Wetlands along the creeks in those areas will capture some runoff, but not all stormwater will be captured. Wetlands on the golf course can help collect some runoff and create opportunities to prevent significant amounts of water from running down stream. Each proposal has a design and a site grading plan which allows for comparison of the volume of stormwater collected for each proposal.

Area wetland connection

The wetland corridor plan conceptually showed wetlands being implemented into the existing site and connected to wetlands along Little Kittlen Creek and Wildcat Creek.

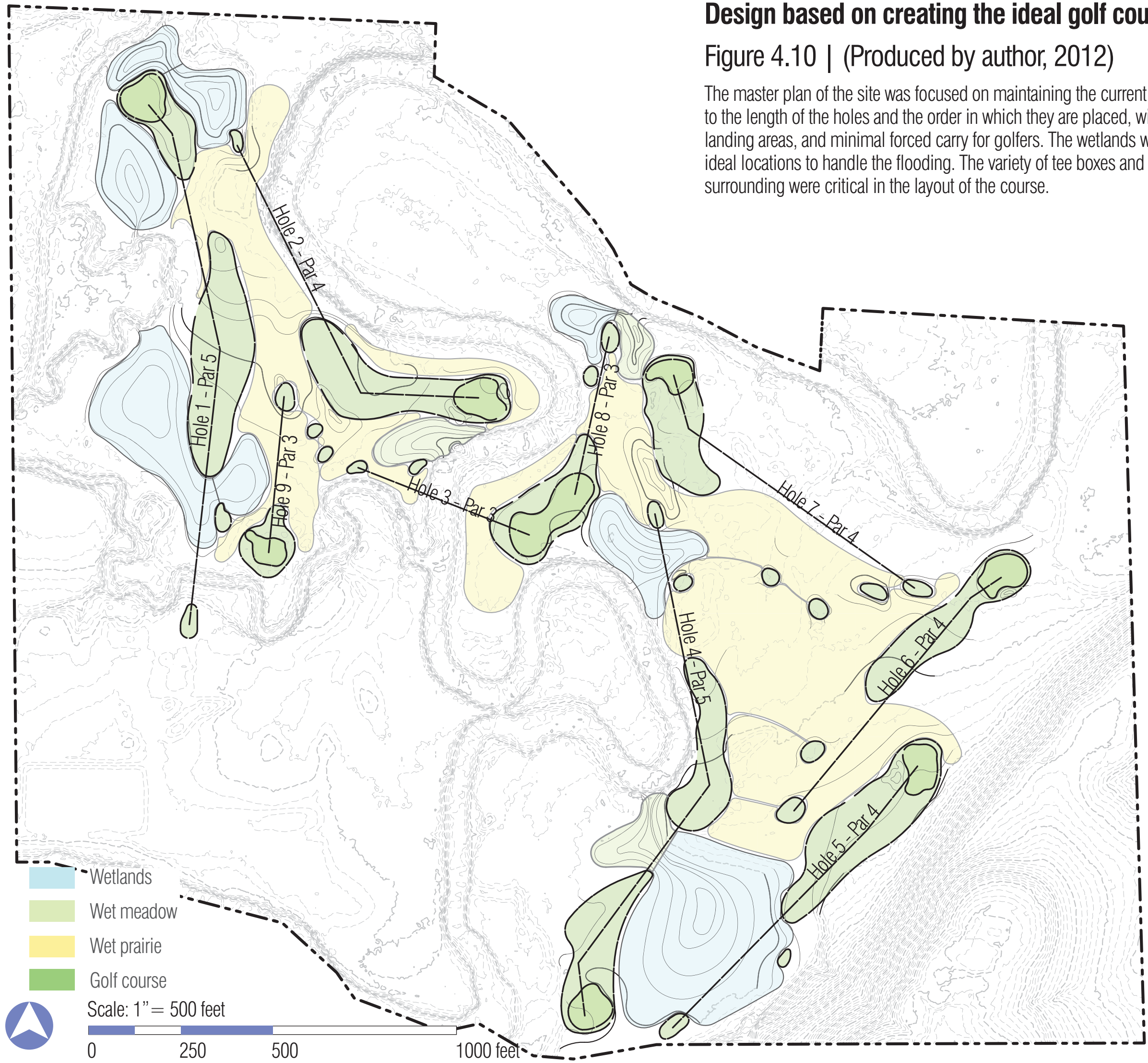
Figure 4.09 | (Produced by author, 2012)



Design based on creating the ideal golf course

Figure 4.10 | (Produced by author, 2012)

The master plan of the site was focused on maintaining the current clientele, beginners. There is more logic to the length of the holes and the order in which they are placed, wider landing areas and land that connects landing areas, and minimal forced carry for golfers. The wetlands were then placed around the course in ideal locations to handle the flooding. The variety of tee boxes and the interaction of the holes with the surrounding were critical in the layout of the course.

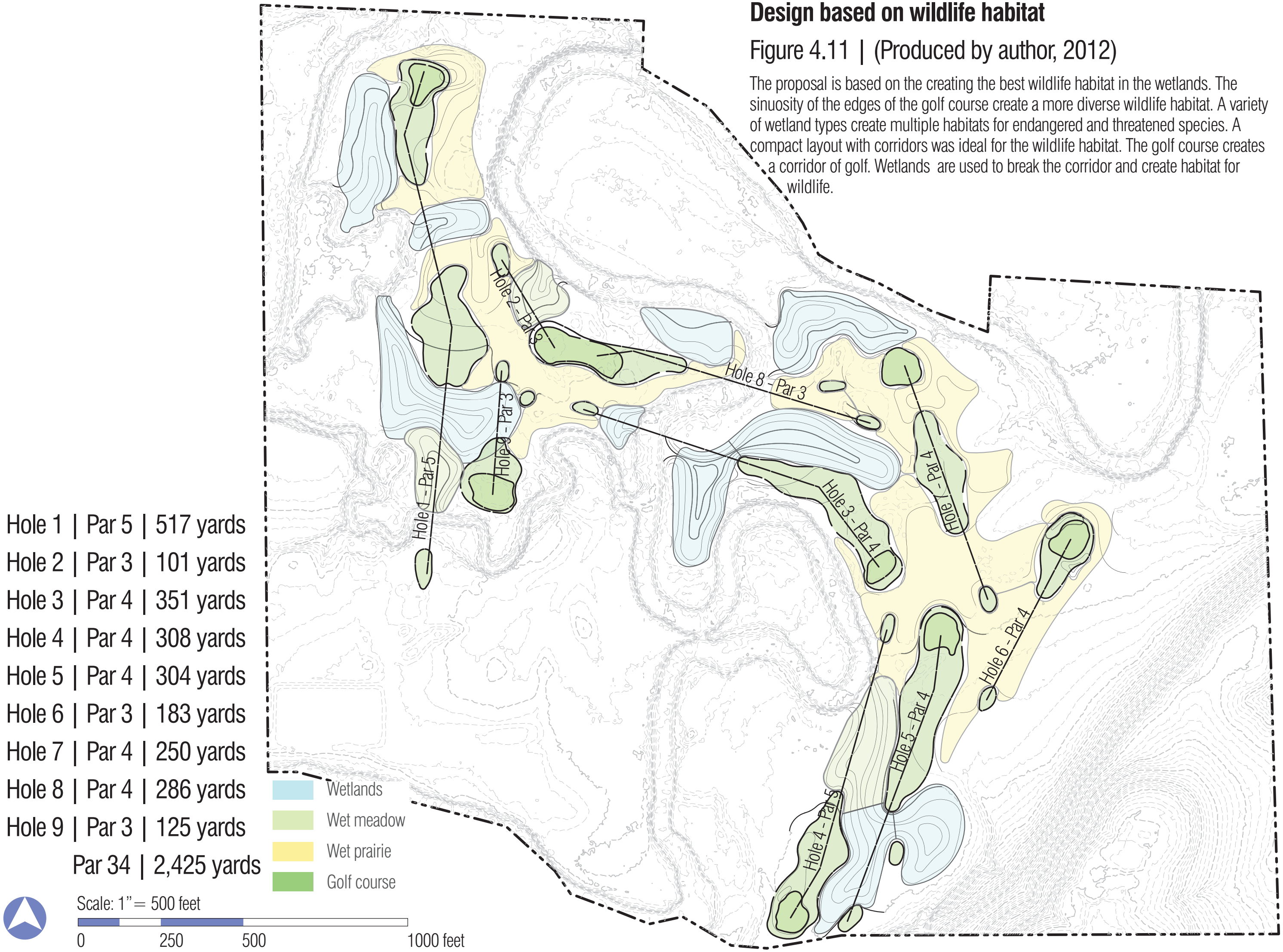


Hole 1	Par 5	483 yards
Hole 2	Par 4	358 yards
Hole 3	Par 3	166 yards
Hole 4	Par 5	498 yards
Hole 5	Par 4	324 yards
Hole 6	Par 4	283 yards
Hole 7	Par 4	300 yards
Hole 8	Par 3	145 yards
Hole 9	Par 3	141 yards
	Par 35	2,698 yards

Design based on wildlife habitat

Figure 4.11 | (Produced by author, 2012)

The proposal is based on the creating the best wildlife habitat in the wetlands. The sinuosity of the edges of the golf course create a more diverse wildlife habitat. A variety of wetland types create multiple habitats for endangered and threatened species. A compact layout with corridors was ideal for the wildlife habitat. The golf course creates a corridor of golf. Wetlands are used to break the corridor and create habitat for wildlife.

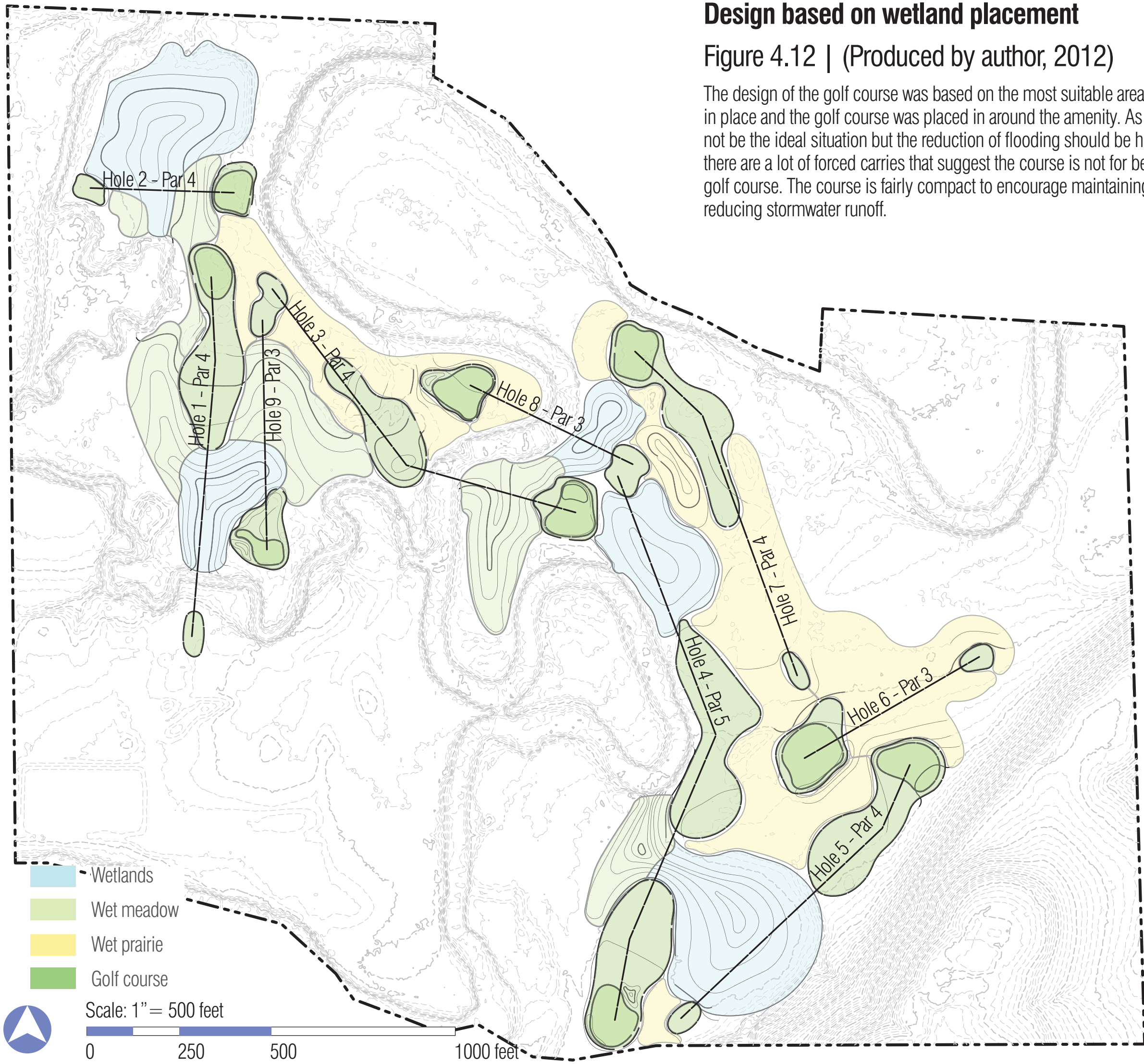


Hole 1 | Par 5 | 517 yards
Hole 2 | Par 3 | 101 yards
Hole 3 | Par 4 | 351 yards
Hole 4 | Par 4 | 308 yards
Hole 5 | Par 4 | 304 yards
Hole 6 | Par 3 | 183 yards
Hole 7 | Par 4 | 250 yards
Hole 8 | Par 4 | 286 yards
Hole 9 | Par 3 | 125 yards
Par 34 | 2,425 yards

Design based on wetland placement

Figure 4.12 | (Produced by author, 2012)

The design of the golf course was based on the most suitable areas for wetlands. The wetlands were put in place and the golf course was placed in around the amenity. As a result, the golf portion of the site may not be the ideal situation but the reduction of flooding should be highest. The first par 3 is the 5th hole, and there are a lot of forced carries that suggest the course is not for beginners or the current clientele of the golf course. The course is fairly compact to encourage maintaining existing vegetation that is beneficial to reducing stormwater runoff.



Hole 1 | Par 4 | 325 yards
Hole 2 | Par 3 | 130 yards
Hole 3 | Par 4 | 360 yards
Hole 4 | Par 5 | 525 yards
Hole 5 | Par 4 | 315 yards
Hole 6 | Par 3 | 185 yards
Hole 7 | Par 4 | 335 yards
Hole 8 | Par 3 | 165 yards
Hole 9 | Par 3 | 207 yards
Par 34 | 2,547 yards

Wetlands

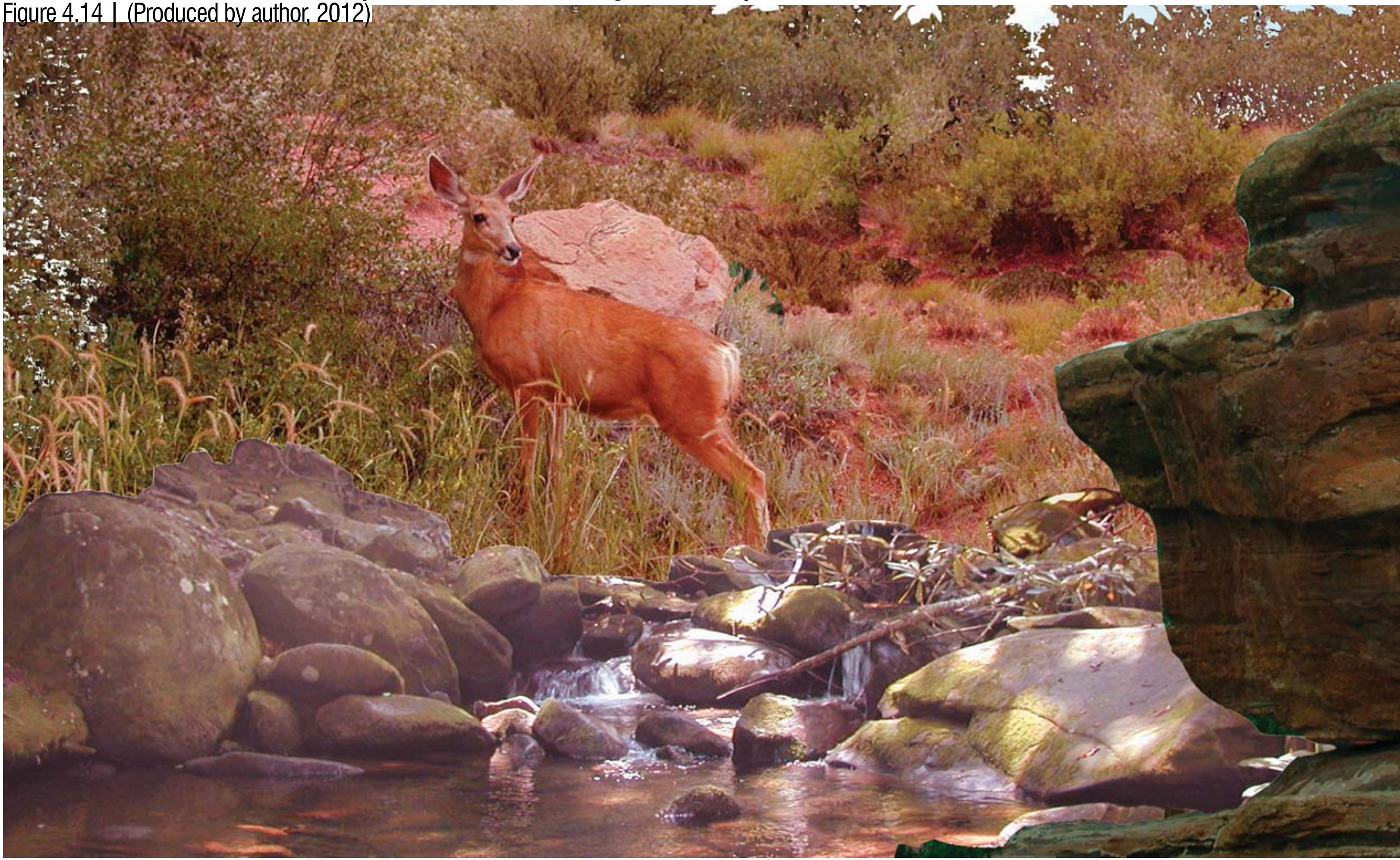
Filled from upland runoff and riffle construction and is best suited for the Whooping and Sandhill Crane habitats

Figure 4.13 | (Produced by author, 2012)

Riffle creation + wet meadow

The riffles help to focus flooding in specific areas of the watershed. Water is not held in this wet meadow, but helps slow runoff and increase infiltration. Topeka Shiner and Golden Eagle are ideal species for a wet meadow.

Figure 4.14 | (Produced by author, 2012)



Wet prairie

Intended to reduce runoff and increase infiltration in upland areas or off-channel areas.
Wet prairies are ideal habitats for the Golden Eagle and Henslow's Sparrow.

Figure 4.15 | (Produced by author, 2012)

Evaluation

The master plan and design of wildcat creek golf course is evaluated for the effectiveness of the wetlands, quality of the wildlife habitat, playability for the golfers, and cost of implementation.

Estimation of runoff (TR-55 method)
Quality of wildlife habitat
- Patch
- Corridor
- Network

Playability assessment (First Tee criteria)
- First Tee standards
- Forced carry
- Hole configuration
- Distance control

Feasibility of design

There were three proposals for the redesign of Wildcat Creek Golf Course. Each proposal expanded the course to a par 34, was safe for playing golf, incorporated wetlands and wildlife habitat into the course, and created challenge and excitement for everyone playing the course. A design proposal for each pillar (golf, wildlife, or wetland) was produced and included a layout of the course and a grading plan. The proposals were compared by the amount of water the wetlands could hold in a flooding event, the quality of the wildlife habitat, the playability of the course for all levels, and the cost of implementation.

stormwater runoff estimation

The stormwater runoff for each design proposal was evaluated by determining the runoff of the site and surrounding area and comparing that to the volume that is held in the wetlands. The surrounding area and the site were evaluated through a TR-55 estimation of run-off for a 100 year storm in Manhattan, KS. If the entire area is getting a 100 year flood, or 7.5 inches of rain per 24-hour time period, then there are 391.66 acre feet of runoff. The existing golf course site creates 44.2 acre feet of runoff, as calculated from a TR-55 runoff. The same site was calculated with the rational method of stormwater runoff to compare the quantity difference on a site of 155.5 acres. In comparison, the rational method produced 93.1 acre feet of stormwater runoff in a 24-hour period on the golf course site.

Once the amount of runoff was calculated, the volumes of the proposed wetlands on each proposal were determined. Each proposal has a series of wetlands that are divided into eleven to fourteen wetlands, depending on the plan. Each wetland was defined by creating large empty volumes that drain inward. When the wetland comes inward, a solid volume is formed that creates a boundary of the wetland. If there is an adjacent wetland, a separate volume was calculated. Volumes were calculated by creating surfaces of the proposed wetland and the maximum capacity elevation, then running an earthwork calculation to determine the difference between the two surfaces. For each proposal, wetland volumes were summed together to determine the volume of stormwater in the wetlands for each proposal.

Estimation of runoff table

Table 4.01 | (Produced by author, 2012)

Estimation of runoff is calculated through the TR-55 method for the site scale. The runoff quantity is compared to the amount of water wetlands could hold at high flooding stages.

The water heading downstream was determined on a site scale, with the volume of the wetland capacity being subtracted from the on-site wetland capacity. This helped to estimate how much water is headed to other sites downstream and may contribute to the flooding of the other areas of the watershed.

The earthwork that is needed to create the wetlands needs to have a net cut to maintain the existing floodplain. Any net fill of the site increases the floodplain elevation and reduces places where water can be detained in the event of 100 year floods. Part of making the course practical to build would be having an equal amount of earthwork. The proposals all have significant amounts of cut needed to make them possible, but needing to get rid of or sell less cut makes the course design more desirable. The earthwork calculations were done with rough estimates in AutoCAD Civil 3D. Surfaces of each proposal were compared with the surface of the existing course. An adjustment was made of 1.10 on the net fill required to consider the compaction of soil.

The wetland water will be slowly released back into the creek through use of adjustable head gates that will prevent the flooding on-site and downstream. The gates are manually adjusted to control the amount of water that is held in the wetlands and the amount of water in the creek. The release of water still allows the creek to have a natural flow of water. The estimation of stormwater runoff matrix is found in Table 4.01.

Evaluation of Golf Course Design						
	Golf Proposal	**Golf Rating**	**Wildlife Proposal**	**Wildlife Rating**	**Wetland Proposal**	**Wetland Rating**
Estimation of Runoff						
How much water is produced in the area? (acre feet)	391.66		391.66		391.66	
How much water is produced on site?	44.21		44.21		44.21	
How much water is the wetland capacity on site? (acre feet)	35.38	2.00	41.37	5.00	128.01	5.00
Does the wetland capacity exceed the area runoff?	NO		NO		YES	
How much water heads down stream? (acre feet)	8.83		2.84		-83.80	
Cut and fill balanced? (net adjusted - cu. Yds of cut)	52,942.99	2.00	77,020.47	1.00	48,691.29	4.00
Subtotal -		4.00		6.00		9.00
number of categories		10.00		10.00		10.00
total		0.40		0.60		0.90
category weight		25.00		25.00		25.00
Stormwater Final		10.00		15.00		22.50

wildlife habitat

Wetlands and other open spaces serve as a source of healthy habitat for wildlife. Richard Forman's (1986) research served as inspiration in developing criteria to evaluate and compare wildlife habitat within design proposals. The use of patches, corridors, and networks are the base for wildlife habitat evaluations. The wildlife area for this study is defined as the wetlands and natural open space. The wildlife area is compared and contrasted to the highly manicured golf course turf of the site based on a matrix and standard criteria produced by the author (demonstrated in figure 4.16). The patches of the wildlife habitats are best shown through the circumference of the edges between the golf course and the wetland areas. The larger the patches and greater circumference length they have allowing the more movement and edge length for the wildlife habitat. The research Forman (1986) has done suggests that an edge that moves, creating coves and lobes, creates healthier areas for wildlife than a straight edge. A curving edge condition has a longer circumference.

Creating corridors for the wildlife allows connections and a continuous ground for them to wander. The corridors are measured by the number of patches of wetlands. Patches of the wetlands disrupt the flow and corridor for the wildlife. The lower the number of patches of wetlands, the more fully connected the wetlands and wildlife habitat. The corridor evaluation also includes the area of the wildlife habitat. The more wetland and prairie area that is present, the more wildlife habitat that is available. The area, measured in square feet, shows the amount of wetland area and space for wildlife species to find habitat.

A network was created using a combination of golf islands within the wetlands. The higher the number of islands, the more connections and larger wetland network that has been created across the site. The network is combining systems together to create places and areas for wildlife species to travel. One way to connect the golf course and create a network of the golf course included using bridges to cross wetlands. The more bridges that are needed for a wetland, the greater the presence of wetlands for the wildlife. The bridges offer a complexity for the network and create overlap between the golf course and wetlands, offering more options for wildlife.

Establishing healthy wildlife habitats will help create opportunities for the endangered species in the area. Each proposal allows for a variety of wetland options including freshwater wetlands, marshes, and wet prairies. The on-site wetlands build on a larger network of wetlands that help establish healthy habitats especially for Topeka Shiner, Whooping Cranes, Sandhill Cranes, Golden Eagles and Henslow's Sparrows. The matrix showing wildlife results is Table 4.02.

Wildcat habitat definition

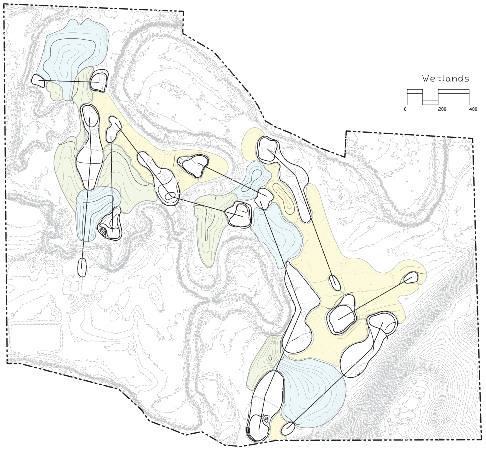
Figure 4.16 | (Produced by author, 2012)

Quality of wildlife habitat has been researched extensively by Richard Forman. As a result, he developed the language of Patches, Corridors, and Networks when talking about habitat. That vocabulary was used to create a matrix that compares different proposals based on the patches, corridors, and networks. Note: Images not to scale.

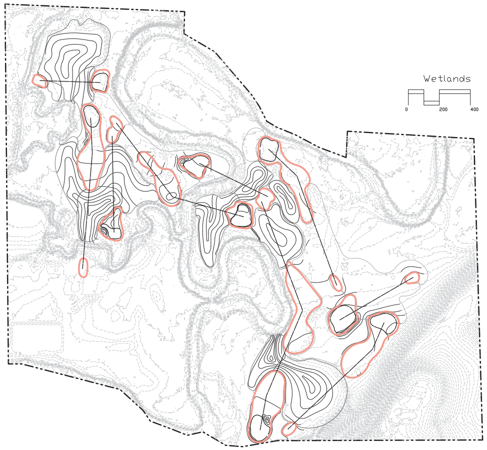
Wildcat habitat table

Table 4.02 | (Produced by author, 2012)

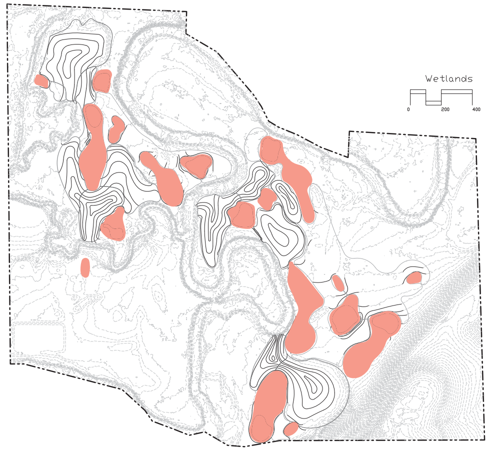
Quality of wildlife habitat has been researched extensively by Richard Forman. In the table, results are shown for the comparison between the three proposals.



corridors = number of individual wetlands
Wetland, wet meadow, and wet prairie were each counted separately. (less wetlands the better)



circumference = length of golf course outline
Shows separation between wetlands and the golf course and edge condition of wetlands. (larger length the better)



network = number of pink golf course components
The network is about the overlap and connection between golf course and the wetlands. (more patches the better)

Evaluation of Golf Course Design

	Golf Proposal	Golf Rating	Wildlife Proposal	Wildlife Rating	Wetland Proposal	Wetland Rating
Wildlife Habitat						
Corridors						
Number of patches? (Lower the better)	13.00	4.00	17.00	2.00	15.00	3.00
Area of the wetlands	543,803.68	2.00	645,210.53	3.00	780,607.14	4.00
Area of the prairie	774,640.11	4.00	589,169.30	3.00	550,251.02	2.00
Patches						
Circumference for edge treatment and condition	14,666.34	5.00	12,001.30	3.00	12,696.75	3.00
Network						
Patches of the golf course	30.00	5.00	22.00	4.00	18.00	3.00
Number of bridges or wetland crossings needed	5.00	3.00	6.00	4.00	7.00	5.00
Subtotal -		23.00		19.00		20.00
number of categories		30.00		30.00		30.00
total		0.77		0.63		0.67
category weight		25.00		25.00		25.00
Habitat Final		19.17		15.83		16.67

golf course playability

In the redesign of the golf course, the proposal still needs to cater to the clientele and demographic of the golf course. Currently, the course is most heavily used by families including people of all ages and skill levels. Creating something that is fun and challenging to play at all levels is critical to the rebuilding of the course.

One way that children learn the game of golf is through The First Tee program, a national initiative founded by the LPGA, the Masters Tournament, the PGA of America, the PGA Tour, and the USGA. The program takes children from never having held a club before to competing in elite-level tournaments. The program is split into two categories: playing ability and "LifeSkills". Children are taught the game of golf through learning life values that include integrity, discipline, focus, responsibility, work-ethic, positive spirit, respect, and dedication. The kids move between Player, Par, Birdie, Eagle and eventually Ace levels to grow in the game of golf and life. The new Wildcat Creek Golf Course should promote fast play, safe golf, courtesy, honesty, integrity, and responsibility as well as teach score keeping, confidence, perseverance, integrity, goal making, and planning for the future all while having fun and enjoying the game of golf. Each of these skills helps kids to grow through the game of golf. Each of these elements are applied to children through The First Tee program but can also be applied to adults learning the game.

Score, speed of play, safety and layout, golf shots, and learning the rules create quantitative and qualitative criteria that allow people to grow in the game of golf and life skills. The score of the player goes down (improves) when you do not have as great of a risk of having penalty strokes due to not making a forced carry or having small landing areas. Forcing a carry over 450 feet (150 yards) or a landing area smaller than 135 feet creates much tougher playing conditions for beginners. Limiting the number of forced carries also creates faster play. The layout of the course is most interesting when the pars of holes are varied and there are not 3 or more holes of the same par in a row. The safety of the course also includes not having any blind shots to ensure that no one gets hit or hurt. To go between levels of The First Tee program certain distances need to be perfected including approach spots of 55 to 75 yards, 80 to 100 yards, and second shots on par 5's of 160 to 190 yards. These shot levels need to be practiced to encourage movement between levels of the program, growth in the game of golf, and accuracy of shot making. People need to learn the game of golf and have practice keeping an accurate score by incorporating different penalty strokes. People want to be able

Playability of golf course table

Table 4.03 | (Produced by author, 2012)

Each proposal was evaluated for how playable the course is for all skill levels and abilities. The criteria are based on The First Tee program that considers children just learning to golf and life skills they should follow.

to grow while still playing the same course, learn to challenge themselves with increasing difficulty, and have fun with the game of golf. Part of growing with a course is having a variety of tee distances, approaches, and angles to the green for people to choose. Each of these criteria helped create a course that allows people of all skills to play a challenging and fun course. The matrix for playability is found in Table 4.03

Evaluation of Golf Course Design						
	Golf Proposal	**Golf Rating**	**Wildlife Proposal**	**Wildlife Rating**	**Wetland Proposal**	**Wetland Rating**
Playability (Based on the First Tee Criteria for Advancing Children)						
Score (How to reduce the score and penalties)						
Number of forced carries above 450 feet (reminder it is intended for beginners)	2.00	4.00	4.00	2.00	3.00	3.00
Dimension of landing area is between 135-350 feet	3.00	3.00	4.00	4.00	3.00	3.00
Fast						
Number of forced carries (lower=better)	11.00	3.00	11.00	3.00	11.00	3.00
Safety & Layout						
No more than 2 of the same par rating of a hole in a row	1 stretch	3.00	1 stretch	3.00	1 stretch	3.00
Ability to vary the number of holes played (for junior ability)	NO	2.00	YES	4.00	YES	4.00
Number of blind shots or potential for blind shots	0.00	4.00	0.00	4.00	0.00	4.00
Golf Skills Requirements						
Opportunity to practice 55 to 75 yard shots into a green	2.00	3.00	4.00	5.00	2.00	3.00
Opportunity to practice 80 to 100 yard shots into a green	1.00	3.00	1.00	3.00	2.00	4.00
Opportunity to practice 2nd shots on par 5's (160-190 yards)	1.00	3.00	1.00	3.00	1.00	3.00
LifeSkills						
Number of wetland areas as yellow stakes	3.00	4.00	2.00	3.00	2.00	3.00
Number of wetland areas as red stakes	8.00	4.00	9.00	3.00	9.00	3.00
Number of holes with the ability to have varying tee sets for different levels	8.00	5.00	6.00	4.00	0.00	1.00
Excitement factor | Interest level | Challenge						
Subtotal -		38.00		38.00		34.00
number of categories		55.00		55.00		55.00
total		0.69		0.69		0.62
category weight		25.00		25.00		25.00
Playability Final		17.27		17.27		15.45

cost of implementation

Part of making the redesign of Wildcat Creek Golf Course possible would be the feasibility of implementation of wetlands and the course redesign. Process of construction includes closing the course resulting in a loss in revenue, earthwork moving, constructing new green and tee complexes, and cost of wetland and prairie grass seeds. The cost of repairing flooding should significantly decrease with the inclusion of wetlands in the remodel. To determine the cost of the possibilities, websites and experts were consulted regarding restoration and golf course construction.

Prairie Nursery is a company that specializes in a variety of seed mixes including a Detention Basin Wet Prairie Mix, a Moist Meadow / Rain Garden Mix, and a Tall Prairie for Dry Soils. Each of these seed mixes had similar plants to what was chosen for the desired habitats of the endangered wildlife species that were chosen to study previously in this project. The cost of wetland and prairie grass seeds is $1250.00 per 44,000 square feet (1.01 acres) and $995.00 per 44,000 square feet (1.01 acres) respectively. The areas that were determined for calculating the volumes were used for area calculations to determine the total cost of the site.

The cost to move earth and bring machinery into the site was estimated by using numbers from Lohmann Golf Design, a Midwest design/build business that focuses on renovation and new construction of golf courses. Their estimate was $6.00 per cubic yard of soil movement with $3.50 per cubic yard for topsoil management. The course's area for limit of earthwork was calculated for each proposal. That area was multiplied by the topsoil depth of six inches to get a volume of topsoil work. That volume was then multiplied by the cost of the topsoil management. The volume was also subtracted from the total earthwork volume to determine the amount of soil movement is needed. The new volume of soil movement was then multiplied by the cost of soil movement. Earthwork calculation estimates were completed in the estimation of runoff phase of the evaluation.

Lohmann Golf Design also gave a round estimate of $60,000 for constructing a new green complex, $40,000 for constructing a tee complex for par 4 or 5's, and $50,000 for constructing a tee complex on a par 3. These are rough numbers that helped determine the cost of building new greens and tees instead of using what currently exists on site.

In order to complete the construction, the course would require closing for one season using April to September for construction and October to May at minimum for seeding, possibly

Feasibility of implementation table

Table 4.04 | (Produced by author, 2012)

The table shows the practicality of implementing the design, what it would cost, and what the benefit and payback life would be if the proposal was chosen.

longer depending on the winter. Optimal seeding time is in fall with a summer opening in May or June. That would mean a loss of $182,000 in revenue a year according to Kevin Fateley, owner of Wildcat Creek Golf Course. There are roughly 13,000 rounds of golf a year, charging rates of $13 per round on weekdays and $15 per round on weekends. The revenue estimate is based on half the rounds being on weekdays and half the rounds being on weekends, averaging at $14 per round.

In the past 5 years, there have been three summers in which significant flooding occurred. In 2007, two heavy storms occurred two weeks apart and cost Wildcat Creek Golf Course $25,000. 2010 had $30,000 worth of damage from one June storm, while $15,000 was spent on the 2011 flooding event in June. The course has improved its method of clean up over the years, but there could be substantial damage that continues to get worse over the years. In the calculations, the total amount of the flooding was subtracted from the construction cost. If the same flooding frequency and damage occurs in the next five years, the cost of the repairs would not be needed if the redesign was completed. The cost matrix can be found in table 4.04.

Evaluation of Golf Course Design						
	Golf Proposal	**Golf Rating**	**Wildlife Proposal**	**Wildlife Rating**	**Wetland Proposal**	**Wetland Rating**
Cost						
Wetlands cost ($1250.00 per 44,000 square feet)	15,448.97		18,329.84		22,176.34	
Prairie cost ($995.00 per 44,000 square feet)	17,517.43		13,323.26		12,443.18	
Topsoil Earthwork cost ($ 3.50 per cubic yard)	407,714.13		363,923.84		322,401.92	
Earthwork cost ($6 per cubic yard soil moving)	35,657.29		176,526.54		126,920.73	
Green complex cost ($60,000)	480,000.00		300,000.00		300,000.00	
Tee complex cost for par 4 and 5 ($ 40,000)	200,000.00		200,000.00		120,000.00	
Tee complex cost for par 3 ($50,000)	125,000.00		150,000.00		150,000.00	
Golf course seed and grow in period cost $___per acre	182,000.00		182,000.00		182,000.00	
Cost of flood clean up (2007+2010+2011)?	70,000.00		70,000.00		70,000.00	
What would a broad cost estimate be?	1,357,680.53	1.00	1,157,576.95	2.00	1,039,021.44	3.00
Number of years (at $30,000) of flood clean up to offset construction costs	45.26	2.00	38.59	3.00	34.63	4.00
Subtotal -		3.00		5.00		7.00
number of categories		10.00		10.00		10.00
total		0.30		0.50		0.70
category weight		25.00		25.00		25.00
Feasibility Final		7.50		12.50		17.50

Final comparison table

Table 4.05 | (Produced by author, 2012)

The final table considers the result of every category at an equal 25% of the total perfect score.

evaluation summary

Each proposal was put through the evaluation matrix to determine the best master plan to move forward. In the estimation of runoff category, the wetland proposal received the highest rating, followed by the wildlife proposal, and the golf proposal coming in last place. In the wildlife category, the golf proposal recorded the highest score, with the wetlands proposal taking second, and lastly the wildlife proposal. Playability of the golf course evaluation scored the golf and wildlife proposals as the highest and the wetland proposal coming in last. The wetland proposal turned out the most cost-feasible option followed by the golf course proposal and the wildlife proposal respectively. Each category was weighted equally and normalized which resulted in the wetland proposal ranking highest in the proposal evaluation matrix. The final matrices are found in table 4.05.

Evaluation of Golf Course Design						
	Golf Proposal	**Golf Rating**	**Wildlife Proposal**	**Wildlife Rating**	**Wetland Proposal**	**Wetland Rating**
Stormwater Final		10.00		15.00		22.50
Habitat Final		19.17		15.83		16.67
Playability Final		17.27		17.27		15.45
Feasibility Final		10.00		7.50		17.50
Evaluation Total		53.94		60.61		72.12

Design Development

This section is further developing the wetland proposal that was developed in the planning stage and chosen in the evaluation. The proposal goes through the course hole by hole to consider strategy of the course.

wetlands proposal

After the evaluation was completed on all three proposals, the wetland design came out with a higher score and was taken forward for further design and development of the course into the existing landscape (shown in figure 4.17). The category in which the wetland design scored lowest was the playability factor, and more specifically, the varied tee locations for people to choose from to fit their skill level. As the wetland proposal was further designed, each hole was developed with a strategy that included more teeing locations with a variety of lengths while further defining mounds, bunkers, and hazards of each hole (as shown in figure 4.18). The feasibility section in the evaluation criteria would increase slightly with more tee boxes being added. The cost estimate would still come in under the other proposals since the initial estimate was $120,000 lower then the next lowest proposal. The following holes showcase the ability for the golf course to be combined with wetlands and wildlife habitat and promote the three pillars: golf, wildlife, and wetlands (see figure 4.37).

Site development and retention of woody vegetation

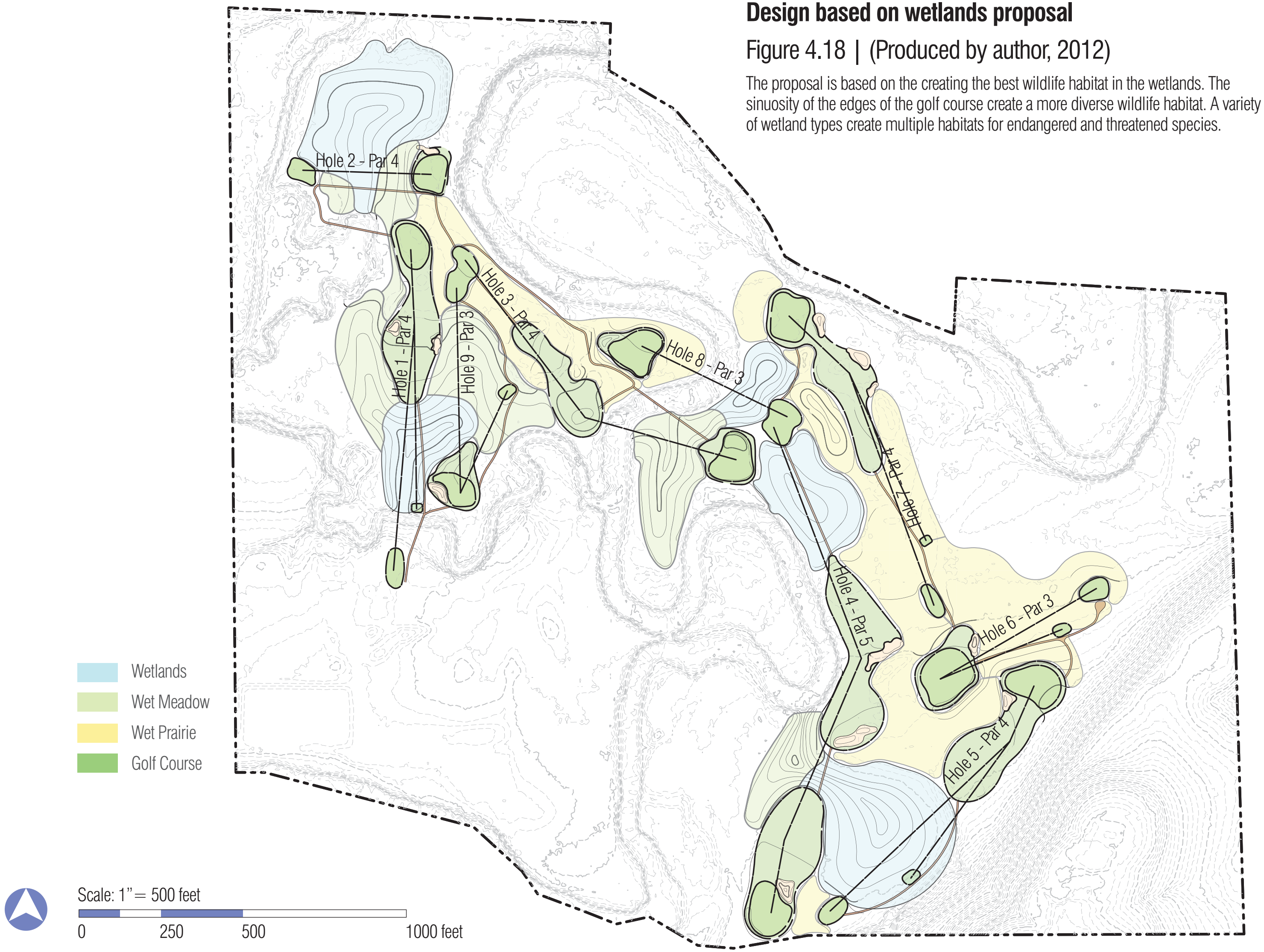
Figure 4.17 | (Produced by author, 2012)

The course is integrated into the existing woody vegetation and wetland creation to increase wildlife habitat and create an identity for Wildcat Creek Golf Course.

Design based on wetlands proposal

Figure 4.18 | (Produced by author, 2012)

The proposal is based on the creating the best wildlife habitat in the wetlands. The sinuosity of the edges of the golf course create a more diverse wildlife habitat. A variety of wetland types create multiple habitats for endangered and threatened species.



hole one

Par 4 | 325 Yards

The starting hole uses the existing tee area for the middle and back tees of the first hole. An additional tee has been placed forward to accommodate a variety of skill levels and reduce the carry over the wetlands as shown in figure 4.19. Near the landing area of the first shot, a bunker is on the right side of the fairway. The sand bunker falls down to the wetland. A second bunker is on the left side of the fairway. There is a small mound that backs the bunker and is covered with native grasses. The green complex uses the existing grades with prairie on the right and wetland behind the green as shown in the hole plan (figure 4.20).

Teeing off across the wetlands

Figure 4.19 | (Produced by author, 2012)

The first hole introduces wetlands and habitat to the golf course immediately.

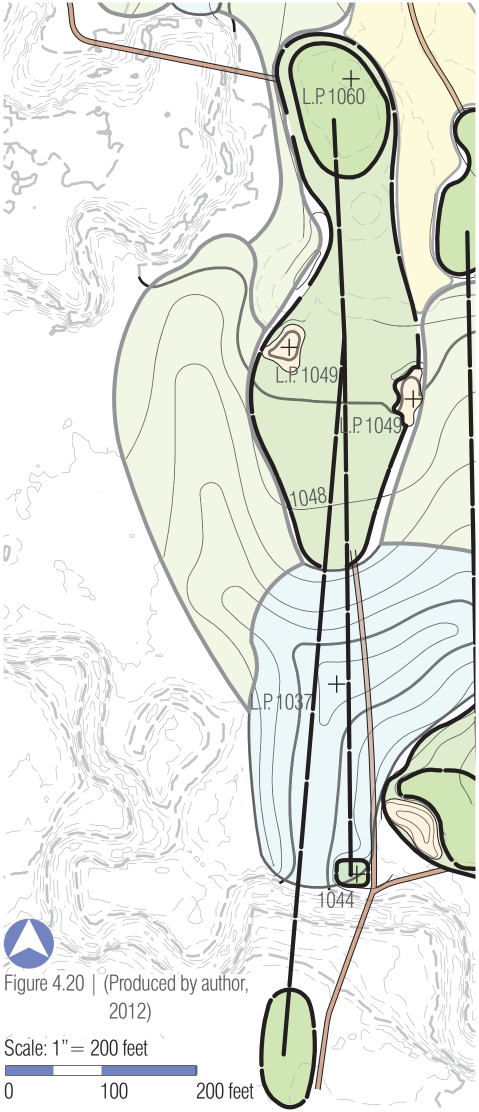


Figure 4.20 | (Produced by author, 2012)

Typical Legend for all hole plans

- Wetlands
- Wet Meadow
- Wet Prairie
- Golf Course Fairway
- Golf Course Tee and Greens

hole two

Par 3 | 130 Yards

The second hole is built around the edges of a large wetland as shown in figure 4.21. The tee box is in the same geographic area as the existing tees, but is expanded to a new large area that can accommodate three sets of tees. The wetland creates a forced carry utilizing the existing green shown in the hole plan (figure 4.22). The existing green has slope and size to catch a shot. Golfers do not want to be short; otherwise, they will end up in the wetland.

Wetlands surround the green

Figure 4.21 | (Produced by author, 2012)

An island-like green is presented on the second hole with wetlands encompassing the green.

