Perry Creek
Flood Control and Design

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Executive Summary

The extent of Perry Creek north of Stone Park Blvd. is in desperate need of a civil engineering solution. In response to significant issues related to flash flooding, severe embankment erosion, and poor water quality, the City of Sioux City awarded a contract to å Engineering, Inc. of Iowa City to design a comprehensive solution to mitigate these concerns and restore Perry Creek to the safe and healthy waterway it once was. To do so effectively, the group had to address several constraints and challenges, such as cost, phasing, project space, societal and environmental impacts, and design feasibility. After designing several alternatives, the group and client agreed upon a multi-phased design solution which incorporates synergistic components, including dry detention basins, grade control structures, and critical embankment stabilization.

The total project cost is estimated to be roughly $4.4 million when the costs of each design phase are summed. å Engineering, Inc. recognizes that this amount well exceeds the established budget of $2 million and therefore is an unrealistic investment to be made at one time. However, when spaced out into separate phases, this cost could be deemed as more manageable over the course of the forecasted project time of 14 years.

The main component of the design is a 43 acre dry detention basin located at S. Ridge Rd. in rural Plymouth County. The basin's volume, a total 333 acre-feet, is designed to detain a 100-year, 1-hour storm event, effectively reducing the flow of the creek to one-fourth of what would normally cascade downstream into Sioux City. Detained by a 210-foot long sheet pile reinforced earthen embankment, the basin is designed with appropriate features, such as a sedimentation forebay, outlet structure, and emergency spillway, as specified by Iowa Technical Bulletin No. 16 for dams. While a small berm is required to protect a private property on the site, several benefits are reaped by implementing this dry detention basin including flash flood protection during heavy rain events, erosion reduction downstream, and the creation of a wildlife sanctuary and recreational space for the entire community to enjoy. With an estimated cost of $2.02 million, this component serves as the first of several modifications to the Perry Creek Watershed proposed by å Engineering, Inc.'s design solution.

Additional features are incorporated into later phases of the final design solution to complement the impact of the S. Ridge Rd. dry detention basin. Seven grade control structures, implemented at various points on the extent of Perry Creek within the city limits of Sioux City, are designed to reduce the creek's velocity under normal flow conditions by ponding water and releasing it at a controlled rate. With elevated ponding heights ranging from 1 to 3 feet, the rock structures effectively decrease the longitudinal slope of the creek by half, encouraging sedimentation and preventing further embankment destabilization. In several instances, the grade control structures are placed at locations that have already experienced embankment failure or are in imminent danger of destabilization. To protect these critical embankments, measures such as riprap, geotextile erosion sheeting, and gabion baskets are proposed.

Two supplementary dry detention basins are designed to detain an additional 200 acre-feet of storm water if deemed necessary once the aforementioned measures are implemented. These basins, similar to the S. Ridge Rd. basin, are located in rural Plymouth County and cause minimal societal inconvenience, collectively inundating 65 acres of agrarian development during the 100-year, 1-

hour storm event. While these basins are not legally mandated by Iowa Technical Bulletin 16, they are still designed with appropriate features to ensure the safety of all property owners downstream.

While the specific designed project components are contained within the described dry detention basins, grade control structures, and critical embankment stabilization, å Engineering, Inc. has also conducted research and prepared information with regard to actions and initiatives which can be taken by members of the community to improve the health of the watershed. Several best management practices, or BMPs, such as rain gardens, tree box filters, and pocket wetlands, are described in detail in the report. These simple, cost-effective solutions allow property owners to control the amount of water entering into Perry Creek from their properties. On a grander scale, the group suggests the adoption of a watershed management authority for Perry Creek. This mechanism would for multiple stakeholders within the watershed to collaborate on future projects and efforts to improve Perry Creek and give communities the authority to request for funding from government agencies and organizations to accomplish these projects.

Although the problems facing Sioux City with regard to this project appear daunting, å Engineering, Inc. believes that the proposed design solution, in addition to wholehearted, community-wide engagement within the watershed, will lead to a safer, healthier, and happier Perry Creek Watershed.

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Mission Statement

The team members at å Engineering, Inc. are dedicated to giving the community surrounding Perry Creek in Sioux City, Iowa a long lasting and effective solution to mitigate the creek's existing issues. The group will be successful in doing so when a plan addressing the creek's flash flooding and water quality issues is crafted in a manner which is feasible, has minimal negative impact on the community, and engages all stakeholders in a final design solution.

Introduction

Perry Creek is a 28.9-mile long creek that flows from Plymouth County, through Woodbury County, namely Sioux City, and into the Missouri River to the west of downtown. In total, the creek has a watershed that encompasses more than 70 square miles of loess soils, a sandy silt mixture with minor amounts of clay. The Perry Creek Watershed consists mostly agricultural farmland, with the obvious exception of residential and commercial districts located within the city limits of Sioux City. As a result of both agrarian and urban development, the creek has transformed from a healthy, stable waterway to a sick, quickly eroding channel perfect for floodwaters to cascade down during heavy rain events.

According to the U.S. Geological Survey, Perry Creek has flooded 24 times in the city's history, exposing residents to direct danger and risk of loss of life and property. During major rainstorms, the narrow creek has surged water downstream, producing flash flooding conditions and major embankment erosion. After an especially devastating flood in 1990, the U.S. Army Corps of Engineers was contracted to design and implement a creek channelization project for the southern extent of the waterway, thus completely eliminating the flood risk for this portion of the community. This project was completed in 2007 for a total cost of $97 million. Perry Creek to the north of Stone Park Blvd., however, was left untouched and has continued to degrade.

Specifically, the northern extent of Perry Creek within the city limits is surrounded by six residential neighborhoods, a private golf course, a small business district, and an elementary school. These properties have slowly but surely been encroached upon by embankment failure. In summer of 2014, a major flood event estimated to have a 30-year return period swept through the community. While the community surrounding the southern, modified extent of Perry Creek faired relatively unscathed, the community surrounding the northern, unmodified extent of the creek was not as fortunate. As a result of the rapid waters, several embankments experienced complete failure. These failures caused extensive amounts of vegetation from the riparian zone to fall into and clog the creek, as well as compromised much of the infrastructure owned by the city near the creek such as stormwater outlets.

More startling, however, were the impacts of the flooding felt by private property owners. Due to this event, several residential properties lost portions of fence and backyards to the creek, with some structures now within less than 10 feet of shear embankments. Left unmodified, it is certain that several homes would eventually be swallowed by the raging torrent that is Perry Creek during high water conditions. Most concerning is the situation that has developed at Clark Elementary School. The school owns a pedestrian bridge which provides access to students living on the opposite side of the creek. During the storm event, the westward footing of the bridge was completely compromised. Somehow, the bridge remains standing but is impassable, causing much burden to several families of Clark Elementary.

In general, this extent of Perry Creek has caused significant hardship to the community and will continue to cause issues until the creek becomes stable in a fluvial geomorphologic context, i.e. until the embankments erode away enough for the creek to establish a new flow path. Unfortunately for those living near the creek, this means loss of property and livelihood. As this is not a realistic option for the community to consider, action must be taken now to rehabilitate and modify Perry Creek before it is too late.

Problem Statement

Initially, a generic scope of work expected of this project was provided to å Engineering, Inc. in the RFP in January 2015. The work tasks included "potential widening, straightening, embankment work along the creek, design of levees and drainage structures, public and private utilities relocation, bridge and street reconstruction, and cost estimates." While this basic statement guided the team in crafting an initial contract proposal, the actual problem remained unidentified until visiting Perry Creek in person. After conducting a site visit along Perry Creek and speaking with the City Engineer of Sioux City, Glenn Ellis, the group was able to identify the issues at hand.

Because of societal interference, the natural course of water flowing within the watershed has been altered. These interferences include impervious surfaces such as homes and roadways, agricultural tiling in the northern area of the watershed, and continued growth and development in Sioux City. As a result of these activities, a significant amount of water which falls in the watershed does not have the chance to infiltrate into the ground. Instead, in many instances, the water flows over the impervious surface or is sent into drainage pipes, ultimately being directly discharged into Perry Creek. While under light rain conditions the interference to water's course is negligible, heavy rain events produce large flows of water that are sent cascading down the creek in a short amount of time, often times causing flash flooding in the downstream portion of the watershed as documented over the course of the city's history.

To compound the issue of flooding, the soil in the watershed is part of the larger loess formation in northwest Iowa. This same loose and rich soil which first attracted settlers to this corner of Iowa

also happens to be extremely erodible. When subjected to the flows created during heavy rain events, the soil embankments are easily washed away. While erosion is a natural part of the fluvial geomorphologic process of any watershed, the combination of excessive flows and soil type has accelerated the erosion experienced along Perry Creek, especially in the urban areas on the southern extent of the project area. As identified during site visits, erosion is now encroaching on the property of community members along the creek, as seen in Figure 1.

Figure 1: Example of property encroachment along Perry Creek

The erosion not only threatens private property owners, but also the city's infrastructure surrounding the creek. Several bridges and sewer outfalls have been impacted as a result of the floods experienced in the creek. An extreme example of this threat to infrastructure was witnessed in the summer floods in 2014, when the embankment supporting a pedestrian bridge and outfall was compromised, incapacitating the bridge, destroying the outfall, and causing a significant burden for the community. This bridge, pictured in Figure 2, serves as a link to Clark Elementary School; without it, the community was forced to fund alternative means of transporting roughly 60 students to and from school.

Figure 2: Extreme erosion at Clark Elementary pedestrian bridge

Unfortunately, the Clark Elementary School pedestrian bridge is not an isolated incident, but rather the norm observed throughout the creek. While visiting the project area, å Engineering, Inc. pinpointed numerous locations where embankments were in the process of or had already failed. The former was identified by separated banks that were in process of sliding into the creek, as displayed in Figure 3a, while the latter was identified by shear walls of stratified soil, as displayed in Figure 3b.

Figure 3a: Banks sliding into creek

Figure 3b: Shear walls of erosion

To add to the complexity of the problem statement, the majority of Perry Creek is privately owned instead of falling under the jurisdiction of the municipality. Within city limits, residents who own land bordering the creek have sole property rights to its thalweg. There have been several pleas by some residents to the city to do something to stop the erosion and flooding, but the city simply does not have the authority to make alterations to private property. Thus, the problems plaguing the watershed continue to pose danger to the community.

While the major concern associated with Perry Creek is flooding and erosion, there are also several additional concerns to be addressed in the problem statement. The creek was placed on the List of Impaired Iowa Waters due to environmental concerns in 2010. After talking with Glenn Ellis, the environmental concerns related to turbidity and nutrient levels in general. In reality, this designation served as the spark for the city to produce funds to make this project possible. The city is also upgrading infrastructure surrounding the creek, namely roadway bridges. Certain city officials and community members, however, are anxious about the unstable and volatile nature of the creek and desire to have regulated and safe project areas to work in.

Design Objectives

After evaluating Perry Creek in its current state, the team collaborated to create design objectives to guide the project effort to alleviate problems and address issues in the area of concern. While the Mission Statement of the project served as the group's guiding principle, the design objectives served as a set of simple and declarative statements of what impacts and results were to be expected of the final design solution.

å Engineering, Inc. resolved to provide a solution which primarily addresses flooding and erosion concerns because these issues impact the community most directly. The water quality of the creek, however, was evaluated to be just as important of a controlling criteria because funding for this project was made possible to improve the creek's quality. The group adopted these two congruent issues as the driving force behind crafting a solution.

In addition to these two issues, the team also resolved to create a realistic and cost-effective solution that is easily implemented into the creek in a manner which does not cause irreparable damage to the watershed. The design solution must be feasible not only during its initial implementation, but also throughout the course of its life; the solution created must exhibit a reasonable amount of sustainability, requiring minimal investment for maintenance and upkeep.

The solution created must cause as minimal negative societal impact to the community surrounding Perry Creek, and in fact benefit the community in several ways. While not officially declared in the RFP, the group was also able to infer that the client preferred a design solution

that served a secondary benefit to the community. The solution created must provide certain recreational opportunities to the general population.

The design objectives required different technical approaches to be effectively accomplished. In doing so, the group addressed several hard and soft constraints and challenges, as well as kept in mind the delicate societal structure and the implications this project may have on the people who call the Perry Creek Watershed, and beyond, home.

Approaches

For the Perry Creek Flood Control and Design project, the group adopted an approach which not only followed proper guidelines and necessary permitting process as established by appropriate manuals and agencies, but also one which valued the balance between theoretical effectiveness of a design and practical feasibility of its realization. The approach taken by the group produced results which reduce flood risk in the Perry Creek Watershed, while impacting the community socially and environmentally as minimally negative as possible.

As confirmed by the City of Sioux City, å Engineering, Inc. provided a solution which follows the standards as described in the Iowa Statewide Urban Design and Specifications (SUDAS) manual. To supplement the guidelines found in SUDAS, the group also used the Iowa Stormwater Management Manual (ISWMM) for further information in the design process. In the off chance that these two manuals presented conflicting information, SUDAS guidelines took precedence over ISWMM guidelines.

Several permits will be needed for the project to be successful and are rewarded from several different government organizations. The City of Sioux City requires that all projects that occur within city limits acquire three special permits. The permits are the Building Construction Permit, Rental Housing Permit, and Property Maintenance/Public Nuisance Complaints. These permits are meant to maintain the integrity of the community and protect those involved with the project. These three permits all are accompanied by a series of inspections. In addition, the Iowa DNR mandates that the team acquires the NPDES General Permit No. 2, which is a permit for projects of area greater than one acre with stormwater discharge associated with industrial and construction activities. The DNR also requires a Pollution Prevention Plan permit, which ensures the firm will minimize pollution created before environmental implications occur. Because the project involves the alteration of a navigable water's course, several permits are also needed from the US Army Corps of Engineers. These include the Individual Permit, which declares the project as an approved project by the Army Corps, a Standard Permit, which involve notification of the public and commenting agencies of the project, and a Letter of Permission, which involves several Federal and State fish and wildlife agencies, public interest evaluation, and a public notice of the project.

Guided by an approach based on appropriate and required industry standards, the group drafted three design alternatives as potential solutions for the City of Sioux City to consider. As mentioned, the solutions not only address the issues presented by this project in a theoretically based manner, but also in a manner which recognizes and understands the importance of integrating the surrounding community and environment of the watershed into the potential design alternatives. The alternatives prepared are entitled 1, 2, and 3 and are listed and described in the report.

Constraints

As with all civil engineering projects, there were several constraints to be considered for the Perry Creek Flood Control and Design project. The group provided solutions that exist within the envelope of the established constraints. Some of these constraints have been set by the City of Sioux City, while others originate from certain manuals and organizations which mandate flood control projects. The project has both “hard” and “soft” constraints. The hard constraints of the project include cost, time, design guide requirements, and current projects in the area of concern, while the soft constraints of the project include space, societal impacts, environmental considerations, and aesthetics.

As requested by the City of Sioux City, the project shall not have a total budget exceeding $2 million. This total cost includes the proposal cost, as well as the estimated cost of completing the project. The group has deemed this budget as unrealistic and somewhat burdensome. In 2007, the US Army Corps completed its Perry Creek Flood Control Project on the southern extent of the creek with a final cost of $97 million. For this amount, the Corps was able to straighten, deepen, and widen the channel, buyout and remove dozens of at-risk structures, upgrade bridges and streets, relocate utility lines, and clear the creek of trees and brush.

While the 2007 project had a similar scope to this project, this project is focused on the northern extent of the creek which is in a far less developed area of the city. Thus, the total cost of the project is expected to be at the requested budget amount, lower than the $97 million cost of the previous project; however, cost is expected to be very high for a project with such a large and comprehensive scope of work. The group addressed these constraints by creating design solutions which are easily phased out into several steps that are time independent.

The team also recognized the constraint of time. In the matter of 13 weeks, the group produced a final product for the City of Sioux City. The community around Perry Creek is ready for change, and the group is dedicated to alleviating the risk of flooding along this water corridor. The Perry Creek Flood Control and Design project adhered to the contract period specified by the City of Sioux City and followed the work plan set out by the group. With regard to project

implementation, the group notes the fact that this project is very large in scale and will take much coordination to be completed in a timely manner.

In addition to cost and time, the project adhered to the design requirements as set in appropriate manuals which mandate flood control and design projects within the State of Iowa. After speaking with the City of Sioux City and determining the municipality's preference, the group decided to use the guidelines as set by the Iowa Statewide Urban Design and Specifications manual (SUDAS) and the Iowa Stormwater Management Manual (ISWMM). These two manuals contain the widely accepted and used standards for projects of similar scope within the state. While the manuals cover a wide range of topics, only certain sections of each were utilized by the group. In SUDAS, Chapter 2: Stormwater and Chapter 7: Erosion and Sediment Control were heavily relied on while in ISWMM, Part 2C – Stormwater Hydrology, Part 2D – BMP Types and Applications, and Part 2O – Open Channel Flow were used most frequently. These manuals served as a hard constraint because the policy outlined within them are government mandated. The group followed the design constraints by ensuring that all aspects of the project appropriately reflected the manual policies.

There are several ongoing city projects which were considered hard constraints for the Perry Creek Flood Control and Design project. The City of Sioux City is in the process of reconstructing Perry Creek crossings at Dearborn Avenue and 38th Street. While certain design components may have been placed near these projects, design solutions do not compromise the integrity or feasibility of the projects. In addition, FEMA has awarded disaster relief money to the City of Sioux City and the Sioux City Community School District to repair the pedestrian bridge behind Clark Elementary School. While the group addressed stream concerns at Clark, the design alternatives did not alter the pedestrian bridge as it currently stands.

With regard to space constraints, the project must exist within the bounds of Stone Park Boulevard and the Perry Creek Watershed north of this thoroughfare. The city limits were crossed, as allowed by the City of Sioux City. The project, however, only must address the extent of Perry Creek which is within the boundary of the city.

While no specific space constraints were set for the project, there was a constraint of space with regard to right of way; much of the property along Perry Creek is privately owned by residents and businesses. In concocting design alternatives, the right of way constraint was dealt with through public forums and controlled interactions between å Engineering, Inc. and residents in the areas of concern. It was generally asserted by the group, however, that the project should have as little negative impact as possible on the City of Sioux City and the citizens who call the city home.

Included under the umbrella of negative impact is land acquisition and relocation of citizens. As mentioned, the group valued the community which surrounds Perry Creek. Going through

the design process, the group strongly considered options which minimally went beyond the bounds of Perry Creek's designated channel, especially in areas with neighborhoods and businesses in the immediate vicinity of the creek. That is not to say that land acquisition and demolition of homes were not needed; if a home was in an at-risk location, the group created designs accordingly. The design solutions created were fashioned in a manner which minimized unfavorable impacts on the City of Sioux City. This included not only avoiding resident relocation, but also the creation of any unnecessary flooding and new high-risk zones in areas where there are high volumes of civilians around the creek.

The group also recognized the impact the project will have on the environment. For the project to be successful, a large amount of foliage, and therefore habitat for native flora and fauna, must be removed. An important constraint considered is the environmental impact on the ecosystem in Perry Creek. To reduce the negative impact, the group incorporated project components such as BMPs and green practices in the design solutions. The solutions therefore provide a viable option to replenish the natural environment which may be lost through the project.

With the proposed design solutions, the group also valued the soft constraint of aesthetics. In each design solution offered, components of the project were included to highlight the natural beauty of the community as well as the city as a whole. The alternatives provided complement and augment the surrounding neighborhoods in the watershed.

Challenges

The project posed many challenges for the team. The team provided detailed instruction on how to eliminate or minimize these challenges. These challenges originate from societal influences, environmental hazards and impacts, design effectiveness, and constructability.

One of the most important aspects of the project will be to implement the design solution in time and manner that is accepted by the community. The project may require demolition which will produce negative impacts to the community, especially for people that own property within the project boundaries. There are also public areas that border the creek including Sioux City Country Club Golf Course and Clark Elementary School. These areas were denoted as high priority locations of societal sensitivity.

Another important challenge considered was how the designs impacted the environment. The designs assessed future environmental prediction, and focused on minimizing sediment transportation due to erosion. The current erosion issues were high priority design parameters. Design solutions were to be environmentally sustainable, meaning they must not promote potentially dangerous hazards to ecosystems throughout its lifetime. The group produced alternatives which were effective without creating large and negative environmental impacts.

Environmental assessments must be conducted before design implementation. In addition, the water quality of the creek must be measured constantly to ensure that project activities are not impacting the creek and ecosystem negatively.

The project is approximately 300 miles from the å Engineering, Inc. headquarters. While initially thought to be a challenge, consistent contact with clients and the community was achieved using both in-person visits and electronic communication. Bi-weekly updates were provided to the City Engineer of Sioux City. The team also visited Sioux City several times to meet with not only the City Engineer, but also citizens within the community.

Another important issue considered was design feasibility. This project is large in scale, and the group wanted to provide a realistic solution for the community. Excavation and construction may be required along property boundaries. Thus, cooperation with private property owners must occur. If utilities are located within construction limits, they must be handled with caution and be relocated prior to construction. The design must also be sustainable, i.e. the constructed design must endure the elements with low maintenance. The design must provide healthy waters downstream, also reduce water withdrawals and increase water recharge at a rate that creates a balanced watershed.

Utilities located within the construction boundaries will pose a challenges in the construction process. These utilities must be located prior to construction and georeferenced in construction documents. Each utility must be handled with caution during the construction process due to potential hazards to workers or the community. Often, utilities are not easily located. Heavy research must be implemented on past projects and contact must be made with prior consultants and contractors if questions do arise.

Societal Impacts

The societal impacts of the proposed projects are astronomical. Similar to the US Army Corp of Engineers' project on the southern part of Perry Creek, this project will reduce the risk of flooding for many Sioux City residents living north of Stone Park Boulevard, increase the water quality, and partner with Iowa businesses and community members.

One of the most prominent impacts to the residents of Sioux City is the major reduction in flood insurance costs for those living within the floodplain. According to an article in the Sioux City Journal, residents who live in the floodplain pay anywhere from $700 to more than $1000 annually for flood insurance. With the implementation of flood control design measures, hundreds of families will no longer be affected by inundation and therefore have no need for flood insurance.

As stated by Glenn Ellis, the City Engineer for Sioux City, a major concern for Perry Creek was the extensive erosion that occurs during inundation. Soil erosion causes instability of the embankment, very turbid water, and in general, poor water quality. å Engineering designed flood control measures that minimized soil erosion. These measures decrease the turbidity and in return increase the water quality for aquatic life and natural beauty as it flows through Sioux City. A healthy ecological system is a happy community.

With the extensive work proposed for Perry Creek north of Stone Park Boulevard, the finished product will require å Engineering and Sioux City to partner with Iowa businesses. Subcontractors will be hired to assess possible bridge redesign for any of the five bridges that cross Perry Creek north of Stone Park Boulevard. This collaboration will benefit the City of Sioux City.

Preliminary Development of Alternative Solutions

Three design alternatives were designed by å Engineering, Inc. to address the project objectives in a manner that considered the design constraints and challenges. Each of the design alternatives take different approaches to achieve similar results.

Design Alternative 1 - Wet detention basin

The main component of Design Alternative 1 is a wet detention basin located north of Sioux City. Located at S. Ridge Rd. in unincorporated Plymouth County, the 55-acre basin is detained by an earthen embankment structure with a minimum elevation of 1190 ft. The permanent pond has a normal pool surface level of 1175 ft. The basin has the capacity to detain a 50-year design storm safely; above a surface elevation of 1180 ft., excess discharge is diverted into an emergency spillway. An aerial overview of the wet detention basin is displayed in Figure A.1 in Appendix A.

The design of the wet detention basin follows regulations outlined in the Iowa Stormwater Management Manual (ISWMM) Section 2G-3, and the American Society of Civil Engineers (ASCE) Design of Urban Stormwater Controls, Second Edition. These regulations include, but are not limited to, achieving water quality volume standards in permanent pool sizing, active storage sizing to temporarily store the volume of runoff for flood protection from between a 25 year return period to a 100 year return period, have an evacuation time of 24-48 hours, max depth of the basin should be no greater than 10 feet, length-to-width ratio of 2:1 or greater, basin side slopes of 4:1, a sedimentation forebay with a volume equal to approximately 10% of total design volume, and aquatic and safety benches.

The location of the wet detention basin was chosen because it is in an unpopulated area, it is row crop farmland, and the natural slope of the surrounding areas. The wet detention basin will require inlet and outlet structures, as well as an embankment structure following the paths of Fox Ave., S. Ridge Rd., and Hamilton Blvd. An emergency spillway is also required with this design.

Two foot contour lines were downloaded from GeoTree and imported into two ArcGIS programs, ArcMap and ArcScene. From these programs a 2D and 3D surface area and a 3D surface volume was calculated for the approximate area of the wet detention basin. The 2D surface area is approximately 54.2 acres, 3D surface area is approximately 56.5 acres and the 3D surface volume is 529.9 acre-feet. These areas and volumes correspond to a max ponding elevation of 1180 feet.

After obtaining these approximate areas and volumes, specifications for the outlet structure were determined. A max velocity of 5 feet per second was estimated from ISWMM, Section 2O-2 – Open Channel Flow, but is expected to change after obtaining results from soil analyses on this area. Having a velocity of less than 5 feet per second, as well as a riprap lining along certain stretches, will prevent scouring and further soil erosion. Land acquisition and minor roadway altercations are necessary with this design, and regular maintenance is required for wet detention basins.

In addition to the wet detention basin, bank stabilization and restoration is performed in at risk areas further downstream in this alternative. Best management practices (BMPs) are implemented throughout the corridor to complement the effectiveness of the basin upstream.

A potential phasing plan for Design Alternative 1 is presented below:

Phase 1: Land acquisition of roughly 30 acres (with flooding easements for additional 25 acres) of agricultural property in southern Plymouth County. Removal of existing vegetation and debris within the planned flooding area.

Phase 2: Construction of 1660 ft. earthen embankment structure with Fox Ave. and S. Ridge Rd. requiring lifting. While not absolutely necessary, it is suggested that Hamilton Blvd. is reconfigured to maintain the roadway for major north-south traffic patterns during high water events. Outlet structures and emergency spillway constructed with embankment structure.

Phase 3: Sedimentation forebays, an outlet structure, and additional modifications as necessary are placed within basin.

Phase 4: Wet detention basin filled to normal standing level of 1175 ft.

Phase 5: Removal of debris from Perry Creek within city limits. Where applicable, embankment structures and riprap added to major areas of erosion.

Phase 6: BMPs implemented downstream.

The impacts of Design Alternative 1 are astounding. This alternative has significant ability to improve water quality by allowing sediment to drop from the water at all times in the wet detention basin, thus reducing the turbidity of the water in Perry Creek downstream. The design of the wet detention basin also reduces the amount of flooding expected during moderate to heavy rain events, and will eliminate the flash flood conditions that characterize the watershed. With the amount of land acquisition and roadway configuration required for this alternative, one may deem this the least feasible out of the three alternatives, especially considering some families will need to be moved out of the basin. The amount of impact with regard to water quality and flood mitigation, however, justifies the actions needed to make this alternative into a reality. In addition, because this option requires little to no alterations be performed in the city limit, the alternative is not as invasive as other options.

The societal impacts of this alternative are also intense. On one of the spectrum, citizens of Sioux City will have permanent protection from frequent flooding; however, approximately five families will be directly, negatively impacted in the sense that their homesteads will need to be acquired and subsequently flooded. This alternative provides both the greatest benefit as well as detriment for several people and properties in the area.

Design Alternative 1 has a very high recreational value to be offered to the community. The pond itself can be used for light water recreation (canoeing, kayaking, etc.). In addition, a small beach/park on the shore of the pond would serve as a pleasant addition to the community. The wildlife habitats created by the pond are similar to the original wetlands that covered Iowa before its cultivation. As a result, the areas around the pond have a natural beauty the caliber of a county or state park.

This total cost estimate of this design is $2,900,000. The estimate includes removal of vegetation, embankment, road reconfiguration, embankment and levee structures, grade control structures, acquiring land and vegetation costs. Only one grade control structure was included in the cost and the design may require more. This is a rough preliminary cost estimate and is subject to change.

Design Alternative 2 - Dry Detention Basin

Instead of a wet detention basin, Design Alternative 2 incorporates a dry detention basin and grade control structures to alleviate the identified concerns of Perry Creek. The dry detention basin is to be located just north of S. Ridge Rd, in the same location as the wet detention basin in Design Alternative 1, with a storage volume over 18 million cubic feet. The location of the dry detention basin is shown in Figure B.1 in Appendix B. This volume exceeds the water quality volume, which is approximately 15 million cubic feet.

The design of the dry detention basin follows regulations outlined in the Iowa Stormwater Management Manual (ISWMM) and the American Society of Civil Engineers (ASCE) Design of Urban Stormwater Controls, Second Edition. These regulations include, but are not limited to, sizing to temporarily store the volume of runoff for flood protection from between a 5 year return period to a 25 year return period, have an evacuation time of 24-48 hours, max depth of the basin should be no greater than 10 feet, length-to-width ratio of 2:1 or greater, basin side slopes of 4:1, a forebay with a volume equal to approximately 10% of total design volume.

The dry detention basin also requires an inlet and outlet structure, as well as a levee in the NW corner to stop flooding of a private property and an extent of Fox Ave. The locations of the inlet and outlet structures is displayed in Figure B.2 in Appendix B.

Two foot contour lines were downloaded from GeoTree and imported into two ArcGIS programs, ArcMap and ArcScene. From these programs a 2D and 3D surface area and a 3D surface volume was calculated for the approximate area of the dry detention basin. The 2D surface area is approximately 2.13 million ft^2 (197,652 m^2), 3D surface area is approximately 2.22 million ft^3 (205,979 m^3), and the 3D surface volume is 18 million ft^3. These areas and volumes correspond to a max ponding elevation of 1170 feet which can be seen in Figure B.3 in Appendix B.

After obtaining these approximate areas and volumes, specifications for the outlet structure were determined. A max velocity of 5 feet per second was estimated from ISWMM, Section 2O-2 – Open Channel Flow, but is expected to change after obtaining results from soil analyses on this area. Having a velocity of 5 feet per second, along with a riprap lining, will prevent scouring and further soil erosion.

This alternative also includes grade control structures downstream of the detention basin to decrease the velocity of the creek and prevent erosion. Grade control structures are placed periodically in Perry Creek from S Ridge Rd to Stone Park Blvd. The structures are placed at locations with velocities greater than 5 feet per second to slow down the water and prevent erosion. In addition to the grade control structures, Design Alternative 2 gives homeowners the option to implement one of many different technologies on their land to prevent bank erosion

from occurring along their stretches of Perry Creek. These technologies include, but are not limited to, erosion control blankets, gabion baskets, and interlocking concrete squares.

A potential phasing plan for Design Alternative 2 is presented below:

Phase 1: Remove debris from creek and trees in areas around creek.