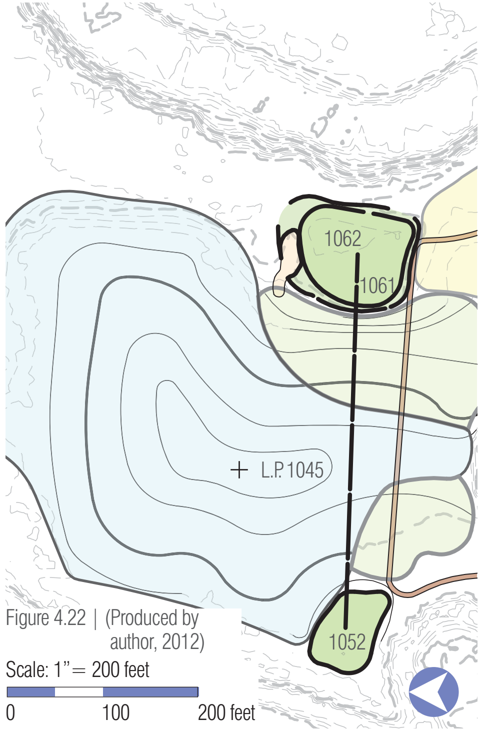


Figure 4.22 | (Produced by author, 2012)

hole three

Par 4 | 360 Yards

The third hole is a par 4 that requires accuracy and strategic placement on the first shot. A 200 yard shot over wetlands (figure 4.23) would land at the top of a slight hill in the fairway before reaching a hazard and the creek. A mound on the left side of the fairway covered in prairie creates separation between the third fairway and the eighth green. The approach shot to the green crosses Wildcat Creek and a wetland and requires length to get there. There is a drop area on the other side if distance is misjudged. The green has a natural mound on the right edge and a terrace on the left edge. The hole design strategy is shown in figure 4.24.

Wet prairie surrounds the fairways

Figure 4.23 | (Produced by author, 2012)

A drive needs to be strategically placed so the second shot can cross the creek.

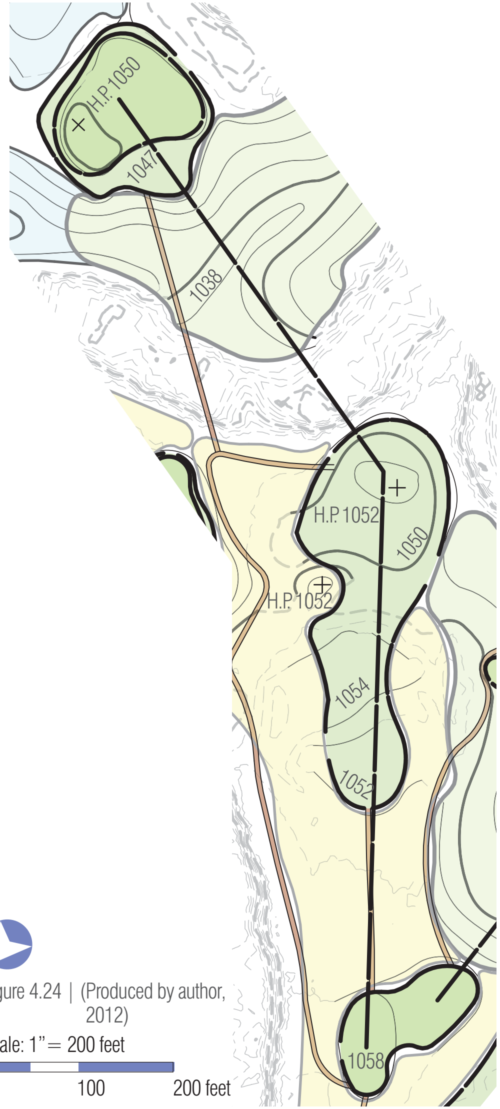


Figure 4.24 | (Produced by author, 2012)

Scale: 1" = 200 feet

0 100 200 feet

hole four

Par 5 | 525 Yards

The only par 5 on the course occurs in the fourth hole. A shared tee starts the hole with a long shot over wetlands, shown in figure 4.25, demanding strategic placement to avoid the sand bunkers on the left two-thirds of the fairway. The bunkers flow into a mound that is behind the bunkers. The second shot requires risk if the golfer wants to attempt to clear the wetland. For the golfer who does not want take that risk, a sand bunker helps to create a buffer between most of the fairway and the crossing wetland, as shown in the hole plan (figure 4.26). The approach into the green is best made from the right side of the fairway to avoid the sand bunker on the front left edge of the green.

Forced carries over wetlands create difficulty on the hole

Figure 4.25 | (Produced by author, 2012)

The fourth hole has two forced carries over wetlands that encourage placement of shots and integration of wetlands into the course.

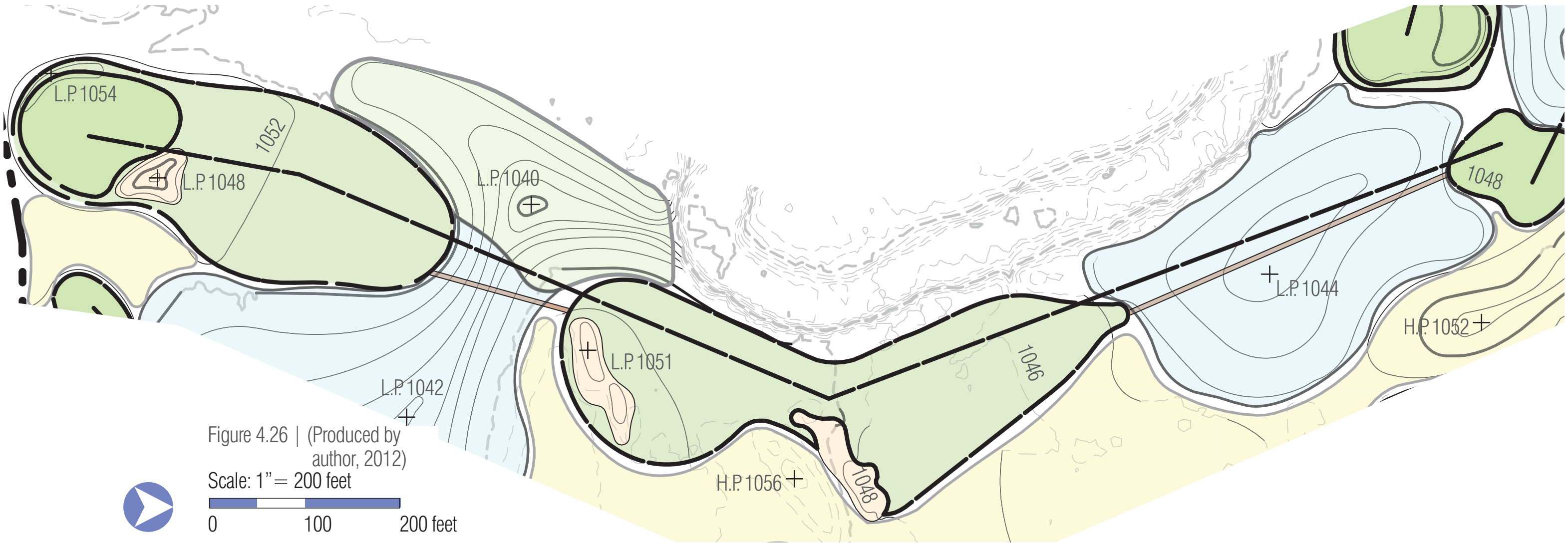


Figure 4.26 | (Produced by author, 2012)

hole five

Par 4 | 315 Yards

The fifth hole focuses on the trees and elevation change on the right side of the hole (shown in figure 4.27). The middle and back tees have a long carry over the wetland. A forward set of tees is tucked next to the trees and offers a shorter carry distance. The approach to the green is easiest from the right side of the fairway due to a slight dog-leg left and a bunker on the front left side of the green. The design strategy is shown on the hole plan, figure 4.28.

Trees guard the right side of the fifth hole

Figure 4.27 | (Produced by author, 2012)

Trees and wooded vegetation are lined along the right side of the fairway which sits at the bottom of the hill.

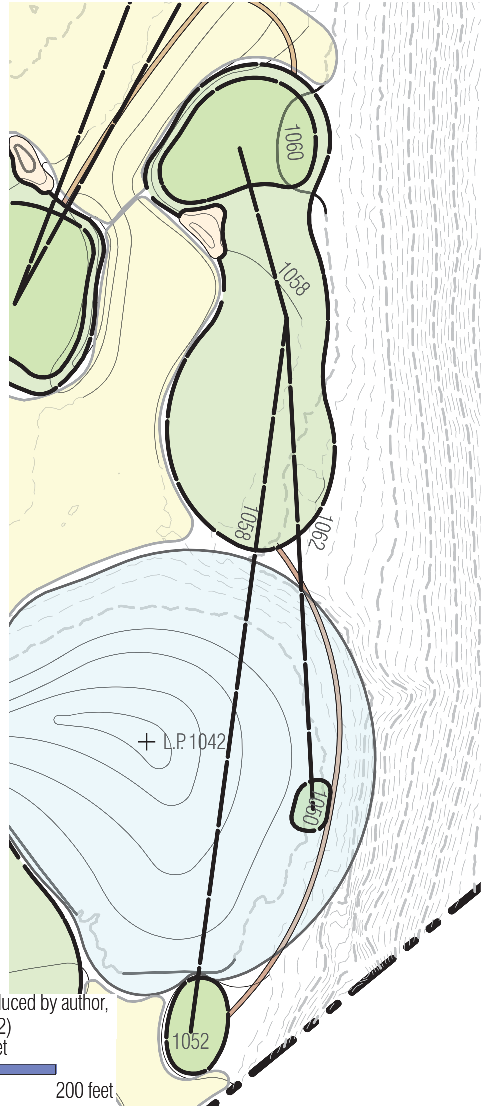


Figure 4.28 | (Produced by author, 2012)

Scale: 1" = 200 feet

0 100 200 feet

hole six

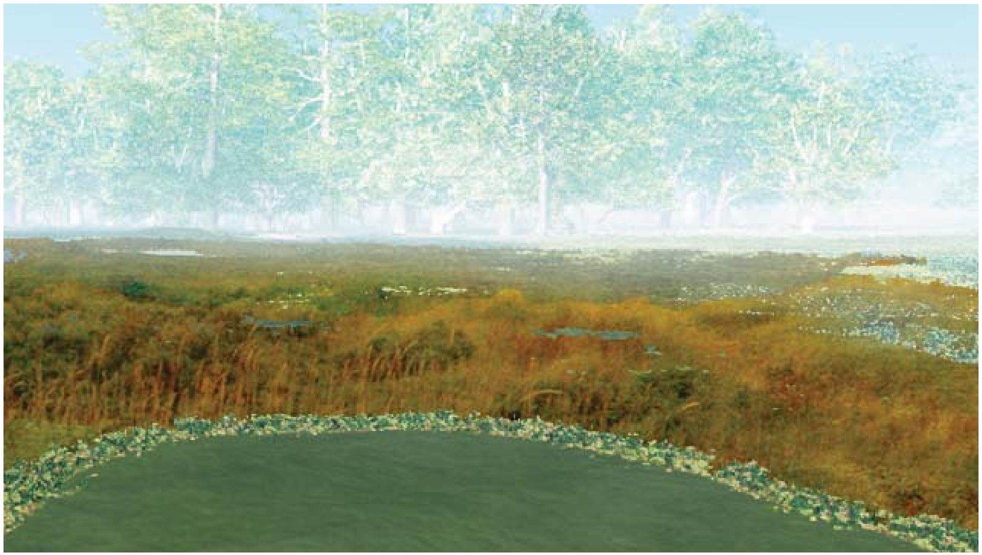
Par 3 | 185 Yards

The sixth hole, a par three, brings the course back to a wet prairie ecosystem. A mix of teeing distances that all require a carry over the prairie (figure 4.29) to a green is tucked into the prairie hillside on the left side of the green. A small landing area and drop circle is offered on the front right side of the green. The hole strategy is shown in plan in figure 4.30.

Wet prairie stands between the tees and the green

Figure 4.29 | (Produced by author, 2012)

Wet prairie creates wildlife habitat and reduction of runoff in upland, off-channel locations.



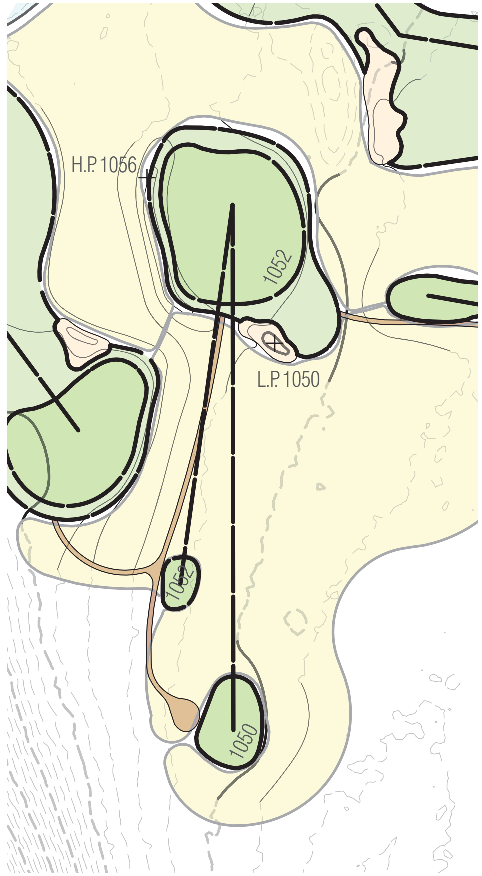


Figure 4.30 | (Produced by author, 2012)
Scale: 1" = 200 feet
0 100 200 feet

hole seven

Par 4 | 335 Yards

The last par 4 of the course occurs at the seventh hole. The tee shot requires a strong drive to reach the larger opening of the fairway. The first part of the fairway is surrounded by two prairie mounds. The sand bunkers in the fairway clearing shown in figure 4.31 persuade the golfer to avoid the right side of the fairway. The approach shot is best from the left side of the fairway, but has a mound on the front edge creating interest in the existing green complex. The existing bunker on the right side of the teeing complex is being maintained to create a narrow opening to the green, shown in figure 4.32.

Existing green complexes are incorporated into the new design

Figure 4.31 | (Produced by author, 2012)

Sand and mounds surround the fairway and create a buffer between the fairway and Wildcat Creek.

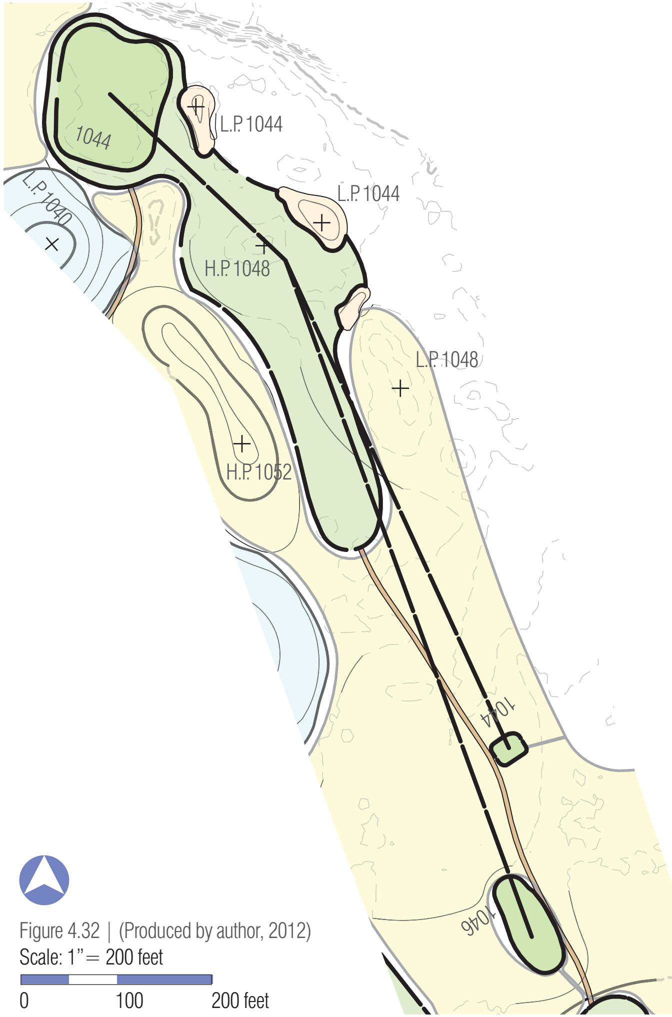


Figure 4.32 | (Produced by author, 2012)
Scale: 1"= 200 feet

hole eight

Par 3 | 165 Yards

The eighth hole crosses over a wetland directly adjacent to the front of the tee box, then continues over Wildcat Creek as shown in figure 4.33. The green complex has a terrace on the right side of the green allowing for a variety of tee placements and ways to play the hole. There is a mound on the back left side of the green that gives definition to the green complex. Hole strategy is shown in plan, figure 4.34.

Crossing the creek

Figure 4.33 | (Produced by author, 2012)

The creek and prairie fronting the green requires enough club to reach the green, because you do not want to be short.

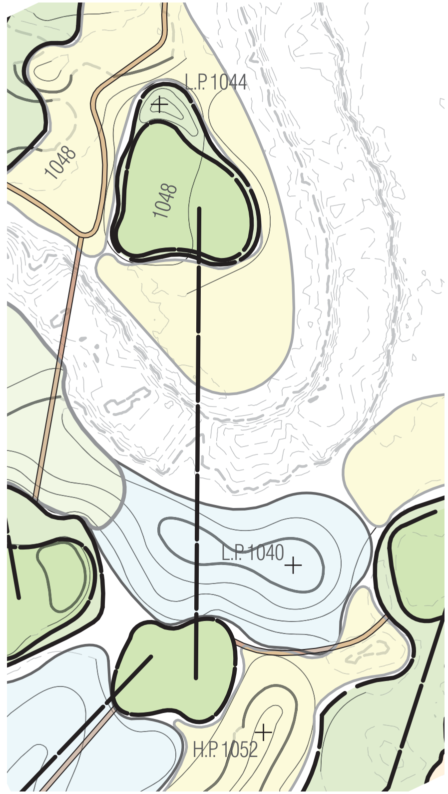


Figure 4.34 | (Produced by author, 2012)
Scale: 1"= 200 feet
0 100 200 feet

hole nine

Par 3 | 207 Yards

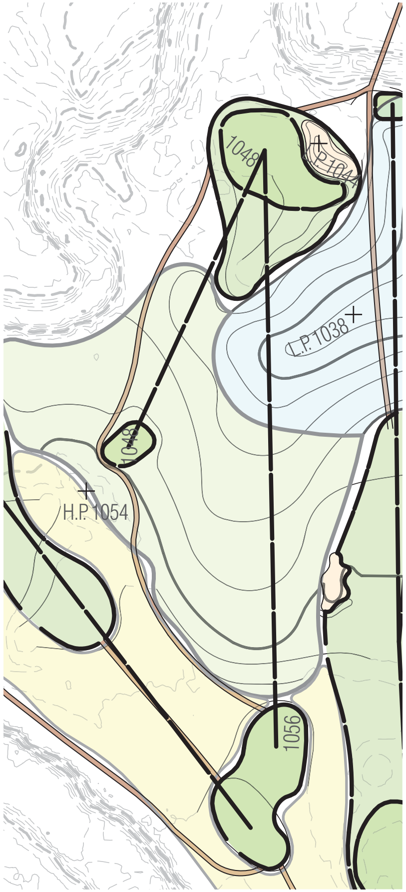


Figure 4.35 | (Produced by author, 2012)

Scale: 1" = 200 feet

0 100 200 feet

The last hole on the course is a long par 3 that shares a middle and back tee box with the second hole (shown in figure 4.35). The forward tees have a much shorter required carry over the wetland (shown in figure 4.36). The green complex uses the existing ninth hole green with an extended fairway and the addition of a bunker in the back right side of the green.

Wetland finale

Figure 4.36 | (Produced by author, 2012)

The final hole emphasizes the pillars of the course (golf, wildlife, and wetlands) through a wetland carry and the green being backed by Wildcat Creek.

Master plan blends into surroundings

Figure 4.37 | (Produced by author, 2012)

Project Conclusion

The project examined the watershed, Wildcat Creek Golf Course, wetlands, and endangered species in the region

Implementation

Summary

Personal Reflection

implementation strategies

Wetlands were first considered at a conceptual level for the watershed scale plan. At site scale, wetlands were then strategically placed within the existing land use to reduce the stormwater runoff and increase wildlife habitat. A typology of wetlands was created for the Wildcat Creek Golf Course site with each wetland having a different purpose and goal. One wetland type is intended to hold water when it is captured and could retain a significant amount of water during strong storms and flash flooding. Another wetland type does not collect water, but uses wetland plants to slow the stormwater runoff and increase infiltration of stormwater. The last type of wetland is a wet prairie that is not intend to hold water, but slows runoff and increases infiltration in higher ground areas. The types of wetlands are demonstrated in figures 4.13, 4.14, and 4.15 beginning on page 131 in the golf course chapter.

In order to implement the wetlands, the existing land needs to be re-energized. If the land cover is primarily grasses, the site can be burned in the spring, and then turned over to re-circulate the seeds of existing vegetation. If the land has woody vegetation, it will need to be cleared. Once the site has been prepared, existing topsoil within the limit of earthwork will be stripped and stockpiled to be use at a later point. The major earthwork and grading of the site can be completed, shaping holes and wetlands on the golf course. Extra cut will need to be stockpiled in a location away from the creek. Excess soil can be sold with the condition that the soil would not be used as fill within the 100 year floodplain of Wildcat Creek or any other creek in the area. Once the earthwork is complete, topsoil can be placed back on the site, and the site will be ready for the planting of wetlands.

Each type of wetland provides particular habitat opportunities for species of wildlife that generally use the site. For each species, a planting palette that identifies plants best suited for the wildlife habitat and Wildcat Creek watershed has been developed. Instead of strategically placing plants on site, a seed mix should be generated for each type of wetland. The seed mix will be placed across each location that is marked for that type of wetland, then natural selection will let the seeds grow in water and sun conditions that best fit the plant. Using a survival of the fittest method allows plants to grow as they would naturally and become well established for the future.

Another way to implement wetlands would be to do a specific planting plan showing the exact location of plants and exact quantities of each type of plant needed. The labor and cost of this strategy is very high, but could result in the exact design the owner desires. Using seed mixes is significantly less expensive and labor intensive than detailed planting plans according to Carl Korfmacher (2011), a landscape architect who has used both strategies for wetland implementation. Both options offer ways to implement wetlands and create more vegetation on-site that will increase infiltration and slow the runoff of stormwater.

Once wetlands have been planted and established on the site, they need to be maintained on an annual or biennial (every other year) basis by burning the wetlands. The burning of wetlands helps to re-establish the seeds and ecosystem of the wetland. Re-invigorating the ecosystem helps control the weeds and maintains the health of the desired plants.

summary

Wildcat Creek in Manhattan and Riley County, Kansas has caused significant damage from flash flooding in June 2010 and June 2011. The creek has a history of flooding in some areas on a regular basis and of causing substantial damage to surrounding properties. The flooding and resultant property damage is caused from a variety of factors in the watershed that include urban development near or in the floodplain, reduction of natural areas, changes to the channel shape and size, as well as increase in sediment supply from farming, military training, and building development.

The first step in the process was better understanding how the creek channel is formed and what areas across the watershed may be contributing to the flooding. A Watershed Assessment of River Stability and Sediment Supply (WARSSS, Rosgan, 2007) was conducted by a group of landscape architecture, planning, and engineering students for the Wildcat Creek watershed. The assessment served as the basis for understanding the watershed, the creek, and the flooding issues. Wetlands are one opportunity to reduce flooding in the watershed. A watershed scale analysis was done for on-channel and off-channel wetlands to determine the most suitable areas for wetlands to be implemented. Two watershed scale plans were created to show conceptual ideas of wetlands throughout the watershed. One plan focused on specific locations of wetlands while the other plan focused on the connection of wetlands to create a corridor throughout the watershed. A TR-55 estimation of stormwater runoff was done for each sub-watershed and compared with the wetland quantities in each proposal to determine which proposal best fit the requirements for reducing stormwater runoff. The proposals were also evaluated for the quality of wildlife habitat they created. The habitats were evaluated based on their patches, edge type, corridor creation, and network. As a result, the proposal that considered the corridor approach of wetlands was determined to be the most appropriate for the Wildcat Creek Watershed.

Once an understanding of what would need to be done at a large scale was attained, further development needed to be done at the site scale in order to implement the wetlands. The wetlands can be strategically placed within the existing land use and land cover to best maintain the existing land use. Wildcat Creek Golf Course was chosen as the site to implement wetlands to reduce flooding on-site and downstream. According to the watershed scale plan, on-channel wetlands are best suited for the site. A site suitability assessment was done to determine the best locations for these wetlands to occur. Based on that analysis, three master

plan proposals were generated. Each proposal had a primary design focus (golf experience, wildlife habitat quality, or wetland capacity). The proposals were then compared and evaluated on the wetland capacity from estimated stormwater runoff (TR-55 method), quality of wildlife habitat (author used Forman's research (1986) to develop comparative criteria), playability of the golf course (author used The First Tee program goals and advancement skills to develop comparative criteria), and the feasibility of implementation (cost comparison). The wetland proposal was the highest rated proposal and selected for further development. In reflection of the evaluation, the playability of the course was of concern in the wetland proposal. During the further development of the golf course, more tee boxes, sand bunkers, mounds and golf interest features were added to the design to improve the playability.

Wetlands create opportunities to increase wildlife habitat in the area, especially for threatened and endangered species. Topeka Shiner, Whooping Crane, Sandhill Crane, Golden Eagle, and Henslow's Sparrow rely upon wetland habitats in some way. A plant palette was established for each species and used to consider types of wetlands implemented at the site scale. Each species would benefit from more habitat as they are resting within the watershed or migrating through the region. Wetlands help create more habitat opportunities for the species and decrease the risk of them becoming extinct in the region.

Wetlands offered an opportunity for regenerative design through an increase in habitat, location for water to go, and use of burning grasses to re-enliven the ecosystem. Wetlands are not just a one time solution, but as long as they are maintained, can be a stable regular solution. The solution does not have to hold water to be successful, but can adapt to the conditions at the time of need.

The wetland plans offer an opportunity to help reduce flooding and preserve nearby properties in the community. Wetlands are not the only solution for flooding and cannot be the only stormwater management solution to solve the flooding. They should be a part of a larger stormwater management system that is utilized to control the flooding of Wildcat Creek and the flood-prone areas in Manhattan, Kansas.

personal reflection

The project has been a tremendous learning experience for me as an individual and future landscape architect. Organization, time management, and leadership were individual objectives that were further refined through the process of completing a master's report. The project and process were my responsibility to grow, progress, design, and complete. The project and course taught me a significant amount about creek and river forms and natural systems. I was able to learn more about how a creek grows and changes, what factors cause change to the river, and how that little change can have large effects on the area.

If I were to complete the project again, I would more closely consider the plant palette and the effects of which plants were chosen. I considered the plants for each wildlife species and gave plants that are reflective of every portion of the ecosystem. I diagramed a standard ecosystem of the area, but would have liked to do a more thorough examination of the ecosystem for each species. That ecosystem diagram would have given the species a better foundation for surviving and thriving in the area. A majority of the wildlife chosen were migratory birds that travel through the region. Looking at those migratory patterns and learning more about their full journey would have been helpful in determining where the Wildcat Creek watershed fits into the larger (national) scale, see what other areas in the country are they lacking habitat, and whether or not a larger wetland plan could be considered for each migratory species.

If time allowed, the next steps on this project would be to examine how the wetlands could fit into a stormwater management plan for the city and the county. Wetlands are not going to solely solve the flooding problems in the region, so other stormwater management strategies (possibly those proposed by student colleagues that worked on the WARSSS assessment) would need to be added and compiled to develop a more comprehensive, multifaceted strategy for the community. Further questions would need to be answered. For example, how would a stormwater management plan be realized in the region? What phasing options are available? What impact would those phases have on stormwater and flooding in the watershed? Showing how the stormwater management plan could be compiled would help the community consider a variety of options and solutions for resolving their flooding concerns and preventing a repeat of the damages experienced in June 2010 or June 2011.

Initially my master's report was tailored to follow my personal dream of designing golf courses. I knew that golf course design alone could not be the entire project, but did not know the extent or shape the project would take over time. The broad dilemma of the flooding of Wildcat Creek opened many roads and solutions for expanding the project and creating a project that was far more than a golf course design. Expanding my knowledge to wetlands, natural systems, and wildlife habitats has personally created more interest and joy in a larger scale of landscape architecture. The project has expanded my vision of large scale planning with natural resources and hopefully will create more opportunities for developing a career in landscape architecture.

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Appendices

Glossary

WARSSS: RLA

WARSSS: RRISSC

TR-55 calcualations: Watershed scale

Glossary

Definitions of critical terms

100 year Floodplain- Land that has a 1 to 100 probability of flooding each year.

Aggradation- "A raising of local base level due to sediment depositional processes over time" (Rosgen, 2006)

Bankflow depth (mean)- the distance between the creek surface and bankfull stage (Rosgen, 2006)

Bankflow width- Width of the stream at bankfull stage (Rosgen, 2006)

Base flow- "Stream flow coming from groundwater seepage into stream." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Basin – "A physiographic region bounded by a drainage divide; consists of a drainage system comprised of streams and often natural or man-made lakes." Another name for a watershed. (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Best Management Practice- Slowing and controlling stormwater runoff through systems that improve the quality of water in urban and rural environments. Typically used with areas that do not have high levels of infiltration and do collect stormwater runoff.

Biological Characteristics – "A characteristic of water defined by the levels of bacteria, viruses, and microscopic animals present." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) Characteristics that are used to determine water quality.

Channel- An area intended for a concentrated flow of water that is designed and built to handle stream flow/water movement. Some areas may be ephemeral, but during rain events, water fills the otherwise dry creek bed.

Conservation – "Conservation is the wise use of natural resources (nutrients, minerals, water, plants, animals, etc.) Planned action or non-action to preserve or protect living and non-living resources." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Constructed Wetland- An ecosystem that is produced by man to hold water and improve water quality. Plant selection and habitat are considered in this sustainable landscape feature.

Degradation - "A lowering of local base level over time due to channel incision processes" (Rosgen, 2006)

2011 Flooding in Manhattan

Figure 7.1 | (Jankovich, R. & Johnson, A., 2011)

Within the City of Manhattan boundaries, the flooding extent during 2011 was documented by the City of Manhattan.

Ecosystem- Elements that bring together everything necessary for the species to survive and thrive in the area. Species help support each other through food and shelter sources to give everything in the area a purpose and reason to be there.

Fauna – "The collection of animal species in a particular ecosystem." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Fertilizer – "Nutrients essential for plant life containing nitrogen, phosphates." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) Can be used for crop production, golf courses, or other manicured land.

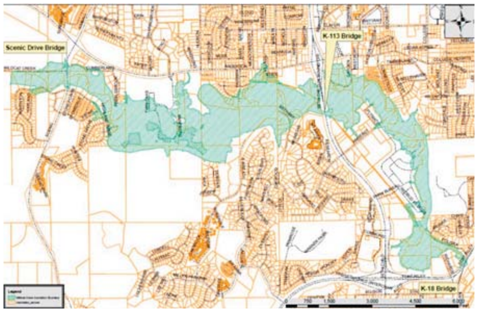
Filtration – "A treatment technology used to remove inorganic compounds from water." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) Gravel or vegetative sources can be used to clean water as it passes through.

Flooding Extent- The zone in which a flooding event extended to. For the June 2011 flood in the City of Manhattan, see Figure 6.1.

Flood Plain – A lowland area that has a high flooding risk. The official boundary is set by FEMA, causing higher insurance rates of developed land within this area.

Flora – "The collection of plant species in a particular ecosystem." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Flow – "The rate of water discharged from a source expressed in volume with respect to time." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)



Freshwater Marsh- A type of non-tidal wetland that is based on grasses, sedges, reeds, and other soft-stemmed aquatic based plants. There is minimal peat build up that the marsh survives on (Mitsch, et al, 2009).

Freshwater Swamp- A type of non-tidal wetland that is typically based on tree species. The swamp includes a forest with understory that thrive in very wet conditions (Mitsch, et al, 2009).

Groundwater – "Water that flows or seeps downward and saturates soil or rock forming pockets of stored water." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Habitat- Food, shelter, water, and reproductive measures are componenets that make up an ecosystem (Sanderson, 2011). The elements work together to provide healthy and safe environments for animals and humans to be in.

Hydrologic Cycle- "Complete cycle through which water moves from the oceans, through the atmosphere, to the land and back to the oceans." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) The cycle or evaporation, clouds forming, rain or snow falling, and runoff back into the water source.

Hydrology- "A study of water and its properties, circulation, principles and distribution." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Impermeable- "Geologic formations that resist water percolating through them." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) Buildings, pavement (impermeable), infrastructure, and rock are some examples of impermeable surfaces that don't collect water and create higher levels of runoff.

Intermittent Stream- "A stream or reach of a stream that flows only at certain times of the year." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Infiltration- Water seeping into the ground and creating moist soil, feeding plants through the root system, and preventing water from leaving the site. This is encouraged through the use of permeable materials, sandy soils, and vegetation.

Microbe- "A microorganism, especially a bacterium that causes disease; a minute life form." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Mouth of Stream- "The point of discharge of a stream into another stream, lake or sea." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) The point to were a tributary enters Wildcat Creek or were Wildcat Creek enters the Kansas River.

Permeable- "A characteristic of underground formations which have pores or openings that permit liquids to pass through." (Bell, Eccles, Garber, Kerby & Swaffar, 2004). Areas or materials with high levels of infiltration.

Pesticides- "Toxic chemicals used to eliminate or control unwanted insects, plants, or other organisms. Pesticides include insecticides, herbicides, and fungicides." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) Often applied to crop production, golf courses, and manicured landscapes.

Regenerative Systems- "A regenerative system provides for continuous replacement, through its own functional processes, of the energy and materials used in its operation" (Lyle, 1994, p. 10). A system that can produce food and shelter for every species and have species work together to sustain its growth as a habitat.

Reservoir- "A man-made body of water replenished by rain and river or stream flow that is formed after a dam is built on a river. Flood control and water supply are the two principle purposes. Reservoirs also provide wildlife habitats, recreational areas and, in some states hydroelectric power." (Bell, Eccles, Garber, Kerby & Swaffar, 2004)

Runoff- Stormwater that leaves the original point source and continues onto another property or location. Finding ways to reduce runoff will reduce flooding. Part of flooding is a result of too much runoff from other locations descending into a new location.

Sedimentation- "The deposition of silt, soil, clay or sand particles in locations where slow-moving water loses its ability to hold heavier particles in suspension." (Bell, Eccles, Garber, Kerby & Swaffar, 2004) The changes in erosion processes will become critical in the RLA portion of the WARSSS analysis.

Stream Bank Stabilization- Using measures to prevent the soil and stream bank from cutting into the land that exists. Woody vegetation is often used as a measure to stabilize the stream bank.

Surface Erosion- "The wearing away of the surface by water, wind, ice, or other erosional processes" (Rosgen, 2006)

Sustainability- A blend of social, economic, and environmental features in the landscape that allow the site to survive and hopefully thrive into the future. (Triple Bottom Line)

Upland- Area within watershed that does not exist in the floodplain.

Watershed- Land that directs water into a concentrated water drainage way.

Wetland- An ecosystem that consists of physiochemical environment (e.g., soil, chemistry, and water quality), hydrology (e.g., water level flow, frequency, and water quantity), and biota

WARSSS | RLA

Dedicated to the Reconnaissance Level Assessment phase of the Watershed Assessment for River Stability and Stream Supply, in the Wildcat Creek Watershed. The complete Wildcat Creek watershed assessment can be found here https://krex.k-state.edu/dspace/handle/2097/13605.

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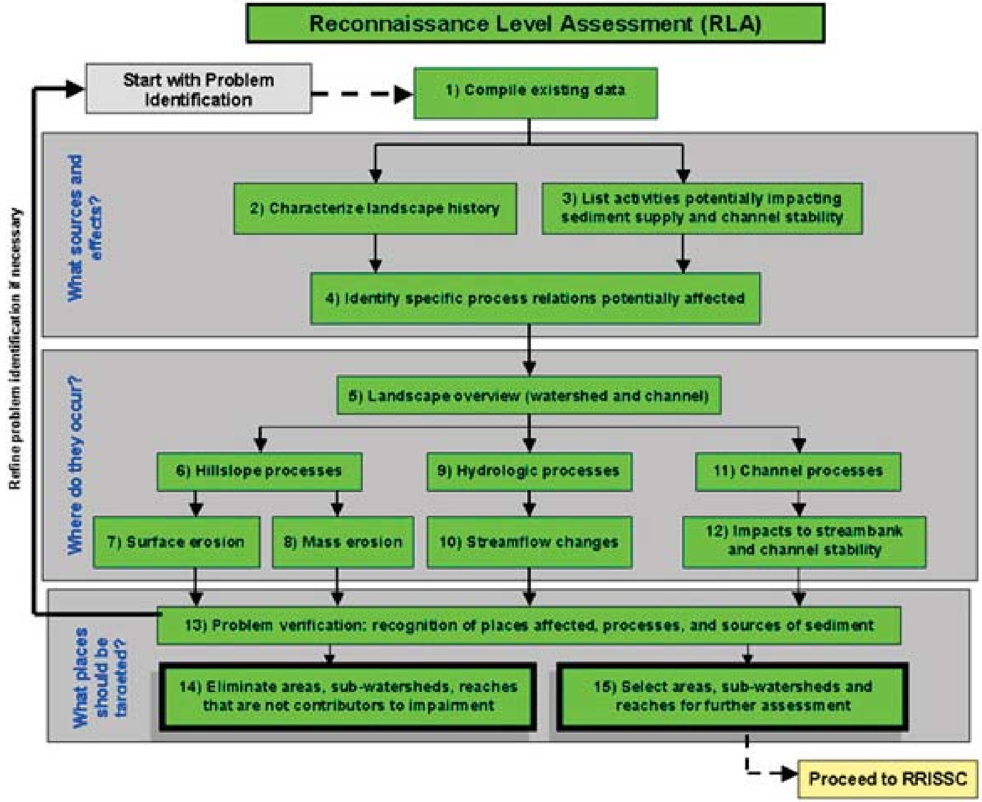
Reconnaissance Level Assessment

Initial Phase of Rosgen's WARSSS

As mentioned previously, the Reconnaissance Level Assessment (figure 8.01) serves to explore the general landscape character of the area selected for the WARSSS assessment. The brief and rapid screening reduces the time and cost of the assessment, and provides base knowledge before in-depth analysis (U.S. EPA, 2011).

Conducting the RLA phase helps the user gather information about the watershed in question. The information includes but is not limited to land use/land cover maps, soil maps, topographic maps, aerial photographs and geologic maps (U.S. EPA, 2011). Aided by the collected information, the user can begin to identify problem areas and begin to eliminate sub-watersheds, reaches etc. that do not contribute to excess sediment. Alternatively, areas that contribute to excess sediment are brought into the second phase (RRISSC) of the WARSSS analysis (U.S. EPA, 2011).



WARSSS reconnaissance level assessment method

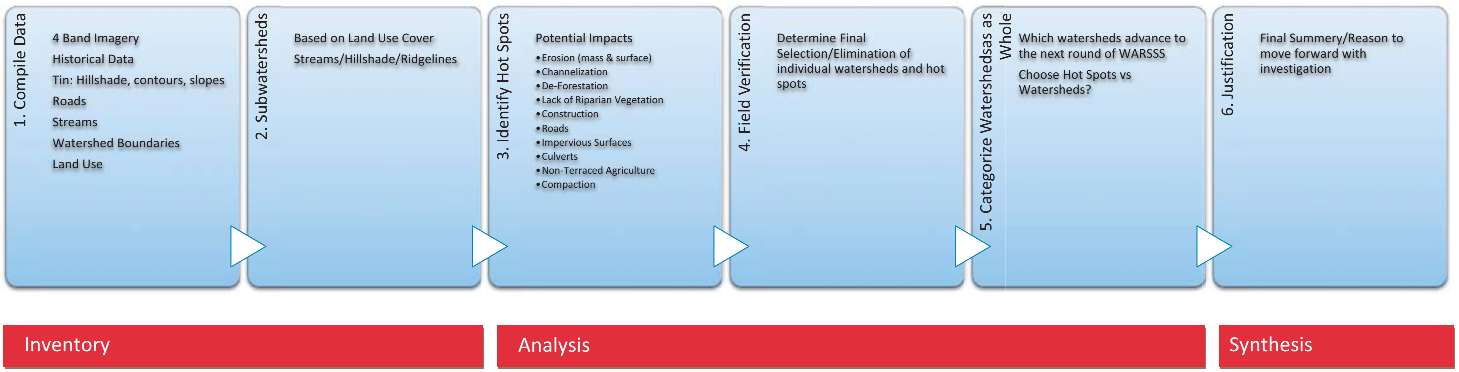
Figure 8.01 | (Rosgen, 2006)

The steps and process Rosgen uses to evaluate a watershed in the first look at the watershed. A quick evaluation of the watershed determines areas that move forward for more evaluation.

Process of Completion

Objectives

To complete the Reconnaissance Level Assessment of WARSSS, there were three objectives to achieve. The first objective was to find areas where land activities increase sediment yield and contribute to channel stability problems, the second objective was to bring clarity to identified problems, and the third objective was to determine which stream reaches to include for more thorough evaluation and which to exclude from further assessment. The process used to achieve these objectives is diagrammed in figure 8.02.



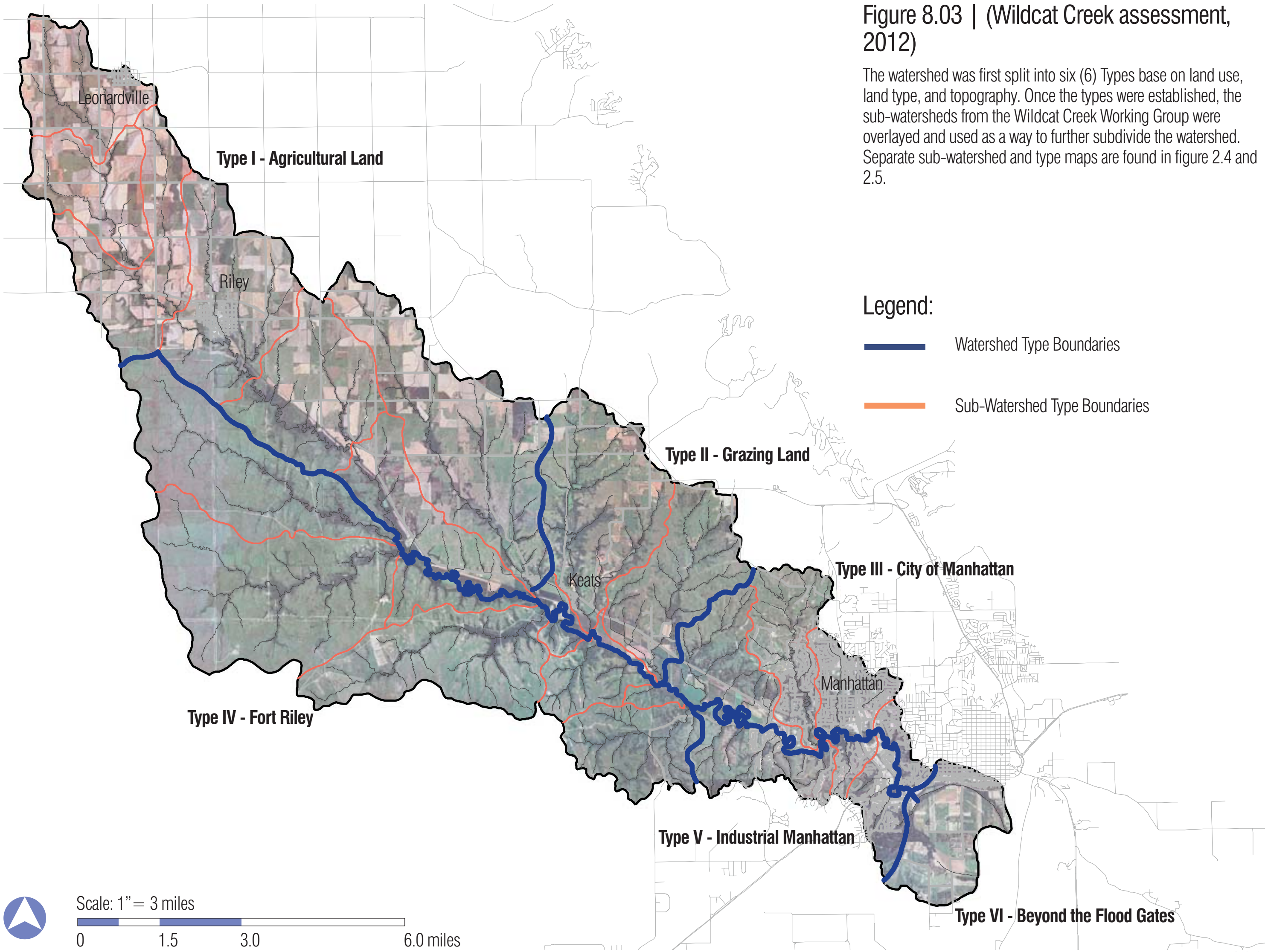
Team process diagram

Figure 8.02 | (Wildcat Creek assessment, 2012)

Inventory

The initial step of the RLA phase consists of collecting and compiling existing data. Geographic Information Systems (GIS) data acquired from USDA: Natural Resources Conservation Service (NRCS) includes topographic maps, four band aerial photography from 2008, 2006 LiDAR imagery, and soil information. Historical aerial photographs were collected from the Kansas Aerial Photography Initiative of the Kansas State University Library. About one hundred aerial shots from the year 1950 were geo-referenced into a working GIS map file. The student group encountered some difficulties gathering data. Access to real-time stream flow information giving water heights, rate of speed of the water, and that location's weather information of Wildcat Creek is non-existent and information for other creeks in the area is limited.

After compiling the GIS data, the student group used a map released by the Wildcat Creek Working Group to divide the Wildcat Creek Watershed into sub-watersheds. The watershed was divided into 19 sub-watersheds (figure 8.04). The student group then categorized the sub-watersheds by land activity. Type I is predominately agricultural tillage, Type II is an agricultural valley and grazing land with larger stream types, Type III is the city of Manhattan, Type IV is Fort Riley, Type V is the expansion of the city of Manhattan into grazing land, and Type VI is agricultural land below the flood wall heading toward the Kansas River (figure 8.05). The sub-watersheds and types are combined in figure 8.03.



Types and sub-watersheds

Figure 8.03 | (Wildcat Creek assessment, 2012)

The watershed was first split into six (6) Types base on land use, land type, and topography. Once the types were established, the sub-watersheds from the Wildcat Creek Working Group were overlayed and used as a way to further subdivide the watershed. Separate sub-watershed and type maps are found in figure 2.4 and 2.5.