Phase 2: Embankment structure constructed at S Ridge Rd. Protection levee also constructed on NW corner of dry detention basin.

Phase 3: Inlet and outlet structures placed.

Phase 4: Grade control structures placed into the creek to decrease velocity.

Phase 5: Best management practices plans for homeowners created.

This alternative has the ability to improve water quality by allowing sediment to settle in the dry detention basin during storm events. Flood mitigation is also provided since the detention basin accommodates the water quality volume and stores water when flooding occurs. This design is fairly feasible. It requires minor modification to the landscape, but not a large amount of excavation.

The land will need to be acquired or granted with an easement, yet it requires no property owners to be relocated. The societal impact is minimal since no one is directly affected by this design. More importantly, it will reduce the creek velocity and prevent flooding downstream. Maintenance would require regular mowing and removing debris, annual inspection of erosion and structures, and removing sediment every few years.

While Design Alternative 2 has a lower recreational value than Design Alternative 1 because the water level will usually be low except during times of flooding, there is still a potential recreational opportunity if the basin is created into a wildlife habitat for native flora and fauna.

The total cost estimate of this alternative is $1,900,000. The estimate includes removal of trees, grading, embankments, basin structures, grade control structures, acquiring land and vegetation costs. Only one grade control structure was included in the cost and the design may require more. This is a rough preliminary cost estimate and is subject to change.

Design Alternative 3 - Embankment Protection

This design alternative prioritizes embankment protection in place of flood mitigation. Design Alternative 3 consists of installing riprap and gabion baskets to specific locations of the creek which are in need of erosion control, both of which are easy to install, slow down water velocities, and protect embankments. Given that there were many storm water piping outlets extending into the creek, this alternative helps reduce the bank erosion, thus protecting these components of the city's infrastructure. The locations of the improvements were taken at different areas of Perry Creek. The areas were picked because they possess the greatest levels of erosion (most of which are around bends of the creek).

An embankment slope of 5:1 produces a water stress low enough to install riprap and Baekert gabion baskets. Due to the current, eroded state of the embankments along much of the creek, excavation is required. During this process, soil compaction tests are recommended to ensure bank quality. The type of rock used for the riprap will be the same placed in the gabion baskets.

Based on preliminary calculations, the rock used in the riprap of this this alternative requires a nominal 6-inch mixture, a density of 2.6 tons/m^3, and must be unweathered and solid without evident flaking.

The gabion baskets are 3 feet high and 27 cubic feet in volume. The gabion baskets are hexagonal triple twist steel wire mesh; galvanized steel wire; zinc coating being 11 ¼ gage mesh and 9 gage selvage rod, which is required by the Iowa Department of Transportation.

In this alternative, soil is placed at the pedestrian bridge at Clark Elementary. Soil will be compacted to meet design standards and the bank slope will be 5:1. The stormwater pipe at that location must be at a 1:10 ratio to slow the flow rate entering the creek, and is proposed to be reconstructed using reinforced concrete. The soil placed in the design is compacted to meet design requirements of 90% compaction according to ASTM – 698.

Each location chosen for embankment stabilization is follow similar suite to the process proposed for Clark Elementary. For the reconstruction of the stormwater outfalls, the pipes are structured to form the same slope as the creeks bank sitting on top of the riprap. These pipes are slotted drains to promote drainage onto the riprap and decrease heavy flow entering the creek. The riprap is placed a minimum of 2 feet above the outfalls to secure the pipes location. The locations of riprap and gabion baskets are shown in Figures C.1- C.6 in Appendix C.

A potential phasing plan for Design Alternative 3 is presented below:

Phase 1: Excavation of bank soil to form a 5:1 slope and installation of riprap outside of the city limits. The leftover soil will be transported to Clark Elementary.

Phase 2: Soil placed in the pedestrian bridge embankment to replenish the area of erosion. During this time the stormwater pipe beneath the bridge reconstructed. When enough soil is in place, the bank is to be filled with riprap to provide an erosion free bank and safe passage over the bridge.

Phase 3: Excavation and riprap placed on the outside shore of each channel meander location in the extents of the creek from S Ridge Rd to Buckwalter Dr. The excavated soil is stored for later use.

Phase 4: Starting from the city limits and heading south, poorly structured stormwater outfalls are reconstructed so water exits at the surface of the creek and oriented parallel to creek flow. Each outfall is surrounded by riprap to eliminate scouring and erosion.

Phase 5: Riprap placed near bridges on the creek banks and stretch 20 feet on both sides of the corresponding bridge.

Incorporating riprap or gabion baskets will help reduce the flood mitigation for the creek with less water reaching properties. Since most of the area around the creek is under the private easements of the homeowners, it is essential to create an easy installation plan and provide a solution that is easy to maintain so that the public is happy to install them. This alternative is both fairly feasible and effective. With the rock designs against the banks of the creek, there is less debris flowing in the creek which in turn will help the water quality to be better.

The total cost of Design Alternative 3 is roughly $1,200,000. The selected locations were measured in distance and then multiplied by the average cost for riprap and gabion baskets. The rate for random pieces of 25-500# pieces is $30.35 per cubic yard. The rate for gabion baskets for a 36 in, galvanized steel mesh boxes stone filled is $117.65 per square yard. The actual range of cost varies depending on the amounts of each type of embankment protection used. For example, because riprap is less expensive than gabion baskets, cost estimations for a design solution using solely one or the other technique are respectively $1,150,000 and $1,270,000.

Design Alternative Selection Process

The final design alternative was selected after examining multiple design parameters. The team decided to implement a decision matrix, an evaluation tool used to compare several design alternatives for different criteria, ultimately identifying a suggested final design. This design matrix process was conducted both by the members of the team as well as the client. After conversing with Mr. Ellis, the client and the team were able to select the most effective alternative for Perry Creek.

Design Matrix Criteria

The decision matrix included six weighted categories: Water Quality Effectiveness, Flood Mitigation Effectiveness, Feasibility, Societal Impacts, Maintenance and Upkeep, and Recreational Value. Each category was weighted on its significance in creating the most optimal design. In ranking the design solutions, a scoring from 1, 2 or 3 was given to each of the categories for each design, with 3 being the best, 1 the worst. After ranking each category and calculating the sum, the alternative with the highest score was effectively chosen as the best design.

Water Quality Effectiveness

Water quality effectiveness relates to how the designed system improves the quality of the creek's water, ecosystem health, and human health safety. The best design will provide healthy waters to the community that meet state and federal water quality standards. This category was given a multiplier weight of 4 because the funding for the project was supplied to increase the stream's water quality. Therefore, providing a water quality based design was the highest priority**.**

Flood Mitigation Effectiveness

Flood mitigation effectiveness is the level of success a design has in managing and controlling flood waters. This category was given a multiplier weight of 4 because of the impacts of recent flooding at the creek. The flooding is responsible for extreme bank erosion that has interfered with multiple private properties and infrastructure throughout Sioux City.

Feasibility

Feasibility relates to the capability of accomplishing the project, and the constructability of the design. The two most important factors that determine the project's feasibility are constructability and cost. Feasibility was given a multiplier weight of 4 because the project must be constructible while being within budget, if the project does not meet both requirements, it will not be constructed. Therefore, feasibility is as important as the effectiveness of the design.

Societal Impacts

Societal impacts are related to how the design solution impacts the structure, organization, or function of the community. A design that provides safety and convenience for the community has a large influence on its success. Societal impacts as a category was given a multiplier weight of 3. Providing a design that benefits the well-being of individuals and families of Sioux City is a high priority.

Societal impacts was given a lower weight multiplier than water quality effectiveness, flood mitigation effectiveness, and feasibility because the effectiveness and feasibility decide whether the design will be constructed, and they both directly and indirectly affect society. For example, water quality and flood mitigation will provide a stream with safe and healthy water while lowering disastrous flood probabilities.

Maintenance and Upkeep

Maintenance and upkeep involves repairing damaged components of the design's structural systems and performing routine service to preserve its structural ability. Maintenance and upkeep was given a multiplier weight of 2. Limiting the in-situ maintenance and upkeep post construction is important primarily as a cost parameter. If the design requires heavy maintenance and upkeep it will be an expensive entity in the future. Therefore, it makes a large impact on producing an optimal design.

In comparison with the previous categories, maintenance and upkeep do not pose as much of a design constraint as the other categories. Effectiveness, feasibility and societal impacts are more important because they are more noticeable from a societal standpoint. Also, maintenance is not an acute issue, and may not be necessary for an extended period of time.

Recreation Value

Recreational value relates to how the new design will improve the leisure opportunities for people in the community. Many factors affect the recreational value of a design, including aesthetics, variety of destinations to provide a continuous experience, steepness of grade, and safety.

Recreational value was given a multiplier weight of 1. Recreational value is not a major design parameter. Providing residents of Sioux City with a design that provides an increase in recreational opportunity, however, is important as implied by the client. If recreational opportunities can be implemented into the design, residents of the community will be more likely to approve of the project, which is an effortless way to achieve community buy-in.

Design Matrix Structure

During a conference call with the client, the design matrix was explained in its entirety, at which time the group and client filled out the evaluation tool. The required input to the evaluation tool were the boxes shaded grey in Table 1.

Table 1: Completed design matrix

PERRY CREEK DESIGN MATRIX								
Criteria		Ranking				Augmented Ranking		
Category Description	Weight	Design 1	Design 2	Design 3		Design 1	Design 2	Design 3
Water Quality Effectiveness	*4*	3	2	1		12	8	4
Flood Mitigation Effectiveness	*4*	3	2	1		12	8	4
Feasibility	*4*	1	3	2		4	12	8
Societal Impacts	*3*	1	3	2		3	9	6
Maintenance and Upkeep	*2*	1	2	3		2	4	6
Recreational Value	*1*	3	2	1		3	2	1
Directions: Fill out the 18 "Ranking" boxes and score the three design alternatives with a score of 1, 2, or 3 for each criteria. ***A score of 1 is the lowest/worst ranking, while a score of 3 is the highest/best.*** The "Augmented Ranking" boxes weighs the rankings in accordance with the designated weight of each criteria. The highest "Total" score is the best solution alternative for the project.					Total	**36**	**43**	**29**

To fill out the boxes as objectively as possible, each design alternative was described in the context of each criteria in a technical and economic context. With the mutually agreed upon input, the matrix augmented the rankings to produce a total score for each design alternative.

Matrix Scoring Justification

The discussion surrounding the ranking of each design alternative remained objective to ensure an effective design alternative was selected, regardless of personal bias or preferences. Each criteria was explained to the client, allowing the alternatives to be evaluated accurately.

Water Quality Effectiveness

Design Alternative 1: The results from the water quality effectiveness category shows that Design Alternative 1 is the most effective because it is a controlled system. The controlled wet detention basin is the most effective in retaining total suspended solid (turbidity) and heavy metals.

Design Alternative 2: The dry detention is not controlled, therefore it will not retain pollutants at the extent of the wet detention basin.

Design Alternative 3: The third alternative provides the least effectiveness on water quality, the stream will remain relatively similar, but less suspended solids will enter the creek from bank erosion due to bank stabilization, but this design will not effectively control the emission of the suspended solids similar to that of the wet or dry detention basins.

Flood Mitigation Effectiveness

Design Alternative 1: The results the from flood mitigation effectiveness category reveal that Design Alternative 1 provides the most successful approach. The ability to keep stream flow steady and below large flood levels proves that this design is the best in terms of mitigating floods.

Design Alternative 2: The dry detention basin is not as effective in reducing floods, but the ability to retain water responsible for larger floods makes this design a highly effective solution.

Design Alternative 3: The embankment protection design is the least effective because it does not control large flows. The flows will act similar to current conditions, therefore this design will not be effective.

Feasibility

Design Alternative 2: The results from the feasibility category show that Design Alternative 2 is the best choice. Design Alternative 2 requires the least amount of construction of the three alternatives. The primary constraint is the purchase of property near the Plymouth-Woodbury county line.

Design Alternative 3: Design Alternative 3 possesses the lowest capital cost, but easements must be gathered because the creek is primarily private property. The constructability of this design is an issue because, it requires work along a high percentage of private property embankments. Therefore, construction costs will be high and the feasibility of this design is low.

Design Alternative 1: Design Alternative 1 provides the least feasible product. The design exceeds the budget, and construction costs will greatly increase the total cost. Therefore, this design is not feasible.

Societal Impacts

Design Alternative 2: The results from the societal impacts category prove that Design Alternative 2 is the most effective. This design will keep flows low, therefore mitigating

flood probabilities that harm residents. The dry detention basin will require land acquisition, but no homeowners will be affected.

Design Alternative 3: For Design Alternative 3 residents along the creek boundary will be affected during construction. Construction equipment must intrude their property, which highly influences the impacts on society. Also, flooding is not completely mitigated. Both indirect and direct community problems will be associated with flooding. Therefore, this design is not favorable for the community.

Design Alternative 1: Design Alternative 1 requires a large amount of property for the wet detention basin that will affect many homeowners. To construct the wet detention basin, roads and bridges will need to be reconstructed having a major on transportation.

Maintenance and Upkeep

Design Alternative 3: The results from the maintenance and upkeep category show that Design Alternative 3 is the most effective. After the installation of gabion baskets and riprap, minimal to zero maintenance will be necessary. Adding or removing riprap and gabion basket replacement are at the extent of maintenance and upkeep.

Design Alternative 2: Design alternative 2 does not require heavy maintenance and upkeep, it is an uncontrolled natural system. The outlet structure will need to be routinely inspected to provide consistent downstream flow.

Design Alternative 1: Design Alternative 1 is the least effective in terms of maintenance and upkeep. The design is controlled, therefore, maintenance and upkeep must consistently be provided. Mechanical and electrical equipment must be working effectively, therefore, staff must be present routinely.

Recreational Value

Design Alternative 1: Design Alternative 1 provides the greatest recreational value. The basin provides the community with recreational opportunity because it holds a permanent pond of water.

Design Alternative 2: Design Alternative 2 leaves the stream in the current state, therefore it does not diminish the recreational value, making it the preferred design over Design Alternative 3. The basin has the ability of ponding, allowing for recreational opportunity.

Design Alternative 3: Design Alternative 3 provides the least recreational value. The embankment will be similar to the current state, but will be lined with riprap and gabion baskets making the embankments injury prone areas, diminishing its recreational values in locations present of riprap and gabion baskets.

Final Design Selection

With an overall score of 43, Design Alternative 2 was selected as the final design solution. This selection in actuality went against the preference of the client. Because the decision was supported by objective information supplied by the group, however, the client agreed that the preferred solution simply could not be adopted as a final solution. å Engineering, Inc. continued forward in the design process with Design Alternative 2.

Final Design Details

With a budget of only $2 million, both å Engineering, Inc. and the client established fairly early in the contract period that a comprehensive design solution to resolve Perry Creek would be challenging, if possible at all.

Instead of designing a solution which remained within the budget, the team created a final design solution which, while clearly extending beyond the bounds of the funds set aside by the city, strived to address the issues of Perry Creek in a long lasting manner. To counteract the total cost of the solution, the design was crafted to allow for a series of active and dormant periods of project work. The active periods consist of design implementation, while the dormant periods consist of extended periods of monitoring and observation in which more funds could be acquired after the initial $2 million invest is depleted. The active periods, or phases, are described in detail below.

Phasing

The components of the final design solution have been polarized into separate phases. While some of the phases are time-dependent and interdependent, other phases of the project are independent and can be implemented at any instance.

Phase 1 - S. Ridge Rd. Dry Detention Basin

The main component of the final design solution is a dry detention basin, as identified in the design alternative selection process. This basin serves as the first of many phases for the solution. In reality, this phase is the only phase able to be completed in entirety with the established budget of $2 million.

Located north of S. Ridge Rd., the basin is in Plymouth County - outside of Sioux City limits. This basin controls the waters from all of Perry Creek's watershed north of this crossing. The area of this proposed basin is currently occupied by riparian zone, and a large scale contour farming operation. This site was selected because of its topography and lack of development. The proposed site of the basin is depicted the photograph taken during a site visit in Figure 4.

Figure 4: Site of S. Ridge Rd. dry detention basin

The upstream area of the watershed impounded by the basin, which consists of rural, agrarian conditions and sparsely spaced housing, is approximately 9900 acres. The calculated water quality volume required for this site is 187 acre-feet. A storage volume of 333 acre-feet will effectively detain a 100-year, 1-hour storm event. During this storm event, with the embankment as designed, roughly 43 acres will be inundated with storm waters. The storage volume is well above the required water quality volume of 187 acre-feet; so the 100-year storm served as the controlling factor for basin sizing. Per the Iowa SUDAS 2G - Detention Practices guidelines, with a surface volume greater than 100 acre-feet, the basin is required to meet the regulations set forth in the Iowa dams and impoundment regulations (IAC 567 - Chapters 70-73) and Iowa DNR Technical Bulletin No. 16 (December 1990). When assessing the Iowa dams and impoundment regulations and Iowa DNR Technical Bulletin No. 16, The S. Ridge Rd. Basin is assumed to be a moderate hazard, low head dam because it is located near isolated homes and moderately traveled roads.

The dry detention basin in this phase is impounded by a 210-ft long combination sheet pile-earthen embankment with a top-elevation of 1174 ft. The foreslope and backslope of the embankment are designed with a slope of 3:1, and are equipped with appropriate erosion control stabilization in the form of riprap. The top of the embankment is 10 feet wide, and has a freeboard of 2 feet during uncontrolled emergency spillway discharge. To provide failure protection, a three tiered embankment with sheet piles located at the center, surrounded by compacted loess soil, followed by a heavy outside layer of riprap is proposed. The construction of the sheet pile layer will follow NRCS Construction Specifications - IA13 Sheet Piling. The

riprap layer will extended over the entirety of the embankment, with a 2.5 ft. thick layer of gravel and riprap on the foreslope, backslope, and top of the embankment structure. Gravel and riprap will extend beyond the backslope of the embankment to protect the S. Ridge Rd. bridge piers, which are located just downstream of the embankment. In addition, an anti-seepage collar is fashioned to prevent seepage during storm events. In total, roughly 28,600 cubic yards of soil is required for this embankment. A cross-section of the embankment at its deepest point is shown in Figure E.1 in Appendix E.

The inlet of the storage basin consists of a sedimentation forebay. The volume of the forebay is roughly 10% of the total WQv, or 33.3 acre-feet with a depth of 6 feet, per Iowa SUDAS 2C-11 Inlet Sediment Forebays. The forebay controls turbulent waters coming into the basin during storm events and encourages sediment drop throughout the structure. The forebay is designed to be vegetated with native wetlands plants.

An earthen levee west of the storage basin inlet is required to protect a home and farming operations from flooding in the event of a 100-year, 1-hour storm. The levee is designed according to U.S. Army Corp of Engineers - Levee Design and Construction Guidelines. The levee will be constructed of native loess soil and will not impede any current farmed cropland. Figures E.1-E.3 display specifications of the embankment structure while a schematic of the levee is shown in Figure E.4 in Appendix E.

The outlet of the storage basin consists of a conduit outfall. The conduit has a 7 ft. diameter opening, with a cross-sectional area of 38.5 square feet, which allows a 1.5-year design flow of 951 cubic feet per second to safely evacuate the basin. Trash racks and bars are incorporated into the design to prevent debris from clogging the outlet structure. The outlet is protected by riprap bedding both upstream and downstream of the embankment to prevent scouring or erosion from occurring. A schematic of the outlet is shown in Figure E.1 in Appendix E

For storm events greater than the 100-year return period, an emergency spillway, centered above the outlet conduit, is used for overflow. The emergency spillway weir consists of the same sheet pile material used at the core of the embankment. With a width of 15 ft. and depth of 3 ft. the spillway safely averts water from the basin and into the downstream reach of the creek.

To apply for the permit for this detention basin, the application form located in Appendix J must be filled out entirely. While most of the criteria needed for the application of an Iowa DNR Dam Permit are included in this report, there are a few missing criteria. The criteria needed for final design and permit applications include, but are not limited to, a stream slope based on a minimum of two survey shots taken on the water surface, at least one stream valley cross-section taken perpendicular to the direction of flow during typical conditions, and hydrologic modeling and analysis from a FEMA Flood Insurance Study (FIS) or HEC-RAS/HEC2 modeling software.

An aerial overview of the entire dry detention basin is shown in Figure 5.

Figure 5: Aerial view of dry detention basin with berm (red) at S. Ridge Rd.

Because this phase serves as the primary component of the design solution, detailed construction staging is crucial to be established before the design is implemented. The construction process

for the S. Ridge extended detention basin will occur in five phases. The duration to complete each phase will be dependent on the weather and water depth in Perry Creek. But it is estimated that the basin will take two years to completely construct.

Phase 1: Tree Removal

While extensive tree removal is not an environmental friendly decision, it is necessary for the construction of the basin. Not all trees on the site will be removed; trees will only be removed if they pose a threat to the embankment or outlet structure. Threats posed by trees include clogging the outlet conduit or transfixing the riprap embankment. An estimated 18 acres of tree removal will be required. Any soil loosed by the tree removal will have to be excavated as well. This is to prevent large sediment buildup near the outlet during a storm event. The extra soil is used in later phases.

Phase 2: Sediment Forebay

As previously stated, the construction of the sediment forebay will follow Iowa SUDAS 2C-11 Inlet Sediment Forebays. The sediment forebay berm will be constructed of the native loess soils that surround the area. After the completion of the berm, native vegetation will be planted in and around the forebay. Iowa's native vegetation for this area include, but are not limited to, Coontail, Nut Grass, American Lotus, Swamp Birch, Sage Willow, and Purple Fringed orchid. A vegetated forebay will promote sedimentation in the forebay. City officials and conservationists may choose the details and what vegetation will be planted.

Phase 3: Embankment and Outlet Structure

The construction of the outlet and embankment will begin after the sedimentation forebay is completed. A cofferdam will be constructed to divert flow to one side of the channel. The embankment construction will begin with driving the sheet piles into bedrock, then the soil from the tree removal will be added over the sheet piles and compacted. The sheet piles will have to be modified at the center of the embankment to allow the conduit outfall to pass through. Laying on the surface will be 2 ft. thick riprap. Once a half of the embankment is completed, the cofferdam will be switched to allow for construction completion of the other. The cofferdam can be removed upon completion of the embankment structure.

Phase 4: Berm

The small berm in the northwest corner of the detention basin will be the last major construction project for this design. Construction processes will follow regulations mandated by the U.S. Army Corps of Engineers.

Phase 5: Landscaping and Aesthetics

The final stage of the implementation of the basin will be to add landscaping and other aesthetically pleasing things to the detention basin area. Landscaping may include, re-seeding of prairie grasses, planting native trees and shrubs, or a recreational walk/bike trail. Other options to improve the aesthetics of the detention basin include a playground, wildflower patches, or picnic areas. These features, as decided upon by the city, can be used to define the space of the detention basin as a regionally acclaimed recreation area for all to enjoy or a wildlife habitat for native flora and fauna, whichever the preference of the client.

Phase 2 – Grade Control Structures

Once the dry detention basin has been implemented, Phase 2 will be installing grade control structures throughout Perry Creek. A grade control structure is used to prevent bank erosion and decrease water velocity by dissipating energy as water flows over the structure to a lower elevation. The structure causes upstream water to pool and decreases the slope of the creek. As the flow velocities of the creek decrease, less erosion will occur causing the banks to become more stable. Manning's equation shows the direct relationship between the bed slope and velocity, and as the bed slope decreases then the velocity will also decrease. Sample calculations using Manning's equation can be seen in Appendix D.

The banks of the creek will become stable by the reducing the flow velocity and the slope of the creek. To prevent further erosion of the banks, the flow velocity of the creek must remain below 3 feet per second (IDNR). The slope of the creek from the outlet of the dry detention basin to Stone Creek Boulevard is 0.153%. The dry detention basin will allow the flow of a 1.5 year storm through the outlet which is 1427 cubic feet per second or 4.46 feet per second. Using Manning's Equation, the slope necessary to achieve a velocity of 3 feet per second is 0.0691%. Preliminary locations of grade control structures were found by using the current and future bed slopes with a structure height of two feet. The preliminary locations were spaced 2300 feet apart. After seeing the potential locations of the grade control structures, the final placement of each structure was chosen. Most are placed at bridges because the riprap from the structure can be tied into the bridge for protection. For bridges that are being replaced, such as the 38th Street Bridge and the Dearborn Ave. Bridge, the grade control structure can be constructed parallel with the bridge during construction (Grade Stabilization Techniques). The heights of each structure are based on the slope between the structures. Some structures may be greater or less than the preliminary 2 ft. depending on how the actual slope between structures related to the slope of the entire stretch of the project. Table F.1 in Appendix F shows the slopes and distances between the grade control structures. In certain locations, the slopes were much less than the total slope of the creek which meant a lower height of structure. The final proposed grade

control structure locations and structure heights can be seen in Table 2 and Figures F.1- F.7 in Appendix F.

Table 2: Locations and heights of grade control structures

Location	Structure Height
West of Deerfield Drive	1’
West of Buckwalter Drive	1’
Kings Hwy Bridge	3’
Pedestrian Bridge (4209 Hamilton Blvd)	2’
38th Street Bridge	1’
Hamilton Blvd. Bridge	3’
Dearborn Ave. Bridge	3’

The two most northern grade control structure locations were chosen for ease of accessibility. Access to the creek may be difficult to the north, and the structure location west of Deerfield Drive has different possible points of access. The structure west of Buckwalter Drive would also allow for easy access from Buckwalter Drive. The rest of the locations are at bridges which provide high level accessibility for the equipment needed to install the structures. Easements or land requisition will be necessary for the two northern structures and the location at 4209 Hamilton Blvd.

The type of grade control structure is a rock structure with a steel sheet pile for reinforcement. Rock structures are economical to design and build and also have limited environmental impacts. The steel sheet pile will prevent any seepage beneath the structure or erosion that may cause the structure to fail.

The design of the grade control structures is the Cross-Vane. This design type can be seen in Figures F.8- F.11 in Appendix F. The energy in the center of the channel is increased, and the boundary stress and higher velocity gradients are moved away from the banks (Rosgen, P.H).

The size of the boulders for the structure are approximately 3 feet in diameter (Design of Rock Weirs). Footer boulders are placed at least half of the diameter below grade. The header boulders are placed above the footer rocks and partially below grade. Riprap for the upstream and downstream slope of the grade control structure have a D_{50} of 12 inches which is the same as the riprap used on the banks of the creek. Upstream of the grade control structure, the slope of the riprap is 1.5: 1 (Grade Control Design). The downstream slope of the riprap is 3: 1 (Chapter 3. Grade Control Structure Design). The boulders of the structure have an upward slope of 5% from the center of the structure toward the boulders near the banks (Rosgen, P.H.). This allows water to be directed away from the banks. Riprap is placed along the banks extending 20 feet upstream and downstream of the structure and to the top of the banks. This

provides additional stability for the grade control structures as well as the banks of the creek. The total length of the apron is 30 feet from the start of the grade control structure.

Steel sheet piles will be inserted directly downstream of the boulders to provide stability. The sheet piles have a below grade depth of 20 ft. which is consistent to similar projects in western Iowa (Grade Control Structures in Western Iowa Streams). The sheet piles follow the shape of the boulders and extend to the boulders near the banks of the creek. Sheet piles extend above grade to a height 6 inches below the grade control structures. The sheet pile are a Z-Type Steel Sheet Piling that is commonly used for retaining walls and cofferdams.

A geotextile fabric will be placed below the footer rocks and the apron of the grade control structure. This geotextile fabric is the same as the fabric used in the riprap installation. The fabric will be placed 6 inches below grade or below footer rocks and topped with backfill. The start of the geotextile fabric at the upstream riprap will curl and fold down 2' to prevent any potential movement of the fabric.

Currently, Perry Creek is an impaired waterway and does not sustain the life of any fish. In the future, if there are fish in Perry Creek then the design of the grade control structures may need to be modified slightly. The upstream slope of the riprap needs to be 4:1, and the downstream slope needs to be 15:1 (Grade Stabilization Techniques). These modifications can be seen in Figure F.12 in Appendix F and allow for fish passage throughout the creek.

Design specifications for the grade control structure at the Kings Hwy Bridge were calculated. Schematics of this grade control structure can be seen in Figure F.13-F.17. Due to the lack of survey data, specific designs for each grade control structure were not created. The grade control structures should be placed in the following order: Kings Hwy Bridge, Hamilton Blvd. Bridge, West of Deerfield Drive, Pedestrian Bridge, Dearborn Ave. Bridge, West of Buckwalter Drive, and 38th Street Bridge.

For each location, the general grade control structure phasing that should be followed to ensure a successful final product is suggested as follows:

Phase 1: Remove any debris and vegetation from project site

Phase 2: Build small coffer dam to avert water to excavate soil and place geotextile fabric

Phase 3: Install sheet pile to a depth of 20 ft.

Phase 4: Set footer rocks below grade with header rocks directly above

Phase 5: Place riprap upstream and downstream of structure to desired slope

Phase 6: Complete bank stabilization by installing geotextile fabric, gravel, riprap, and gabion baskets

Before construction of the grade control structures, a flood plain permit from the IDNR Flood Plain Management Program will need to be acquired. This permit is required of any low-head dam structure in a rural area that drains more than 10 square miles or any structure in an urban area draining more than 2 square miles. The low-head dam permit is located in Appendix J.

Phase 3 - Critical Embankment Stabilization

The third phase consists of bank stabilization at seven grade control structure locations. Each of the bank stabilization areas are located at the banks of grade control structures. At each location, two layers of riprap, one layer of erosion control lining, a gravel base, and gabion baskets will be placed. The riprap diameter must be 12 inches. The diameter was determined after calculating the D_{50} (median diameter of riprap). The difference in embankment slopes at each location is responsible for the change in required riprap diameter. The riprap diameter must not exceed 1.5 times the D_{50} (Iowa DNR).

The erosion control lining and riprap controls the embankment slopes by declining erosion. The declined erosion near both the grade control structures requires less maintenance and upkeep. The erosion control lining and riprap protects these systems from scouring and erosion prone breakdown. Limiting the breakdown of each grade control structure ensures the structures orientation remains consistent steady. Grade control structure embankment work near bridges ensures bridge embankment stabilization, and provide the Sioux City residents with safe transportation. Protecting the embankments yields a longer life span for each structure. Overall, these systems will save the City of Sioux City a large sum over each structures lifetime.

Grade control structure embankments will be lined with a 1-inch layer of geotextile erosion fabric, a 6-inch layer of base gravel, 2 feet of riprap, and 3'x 3' gabion baskets at the creek boundary and elevation of a 1.5 year design flood. These structural entities extend 20 feet upstream and downstream of the control structure boundary. Each embankment possesses different terrain orientations. Each follows the same design style, but require different amounts of riprap, gravel, erosion control lining, and gabion baskets. Each of the locations have engineered designs that are thoroughly discussed below.