Legend:

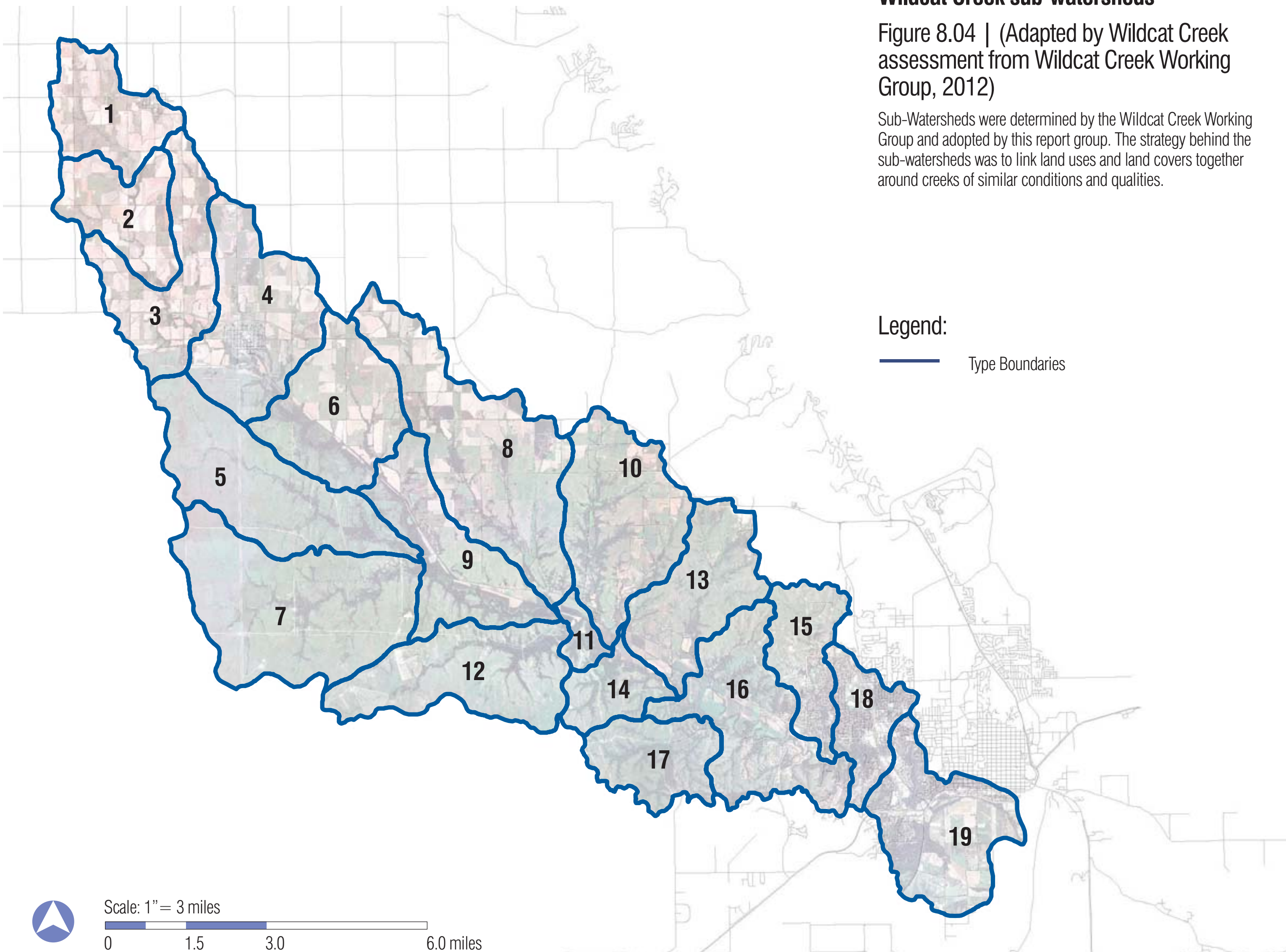
Watershed Type Boundaries

Sub-Watershed Type Boundaries

Wildcat Creek sub-watersheds

Figure 8.04 | (Adapted by Wildcat Creek assessment from Wildcat Creek Working Group, 2012)

Sub-Watersheds were determined by the Wildcat Creek Working Group and adopted by this report group. The strategy behind the sub-watersheds was to link land uses and land covers together around creeks of similar conditions and qualities.



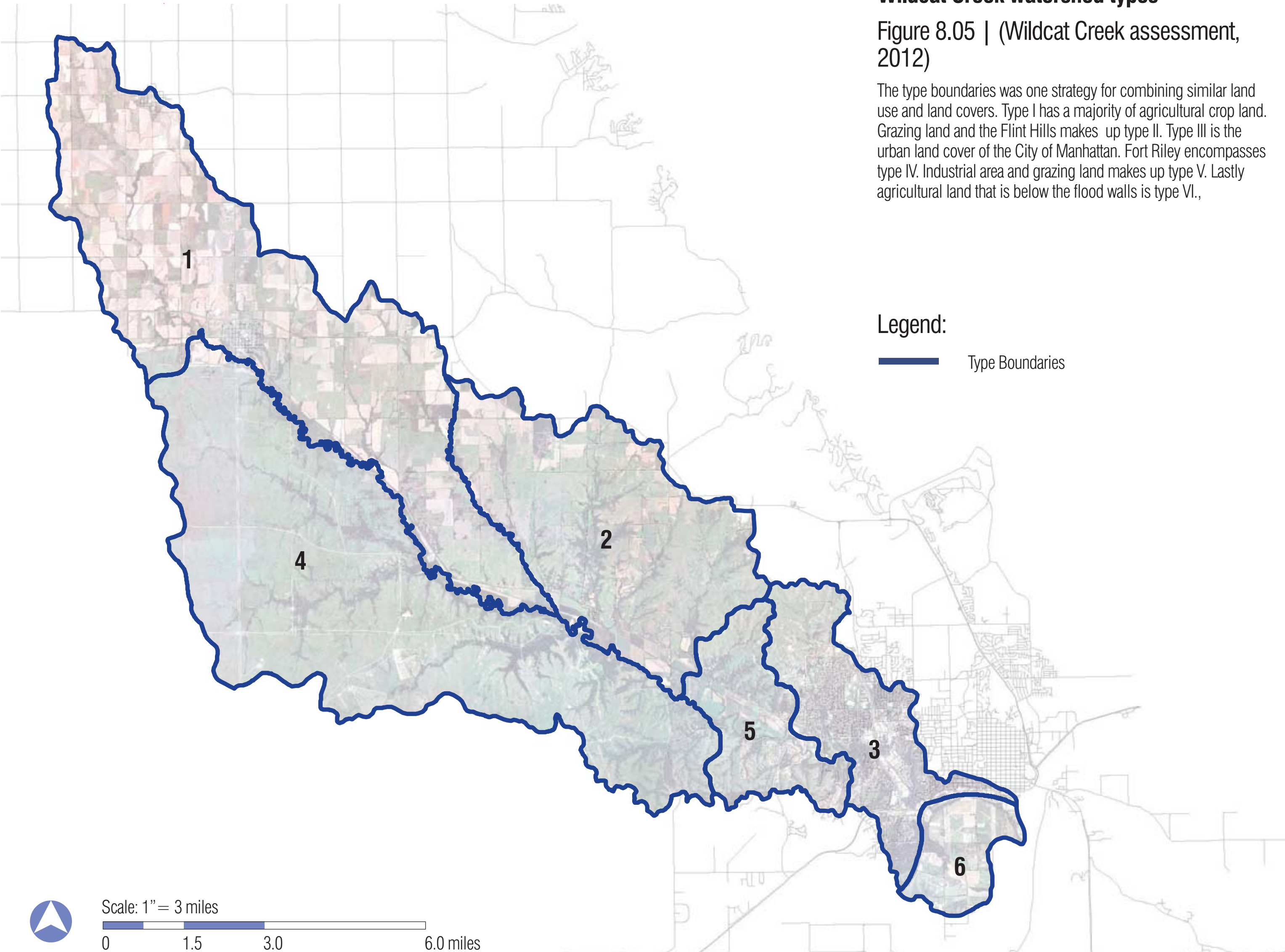
Legend:

Type Boundaries

Wildcat Creek watershed types

Figure 8.05 | (Wildcat Creek assessment, 2012)

The type boundaries was one strategy for combining similar land use and land covers. Type I has a majority of agricultural crop land. Grazing land and the Flint Hills makes up type II. Type III is the urban land cover of the City of Manhattan. Fort Riley encompasses type IV. Industrial area and grazing land makes up type V. Lastly agricultural land that is below the flood walls is type VI.,



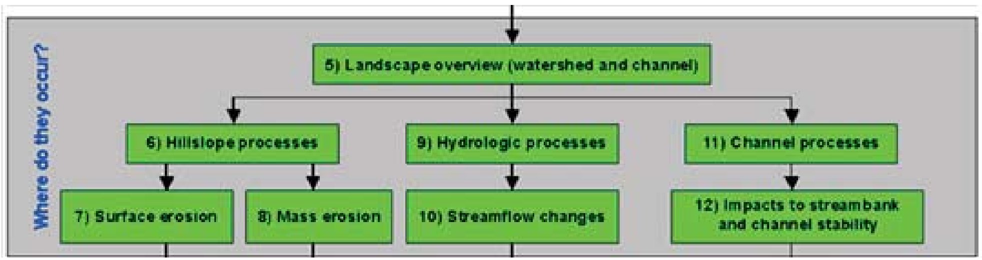
Legend:

Type Boundaries

Analysis

Using the aerial photography, LiDAR data, hillslope, and historical data, sub-watersheds were individually screened to identify areas and processes that have a high risk of impact on sediment supply and channel stability. The group defined these areas of high risk as "hotspots" informed by Steps 5 through 12 of the RLA process (figure 8.06). Using the gathered data the group visually examined the topography, hillshade processes, and aerial photography from 1950 and 2008 to determine areas that appeared straighter or have been channelized. The group also pinpointed areas with limited wooded vegetation or a loss in vegetation, areas with urban development, and land use practices that would cause high levels of runoff (e.g. non-terraced agriculture and tank routes) within each sub-watershed.

Hotspots were discussed and revised on a case by case basis. After all the types were looked at together, some hotspots were added to make all the types consistent in the method in which they were selected. The hotspots were given a rating of one, two, or three according to the ambiguity of conditions observed in aerial photography and the need to make field observations during site visits. A rating of one identified hotspots that were imperative to visit, a rating of two identified those that were recommended to visit, and a rating of three was assigned to the hotspots that were undoubtedly contributing to sediment excess and channel instability.



Steps 5 through 12 of RLA process

Figure 8.06 | (U.S. EPA, 2011)

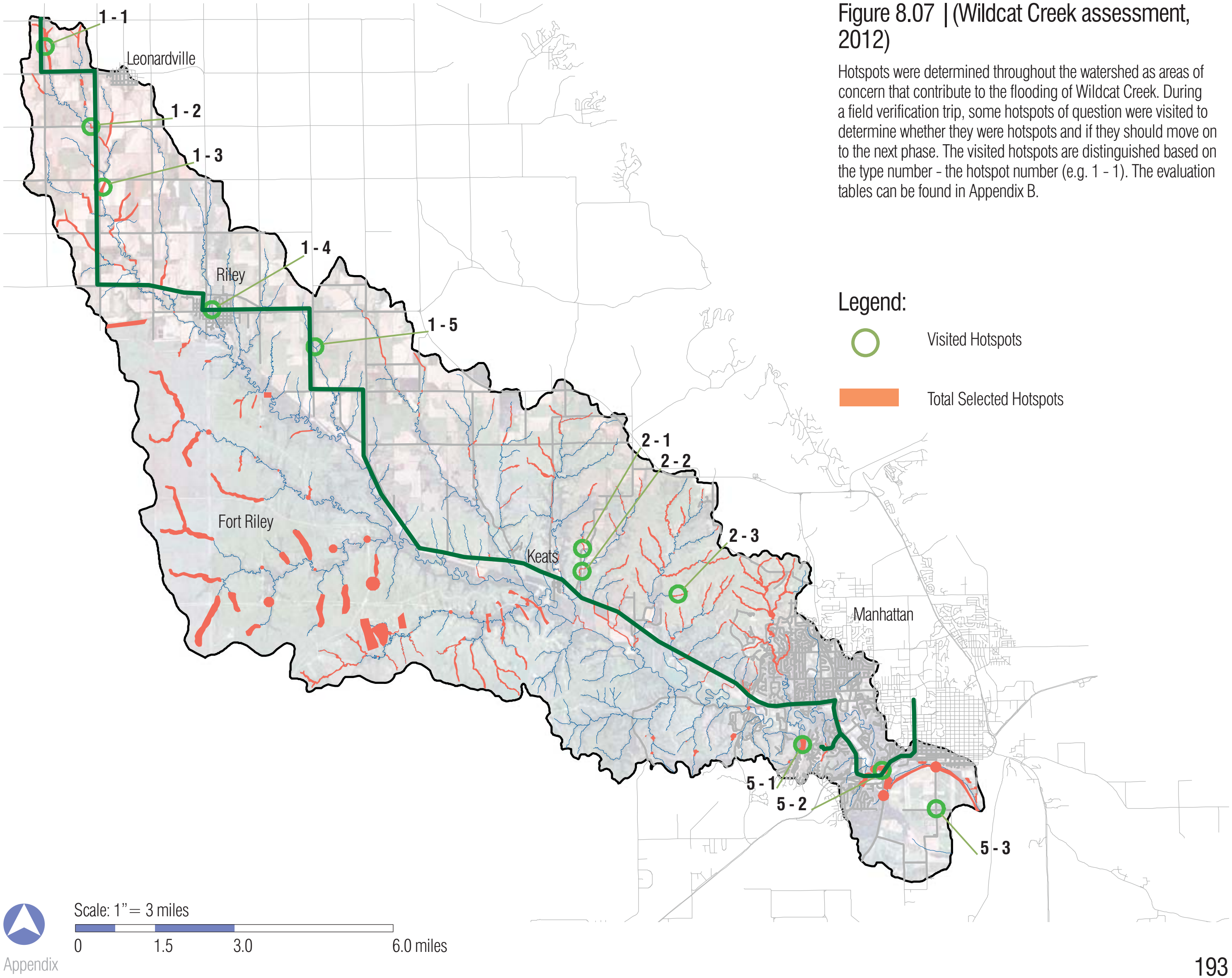
Site Visit (figure 8.07)

The second objective of bringing clarity to potentially problematic areas was undertaken through ground truth and site visits. A route was established according to hotspots given a priority of one or two (figure 8.07), and a checklist was developed for field observation (see assessment document). The checklist was formed to have a consistent list of criteria for choosing hotspots that were in question. The criteria were based on the land activities that impact sediment and channel stability and the factor of disturbance in the area. The checklist also allowed a way to track what was seen in the field, where problems occur, and what problems exist. Working from southeast to northwest, all sub-watershed types were visited with the exception of Fort Riley due to limited access. Eleven different hotspots were up for verification all but two were identified as finalists for the Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC) assessment level. The map in figure 8 serves as a contextual reference for the narrative summaries to follow. Each visited hotspot is labeled based on the type number first then the hotspot number.

Hotspots and visited locations

Figure 8.07 | (Wildcat Creek assessment, 2012)

Hotspots were determined throughout the watershed as areas of concern that contribute to the flooding of Wildcat Creek. During a field verification trip, some hotspots of question were visited to determine whether they were hotspots and if they should move on to the next phase. The visited hotspots are distinguished based on the type number - the hotspot number (e.g. 1 - 1). The evaluation tables can be found in Appendix B.



Synthesis

The final step in the RLA assessment was to determine which sub-waterheds areas are to be assessed more critically in the RRISSC phase. By combining the field verifications of the identified hot spots that were of questionable erosive potential with the aerial assessment of each sub watershed the group was able to determine which areas would move on to the RRISSC phase. It is important to note that while some hot spots will be moving to the next assessment level, it does not necessarily mean that the entire sub-watershed where the spot is located will be advancing as well. Hot spots are primarily an identification of areas that are major contributors to surface erosion, and not solely used to identify which sub-watersheds advance within the WARSSS assessment process. The identified hot spots within sub-watersheds that are not advancing to the next level of WARSSS will still move to the RRISSC level. This means that by analyzing each sub-watershed and the hot spots within them, an accurate distinction can be made as to which sub-watersheds as a whole will be more thoroughly assessed in the next phase, and which sub-watersheds include just hot spots that will need move on to the next phase.

Additionally, aerial photography, GIS, and site visits verified the land activity within each sub-watershed. These land activities gave insight as to its impact on sediment movement and channel stability and the disturbance factors contributing to those activities. This information was also utilized to determine the final areas to exclude from future analysis, and which areas to assess more critically in the RRISSC assessment level. The entire RLA process up to this point has contributed to the synthesis of the analysis for each sub-watershed and hot spot. As previously mentioned the sub-watersheds were grouped according to land use activity into types. Type I is predominately agricultural tillage, Type II is an agricultural valley with larger stream types and expanding development, Type III is the city of Manhattan, Type IV is Fort Riley, Type V is urban expansion and grazing land, and Type VI is agricultural land below the flood wall and heading toward the Kansas River. Due to similar land uses, the erosion and hillshade conditions were similar in sub-watersheds resulting in the same movement on to the next level (RRISSC) within the type. Types moving forward are shown in figure 8.14. The types are identified and summarized according to their status within the WARSSS assessment process.

Type I: Agricultural Land

Type I sub-watersheds are located on the northern edge of the watershed (as shown in figure 8.08). Between Keats and Riley up to Leonardville the land is a mixture of terraced and non-terraced agriculture land. Many farmers have chosen to use the terraced agriculture as visible through crop lines. Beyond Riley, there appears to be more non-terraced agriculture fields. The fields were based on the public land survey system that was used to divide Kansas when it was originally settled by Europeans. Type I is focused on agricultural land with one small town, Riley within its boundary. Type I is in the most upstream portion of the watershed. The likelihood of great runoff and a constant stream of water lessens resulting in a greater number of ephemeral streams, especially on the tributaries of Wildcat Creek.

The hotspot locations were determined mostly by de-vegetation and channelization and tend to be found upstream from the Wildcat Creek channel. The de-vegetation is most often found at the ends of streams that run through agricultural fields. The channelization is commonly found in agricultural fields that are in active use and places farmers wanted to get more farmable land both in the main stream and smaller tributaries of Wildcat Creek. The small tributaries that feed into the area run through agricultural fields and were originally altered to improve crop production. The fields have not had recent modification to their appearance beyond the turnover, tillage, and planting of crops each year. Non-terraced agricultural fields create greater surface erosion, resulting in hotspots in those areas along the creek. The de-vegetation occurs sporadically along the tributary channels. Finally, channelization is found in many of the agricultural fields to create larger parcels of land that are large enough to farm and fit within the public land survey system.

Type I has a significant amount of agricultural land which still allows the channels to have some sinuosity and freedom without having woody vegetation. Terraced agriculture helps reduce the surface erosion and shows positive use of land by the farmers. However, unstable, Class G stream types (Rosgen, 2006) are seen throughout the Type I area. The tall grass prairie was the native ecosystem of the area with woody vegetation around the creek channel, but not thick forested land.

As aforementioned, the town of Riley is also located within Type I. The town spans about half a square mile with a population of just under 1000 people. A small tributary of Wildcat Creek crosses through the entirety of the town from north to south. Even though Riley is considered a small town, its development has compromised the integrity of the tributary. Hotspots within the town of Riley were determined in areas where the tributary was disrupted by roads, loss of vegetative cover and the presence in impervious surfaces. From aerial photography and site verification, the entirety of the tributary through the town of Riley had been disrupted by a network of roads, crossing the tributary at several points. The loss of vegetation around the tributary to accommodate the development of structures and, consequently, the increased amount of impervious surfaces around the tributary have also compromised the tributary.

From this RLA level analysis, all the sub-watersheds in Type 1 can be carried forward to the RRISSC level. Even with the degree of terraced agriculture found within Type 1, many of the streams have been affected by various factors including the loss of vegetation, non-terraced agriculture and channelization. The presence of Riley further contributes to the degradation of Type 1. (For field verification charts see group document).

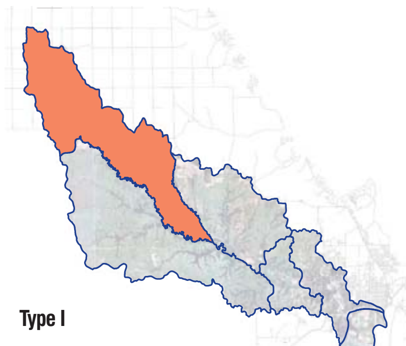


Figure 8.08 | (Wildcat Creek assessment, 2012)

Type II: Grazing Land

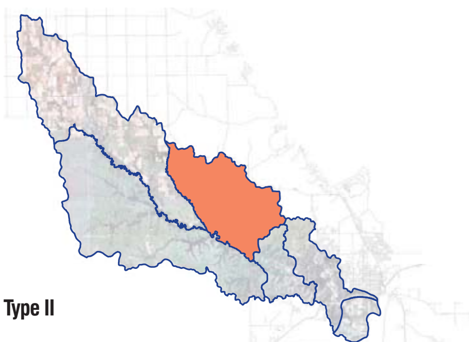
Type II begins at the Type I boundary between Riley and Keats and extends down to the edge of the City of Manhattan development, the Type III boundary (figure 8.09). The majority of the area is grazing land. At the northern edge, there is a small influence of terraced and non-terraced agricultural land is interspersed within the grazing land. The northern portion of Type II is relatively flat as compared to the southern half of the watershed that has more topographical changes. U.S. Highway 24 serves as a valley edge for the Wildcat Creek channel. Agricultural fields lie to the south of the highway.

Overgrazing can be a significant factor in determining whether an area is a hotspot or not. The impact of grazing on an area of land can be determined by the intensity and duration of grazing. Overgrazing increases the chances of soil erosion, as the soil is exposed to the elements (sun, wind, etc.) (WVU Extension Service, 2000). Overgrazed areas in the watershed would be considered as a hotspot due to the increased chance of possible soil erosion and possible sediment runoff. The sediment runoff and damage done to the land is greater and has a larger impact on nearby creeks and tributaries. The other determining factor in hotspots was the lack of woody vegetation around the creek channel. Some tributaries that have lost considerable woody vegetation and have high levels of surrounding sediment are designated as hotspots. Some areas have beneficial grazing land surrounding the creek and take the place of woody vegetation. Since there are not high levels of sediment in those areas, the area is not considered a hotspot.

Type II has a significant amount of grazing land. However, the majority of the grazing land does not seem to be overgrazed and thus does not contribute excess sediment to the creeks and the small amounts of agricultural fields in north part of Type II are terraced. The terraced fields produce less sediment than the non-terraced fields. The amount of sediment that enters the creek in Type II varies from each parcel of land, but not widely seen across the watershed. There are areas that lack woody vegetation around the creek channel, but there are also some areas that have very healthy woody vegetation that helps create stabilization and reduce sediment supply. Significant levels of channelization or channel changes are not present in Type II. Agricultural fields south of U.S. Highway 24 contribute some sediment to the creek, but the fields are in flat flood plain areas that do not produce the same amount of sediment that it would in an area with more topographical changes.

Type II, like Type I also has the presence of a populated area. Keats is an unincorporated town within Riley County. However, unlike Riley, Keats does not have a significant effect on the tributaries in the watershed. There are no significant tributaries crossing through Keats. The streams found in proximity to the town are protected by a significant presence of riparian vegetation. There is less development within the town of Keats as compared to Riley, thus less impervious surfaces are found within the town. Furthermore, a significant area of Keats is dedicated to a county park (Keats Park). Keats Park abuts a major stream protecting the stream from the development to the west. With these aspects in mind, Keats was not considered as a factor that added to the degradation to any of the streams.

As a result, Type II as a whole does not move forward to the RRISSC stage and possesses some very positive aspects and conditions within the watershed as a whole. There are hotspot locations within the Type II sub-watersheds that are moving forward to the RRISSC stage based on the considerations and factors listed above. (For field verification charts see group document.)



Type II

Figure 8.09 | (Wildcat Creek assessment, 2012)

Type III: City of Manhattan

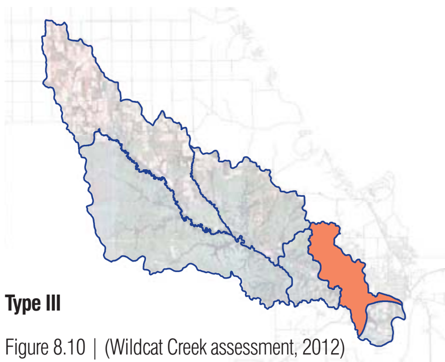
The sub-watersheds within Type III include the majority of the Manhattan urban context (figure 8.10). Type III is bordered by Wildcat Creek to the south, expanding northwest to the western ridgeline of Natalies Creek watershed, just north of Wildcat Park. From west to east, Type III transitions from primarily grazing land, to Colbert Hills golf course, into small rural neighborhoods, then into the city of Manhattan. Hotspots within Type III were determined mostly by urbanization, lack of woody riparian vegetation, and slope alteration.

Moving again from west to east, the lack of woody riparian vegetation within the grazing areas creates high potential for sediment displacement due to a low friction coefficient from a lack of root stability, increasing the possibility of runoff. These areas can still provide stable drainage ways depending on the type of grazing being conducted and to what extent. Much like in Type II, grazing plays a role in the increased possibility of surface erosion. The severity of erosion potential is mostly due to grazing intensity and duration. Hot spots in this type were identified because of their lack of woody riparian vegetation, attributed to clearing, and the adjacency to overgrazed areas.

Continuing to move east, the Colbert Hills Golf Course was identified as a hot spot due to the lack of woody riparian vegetation, and slope alterations that are in place and that were conducted during its construction. While this area is very well kept, it is based on a system that displaces water at a fast pace, increasing the possibility for sediment displacement.

Moving further east into the neighborhoods on the east end of town there are large amounts of channelization, greater amounts of impervious surfaces, and less woody riparian vegetation. The combination of these three issues results in the entire urban area of Manhattan being identified as a hot spot. Having said this, there are some areas that can be directly identified as contributing larger amounts of sediment displacement than others. Two of these areas include Little Kitten Creek and CiCo Park and the tributary extending south from it into Wildcat Creek proper. Little Kitten Creek provides some woody riparian vegetation; however it winds through neighborhoods on the east end of town collecting street and roof top runoff, increasing the overall discharge of the tributary without allowing for any flood plain. The tributary flowing through CiCo Park has been severely channelized to the point where in the near future houses adjacent to the creek will need to either be moved or the creek will need it's bank structurally reinforced, only slowing down the erosion problem. The channelization process straightens the flow of water, increasing the overall discharge, in turn contributing to the erosion process. This narrowing of the creek eliminates the use of floodplains which decreases the streams ability to 'spread out' during times of excess flow in order to slow down the velocity and allow sediment to settle.

All the sub-watersheds delineated in Type III will move forward to the RRISSC stage due to these sediment contributing factors: urbanization, lack of woody riparian vegetation, and slope alteration and channelization. The urban portion of this sub-watershed will need to be addressed more closely on a site by site basis in order to understand where waterways are contributing to stormwater inlets, and where the water is then conveyed. (For field verification charts see group document)



Type III

Figure 8.10 | (Wildcat Creek assessment, 2012)

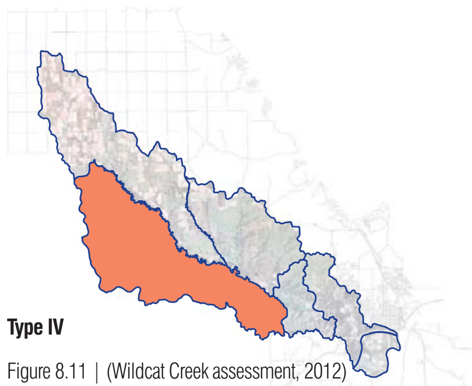
Type IV is located on the Northeastern portion of the Fort Riley military installation (figure 8.11). The area was historically agricultural lands reflecting those of Type I and II, but has since been acquired by the fort for military functions. Aerial imagery reveals evidence of terraced fields that have long since returned to grassy vegetation. While precise land use data was unavailable for type IV, the area is actively used for military training. Possibly the most important aspect of Type IV is the presence of tanks and other large military vehicles on a regular basis as Fort Riley is home to an armored detachment.

Type IV hotspots were determined in most instances due to a lack of woody riparian vegetation or stream disturbance due to vehicular crossings. The removal of woody riparian vegetation is detrimental to most streams from a stability standpoint. Loss of the structural support provided by the root systems of woody vegetation causes the stream bank to become less stable. Thus, areas lacking woody vegetation are susceptible to stream bank erosion and excess sedimentation. Lack of vegetation is the primary reasoning behind the identification of hotspots in the northern portion of Type IV.

However, as you move south, aerial imagery shows evidence of soil disturbance in several areas as well as near tributaries. This is cause for concern as tracked vehicles such as tanks can produce significant disturbance to the soil surface as well as compaction. By damaging plants and reducing the root structure present vehicles create soil stability issues. In contrast, the weight of the vehicle causes compaction in the sub soil reducing infiltration rates. In combination these factors can produce a large amount of surface erosion and excess sediment flow. Dirt roads found in many parts of rural America can be used as an example of this. While the surface degrades over time from tire tread disturbance and requires frequent grading, the base of the road continues to harden with use, creating a solid platform for vehicular traffic. The effects of this compaction in terms of infiltration are evident in the requisite drainage ditches found alongside these dirt roads. Vehicular soil compaction can contribute to vegetation issues as well. As the soil around trees is compacted the ability for roots to function properly in terms of water and nutrient uptake is reduced causing health problems or death. It is easy to see that an area used for tank warfare training is highly susceptible to these issues.

The southernmost sub-watershed of type V consists mainly of native grasslands, and canopy cover. The reason this sub-watershed was carried into the next level was because of the steep slopes and lack of riparian vegetation along many of the smaller streams that eventually flow into the main channel of Wildcat Creek. There is a corridor throughout the sub-watershed that contains bare earth that appears to be recently tilled ground. This corridor crosses many of the streams and has a potential to contribute to excess sediment.

As a result of issues associated with land use, vegetation scarcity, and road crossings, the type IV sub-watersheds must move forward into the RRISSC stage of the WARSSS process. Areas of the type IV sub-watersheds that were designated to be hotspots will need to be the focal points of the area in subsequent phases of WARSSS.



Type IV

Figure 8.11 | (Wildcat Creek assessment, 2012)

Type V: Expanding Manhattan

Type V focuses on the southern and wester expansion of the City of Manhattan as well as grazing land that may some day become urban (figure 8.12). All sub-watersheds were advanced to the next phase, Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC). Type V borders the south side of Wildcat Creek. There is a gradual increase in land activities that impact the stream as you move closer to the city of Manhattan. The number of hotspots increases the closer you get to the city of Manhattan.

There were many factors taken into consideration when determining the location of hotspots and the identification of areas where land activities increase sediment and contribute to channel stability problems. The Reconnaissance Level Assessment (RLA) phase of the analysis looks at the character of the area from a general point of view. The main points evaluated were the stream channel stability, stream flow changes, sediment loads, potential for erosion, and lack of vegetation. The most important factor looked at when determining whether or not to include the area for advancement to the RRISSC level was whether or not there was good riparian vegetation. This is because lack of good riparian vegetation means there is a high likelihood for mass erosion . One example of mass erosion was a new neighborhood being built to the south of Wildcat Creek where a steep hillside has been cleared of vegetation for construction. There is a high likely hood of erosion from the hillside entering into Wildcat Creek.

The northern most area was the first sub-watershed studied. The area was carried on was due to of the new construction, proximity to the steam channel, and impervious surface, all of which occur directly south of the creek. Erosion due to steep slopes and bare earth create a potential for excess sediment to be carried into Wildcat Creek.

Wildcat Creek Golf Course and Frank Anneberg Park were marked as a hotspot, not because of excess sediment but because this area is now contributing more water from surface runoff and the development associated with the location than before this area was developed.

The main concerns in this area were stream bank erosion, road crossings, and bridges. Box culverts were marked as hotspots for degradation and excess sediment. The southernmost sub-watershed of Type V contains the most impervious surface, channelization, removal of riparian vegetation, road crossings, and changed stream flow. This sub-watershed was selected for the land activities that impact sediment and channel stability. Two hotspots were visited on-site one is located within a neighborhood development. Culverts, new construction, removal of riparian vegetation, road crossings, proximity to roads, and impervious surfaces occur where the stream flows through the neighborhood. The location where the stream flows through the neighborhood is flagged as a hotspot. Once it leaves the neighborhood the riparian edge has good vegetation, so this area was determined not to be a major factor contributing to excess sediment supply.

The other hotspot in this area was advanced to the RRISSC level because of the stream bank erosion. The water course is constricted in this area and does not have floodplain contact. The sheer stress and high velocity stays in the stream which leads to more erosive force that can be carried through the stream.

As a result of new development, proximity to the city of Manhattan, impervious surface, road crossings, stream channelization, de-vegetation and land use practices all sub-watersheds within Type V were advanced to the next phase for further assessment. (For

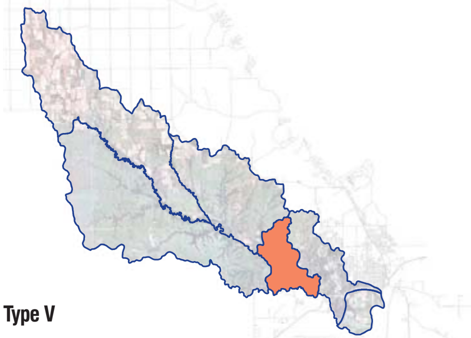


Figure 8.12 | (Wildcat Creek assessment, 2012)

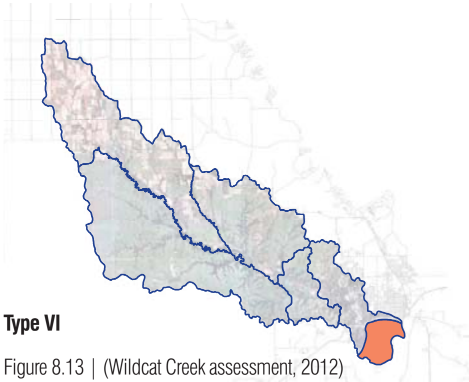
Type VI: Flood Wall

The final sub-watershed type, Flood Wall, is located at the far southeast of the Wildcat Creek watershed where the creek flows directly into the Kansas River (figure 8.13). This portion of the watershed is located below the flood wall, and generally consists of agricultural land. It consists of only one sub-watershed.

Upon initial observation of aerial photos, three areas were flagged as potential hotspots, and the absence of terraces in this predominantly agricultural area was noted as well. The first potential hotspot was marked where South Manhattan Avenue crosses Wildcat Creek. Two additional areas were flagged for minor riparian removal, and the entire northern edge of the sub-watershed was included for having noticeably thinner riparian vegetation than the northern bank where the historic rail line has been retrofitted to a paved and crushed limestone recreational trail.

After driving to see the site on the day of field verifications, it was determined that these hotspots and the sub-watershed as a whole can be eliminated from further assessment at the RISSCC level. While the fields are not terraced and therefore likely to contribute excess sediment, the general slope is not steep enough to contribute significant sediment. The critical areas contributing sediment are further up the creek, and this subwatershed is ultimately below the region of major concern.

Also, due to the immediate proximity to the Kansas River and the fact that the entire area will flood in a large rain event, it is not advisable to invest in wetland construction in this area. (For field verification charts see group document)



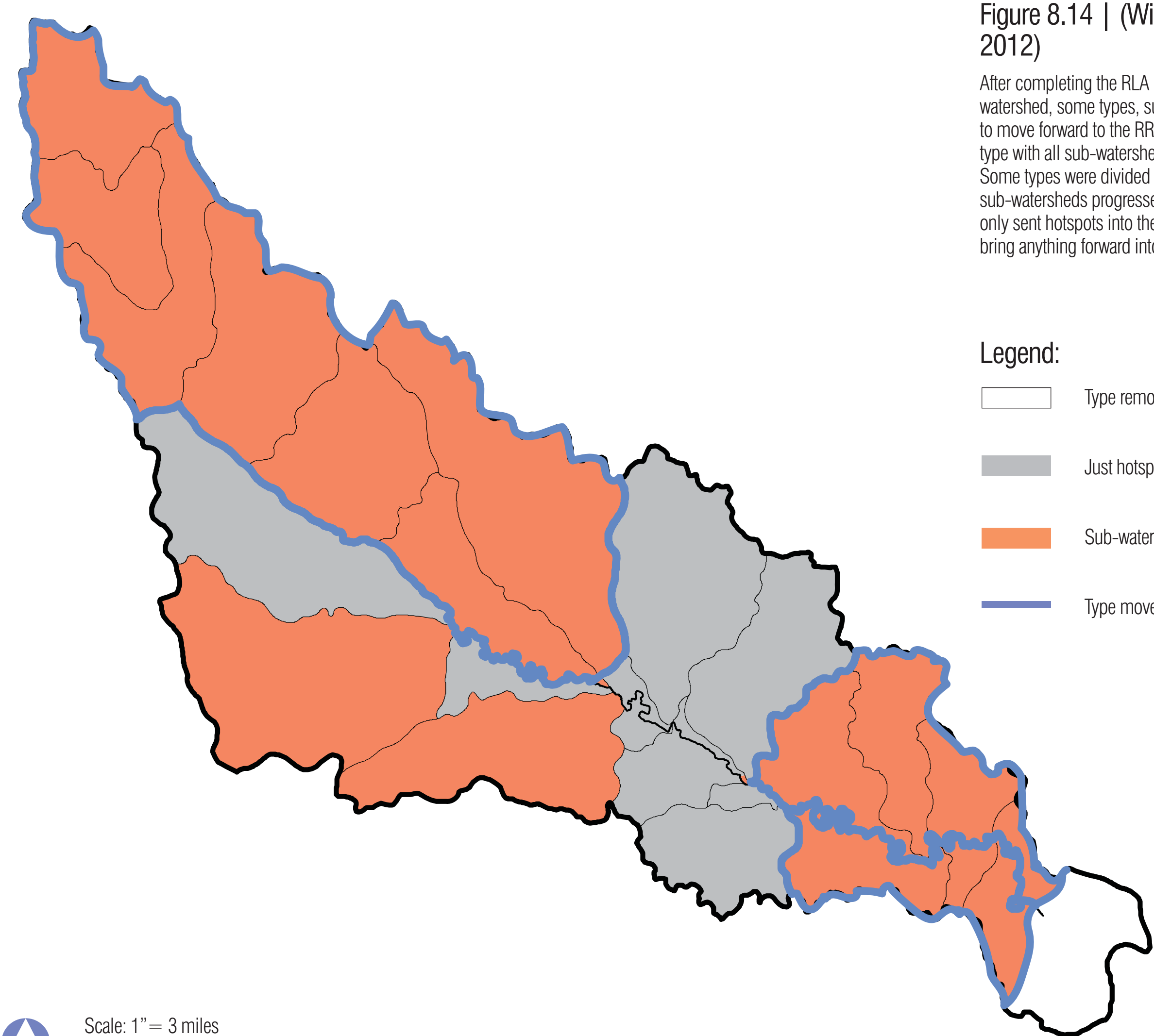
Type VI

Figure 8.13 | (Wildcat Creek assessment, 2012)

Moving forward to the RRISSC phase

Figure 8.14 | (Wildcat Creek assessment, 2012)

After completing the RLA phase and doing an intial look at the watershed, some types, sub-watersheds, and hotspots were chosen to move forward to the RRISSC phase. In some cases, the entire type with all sub-watersheds and hotspots in the area move forward. Some types were divided by sub-watersheds to determine which sub-watersheds progressed as a whole and which sub-watersheds only sent hotspots into the next round. The last option was to not bring anything forward into the RRISSC phase.



Legend:

Type removed from the assessment

Just hotspots move forward

Sub-watershed moves foward

Type moves forward

Scale: 1”= 3 miles

0 1.5 3.0 6.0 miles

Conclusions

Out of the six different types, type I, III, IV, and Type V were selected to move on to the Rapid Resource Inventory for Sediment and Stability Consequence (RISSCC) level assessment (figure 8.14). Two types, type II and type VI, were eliminated from further assessment. In type II the hotspots will still advance into the next round in order to be evaluated in a more detailed assessment for their impact on sediment supply and stream bank stability within the watershed. Type VI will be eliminated altogether from future stages of the WARSSS assessment due to the location within the watershed.

The completion of the RLA phase gave the group basic familiarity with the relative conditions of the Wildcat Creek Watershed and the land activities taking place throughout. The RLA phase of the assessment has identified a general understanding of the locations and processes within the watershed that are affecting channel stability and contributing to excess sediment supply.

With this first phase complete, the group conducted the second phase of the WARSSS process. The second phase, Rapid Resource Inventory for Sediment and Stability Consequence (RRISSC) was used to make a more detailed assessment of the problem areas within the Wildcat Creek Watershed.

WARSSS | RRISSC

Dedicated to the Rapid Resource Inventory for Sediment and Stability Consequence phase of the Watershed Assessment for River Stability and Stream Supply, in the Wildcat Creek Watershed. The complete Wildcat Creek watershed assessment can be found here https://krex.k-state.edu/dspace/handle/2097/13605.

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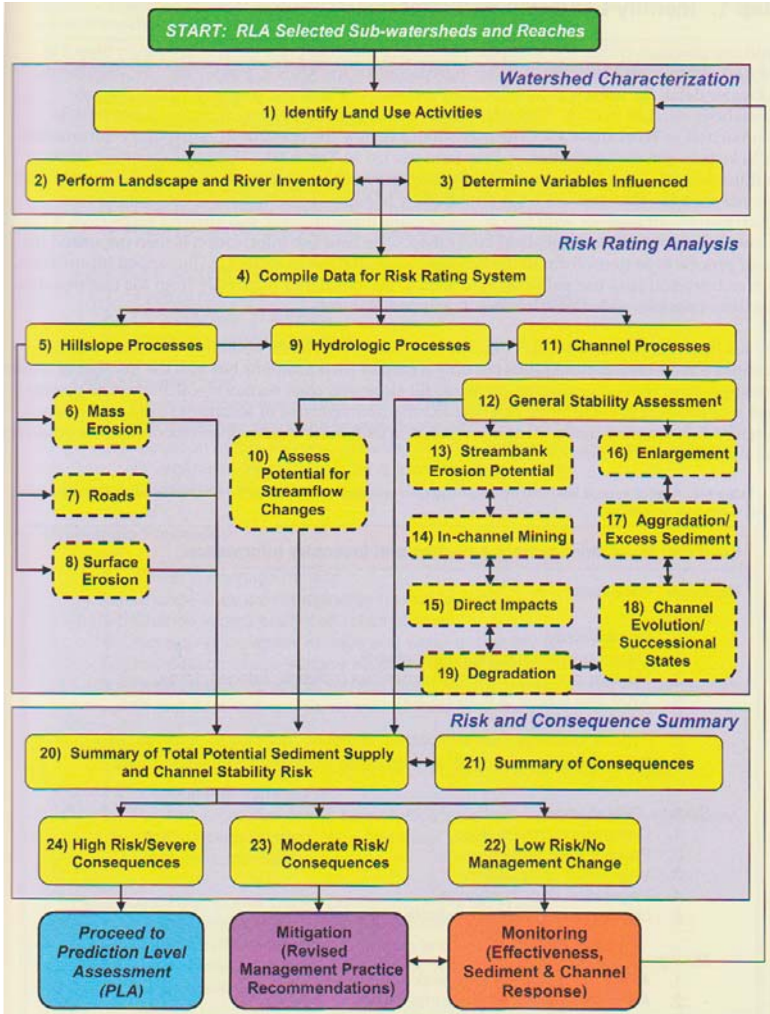
The risk analysis for sediment supply and stream channel stability (RRISSC) process is detailed in the following discussion. The basis for the rating of risk in each of the following categories is a five level scale, five being the highest risk and one the lowest. Once all categories were assessed, the numerical totals for each were added and divided by the number of categories. The resultant number represents the risk assessment.

RRISSC evaluations were calculated for 19 sub-watersheds. Sub-watershed 19 was only evaluated northwest of the levee on the south of Fort Riley Boulevard in the City of Manhattan. Each sub-watershed was rated for mass erosion, roads, surface erosion, streamflow change, streambank erosion, direct channel impacts, channel enlargement, aggradation/excess sediment, channel evolution/succession states, degradation.



RRISSC process diagram

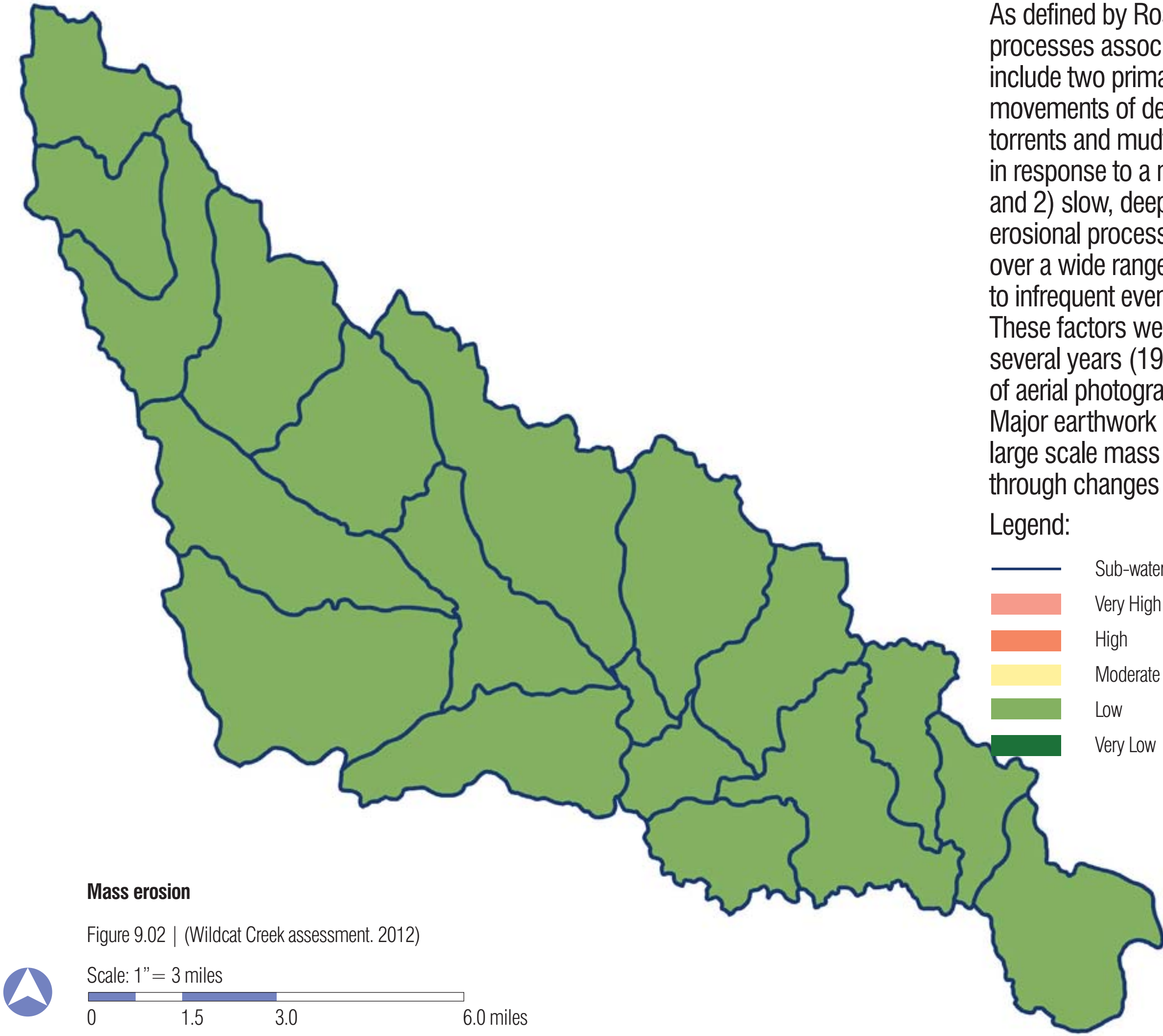
Figure 9.01 | (Rosgen, 2008)

Mass Erosion

As defined by Rosgen (2008), "The processes associated with mass erosion include two primary types: 1) shallow, fast movements of debris avalanche/debris torrents and mudflows that generally move in response to a major precipitation event, and 2) slow, deep-seated slump, earthflow erosional processes that move intermittently over a wide range of time scales in response to infrequent events or disturbance factors." These factors were assessed by comparing several years (1950, 2008, 2010, and 2012) of aerial photographs of the watershed. Major earthwork changes and locations of large scale mass movement were identified through changes in aerial photographs.