The style of riprap must be hard and angular field stone or rough unhewn quarry stone. The maximum riprap stone diameter must not exceed 1.5 times the D_{50}. Therefore, the minimum thickness of the embankment riprap layer is 1.5 times the maximum stone size. The specific gravity of each individual stone must reach or exceed 2.5 (Iowa DNR). The heaviest rocks must

be placed near the lower levels of the embankment. The gabion basket must be filled with the same riprap stone. The riprap design is shown in Figure G.1 in Appendix G.

The geotextile erosion fabric is plastic filter cloth that is placed below the base gravel layer and riprap. They must be woven yarns with a thickness of 0.4-2.36 inches, and possess a grab strength 90-120 (tensile strength). The design provides a thickness of 1 inch.

Dearborn Avenue is the southernmost grade control structure location. The west bank is 64.9 degrees, a slope of 1:2.1. The surface area of riprap and geotextile erosion fabric required for the west bank is 1,880 square feet. The east bank is 74.5 degrees, a slope of 1:3.6. The surface area of riprap and geotextile erosion fabric required for the east bank is 3,000 square feet.

The west bank at the Hamilton Avenue grade control structure is 76.8 degrees, a slope of 1:5.1. The surface area of riprap and geotextile erosion fabric required for the west bank is 2,104 square feet. The east bank is 74.7 degrees, a slope of 1:3.7. The surface area of riprap and geotextile erosion fabric required for the east bank is 2,120 square feet.

The west bank at the 38th street bridge grade control structure is 75.5 degrees, a slope of 1:3.8. The surface area of riprap and geotextile erosion fabric required for the west bank is 2,500 square feet. The east bank is 74.5 degrees, a slope of 1:3.6. The surface area of riprap and geotextile erosion fabric required for the east bank is 2,500 square feet.

The west bank at the pedestrian bridge at 4209 Hamilton Blvd. grade control structure is 75.1 degrees, a slope of 1:3.8. The surface area of riprap and geotextile erosion fabric required for the west bank is 2,800 square feet. The east bank is 76.2 degrees, a slope of 1:4.1. The surface area of riprap and geotextile erosion fabric required for the east bank is 3,360 square feet.

The west bank at the Kings Hwy grade control structure is 75.2 degrees, a slope of 1:3.8. The surface area of riprap and geotextile erosion fabric required for the west bank is 3,760 square feet. The east bank is 66.4 degrees, a slope of 1:2.3. The surface area of riprap and geotextile erosion fabric required for the east bank is 600 square feet.

The west bank at the grade control structure west of Buckwalter Dr. is 80.2 degrees, slope of 1:5.8. Surface area of riprap and geotextile erosion fabric required for the west bank is 4,240 square feet. The east bank is 74.4 degrees, a slope of 1:3.6. The surface area of riprap and geotextile erosion fabric required for the east bank is 2,680 square feet.

The west bank at the grade control structure west of Deerfield Dr. is 75.7 degrees, slope of 1:3.9. Surface area of riprap and geotextile erosion fabric required for the west bank is 2,600 square feet. The east bank is 75.5 degrees, a slope of 1:3.9. The surface area or riprap and geotextile erosion fabric required for the east bank is 1,600 square feet.

Riprap will need to be applied to storm outlet structures within city owned properties. The riprap will expand 10 feet upstream and downstream of each structures outfall. The riprap will also require 6 inch base gravel and 1 inch geotextile erosion fabric (thickness). Structure outlets without riprap will require addition of two layers of 12 inch diameter riprap (24”). Each structure that extends greater than 3 feet from the embankment surface must be trimmed to a distance of 3 feet from the embankment surface. Therefore, each structure should extend no greater than 1 foot from the riprap surface. Decreasing the pipe length will reduce scouring and increase water contact with riprap to diminish energy of water entering the stream. A schematic of the storm outlet riprap design is shown in Figure G.2 in Appendix G.

Phase 4 - 250th St. Dry Detention Basin

The dry detention basin proposed at 250th St. serves as a measure of redundancy for the main dry detention basin at S. Ridge Rd. As outlined in ISWMM, redundancy in the form of placing detention basins in series allows for stormwater from a watershed to be more easily managed during large storm events. By placing these two basins in series, the amount of water quantity strain placed on the S. Ridge Rd. basin is reduced. Also, because water passes greater distances through the basins, water quality efficiency of the system is improved. This basin controls the waters from the northernmost extent of Perry Creek. The area of this proposed basin is currently occupied by a large grass field, and a small portion of a large scale contour farming operation. The proposed site of the basin is depicted the photograph taken during a site visit in Figure 6.

Figure 6: Site of 250th St. dry detention basin

The upstream area of the watershed impounded by the basin, which consists of rural, agrarian conditions and sparsely spaced housing, is approximately 9900 acres. The calculated water quality volume required for this site is 98 acre-feet; the water quality volume does not exceed the minimum regulated value as set by Technical Bulletin No. 16. Instead, Iowa SUDAS 2G - Detention Practices was consulted for designing the basin.

The dry detention basin in this phase is impounded by a 200-ft long earthen embankment with a minimum top-elevation of 1305 ft. The foreslope and backslope of the embankment are designed with a slope of 3:1, and are equipped with appropriate erosion control stabilization in the form of riprap. The top of the embankment is 6 feet wide, and has a freeboard of 1 foot during uncontrolled emergency spillway discharge. To provide failure protection, a heavy riprap layer is designed to be buried on the downstream face of the structure. In addition, an anti-seepage collar is fashioned to prevent seepage during storm events. In total, roughly 1200 cubic yards of soil is required for this embankment. A cross-section of the embankment at its deepest point is shown in Figure H.1 in Appendix H.

The basin is able to effectively detain a 100-year, 6-hour storm event. To accommodate this storm, a minimum of 116.6 acre-feet of storage is needed. This volume is more than the required water quality volume of 98 acre-feet; the 100-year storm served as the controlling factor for basin sizing. During this storm event, with the embankment as designed, roughly 27 acres will be inundated with storm waters at an average depth of 4 feet. Thus, the storage volume of the basin is estimated to be roughly 128.3 acre-feet, which is concurrent with the SUDAS guideline 110% volume sizing to account for sedimentation.

The inlet of the storage basin consists of a sedimentation forebay. The volume of the forebay is roughly 10% of the total WQv, or 9.8 acre-feet with a depth of 4 feet. The forebay controls turbulent waters coming into the basin during storm events and encourages sediment drop throughout the structure. The forebay is designed to be vegetated with native wetlands plants.

The outlet of the storage basin consists of a single-stage riser. The orifice of the structure has a cross-sectional area of 16 square feet, which allows for a 1.5-year design flow to safely evacuate the basin. Trash racks and bars are incorporated into the design to prevent debris from clogging the outlet structure. The outlet is protected by riprap bedding both upstream and downstream of the embankment to prevent scouring or erosion from occurring. A schematic of the outlet is shown in Figure H.1 in Appendix H.

For storm events greater than the 100-year return period, an emergency spillway to the east of the embankment is used for overflow. With a width of 10 ft and depth of 2 ft, the spillway safely averts water from the basin and into the downstream reach of the creek. During these events,

the detention basin at S. Ridge Rd. would handle the overflow from this basin. Figure H.2 in Appendix H labels the different components of the dry detention basin.

An aerial overview of the entire dry detention basin is shown in Figure 7.

Figure 7: Aerial view of dry detention basin at 250th Street

The staging for this basin is suggested to follow the installation of grade control structures and critical embankment stabilization.

Phase 5 - Forest Rd. Dry Detention Basin

Similar to the dry detention basin located at 250th St., the dry detention basin proposed at Forest Rd. serves as redundancy for the main dry detention basin at S. Ridge Rd. As discussed, this redundancy reduces the stress on and therefore increases the efficiency of the main dry detention basin. This basin controls the waters from the West Branch of Perry Creek. The area of this proposed basin is currently occupied by natural riparian buffer zones, grass fields, and a small portion of a large scale contour farming operation. The proposed site of the basin is depicted in the photograph taken during a site visit in Figure 8.

Figure 8: Site of Forest Rd. dry detention basin

The upstream area of the watershed impounded by the basin, which consists of rural, agrarian conditions and sparsely spaced housing, is approximately 7050 acres. The calculated water quality volume required for this site is 70 acre-feet; the water quality volume does not exceed the minimum regulated value as set by Technical Bulletin No. 16. Instead, Iowa SUDAS 2G - Detention Practices was consulted for designing the basin.

The dry detention basin in this phase is impounded by a 400-ft long earthen embankment with a minimum top-elevation of 1220 ft. The foreslope and backslope of the embankment are designed with a slope of 3:1, and are equipped with appropriate erosion control stabilization in the form of riprap. The top of the embankment is 6 feet wide, and has a freeboard of 1 foot during uncontrolled emergency spillway discharge. To provide failure protection, a heavy riprap layer is designed to be buried on the downstream face of the structure. In addition, an

anti-seepage collar is fashioned to prevent seepage during storm events. In total, roughly 5100 cubic yards of soil is required for this embankment. A cross-section of the embankment at its deepest point is shown in Figure I.1 in Appendix I.

The basin is able to effectively detain a 100-year, 6-hour storm event. To accommodate this storm, a minimum of 81 acre-feet of storage is needed. This volume is more than the required water quality volume of 70 acre-feet; the 100-year storm served as the controlling factor for basin sizing. During this storm event, with the embankment as designed, roughly 38 acres will be inundated with storm waters at an average depth of 2.5 feet. Thus, the storage volume of the basin is estimated to be roughly 89.1 acre-feet, which is concurrent with the SUDAS guideline 110% volume sizing to account for sedimentation.

The inlet of the storage basin consists of a sedimentation forebay. The volume of the forebay is roughly 10% of the total WQv, or 7 acre-feet with a depth of 4 feet. The forebay controls turbulent waters coming into the basin during storm events and encourages sediment drop throughout the structure. The forebay is designed to be vegetated with native wetlands plants.

The outlet of the storage basin consists of a single-stage riser. The orifice of the structure has a cross-sectional area of 9 square feet, which allows for a 1.5-year design flow to safely evacuate the basin. Trash racks and bars are incorporated into the design to prevent debris from clogging the outlet structure. The outlet is protected by riprap bedding both upstream and downstream of the embankment to prevent scouring or erosion from occurring. A schematic of the outlet is shown in Figure I.1 in Appendix I.

For storm events greater than the 100-year return period, an emergency spillway to the east of the embankment is used for overflow. With a width of 10 ft. and depth of 2 ft. the spillway safely averts water from the basin and into the downstream reach of the creek. During these events, the detention basin at S. Ridge Rd. would handle the overflow from this basin. Figure I.2 labels the different components of the dry detention basin.

An aerial overview of the entire dry detention basin is shown in Figure 9.

Figure 9: Aerial view of the dry detention basin at Forest Rd.

The dry detention basin at Forest Rd. serves as the final phase of the solution design by å Engineering, Inc. and, along with the basin at 250th St., should only be implemented if deemed necessary by the client.

Implementation

The phasing of this project has been designed with the notion that Sioux City will implement the proposed components over the course of several years. While one of the main reasons for doing so was to allow for the client to raise appropriate funds for each component between phase implementation, another reason stems from the potential effectiveness of the design. For example, if after implementing the S. Ridge Rd. dry detention basin and only a few grade control structures the creek begins to show signs of significant improvement, the client may decide that the additional measures outlined in the report are unnecessary.

The dry detention basin at S. Ridge Rd. was given a completion time of two and a half years. For a period of up to two years following the completion of the basin, Perry Creek should be monitored for any noticeable signs of change. In that time, the funds for three grade control structures should be obtained. The grade control structures required roughly six months to implement, after which time a minimum waiting period of three years should be observed to reevaluate Perry Creek.

If after reevaluation more modification is deemed necessary, the remaining grade control structures may be implemented, again in six months. Following another three year observation period, the client may elect to construct the two additional dry detention basins at 250th St. and Forest Rd., a process which would take a total of one year each.

The design solution has been spaced out to be achieved in 14 years, total.

Cost Analysis

The cost estimate for the Perry Creek Flood Control and Design project is split into the same phases as the implementation. The $2 million budget proved to be a major design constraint, and å Engineering, Inc. decided to only implement Phase 1 with the given budget. A cost estimate is given for Phases 2 through 5 that may be constructed at a later date. The cost estimation for each phase includes land, construction, design, permitting and contingency costs.

The total cost for Phase 1 is $2,022,000. To construct the dry detention basin at S. Ridge Rd., the land of the site needs to be purchased for approximately $100,000. Preparing the site by clearing, grubbing and removing necessary trees costs $243,500. The cost of implementing the sedimentation forebay costs about $50,000 (Obropta, Ph.D., P.E.). A majority of the estimated cost for Phase 1 is for outlet of the basin which is comprised of the embankment, orifice, sheet pile, anti-seepage collar and riprap at $1.2 million. The price of the 84” diameter orifice is $550 per linear foot for a total cost of $115,000 (Plain Joint Concrete Pipe). The price of the levee adds a cost of $15,000 to the total. Landscaping costs to make the dry detention more

aesthetically pleasing and a possible wildlife habitat are $3,000 per acre (Narayanan, 2006). Extra costs for Phase 1 include mobilization, contingency, engineering costs, and permitting. A breakdown of the cost estimation for Phase 1 is in Table L.1 in Appendix L.

For Phase 2, the total cost includes all seven of the grade control structures. The price of each grade control structure varies due to different structure and creek bank slopes. The structure at Kings Hwy costs approximately $160,000. The boulders for the structure have a total cost $26,000, and the riprap upstream and downstream of the structure is $11,000. The steel sheet pile for reinforcement costs $34.50 per square foot (RSMeans Landscaping Cost Data, 2015). Geotextile fabric will also be installed in the creek bed for $2.50 per square foot (Free Construction Cost Data, 2015). To stabilize the creek banks, soil will be excavated and gravel, riprap and gabion baskets will be installed. The cost for gabion baskets costs $57,000. The total cost for all seven structures is $1,139,000 with an average of $163,000 per structure. The cost estimate for each grade control structure can be seen in Table L.2- L8 in Appendix L. The costs for Phase 3 are included in the price of Phase 2.

The dry detention basins for Phases 4 and 5 have similar cost features as the detention basin in Phase 1 with the exception of a few items. The total cost of the basin at 250th Street in Phase 4 is $472,000, and the total cost for the Forest Rd. Basin is $794,000. The cost breakdown for both phases are in Tables L.9 and L.10 in Appendix L.

The EPA provides an equation to estimate the construction, design and permitting cost of dry detention basins based on the volume needed to hold a 10-year storm (Dry Detention Basins, 2014). The equation and sample calculation are seen in Appendix D. The estimated cost of the dry detention basin in Phase 1 using Equation 5 is approximately $2.5 million which is about $350,000 greater than the estimated cost. Using Equation 5, the cost of the 250th basin in Phase 4 is $871,000 and almost double the estimated cost. The cause of difference in cost could be since the site does not require much clearing or excavation and the embankment structure is not very long. The situation for Phase 5 is opposite of Phase 4. The cost of the dry detention basin in Phase 5 using Equation 5 is $662,000 and the estimated cost is $794,000. Since the basin at Forest Rd. requires more clearing and a much larger embankment structure, the total cost is increased.

The cost for each phase of the project as well as the complete cost of the proposed flood control and design project is displayed in Table 3. The tables in Appendix L show a cost breakdown of each phase. For each phase, labor cost is also included in the listed unit prices.

Table 3: Final, comprehensive cost analysis

Phase	Cost
Phase 1- S. Ridge Rd. Dry Detention Basin	$2,022,000
Phase 2-	
West of Deerfield Ave	$130,000
West of Buckwalter Drive	$185,000
Kings Hwy Bridge	$160,000
Pedestrian Bridge	$189,000
38th Street Bridge	$146,000
Hamilton Blvd. Bridge	$158,000
Dearborn Ave. Bridge	$171,000
Phase 4- Forest Rd. Dry Detention Basin	$794,000
Phase 5- 250th Street Dry Detention Basin	$472,000
Total Cost	**$4,427,000**

The total final cost for the project is estimated to be slightly more than $4.4 million.

Community Initiatives

In addition to the outlined phases of the design solution provided by the group, several actions and initiatives can easily be implemented by the community to reduce the impact of rainwater runoff and flooding. These efforts are strongly encouraged to be adopted by the community in a fully engaged and inclusive effort to improve the lives of those living in the watershed.

Best Management Practices

Best Management Practices (BMPs) are different technologies and methods used to control how pollutants are being removed and how the water supply is being drained. Many different techniques can be implemented to control the quantity and quality of water runoff. Reducing the water runoff offers protection for ecosystems, water resources and most importantly public health. The objective of BMPs are to decrease sediments and contaminants in the water. These designs help with runoff draining into creeks as well as up keeping the aesthetics for the community. Some common best management practices are listed below that the public can install to help diminish the rainwater draining into Perry Creek.

Rain Gardens

Rain gardens are small gardens that collect and store rainwater by the plants and materials used in them. Rain gardens slow down the speed of the rainwater as it travels

along the areas causing more water infiltrate into the soil and decrease the erosion and quantity in the creek. Deep rooted, regional native plants are ideal for rain gardens because they provide better filtration of rainwater for the environment. The native plants are already used to the climate, soil and water conditions of the area which will help them become an important asset to rain gardens. Rain gardens can be made for $3-4 per square foot depending on how many plants are wanted and garden size.

The calculation of size for the rain garden is done by determining your roof size, rain gardens should be less area than the impervious area of you roof. Rain gardens should be in the lowest part of the yard so the most rainwater will runoff to the garden. Choosing native plants is important because the ones that don't need a lot of water and will work well with the area it is being place. The only downside to rain gardens is that there is just as much maintenance as any other garden for the property.

Bioswales/ Swales

A swale is a vegetated channel with the bottom and side slopes covered in vegetation. According to the EPA, swales can be natural or manmade with the purpose to trap pollutants, help infiltration, and to reduce the flow speed of runoff to the channel. The locations of swales are usually at the lower ends of the property because they require some excavation. Swales usually connect to other water networks like storm drains or culverts.

To make the trench, the sod already in the area of the swale needs to be cut and stripped so that a trench could be dug. The trench should be shaped into a U shaped channel so it keeps the appearance as a channel. Landscaping fabric is then laid on the trench and layered with gravel and drain tile. Once the drain tile is covered with gravel soil and sod is then placed. Even though swales reduce the speed of flow, remove pollutants and lower capital cost, swales are impractical in areas with erosive soil and can be potential odor and mosquito problems.

Rain Barrels

Rain barrels collect and store rainwater from a homeowner's roof for future use. Rain barrels are placed under downspouts for rainwater collection. The EPA website says a barrel system consists typically of a 55 gallon drum, a hose, PVC couplings, and a screen to keep insects and debris out of the barrel. The hose is similar to any regular hose used for watering around the yard. Barrels can be maintained very easily which makes them an efficient way to stop some of the rainwater draining into the creek.

Installing rain barrels is an easy process because the plastic barrels can be bought already made for runoff from your roof. Typical rain barrels on spruce creek rainsaver.com cost about $99 for a 55 gallon barrel initially but it will pay for itself for outdoor water use. A lot of household watering has to do with lawn and garden car especially in the summer. So barreling water will not only protect the environment but it will also save the public money on water bill costs.

Permeable Pavers

Permeable pavers are made up of common materials like asphalt or concrete that collect water through the surface. It also filters pollutants from the water as it trickles into the voids. The disadvantages outweigh the advantages even though paver's aesthetics look very nice when completed. Permeable pavers cannot handle a large runoff load because this design incorporates some impervious materials, so in some cases they are not ideal. There is also a lot of maintenance and cost that go with this design practice due to the weeds that might grow between pavers or even grass.

To install the pavers, the area needs to be excavated. Then a layer of gravel needs to be placed followed by a geotextile fabric. Sand is evenly positioned on the geotextile fabric. Concrete bricks or whichever material chosen can then be laid out over the sand layer. Installation of permeable pavers is very labor intensive and they need to be maintained more.

Riparian buffers

Riparian buffers are vegetated areas near streams that help protect it from neighboring land use. Trees and shrubs can be planted along the banks for stabilization. This is a key for Sioux City's erosion prone areas. It also increases the habitats surrounding the creek with the trees. Planting trees and shrubs around the creek also make it pleasing to the public and produces shade for them in the warm months.

The installation process is no more than planting trees, shrubs or wetland grasses. The roots of the plants help maintain the integrity of the bank. There is little to no cost for riparian buffers but there is a high initial cost for labor, tools and materials. Native vegetation is highly recommended because these plants are used to growing in this type of climate and soils.

Tree Box Filters

According to Urban Design Tools, tree box filters are mini bio retention areas installed beneath trees to collect and filter the rainwater before sending the excess water to the

storm drains. In the process, the trees or shrubs planted and sealed in by an open grate to collect water. The system consists of a soil layer, a mulch layer, and an underdrain system with a tree or shrub. Boxes already are prefabricated concrete so the only addition to the box is soil and mulch for materials.

The only installation step is to dig a hole deep enough so the top of the box sits flush with the surface. There is a high initial cost for installing these BMPs. Tree box filters have low maintenance, the only thing the public would have to do is an inspection of them. Clearing debris or garbage and replacing dead plants could be needed after checking up on these boxes.

Pocket Wetlands

Pocket wetlands are constructed wetland systems designed to control stormwater volumes and to help remove pollutants from the water. Making these wetlands help with flood control and channel protection. The aesthetics of pocket wetlands may look pleasing but there are many limitations. Pocket wetlands need a large amount of space which may be hard to place after a project is done. Also if these structures are designed wrong, the wetlands can produce mosquitoes and may release an unpleasing odor.

The installation process requires a large amount of labor because of all the excavating and planting of wetland plants. Wetland maintenance is very high the first couple of years when the plants are still growing around the wetland. Once the plants are grown in, all the maintenance that will have to be done is annual inspections. The initial cost of these wetlands are reasonably high with all the prep work.

Watershed Management Authority

One of the best and most collaborative ways for communities to keep their watersheds healthy is by establishing a watershed management authority, or WMA. In 2010, the State of Iowa established Iowa Code Chapter 466B.2 which allows for the formation of these agreements. As defined by the Iowa DNR, a WMA is a mechanism for cities, counties, soil and water conservation districts, and other stakeholders to cooperatively engage in watershed planning and management.

Working through the Iowa Economic Development Authority and Iowa DNR, state-level government officials and organizations have encouraged local entities to apply for federal grant funding to form these comprehensive plans. As of September 2014, there were 11 functioning WMA's in the State of Iowa, ranging in size from 93 square miles to over 1700 square miles.

In the short time these WMA's have existed, involved communities have noticed an increased sense of ownership from property owners, both those directly-impacted by flooding and those simply living within the watershed. Through these organized efforts to manage and maintain healthy watersheds, participants have also had success in applying for additional funding for water quality and flood mitigation projects from state and federal sources.

A noticeable example of an effective WMA within the state is the Indian Creek Watershed Management Authority in eastern Iowa. The process of forming this WMA was sponsored by the City of Marion and assisted by the East Central Iowa Council of Governments. Initially guided by the basic mission to reduce flood risk and improve water quality of Indian Creek, this WMA brought together the municipal governments from large cities and small towns alike, as well as several different regional and statewide organizations, and fostered a sense of community within the entire watershed between these communities. The WMA now allows for the involved communities to easily identify concerns within the watershed and address these issues effectively as a team instead of as individuals.

In light of such successes across the state, å Engineering, Inc. strongly encourages the City of Sioux City to begin the process of forming a watershed management authority for Perry Creek.

The group of government entities which are legally able to collaborate together to form a watershed management authority include the City of Sioux City, Woodbury County, Plymouth County, and the Soil & Water Conservation Districts for these two counties. Interestingly enough, in several cases the motivation of local community members and organizations in the form of grass roots efforts as opposed to top-down efforts. Although community engagement is a great thing to have in forming a WMA, the government entities are still required to be the leading individuals responsible for enacting the program and serving on the advisory board for the WMA. Other organizations, such as the Iowa DNR, U.S. Army Corps of Engineers, and Iowa DOT, are strongly encouraged to be involved in the formation of the watershed management authority.

To begin the process of creating a WMA for Perry Creek, a survey should be conducted to gather data from residents within the watershed. Past efforts have shown that print surveys have higher rates of completion that electronic surveys, but either method is acceptable. The survey should keep in mind the wide variety of participants who are considered stakeholders, and should strive to receive results from all: farmers, residents, business owners, commuters, recreationalists, etc. While surveys should collect a wide range of information regarding societal context, environmental impacts, and usage statistics, they should be kept relatively short and simple to encourage higher completion rates. Incentives may also be offered to participants who complete the survey.

With the results of the survey, the advisory board may discover further issues which are impacting stakeholders or realize that there is a lack of understanding with regard to watershed health. In any case, these results are highly useful in writing the actual WMA plan because they represent direct input from members of the community. Through the entire process, connectivity is crucial.

Typical components of a final WMA plan may include a mission statement, guiding objectives, definitions, contact information for all stakeholders involved, historical data, and desired goals for the future. Each watershed management authority, however, should be crafted and tailored to the specific needs of the watershed in question. Watershed management authorities must follow the guidelines as specified in Chapter 466B of Iowa Legislation, provided in its full extent in Appendix K.

Final Comments

å Engineering Inc. successfully designed a low cost solution which adheres to the design objectives established at the beginning of the design process. The design incorporates flood mitigation, erosion prevention, and water quality improvement while taking into account the several constraints and challenges which were presented with this complex, multifaceted project. The group realized early on that Sioux City could not economically complete a project of this magnitude all at once, and thus developed a multi-phase design solution.

Time is of essence for Sioux City, and the key to this project's success was to develop a plan that allows Sioux City to budget the cost over multiple years. After implementation of a single phase, a period of waiting is strongly encouraged to be observed. This will allow the client to assess the impact each phase has on Perry Creek and only approve implementation of the next phase when there is both necessity and capital present. While some skeptics may be inclined to decline this "wait and see" philosophy, allowing the creek to respond and modify itself will allow for the design solution to exist without causing irreparable or unnecessary modifications.

The most difficult part of this project for the community to accept is that compromises are necessary for its success. Unfortunately, some property owners will have to face the reality that a portion of their land may be degraded by the design solution's approach to allow Perry Creek to correct itself after each phase. Without this project, however, the creek would continue on its violent and unpredictable course of destruction and cause hardship for the community. With this solution, å Engineering Inc. hopes that the community is able to realize that the problems plaguing the watershed are slowly but surely coming to an end, once and for all.

Meanwhile, the most incredible part of this project is the potential to improve the community beyond what was requested through immense recreational value at the S. Ridge Rd. detention basin site, as well as aesthetically improving the Perry Creek channel and homeowner's land through best management practices. This design solution will be truly feasible only when the entire community engages in the process to rehabilitate the integrity of Perry Creek.

Acknowledgements

The team members at å Engineering, Inc. would not have been able to achieve the level of success they have with the Perry Creek Flood Control and Design project without the help of several groups and individuals.

Glenn Ellis, the City Engineer of Sioux City, served as the group's main point of contact with the client. In general, Glenn and his staff took time from their busy schedules to collaborate with the group, attend site visits, and provide guidance whenever needed. In addition, Glenn strived to engage the group with the Sioux City community by inviting å Engineering, Inc. to attend community meetings and informing the group of ongoing events in the community. He also made available to the group as much digital data as he was allowed to give, which allowed design solutions to be accurately drafted and produced.

The instructors of CEE: 3084 Project Design and Management served as the mentors and primary support system for the team at the University of Iowa. Professor A. Jacob Odgaard was an invaluable resource to the group. His expertise in river meandering and channel stability, regional detention basins, and grade control structures allowed the group to bring the vision of the design solution to an achievable reality. Meanwhile, Professor Paul F. Hanley's knowledge with regard to general project management and design techniques also helped the group make progress in achieving the project's Mission Statement. The two professors attended site visits, provided advice, and conducted weekly check-ins to assure the group was properly equipped to succeed.

In general, the entire Civil and Environmental Engineering Department within the College of Engineering at the University of Iowa was wholeheartedly supportive of the group, especially concerning project activities which required absences from other commitments. Faculty and staff members wanted nothing but success for the team, and this was duly noted throughout the entire design process.

The Iowa Initiative for Sustainable Communities made the site visits possible for the group. Working with Sarah SanGiovanni, the Program Coordinator, was an absolute pleasure as she was always very diligent and kind in coordinating the details of the visits, such as lodging, transportation, and meal reimbursement.

Several outside organizations and individuals also contributed to the success of the project. For example, Deb Schiel-Larson from the Iowa DNR provided the group with information regarding environmental permitting for the project. Roger Kay from the U.S. Army Corps of Engineers - Omaha District allowed the group to have access to its design project documents from prior projects on Perry Creek. Jennifer Fencl from the East Central Iowa Council of Governments spoke with the group about the process of crafting watershed management authorities and the importance of

incorporating the community in the solution creation process. Without these contributions, the group would have neglected several important factors in designing the final design solution.

Finally, å Engineering, Inc. would like to thank the community members of Sioux City for welcoming the project team with open arms and classic Midwestern hospitality. This project has the potential of causing several consequences, both good and bad, within the community, and it is evident to the team that the families and business who call the city home are ready to invest themselves into a solution which creates a healthy Perry Creek for future generations to enjoy.