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



Mass erosion

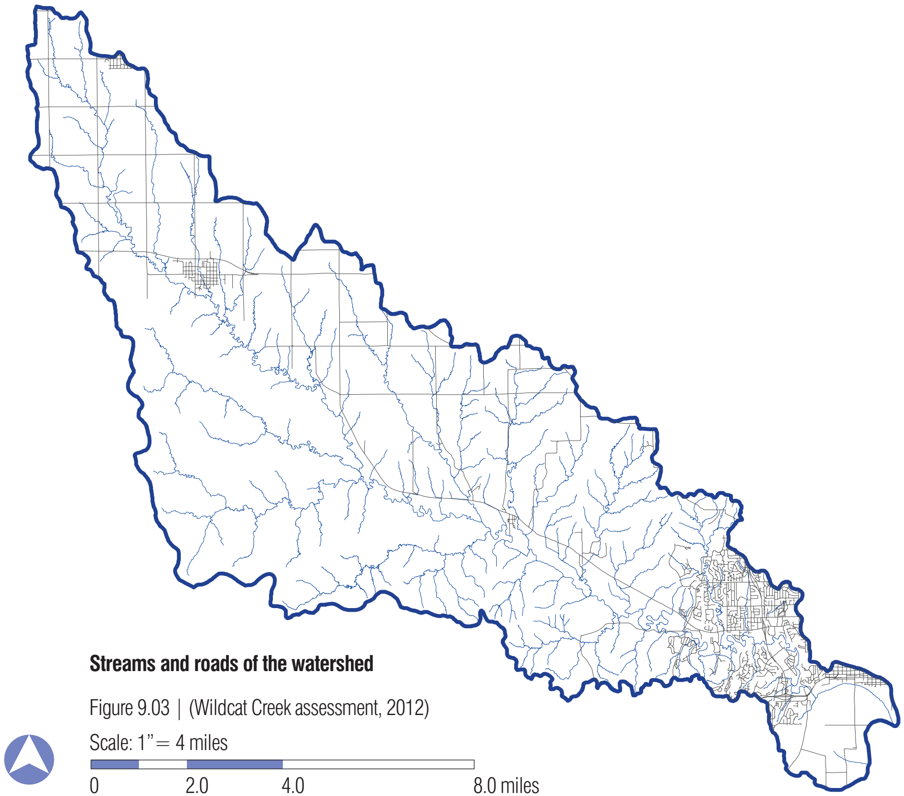
Figure 9.02 | (Wildcat Creek assessment. 2012)

Scale: 1"= 3 miles

0 1.5 3.0 6.0 miles

Roads

The evaluation of road impacts are important due to the fact that they can produce increased sediment from a variety of sources such as cut banks, road fills, road surfaces and ditch-line erosion. The roads can cause increased degradation or aggradation of stream channels and blockages at culverts that increased stream instability and decreased floodplain function. The data required for this analysis included acres of sub-watershed, acres of surface disturbance of roads including road surface, number of stream crossings, slope position, age of road, mitigation such as road surfacing, vegetative cover of cut banks and road fills, and presence of unstable, terrain associated with mass erosion processes. The road disturbance size included the road width plus the drainage way of the road. Stream crossings, locations where the stream may have an increase in sediment or shrinkage in streamflow, were counted by hand. The locations of the roads were isolated from the slope percentages and an average was calculated for each sub-watershed. The average elevation height of the roads and average length from the road to the stream channel were estimated based on aerial photographs. The slope percentages of the land were compiled for each sub-watershed. The adjacency of the road to the stream also considered the road crossings and conditions where the road runs parallel to the creek channel.



Streams and roads of the watershed

Figure 9.03 | (Wildcat Creek assessment, 2012)

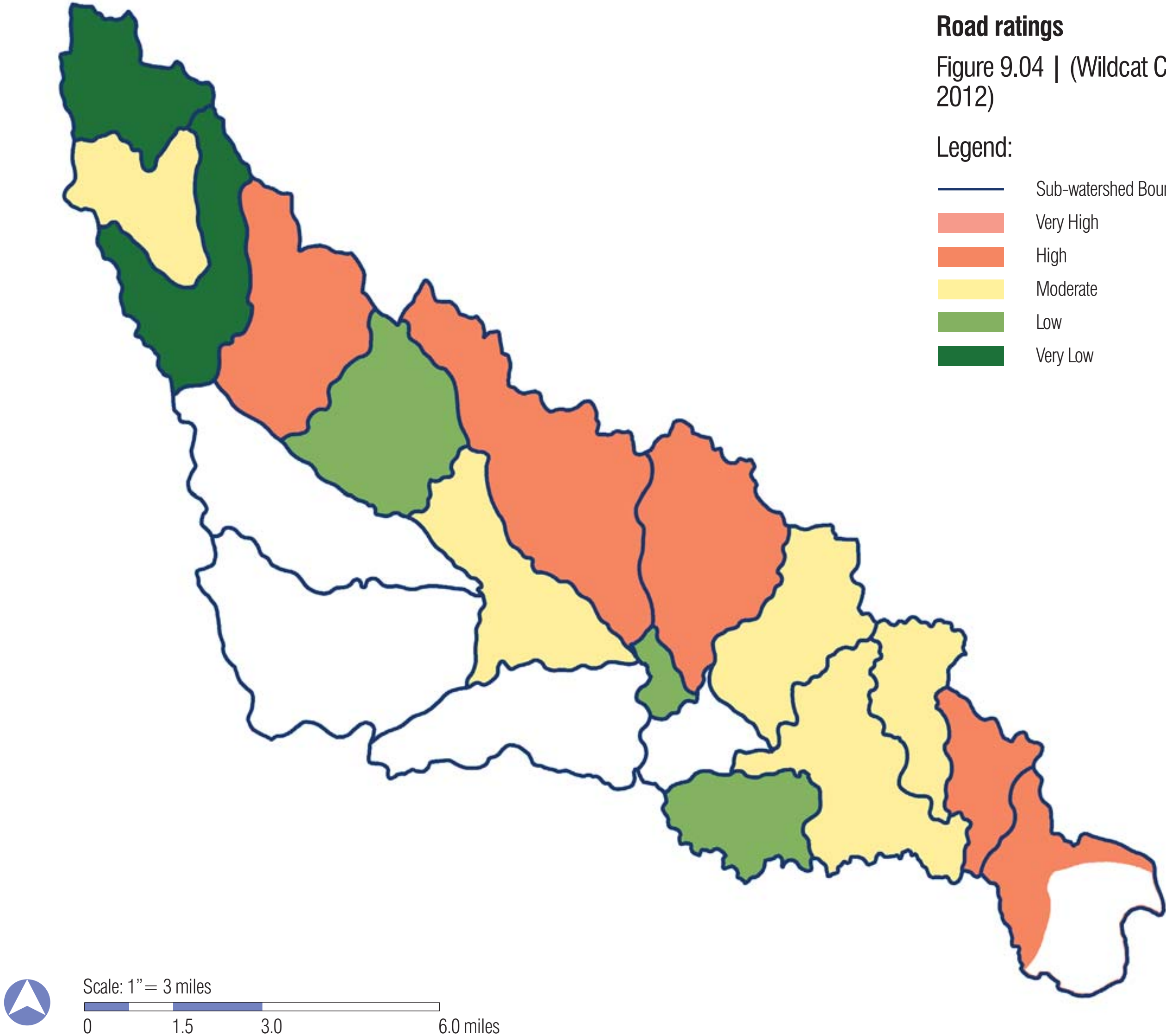
Scale: 1" = 4 miles

Road ratings

Figure 9.04 | (Wildcat Creek assessment, 2012)

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Sub-watershed Location (I.D.)	Acres of Sub-watershed (200–5000 acres)	Acres of Disturbance of Road (Include Cut Bank, Fill Slope, Road Surface)	Number of Stream Crossings	Calculate Road Impact Index [(3)/(2)X(4)] *If Crossings = 0, Multiply by 1.	Slope Position (Lower or Mid-Upper)	Risk Rating: Road Impact Index (5) by Slope Position	Distance of Road Fill to Stream (ft)	Risk Rating: Distance of Road Fill to Stream (ft)	Slope of Road (%)	Risk Rating: Slope of Road (%)	Total Individual Risk Rating Points ∑[(7)+(9)+(11)]	Overall Risk Rating for Potential Sediment from Roads
1. sub-watershed one	2,394	89	7	0.026	Mid-Upper	2	200+	1	2.50%-3.50%	2	5	2
2. sub-watershed two	2,336	50	6	0.013	Lower	4	140-200	1	3.50%-5.0%	3	8	3
3. sub-watershed three	3,302	87	10	0.026	Mid-Upper	2	200+	1	2.50%-3.50%	2	5	2
4. sub-watershed four	4,119	201	17	0.083	Lower	5	70-140	2	3.50%-5.0%	3	10	4
5. sub-watershed five	4,659	x	x	x	x	x	x	x	x	x	0	x
6. sub-watershed six	3,674	56	6	0.009	Mid-Upper	0	200+	1	3.50%-5.0%	3	4	1
7. sub-watershed seven	6,362	x	x	x	x	x	x	x	x	x	0	x
8. sub-watershed eight	6,150	138	21	0.047	Lower	5	70-140	2	3.50%-5.0%	3	10	4
9. sub-watershed nine	3,441	65	8	0.015	Lower	4	140-200	1	2.50%-3.50%	2	7	3
10. sub-watershed ten	4,375	121	16	0.044	Lower	5	70-140	2	3.50%-5.0%	3	10	4
11. sub-watershed eleven	518	9	1	0.002	Lower	0	70-140	2	2.50%-3.50%	2	4	1
12. sub-watershed twelve	3,981	x	x	x	x	x	x	x	x	x	0	x
13. sub-watershed thirteen	3,212	57	7	0.012	Lower	4	140-200	1	3.50%-5.0%	3	8	3
14. sub-watershed fourteen	1,350	1	x	0.000	Lower	0	x	x	x	x	0	x
15. sub-watershed fifteen	2,016	19	16	0.015	Mid-Upper	2	70-140	2	5.0%-7.0%	4	8	3
16. sub-watershed sixteen	4,166	173	24	0.100	Lower	4	140-200	1	3.50%-5.0%	3	8	3
17. sub-watershed seventeen	2,118	18	4	0.003	Mid-Upper	0	140-200	1	3.50%-5.0%	3	4	1
18. sub-watershed eighteen	1,670	445	12	0.320	Mid-Upper	4	38-70	3	3.50%-5.0%	3	10	4
19. sub-watershed nineteen	3,795	449	13	0.154	Lower	4	70-140	2	3.50%-5.0%	3	9	4

(14)				(15)	(16)	(17)
Adjustments for Construction, Design and Age of Road				Risk Rating Adjustments for Mass Erosion Potential Slump/ Earthflow***	Debris Torrent/ Avalanche: If Erosion Risk and Sediment Delivery Potential is *High*, Raise Final Road Risk Rating to *Very High*	Final Risk Rating of Potential Sediment from Roads
Age of Road: If > 7 yrs and Sediment Delivery Potential = *Low*, Reduce One Risk Category*	Road Surfacing: If Gravel/ Asphalt, then Reduce One Risk Category**	Ditch Line: If Surfacing Out-sloped, Reduce One Risk Category	Vegetative Condition of Cut Banks, Road Fills: If > 50% Ground Cover, Reduce One Risk Category			
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x
x	x	x	x	x	x	x

Summary of risk ratings for roads

Table 9.01 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

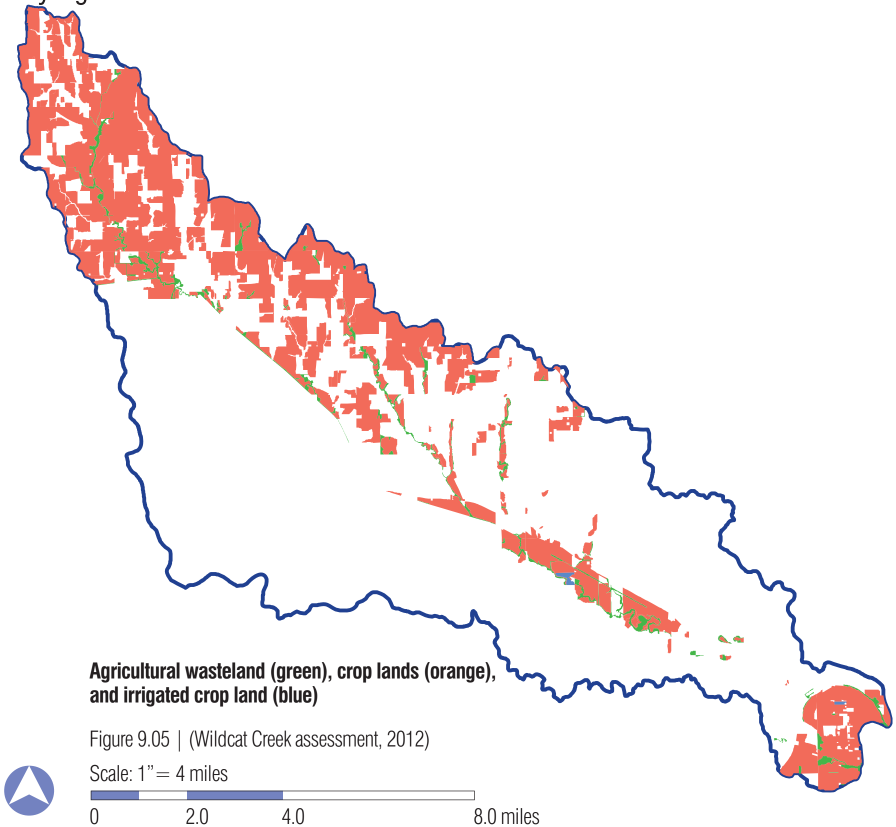
*Unless: Road has not recovered; poor maintenance; poor vegetative cover on cut bank and fill slopes - ditch line is still leading water into stream.

**Unless: Road cut bank, fills and ditch line continue to provide sediment source to stream

*** If risk is high or potential sediment delivery of mass erosion (Worksheet 4-3), then adjust overall risk up one category.

Surface Erosion | Sediment Delivery Potential

The major areas of concern in assessing an area's susceptibility for accelerated erosion were bare soils, compacted soils, and poor land use practices (i.e. agriculture, surface mining, land clearing and silviculture). Seven distinct data sets were analyzed to create the risk rating for this category. The seven data sets were total acres being evaluated for a sub-watershed and soil type erodibility potential, the acres impacted, percent bare ground of impacted acres, drainage density if impacted slope or width of interfluve spacing, slope position and gradient, distance of disturbance to nearest stream, and buffer width of riparian corridor. Areas that surface erosion impacted were calculated from the combination of agricultural wasteland, crop lands, and irrigated crop lands from Riley County land use maps. The crop land areas were determined as the only areas with more than 50% bare ground. Drainage density was calculated for each sub-watershed by using stream length (length of flow lines) over basin area. A slope percentage of less than ten (10) was used for each sub-watershed. The slope position was determined by taking an average slope of the area impacted. The percent ground cover was the inverse of the percent acreage of the sub-watershed impacted by surface erosion (step 4). The distance of the disturbance to the stream was measured using aerial photography. The stream buffer risk rating was determined by the amount of riparian vegetation. Locations with healthy riparian vegetation were rated very low, while intermittent to no vegetation was rated as very high.

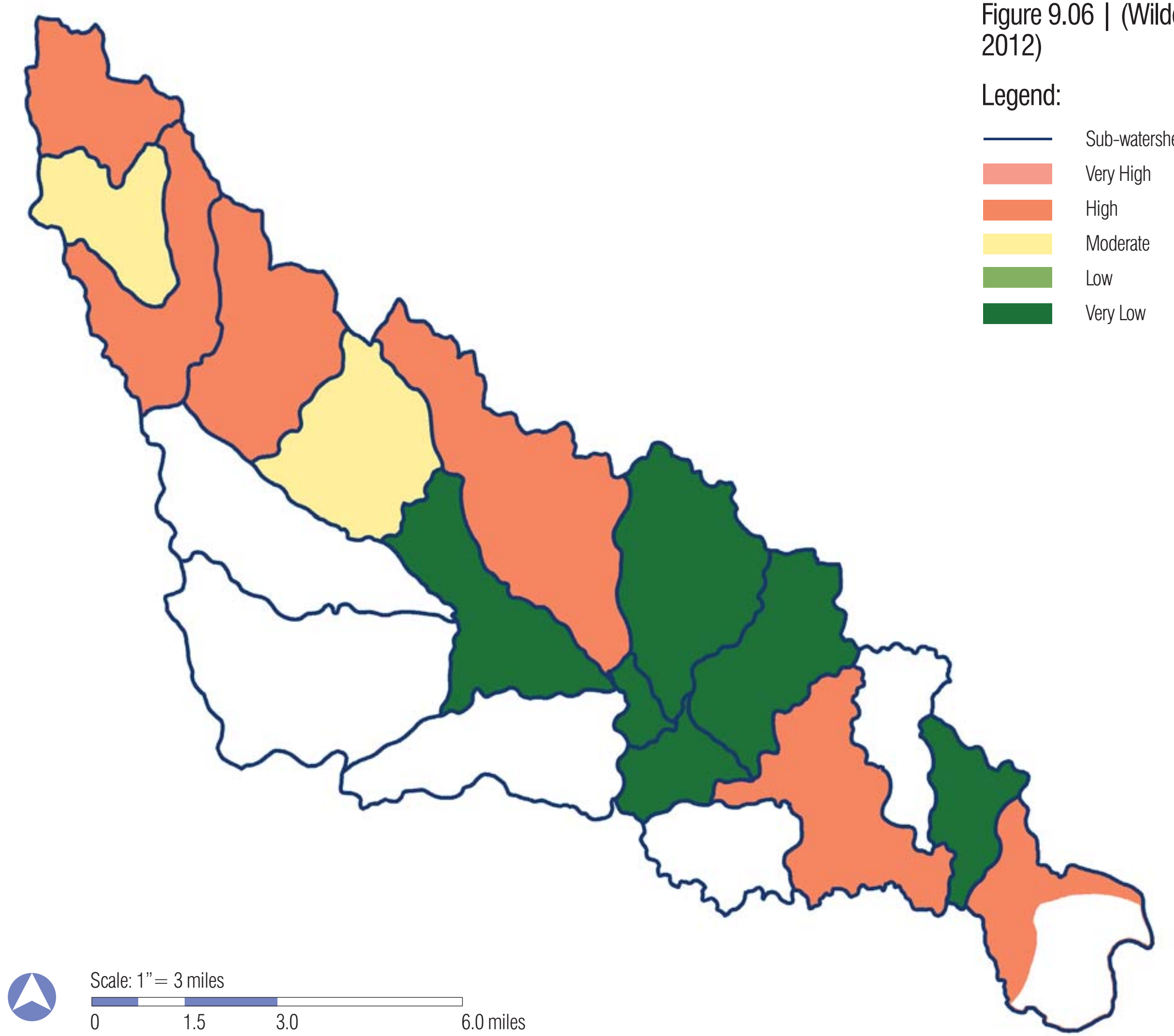


Agricultural wasteland (green), crop lands (orange), and irrigated crop land (blue)

Figure 9.05 | (Wildcat Creek assessment, 2012)

Surface erosion ratings

Figure 9.06 | (Wildcat Creek assessment, 2012)



	Surface Erosion Potential								
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Sub-watershed Location (I.D.)	Total Acres of Sub-watershed	Acres Impacted (Road acres not included)	Percent of Acres Impacted [(3)/(2)X100]	Acres Impacted (3) with more than 50% Bare Ground	Percent of Acres Impacted with more than 50% Bare Ground [(5)/(3)X100]	Landscape Type (Stable or Unstable)	Overall Risk Rating: Surface Erosion	Converted Ratios or Risk Rating: Drainage Density by Slope Gradient (%)	Risk Rating: Slope Position
1. sub-watershed one	2,394	1,697	70.89%	1,682	99.11%	Unstable	VeryHigh	1.64% 1-VeryLow	3
2. sub-watershed two	2,336	1,734	74.23%	1,637	94.40%	Unstable	VeryHigh	2.21% 1-VeryLow	3
3. sub-watershed three	3,302	2,372	71.80%	2,296	96.80%	Unstable	VeryHigh	1.50% 1-VeryLow	3
4. sub-watershed four	4,119	2,004	48.70%	1,903	95.00%	Unstable	VeryHigh	12.74% 1-VeryLow	3
5. sub-watershed five	4,659	0	0.00%	0	0.00%	Unstable	VeryLow	x	x
6. sub-watershed six	3,674	1,187	32.30%	1,144	90.00%	Unstable	VeryHigh	12.87% 1-VeryLow	3
7. sub-watershed seven	6,362	0	0.00%	0	0.00%	Unstable	VeryLow	x	x
8. sub-watershed eight	6,150	2,954	48.00%	2,778	94.00%	Unstable	VeryHigh	19.95% 1-VeryLow	3
9. sub-watershed nine	3,441	461	13.40%	432	93.70%	Unstable	VeryHigh	14.49% 2-Low	3
10. sub-watershed ten	4,375	604	13.80%	541	89.60%	Unstable	VeryHigh	14.12% 1-VeryLow	3
11. sub-watershed eleven	518	136	26.00%	122	89.70%	Unstable	VeryHigh	3.50% 3-Moderate	3
12. sub-watershed twelve	3,981	0	0.00%	0	0.00%	Unstable	VeryLow	x	x
13. sub-watershed thirteen	3,212	463	14.40%	417	90.00%	Unstable	VeryHigh	17.30% 2-Low	3
14. sub-watershed fourteen	1,350	138	10.20%	114	83.00%	Unstable	VeryHigh	8.37% 3-Moderate	3
15. sub-watershed fifteen	2,016	0	0.00%	0	0.00%	Unstable	VeryLow	x	x
16. sub-watershed sixteen	4,166	697	16.50%	540	78.60%	Unstable	VeryHigh	25.29% 3-Moderate	3
17. sub-watershed seventeen	2,118	0.23	0.01%	0	0.00%	Unstable	VeryLow	x	x
18. sub-watershed eighteen	1,670	29	1.74%	14	48.30%	Unstable	VeryHigh	5.41% 1-VeryLow	3
19. sub-watershed nineteen	3,795	1,661	44.00%	1,530	92.00%	Unstable	VeryHigh	8.35% 1-VeryLow	3

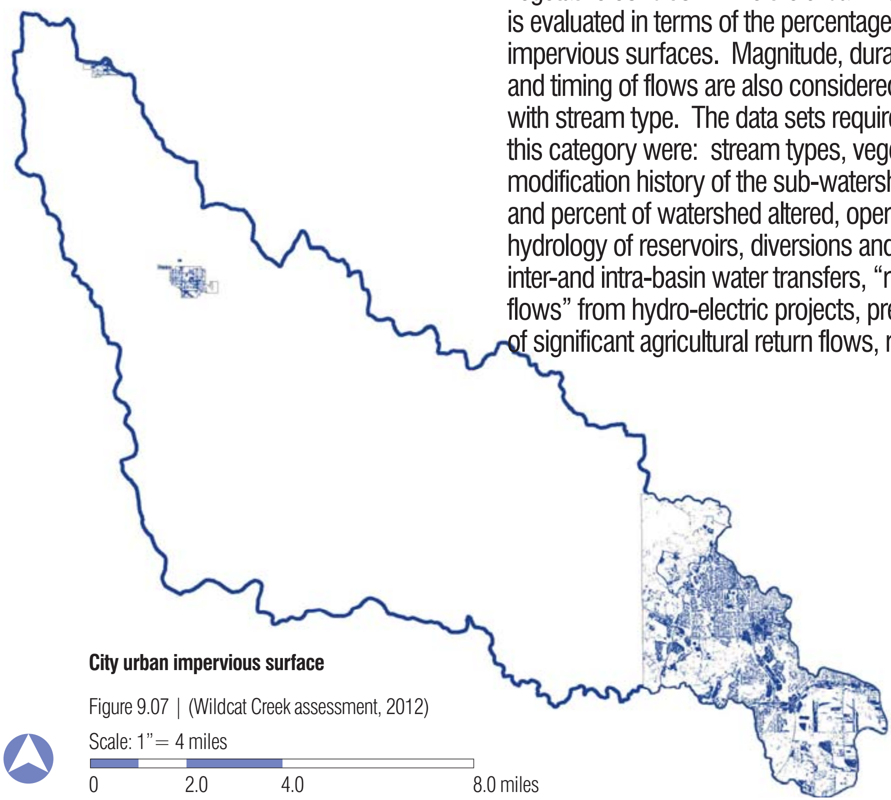
Summary of risk ratings for surface erosion

Table 9.02 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

Sediment Delivery Potential					
(11)	(12)	(13)	(14)	(15)	(16)
Conditions for Numerical Risk Ratings of Sediment Delivery Potential				Overall Risk Rating: Sediment Delivery Potential; Use (14)	% of Sub-watershed with H or VH Erosion Potential, and with H or VH Sediment Delivery Potential
Risk Rating: Percent Ground Cover	Risk Rating: Distance of Disturbance to Stream (ft)	Risk Rating: Stream Buffer	Total Individual Risk Rating Points ∑[(9) through (13)]		
4-High	5-VeryHigh	5-VeryHigh	18	High	71.00%
4-High	5-VeryHigh	1-VeryLow	14	Moderate	x
4-High	5-VeryHigh	5-VeryHigh	18	High	72.00%
3-Moderate	5-VeryHigh	5-VeryHigh	17	High	49.00%
x	x	x	x	x	x
2-Low	5-VeryHigh	1-VeryLow	13	Moderate	x
x	x	x	x	x	x
3-Moderate	5-VeryHigh	5-VeryHigh	17	High	48.00%
1-VeryLow	1-VeryLow	1-VeryLow	8	Low	x
1-VeryLow	5-VeryHigh	1-VeryLow	11	Low	x
1-VeryLow	1-VeryLow	1-VeryLow	9	Low	x
x	x	x	x	x	x
1-VeryLow	1-VeryLow	5-VeryHigh	12	Low	x
1-VeryLow	1-VeryLow	1-VeryLow	9	Low	x
x	x	x	x	x	x
1-VeryLow	5-VeryHigh	5-VeryHigh	17	High	17.00%
x	x	x	x	x	x
1-VeryLow	1-VeryLow	1-VeryLow	7	Low	x
3-Moderate	5-VeryHigh	5-VeryHigh	17	High	44.00%

Streamflow Change

Streamflow changes are evaluated for the potential for increased water yield and associated flow-related sediment increases. The watersheds were assessed as rural or urban. The rural watersheds were evaluated in terms of the percentage in a modified vegetative condition while the urban watershed is evaluated in terms of the percentage of impervious surfaces. Magnitude, duration and timing of flows are also considered along with stream type. The data sets required for this category were: stream types, vegetative modification history of the sub-watershed and percent of watershed altered, operational hydrology of reservoirs, diversions and inter-and intra-basin water transfers, “ramping flows” from hydro-electric projects, presence of significant agricultural return flows, road densities on steep/dissected slopes, wildfire locations and history, and percent of the urban watershed that is impervious. In rural locations, outside of city limits, vegetation of acres cleared and harvested were calculated based on land use types. Agriculture wasteland, cropland, and irrigated cropland land types were combined to get acreage of cleared and harvested land. All streams were classified based on Rosgen’s (2006) method of stream classification with use of the aerial photographs and local knowledge. The classification is based on dominant bed material, entrenchment ratio, width/depth ratio, sinuosity, and slope. Typically, the tributaries all came out as stream type G4 or G6, while the main channel below Riley was most commonly classified as F4. The streams in the northern agricultural lands of the site consisted of silt-clay material, while the lower reaches of the watershed, the Flint Hills Region, had a gravel base. In urban areas, within incorporated city boundaries, impervious surfaces were calculated with an image classification to distinguish impervious from pervious surfaces. The percentage was then calculated from the attributes table. Keats, Kansas was not included in the impervious surface calculations since it is unincorporated. For each sub-watershed, a risk rating was calculated for rural and urban areas, then combined to create an overall risk rating.



City urban impervious surface

Figure 9.07 | (Wildcat Creek assessment, 2012)

Scale: 1”= 4 miles

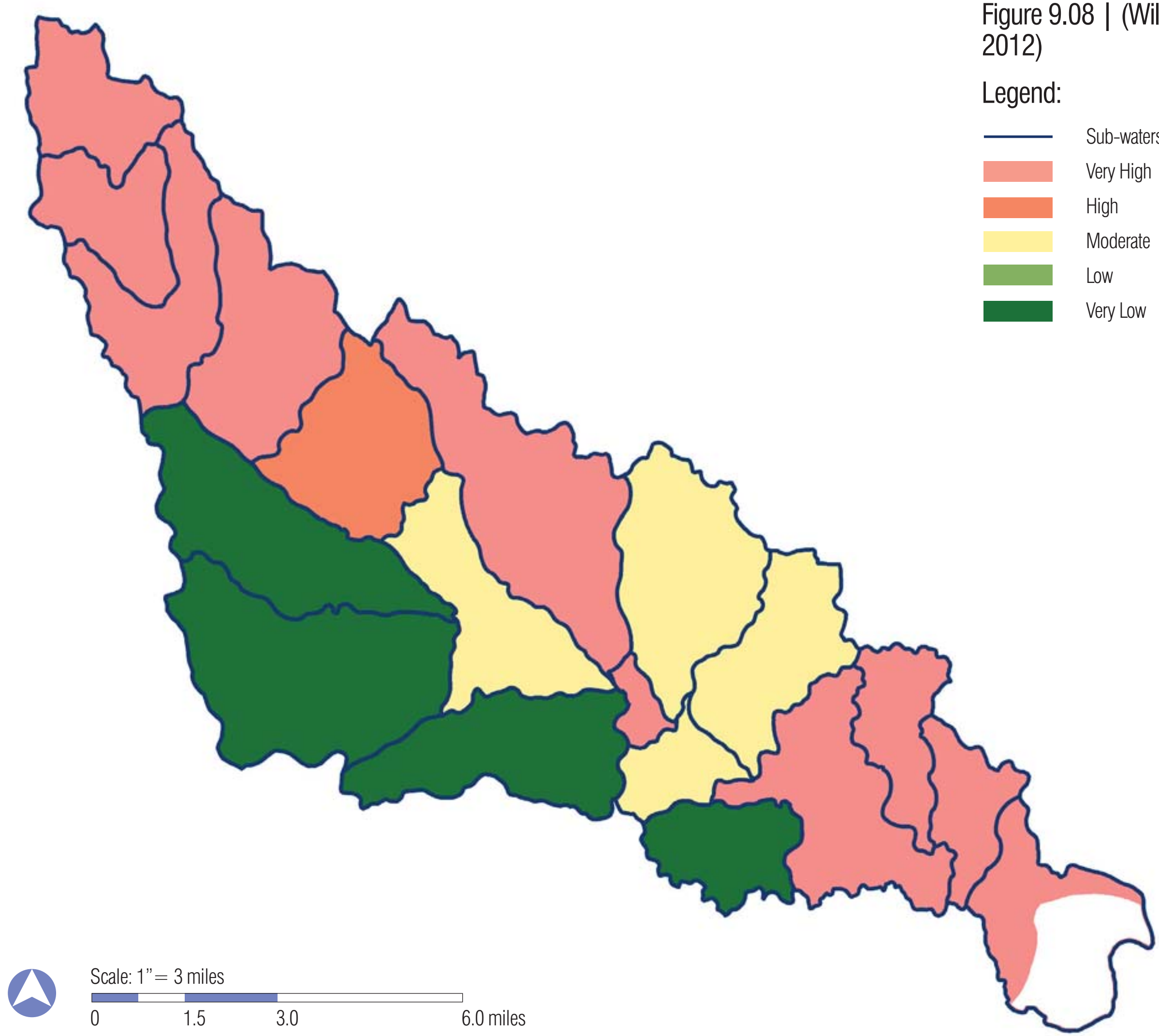
0 2.0 4.0 8.0 miles

Stream flow change ratings

Figure 9.08 | (Wildcat Creek assessment, 2012)

Legend:

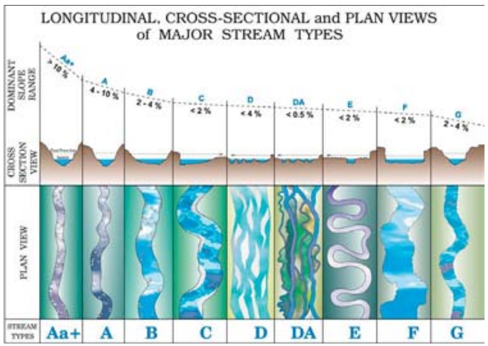
- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



Stream Type Classification

Rosgen's Stream Classification System

Stream classification is an important part of the watershed assessment. Eight main stream channel shapes and six bed materials define type of stream. Stream channels can be stable or unstable. Unstable streams are typically incised in the channels with high sediment supply and constant changes. Stable channels are not static channels. They still move and change, but the bank height, bank width, and floodplain elevations stay consistent. Stream types D, F, and G are the most common unstable stream types, while type A,B,and C are commonly stable. There are always situations when the streams do not match the typical stream. In Wildcat Creek, the type F and G channels are generally unstable while the B and C streams in the watershed are generally stable (figure 3.10). Figures 9.9 and table 9.3 show the Rosgen's (2007) stream classification method. More information can be found in Applied River Morphology (Rosgen, 1996).



Stream type images

Figure 9.09 | (Rosgen and Silvey, 1996)

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/ Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.4	<.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.4	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

Stream type descriptions

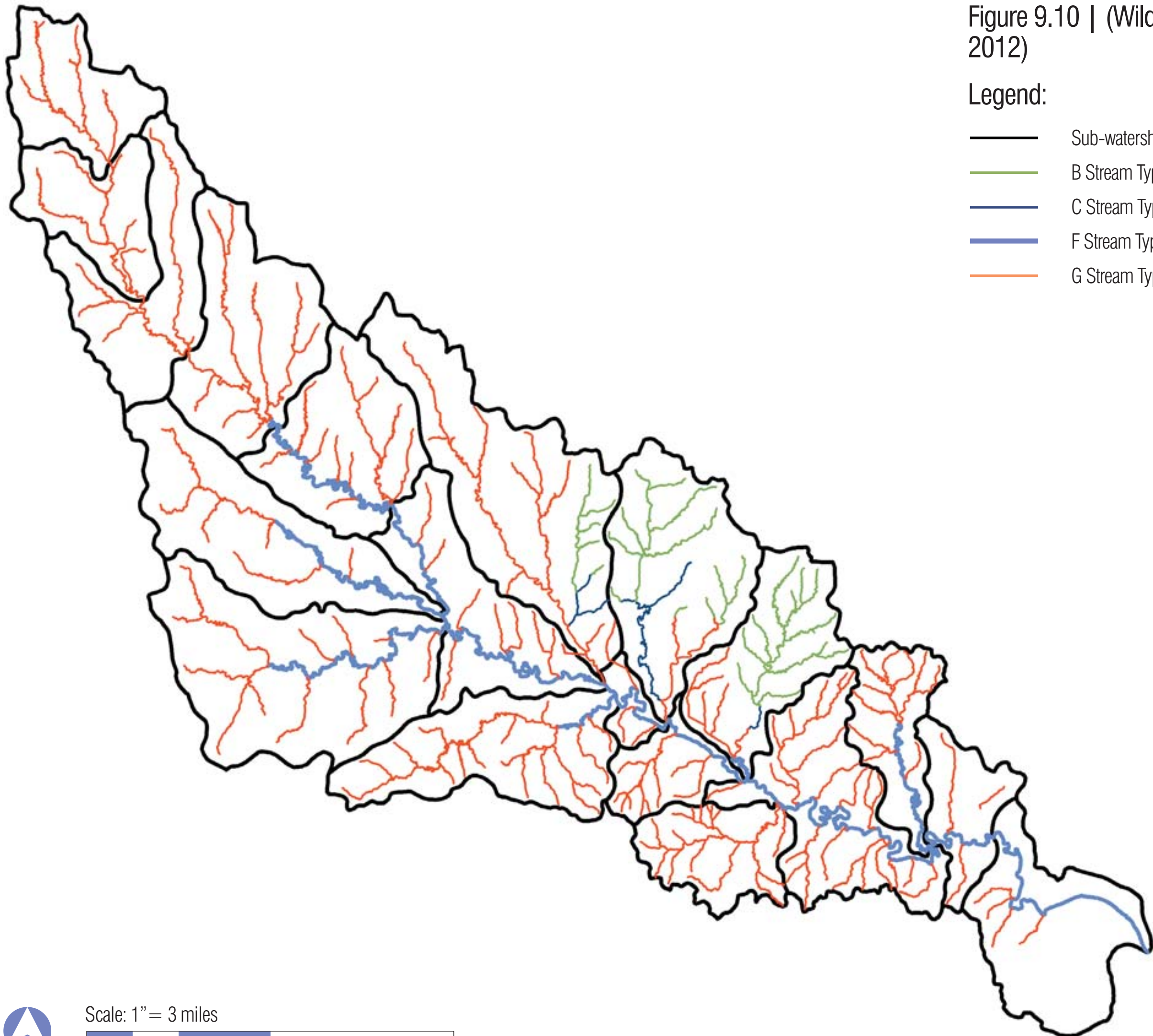
Table 9.03 | (Rosgen and Silvey, 1996)

Stream type classification

Figure 9.10 | (Wildcat Creek assessment, 2012)

Legend:

- Sub-watershed Boundary
- B Stream Type
- C Stream Type
- F Stream Type
- G Stream Type



Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

		Rural Sub-watershed Risk			
(1)	(2)	(3)	(4)	(5)	(6)
Sub-watershed Location/River Reach I.D. (Include Cumulative Total Watershed following Sub-watershed I.D.s)	Total Acres	Acres Cleared/ Harvested (Include Roads) [Roads + Clearcut = Total]	Percent Cleared/ Harvested of Total [(3)/(2)X100]	Stream Type Most Susceptible to Change or "Weak Link"	Risk Rating: Rural Sub-watershed Risk (Fig. 4-14) (4) by Stream Type (5)
1. sub-watershed one	2,394	1,682	70.30%	G6	5-VeryHigh
2. sub-watershed two	2,336	1,637	70.10%	G6	5-VeryHigh
3. sub-watershed three	3,302	2,296	69.50%	G6	5-VeryHigh
4. sub-watershed four	4,119	1,903	46.20%	G4	5-VeryHigh
5. sub-watershed five	4,659	0	0.00%	G4 (F4)	1-VeryLow
6. sub-watershed six	3,674	1,144	31.10%	G4 (F4)	4-High
7. sub-watershed seven	6,362	0	0.00%	G4 (F4)	1-VeryLow
8. sub-watershed eight	6,150	2,778	45.17%	G4	5-VeryHigh
9. sub-watershed nine	3,441	432	12.60%	G4	3-Moderate
10. sub-watershed ten	4,375	541	12.40%	G4	3-Moderate
11. sub-watershed eleven	518	122	23.60%	G4	5-VeryHigh
12. sub-watershed twelve	3,981	0	0.00%	G4	1-VeryLow
13. sub-watershed thirteen	3,212	417	13.00%	G4	3-Moderate
14. sub-watershed fourteen	1,350	114	8.44%	G4	3-Moderate
15. sub-watershed fifteen	2,016	0	0.00%	G4	1-VeryLow
16. sub-watershed sixteen	4,166	540	13.00%	G4	3-Moderate
17. sub-watershed seventeen	2,118	0	0.00%	G4	1-VeryLow
18. sub-watershed eighteen	1,670	14	0.80%	G4 (F4)	1-VeryLow
19. sub-watershed nineteen	3,795	1530	40.30%	G4 (F4)	5-VeryHigh

Urban Sub-watershed Risk				Adjustments		
(7)	(8)	(9)	(10)	(11)	(12)	(13)
Total Impervious Acres	Percent Impervious [(7)/(2)X100]	Stream Type Most Susceptible to Change or "Weak Link"	Risk Rating: Urban Sub-watershed Risk (8) by Stream Type (9)	Risk Rating: Percent Increase over Bankfull Discharge*	Risk Rating: Percent Reduction in Bankfull Discharge*	Overall Risk Rating: Streamflow Changes (Insert Adjective and Numeric Rating)
28.3	14.90%	G6	5-VeryHigh	x	x	5-VeryHigh
x	x	x	x	x	x	5-VeryHigh
1.6	37.80%	G6	5-VeryHigh	x	x	5-VeryHigh
98.5	32.40%	G6	5-VeryHigh	x	x	5-VeryHigh
x	x	x	x	x	x	1-VeryLow
x	x	x	x	x	x	4-High
x	x	x	x	x	x	1-VeryLow
x	x	x	x	x	x	5-VeryHigh
x	x	x	x	x	x	3-Moderate
x	x	x	x	x	x	3-Moderate
x	x	x	x	x	x	5-VeryHigh
x	x	x	x	x	x	1-VeryLow
1.5	1.60%	B6	1-VeryLow	x	x	3-Moderate
x	x	x	x	x	x	3-Moderate
368.2	18.30%	F4	5-VeryHigh	x	x	5-VeryHigh
364.6	17.50%	F4	5-VeryHigh	x	x	5-VeryHigh
x	x	x	x	x	x	1-VeryLow
630.7	37.80%	F4	5-VeryHigh	x	x	5-VeryHigh
922.3	24.30%	F4	5-VeryHigh	x	x	5-VeryHigh

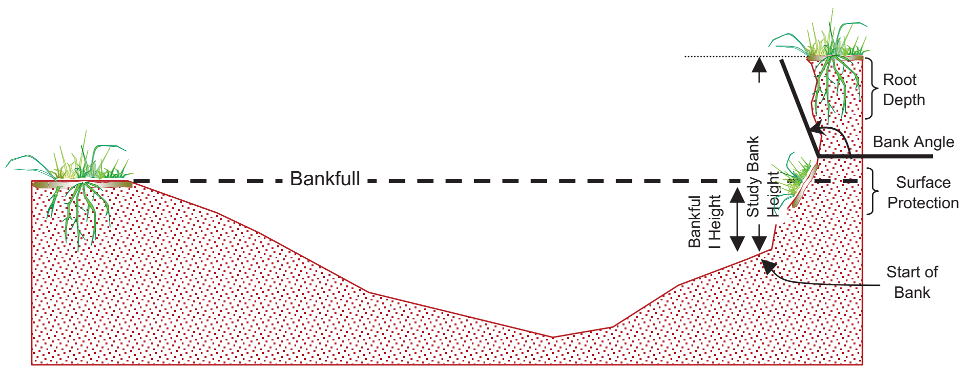
Summary of risk ratings for streamflow change

Table 9.04 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

* Describe source of increased or decreased bankfull discharge adjustment. (e.g., operational hydrology of reservoir.)

Streambank Erosion

Streambank erosion can be a major impact upon the stability of a fluvial system. The observed data used for this assessment includes: stream types, aerial photographs and drainage area maps, regional curves, bankfull width, radius of curvature, riparian species composition, bank height, and bankfull depth. The vegetation composition of each sub-watershed was determined by local knowledge and aerial photography. The amount of annual grass/forbs, perennial grass, and woody riparian vegetation was identified for each sub-watershed as well as if the sub-watershed has some land that is within city limits or shooting ranges. The bank height ratio was determined for each order of streams, then averaged resulting in stream types G and F having a bank height ratio of 1.4-2 and stream types B and C having a bank height ration of 1.2-1.4. The radius of curvature was measured from the aerial photographs. The curvature and Flint Hills Regional Curves then determined the bankfull width.



Bank height and bank width depictions

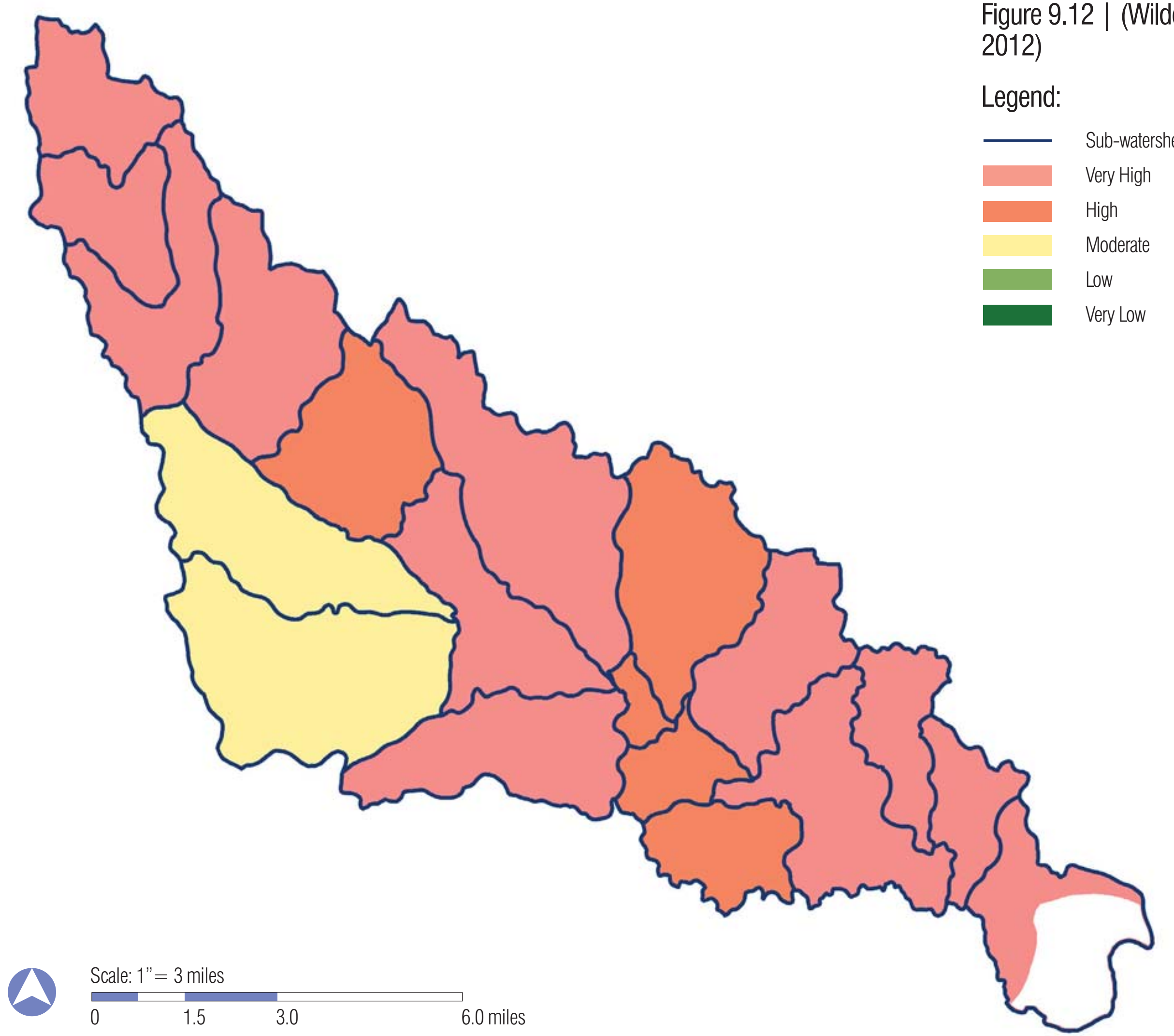
Figure 9.11 | (Rosgen and Silvey, 1996)

Stream bank erosion ratings

Figure 9.12 | (Wildcat Creek assessment, 2012)

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



(1)	(2)	(3)	(4)	(5)
Location Code/ River Reach I.D.	Vegetation Composition	Risk Rating: Vegetation Composition	Bank-Height Ratio (Average of first, second, and third order)	Risk Rating: Bank-Height Ratio
1. sub-watershed one	Annual Grasses & Forbs; Perennial Grasses	4-High	>2.0	5-VeryHigh
2. sub-watershed two	Annual Grasses & Forbs; Perennial Grasses	4-High	>2.0	5-VeryHigh
3. sub-watershed three	Annual Grasses & Forbs; Woody Riparian	3-Moderate	>2.0	5-VeryHigh
4. sub-watershed four	Annual Grasses & Forbs; Perennial Grasses	4-High	>2.0	5-VeryHigh
5. sub-watershed five	Good Forbs & Woody Riparian	2-Low	1.4	3-Moderate
6. sub-watershed six	Agricultural Land Annual Grasses; Good Woody Vegetation	3-Moderate	2.0	4-High
7. sub-watershed seven	Good Forbs & Woody Riparian	2-Low	1.4	3-Moderate
8. sub-watershed eight	Annual Grasses & Forbs; Perennial Grasses	4-High	>2.0	5-VeryHigh
9. sub-watershed nine	Good Woody Vegetation; some Annual Grasses & Forbs	3-Moderate	2.0	4-High
10. sub-watershed ten	Good Woody Vegetation; some Annual Grasses & Forbs	2-Low	1.4	3-Moderate
11. sub-watershed eleven	Good Woody Riparian	2-Low	2.0	4-High
12. sub-watershed twelve	Shooting grounds & Good Woody Riparian	3-Moderate	1.4	3-Moderate
13. sub-watershed thirteen	Some Annual Grasses & Perennial Grasses; Some Woody Riparian	4-High	1.4	3-Moderate
14. sub-watershed fourteen	Good Woody Riparian	2-Low	2.0	4-High
15. sub-watershed fifteen	City Limits; Some Woody Riparian	4-High	2.0	4-High
16. sub-watershed sixteen	Some Woody Riparian; Some Annual Grasses & Perennial Grasses	4-High	1.4	3-Moderate
17. sub-watershed seventeen	Some Woody Riparian; Spots of Annual Grasses & Forbs	2-Low	>2.0	5-VeryHigh
18. sub-watershed eighteen	City Limits; Some Woody Riparian	5-VeryHigh	2.0	4-High
19. sub-watershed nineteen	City Limits; Some Woody Riparian; Annual Grasses & Forbs	4-High	2.0	4-High

Summary of risk ratings for stream bank erosion

Table 9.05 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

(6) Radius of Curvature Divided by Bankfull Width	(7) Risk Rating: Radius of Curvature Divided by Bankfull Width	(8) Total Individual Risk Rating Points by Reach $\Sigma[(3)+(5)+(7)]$	(9) Overall Risk Rating by Stream Type
6.88	1-VeryLow	10	5-VeryHigh
3.94	1-VeryLow	10	5-VeryHigh
3.72	1-VeryLow	9	5-VeryHigh
4.49	1-VeryLow	10	5-VeryHigh
3.27	1-VeryLow	6	3-Medium
4.49	1-VeryLow	8	4-High
6.22	1-VeryLow	6	3-Moderate
2.37	3-Moderate	12	5-VeryHigh
1.22	4-High	11	5-VeryHigh
2.23	3-Moderate	8	4-High
3.02	1-VeryLow	7	4-High
2.16	4-High	10	5-VeryHigh
2.84	2-Low	9	5-VeryHigh
4.06	1-VeryLow	7	4-High
4.56	1-VeryLow	9	5-VeryHigh
2.44	3-Moderate	10	5-VeryHigh
4.08	1-VeryLow	8	4-High
9.99	1-VeryLow	10	5-VeryHigh
6.66	1-VeryLow	9	5-VeryHigh

Direct Channel Impacts

Direct channel impacts included flood control, land drainage, vegetative conversions, heavy grazing pressure, livestock concentrations, straightening, levees, dredging, clearing vegetation, and assorted “river engineering” projects. The data required to determine risk for this category includes stream types, time-trend aerial photos, percent of riparian vegetation changed, length of channel with changed riparian vegetation with consideration to the nature of direct disturbance and percent of channel directly impacted, and percent of channel blockage, including woody debris. Riparian vegetation around the channels in 1992 and 2012 were compared to determine areas that had changed. In the areas that had changed, the stream length of the riparian vegetation change was calculated. Locations of channelization were identified and measured from aerial photographs. The channel was not significantly blocked by woody debris and was not factored into the risk rating. Sub-watersheds that were not indicated as critical in the RLA phase were only given risk ratings for their riparian vegetation change.