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Appendices

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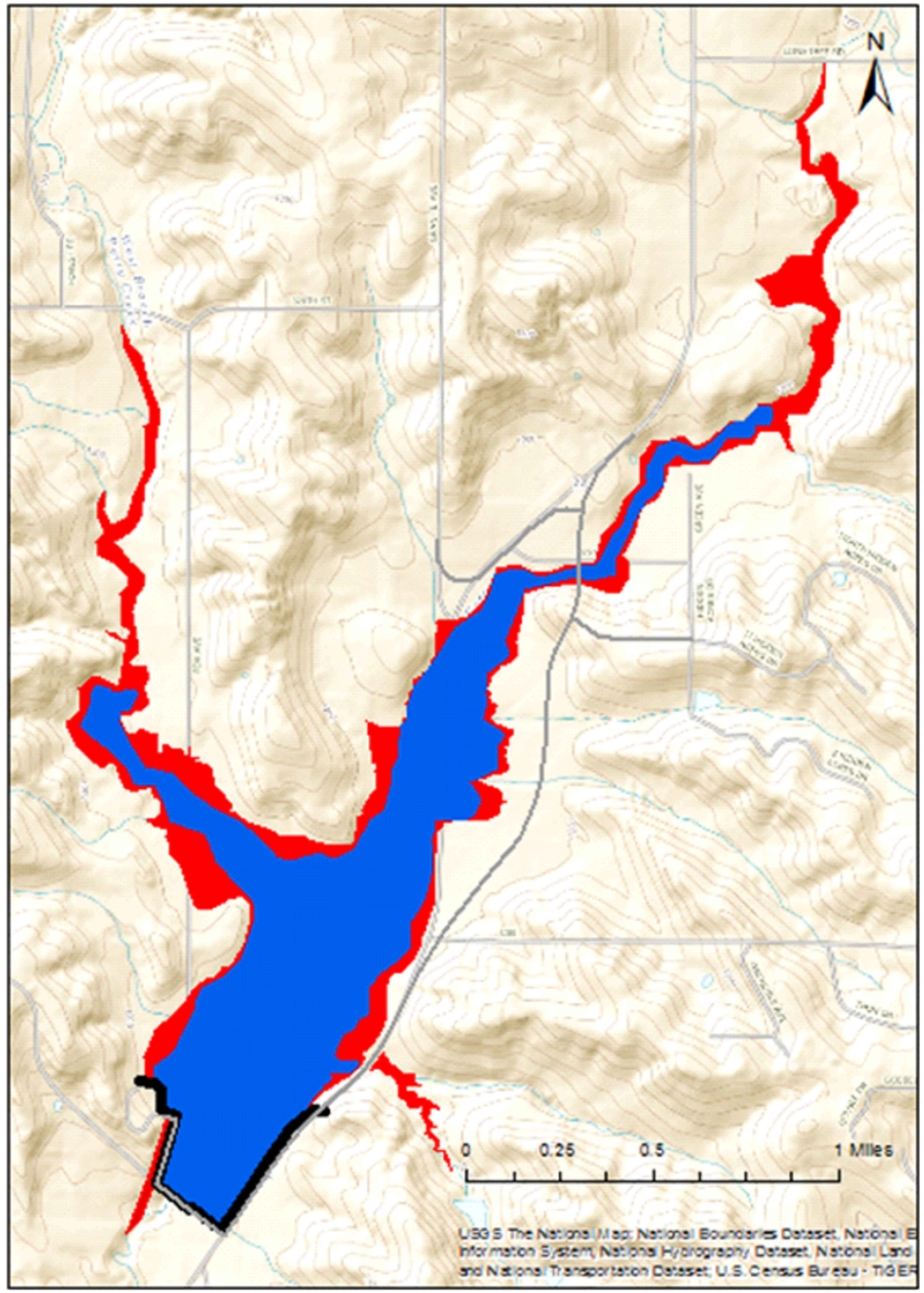

A.1 WET DETENTION BASIN

General Notes

THE HOLDING CAPACITY OF THE WET DETENTION BASIN.

THE BLUE POND REPRESENTS THE PERMANENT POND

THE RED REPRESENTS HIGH WATER CONDITIONS

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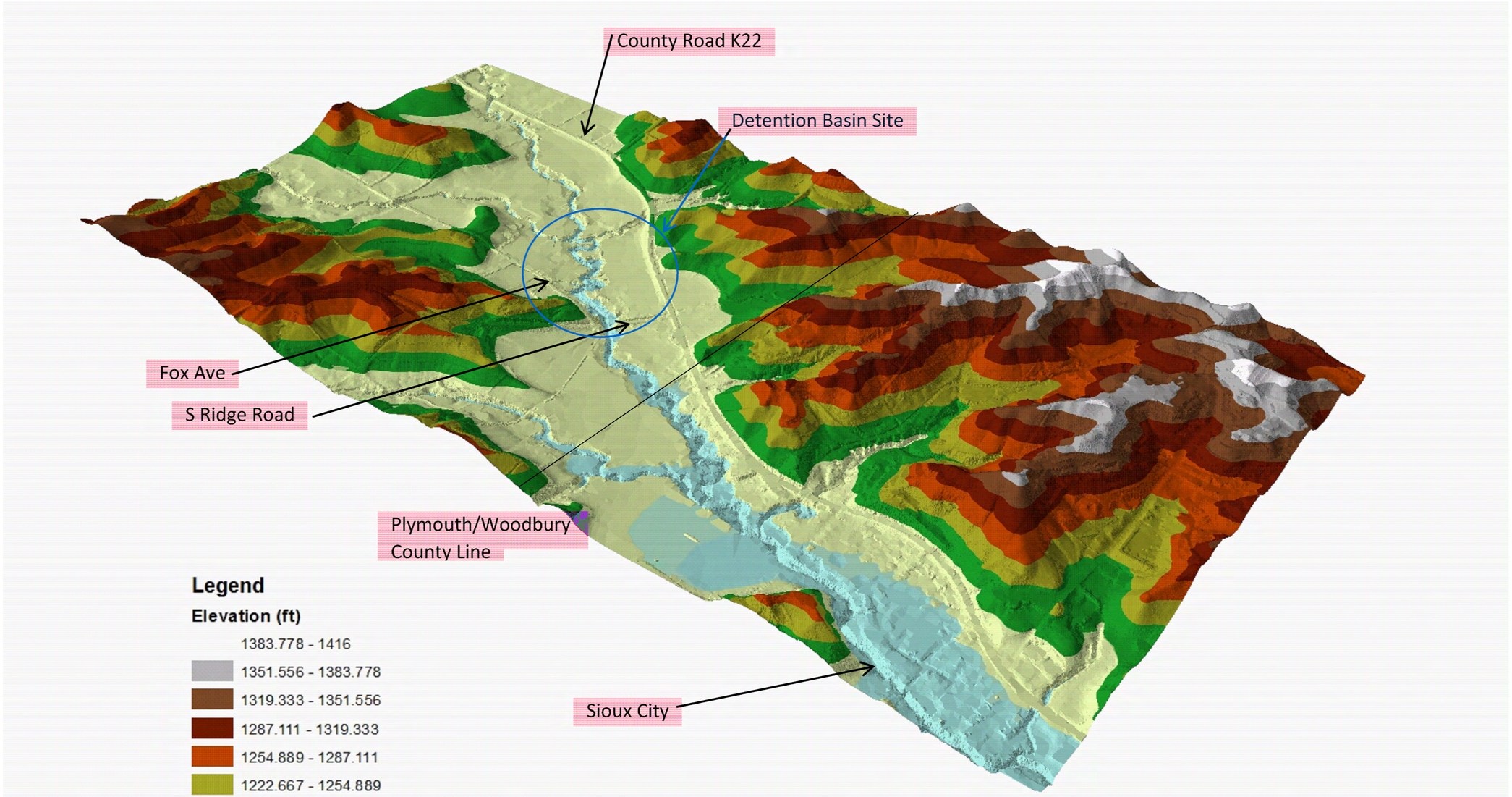

B.1 LOCATION OF DRY DETENTION BASIN

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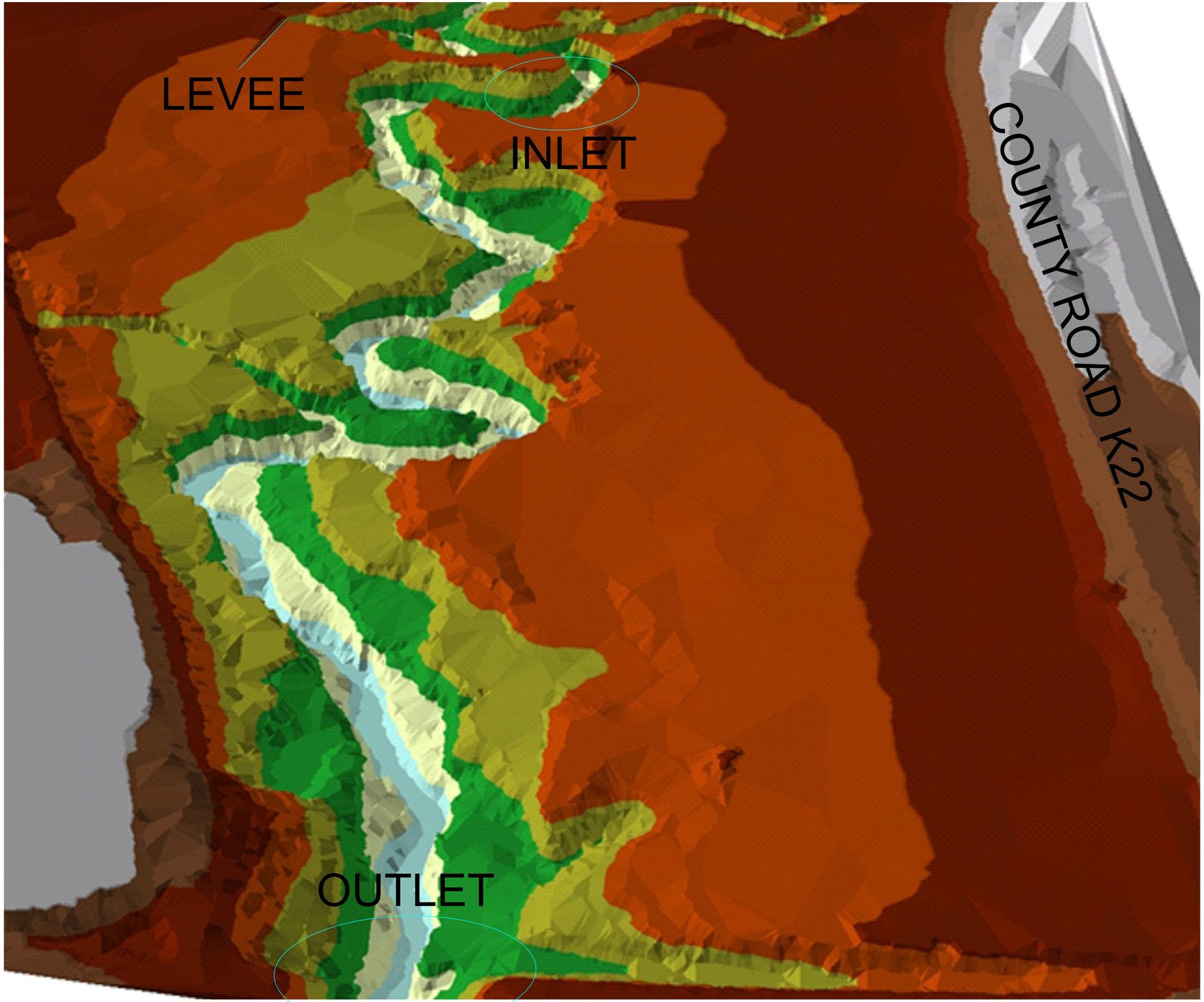

B.2 LOCATION OF INLET/OUTLET STRUCTURES & LEVEE

General Notes

UPPER CYAN CIRCLE = INLET

LOWER CYAN CIRCLE = OUTLET

CYAN LINE = LEVEE

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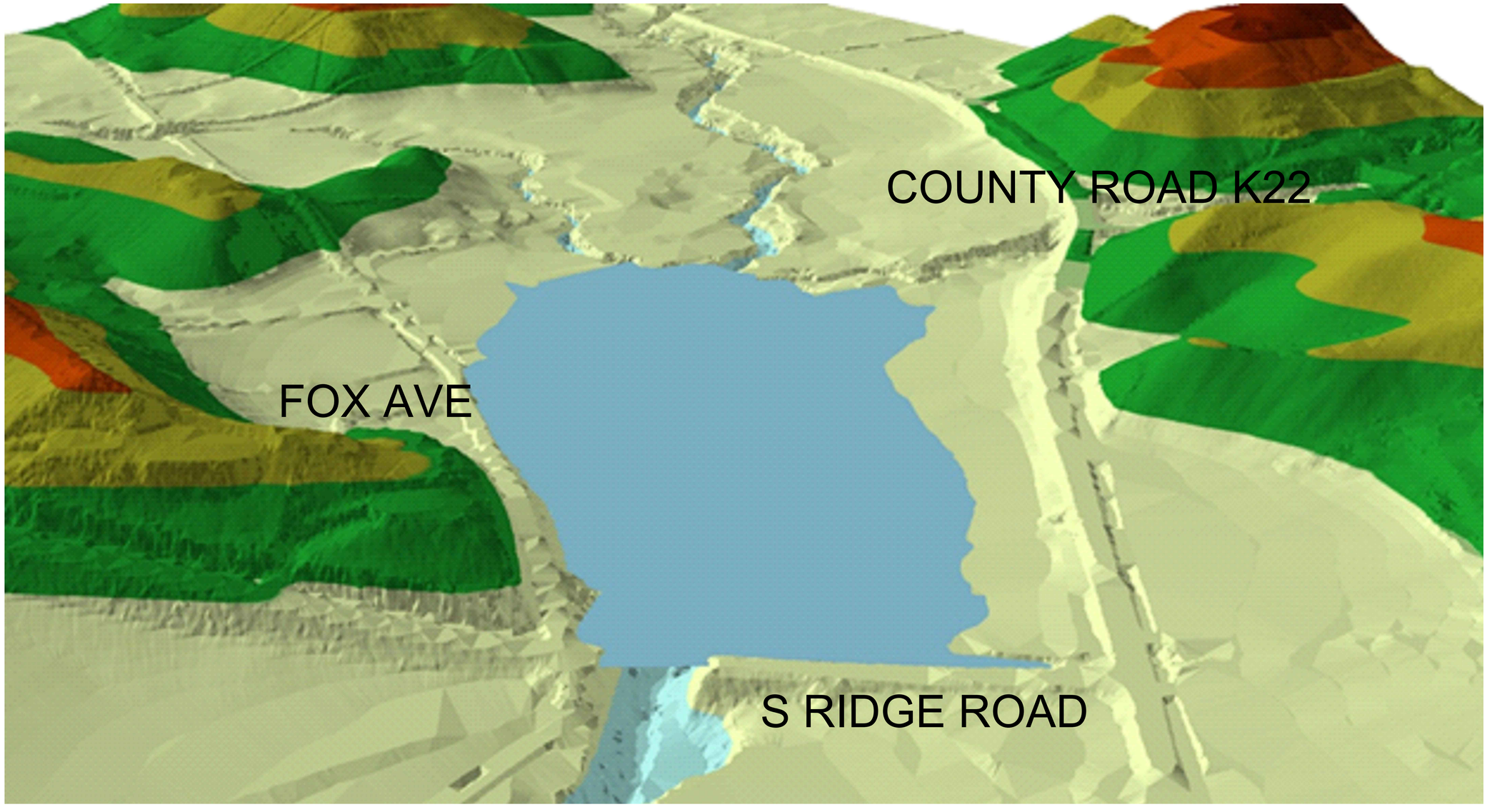