One of many locations of channelization

Figure 9.13 | (Wildcat Creek assessment, 2012)

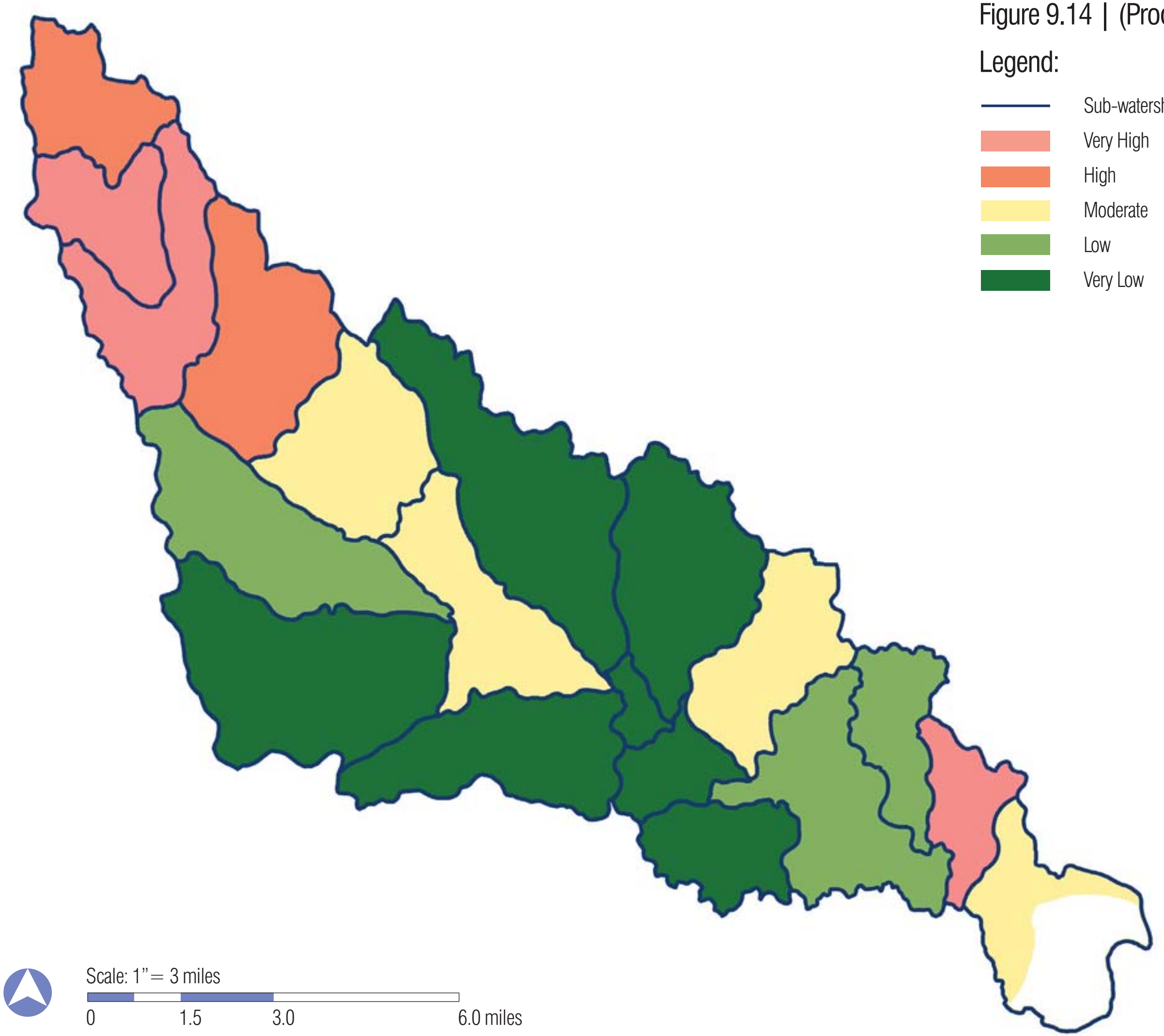
Locations of channelization were identified throughout the watershed. Most of the locations are found in agricultural settings where more crop land or land to build homes were used and the channel was straightened around those areas.

Direct channel impact ratings

Figure 9.14 | (Produced by authors, 2012)

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



Scale: 1"= 3 miles

0 1.5 3.0 6.0 miles

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Location Code/ River Reach I.D.	Total Channel Length (ft)	Riparian Vegetation Change (ft)	Percent of Total Length Impacted [(3)/(2)X100]	Risk Rating: Percent of Riparian Vegetation Change (4) by Stream Type	Length Impacted by Direct Channel Disturbance (ft)	Percent of Total Length Impacted [(6)/(2)X100]
1. sub-watershed one	36,326 ft	0 ft	0.00%	1-VeryLow	8321 ft	22.90%
2. sub-watershed two	42,504 ft	7,545 ft	17.75%	2-Low	18170 ft	42.70%
3. sub-watershed three	41,659 ft	247 ft	0.60%	1-VeryLow	17139 ft	41.10%
4. sub-watershed four	67,267 ft	1,302 ft	2.00%	1-VeryLow	18079 ft	26.90%
5. sub-watershed five	61,550 ft	6,133 ft	10.00%	2-Low	x	x
6. sub-watershed six	67,954 ft	1,578 ft	2.32%	1-VeryLow	12,569 ft	18.50%
7. sub-watershed seven	85,822 ft	2,444 ft	2.85%	1-VeryLow	x	x
8. sub-watershed eight	105,336 ft	279 ft	0.26%	1-VeryLow	x	x
9. sub-watershed nine	76,507 ft	350 ft	0.46%	1-VeryLow	12,107 ft	15.80%
10. sub-watershed ten	78,507 ft	398 ft	0.51%	1-VeryLow	x	x
11. sub-watershed eleven	18,480 ft	408 ft	2.21%	1-VeryLow	x	x
12. sub-watershed twelve	88,130 ft	2,518 ft	2.85%	1-VeryLow	x	x
13. sub-watershed thirteen	91,816 ft	0 ft	0.00%	1-VeryLow	11,303 ft	12.30%
14. sub-watershed fourteen	44,194 ft	1,513 ft	3.42%	1-VeryLow	x	x
15. sub-watershed fifteen	63,513 ft	6,199 ft	9.76%	2-Low	6,400 ft	10.10%
16. sub-watershed sixteen	133,531 ft	3,919 ft	2.93%	1-VeryLow	8,850 ft	6.60%
17. sub-watershed seventeen	62,031 ft	1,472 ft	2.37%	1-VeryLow	200 ft	0.30%
18. sub-watershed eighteen	28,565 ft	1,813 ft	6.35%	1-VeryLow	14,046 ft	49.20%
19. sub-watershed nineteen	44,088 ft	4,133 ft	9.37%	2-Low	7,761 ft	17.60%

(8)	(9)	(10)	(11)	(12)
Risk Rating: Percent of Channel Length Impacted (7) by Stream Type	Length Impacted by Large Woody Debris	Percent of Length of Debris Blockage [(9)/(2)X100]	Risk Rating: Debris Blockage	Overall Risk Rating for Direct Channel Impacts (Insert Highest Risk Rating from Columns 5, 8 and 11)
4-High	x	x	x	4-High
5-VeryHigh	x	x	x	5-VeryHigh
5-VeryHigh	x	x	x	5-VeryHigh
4-High	x	x	x	4-High
x	x	x	x	2-Low
3-Moderate	x	x	x	3-Moderate
x	x	x	x	1-VeryLow
x	x	x	x	1-VeryLow
3-Moderate	x	x	x	3-Moderate
x	x	x	x	1-VeryLow
x	x	x	x	1-VeryLow
x	x	x	x	1-VeryLow
3-Moderate	x	x	x	3-Moderate
x	x	x	x	1-VeryLow
2-Low	x	x	x	2-Low
2-Low	x	x	x	2-Low
1-VeryLow	x	x	x	1-VeryLow
5-VeryHigh	x	x	x	5-VeryHigh
3-Moderate	x	x	x	3-Moderate

Summary of risk ratings for direct channel impacts

Table 9.06 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

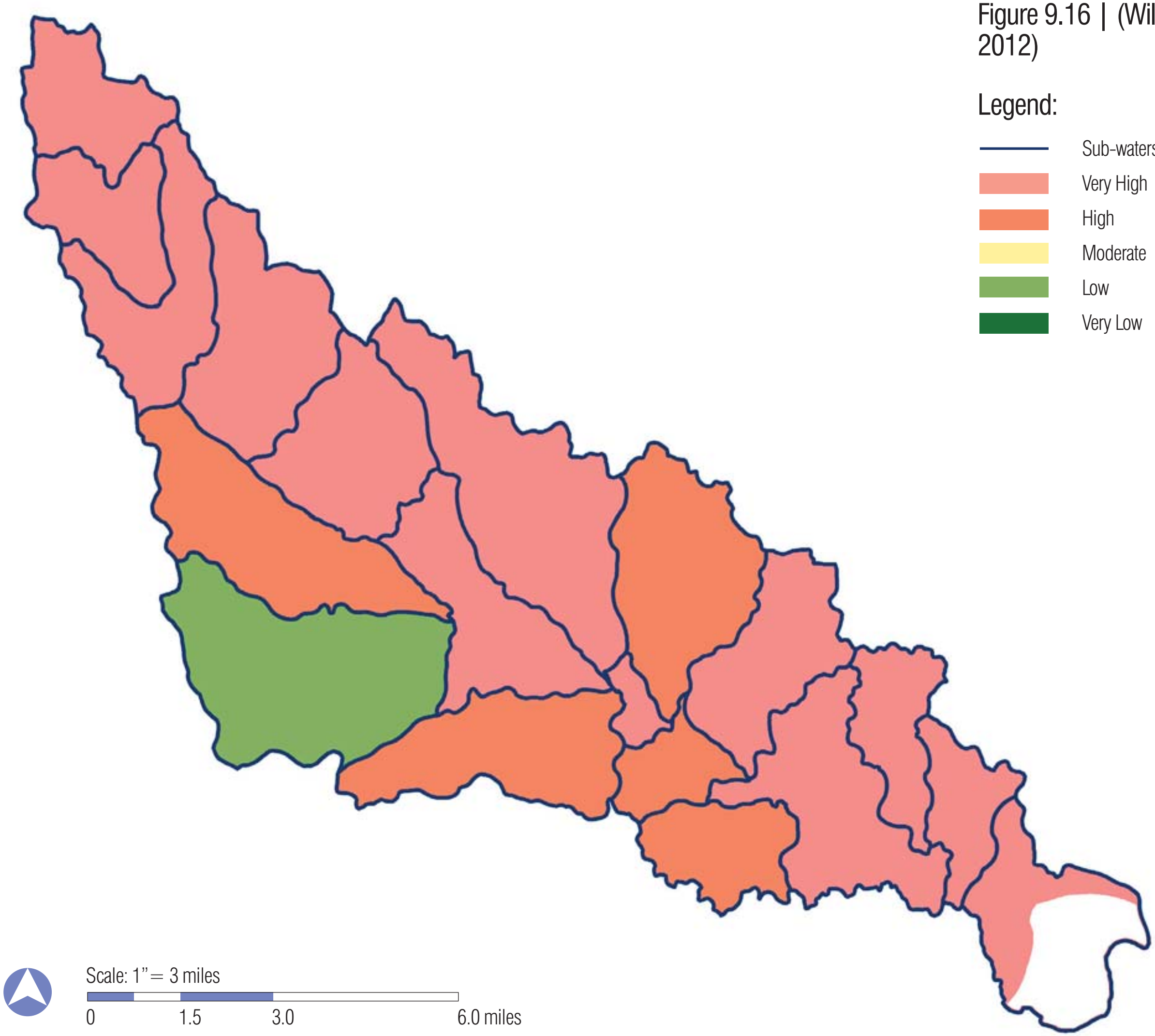
Channel Enlargement

Channel enlargement was based on the "susceptibility of streams to incise and or widen at an accelerated rate due to changes in flow, clear water discharge, direct disturbance and streambank erosion" (Rosgen, 2008). The data needed for review for this assessment includes stream types (figure 9.11), streamflow changes risk (table 9.4), streambank erosion risk (table 9.5, in-channel mining impact risk (not a risk in the Wildcat Creek watershed), and direct channel disturbance risk (table 9.6). All of the data used to determine the risk rating of channel enlargement comes from pervious calculations and ratings.

Channel erosion on Wildcat Creek

Figure 9.15 | (Denlinger, 2011)

Channel erosion and incised channels are one indication that the channel is unstable. Unstable channels are highly susceptibly to channel enlargement and rapid channel changes.



Channel enlargement ratings

Figure 9.16 | (Wildcat Creek assessment, 2012)

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low

Scale: 1"= 3 miles

0 1.5 3.0 6.0 miles

(1)	(2)	(3)	(4)
Location Code/ River Reach I.D.	Overall Risk Rating: Streamflow Changes (Table 3.4)	Overall Risk Rating: Streambank Erosion (Table 3.5)	Overall Risk Rating: Direct Channel Impacts (Table 3.6)
1. sub-watershed one	5-VeryHigh	5-VeryHigh	4-High
2. sub-watershed two	5-VeryHigh	5-VeryHigh	5-VeryHigh
3. sub-watershed three	5-VeryHigh	5-VeryHigh	5-VeryHigh
4. sub-watershed four	5-VeryHigh	5-VeryHigh	4-High
5. sub-watershed five	1-VeryLow	3-Moderate	2-Low
6. sub-watershed six	4-High	4-High	3-Moderate
7. sub-watershed seven	1-VeryLow	3-Moderate	1-VeryLow
8. sub-watershed eight	5-VeryHigh	5-VeryHigh	1-VeryLow
9. sub-watershed nine	3-Moderate	5-VeryHigh	3-Moderate
10. sub-watershed ten	3-Moderate	4-High	1-VeryLow
11. sub-watershed eleven	5-VeryHigh	4-High	1-VeryLow
12. sub-watershed twelve	1-VeryLow	5-VeryHigh	1-VeryLow
13. sub-watershed thirteen	3-Moderate	5-VeryHigh	3-Moderate
14. sub-watershed fourteen	3-Moderate	4-High	1-VeryLow
15. sub-watershed fifteen	5-VeryHigh	5-VeryHigh	2-Low
16. sub-watershed sixteen	5-VeryHigh	5-VeryHigh	2-Low
17. sub-watershed seventeen	1-VeryLow	4-High	1-VeryLow
18. sub-watershed eighteen	5-VeryHigh	5-VeryHigh	5-VeryHigh
19. sub-watershed nineteen	5-VeryHigh	5-VeryHigh	3-Moderate

Summary of risk ratings for channel enlargement

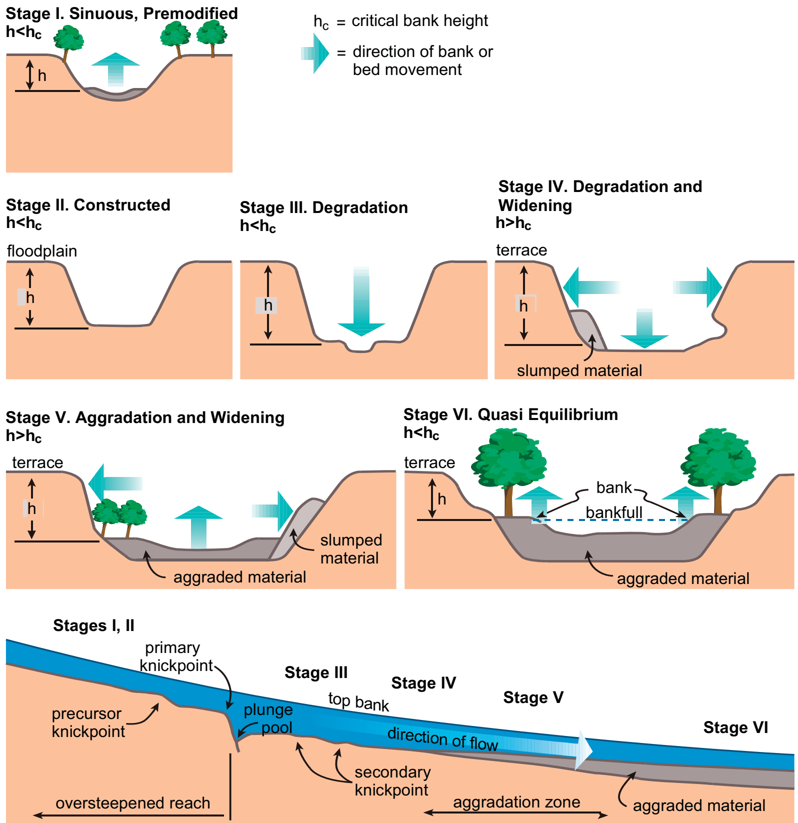
Table 9.07 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

(5)	(6)	(7)
Total Numeric Score $\sum[(2)+(3)+(4)]$	Overall Risk Rating for Channel Enlargement by Stream Type	Adjustment Due to In-Channel Mining
14	5-VeryHigh	x
15	5-VeryHigh	x
15	5-VeryHigh	x
14	5-VeryHigh	x
6	4-High	x
11	5-VeryHigh	x
5	2-Low	x
11	5-VeryHigh	x
11	5-VeryHigh	x
8	4-High	x
10	5-VeryHigh	x
7	4-High	x
11	5-VeryHigh	x
8	4-High	x
12	5-VeryHigh	x
12	5-VeryHigh	x
6	4-High	x
15	5-VeryHigh	x
13	5-VeryHigh	x

Aggradation | Excess Sediment Supply

The risk assessment of aggradation/excess sediment supply concerns increased in width/depth ratio or slope changes. Examples of such impacts are over-widening due to bridge construction, channelization, riparian vegetation reduction, and poor grazing practices. The data required to assess the risk of aggradation/excess sediment supply was split into two broad categories: hillslope risk ratings (sediment supply) and channel process response to excess sediment. The hillslope assessment included mass erosion risk (low for entire watershed), roads risk (table 9.1), and surface erosion risk (table 9.2). Risk rates for the hillslope assessment were calculated in prior evaluations. Channel processes included bankfull width/depth ratio of existing and reference reaches, channel enlargement risk (table 9.7), streambank erosion risk (table 9.5), and depositional pattern evaluation. The bankfull widths and depths were determined using the Flint Hills Regional Curves of the associating drainage areas for the different stream order stream types. The channel enlargement and stream bank erosion risk ratings can be found in prior evaluations.

SIMON CHANNEL EVOLUTION SEQUENCE (FROM SIMON 1989)



Examples of aggradation and degradation that cause changes in channel type evolution

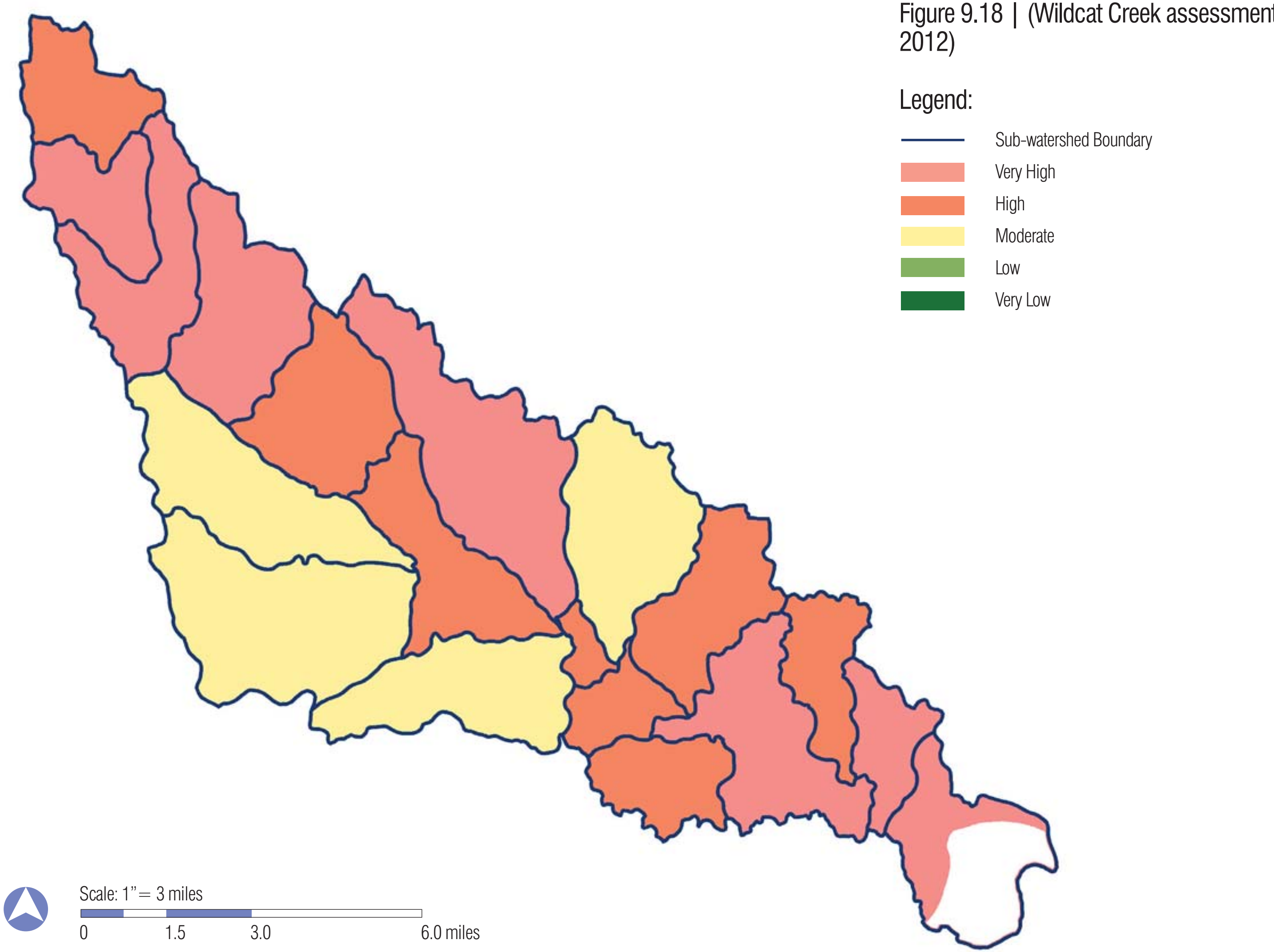
Figure 9.17 | (Simon, 1989)

Changes in the stream channel occur from incising or widening of the stream channel. Different stages of aggradation and degradation are needed to move between channel stages.

Aggradation | Excess sediment ratings

Figure 9.18 | (Wildcat Creek assessment, 2012)

Legend:



	Hillslope Risk Ratings (Sediment Supply)								
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Location Code/ River Reach I.D.	Risk Rating: Mass Erosion	Risk Rating: Roads (Table 3.1)	Risk Rating: Surface Erosion Risk/ Delivered Sediment Risk	Point Subtotal ∑[(2)+(3)+(4)]	Hillslope Summary Overall Rating; Use Points from Column (5) VL(1) = 3 L(2) = 4–7 M(3) = 8–10 H(4) = 11–14 VH(5) = >14	Representative location & associated rating points from column (6)*	Risk Rating: Width/Depth Ratio Departure VL(1) = HS L(2) = S M(3) = MU H(4) = U VH(5) = HU	Risk Rating: Channel Enlargement (Table 4.7)	Risk Rating: Streambank Erosion (Table 4.5)
1. sub-watershed one	2-Low	2-Low	4-High	8	3-Moderate ; 8-10	3-Moderate ; G	3-Moderate ; 1.34 MU	5-VeryHigh	5-VeryHigh
2. sub-watershed two	2-Low	3-Moderate	3-Moderate	8	3-Moderate ; 8-10	3-Moderate ; G	4-High ; 1.49 U	5-VeryHigh	5-VeryHigh
3. sub-watershed three	2-Low	2-Low	4-High	8	3-Moderate ; 8-10	3-Moderate ; G	4-High ; 1.57 U	5-VeryHigh	5-VeryHigh
4. sub-watershed four	2-Low	4-High	4-High	10	3-Moderate ; 8-10	3-Moderate ; G	4-High ; 1.54 U	5-VeryHigh	5-VeryHigh
5. sub-watershed five	2-Low	x	x	2	1-VeryLow ; 3	1-VeryLow ; G	4-High ; 1.47 U	4-High	1-VeryLow
6. sub-watershed six	2-Low	1-VeryLow	3-Moderate	6	2-Low ; 4-7	2-Low ; G	4-High ; 1.46 U	5-VeryHigh	4-High
7. sub-watershed seven	2-Low	x	x	2	1-VeryLow ; 3	1-VeryLow ; G	5-VeryHigh ; 1.80 HU	2-Low	1-VeryLow
8. sub-watershed eight	2-Low	4-High	4-High	10	3-Moderate ; 8-10	3-Moderate ; G	5-VeryHigh ; 1.61 HU	5-VeryHigh	5-VeryHigh
9. sub-watershed nine	2-Low	3-Moderate	1-VeryLow	6	2-Low ; 4-7	2-Low ; F	5-VeryHigh ; 1.78 HU	5-VeryHigh	3-Moderate
10. sub-watershed ten	2-Low	4-High	1-VeryLow	7	2-Low ; 4-7	2-Low ; B	3-Moderate ; 1.29 MU	4-High	3-Moderate
11. sub-watershed eleven	2-Low	1-VeryLow	1-VeryLow	4	2-Low ; 4-7	2-Low ; F	4-High ; 1.55 U	5-VeryHigh	5-VeryHigh
12. sub-watershed twelve	2-Low	x	x	2	1-VeryLow ; 3	1-VeryLow ; G	4-High ; 1.52 U	4-High	1-VeryLow
13. sub-watershed thirteen	2-Low	3-Moderate	1-VeryLow	6	2-Low ; 4-7	2-Low ; B	3-Moderate ; 1.27 MU	5-VeryHigh	3-Moderate
14. sub-watershed fourteen	2-Low	x	1-VeryLow	3	1-VeryLow ; 3	1-VeryLow ; G	5-VeryHigh ; 1.71 HU	4-High	3-Moderate
15. sub-watershed fifteen	2-Low	3-Moderate	x	5	2-Low ; 4-7	2-Low ; G	4-High ; 1.54 U	5-VeryHigh	5-VeryHigh
16. sub-watershed sixteen	2-Low	3-Moderate	4-High	9	3-Moderate ; 8-10	3-Moderate ; G	5-VeryHigh ; 1.61 HU	5-VeryHigh	5-VeryHigh
17. sub-watershed seventeen	2-Low	1-VeryLow	x	3	1-VeryLow ; 3	1-VeryLow ; G	4-High ; 1.54 U	4-High	4-High
18. sub-watershed eighteen	2-Low	4-High	1-VeryLow	7	2-Low ; 4-7	2-Low ; G	5-VeryHigh ; 1.61 HU	5-VeryHigh	5-VeryHigh
19. sub-watershed nineteen	2-Low	4-High	4-High	10	3-Moderate ; 8-10	3-Moderate ; G	4-High ; 1.55 U	5-VeryHigh	5-VeryHigh

Channel Process Response to Excess Sediment				
(11)	(12)	(13)	(14)	(15)
Point Subtotal ∑[(7)+(8)+(9)+(10)]	Risk Rating: Use Points from Column (11) VL(1) < 5 L(2) = 5–8 M(3) = 9–12 H(4) = 13–16 VH(5) >16	Adjustments:Aggradation/Excess Sediment Indicators** a. Obvious excess deposition b. Filling of pools c. Deposition of sand or larger material on floodplain d. Bi-modal e. Depositional patterns	Adjustment: Reduction in Flow Due to Regulation**	Final Aggradation/ Excess Sediment Deposition Risk Rating
16	4-High	x	x	4-High
17	5-VeryHigh	x	x	5-VeryHigh
17	5-VeryHigh	x	x	5-VeryHigh
17	5-VeryHigh	x	x	5-VeryHigh
10	3-Moderate	x	x	3-Moderate
15	4-High	x	x	4-High
9	3-Medium	x	x	3-Moderate
18	5-VeryHigh	x	x	5-VeryHigh
15	4-High	x	x	4-High
12	3-Moderate	x	x	3-Moderate
16	4-High	x	x	4-High
10	3-Moderate	x	x	3-Moderate
13	4-High	x	x	4-High
13	4-High	x	x	4-High
16	4-High	x	x	4-High
18	5-VeryHigh	x	x	5-VeryHigh
13	4-High	x	x	4-High
17	5-VeryHigh	x	x	5-VeryHigh
17	5-VeryHigh	x	x	5-VeryHigh

Summary of risk ratings for aggradation

Table 9.08 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

* To appy risk rating from Hillslope Processes for aggradation risk, it is important to identify the location of the sediment supply in relation to the most representative stream type.

** Adjust a full risk category upward if streamflow decrease and/or indicators provide evidence appropriate to the observed condition such as the aggradation indicators listed above.

Channel Evolution

Successional States

The determination of channel evolution/ successional states dealt with the changes over time due to geologic influences and the tendency of rivers to seek their own stability within a specific climatic parameter (see figure 9.16). Reference reaches are considered stable and used as a baseline for assessments. The data required for this assessment included stream types (figure 9.11), reference condition, and scenarios of successional stages of stream channel evolution. The percentages of different types of stream classification were calculated for each sub-watershed. The risk ratings were then averaged from different stream type successional patterns.

Channel Successional States of Stream Type Evolution	Risk Rating
E to C	3-Moderate
C to D	5-VeryHigh
B, C, E or D to G	5-VeryHigh
G to F	4-High
G to B	1-VeryLow
F to B	1-VeryLow
F to C	2-Low
F to D	3-Moderate
All others (e.g. C to E)	2-Low

Channel evolution rating system

Table 9.09 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

(1)	(2)	(3)	(4)	(5)
Location Code/ River Reach I.D.	Stream Type Most Susceptible to Change or "Weak Link" (4) and (9) Table 3.4	Channel Successional States of Stream Type Evolution	Channel Successional States of Stream Type Evolution; Risk Rating	Channel Successional States of Stream Type Evolution; Risk Rating (average for sub-watershed)
1. sub-watershed one	G6	G to F	4-High	4-High
2. sub-watershed two	G6	G to F	4-High	4-High
3. sub-watershed three	G6	G to F	4-High	4-High
4. sub-watershed four	G6	G to F	4-High	4-High
5. sub-watershed five	G4 ; F4	G to F ; F to C	4-High ; 2-Low	3-Moderate
6. sub-watershed six	G4 ; F4	G to F ; F to C	4-High ; 2-Low	3-Moderate
7. sub-watershed seven	G4 ; F4	G to F ; F to C	4-High ; 2-Low	3-Moderate
8. sub-watershed eight	G4	G to F	4-High	4-High
9. sub-watershed nine	G4 ; F4	G to F ; F to C	4-High ; 2-Low	3-Moderate
10. sub-watershed ten	B	x	1-VeryLow	1-VeryLow
11. sub-watershed eleven	G4 ; F4	G to F ; F to C	4-High ; 2-Low	3-Moderate
12. sub-watershed twelve	G4	G to F	4-High	4-High
13. sub-watershed thirteen	F	F to C	2-Low	2-Low
14. sub-watershed fourteen	G4	G to F	4-High	4-High
15. sub-watershed fifteen	F ; G4	F to B ; G to F	1-VeryLow ; 4-High	3-Moderate
16. sub-watershed sixteen	F ; G4	F to B ; G to F	1-VeryLow ; 4-High	3-Moderate
17. sub-watershed seventeen	G4	G to F	4-High	4-High
18. sub-watershed eighteen	F4	F to C	2-Low	2-Low
19. sub-watershed nineteen	F ; G4	F to B ; G to F	1-VeryLow ; 4-High	3-Moderate

Summary of risk ratings for channel evolution

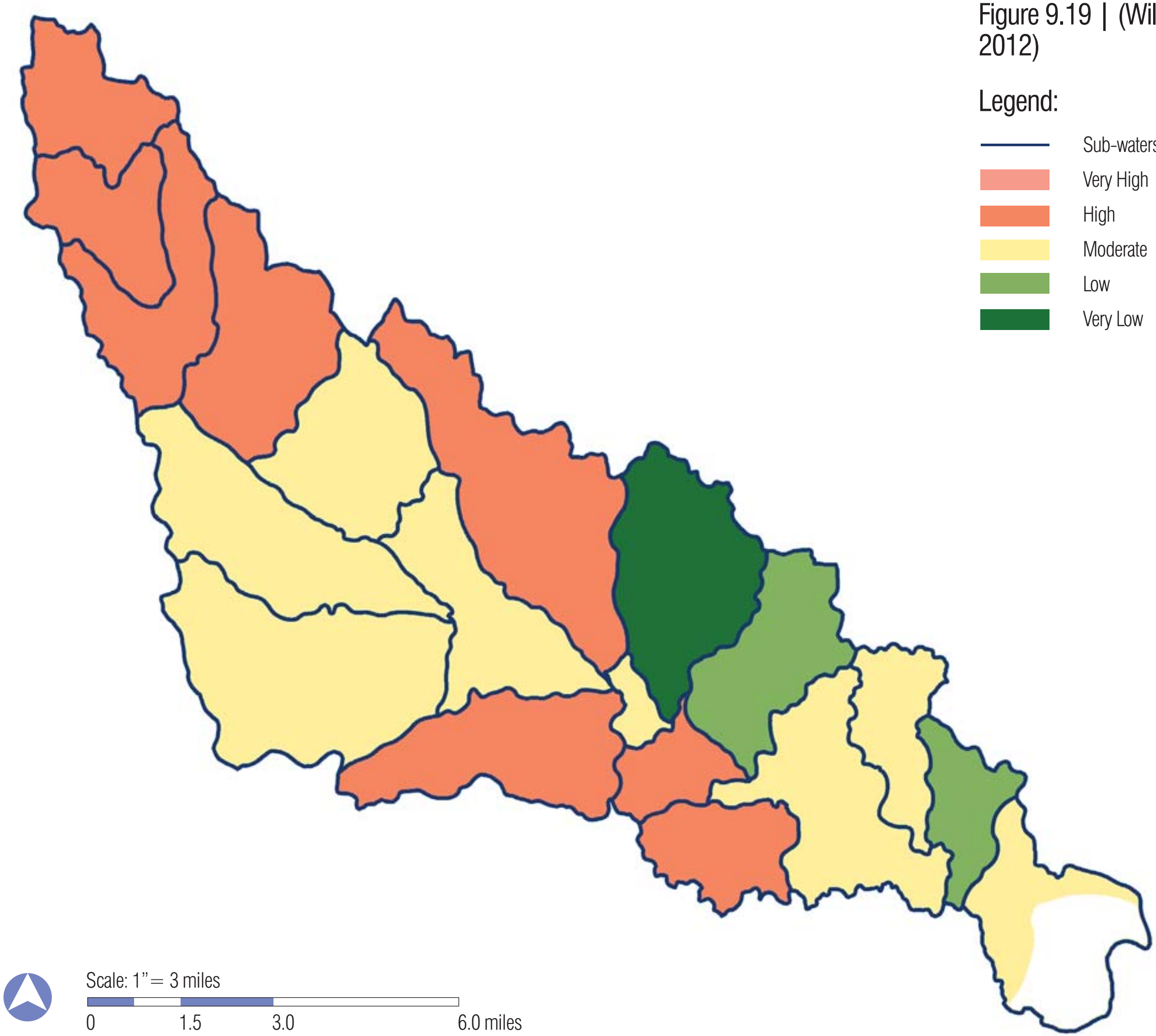
Table 9.10 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

Channel evolution ratings

Figure 9.19 | (Wildcat Creek assessment, 2012)

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

Degradation

The risk of degradation is important in considering the stability of a stream (figure 9.16). By lowering the level of the channel bed, the ability for vegetation to stabilize erosion is decreased as the channel forces act below the root zone. Degradation advances head-ward in the stream and tributaries, increasing erosion and instability. The data required for a degradation assessment included stream types (figure 9.11), stream channel evolution risk (table 9.10), streamflow changes risk (table 9.4), roads (table 9.1), drainage way crossing designs (table 9.12), in-channel mining associated with base-level shifts (not found in Wildcat Creek watershed), and direct channel impact risk (table 9.6). All data was calculated in previous assessments.

Increase in sediment supply and unstable stream conditions

Figure 9.20 | (Denlinger, 2012)

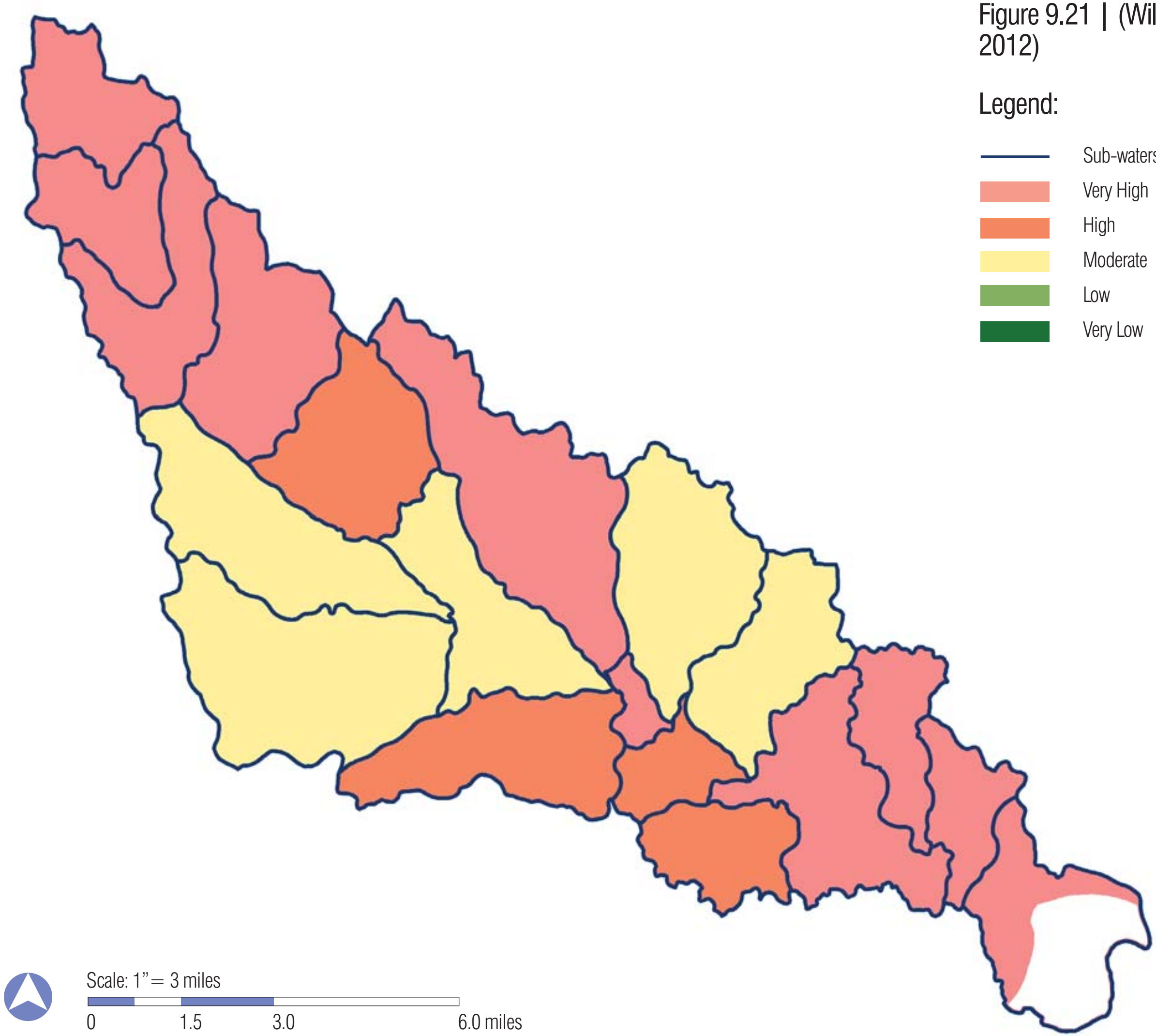
One of a multitude of locations throughout the watershed that have high levels of sediment supply and unstable streams that are going through degradation phases.

Degradation ratings

Figure 9.21 | (Wildcat Creek assessment, 2012)

Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low



(1)	(2)	(3)	(4)
Location Code/ River Reach I.D.	Risk Rating: Streamflow Changes (Table 3.4)	Risk Rating: In-Channel Mining Associated with Base-Level Shifts (Not applicable for this watershed)	Risk Rating: Channel Evolution (Table 3.9)
1. sub-watershed one	5-VeryHigh	x	4-High
2. sub-watershed two	5-VeryHigh	x	4-High
3. sub-watershed three	5-VeryHigh	x	4-High
4. sub-watershed four	5-VeryHigh	x	4-High
5. sub-watershed five	1-VeryLow	x	3-Moderate
6. sub-watershed six	4-High	x	3-Moderate
7. sub-watershed seven	1-VeryLow	x	3-Moderate
8. sub-watershed eight	4-High	x	4-High
9. sub-watershed nine	1-VeryLow	x	3-Moderate
10. sub-watershed ten	4-High	x	1-VeryLow
11. sub-watershed eleven	1-VeryLow	x	3-Moderate
12. sub-watershed twelve	5-VeryHigh	x	4-High
13. sub-watershed thirteen	3-Moderate	x	2-Low
14. sub-watershed fourteen	3-Moderate	x	4-High
15. sub-watershed fifteen	5-VeryHigh	x	3-Moderate
16. sub-watershed sixteen	1-VeryLow	x	3-Moderate
17. sub-watershed seventeen	3-Moderate	x	4-High
18. sub-watershed eighteen	3-Moderate	x	2-Low
19. sub-watershed nineteen	5-VeryHigh	x	3-Moderate

(5)	(6)	(7)
Risk Rating: Road Drainage Designs, "Shot Gun" Culverts (Base-Level Shifts) (Table 3.12)	Risk Rating: Direct Channel Impacts (Table 3.6)	Overall Risk Rating for Degradation (Insert highest adjective rating from Columns 2-6)
2-Low	4-High	5-VeryHigh
3-Moderate	5-VeryHigh	5-VeryHigh
2-Low	5-VeryHigh	5-VeryHigh
2-Low	4-High	5-VeryHigh
2-Low	2-Low	3-Moderate
3-Moderate	3-Moderate	4-High
2-Low	1-VeryLow	3-Moderate
2-Low	1-VeryLow	5-VeryHigh
2-Low	3-Moderate	3-Moderate
3-Moderate	1-VeryLow	3-Moderate
2-Low	1-VeryLow	5-VeryHigh
2-Low	1-VeryLow	4-High
3-Moderate	3-Moderate	3-Moderate
2-Low	1-VeryLow	4-High
2-Low	2-Low	5-VeryHigh
2-Low	2-Low	5-VeryHigh
3-Moderate	1-VeryLow	4-High
2-Low	5-VeryHigh	5-VeryHigh
2-Low	3-Moderate	5-VeryHigh

Summary of risk ratings for degradation

Table 9.11 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

Summary of risk ratings for drainage way crossing designs

Table 9.12 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

(1)	(2)	(3)	(4)	(5)
Location Code/ River Reach I.D.	Percent Reduction of Sinuosity (Insert Numeric Rating) (1) = No change (2) = Sinuosity reduced up to 50% (3) = Sinuosity reduced 50–80% (4) = Sinuosity reduced more than 80%	Stream Crossing Structure (Insert Numeric Rating) (1) = Bridge (2) = Arch culvert (3) = Culvert (4) = Over-steepened culvert	Subtotal S[(2)+(3)]	Increase in Energy Slope (Use (4)) VL (1) = 2 L (2) = 3 M (3) = 4 H (4) = 5–6 VH (5) = 7–8
1. sub-watershed one	2	2	4	3
2. sub-watershed two	2	3	5	4
3. sub-watershed three	2	2	4	3
4. sub-watershed four	2	1	3	2
5. sub-watershed five	1	x	1	1
6. sub-watershed six	2	3	5	4
7. sub-watershed seven	1	x	1	2
8. sub-watershed eight	1	3	4	3
9. sub-watershed nine	2	1	3	2
10. sub-watershed ten	1	3	4	3
11. sub-watershed eleven	1	1	2	1
12. sub-watershed twelve	1	x	1	1
13. sub-watershed thirteen	2	2	4	3
14. sub-watershed fourteen	1	x	1	1
15. sub-watershed fifteen	2	1	3	2
16. sub-watershed sixteen	2	1	3	2
17. sub-watershed seventeen	2	3	5	4
18. sub-watershed eighteen	2	1	3	2
19. sub-watershed nineteen	2	1	3	2

(6)	(7)	(8)	(9)	(10)
Ratio of a Decrease in W/d Ratio to Existing Reference W/d Ratio VL (1) > 8.0 L (2) = 0.61–0.80 M (3) = 0.41–0.60 H (4) = 0.21–0.40 VH (5) ≤ 0.20	Backwater Potential above Structure (Insert Numeric Rating) VL (1) = None L (2) = Slight only for floods > 50 yr recurrence interval M (3) = Some for floods 11–50 yr recurrence interval H (4) = Evident for floods 2–10 yr recurrence interval VH (5) = Backwater at bankfull discharge	Presence of Floodplain Drains (Through Fills) (Insert Numeric Rating) VL (1) = All floods greater than bankfull drain through fill L (2) = Accomodates 90% of floods M (3) = Accomodates 50–89% of floods H (4) = Evident for floods 2–10 yr recurrence interval VH (5) = Backwater at bankfull discharge	Subtotal S[(5)+(6)+(7)+(8)]	Overall Risk Rating: Culverts or Bridges VL (1) = 4 L (2) = 5–8 M (3) = 9–12 H (4) = 13–16 VH (5) = 17–20
3-Moderate	1-VeryLow	1-VeryLow	8	2-Low
3-Moderate	1-VeryLow	1-VeryLow	9	3-Moderate
3-Moderate	1-VeryLow	1-VeryLow	8	2-Low
3-Moderate	1-VeryLow	1-VeryLow	7	2-Low
3-Moderate	1-VeryLow	1-VeryLow	6	2-Low
3-Moderate	1-VeryLow	1-VeryLow	9	3-Moderate
3-Moderate	1-VeryLow	1-VeryLow	7	2-Low
3-Moderate	1-VeryLow	1-VeryLow	8	2-Low
2-Low	1-VeryLow	1-VeryLow	6	2-Low
4-High	1-VeryLow	1-VeryLow	9	3-Moderate
2-Low	1-VeryLow	1-VeryLow	5	2-Low
3-Moderate	1-VeryLow	1-VeryLow	6	2-Low
4-High	1-VeryLow	1-VeryLow	9	3-Moderate
3-Moderate	1-VeryLow	1-VeryLow	6	2-Low
3-Moderate	1-VeryLow	1-VeryLow	7	2-Low
3-Moderate	1-VeryLow	1-VeryLow	7	2-Low
3-Moderate	1-VeryLow	1-VeryLow	9	3-Moderate
3-Moderate	1-VeryLow	1-VeryLow	7	2-Low
3-Moderate	1-VeryLow	1-VeryLow	7	2-Low

Watershed Name: Wildcat Creek Watershed					Date: Spring 2012		
	Geographic Location				Stream Type Location		
Location Code/ River Reach I.D.	Step 6: Mass Erosion	Step 7: Roads Table 3.1	Step 8: Surface Erosion Table 3.2	Step 10: Streamflow Change Table 3.4	Step 13: Streambank Erosion Table 3.5	Step 14: In-Channel Mining	Step 15: Direct Channel Impacts Table 3.6
1. sub-watershed one	2-Low	2-Low	4-High	5-VeryHigh	5-VeryHigh	x	4-High
2. sub-watershed two	2-Low	3-Moderate	3-Moderate	5-VeryHigh	5-VeryHigh	x	5-VeryHigh
3. sub-watershed three	2-Low	2-Low	4-High	5-VeryHigh	5-VeryHigh	x	5-VeryHigh
4. sub-watershed four	2-Low	4-High	4-High	5-VeryHigh	5-VeryHigh	x	4-High
5. sub-watershed five	2-Low	x	x	1-VeryLow	3-Moderate	x	2-Low
6. sub-watershed six	2-Low	1-Low	3-Moderate	4-High	4-High	x	3-Moderate
7. sub-watershed seven	2-Low	x	x	1-VeryLow	3-Moderate	x	1-VeryLow
8. sub-watershed eight	2-Low	4-High	4-High	5-VeryHigh	5-VeryHigh	x	1-VeryLow
9. sub-watershed nine	2-Low	3-Moderate	1-Low	3-Moderate	5-VeryHigh	x	3-Moderate
10. sub-watershed ten	2-Low	4-High	1-Low	3-Moderate	4-High	x	1-VeryLow
11. sub-watershed eleven	2-Low	1-VeryLow	1-Low	5-VeryHigh	4-High	x	1-VeryLow
12. sub-watershed twelve	2-Low	x	x	1-VeryLow	5-VeryHigh	x	1-VeryLow
13. sub-watershed thirteen	2-Low	3-Moderate	1-Low	3-Moderate	5-VeryHigh	x	3-Moderate
14. sub-watershed fourteen	2-Low	x	1-Low	3-Moderate	4-High	x	1-VeryLow
15. sub-watershed fifteen	2-Low	3-Moderate	x	5-VeryHigh	5-VeryHigh	x	2-Low
16. sub-watershed sixteen	2-Low	3-Moderate	4-High	5-VeryHigh	5-VeryHigh	x	2-Low
17. sub-watershed seventeen	2-Low	1-VeryLow	x	1-VeryLow	4-High	x	1-VeryLow
18. sub-watershed eighteen	2-Low	4-High	1-VeryLow	5-VeryHigh	5-VeryHigh	x	5-VeryHigh
19. sub-watershed nineteen	2-Low	4-High	4-High	5-VeryHigh	5-VeryHigh	x	3-Moderate

Summary of risk ratings for RRISSC in the Wildcat Creek watershed

Table 9.13 | (Adapted from Rosgen (2009) for Wildcat Creek watershed by Wildcat Creek assessment, 2012)

Observers: Wildcat Creek WARSSS Group

Step 16: Channel Enlargement Table 3.7	Step 17: Aggradation/ Excess Sediment Table 3.8	Step 18: Channel Evolution/ Succession States Table 3.10	Step 19: Degradation Table 3.11	Processes Identified by Step for Advancement to *PLA*	Check Location Selected for Advancement to *PLA*
5-VeryHigh	4-High	4-High	5-VeryHigh	5-VeryHigh	√
5-VeryHigh	5-VeryHigh	4-High	5-VeryHigh	5-VeryHigh	√
5-VeryHigh	5-VeryHigh	4-High	5-VeryHigh	5-VeryHigh	√
5-VeryHigh	5-VeryHigh	4-High	5-VeryHigh	5-VeryHigh	√
4-High	3-Moderate	3-Moderate	3-Moderate	4-High	√
5-VeryHigh	4-High	3-Moderate	4-High	5-VeryHigh	√
2-Low	3-Moderate	3-Moderate	3-Moderate	3-Moderate	
5-VeryHigh	5-VeryHigh	4-High	5-VeryHigh	5-VeryHigh	√
5-VeryHigh	4-High	3-Moderate	3-Moderate	5-VeryHigh	√
4-High	3-Moderate	1-VeryLow	3-Moderate	4-High	√
5-VeryHigh	4-High	3-Moderate	5-VeryHigh	5-VeryHigh	√
4-High	3-Moderate	4-High	4-High	4-High	√
5-VeryHigh	4-High	2-Low	3-Moderate	5-VeryHigh	√
4-High	4-High	4-High	4-High	4-High	√
5-VeryHigh	4-High	3-Moderate	5-VeryHigh	5-VeryHigh	√
5-VeryHigh	5-VeryHigh	3-Moderate	5-VeryHigh	5-VeryHigh	√
4-High	4-High	4-High	4-High	4-High	√
5-VeryHigh	4-High	2-Low	5-VeryHigh	5-VeryHigh	√
5-VeryHigh	5-VeryHigh	3-Moderate	5-VeryHigh	5-VeryHigh	√

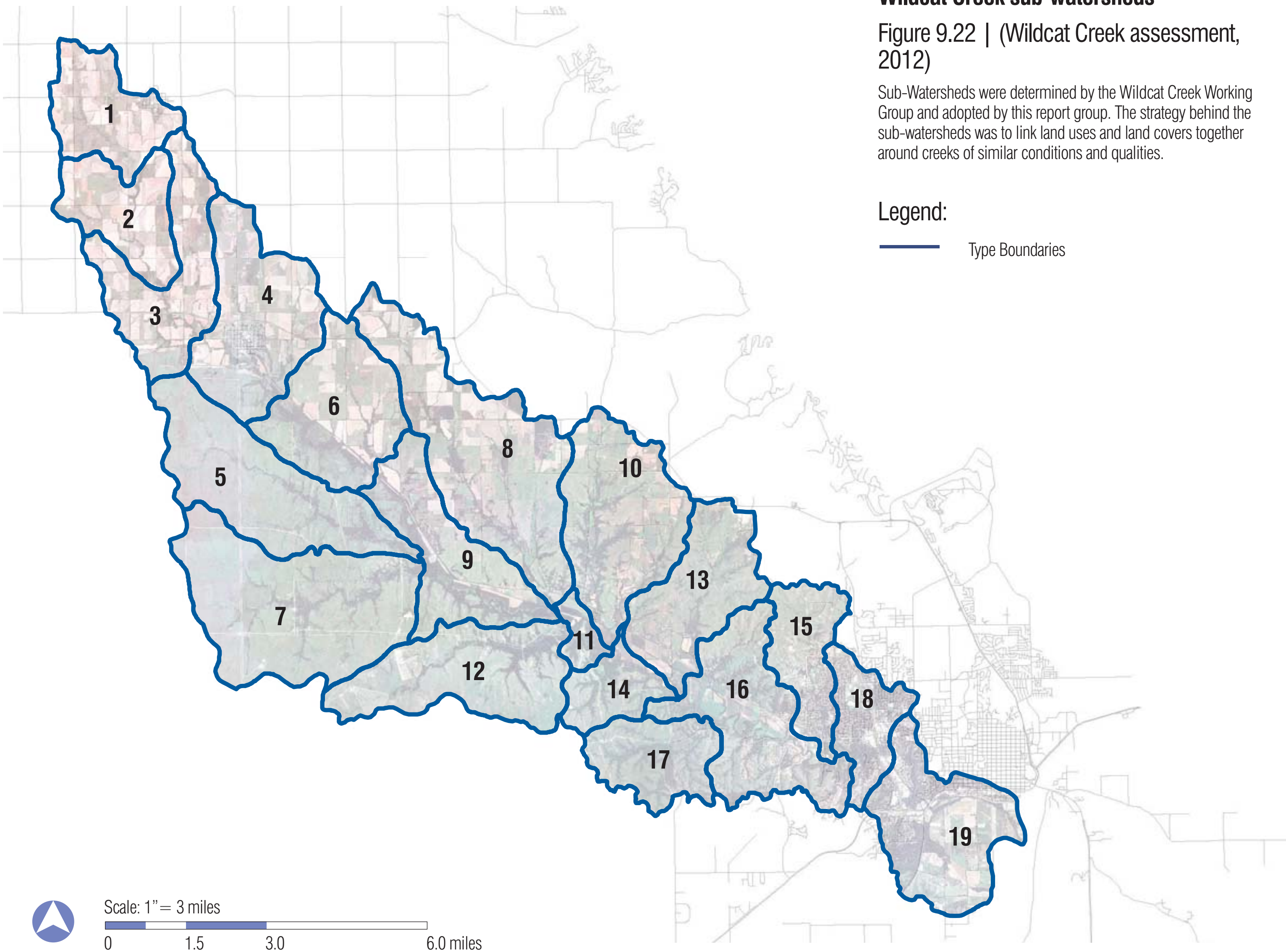
Wildcat Creek sub-watersheds

Figure 9.22 | (Wildcat Creek assessment, 2012)

Sub-Watersheds were determined by the Wildcat Creek Working Group and adopted by this report group. The strategy behind the sub-watersheds was to link land uses and land covers together around creeks of similar conditions and qualities.

Legend:

Type Boundaries



Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

Sub-Watershed 1

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Surface Erosion

Sub-watershed 1 contains large areas of conventional agricultural practices which expose over 50 percent of the bare earth making it vulnerable to surface erosion. Additionally, a lack of sufficient stream buffers and a small distance from disturbances to the streams are contributing factors. Sub-watershed 1 is given a rating of *Very High* for this vulnerability and thus is forwarded to the *PLA* level.

Streamflow Change

Sub-watershed 1 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of conventional agriculture along with the town of Leonardville's impervious surfaces, create an environment susceptible to increased run-off due to land use practices especially for the "weak link" G6 streams.

Streambreak Erosion

All stream types within sub-watershed 1 are classified as G or F types. The streams within sub watershed 1 rated as *Very High* regarding streambank erosion risk as a result of the bank-height ratio evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub watershed 1.

Direct Channel Impacts

The F and G type streams within sub-watershed 1 rated as *High* risk. The percentage of channel length impacted was evaluated as a *High* risk, resulting in the overall *High* rating. All streams within sub-watershed 1 require evaluation at the *PLA* level.

Channel Enlargment

The F and G type streams within sub-watershed 1 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes and streambank erosion within sub-watershed 1. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 1 require evaluation at the *PLA* level.

Aggradation/Excess Sediment Supply

The F type streams within sub-watershed 1 rated as *High* risk. This is a result of the contribution from the risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single elevated rating would have required the classification of aggradation or an excess sediment supply as a *High* risk, two elevated contributing factors reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 1 require evaluation at the *PLA* level.

Channel Evolution/ Successional States

Within sub-watershed 1 a stream received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub-watershed 1 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 1 is stream flow changes. All streams within sub watershed 1 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub watershed 1 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 2

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streamflow Change

Sub-watershed 2 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of conventional agriculture creates an environment susceptible to increased run-off due to land use practices particularly for "weak link" G6 streams.

Streambank Erosion

All stream types within sub-watershed 2 are classified as G or F types. All of the streams within sub-watershed 2 rated as *Very High* regarding streambank erosion risk as a result of the bank-height ratio evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 2.

Direct Channel Impacts

The F and G type streams within sub-watershed 2 rated as *Very High* risk. The percentage of channel length impacted was evaluated as a *Very High* risk, resulting in the overall *Very High* rating. All streams within sub-watershed 2 require evaluation at the *PLA* level.

Channel Enlargement

The F and G type streams within sub-watershed 2 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes, streambank erosion, and direct channel impacts within sub-watershed 2. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, three contributing factor's risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 2 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 2 rated as *Very High* risk. This is a result of the *Very High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 2 require evaluation at the *PLA* level.

Channel Evolution | Successional States

Within sub-watershed 2, a stream received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub-watershed 2 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub watershed 2 is direct channel impacts. All streams within sub-watershed 2 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 2 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 3

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Surface Erosion

Sub-watershed 3 contains large areas of conventional agricultural practices which expose over 50 percent of the bare earth making it vulnerable to surface erosion. Additionally, a lack of sufficient stream buffers and a small distance from disturbances to the streams are contributing factors. Sub-watershed 3 is given a rating of *Very High* for this vulnerability and thus is forwarded to the *PLA* level.

Streamflow Change

Sub-watershed 3 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of conventional agriculture along with the town of Riley's impervious surfaces, create an environment susceptible to increased run-off due to land use practices especially for the "weak link" G6 streams.

Streambank Erosion

All stream types within sub-watershed 3 are classified as G or F types. The streams within sub-watershed 3 rated as *Very High* regarding streambank erosion risk as a result of the bank-height ratio evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub watershed 3.

Direct Channel Impacts

The F and G type streams within sub-watershed 3 rated as *Very High* risk. The percentage of channel length impacted was evaluated as a *Very High* risk, resulting in the overall *High* rating. All streams within sub-watershed 3 require evaluation at the *PLA* level.

Channel Enlargement

The F and G type streams within sub-watershed 3 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes, streambank erosion, and direct channel impacts within sub-watershed 3. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, three contributing factor's risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 3 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 3 rated as *Very High* risk. This is a result of the *Very High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 3 require evaluation at the *PLA* level.

Channel Evolution | Successional States

Within sub-watershed 3 streams received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub watershed 3 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. The new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 3 is direct channel impacts. All streams within sub-watershed 3 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 3 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 4

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Roads

Roads in sub-watershed 4 rated *High* risk to sediment contribution. The roads will be forwarded to the *PLA* phase for further assessment concerning specific annual sediment contributions and potential remediation.

Surface Erosion

Sub-watershed 4 contains large areas of conventional agricultural practices which expose over 50 percent of the bare earth making it vulnerable to surface erosion. Additionally, a lack of sufficient stream buffers and a small distance from disturbances to the streams are contributing factors. A rating of *Very High* was given for this vulnerability and thus is forwarded to the *PLA* level.

Streamflow Changes

Sub-watershed 4 is designated as a *Very High* risk rating and requires further assessment at the *PLA* level. The large area of conventional agriculture along with the town of Riley's impervious surfaces, create an environment susceptible to increased run-off due to land use practices especially for the "weak link" G4 streams.

Streambank Erosion

All stream types within sub-watershed 4 are classified as G or F types resulting in a *Very High* rating from the bank-height ratio evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 4.

Direct Channel Impacts

The F and G type streams within sub-watershed 4 rated as *High* risk and the percentage of channel length impacted was evaluated as a *High* risk, resulting in the overall *High* rating. All streams within sub-watershed 4 require evaluation at the *PLA* level.

Channel Enlargement

The F and G type streams within sub-watershed 4 rated as *Very High* risk as a result of the combined effects of streamflow changes and streambank erosion within sub-watershed 4. Although a single *Very High* rating was required to classify channel enlargement as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 4 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 4 rated as *Very High* risk. A result of the *Very High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of an increase in aggradation or excess sediment supply. All streams within sub-watershed 4 require evaluation at the *PLA* level.

Channel Evoluation | Successional States

Within sub-watershed 4 a stream received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub-watershed 4 rated as *Very High* risk. The down cutting common with G type streams results in a decrease in width/depth ratio causing a lowering of the base level and abandonment of the floodplain advancing on all connected reaches. The most likely factor to encourage degradation in sub-watershed 4 is direct channel impacts. All streams within sub-watershed 4 advanced to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub watershed 4 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 5 and 7

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streambank Erosion

All stream types within sub-watersheds 5 and 7 are located within Fort Riley and classified as G or F types. All of the streams within sub-watersheds 5 and 7 are rated as *Moderate* regarding streambank erosion risk. Vegetation along stream banks for most areas is consistent the likelihood that sub watersheds 5 and 7 will suffer from increased erosion rates is a moderate risk. Monitoring is required for sub-watersheds 5 and 7.

Channel Enlargement

The F and G type streams within sub-watershed 5 are rated as *High* risk. The *High* risk rating was a result of local knowledge of the northern Ft. Riley area which moved the risk from *Moderate* to *High*. All streams within sub-watershed 5 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watersheds 5 and 7 are rated as *Moderate* risk. This is a result of the adjustment of the *High* risk rating of channel enlargement for sub-watershed 5 to reflect the unadjusted risk. All streams within sub watershed 5 and 7 require monitoring.

Channel Evolution | Successional States

Within sub-watershed 5 and 7 streams received a *Moderate* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further monitoring.

Degradation

The G type streams within sub-watersheds 5 and 7 rated as *Moderate* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub watershed 3 is channel evolution. All streams within sub-watersheds 5 and 7 should be monitored for change.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 5 had at least **one** *High* risk rating. Sub-watershed 7 had at least **one** *Moderate* risk rating. Due to the adjacency of the watersheds and that they share the mitigating factor of military land use, it is suggested that both sub-watersheds advance to the *PLA* phase for further detailed evaluation.

Sub-Watershed 6

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streamflow Change

Sub-watershed 6 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of conventional agriculture creates an environment susceptible to increased run-off due to land use practices particularly for "weak link" G4 and F4 streams.

Streambank Erosion

All stream types within sub-watershed 6 are classified as G or F types. All of the streams within sub watershed 6 rated as *High* regarding streambank erosion risk as a result of the bank-height ratio evaluation as *High* risk. Further analysis at the *PLA* level is required for sub watershed 6.

Channel Enlargement

The F type streams within sub-watershed 6 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes, streambank erosion, and an adjustment up one risk level due to local knowledge of the area. The local knowledge available concerning behavior of the stream in this reach reinforces the probability of Channel Enlargement. All streams within sub-watershed 6 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F and G type streams within sub-watershed 6 rated as *High* risk. This is a result of the adjustment of the *Very High* risk rating of channel enlargement for sub watershed 6 to reflect the unadjusted risk. All streams within sub watershed 6 require evaluation at the *PLA* level.

Degradation

The G type streams within sub-watershed 6 rated as *High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 6 is stream flow changes. All streams within sub-watershed 6 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 6 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 8

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Roads

The roads in sub-watershed 8 rated as a *High* risk to sediment contribution. The roads in sub-watershed 8 thus, will be forwarded to the *PLA* phase for further assessment concerning specific annual sediment contributions as well as potential remediation.

Surface Erosion

Sub-watershed 8 contains large areas of conventional agricultural practices which expose over 50 percent of the bare earth making it vulnerable to surface erosion. Additionally, a lack of sufficient stream buffers and a small distance from disturbances to the streams are contributing factors. Sub-watershed 8 is given a rating of *High* for this vulnerability and thus is forwarded to the *PLA* level.

Streamflow Change

Sub-watershed 1 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of conventional agriculture creates an environment susceptible to increased run-off due to land use practices especially for the "weak link" G4 streams.

Streambank Erosion

All stream types within sub-watershed 8 are classified as G or F types. The streams within sub-watershed 8 rated as *Very High* regarding streambank erosion risk as a result of the bank-height ratio evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 8.

Channel Enlargement

The F and G type streams within sub-watershed 8 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes and streambank erosion within sub-watershed 8. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 8 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 8 rated as *Very High* risk. This is a result of the *Very High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 8 require evaluation at the *PLA* level.

Channel Evolution | Successional States

Within sub-watershed 8 streams received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub-watershed 8 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 8 is stream flow changes. All streams within sub-watershed 8 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 8 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 9

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streambank Erosion

All stream types within sub-watershed 9 are classified as G or F types. The streams within sub-watershed 9 rated as *Very High* regarding streambank erosion risk as adjustments up one risk level to the bank-height ratio evaluation and radius of curvature divided by bankfull width. Further analysis at the *PLA* level is required for sub-watershed 9.

Channel Enlargement

The F and G type streams within sub-watershed 9 rated as *Very High* risk. The *Very High* risk rating was a result of the effect of streambank erosion within sub-watershed 9. All streams within sub-watershed 9 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 9 rated as *High* risk. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. All streams within sub-watershed 9 require evaluation at the *PLA* level.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 9 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 10

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Roads

The roads in sub-watershed 10 rated as a *High* risk to sediment contribution. The roads in sub-watershed 10 thus, will be forwarded to the *PLA* phase for further assessment concerning specific annual sediment contributions as well as potential remediation.

Streambank Erosion

All stream types within sub-watershed 10 are classified as G or F types. The streams within sub-watershed 10 rated as *High* regarding streambank erosion risk as a result of an adjustment up one risk level due to local knowledge. Further analysis at the *PLA* level is required for sub watershed 10.

Channel Enlargement

The F and G type streams within sub-watershed 10 rated as *High* risk. The *High* risk rating was a result of the effect of the streambank erosion adjusted risk rating within sub-watershed 10. All streams within sub-watershed 10 require evaluation at the *PLA* level.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 4 had at least **one** *High* risk rating. The location of the sub-watershed within an area of grazed grassland, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 11

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streamflow Change

Sub-watershed 11 is designated as having *Very High* risk ratings and requires further assessment at the PLA level. The large area of conventional agriculture creates an environment susceptible to increased run-off due to land use practices especially for the “weak link” G4 streams.

Streambank Erosion

All stream types within sub-watershed 11 are classified as G or F types. The streams within sub-watershed 11 rated as High regarding streambank erosion risk as a result of the bank-height ratio evaluation as *High* risk. Further analysis at the PLA level is required for sub-watershed 11.

Channel Enlargement

The F and G type streams within sub-watershed 11 rated as *Very High* risk. The *Very High* risk rating was a result of the effect of streamflow changes within sub-watershed 11. All streams within sub-watershed 11 require evaluation at the PLA level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 11 rated as *High* risk. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. All streams within sub-watershed 11 require evaluation at the PLA level.

Degradation

The G type streams within sub-watershed 11 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 11 is stream flow changes. All streams within sub-watershed 11 should advance to the PLA level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 11 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the PLA phase for further detailed evaluation.

Sub-Watershed 12

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streambank Erosion

All stream types within sub-watershed 12 are classified as G or F types. The streams within sub-watershed 12 rated as *Very High* regarding streambank erosion risk as a result of the increase one level of the bank-height ratio evaluation from *High* risk. Further analysis at the PLA level is required for sub-watershed 12.

Channel Enlargement

The F and G type streams within sub-watershed 12 rated as *High* risk. The *High* risk rating was a result the reduction of the *Very High* risk rating of the effect of streambank erosion to the original level. All streams within sub-watershed 12 require evaluation at the PLA level.

Channel Evolution | Successional States

Within sub-watershed 12 streams received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the PLA level.

Degradation

The G type streams within sub-watershed 12 rated as *High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. The new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 12 is direct channel impacts. All streams within sub-watershed 12 should advance to the PLA level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 12 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the PLA phase for further detailed evaluation.

Sub-Watershed 13

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streambank Erosion

All stream types within sub-watershed 13 are classified as G or F types. All of the streams within sub-watershed 13 rated as *Very High* due to the one level adjustment caused by the sporadic nature of the vegetative composition evaluated as *High* risk. Further analysis at the *PLA* level is required for sub-watershed 13.

Channel Enlargement

The F type streams within sub-watershed 13 rated as *Very High* risk. The *Very High* risk rating was a result of the effect of streambank erosion, and an adjustment up one risk level due to local knowledge of the area. The local knowledge available concerning behavior of the stream in this reach reinforces the probability of Channel Enlargement. All streams within sub-watershed 13 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F and G type streams within sub-watershed 13 rated as *High* risk. This is a result of the adjustment of the *Very High* risk rating of channel enlargement for sub-watershed 13 to reflect the unadjusted risk. All streams within sub-watershed 13 require evaluation at the *PLA* level.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 13 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 14

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streambank Erosion

All stream types within sub-watershed 14 are classified as G or F types. All of the streams within sub-watershed 14 rated as *High* regarding streambank erosion risk as a result of the bank-height ratio evaluation as *High* risk. Further analysis at the *PLA* level is required for sub-watershed 14.

Channel Enlargement

The F type streams within sub-watershed 14 rated as *High* risk. The *High* risk rating was a result of the effect of the *High* streambank erosion risk rating. All streams within sub-watershed 14 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F and G type streams within sub-watershed 14 rated as *High* risk. This is a result of the *High* risk rating of channel enlargement for sub-watershed 14. All streams within sub-watershed 14 require evaluation at the *PLA* level.

Channel Evolution | Successional States

Within sub-watershed 14 streams received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub-watershed 14 rated as *High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. The new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 14 is the effect of channel evolution. All streams within sub-watershed 14 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 14 had at least **one** *High* risk rating. The location of the sub-watershed within a grazed pasture area, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 15

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streamflow Change

Sub-watershed 15 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of grazed pasture, along with the suburban areas of Manhattan's impervious surfaces, create an environment susceptible to increased run-off due to land use practices especially for the "weak link" G4 streams.

Streambank Erosion

All stream types within sub-watershed 15 are classified as G or F types. The streams within sub-watershed 15 rated as *Very High* regarding streambank erosion risk. The rating resulted from the upward adjustments of bank-height ratio and vegetative composition due to the proximity and influence of the urban elements of Manhattan, to *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 15.

Channel Enlargement

The F and G type streams within sub-watershed 15 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes and streambank erosion within sub-watershed 15. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of channel enlargement. All streams within sub-watershed 15 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 15 rated as *High* risk. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. All streams within sub-watershed 4 require evaluation at the *PLA* level.

Degradation

The G type streams within sub-watershed 15 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 15 is streamflow changes. All streams within sub-watershed 15 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 15 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 16

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Surface Erosion

Sub-watershed 16 contains large areas of conventional agricultural practices, grazed pasture, and suburban sprawl which expose over 50 percent of the bare earth making it vulnerable to surface erosion. Additionally, a lack of sufficient stream buffers and a small distance from disturbances to the streams are contributing factors. Sub-watershed 16 is given a rating of *Very High* for this vulnerability and thus is forwarded to the *PLA* level.

Streamflow Change

Sub-watershed 16 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of conventional agriculture and grazed pasture along with the impervious surfaces of suburban Manhattan, create an environment susceptible to increased run-off due to land use practices especially for the “weak link” G4 streams.

Streambank Erosion

All stream types within sub-watershed 16 are classified as G or F types. The streams within sub-watershed 16 rated as *Very High* regarding streambank erosion risk as a result of the vegetation composition evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 16.

Channel Enlargement

The F and G type streams within sub-watershed 16 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes and streambank erosion within sub-watershed 16. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, two contributing factor’s risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 16 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 16 rated as *Very High* risk. This is a result of the *Very High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor’s risk rating as *Very High* reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 16 require evaluation at the *PLA* level.

Degradation

The G type streams within sub-watershed 16 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 16 is streamflow changes. All streams within sub-watershed 16 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 16 had at least **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural, grazed pasture, and suburban zone, with the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 17

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Streambank Erosion

All stream types within sub-watershed 17 are classified as G or F types. The streams within sub-watershed 17 rated as *High* regarding streambank erosion risk as a result of the decrease of one level of the bank-height ratio evaluation from *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 17.

Channel Enlargement

The F and G type streams within sub-watershed 17 rated as *High* risk. The *High* risk rating was a result the reduction of the *Very High* risk rating of the effect of streambank erosion to the *High* level. All streams within sub-watershed 17 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 17 rated as *High* risk. This is a result of the *High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor's risk rating as *Very High* reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 17 require evaluation at the *PLA* level.

Channel Evolution | Successional States

Within sub-watershed 17 streams received a *High* risk rating for reaches which will have the probability to incur a time-trend shift from G to F. The targeted reaches will require further assessment at the *PLA* level.

Degradation

The G type streams within sub-watershed 17 rated as *High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. The new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 17 is channel evolution. All streams within sub-watershed 17 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 17 had at least **one** *High* risk rating. The location of the sub watershed within a grazed pasture area, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 18

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Roads

The roads in sub-watershed 18 rated as a *High* risk to sediment contribution. The roads in sub-watershed 18 thus, will be forwarded to the *PLA* phase for further assessment concerning specific annual sediment contributions as well as potential remediation.

Streamflow Change

Sub-watershed 18 is designated as having *Very High* risk ratings and requires further assessment at the *PLA* level. The large area of suburban sprawl creates an environment susceptible to increased run-off due to land use practices especially for the "weak link" G4 and F4 streams.

Streambank Erosion

All stream types within sub-watershed 18 are classified as G or F types. The streams within sub-watershed 18 rated as *Very High* regarding streambank erosion risk as a result of the vegetative composition evaluation as *Very High* risk. Further analysis at the *PLA* level is required for sub-watershed 18.

Direct Channel Impacts

The F and G type streams within sub-watershed 18 rated as *Very High* risk. The percentage of channel length impacted was evaluated as a *Very High* risk, resulting in the overall *Very High* rating. All streams within sub-watershed 18 require evaluation at the *PLA* level.

Channel Enlargement

The F and G type streams within sub-watershed 18 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes, streambank erosion, and direct channel impacts within sub watershed 18. Although a single *Very High* rating would have been required to classify channel enlargement as a *Very High* risk, three contributing factor's risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 18 require evaluation at the *PLA* level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 18 rated as *High* risk. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. All streams within sub-watershed 18 require evaluation at the *PLA* level.

Degradation

The G type streams within sub-watershed 18 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. The new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 18 is direct channel impacts. All streams within sub-watershed 18 should advance to the *PLA* level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 18 had at least **one** *High* risk rating and **one** *Very High* risk rating. The location of the sub-watershed within a conventional agricultural zone, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the *PLA* phase for further detailed evaluation.

Sub-Watershed 19

Table 9.13 is the summary of the process-based risk analysis for sediment supply and stream channel stability (RRISSC). The following recommendations are based upon the RRISSC analysis.

Roads

The roads in sub-watershed 19 rated as a *High* risk to sediment contribution. The roads in sub-watershed 19 thus, will be forwarded to the PLA phase for further assessment concerning specific annual sediment contributions as well as potential remediation.

Surface Erosion

Sub-watershed 19 contains large areas densely populated urban land practices which expose over 50 percent of the bare earth making it vulnerable to surface erosion. Additionally, a lack of sufficient stream buffers and a small distance from disturbances to the streams are contributing factors. Sub-watershed 19 is given a rating of *Very High* for this vulnerability and thus is forwarded to the PLA level.

Streamflow Change

Sub-watershed 19 is designated as having *Very High* risk ratings and requires further assessment at the PLA level. The large urban area of Manhattan creates an environment susceptible to increased run-off due to land use practices particularly for “weak link” G4 and F4 streams.

Streambank Erosion

All stream types within sub-watershed 19 are classified as G or F types. All of the streams within sub-watershed 19 rated as *Very High* regarding streambank erosion risk as a result of an increase of one risk level of the bank-height ratio and vegetative composition evaluations from *High* risk to *Very High* risk. Further analysis at the PLA level is required for sub-watershed 19.

Channel Enlargement

The F and G type streams within sub-watershed 19 rated as *Very High* risk. The *Very High* risk rating was a result of the combined effects of streamflow changes and streambank erosion within sub-watershed 19. Although a single Very High rating would have been required to classify channel enlargement as a *Very High* risk, three contributing factor’s risk rating as *Very High* reinforces the probability of Channel Enlargement. All streams within sub-watershed 19 require evaluation at the PLA level.

Aggradation | Excess Sediment Supply

The F type streams within sub-watershed 19 rated as *Very High* risk. This is a result of the *Very High* risk ratings of channel enlargement and streambank erosion factors. The increased erosion causes an excess in sediment supply which influence an increase in both belt width and width/depth ratio. Although a single *Very High* rating would have been required to classify aggradation or an excess sediment supply as a *Very High* risk, two contributing factor’s risk rating as *Very High* reinforces the probability of an increase in aggradation or an excess sediment supply. All streams within sub-watershed 19 require evaluation at the PLA level.

Degradation

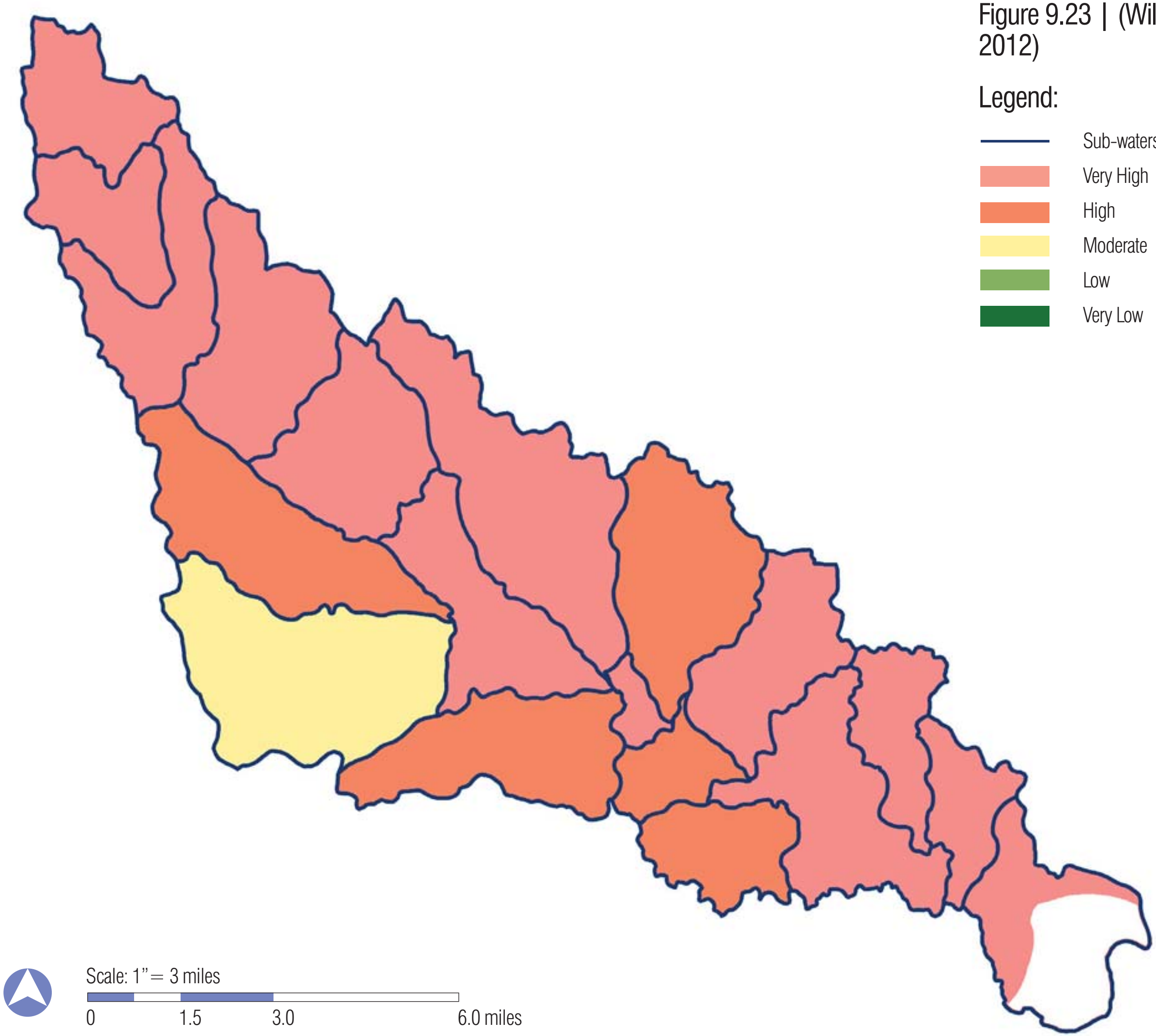
The G type streams within sub-watershed 19 rated as *Very High* risk. The down cutting common with G type streams will result in a decrease in width/depth ratio. This will cause a lowering of the base level and abandonment of the flood plain. This new base level will then advance on all connected reaches. The most likely factor to encourage degradation in sub-watershed 19 is stream flow changes. All streams within sub-watershed 19 should advance to the PLA level for detailed location analysis and evaluation.

Overall Review

The overall RRISSC summary worksheet indicates that sub-watershed 19 had at least **one** *High* risk rating and **one** *Very High* risk rating. The lower area of sub-watershed 19 below the locks were not considered in this assessment. The location of the sub-watershed within a densely populated urban area, and the associated land use practices are a driving force behind these elevated risk ratings. The areas rated as *High* and *Very High* will be forwarded to the PLA phase for further detailed evaluation.

Advancement Ratings

Figure 9.23 | (Wildcat Creek assessment, 2012)



Legend:

- Sub-watershed Boundary
- Very High
- High
- Moderate
- Low
- Very Low

Scale: 1" = 3 miles

0 1.5 3.0 6.0 miles

TR-55 Calculations

The calculations done for the TR-55 watershed assessment were used in determining the estimation of runoff for the watershed scale design.

For each sub-watershed

Sub-watershed 1

Table 10.1 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
1	1	60,402.63	97,044,408.37	2,227.83	0.93	row_c+t_poor	d	80.00	74.44		
20	1	16,949.49	3,828,715.77	87.90	0.04	1/3_acre	d	86.00	3.16		
71	1	2,958.20	452,323.59	10.38	0.00	row_c+t_poor	b	70.00	0.30		
72	1	8,858.25	2,037,016.24	46.76	0.02	row_c+t_poor	b	70.00	1.37		
73	1	1,196.84	77,239.39	1.77	0.00	row_c+t_poor	u_d	80.00	0.06		
74	1	1,540.74	130,530.94	3.00	0.00	row_c+t_poor	u_d	80.00	0.10		
986	1	1,800.08	202,451.51	4.65	0.00	com_business	d	95.00	0.18		
987	1	1,023.91	63,586.87	1.46	0.00	com_business	d	95.00	0.06		
988	1	4,850.64	458,397.25	10.52	0.00	com_business	d	95.00	0.42		
			104,294,669.93	**2,394.28**	**1.00**				**80.09**	**2.49**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.17	**0.43**	***1,031.07***	1,054,308.00	24.20	515.53	**21.30**	5,802,028.08	133.20	515.53	**3.87**

Sub-watershed 2

Table 10.2 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
10	10	134,348.72	74,109,327.63	1,701.32	0.39	range_poor	d	89.00	34.61		
52	10	4,961.90	1,383,696.26	31.77	0.01	row_sr_poor	d	91.00	0.66		
53	10	11,571.05	5,284,594.55	121.32	0.03	row_sr_poor	b	81.00	2.25		
54	10	8,182.25	1,612,490.71	37.02	0.01	range_good	c	74.00	0.63		
55	10	2,873.68	482,288.88	11.07	0.00	range_good	d	80.00	0.20		
56	10	6,913.51	1,993,694.88	45.77	0.01	row_c+t_good	d	81.00	0.85		
57	10	7,980.17	2,529,742.59	58.07	0.01	row_c+t_good	d	81.00	1.08		
58	10	24,754.95	5,925,316.83	136.03	0.03	range_good	c	74.00	2.30		
332	10	2,094.32	152,110.28	3.49	0.00	row_sr_poor	c	88.00	0.07		
333	10	2,387.38	333,650.61	7.66	0.00	row_sr_poor	d	91.00	0.16		
334	10	2,108.35	169,411.98	3.89	0.00	row_sr_poor	c	88.00	0.08		
335	10	3,952.01	727,370.51	16.70	0.00	row_sr_poor	c	88.00	0.34		
336	10	384.50	10,116.97	0.23	0.00	row_sr_poor	b	81.00	0.00		
337	10	765.62	15,643.66	0.36	0.00	row_sr_poor	u_d	91.00	0.01		
495	10	3,185.97	437,251.01	10.04	0.00	range_poor	d	89.00	0.20		
496	10	50,051.04	9,584,691.94	220.03	0.05	range_poor	b	79.00	3.97		
497	10	645.19	25,111.58	0.58	0.00	range_poor	d	89.00	0.01		
498	10	992.37	55,912.43	1.28	0.00	range_poor	d	89.00	0.03		
499	10	2,305.73	84,059.01	1.93	0.00	range_poor	c	86.00	0.04		
500	10	19,450.59	2,501,446.12	57.43	0.01	range_poor	c	86.00	1.13		
501	10	24,867.11	3,804,059.93	87.33	0.02	range_poor	b	79.00	1.58		
502	10	1,986.40	151,934.20	3.49	0.00	range_poor	d	89.00	0.07		
503	10	3,374.53	167,692.95	3.85	0.00	range_poor	d	89.00	0.08		
504	10	589.48	17,935.56	0.41	0.00	range_poor	c	86.00	0.01		
505	10	712.67	20,267.12	0.47	0.00	range_poor	c	86.00	0.01		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 2 continued...

Table 10.2 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
505	10	712.67	20,267.12	0.47	0.00	range_poor	c	86.00	0.01		
506	10	6,665.98	893,823.23	20.52	0.00	range_poor	d	89.00	0.42		
507	10	4,890.44	574,045.94	13.18	0.00	range_poor	b	79.00	0.24		
508	10	2,746.83	352,010.36	8.08	0.00	range_poor	c	86.00	0.16		
509	10	56,040.61	21,264,430.00	488.16	0.11	range_poor	c	86.00	9.59		
510	10	83,471.29	43,695,510.82	1,003.11	0.23	range_poor	c	86.00	19.72		
511	10	36,083.84	6,940,254.60	159.33	0.04	range_poor	c	86.00	3.13		
512	10	1,439.28	105,644.91	2.43	0.00	range_poor	c	86.00	0.05		
513	10	5,442.92	800,183.70	18.37	0.00	row_c+t_good	c	78.00	0.33		
514	10	4,189.08	498,723.45	11.45	0.00	row_c+t_good	c	78.00	0.20		
515	10	3,097.57	256,677.08	5.89	0.00	range_good	d	80.00	0.11		
516	10	2,057.10	206,344.67	4.74	0.00	range_good	d	80.00	0.09		
517	10	2,332.53	187,246.36	4.30	0.00	range_good	d	80.00	0.08		
518	10	16,878.38	2,445,091.11	56.13	0.01	range_good	d	80.00	1.03		
519	10	2,481.20	187,872.54	4.31	0.00	range_good	d	80.00	0.08		
520	10	759.97	14,699.14	0.34	0.00	range_good	b	61.00	0.00		
521	10	4,132.64	596,725.50	13.70	0.00	range_good	b	61.00	0.19		
			190,599,101.59	**4,375.55**	**1.00**				**85.75**	**1.66**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.82	**0.48**	***2,121.72***	306,605.20	7.04	1,060.86	**150.72**	2,932,875.33	67.33	1,060.86	**15.76**

Sub-watershed 3

Table 10.3 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
11	11	21,942.34	7,077,870.97	162.49	0.31	row_sr_poor	b	81.00	25.41		
50	11	4,218.78	867,715.57	19.92	0.04	range_poor	c	86.00	3.31		
51	11	16,245.81	8,634,468.01	198.22	0.38	range_good	c	74.00	28.32		
321	11	1,255.57	23,777.72	0.55	0.00	row_sr_poor	u_d	91.00	0.10		
322	11	561.27	10,769.15	0.25	0.00	row_sr_poor	u_d	91.00	0.04		
323	11	1,728.00	22,765.08	0.52	0.00	row_sr_poor	u_d	91.00	0.09		
324	11	12,257.75	509,444.24	11.70	0.02	row_sr_poor	u_d	91.00	2.05		
325	11	1,277.69	69,226.74	1.59	0.00	row_sr_poor	c	91.00	0.28		
326	11	6,668.30	1,351,968.43	31.04	0.06	row_sr_poor	b	91.00	5.45		
327	11	5,510.64	250,530.19	5.75	0.01	row_sr_poor	d	91.00	1.01		
328	11	1,868.65	144,479.79	3.32	0.01	row_sr_poor	b	91.00	0.58		
329	11	4,286.66	479,697.90	11.01	0.02	row_sr_poor	c	91.00	1.93		
330	11	487.40	7,087.16	0.16	0.00	row_sr_poor	d	91.00	0.03		
331	11	8,046.24	2,169,761.74	49.81	0.10	row_sr_poor	c	91.00	8.75		
369	11	1,673.98	128,695.18	2.95	0.01	range_good	b	61.00	0.35		
370	11	135.43	870.53	0.02	0.00	range_good	b	61.00	0.00		
371	11	2,408.82	69,381.42	1.59	0.00	range_good	u_d	80.00	0.25		
372	11	1,302.42	78,694.62	1.81	0.00	range_good	b	61.00	0.21		
373	11	4,150.09	495,903.84	11.38	0.02	range_good	d	80.00	1.76		
374	11	1,620.41	81,221.11	1.86	0.00	range_good	b	61.00	0.22		
375	11	2,366.05	89,805.62	2.06	0.00	range_good	u_d	80.00	0.32		
			22,564,135.04	**518.00**	**1.00**				**80.46**	**2.43**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.21	**0.43**	***224.92***	**7,256,773.41**	**166.59**	**112.46**	**0.68**	**2,729,234.85**	**62.65**	**112.46**	**1.79**

Sub-watershed 4

Table 10.4 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
12	12	106,531.56	44,843,893.34	1,029.47	0.26	range_good	c	74.00	19.13		
43	12	68,766.57	57,427,496.73	1,318.35	0.33	range_fair	d	84.00	27.81		
44	12	2,314.96	280,925.47	6.45	0.00	row_sr_poor	b	81.00	0.13		
287	12	933.99	51,346.40	1.18	0.00	range_fair	d	84.00	0.02		
288	12	787.64	19,822.44	0.46	0.00	range_fair	c	79.00	0.01		
289	12	5,055.77	698,334.66	16.03	0.00	range_fair	c	79.00	0.32		
290	12	10,292.71	1,160,851.19	26.65	0.01	range_fair	c	79.00	0.53		
291	12	3,845.31	421,444.70	9.68	0.00	range_fair	c	79.00	0.19		
292	12	23,890.83	3,924,628.27	90.10	0.02	range_fair	b	69.00	1.56		
293	12	2,316.53	131,117.05	3.01	0.00	range_fair	d	84.00	0.06		
294	12	6,517.32	590,881.49	13.56	0.00	range_fair	c	79.00	0.27		
349	12	2,803.44	185,633.06	4.26	0.00	range_good	c	74.00	0.08		
350	12	2,274.97	168,060.63	3.86	0.00	range_good	c	74.00	0.07		
351	12	4,425.57	597,280.72	13.71	0.00	range_good	d	80.00	0.28		
352	12	6,335.59	649,908.99	14.92	0.00	range_good	c	74.00	0.28		
353	12	2,122.19	162,628.99	3.73	0.00	range_good	c	74.00	0.07		
354	12	630.67	9,525.25	0.22	0.00	range_good	c	74.00	0.00		
355	12	472.43	6,076.65	0.14	0.00	range_good	c	74.00	0.00		
356	12	33,144.59	7,131,805.26	163.72	0.04	range_good	d	80.00	3.29		
357	12	31,269.52	10,825,687.07	248.52	0.06	range_good	c	74.00	4.62		
358	12	3,181.23	343,238.08	7.88	0.00	range_good	b	61.00	0.12		
359	12	4,127.68	424,661.65	9.75	0.00	range_good	c	74.00	0.18		
360	12	2,027.48	143,723.92	3.30	0.00	range_good	c	74.00	0.06		
361	12	75,851.45	29,422,699.47	675.45	0.17	range_good	d	80.00	13.57		
362	12	1,059.31	16,392.50	0.38	0.00	range_good	u_d	80.00	0.01		
363	12	62,067.18	13,553,081.79	311.14	0.08	range_good	b	61.00	4.77		
364	12	2,123.77	214,849.75	4.93	0.00	row_sr_poor	c	88.00	0.11		
365	12	135.27	386.44	0.01	0.00	row_sr_poor	u_d	91.00	0.00		
366	12	766.76	19,552.47	0.45	0.00	row_sr_poor	u_d	91.00	0.01		
367	12	325.29	4,008.88	0.09	0.00	row_sr_poor	u_d	91.00	0.00		
368	12	2,072.99	48,744.30	1.12	0.00	row_sr_poor	u_d	91.00	0.03		
			173,478,687.62	**3,982.52**	**1.00**				**77.57**	**2.89**	**7.50**

			Wetlands Corridor Plan				**Wetlands Stratigic Spot Plan**			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
4.88	**0.41**	***1,620.31***	11,583,670.17	265.92	810.15	**3.05**	6,044,299.94	138.76	810.15	**5.84**

Sub-watershed 5

Table 10.5 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
13	13	94,204.64	41,491,745.47	952.52	0.30	range_good	c	74.00	21.93		
61	13	22,369.88	16,081,754.88	369.19	0.11	row_sr_poor	b	81.00	9.30		
62	13	7,256.61	559,191.63	12.84	0.00	row_c+t_good	b	71.00	0.28		
63	13	3,881.37	981,931.18	22.54	0.01	row_c+t_good	b	71.00	0.50		
64	13	13,179.51	3,695,622.97	84.84	0.03	row_c+t_good	d	81.00	2.14		
65	13	5,915.76	1,509,156.51	34.65	0.01	row_c+t_poor	d	82.00	0.88		
346	13	1,811.15	110,171.91	2.53	0.00	row_sr_poor	c	88.00	0.07		
347	13	3,812.07	532,955.59	12.23	0.00	row_sr_poor	c	88.00	0.33		
348	13	2,562.03	60,326.93	1.38	0.00	row_sr_poor	c	88.00	0.04		
523	13	2,882.47	287,085.43	6.59	0.00	range_good	b	61.00	0.13		
524	13	1,931.48	120,217.75	2.76	0.00	range_good	d	80.00	0.07		
525	13	8,496.42	1,176,659.34	27.01	0.01	range_good	d	80.00	0.67		
526	13	3,387.66	296,499.05	6.81	0.00	range_good	d	80.00	0.17		
527	13	2,871.19	257,890.72	5.92	0.00	range_good	d	80.00	0.15		
528	13	8,030.13	1,222,247.57	28.06	0.01	range_good	d	80.00	0.70		
529	13	2,004.13	195,663.86	4.49	0.00	range_good	d	80.00	0.11		
530	13	8,282.28	1,086,742.83	24.95	0.01	range_good	d	80.00	0.62		
531	13	1,687.56	133,371.32	3.06	0.00	range_good	d	80.00	0.08		
532	13	4,325.03	575,593.59	13.21	0.00	range_good	d	80.00	0.33		
533	13	3,590.37	289,764.32	6.65	0.00	range_good	d	80.00	0.17		
534	13	3,739.83	466,409.38	10.71	0.00	range_good	d	80.00	0.27		
535	13	4,447.06	485,649.91	11.15	0.00	range_good	d	80.00	0.28		
536	13	19,483.34	2,751,260.58	63.16	0.02	range_good	d	80.00	1.57		
537	13	1,856.56	141,567.10	3.25	0.00	range_good	d	80.00	0.08		
538	13	383.08	2,135.46	0.05	0.00	range_good	b	61.00	0.00		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 5 continued....

Table 10.5 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
539	13	1,196.11	38,675.96	0.89	0.00	range_good	d	80.00	0.02		
540	13	546.89	4,082.99	0.09	0.00	range_good	d	80.00	0.00		
541	13	4,558.68	456,975.29	10.49	0.00	range_good	d	80.00	0.26		
542	13	644.02	14,526.06	0.33	0.00	range_good	c	74.00	0.01		
543	13	3,452.32	175,918.51	4.04	0.00	range_good	d	80.00	0.10		
544	13	1,945.42	149,372.42	3.43	0.00	range_good	c	74.00	0.08		
545	13	7,501.29	726,721.97	16.68	0.01	range_good	d	80.00	0.42		
546	13	4,378.46	301,090.56	6.91	0.00	range_good	d	80.00	0.17		
547	13	2,121.79	208,044.05	4.78	0.00	range_good	d	80.00	0.12		
548	13	4,685.49	462,829.14	10.63	0.00	range_good	d	80.00	0.26		
549	13	7,618.47	1,414,575.14	32.47	0.01	range_good	d	80.00	0.81		
550	13	8,901.08	1,095,002.24	25.14	0.01	range_good	d	80.00	0.63		
551	13	8,163.33	2,263,998.32	51.97	0.02	range_good	d	80.00	1.29		
552	13	1,257.23	81,979.19	1.88	0.00	range_good	d	80.00	0.05		
553	13	11,214.46	2,023,219.35	46.45	0.01	range_good	d	80.00	1.16		
554	13	105,375.67	43,657,229.69	1,002.23	0.31	range_good	c	74.00	23.07		
555	13	59,218.39	8,775,959.70	201.47	0.06	range_good	b	61.00	3.82		
556	13	2,301.48	180,713.76	4.15	0.00	row_c+t_good	d	81.00	0.10		
557	13	806.16	25,300.84	0.58	0.00	row_c+t_good	d	81.00	0.01		
558	13	12,741.26	3,286,700.97	75.45	0.02	row_c+t_good	c	78.00	1.83		
559	13	784.10	29,914.19	0.69	0.00	row_c+t_good	c	78.00	0.02		
560	13	1,440.05	134,278.94	3.08	0.00	row_c+t_good	c	78.00	0.07		
			140,018,724.55	**3,214.39**	**1.00**				**75.17**	**3.30**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
4.61	**0.38**	***1,235.39***	2,674,554.90	61.40	617.69	**10.06**	2,957,555.02	67.90	617.69	**9.10**

Sub-watershed 6

Table 10.6 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
14	14	67,759.05	42,515,418.84	976.02	0.72	range_good	c	74.00	53.45		
59	14	2,019.65	187,295.89	4.30	0.00	range_good	c	74.00	0.24		
60	14	21,228.07	5,808,323.84	133.34	0.10	row_sr_poor	b	81.00	7.99		
338	14	1,843.28	161,469.24	3.71	0.00	row_sr_poor	c	88.00	0.24		
339	14	4,576.23	896,648.69	20.58	0.02	row_sr_poor	b	81.00	1.23		
340	14	10,848.03	1,149,113.11	26.38	0.02	row_sr_poor	c	88.00	1.72		
341	14	396.17	6,137.68	0.14	0.00	row_sr_poor	u_d	91.00	0.01		
342	14	438.08	10,099.13	0.23	0.00	row_sr_poor	c	88.00	0.02		
343	14	1,079.70	37,313.69	0.86	0.00	row_sr_poor	u_d	91.00	0.06		
344	14	1,314.03	106,330.38	2.44	0.00	row_sr_poor	b	81.00	0.15		
345	14	13,865.95	565,182.22	12.97	0.01	row_sr_poor	u_d	91.00	0.87		
376	14	2,734.95	244,728.96	5.62	0.00	range_good	d	80.00	0.33		
377	14	637.35	10,947.08	0.25	0.00	range_good	d	80.00	0.01		
378	14	3,109.56	348,995.74	8.01	0.01	range_good	d	80.00	0.47		
379	14	15,476.64	2,667,314.63	61.23	0.05	range_good	d	80.00	3.63		
380	14	21,825.96	2,908,936.56	66.78	0.05	range_good	b	61.00	3.01		
381	14	1,772.45	110,706.68	2.54	0.00	range_good	d	80.00	0.15		
382	14	2,811.97	263,785.97	6.06	0.00	range_good	d	80.00	0.36		
383	14	999.05	50,158.35	1.15	0.00	range_good	c	74.00	0.06		
384	14	3,306.60	211,974.37	4.87	0.00	range_good	d	80.00	0.29		
385	14	1,859.62	175,199.06	4.02	0.00	range_good	d	80.00	0.24		
386	14	1,757.52	85,203.15	1.96	0.00	range_good	b	61.00	0.09		
387	14	2,328.93	79,463.76	1.82	0.00	range_good	u_d	80.00	0.11		
388	14	2,307.90	113,439.29	2.60	0.00	range_good	b	61.00	0.12		
389	14	2,921.27	116,648.07	2.68	0.00	range_good	u_d	80.00	0.16		
522	14	1,186.64	30,797.28	0.71	0.00	range_good	b	61.00	0.03		
			58,861,631.67	**1,351.28**	**1.00**				**75.04**	**3.33**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
4.60	**0.38**	***517.67***	5,267,487.71	120.92	258.83	**2.14**	2,214,029.25	50.83	258.83	**5.09**

Sub-watershed 7

Table 10.7 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
15	15	24,032.99	7,462,559.05	171.32	0.08	open_good	c	74.00	6.28		
69	15	46,387.59	9,442,678.85	216.77	0.11	open_good	c	74.00	7.95		
577	15	2,820.03	112,878.11	2.59	0.00	open_good	d	80.00	0.10		
578	15	4,120.58	286,679.42	6.58	0.00	open_good	d	80.00	0.26		
579	15	3,058.22	246,158.19	5.65	0.00	open_good	d	80.00	0.22		
580	15	1,043.12	39,901.10	0.92	0.00	open_good	d	80.00	0.04		
581	15	3,286.84	326,052.28	7.49	0.00	open_good	d	80.00	0.30		
582	15	2,158.53	147,456.47	3.39	0.00	open_good	d	80.00	0.13		
583	15	1,727.81	151,876.45	3.49	0.00	open_good	d	80.00	0.14		
584	15	3,014.33	417,888.47	9.59	0.00	open_good	d	80.00	0.38		
585	15	9,421.00	1,547,921.93	35.54	0.02	open_good	c	74.00	1.30		
586	15	738.52	24,523.46	0.56	0.00	open_good	d	80.00	0.02		
587	15	1,625.13	128,444.41	2.95	0.00	open_good	d	80.00	0.12		
588	15	2,169.70	199,566.00	4.58	0.00	open_good	d	80.00	0.18		
589	15	4,011.23	417,496.54	9.58	0.00	open_good	c	74.00	0.35		
590	15	28,293.82	4,770,245.38	109.51	0.05	open_good	d	80.00	4.34		
591	15	5,047.15	789,997.28	18.14	0.01	open_good	d	80.00	0.72		
592	15	5,116.58	552,442.38	12.68	0.01	open_good	d	80.00	0.50		
593	15	3,401.49	332,988.61	7.64	0.00	open_good	d	80.00	0.30		
594	15	2,442.85	187,457.24	4.30	0.00	open_good	d	80.00	0.17		
595	15	809.84	15,267.08	0.35	0.00	road_paved	b	89.00	0.02		
596	15	1,734.81	120,300.31	2.76	0.00	road_paved	b	89.00	0.12		
597	15	1,415.85	103,963.29	2.39	0.00	res_1/2acre	c	80.00	0.09		
598	15	2,077.39	157,547.26	3.62	0.00	open_good	d	80.00	0.14		
599	15	77,829.24	21,675,385.23	497.60	0.25	open_poor	c	86.00	21.21		
600	15	3,799.40	320,295.09	7.35	0.00	res_2acre	d	82.00	0.30		
601	15	6,309.50	774,555.41	17.78	0.01	open_good	d	80.00	0.71		
602	15	6,146.21	804,285.34	18.46	0.01	open_good	d	80.00	0.73		
603	15	5,465.74	559,013.32	12.83	0.01	open_good	d	80.00	0.51		
604	15	13,705.58	5,326,657.87	122.28	0.06	open_fair	b	69.00	4.18		
605	15	3,679.56	477,346.33	10.96	0.01	open_good	d	80.00	0.43		
606	15	8,625.86	1,228,907.44	28.21	0.01	open_good	d	80.00	1.12		
607	15	2,817.44	341,926.79	7.85	0.00	res_1/4acre	d	87.00	0.34		
608	15	6,960.51	1,289,282.78	29.60	0.01	open_good	c	74.00	1.09		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 7 continued...

Table 10.7 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
608	15	6,960.51	1,289,282.78	29.60	0.01	open_good	c	74.00	1.09		
609	15	11,746.73	2,469,893.97	56.70	0.03	open_good	d	80.00	2.25		
668	15	2,657.43	230,301.49	5.29	0.00	open_good	d	80.00	0.21		
669	15	1,033.13	40,963.56	0.94	0.00	open_good	d	80.00	0.04		
670	15	4,653.50	708,511.64	16.27	0.01	res_1acre	d	84.00	0.68		
671	15	99.63	395.47	0.01	0.00	res_1acre	d	84.00	0.00		
672	15	1,189.53	69,038.60	1.58	0.00	open_good	c	74.00	0.06		
673	15	4,034.85	740,557.79	17.00	0.01	res_1acre	c	79.00	0.67		
674	15	1,108.20	72,832.61	1.67	0.00	res_1acre	c	79.00	0.07		
675	15	3,594.38	587,322.69	13.48	0.01	res_1acre	c	79.00	0.53		
676	15	5,143.20	1,649,550.27	37.87	0.02	open_fair	c	79.00	1.48		
677	15	1,739.07	171,141.25	3.93	0.00	res_1/8acre	c	90.00	0.18		
678	15	5,546.42	1,195,681.86	27.45	0.01	res_1acre	c	79.00	1.07		
679	15	322.75	3,561.01	0.08	0.00	res_1/8acre	b	85.00	0.00		
680	15	12,008.93	2,767,278.64	63.53	0.03	res_2acre	c	77.00	2.42		
681	15	2,024.01	218,037.80	5.01	0.00	mine_gravel	c	89.00	0.22		
682	15	4,328.84	832,889.81	19.12	0.01	mine_gravel	c	89.00	0.84		
685	15	2,274.56	156,670.83	3.60	0.00	res_1/4acre	d	87.00	0.16		
686	15	6,195.66	895,468.42	20.56	0.01	open_good	b	61.00	0.62		
687	15	2,222.10	156,521.52	3.59	0.00	res_1/8acre	b	85.00	0.15		
688	15	2,127.77	142,057.47	3.26	0.00	res_1/8acre	b	85.00	0.14		
689	15	466.61	10,721.47	0.25	0.00	res_1/8acre	b	85.00	0.01		
690	15	1,281.28	90,600.64	2.08	0.00	res_1/8acre	b	85.00	0.09		
691	15	226.66	1,983.29	0.05	0.00	res_1/2acre	b	70.00	0.00		
692	15	2,364.94	128,151.52	2.94	0.00	res_1/2acre	b	70.00	0.10		
693	15	14,092.46	2,580,935.07	59.25	0.03	res_1acre	b	68.00	2.00		
694	15	422.13	7,016.73	0.16	0.00	res_1/2acre	b	70.00	0.01		
695	15	3,998.51	461,921.85	10.60	0.01	res_2acre	c	77.00	0.40		
696	15	468.10	7,425.43	0.17	0.00	res_2acre	c	77.00	0.01		
697	15	2,808.77	197,420.93	4.53	0.00	res_1acre	c	79.00	0.18		
698	15	567.22	13,913.67	0.32	0.00	res_1/4acre	c	83.00	0.01		
699	15	1,068.27	66,147.90	1.52	0.00	res_1/4acre	c	83.00	0.06		
700	15	1,162.47	69,727.82	1.60	0.00	res_1/4acre	c	83.00	0.07		
701	15	1,225.14	60,470.33	1.39	0.00	street_paved	c	98.00	0.07		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 7 continued

Table 10.7 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
702	15	1,825.95	171,740.15	3.94	0.00	open_good	c	74.00	0.14		
703	15	4,299.69	297,762.18	6.84	0.00	open_good	c	74.00	0.25		
704	15	6,965.70	798,063.79	18.32	0.01	res_1/8acre	c	90.00	0.82		
705	15	22,609.74	7,475,756.58	171.62	0.09	res_1/2acre	c	80.00	6.81		
706	15	2,177.84	155,304.74	3.57	0.00	open_good	c	74.00	0.13		
707	15	5,461.74	982,168.73	22.55	0.01	res_1/2acre	c	80.00	0.89		
708	15	1,100.28	78,106.69	1.79	0.00	res_1/2acre	d	85.00	0.08		
709	15	636.46	11,176.56	0.26	0.00	res_1/2acre	d	85.00	0.01		
710	15	639.56	22,269.43	0.51	0.00	street_paved	d	98.00	0.02		
711	15	2,087.98	90,157.79	2.07	0.00	res_1acre	d	84.00	0.09		
712	15	2,274.40	115,770.78	2.66	0.00	res_1/4acre	d	61.00	0.08		
971	15	513.14	11,076.70	0.25	0.00	mine_gravel	u_d	91.00	0.01		
972	15	1,767.96	83,990.04	1.93	0.00	road_paved	b	89.00	0.09		
			87,878,402.66	**2,017.41**	**1.00**				**79.02**	**2.66**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.05	**0.42**	***848.33***	4,116,155.70	94.49	424.17	**4.49**	5,128,091.55	117.72	424.17	**3.60**

Sub-watershed 8

Table 10.8 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
16	16	53,906.91	16,444,210.71	377.51	0.09	range_good	c	74.00	6.70		
66	16	56,772.79	27,831,728.99	638.93	0.15	range_good	c	74.00	11.34		
67	16	32,864.95	12,307,432.11	282.54	0.07	open_good	c	74.00	5.02		
68	16	28,470.78	21,044,151.51	483.11	0.12	row_sr_poor	b	81.00	9.39		
390	16	1,871.93	129,177.54	2.97	0.00	range_good	d	80.00	0.06		
391	16	2,238.69	156,205.49	3.59	0.00	range_good	d	80.00	0.07		
392	16	728.37	29,345.00	0.67	0.00	range_good	d	80.00	0.01		
393	16	774.44	23,431.80	0.54	0.00	range_good	d	80.00	0.01		
394	16	2,866.45	155,569.46	3.57	0.00	range_good	d	80.00	0.07		
395	16	1,946.94	115,200.77	2.64	0.00	range_good	d	80.00	0.05		
396	16	17,656.67	8,492,036.33	194.95	0.05	range_good	c	74.00	3.46		
397	16	901.59	12,006.00	0.28	0.00	range_good	u_d	80.00	0.01		
398	16	2,920.75	269,672.91	6.19	0.00	range_good	b	61.00	0.09		
435	16	435.80	8,003.42	0.18	0.00	range_good	c	74.00	0.00		
436	16	1,734.40	128,014.30	2.94	0.00	range_good	d	80.00	0.06		
437	16	1,968.92	180,935.05	4.15	0.00	range_good	d	80.00	0.08		
438	16	3,098.21	360,580.31	8.28	0.00	range_good	d	80.00	0.16		
439	16	1,719.05	164,414.89	3.77	0.00	range_good	d	80.00	0.07		
440	16	1,825.07	174,226.24	4.00	0.00	range_good	d	80.00	0.08		
441	16	1,086.16	19,188.69	0.44	0.00	range_good	c	74.00	0.01		
442	16	2,855.72	176,133.83	4.04	0.00	range_good	d	80.00	0.08		
443	16	1,066.30	31,109.75	0.71	0.00	range_good	d	80.00	0.01		
444	16	5,695.50	777,075.43	17.84	0.00	range_good	d	80.00	0.34		
445	16	745.51	20,581.06	0.47	0.00	range_good	d	80.00	0.01		
446	16	2,687.06	264,552.40	6.07	0.00	range_good	d	80.00	0.12		
447	16	12,892.94	1,757,061.39	40.34	0.01	range_good	b	61.00	0.59		
448	16	708.43	31,827.71	0.73	0.00	range_good	b	61.00	0.01		
449	16	2,976.10	45,004.90	1.03	0.00	range_good	u_d	80.00	0.02		
450	16	1,088.88	62,331.58	1.43	0.00	range_good	d	80.00	0.03		
451	16	1,186.45	28,435.55	0.65	0.00	range_good	u_d	80.00	0.01		
452	16	820.81	18,432.49	0.42	0.00	range_good	u_d	80.00	0.01		
453	16	2,011.30	164,523.72	3.78	0.00	range_good	b	61.00	0.06		
454	16	2,237.99	202,316.62	4.64	0.00	range_good	d	80.00	0.09		
455	16	1,160.16	39,615.61	0.91	0.00	range_good	b	61.00	0.01		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 8 continued...

Table 10.8 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
456	16	6,196.31	956,635.76	21.96	0.01	range_good	b	61.00	0.32		
457	16	2,221.68	139,857.48	3.21	0.00	res_1/2acre	d	85.00	0.07		
458	16	2,397.63	127,903.27	2.94	0.00	res_1/8acre	d	92.00	0.06		
459	16	6,359.24	442,201.01	10.15	0.00	open_good	b	61.00	0.15		
460	16	819.07	33,477.21	0.77	0.00	open_poor	b	79.00	0.01		
461	16	1,430.91	62,778.42	1.44	0.00	open_good	b	61.00	0.02		
462	16	1,392.23	35,655.45	0.82	0.00	open_good	u_d	80.00	0.02		
463	16	37,021.24	19,545,337.83	448.70	0.11	open_good	c	74.00	7.96		
464	16	8,841.60	1,649,949.59	37.88	0.01	open_good	b	61.00	0.55		
465	16	2,283.07	150,283.97	3.45	0.00	open_fair	b	69.00	0.06		
466	16	3,471.71	264,735.08	6.08	0.00	res_1/4acre	d	87.00	0.13		
467	16	3,222.27	373,990.10	8.59	0.00	open_good	d	80.00	0.16		
468	16	2,905.54	484,101.21	11.11	0.00	open_good	c	74.00	0.20		
469	16	3,092.54	558,935.76	12.83	0.00	res_1/4acre	c	83.00	0.26		
470	16	1,686.52	125,291.71	2.88	0.00	res_1/4acre	d	87.00	0.06		
471	16	383.83	5,929.08	0.14	0.00	range_good	d	80.00	0.00		
472	16	8,660.98	1,041,891.69	23.92	0.01	open_fair	b	69.00	0.40		
473	16	29,605.25	938,600.08	21.55	0.01	open_good	u_d	80.00	0.41		
474	16	1,511.76	67,797.22	1.56	0.00	com_business	c	94.00	0.04		
475	16	34,084.11	7,001,553.84	160.73	0.04	open_fair	b	69.00	2.66		
476	16	939.01	57,193.19	1.31	0.00	open_good	d	80.00	0.03		
477	16	588.15	12,840.04	0.29	0.00	open_good	d	80.00	0.01		
478	16	1,306.60	23,601.29	0.54	0.00	open_good	d	80.00	0.01		
479	16	5,429.50	692,671.78	15.90	0.00	open_good	d	80.00	0.31		
480	16	973.37	57,166.65	1.31	0.00	open_good	d	80.00	0.03		
481	16	1,259.28	62,376.19	1.43	0.00	open_good	b	61.00	0.02		
482	16	690.13	16,536.00	0.38	0.00	row_sr_poor	c	88.00	0.01		
483	16	4,041.07	442,251.63	10.15	0.00	row_sr_poor	b	81.00	0.20		
484	16	3,810.26	222,880.14	5.12	0.00	row_sr_poor	c	88.00	0.11		
485	16	8,991.28	321,673.18	7.38	0.00	row_sr_poor	u_d	91.00	0.16		
486	16	3,532.00	176,487.00	4.05	0.00	row_sr_poor	c	88.00	0.09		
487	16	361.89	5,641.64	0.13	0.00	row_sr_poor	d	91.00	0.00		
488	16	11,278.21	2,531,535.78	58.12	0.01	row_sr_poor	c	88.00	1.23		
489	16	8,545.95	1,222,512.68	28.07	0.01	row_sr_poor	c	88.00	0.59		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 8 continued...

Table 10.8 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
490	16	7,729.11	1,406,876.33	32.30	0.01	row_sr_poor	b	81.00	0.63		
491	16	10,236.17	1,555,613.16	35.71	0.01	row_sr_poor	b	81.00	0.69		
492	16	1,058.60	41,001.10	0.94	0.00	row_sr_poor	b	81.00	0.02		
493	16	11,436.44	3,642,745.69	83.63	0.02	row_sr_poor	b	81.00	1.62		
494	16	32,657.67	1,338,317.87	30.72	0.01	row_sr_poor	u_d	91.00	0.67		
561	16	5,308.81	793,571.62	18.22	0.00	range_good	d	80.00	0.35		
562	16	5,165.96	693,495.37	15.92	0.00	range_good	d	80.00	0.31		
563	16	7,808.49	790,577.26	18.15	0.00	range_good	b	61.00	0.27		
564	16	2,545.77	300,625.09	6.90	0.00	range_good	d	80.00	0.13		
565	16	39,407.95	18,045,898.41	414.28	0.10	range_good	c	74.00	7.35		
566	16	27,718.78	4,120,055.60	94.58	0.02	range_good	b	61.00	1.38		
567	16	6,557.32	843,986.49	19.38	0.00	range_good	d	80.00	0.37		
568	16	2,478.40	120,591.96	2.77	0.00	range_good	d	80.00	0.05		
569	16	2,007.90	217,506.26	4.99	0.00	range_good	c	74.00	0.09		
570	16	6,892.53	576,664.71	13.24	0.00	range_good	d	80.00	0.25		
571	16	943.83	62,331.93	1.43	0.00	range_good	c	74.00	0.03		
572	16	4,698.30	373,099.59	8.57	0.00	range_good	d	80.00	0.16		
573	16	1,837.05	135,730.09	3.12	0.00	range_good	d	80.00	0.06		
574	16	2,247.45	209,159.56	4.80	0.00	range_good	d	80.00	0.09		
575	16	1,603.05	155,380.33	3.57	0.00	range_good	d	80.00	0.07		
576	16	7,412.39	1,158,500.08	26.60	0.01	range_good	d	80.00	0.51		
683	16	3,280.94	381,715.65	8.76	0.00	res_1/8acre	c	90.00	0.19		
684	16	3,325.10	602,559.21	13.83	0.00	res_1/8acre	c	90.00	0.30		
916	16	1,822.74	190,411.65	4.37	0.00	res_1/8acre	b	85.00	0.09		
917	16	1,261.85	53,764.99	1.23	0.00	res_1/8acre	d	92.00	0.03		
918	16	1,770.83	73,524.54	1.69	0.00	res_1/2acre	d	85.00	0.03		
919	16	1,424.69	123,958.43	2.85	0.00	res_1/8acre	b	85.00	0.06		
920	16	1,484.09	132,946.63	3.05	0.00	res_1/8acre	b	85.00	0.06		
921	16	6,059.58	805,193.09	18.48	0.00	res_1/2acre	b	70.00	0.31		
922	16	1,739.42	197,948.56	4.54	0.00	open_fair	b	69.00	0.08		
923	16	529.27	4,800.78	0.11	0.00	res_1/2acre	d	85.00	0.00		
924	16	403.50	8,003.90	0.18	0.00	open_fair	d	84.00	0.00		
925	16	506.54	6,635.42	0.15	0.00	res_1/2acre	d	85.00	0.00		
926	16	1,567.26	107,176.62	2.46	0.00	res_1/2acre	d	85.00	0.05		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 8 continued...

Table 10.8 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
927	16	2,223.49	128,881.66	2.96	0.00	res_1/8acre	c	90.00	0.06		
928	16	1,144.81	75,947.49	1.74	0.00	res_1/2acre	c	80.00	0.03		
929	16	4,797.30	1,111,260.15	25.51	0.01	res_1/8acre	c	90.00	0.55		
930	16	2,396.27	124,672.36	2.86	0.00	res_1/4acre	c	83.00	0.06		
931	16	1,164.51	31,136.83	0.71	0.00	res_1/4acre	c	83.00	0.01		
932	16	3,033.17	340,893.97	7.83	0.00	res_1/8acre	c	90.00	0.17		
933	16	649.36	19,985.50	0.46	0.00	res_1/4acre	c	83.00	0.01		
934	16	608.15	7,798.09	0.18	0.00	res_1/4acre	c	83.00	0.00		
935	16	3,372.80	355,033.41	8.15	0.00	res_1/4acre	c	83.00	0.16		
936	16	813.67	49,017.50	1.13	0.00	res_1/8acre	d	92.00	0.02		
937	16	1,071.41	52,146.12	1.20	0.00	res_1/4acre	d	75.00	0.02		
938	16	2,319.08	182,026.72	4.18	0.00	open_good	d	80.00	0.08		
939	16	1,291.97	56,284.91	1.29	0.00	res_1/4acre	d	87.00	0.03		
940	16	818.74	23,458.16	0.54	0.00	open_good	d	80.00	0.01		
941	16	356.83	1,321.79	0.03	0.00	res_1/4acre	d	87.00	0.00		
942	16	762.65	19,759.57	0.45	0.00	open_good	d	80.00	0.01		
943	16	2,172.83	124,493.89	2.86	0.00	res_1/4acre	d	87.00	0.06		
944	16	1,912.44	127,350.87	2.92	0.00	open_good	d	80.00	0.06		
945	16	2,620.67	166,118.31	3.81	0.00	res_1/4acre	b	75.00	0.07		
946	16	1,122.79	36,862.07	0.85	0.00	open_good	b	61.00	0.01		
947	16	3,485.51	459,268.66	10.54	0.00	open_good	b	61.00	0.15		
948	16	5,962.85	886,445.47	20.35	0.00	res_1/4acre	b	75.00	0.37		
949	16	5,479.20	810,690.46	18.61	0.00	res_1/8acre	b	85.00	0.38		
950	16	3,880.23	408,038.77	9.37	0.00	open_good	b	61.00	0.14		
951	16	2,915.61	535,654.56	12.30	0.00	res_1/8acre	b	85.00	0.25		
952	16	2,172.85	204,126.81	4.69	0.00	res_1/8acre	b	85.00	0.10		
953	16	4,048.09	519,927.63	11.94	0.00	res_1/8acre	b	85.00	0.24		
954	16	7,088.32	831,718.89	19.09	0.00	res_1/4acre	b	75.00	0.34		
955	16	4,500.79	476,699.96	10.94	0.00	range_good	b	61.00	0.16		
956	16	3,540.83	592,107.53	13.59	0.00	res_1/8acre	b	85.00	0.28		
957	16	3,322.11	189,231.24	4.34	0.00	res_1/8acre	b	85.00	0.09		
958	16	1,081.47	24,632.73	0.57	0.00	open_good	d	80.00	0.01		
959	16	660.73	24,298.65	0.56	0.00	res_1/8acre	d	92.00	0.01		
960	16	292.71	3,937.90	0.09	0.00	res_1/8acre	c	80.00	0.00		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 8 continued...

Table 10.8 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
961	16	341.75	6,230.25	0.14	0.00	res_1/8acre	c	80.00	0.00		
962	16	6,087.32	488,578.94	11.22	0.00	range_good	c	74.00	0.20		
963	16	1,205.92	46,373.60	1.06	0.00	range_good	u_d	80.00	0.02		
964	16	3,438.90	106,756.29	2.45	0.00	res_1/8acre	u_d	92.00	0.05		
965	16	1,416.31	31,136.07	0.71	0.00	open_good	u_d	80.00	0.01		
966	16	5,627.50	122,880.84	2.82	0.00	res_1/8acre	u_d	92.00	0.06		
967	16	1,203.61	12,289.00	0.28	0.00	res_1/8acre	u_d	92.00	0.01		
968	16	3,399.66	310,259.49	7.12	0.00	com_business	b	92.00	0.16		
969	16	2,046.76	90,625.76	2.08	0.00	res_1/8acre	b	85.00	0.04		
970	16	3,185.90	596,318.21	13.69	0.00	res_1acre	b	51.00	0.17		
973	16	739.79	4,871.72	0.11	0.00	com_business	c	94.00	0.00		
			181,604,723.28	**4,169.07**	**1.00**				**75.42**	**3.26**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
4.64	**0.39**	***1,612.03***	30,438,682.07	698.78	806.02	**1.15**	30,678,839.89	704.29	806.02	**1.14**

Sub-watershed 9

Table 10.9 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
17	17	179,140.56	59,210,107.19	1,359.28	0.64	range_good	c	74.00	47.51		
399	17	1,344.32	39,398.88	0.90	0.00	range_good	c	74.00	0.03		
400	17	30,674.29	9,296,403.72	213.42	0.10	range_good	d	80.00	8.06		
401	17	1,880.23	130,758.58	3.00	0.00	range_good	c	74.00	0.10		
402	17	21,308.03	3,490,982.34	80.14	0.04	range_good	d	80.00	3.03		
403	17	4,283.32	468,103.85	10.75	0.01	range_good	d	80.00	0.41		
404	17	2,001.41	189,248.87	4.34	0.00	range_good	d	80.00	0.16		
405	17	4,140.16	439,711.75	10.09	0.00	range_good	d	80.00	0.38		
406	17	1,814.51	80,001.16	1.84	0.00	range_good	c	74.00	0.06		
407	17	5,732.02	553,275.82	12.70	0.01	range_good	d	80.00	0.48		
408	17	1,933.29	110,954.89	2.55	0.00	range_good	d	80.00	0.10		
409	17	2,129.35	135,657.51	3.11	0.00	range_good	d	80.00	0.12		
410	17	1,074.05	60,675.52	1.39	0.00	range_good	c	74.00	0.05		
411	17	4,000.42	450,260.54	10.34	0.00	range_good	d	80.00	0.39		
412	17	3,538.40	325,553.92	7.47	0.00	range_good	d	80.00	0.28		
413	17	3,241.71	273,256.57	6.27	0.00	range_good	d	80.00	0.24		
414	17	3,370.56	482,940.88	11.09	0.01	range_good	d	80.00	0.42		
415	17	2,214.54	210,459.08	4.83	0.00	range_good	d	80.00	0.18		
416	17	2,625.57	63,321.74	1.45	0.00	range_good	d	80.00	0.05		
417	17	440.03	7,155.26	0.16	0.00	range_good	d	80.00	0.01		
418	17	6,043.40	467,473.08	10.73	0.01	range_good	d	80.00	0.41		
419	17	2,653.57	160,855.95	3.69	0.00	range_good	d	80.00	0.14		
420	17	2,572.28	127,747.24	2.93	0.00	range_good	d	80.00	0.11		
421	17	6,147.94	971,901.76	22.31	0.01	range_good	d	80.00	0.84		
422	17	3,441.52	317,742.15	7.29	0.00	range_good	d	80.00	0.28		
423	17	1,592.26	67,379.22	1.55	0.00	range_good	d	80.00	0.06		
424	17	1,845.33	36,976.07	0.85	0.00	range_good	u_d	80.00	0.03		
425	17	7,573.23	1,640,991.28	37.67	0.02	range_good	b	61.00	1.09		
426	17	7,074.47	669,283.48	15.36	0.01	range_good	d	80.00	0.58		
427	17	10,218.15	1,465,036.96	33.63	0.02	range_good	d	80.00	1.27		
428	17	2,462.59	228,304.17	5.24	0.00	range_good	d	80.00	0.20		
429	17	45,571.47	6,449,341.31	148.06	0.07	range_good	b	61.00	4.27		
430	17	5,863.81	1,048,441.24	24.07	0.01	range_good	d	80.00	0.91		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 9 continued...

Table 10.9 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
431	17	8,688.50	1,490,452.22	34.22	0.02	range_good	d	80.00	1.29		
432	17	273.97	2,743.62	0.06	0.00	range_good	c	74.00	0.00		
433	17	293.11	2,345.80	0.05	0.00	range_good	c	74.00	0.00		
434	17	8,636.31	1,052,812.20	24.17	0.01	range_good	d	80.00	0.91		
			92,218,055.79	**2,117.04**	**1.00**				**74.46**	**3.43**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
4.53	**0.38**	***799.62***	492,618.24	11.31	399.81	**35.35**	613,352.00	14.08	399.81	**28.39**

Sub-watershed 10

Table 10.10 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
18	18	36,037.52	8,430,139.46	193.53	0.12	res_1/4acre	c	83.00	9.63		
610	18	1,851.54	168,168.43	3.86	0.00	res_1/3acre	c	81.00	0.19		
611	18	1,723.45	103,634.44	2.38	0.00	res_1/3acre	u_d	86.00	0.12		
612	18	1,288.32	68,652.30	1.58	0.00	res_1/3acre	b	72.00	0.07		
613	18	12,167.74	2,724,024.00	62.53	0.04	res_1/3acre	b	72.00	2.70		
614	18	7,001.09	583,787.07	13.40	0.01	res_1/3acre	d	86.00	0.69		
615	18	13,234.14	4,375,424.92	100.45	0.06	res_1/3acre	c	81.00	4.88		
616	18	5,647.24	1,160,280.66	26.64	0.02	res_1/3acre	b	72.00	1.15		
617	18	1,233.22	89,441.31	2.05	0.00	open_good	b	61.00	0.08		
618	18	13,431.34	2,336,929.93	53.65	0.03	open_good	b	61.00	1.96		
619	18	11,820.41	1,061,800.36	24.38	0.01	open_good	u_d	80.00	1.17		
620	18	9,187.27	1,693,610.74	38.88	0.02	res_1/4acre	b	75.00	1.75		
621	18	5,752.73	523,904.08	12.03	0.01	res_1/4acre	b	75.00	0.54		
622	18	4,573.10	1,144,787.42	26.28	0.02	res_1/4acre	d	87.00	1.37		
623	18	8,667.57	1,115,274.99	25.60	0.02	res_1/4acre	d	87.00	1.33		
624	18	4,683.88	654,434.04	15.02	0.01	com_business	b	92.00	0.83		
625	18	4,024.26	646,780.58	14.85	0.01	res_1/4acre	d	87.00	0.77		
626	18	1,892.49	174,720.28	4.01	0.00	res_1/4acre	d	87.00	0.21		
627	18	10,218.30	2,242,467.06	51.48	0.03	res_1/4acre	d	87.00	2.68		
628	18	3,070.71	469,575.32	10.78	0.01	res_1/4acre	d	87.00	0.56		
629	18	5,351.75	1,038,766.06	23.85	0.01	res_1/4acre	d	87.00	1.24		
630	18	30,302.41	13,463,742.05	309.08	0.19	res_1/4acre	c	83.00	15.37		
713	18	5,186.78	402,700.09	9.24	0.01	open_good	b	61.00	0.34		
714	18	1,580.99	130,658.86	3.00	0.00	open_good	b	61.00	0.11		
715	18	383.27	2,851.56	0.07	0.00	open_good	u_d	80.00	0.00		
716	18	6,208.28	234,885.73	5.39	0.00	open_good	u_d	80.00	0.26		
717	18	2,936.12	78,240.77	1.80	0.00	open_good	u_d	80.00	0.09		
718	18	586.22	10,275.85	0.24	0.00	open_good	u_d	80.00	0.01		
719	18	1,882.38	41,044.29	0.94	0.00	open_good	u_d	80.00	0.05		
720	18	2,163.91	82,936.52	1.90	0.00	road_paved	u_d	93.00	0.11		
721	18	3,246.87	552,100.74	12.67	0.01	com_business	u_d	95.00	0.72		
722	18	838.38	13,528.82	0.31	0.00	open_good	d	80.00	0.01		
723	18	2,003.04	96,820.85	2.22	0.00	open_good	b	61.00	0.08		
724	18	4,088.69	398,086.69	9.14	0.01	res_1/8acre	b	85.00	0.47		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 10 continued...

Table 10.10 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
725	18	3,393.90	413,672.66	9.50	0.01	com_business	b	92.00	0.52		
726	18	1,139.60	39,320.10	0.90	0.00	open_good	b	61.00	0.03		
727	18	435.67	8,335.41	0.19	0.00	com_business	b	92.00	0.01		
728	18	7,414.29	1,069,784.51	24.56	0.01	open_fair	b	69.00	1.02		
729	18	670.36	9,284.40	0.21	0.00	com_business	b	92.00	0.01		
730	18	4,716.94	1,020,658.62	23.43	0.01	res_1/8acre	b	85.00	1.19		
731	18	3,105.38	304,979.63	7.00	0.00	com_business	b	92.00	0.39		
732	18	218.27	2,400.53	0.06	0.00	res_1/8acre	b	85.00	0.00		
733	18	3,655.97	292,906.10	6.72	0.00	res_1/4acre	b	75.00	0.30		
734	18	2,073.67	86,635.23	1.99	0.00	res_1/8acre	b	85.00	0.10		
735	18	1,238.91	64,604.38	1.48	0.00	open_fair	b	69.00	0.06		
736	18	346.30	5,045.84	0.12	0.00	res_1/2acre	b	72.00	0.00		
737	18	2,040.55	181,982.17	4.18	0.00	open_good	c	74.00	0.19		
738	18	8,103.88	2,288,549.02	52.54	0.03	open_good	c	74.00	2.33		
739	18	1,694.91	116,749.08	2.68	0.00	road_paved	c	74.00	0.12		
740	18	3,086.48	331,864.16	7.62	0.00	res_1/8acre	c	90.00	0.41		
741	18	165.86	1,263.28	0.03	0.00	res_1/8acre	d	92.00	0.00		
742	18	1,021.21	50,493.30	1.16	0.00	street_paved	d	98.00	0.07		
743	18	766.77	11,304.47	0.26	0.00	res_1/4acre	c	83.00	0.01		
744	18	1,880.96	222,905.60	5.12	0.00	res_1/8acre	d	92.00	0.28		
745	18	1,397.02	113,087.32	2.60	0.00	res_1/8acre	d	92.00	0.14		
746	18	211.26	951.41	0.02	0.00	res_1/8acre	c	90.00	0.00		
747	18	1,622.19	146,383.02	3.36	0.00	res_1/8acre	c	90.00	0.18		
748	18	798.22	27,531.82	0.63	0.00	res_1/8acre	c	90.00	0.03		
749	18	1,746.00	183,588.99	4.21	0.00	res_1/8acre	c	90.00	0.23		
750	18	838.87	32,150.28	0.74	0.00	com_business	c	94.00	0.04		
751	18	1,303.36	63,116.52	1.45	0.00	res_1/8acre	c	90.00	0.08		
752	18	5,707.70	1,452,647.15	33.35	0.02	com_business	c	94.00	1.88		
753	18	5,053.65	1,559,954.48	35.81	0.02	res_1/8acre	c	90.00	1.93		
754	18	847.92	30,095.28	0.69	0.00	res_1/4acre	c	83.00	0.03		
755	18	4,226.82	772,999.14	17.75	0.01	res_1/8acre	c	90.00	0.96		
756	18	2,542.08	387,038.05	8.89	0.01	com_business	c	94.00	0.50		
757	18	6,325.69	1,535,286.43	35.25	0.02	res_1/8acre	c	90.00	1.90		
758	18	4,216.91	896,948.94	20.59	0.01	com_business	c	94.00	1.16		

			Wetlands Corridor Plan				**Wetlands Stratigic Spot Plan**			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 10 continued...

Table 10.10 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
759	18	10,177.02	2,615,570.07	60.05	0.04	res_1/4acre	c	83.00	2.99		
760	18	1,224.51	77,332.81	1.78	0.00	res_1/8acre	c	90.00	0.10		
761	18	464.12	8,967.95	0.21	0.00	com_business	c	94.00	0.01		
762	18	2,907.69	344,403.85	7.91	0.00	com_business	c	94.00	0.45		
763	18	810.55	30,368.50	0.70	0.00	res_1/8acre	c	90.00	0.04		
764	18	2,960.32	300,189.02	6.89	0.00	com_business	c	94.00	0.39		
765	18	6,574.86	736,296.79	16.90	0.01	road_paved	c	92.00	0.93		
766	18	2,167.99	110,468.31	2.54	0.00	road_paved	d	93.00	0.14		
767	18	2,605.63	231,321.39	5.31	0.00	res_1/3acre	d	86.00	0.27		
768	18	8,276.22	695,378.92	15.96	0.01	open_good	d	80.00	0.77		
769	18	1,404.63	88,151.61	2.02	0.00	res_1/3acre	b	72.00	0.09		
770	18	3,510.75	294,636.46	6.76	0.00	road_paved	b	89.00	0.36		
771	18	1,474.17	103,804.52	2.38	0.00	res_1/8acre	b	85.00	0.12		
772	18	2,851.74	279,361.86	6.41	0.00	res_1/4acre	b	75.00	0.29		
773	18	1,739.95	81,347.02	1.87	0.00	com_business	d	95.00	0.11		
774	18	2,117.15	269,008.48	6.18	0.00	res_1/8acre	d	92.00	0.34		
775	18	190.27	1,294.96	0.03	0.00	res_1/8acre	d	92.00	0.00		
776	18	595.85	14,369.32	0.33	0.00	com_business	d	95.00	0.02		
777	18	1,928.15	146,201.87	3.36	0.00	com_business	d	95.00	0.19		
798	18	250.31	1,908.69	0.04	0.00	com_business	u_d	95.00	0.00		
799	18	895.43	14,930.07	0.34	0.00	com_business	u_d	95.00	0.02		
800	18	1,101.97	20,487.81	0.47	0.00	open_good	u_d	80.00	0.02		
801	18	6,914.04	226,721.18	5.20	0.00	open_good	u_d	80.00	0.25		
820	18	638.74	6,415.96	0.15	0.00	open_good	u_d	80.00	0.01		
821	18	1,956.68	231,069.77	5.30	0.00	open_good	b	61.00	0.19		
822	18	363.75	4,333.81	0.10	0.00	com_business	u_d	95.00	0.01		
823	18	3,020.50	236,525.82	5.43	0.00	open_good	b	61.00	0.20		
824	18	1,298.00	57,628.89	1.32	0.00	com_business	b	92.00	0.07		
898	18	3,339.79	365,150.69	8.38	0.01	res_1/2acre	b	70.00	0.35		
899	18	378.03	4,301.34	0.10	0.00	res_1/2acre	b	70.00	0.00		
900	18	4,535.21	572,918.43	13.15	0.01	open_good	b	61.00	0.48		
901	18	1,351.22	99,237.18	2.28	0.00	res_1/8acre	b	85.00	0.12		
902	18	7,893.27	898,017.91	20.62	0.01	res_1/2acre	b	70.00	0.86		
903	18	387.14	8,202.61	0.19	0.00	res_1/2acre	b	70.00	0.01		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 10 continued...

Table 10.10 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
904	18	297.57	5,196.59	0.12	0.00	open_good	c	74.00	0.01		
905	18	1,659.08	70,966.92	1.63	0.00	res_1/2acre	c	80.00	0.08		
906	18	1,357.00	95,166.08	2.18	0.00	res_1/2acre	c	80.00	0.10		
907	18	4,611.83	277,595.99	6.37	0.00	res_1/2acre	c	80.00	0.31		
908	18	6,696.37	498,618.83	11.45	0.01	open_good	c	74.00	0.51		
909	18	1,416.37	94,316.19	2.17	0.00	com_business	c	94.00	0.12		
910	18	2,517.95	201,916.16	4.64	0.00	road_paved	c	92.00	0.26		
911	18	4,241.68	405,563.78	9.31	0.01	open_good	c	74.00	0.41		
912	18	3,438.75	454,135.89	10.43	0.01	res_1/8acre	c	90.00	0.56		
913	18	4,169.95	774,935.09	17.79	0.01	com_business	c	94.00	1.00		
914	18	1,669.86	129,909.20	2.98	0.00	open_good	c	74.00	0.13		
915	18	734.07	16,919.62	0.39	0.00	open_good	d	80.00	0.02		
974	18	3,019.14	451,039.10	10.35	0.01	res_1/8acre	b	85.00	0.53		
			72,691,596.93	**1,668.77**	**1.00**				**81.88**	**2.21**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
			5,618,383.31							
			1,458,850.33							
5.37	**0.45**	***747.13***	7,077,233.64	162.47	373.57	**2.30**	7,625,879.99	175.07	373.57	**2.13**

Sub-watershed 11

Table 10.11 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
19	19	72,506.33	41,587,496.47	954.72	0.25	row_sr_poor	b	81.00	20.37		
631	19	1,359.14	68,754.25	1.58	0.00	row_sr_poor	c	88.00	0.04		
632	19	2,149.25	125,634.33	2.88	0.00	row_sr_poor	c	88.00	0.07		
633	19	3,015.62	405,571.75	9.31	0.00	row_sr_poor	a	72.00	0.18		
634	19	2,491.21	204,682.00	4.70	0.00	row_sr_poor	u_d	91.00	0.11		
635	19	28,342.70	10,661,898.21	244.76	0.06	row_sr_poor	b	81.00	5.22		
636	19	8,156.54	3,516,777.68	80.73	0.02	row_sr_poor	b	81.00	1.72		
637	19	5,058.25	417,711.73	9.59	0.00	row_sr_poor	u_d	91.00	0.23		
638	19	16,550.39	8,302,429.88	190.60	0.05	row_sr_poor	a	72.00	3.62		
639	19	17,894.14	4,343,594.99	99.72	0.03	row_sr_poor	a	72.00	1.89		
640	19	16,755.54	3,253,431.39	74.69	0.02	row_sr_poor	b	81.00	1.59		
641	19	6,014.14	876,489.43	20.12	0.01	row_sr_poor	u_d	91.00	0.48		
642	19	2,219.64	258,836.05	5.94	0.00	road_paved	u_d	93.00	0.15		
643	19	1,845.99	132,948.07	3.05	0.00	res_1/3acre	b	72.00	0.06		
644	19	3,830.86	655,655.37	15.05	0.00	open_good	b	61.00	0.24		
645	19	1,989.74	150,298.55	3.45	0.00	open_good	b	61.00	0.06		
646	19	26,348.64	6,813,530.87	156.42	0.04	row_sr_poor	c	88.00	3.63		
647	19	5,447.57	648,846.69	14.90	0.00	open_good	d	80.00	0.31		
648	19	2,942.96	159,964.98	3.67	0.00	open_good	d	80.00	0.08		
649	19	4,497.02	462,613.99	10.62	0.00	res_1/2acre	a	54.00	0.15		
650	19	6,367.56	996,159.74	22.87	0.01	row_sr_poor	a	72.00	0.43		
651	19	8,701.09	3,376,228.59	77.51	0.02	row_sr_poor	a	72.00	1.47		
652	19	10,280.21	1,364,702.40	31.33	0.01	row_sr_poor	c	88.00	0.73		
653	19	13,375.32	3,280,587.99	75.31	0.02	row_sr_poor	c	88.00	1.75		
654	19	7,591.68	2,182,002.94	50.09	0.01	row_sr_poor	c	88.00	1.16		
655	19	16,184.23	2,049,499.97	47.05	0.01	row_sr_poor	c	88.00	1.09		
656	19	2,299.09	90,961.57	2.09	0.00	row_sr_poor	u_d	91.00	0.05		
657	19	5,920.30	837,471.89	19.23	0.01	res_1/3acre	c	91.00	0.46		
658	19	677.87	13,002.03	0.30	0.00	open_good	b	61.00	0.00		
659	19	5,391.17	710,713.24	16.32	0.00	res_1/4acre	d	87.00	0.37		
660	19	3,024.69	160,365.92	3.68	0.00	res_1/4acre	b	75.00	0.07		
661	19	1,698.58	95,621.71	2.20	0.00	res_1/8acre	b	85.00	0.05		
662	19	17,670.72	6,218,924.18	142.77	0.04	com_business	b	92.00	3.46		
663	19	6,649.94	265,144.06	6.09	0.00	open_good	u_d	80.00	0.13		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 11 continued...

Table 10.11 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
664	19	2,684.39	342,216.30	7.86	0.00	open_good	b	61.00	0.13		
665	19	1,551.95	120,348.63	2.76	0.00	open_good	b	61.00	0.04		
666	19	3,820.37	729,598.62	16.75	0.00	open_good	b	61.00	0.27		
667	19	9,725.55	3,044,560.61	69.89	0.02	open_good	c	74.00	1.36		
778	19	4,389.08	776,606.03	17.83	0.00	com_business	c	94.00	0.44		
779	19	151.11	1,036.89	0.02	0.00	com_business	c	94.00	0.00		
780	19	2,906.84	413,617.83	9.50	0.00	res_1/3acre	c	81.00	0.20		
781	19	9,810.15	1,318,107.87	30.26	0.01	com_business	c	94.00	0.75		
782	19	1,912.24	78,996.74	1.81	0.00	res_1/8acre	c	90.00	0.04		
783	19	3,590.09	545,521.86	12.52	0.00	res_1/8acre	c	90.00	0.30		
784	19	1,350.54	83,266.14	1.91	0.00	open_good	c	74.00	0.04		
785	19	5,623.53	438,821.43	10.07	0.00	open_good	c	74.00	0.20		
786	19	1,593.05	110,868.05	2.55	0.00	open_good	c	74.00	0.05		
787	19	3,566.52	502,181.23	11.53	0.00	com_business	c	94.00	0.29		
788	19	22,277.23	4,771,783.68	109.55	0.03	res_1/3acre	c	81.00	2.34		
789	19	1,954.69	172,229.05	3.95	0.00	open_good	c	74.00	0.08		
790	19	9,837.88	1,703,165.79	39.10	0.01	res_1/3acre	c	81.00	0.83		
791	19	511.05	5,811.36	0.13	0.00	res_1/3acre	c	81.00	0.00		
792	19	1,719.04	79,180.26	1.82	0.00	com_business	c	94.00	0.05		
793	19	1,858.15	128,774.59	2.96	0.00	open_good	b	61.00	0.05		
794	19	4,163.52	367,873.59	8.45	0.00	open_good	b	61.00	0.14		
795	19	1,083.58	42,554.52	0.98	0.00	com_business	d	95.00	0.02		
796	19	1,467.63	95,900.64	2.20	0.00	res_1/3acre	d	86.00	0.05		
797	19	213.50	2,209.60	0.05	0.00	res_1/2acre	d	85.00	0.00		
802	19	1,391.24	44,767.83	1.03	0.00	open_good	u_d	80.00	0.02		
803	19	1,192.43	12,911.46	0.30	0.00	res_1/8acre	u_d	80.00	0.01		
804	19	253.82	571.12	0.01	0.00	res_1/8acre	u_d	80.00	0.00		
805	19	793.77	19,522.49	0.45	0.00	com_business	u_d	95.00	0.01		
806	19	232.86	692.86	0.02	0.00	com_business	u_d	95.00	0.00		
807	19	185.45	1,466.18	0.03	0.00	res_1/3acre	u_d	86.00	0.00		
808	19	5,785.47	135,942.50	3.12	0.00	open_good	u_d	80.00	0.07		
809	19	1,868.25	38,245.84	0.88	0.00	open_good	u_d	80.00	0.02		
810	19	1,635.82	33,039.87	0.76	0.00	open_good	u_d	80.00	0.02		
811	19	2,038.80	37,647.71	0.86	0.00	open_good	u_d	80.00	0.02		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 11 continued...

Table 10.11 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
812	19	4,816.72	127,642.76	2.93	0.00	open_good	u_d	80.00	0.06		
813	19	356.62	1,685.59	0.04	0.00	open_good	b	61.00	0.00		
814	19	7,242.73	282,538.86	6.49	0.00	open_good	u_d	80.00	0.14		
815	19	87.72	166.32	0.00	0.00	open_good	u_d	80.00	0.00		
816	19	281.05	1,839.17	0.04	0.00	open_good	u_d	80.00	0.00		
817	19	2,039.54	20,906.53	0.48	0.00	open_good	u_d	80.00	0.01		
818	19	381.85	1,150.97	0.03	0.00	open_good	u_d	80.00	0.00		
819	19	2,103.71	48,359.74	1.11	0.00	com_business	u_d	95.00	0.03		
825	19	1,398.21	30,473.15	0.70	0.00	open_good	u_d	80.00	0.01		
826	19	511.23	9,074.74	0.21	0.00	open_good	u_d	80.00	0.00		
827	19	268.65	1,534.85	0.04	0.00	open_good	u_d	80.00	0.00		
828	19	1,604.20	76,864.82	1.76	0.00	open_good	b	61.00	0.03		
829	19	175.25	598.76	0.01	0.00	open_good	u_d	80.00	0.00		
830	19	7,286.91	369,230.08	8.48	0.00	open_good	b	61.00	0.14		
831	19	1,932.90	187,721.32	4.31	0.00	open_good	b	61.00	0.07		
832	19	103.15	568.59	0.01	0.00	open_good	d	80.00	0.00		
833	19	980.62	45,720.24	1.05	0.00	open_good	b	61.00	0.02		
834	19	2,323.83	237,439.83	5.45	0.00	road_paved	b	89.00	0.13		
835	19	5,138.00	412,301.13	9.47	0.00	com_business	c	94.00	0.23		
836	19	7,534.07	668,761.94	15.35	0.00	road_paved	c	92.00	0.37		
837	19	1,842.53	147,317.74	3.38	0.00	com_business	c	94.00	0.08		
838	19	4,244.53	925,844.39	21.25	0.01	com_business	c	94.00	0.53		
839	19	3,203.65	271,609.91	6.24	0.00	res_1/3acre	c	81.00	0.13		
840	19	8,189.72	1,944,054.66	44.63	0.01	open_good	c	74.00	0.87		
841	19	11,774.32	2,865,056.04	65.77	0.02	res_1/3acre	c	81.00	1.40		
842	19	1,543.56	113,397.77	2.60	0.00	com_business	c	94.00	0.06		
843	19	6,774.06	1,100,866.35	25.27	0.01	road_paved	c	92.00	0.61		
844	19	7,278.75	1,470,681.61	33.76	0.01	res_1/3acre	c	81.00	0.72		
845	19	3,163.01	214,609.17	4.93	0.00	res_1/3acre	c	81.00	0.11		
846	19	7,772.74	572,014.28	13.13	0.00	open_good	c	74.00	0.26		
847	19	3,191.00	123,115.11	2.83	0.00	row_sr_poor	c	88.00	0.07		
848	19	1,541.18	46,705.44	1.07	0.00	open_good	c	74.00	0.02		
849	19	16,570.45	3,073,301.73	70.55	0.02	res_1/3acre	c	81.00	1.51		
850	19	20,926.58	3,805,620.57	87.37	0.02	row_sr_poor	c	88.00	2.03		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 11 continued...

Table 10.11 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
851	19	9,660.49	682,920.89	15.68	0.00	row_sr_poor	a	72.00	0.30		
852	19	4,176.55	1,004,715.37	23.07	0.01	row_sr_poor	b	81.00	0.49		
853	19	4,971.96	314,714.70	7.22	0.00	row_sr_poor	b	81.00	0.15		
854	19	9,827.27	1,768,462.59	40.60	0.01	res_1/3acre	b	72.00	0.77		
855	19	1,193.64	34,369.32	0.79	0.00	open_good	b	61.00	0.01		
856	19	148.81	905.49	0.02	0.00	res_1/3acre	b	72.00	0.00		
857	19	10,447.54	1,972,603.02	45.28	0.01	res_1/3acre	b	72.00	0.86		
858	19	1,307.32	50,730.97	1.16	0.00	res_1/3acre	u_d	86.00	0.03		
859	19	3,044.21	257,225.90	5.91	0.00	res_1/3acre	u_d	86.00	0.13		
860	19	254.55	3,236.69	0.07	0.00	open_good	b	61.00	0.00		
861	19	220.34	1,468.81	0.03	0.00	road_paved	d	93.00	0.00		
862	19	928.74	36,798.47	0.84	0.00	road_paved	d	93.00	0.02		
863	19	1,284.48	62,656.04	1.44	0.00	res_1/3acre	d	86.00	0.03		
864	19	2,410.22	153,321.64	3.52	0.00	com_business	d	95.00	0.09		
865	19	542.69	18,649.94	0.43	0.00	com_business	d	95.00	0.01		
866	19	146.68	1,017.79	0.02	0.00	open_good	d	80.00	0.00		
867	19	1,159.31	63,519.25	1.46	0.00	com_business	d	95.00	0.04		
868	19	1,794.38	107,120.42	2.46	0.00	road_paved	d	93.00	0.06		
869	19	1,299.48	86,801.03	1.99	0.00	open_good	b	61.00	0.03		
870	19	5,382.57	625,458.38	14.36	0.00	res_1/3acre	b	72.00	0.27		
871	19	1,076.66	49,637.78	1.14	0.00	row_sr_poor	b	81.00	0.02		
872	19	811.16	9,329.79	0.21	0.00	row_sr_poor	b	81.00	0.00		
873	19	4,329.06	665,852.88	15.29	0.00	com_business	b	92.00	0.37		
874	19	471.12	5,241.24	0.12	0.00	open_good	b	61.00	0.00		
875	19	4,483.75	964,198.97	22.13	0.01	com_business	b	92.00	0.54		
876	19	3,272.08	204,100.06	4.69	0.00	row_sr_poor	b	81.00	0.10		
877	19	1,901.54	74,323.98	1.71	0.00	row_sr_poor	b	81.00	0.04		
878	19	6,367.39	432,316.33	9.92	0.00	com_business	b	92.00	0.24		
879	19	16,850.35	2,156,434.37	49.50	0.01	road_paved	b	89.00	1.16		
880	19	1,107.33	56,965.16	1.31	0.00	com_business	b	92.00	0.03		
881	19	1,391.93	117,501.52	2.70	0.00	open_good	b	61.00	0.04		
882	19	20,908.80	5,016,264.11	115.16	0.03	res_1/8acre	b	85.00	2.58		
883	19	18,179.48	2,046,619.54	46.98	0.01	com_business	b	92.00	1.14		
884	19	4,212.11	520,982.66	11.96	0.00	open_good	b	61.00	0.19		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 11 continued...

Table 10.11 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
885	19	19,377.67	3,879,710.42	89.07	0.02	res_1/4acre	b	75.00	1.76		
886	19	1,337.32	83,425.94	1.92	0.00	open_good	c	74.00	0.04		
887	19	542.38	10,074.23	0.23	0.00	row_sr_poor	a	72.00	0.00		
888	19	3,829.25	325,198.65	7.47	0.00	row_sr_poor	a	72.00	0.14		
889	19	2,400.75	97,666.58	2.24	0.00	row_sr_poor	a	72.00	0.04		
890	19	1,642.79	108,692.76	2.50	0.00	res_1/3acre	c	81.00	0.05		
891	19	476.08	6,734.69	0.15	0.00	res_1/3acre	d	86.00	0.00		
892	19	3,712.10	147,500.28	3.39	0.00	res_1/3acre	d	86.00	0.08		
893	19	2,289.35	189,485.87	4.35	0.00	com_business	b	92.00	0.11		
894	19	2,283.82	273,794.57	6.29	0.00	res_1/3acre	b	72.00	0.12		
895	19	928.92	47,154.17	1.08	0.00	open_good	b	61.00	0.02		
896	19	2,261.23	295,231.04	6.78	0.00	res_1/3acre	b	72.00	0.13		
897	19	3,511.07	240,334.43	5.52	0.00	res_1/3acre	b	72.00	0.10		
			165,358,835.00	**3,796.12**	**1.00**				**81.23**	**2.31**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.30	**0.44**	***1,676.04***	5,314,399.93	122.00	838.02	**6.87**	4,465,668.63	102.52	838.02	**8.17**

Sub-watershed 12

Table 10.12 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
2	2	66,849.86	46,563,716.57	1,068.96	0.46	row_c+t_poor	d	82.00	37.53		
21	2	11,305.11	5,330,050.02	122.36	0.05	row_sr_poor	d	91.00	4.77		
75	2	35,169.81	36,502,018.87	837.97	0.36	row_c+t_poor	d	82.00	29.42		
76	2	40,268.88	12,452,288.80	285.87	0.12	row_c+t_poor	b	74.00	9.06		
77	2	7,333.00	900,895.77	20.68	0.01	row_c+t_poor	b	74.00	0.66		
			101,748,970.02	**2,335.83**	**1.00**				**81.42**	**2.28**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.32	**0.44**	***1,035.59***	9,149,717.65	210.05	517.80	**2.47**	4,014,629.39	92.16	517.80	**5.62**

Sub-watershed 13

Table 10.13 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
3	3	67,674.48	65,389,249.27	1,501.13	0.45	row_c+t_poor	d	82.00	37.26		
22	3	12,463.84	2,392,389.07	54.92	0.02	row_sr_poor	d	91.00	1.51		
23	3	15,580.53	12,527,655.21	287.60	0.09	range_good	d	80.00	6.96		
78	3	42,466.98	51,983,850.64	1,193.39	0.36	row_c+t_poor	d	82.00	29.62		
79	3	3,388.54	397,903.06	9.13	0.00	row_c+t_poor	c	80.00	0.22		
80	3	35,072.75	10,779,810.87	247.47	0.07	row_c+t_poor	b	74.00	5.54		
81	3	1,669.58	110,305.45	2.53	0.00	row_c+t_poor	c	80.00	0.06		
82	3	3,548.17	316,273.33	7.26	0.00	row_c+t_poor	b	74.00	0.16		
			143,897,436.90	**3,303.43**	**1.00**				**81.35**	**2.29**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.31	**0.44**	***1,462.37***	8,666,549.68	198.96	731.18	**3.68**	4,306,741.37	98.87	731.18	**7.40**

Sub-watershed 14

Table 10.14 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
4	4	78,917.04	96,995,583.89	2,226.71	0.54	row_sr_good	d	89.00	48.11		
24	4	16,463.42	6,798,642.48	156.08	0.04	row_c+t_poor	d	82.00	3.11		
25	4	18,970.29	5,446,901.35	125.04	0.03	res_1/3acre	d	86.00	2.61		
26	4	2,704.74	33,711.12	0.77	0.00	range_fair	c	79.00	0.01		
27	4	41,725.05	30,425,580.33	698.48	0.17	range_good	d	80.00	13.56		
28	4	2,114.17	230,735.96	5.30	0.00	range_fair	d	94.00	0.12		
70	4	9,346.86	1,706,023.65	39.16	0.01	row_c+t_poor	d	82.00	0.78		
83	4	3,665.64	494,856.30	11.36	0.00	row_c+t_poor	d	82.00	0.23		
84	4	6,425.60	2,487,424.11	57.10	0.01	row_c+t_poor	d	82.00	1.14		
85	4	6,909.43	1,488,196.39	34.16	0.01	row_c+t_poor	b	74.00	0.61		
86	4	1,086.26	40,212.04	0.92	0.00	range_good	c	74.00	0.02		
87	4	3,216.29	353,323.72	8.11	0.00	range_good	b	61.00	0.12		
88	4	2,754.48	313,239.93	7.19	0.00	range_good	c	74.00	0.13		
89	4	1,898.27	135,690.37	3.12	0.00	range_good	c	74.00	0.06		
90	4	13,707.80	1,662,059.17	38.16	0.01	range_good	c	74.00	0.69		
91	4	2,595.93	237,077.47	5.44	0.00	range_good	d	80.00	0.11		
92	4	2,929.97	210,222.41	4.83	0.00	range_good	c	74.00	0.09		
93	4	9,789.10	3,306,126.46	75.90	0.02	range_good	b	61.00	1.12		
94	4	9,569.59	1,316,998.15	30.23	0.01	open_good	d	80.00	0.59		
95	4	2,783.89	255,998.99	5.88	0.00	open_good	d	80.00	0.11		
96	4	14,253.64	6,522,203.19	149.73	0.04	res_1/3acre	d	86.00	3.13		
97	4	3,445.96	361,836.58	8.31	0.00	com_business	c	94.00	0.19		
98	4	2,363.96	238,916.06	5.48	0.00	open_good	u_d	80.00	0.11		
99	4	1,945.24	112,818.03	2.59	0.00	open_good	u_d	80.00	0.05		
100	4	24,833.50	4,289,904.99	98.48	0.02	open_good	b	61.00	1.46		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 14 continued...

Table 10.14 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
101	4	3,671.32	380,943.23	8.75	0.00	open_good	c	74.00	0.16		
102	4	676.97	26,003.37	0.60	0.00	open_good	c	74.00	0.01		
103	4	8,471.12	794,916.13	18.25	0.00	open_good	b	61.00	0.27		
104	4	167.22	1,246.75	0.03	0.00	open_good	c	74.00	0.00		
105	4	7,759.11	1,283,269.53	29.46	0.01	open_good	d	80.00	0.57		
106	4	430.68	9,832.03	0.23	0.00	row_c+t_poor	b	74.00	0.00		
107	4	1,553.37	38,971.63	0.89	0.00	row_sr_good	b	78.00	0.02		
108	4	7,133.73	1,520,359.15	34.90	0.01	row_sr_good	d	89.00	0.75		
109	4	13,905.13	1,478,499.88	33.94	0.01	row_sr_good	b	78.00	0.64		
110	4	675.72	22,689.87	0.52	0.00	row_sr_good	b	78.00	0.01		
111	4	3,475.39	397,681.22	9.13	0.00	row_sr_good	b	78.00	0.17		
112	4	2,640.95	275,383.19	6.32	0.00	row_sr_good	c	85.00	0.13		
113	4	9,772.09	945,013.58	21.69	0.01	row_sr_good	b	78.00	0.41		
114	4	4,450.03	505,954.06	11.62	0.00	row_sr_good	c	85.00	0.24		
115	4	6,541.07	1,062,913.63	24.40	0.01	row_sr_good	c	85.00	0.50		
116	4	903.20	20,718.79	0.48	0.00	row_sr_good	d	89.00	0.01		
117	4	1,391.91	91,927.33	2.11	0.00	row_sr_good	d	89.00	0.05		
118	4	4,398.94	527,828.85	12.12	0.00	row_sr_good	c	85.00	0.25		
119	4	9,510.98	977,766.42	22.45	0.01	row_sr_good	c	85.00	0.46		
120	4	13,778.54	1,724,768.81	39.60	0.01	row_sr_good	b	78.00	0.75		
975	4	1,018.88	49,474.45	1.14	0.00	com_business	d	95.00	0.03		
976	4	2,749.68	383,974.18	8.81	0.00	com_business	d	95.00	0.20		
977	4	1,256.00	60,319.67	1.38	0.00	com_business	d	95.00	0.03		
978	4	515.06	10,780.82	0.25	0.00	res_1/3acre	d	86.00	0.01		
979	4	2,998.56	526,498.27	12.09	0.00	open_fair	d	84.00	0.25		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 14 continued...

Table 10.14 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
980	4	2,442.07	262,467.62	6.03	0.00	res_1/3acre	b	72.00	0.11		
981	4	1,497.13	85,871.17	1.97	0.00	open_fair	b	69.00	0.03		
982	4	680.17	21,044.84	0.48	0.00	open_fair	b	69.00	0.01		
983	4	2,472.97	264,995.30	6.08	0.00	com_business	b	92.00	0.14		
984	4	2,369.01	234,642.32	5.39	0.00	com_business	d	95.00	0.12		
985	4	131.68	499.65	0.01	0.00	open_fair	d	84.00	0.00		
			179,451,538.86	**4,119.64**	**1.00**				**84.57**	**1.82**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.68	**0.47**	***1,950.56***	14,150,860.37	324.86	975.28	**3.00**	11,922,303.40	273.70	975.28	**3.56**

Sub-watershed 15

Table 10.15 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
5	5	116,413.72	147,131,926.59	3,377.68	0.72	range_good	d	80.00	57.94		
32	5	22,509.67	13,798,949.14	316.78	0.07	range_fair	d	84.00	5.71		
33	5	6,320.24	594,247.99	13.64	0.00	range_fair	c	79.00	0.23		
34	5	7,977.23	690,129.76	15.84	0.00	range_fair	d	84.00	0.29		
151	5	1,110.41	81,618.07	1.87	0.00	range_good	c	74.00	0.03		
152	5	1,270.75	40,652.84	0.93	0.00	range_good	c	74.00	0.01		
153	5	4,909.35	427,117.12	9.81	0.00	range_good	c	74.00	0.16		
154	5	1,227.74	61,425.62	1.41	0.00	range_good	d	80.00	0.02		
155	5	2,174.12	154,149.56	3.54	0.00	range_good	c	74.00	0.06		
156	5	3,671.49	594,171.94	13.64	0.00	range_good	b	61.00	0.18		
157	5	15,584.21	1,908,946.40	43.82	0.01	range_good	c	74.00	0.70		
158	5	2,955.84	426,577.02	9.79	0.00	range_good	c	74.00	0.16		
159	5	2,612.66	333,646.37	7.66	0.00	range_good	c	74.00	0.12		
160	5	8,384.80	1,911,068.42	43.87	0.01	range_good	c	74.00	0.70		
161	5	7,370.08	1,096,247.58	25.17	0.01	range_good	c	74.00	0.40		
162	5	2,099.37	165,042.57	3.79	0.00	range_good	c	74.00	0.06		
163	5	1,463.48	74,679.53	1.71	0.00	range_good	c	74.00	0.03		
164	5	5,567.19	644,293.72	14.79	0.00	range_good	c	74.00	0.23		
165	5	14,106.16	2,158,284.12	49.55	0.01	range_good	c	74.00	0.79		
166	5	54,192.30	12,871,293.69	295.48	0.06	range_good	b	61.00	3.86		
167	5	838.69	25,784.94	0.59	0.00	range_good	d	80.00	0.01		
168	5	16,247.15	2,963,284.49	68.03	0.01	range_good	c	74.00	1.08		
169	5	5,751.48	529,808.99	12.16	0.00	range_good	c	74.00	0.19		
170	5	3,795.55	520,617.40	11.95	0.00	range_good	c	74.00	0.19		
171	5	1,560.77	33,643.73	0.77	0.00	range_good	d	80.00	0.01		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 15 continued...

Table 10.15 | (Produced by author, 2012)

	TR-55 Estimation of Runoff											
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
172	5	1,691.44	109,037.09	2.50	0.00	range_good	c	74.00	0.04		
173	5	666.23	21,763.75	0.50	0.00	range_good	d	80.00	0.01		
174	5	362.99	2,783.47	0.06	0.00	range_good	d	80.00	0.00		
175	5	18,809.24	3,400,125.03	78.06	0.02	range_good	c	74.00	1.24		
176	5	34,915.03	9,846,870.61	226.05	0.05	range_good	d	80.00	3.88		
179	5	1,115.07	74,855.06	1.72	0.00	range_fair	c	79.00	0.03		
180	5	1,263.60	65,985.07	1.51	0.00	range_fair	c	79.00	0.03		
181	5	3,345.44	354,831.14	8.15	0.00	range_fair	c	79.00	0.14		
217	5	385.41	5,625.45	0.13	0.00	range_fair	c	79.00	0.00		
218	5	1,787.59	39,656.28	0.91	0.00	range_fair	u_d	84.00	0.02		
			203,159,140.54	**4,663.89**	**1.00**				**78.52**	**2.74**	**7.50**

			Wetlands Corridor Plan				**Wetlands Stratigic Spot Plan**			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
4.99	**0.42**	***1,939.32***	724,028.13	16.62	969.66	**58.34**	258,898.82	5.94	969.66	**163.15**

Sub-watershed 16

Table 10.16 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
6	6	91,688.74	78,912,041.17	1,811.57	0.49	row_sr_good	d	89.00	43.89		
29	6	40,577.31	23,067,484.27	529.56	0.14	range_good	b	61.00	8.79		
30	6	3,340.15	571,541.84	13.12	0.00	row_sr_good	d	89.00	0.32		
31	6	22,996.99	10,118,725.45	232.29	0.06	range_fair	d	84.00	5.31		
121	6	2,866.85	339,021.70	7.78	0.00	row_sr_good	c	85.00	0.18		
122	6	7,349.02	2,151,203.96	49.38	0.01	range_fair	d	84.00	1.13		
123	6	6,507.93	650,247.96	14.93	0.00	range_fair	b	69.00	0.28		
124	6	18,649.93	2,946,484.34	67.64	0.02	range_fair	c	79.00	1.45		
125	6	932.34	26,551.49	0.61	0.00	range_fair	c	79.00	0.01		
126	6	2,724.03	220,873.31	5.07	0.00	row_sr_good	c	85.00	0.12		
127	6	1,680.69	115,264.19	2.65	0.00	row_sr_good	b	78.00	0.06		
128	6	1,538.14	122,851.00	2.82	0.00	row_sr_good	b	78.00	0.06		
129	6	2,101.98	160,414.98	3.68	0.00	row_sr_good	c	85.00	0.09		
130	6	31,356.25	5,698,969.87	130.83	0.04	row_sr_good	b	78.00	2.78		
131	6	1,578.43	137,004.66	3.15	0.00	row_sr_good	c	85.00	0.07		
132	6	4,370.53	430,152.63	9.87	0.00	row_sr_good	c	85.00	0.23		
133	6	748.67	22,075.40	0.51	0.00	row_sr_good	c	85.00	0.01		
134	6	1,881.02	175,896.24	4.04	0.00	row_sr_good	c	85.00	0.09		
135	6	4,814.84	520,526.66	11.95	0.00	row_sr_good	b	78.00	0.25		
136	6	629.63	15,567.38	0.36	0.00	row_sr_good	c	85.00	0.01		
137	6	1,379.62	33,001.84	0.76	0.00	row_sr_good	c	85.00	0.02		
138	6	747.46	4,814.20	0.11	0.00	row_sr_good	c	85.00	0.00		
139	6	5,769.74	984,365.28	22.60	0.01	range_good	c	74.00	0.46		
140	6	3,048.63	302,825.93	6.95	0.00	range_good	c	74.00	0.14		
141	6	12,502.11	3,415,736.43	78.41	0.02	range_good	d	80.00	1.71		
142	6	4,214.14	151,121.49	3.47	0.00	range_good	d	80.00	0.08		
143	6	11,838.00	2,257,692.46	51.83	0.01	range_good	c	74.00	1.04		
144	6	976.72	50,374.64	1.16	0.00	range_good	d	80.00	0.03		
145	6	14,567.26	2,719,246.86	62.43	0.02	range_good	c	74.00	1.26		
146	6	2,321.59	252,045.35	5.79	0.00	range_good	c	74.00	0.12		
147	6	607.70	20,114.01	0.46	0.00	range_good	c	74.00	0.01		
148	6	13,212.50	3,547,203.63	81.43	0.02	range_good	d	80.00	1.77		
149	6	6,501.75	610,992.39	14.03	0.00	range_good	c	74.00	0.28		
150	6	46,264.89	19,267,585.81	442.32	0.12	range_good	d	80.00	9.63		
			160,020,018.82	**3,673.55**	**1.00**				**81.67**	**2.24**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.35	**0.45**	***1,637.52***	23,932,850.55	549.42	818.76	**1.49**	12,062,674.69	276.92	818.76	**2.96**

Sub-watershed 17

Table 10.17 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
7	7	215112.79	213627686.84	4904.22	0.77	range_fair	d	84.00	64.71		
35	7	12560.92	7754376.38	178.02	0.03	row_c+t_poor	d	82.00	2.29		
36	7	2346.21	172133.85	3.95	0.00	row_c+t_poor	d	82.00	0.05		
37	7	3559.59	106935.79	2.45	0.00	row_c+t_poor	d	82.00	0.03		
177	7	638.07	12552.91	0.29	0.00	row_c+t_poor	c	80.00	0.00		
178	7	263.08	1206.68	0.03	0.00	row_c+t_poor	c	80.00	0.00		
182	7	3413.08	465041.64	10.68	0.00	range_fair	c	79.00	0.13		
183	7	4606.00	689703.89	15.83	0.00	range_fair	d	84.00	0.21		
184	7	17665.15	3177492.90	72.95	0.01	range_fair	c	79.00	0.91		
185	7	1292.91	104277.36	2.39	0.00	range_fair	c	79.00	0.03		
186	7	1408.11	127734.65	2.93	0.00	range_fair	c	79.00	0.04		
187	7	2408.27	222158.74	5.10	0.00	range_fair	c	79.00	0.06		
188	7	2065.68	292208.46	6.71	0.00	range_fair	c	79.00	0.08		
189	7	1476.83	122026.97	2.80	0.00	range_fair	c	79.00	0.03		
190	7	2898.93	361779.24	8.31	0.00	range_fair	d	84.00	0.11		
191	7	2695.94	461374.83	10.59	0.00	range_fair	d	84.00	0.14		
192	7	6347.39	690204.48	15.84	0.00	range_fair	c	79.00	0.20		
193	7	2143.67	119849.84	2.75	0.00	range_fair	c	79.00	0.03		
194	7	6005.27	1055950.67	24.24	0.00	range_fair	c	79.00	0.30		
195	7	1995.87	118947.09	2.73	0.00	range_fair	c	79.00	0.03		
196	7	10795.06	1629101.04	37.40	0.01	range_fair	c	79.00	0.46		
197	7	1505.06	169300.85	3.89	0.00	range_fair	c	79.00	0.05		
198	7	2562.84	140317.02	3.22	0.00	range_fair	c	79.00	0.04		
199	7	1277.76	83350.34	1.91	0.00	range_fair	d	84.00	0.03		
200	7	5234.66	692142.08	15.89	0.00	range_fair	u_d	84.00	0.21		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 17 continued...

Table 10.17 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
201	7	423.70	1759.60	0.04	0.00	range_fair	u_d	84.00	0.00		
202	7	1313.87	119887.13	2.75	0.00	range_fair	c	79.00	0.03		
203	7	1941.31	153373.02	3.52	0.00	range_fair	c	79.00	0.04		
204	7	5854.18	1328978.33	30.51	0.00	range_fair	c	79.00	0.38		
205	7	6678.42	1060216.68	24.34	0.00	range_fair	c	79.00	0.30		
206	7	25036.40	6886092.55	158.08	0.02	range_fair	c	79.00	1.96		
207	7	2010.98	180004.01	4.13	0.00	range_fair	d	84.00	0.05		
208	7	2869.60	317877.90	7.30	0.00	range_fair	d	84.00	0.10		
209	7	3244.26	318953.57	7.32	0.00	range_fair	d	84.00	0.10		
210	7	62907.61	9787019.18	224.68	0.04	range_fair	b	69.00	2.44		
211	7	1797.37	138847.31	3.19	0.00	range_fair	d	84.00	0.04		
212	7	34714.93	10708668.85	245.84	0.04	range_fair	c	79.00	3.05		
213	7	2552.06	355586.79	8.16	0.00	range_fair	d	84.00	0.11		
214	7	40854.19	8646975.48	198.51	0.03	range_fair	b	69.00	2.15		
215	7	2183.58	286028.00	6.57	0.00	range_fair	d	84.00	0.09		
216	7	20245.18	4626993.57	106.22	0.02	range_fair	c	79.00	1.32		
			277315116.48	**6366.28**	**1.00**				**82.34**	**2.14**	**7.50**

			Wetlands Corridor Plan				**Wetlands Stratigic Spot Plan**			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.43	**0.45**	***2878.56***	9658300.69	221.72	1439.28	**6.49**	4932942.78	113.24	1439.28	**12.71**

Sub-watershed 18

Table 10.18 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
8	8	139,956.67	128,807,691.31	2,957.02	0.48	row_sr_good	d	89.00	42.78		
45	8	8,725.02	3,872,754.01	88.91	0.01	row_sr_poor	d	91.00	1.32		
46	8	8,471.56	2,180,031.24	50.05	0.01	row_c+t_poor	d	82.00	0.67		
47	8	13,298.01	10,151,451.36	233.05	0.04	feed lot	d		0.00		
48	8	9,262.50	2,526,329.66	58.00	0.01	row_sr_poor	b	81.00	0.76		
49	8	63,576.85	14,115,140.51	324.04	0.05	range_poor	b	79.00	4.16		
239	8	2,343.55	257,998.89	5.92	0.00	row_sr_good	c	85.00	0.08		
240	8	1,425.89	138,627.65	3.18	0.00	row_sr_good	c	85.00	0.04		
241	8	3,032.95	253,223.13	5.81	0.00	row_sr_good	c	85.00	0.08		
242	8	1,352.33	109,419.57	2.51	0.00	row_sr_good	b	78.00	0.03		
243	8	6,088.50	1,122,062.40	25.76	0.00	row_sr_good	c	85.00	0.36		
244	8	3,817.24	237,919.55	5.46	0.00	row_sr_good	c	85.00	0.08		
245	8	1,616.70	131,090.24	3.01	0.00	row_sr_good	c	85.00	0.04		
246	8	7,853.56	705,670.99	16.20	0.00	row_sr_good	c	85.00	0.22		
247	8	26,095.93	5,225,124.49	119.95	0.02	row_sr_good	c	85.00	1.66		
248	8	13,884.31	2,393,984.53	54.96	0.01	row_sr_good	c	85.00	0.76		
249	8	48,428.76	10,553,406.10	242.27	0.04	row_sr_good	b	78.00	3.07		
250	8	1,642.78	129,994.08	2.98	0.00	range_poor	d	89.00	0.04		
251	8	938.27	38,245.51	0.88	0.00	range_poor	c	86.00	0.01		
252	8	5,182.57	506,555.15	11.63	0.00	range_poor	d	89.00	0.17		
253	8	7,644.70	873,766.20	20.06	0.00	range_poor	d	89.00	0.29		
254	8	1,313.23	33,417.24	0.77	0.00	range_poor	d	89.00	0.01		
255	8	14,423.06	4,814,015.35	110.51	0.02	range_poor	d	89.00	1.60		
256	8	23,454.35	5,578,643.19	128.07	0.02	range_poor	c	86.00	1.79		
257	8	4,604.97	465,482.09	10.69	0.00	range_poor	c	86.00	0.15		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 18 continued...

Table 10.18 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
258	8	2,141.16	152,390.83	3.50	0.00	range_poor	c	86.00	0.05		
259	8	7,528.40	708,653.99	16.27	0.00	range_poor	c	86.00	0.23		
260	8	1,288.49	91,669.86	2.10	0.00	range_poor	c	86.00	0.03		
261	8	39,445.39	15,041,021.58	345.29	0.06	range_poor	d	89.00	5.00		
262	8	1,508.94	111,698.65	2.56	0.00	range_poor	c	86.00	0.04		
263	8	35,369.02	15,850,202.68	363.87	0.06	range_poor	d	89.00	5.26		
264	8	1,613.86	87,528.16	2.01	0.00	range_poor	d	89.00	0.03		
265	8	1,794.81	84,260.36	1.93	0.00	range_poor	d	89.00	0.03		
266	8	3,626.82	296,427.66	6.81	0.00	range_poor	d	89.00	0.10		
267	8	487.81	11,462.20	0.26	0.00	range_poor	d	89.00	0.00		
268	8	42,355.74	20,567,759.19	472.17	0.08	range_poor	c	86.00	6.60		
269	8	27,628.58	10,386,060.52	238.43	0.04	range_poor	d	89.00	3.45		
270	8	1,127.73	89,694.33	2.06	0.00	range_poor	d	89.00	0.03		
271	8	25,752.54	8,799,119.10	202.00	0.03	range_poor	c	86.00	2.82		
272	8	3,061.47	369,391.81	8.48	0.00	range_poor	d	89.00	0.12		
319	8	236.23	2,665.95	0.06	0.00	row_sr_good	c	85.00	0.00		
320	8	1,502.87	79,469.71	1.82	0.00	row_sr_good	c	85.00	0.03		
			267,951,521.03	**6,151.32**	**1.00**				**83.99**	**1.91**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.62	**0.47**	***2,878.64***	80,462.09	1.85	1,439.32	**779.21**	7,093,776.52	162.85	1,439.32	**8.84**

Sub-watershed 19

Table 10.19 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
9	9	33,564.65	15,154,472.96	347.90	0.10	range_good	c	74.00	7.48		
38	9	24,164.45	10,910,558.57	250.47	0.07	range_good	b	61.00	4.44		
39	9	50,351.98	20,850,443.55	478.66	0.14	row_sr_good	d	89.00	12.38		
40	9	18,327.34	9,591,977.69	220.20	0.06	range_fair	c	79.00	5.06		
41	9	58,220.53	19,924,375.98	457.40	0.13	range_poor	c	86.00	11.43		
42	9	27,879.49	7,638,818.91	175.36	0.05	row_sr_poor	b	81.00	4.13		
219	9	763.23	33,614.03	0.77	0.00	range_good	c	74.00	0.02		
220	9	23,733.52	6,663,384.88	152.97	0.04	range_good	d	80.00	3.56		
221	9	12,555.65	2,152,973.25	49.43	0.01	range_good	c	74.00	1.06		
222	9	1,590.63	89,569.07	2.06	0.00	range_good	c	74.00	0.04		
223	9	5,394.68	859,712.67	19.74	0.01	range_good	c	74.00	0.42		
224	9	2,736.55	287,774.45	6.61	0.00	range_good	d	80.00	0.15		
225	9	6,239.01	618,216.87	14.19	0.00	range_good	c	74.00	0.31		
226	9	2,935.15	424,761.80	9.75	0.00	range_good	c	74.00	0.21		
227	9	4,585.96	281,681.31	6.47	0.00	range_good	c	74.00	0.14		
228	9	5,685.48	767,921.20	17.63	0.01	range_good	c	74.00	0.38		
229	9	287.77	2,383.30	0.05	0.00	row_sr_good	b	78.00	0.00		
230	9	10,957.09	3,769,342.10	86.53	0.03	row_sr_good	b	78.00	1.96		
231	9	156.26	1,145.10	0.03	0.00	row_sr_good	b	78.00	0.00		
232	9	6,722.66	718,163.12	16.49	0.00	row_sr_good	d	89.00	0.43		
233	9	3,600.69	480,294.58	11.03	0.00	row_sr_good	d	89.00	0.29		
234	9	4,376.15	633,804.20	14.55	0.00	row_sr_good	u_d	89.00	0.38		
235	9	53,432.44	10,837,206.38	248.79	0.07	row_sr_good	c	85.00	6.15		
236	9	3,364.97	344,355.84	7.91	0.00	row_sr_good	c	85.00	0.20		
237	9	1,150.90	81,459.01	1.87	0.00	row_sr_good	c	85.00	0.05		

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 19 continued...

Table 10.19 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
238	9	3,930.56	406,076.88	9.32	0.00	row_sr_good	c	85.00	0.23		
273	9	4,250.59	749,270.80	17.20	0.00	range_poor	d	89.00	0.44		
274	9	3,905.84	624,821.62	14.34	0.00	range_poor	d	89.00	0.37		
275	9	3,131.03	561,635.54	12.89	0.00	range_poor	d	89.00	0.33		
276	9	3,810.96	446,956.29	10.26	0.00	range_poor	d	89.00	0.27		
277	9	12,927.53	1,923,749.46	44.16	0.01	range_poor	d	89.00	1.14		
278	9	4,884.23	710,054.04	16.30	0.00	range_poor	b	79.00	0.37		
279	9	410.54	6,335.67	0.15	0.00	range_poor	c	86.00	0.00		
280	9	1,401.18	67,877.88	1.56	0.00	range_poor	c	86.00	0.04		
281	9	1,311.11	52,111.05	1.20	0.00	range_poor	c	86.00	0.03		
282	9	20,038.02	4,063,142.35	93.28	0.03	range_poor	d	89.00	2.41		
283	9	3,367.61	519,897.23	11.94	0.00	range_fair	c	79.00	0.27		
284	9	426.69	7,265.78	0.17	0.00	range_fair	b	69.00	0.00		
285	9	9,300.67	3,020,361.13	69.34	0.02	range_fair	b	69.00	1.39		
286	9	20,697.32	4,467,027.82	102.55	0.03	range_fair	d	84.00	2.50		
295	9	5,441.62	544,712.33	12.50	0.00	range_good	d	80.00	0.29		
296	9	5,222.03	1,178,790.76	27.06	0.01	range_good	b	61.00	0.48		
297	9	1,520.62	136,222.60	3.13	0.00	range_good	d	80.00	0.07		
298	9	706.59	10,693.02	0.25	0.00	range_good	d	80.00	0.01		
299	9	12,968.99	1,878,848.33	43.13	0.01	range_good	d	80.00	1.00		
300	9	4,251.59	478,974.22	11.00	0.00	range_good	d	80.00	0.26		
301	9	3,982.83	610,779.38	14.02	0.00	range_good	c	74.00	0.30		
302	9	13,944.84	1,873,671.40	43.01	0.01	range_good	b	61.00	0.76		
303	9	17,455.75	595,236.89	13.66	0.00	range_good	u_d	80.00	0.32		
304	9	2,052.08	165,169.50	3.79	0.00	range_good	b	61.00	0.07		

			Wetlands Corridor Plan				**Wetlands Stratigic Spot Plan**			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands

Sub-watershed 19 continued...

Table 10.19 | (Produced by author, 2012)

	TR-55 Estimation of Runoff										
Shape ID	Subwatershed	Shape Length (feet)	Shape Area (feet)	shape area (acres)	Percent Subwatershed	Land Cover	Soil Type	CN Score	Weighted CN Score	S Value	P Value
305	9	7,724.36	1,563,484.61	35.89	0.01	range_good	b	61.00	0.64		
306	9	17,116.72	3,529,655.34	81.03	0.02	range_good	b	61.00	1.44		
307	9	6,064.87	728,527.28	16.72	0.00	range_good	b	61.00	0.30		
308	9	22,225.06	913,208.76	20.96	0.01	range_good	u_d	80.00	0.49		
309	9	1,205.96	94,665.38	2.17	0.00	row_sr_poor	b	81.00	0.05		
310	9	2,263.87	68,240.65	1.57	0.00	row_sr_poor	u_d	91.00	0.04		
311	9	109.88	533.33	0.01	0.00	row_sr_poor	b	81.00	0.00		
312	9	14,356.54	2,279,819.53	52.34	0.02	row_sr_poor	c	88.00	1.34		
313	9	4,548.76	994,047.58	22.82	0.01	row_sr_poor	d	91.00	0.60		
314	9	6,327.57	997,232.77	22.89	0.01	row_sr_poor	c	88.00	0.59		
315	9	2,591.04	119,613.48	2.75	0.00	row_sr_poor	u_d	91.00	0.07		
316	9	26.68	14.02	0.00	0.00	row_sr_poor	u_d	91.00	0.00		
317	9	2,058.93	121,826.26	2.80	0.00	row_sr_poor	c	88.00	0.07		
318	9	8,160.88	274,781.19	6.31	0.00	row_sr_poor	u_d	91.00	0.17		
			149,903,742.95	**3,441.32**	**1.00**				**79.80**	**2.53**	**7.50**

			Wetlands Corridor Plan				Wetlands Stratigic Spot Plan			
Q Value (inches)	Q Value (feet)	***Runoff Volume (acrefeet)***	Corridor Plan Wetlands Area (feet)	Wetlands Area (acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands (feet)	Spot Plan Wetlands Area (feet)	Wetlands Area (Acres)	1/2 Runoff Volume (acrefeet)	Depth Needed For Wetlands
5.14	**0.43**	***1,472.68***	32,712,497.80	750.98	736.34	**0.98**	9,136,122.29	209.74	736.34	**3.51**