B.3 DRY DETENTION BASIN AT MAX LEVEL

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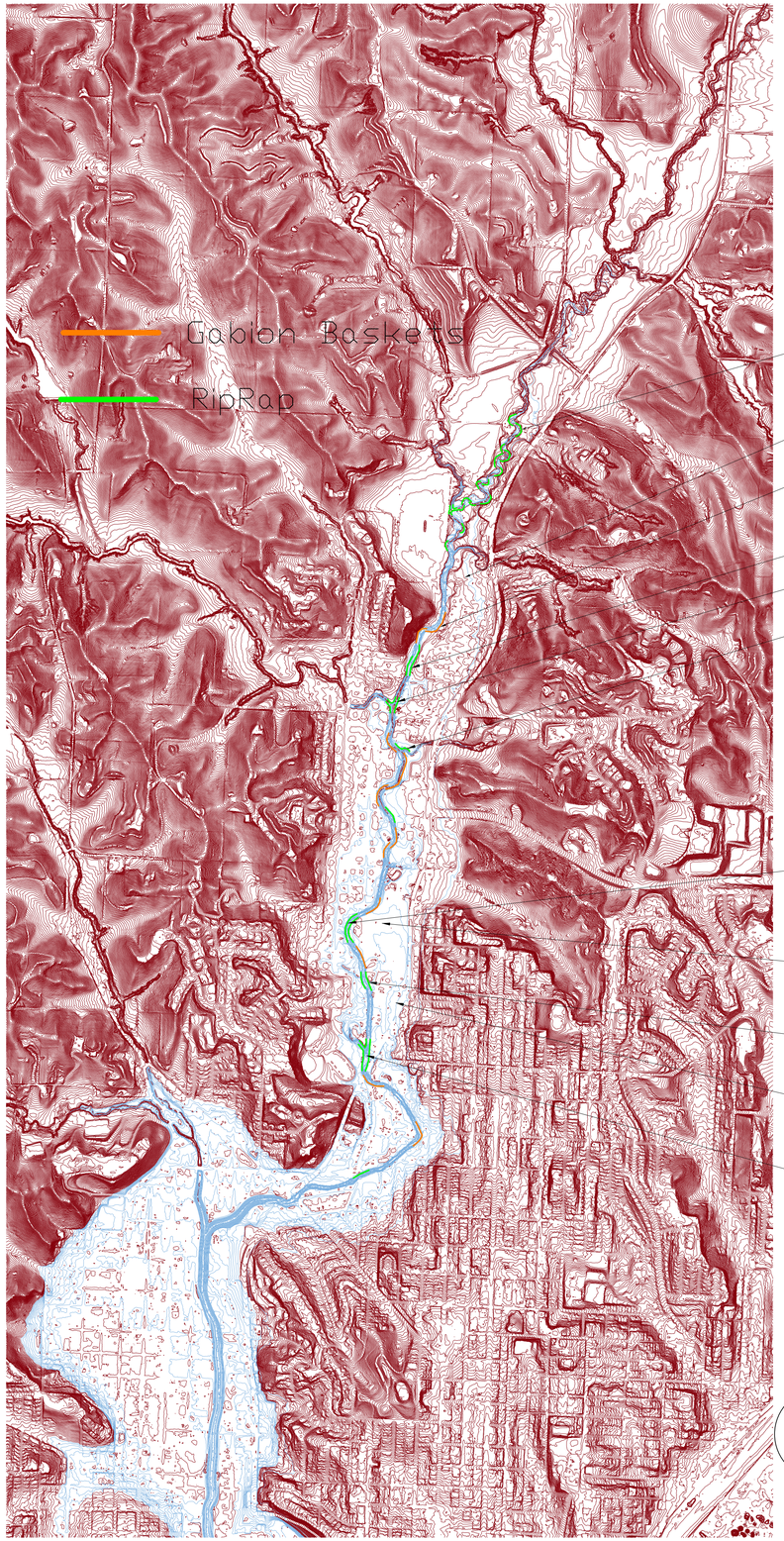

Rip-Rap used outside of city limits, no gabions

Buckwalter Ave

Excavation of bank to 5/1 slope
Soil will be transported to Clark Elementary Bridge

Rip Rap installation under and around bridge

Rip Rap installation at creek junction

Rip Rap installation at creek junction

Clark Elementary School Bridge
Rip Rap installation and storm fallout repair

Clark Elementary School

Rip Rap Installation under and around bridge

Golf Course

Rip Rap installation under and around bridge
Installation of rip rap at creek junction

C.1 LOCATIONS OF RIPRAP & GABION BASKETS

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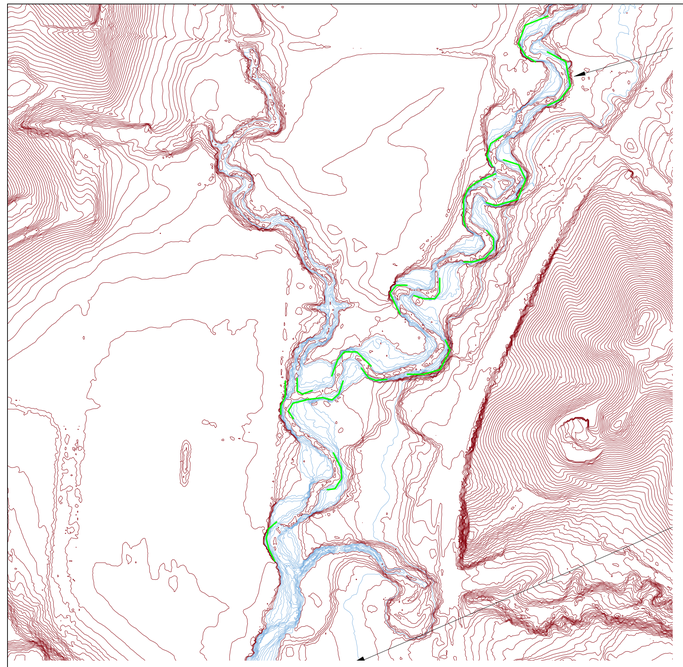

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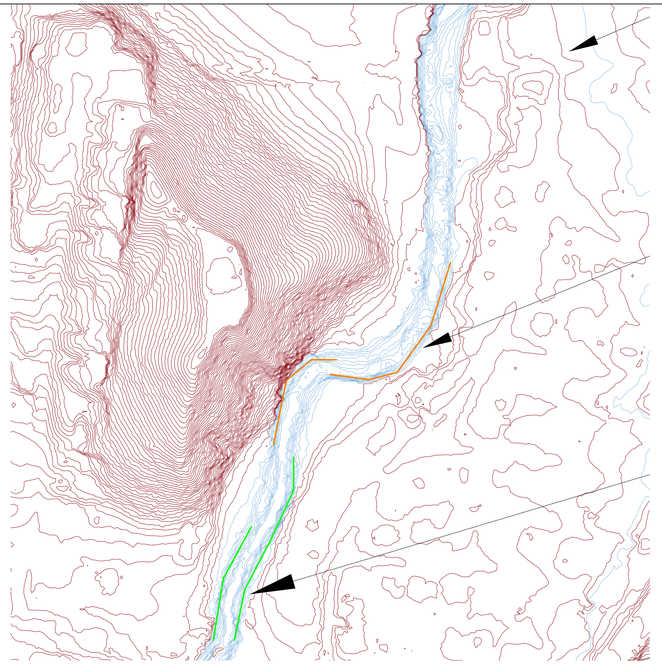

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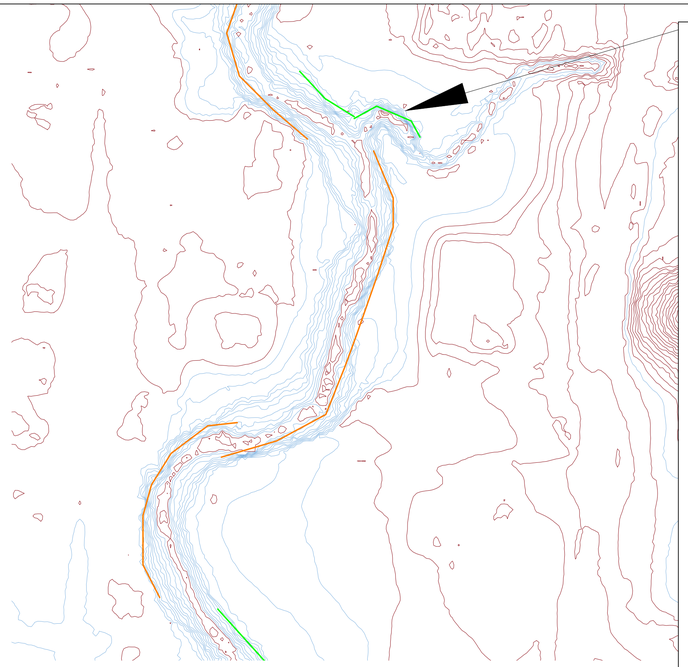

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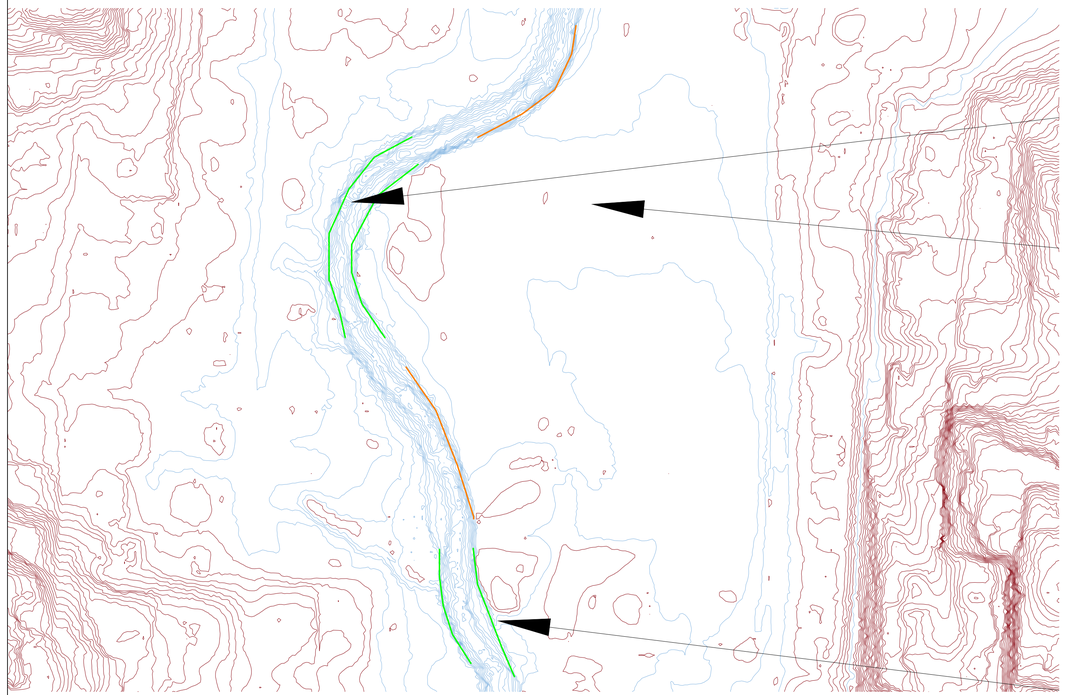

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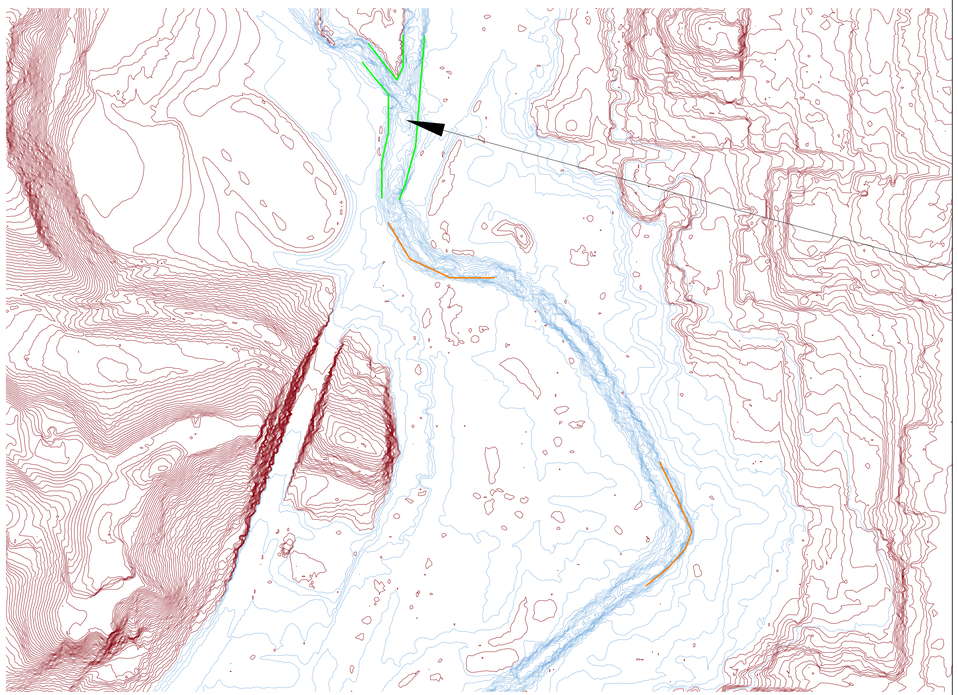

C.6 Section 5

General Notes

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Appendix D: Calculations for Final Design

Riprap Calculations

Assumptions:

Outlet location

Q = 1427 cfs D = 5.71 ft Riprap D_{50} Range: 5.0 in to 22.0 in

$D_{50} = \frac{0.044}{TW}(\frac{Q}{D})^{4/3}$ (Equation 1) TW_1 = 22 + 2(5.1)(5.71) TW_1 = 80.242 ft

$D_{50} = \frac{0.044}{80.242\ ft}(\frac{1427\ cfs}{5.71\ ft})^{4/3}$ $D_{50} = 0.86\ ft = 10.32\ in$

$D_{50} = \frac{0.044}{TW}(\frac{Q}{D})^{4/3}$ TW_2 = 22 + 2(7.2)(5.71) TW_2 = 104.224 ft

$D_{50} = \frac{0.044}{104.224\ ft}(\frac{1427\ cfs}{5.71\ ft})^{4/3}$ $D_{50} = 0.66\ ft = 7.97\ in$

Round up 10.32 in to 12 in *Use D_{50} = 1 ft for Perry Creek Design*

Phase 1:

From ArcGIS:

Volume = 411934 m^3 = 14.5 x 10^6 ft^3 = 332.87 ac-ft

Using USGS data at station on 38th St. and in putting it into Peak FQ software

The 100 yr flood at gage = 9028 ft^3/s

The 1.5 yr flood at gage = 1443 ft^3/s

Using regionalization curve equation from Iowa SWMM

The 100 yr flood at S. Ridge Rd. = 4122 ft^3/s

The 1.5 yr flood at S. Ridge Rd. = 951 ft^3/s

Design Flood = 100 yr, 1 hr storm event

Volumes:

$4122\frac{\text{ft}}{\text{s}}\left(\frac{3600\text{ s}}{\text{hr}}\right)(1\text{ hr}) = 14.84 \text{ x } 10^6 \text{ ft}^3 \text{ (inflow)}$ (Equation 2)

$951\frac{\text{ft}}{\text{s}}\left(\frac{3600\text{ s}}{\text{hr}}\right)(1\text{ hr}) = 3.42 \text{ x } 10^6 \text{ ft}^3 \text{ (outflow)}$

Need total volume = 14.84-3.42 = 11.42 x 10^6 ft^3

From GIS volume have > volume needed

Outlet Condit Equation

$Q = C_d A_o \sqrt{2gh}$ (Equation 3) where Q_o = 951 ft^3/s
C_d = 0.6 (WRE Book)
g = 32.2 ft/s^2
h = 26.5 ft

$$951\ ft^3/s = (0.6)(A_o)\sqrt{2(32.2\ \frac{ft}{s^2})(26.5\ ft)}$$

A_o = 38.37 ft^2
Assume circular conduit

D_o = 6.99 ft. ***Use 7 ft diameter pipe***

Phase 2:

Grade Control Structure Slope Design
Water depth at Bankfull:
Bed width= 21 feet
Right side bank slope= 7.2 H: 1V
Left side bank slope= 5.1H: 1V
$Q_{1.5}$=1427 cfs
S_0=0.00153
n=0.03

$$\text{Perimeter} = 21 + \sqrt{y^2 + 5.1y^2} = 21 + 12.46y$$
$$\text{Area} = (.5 * 5.1y^2) + (.5 * 7.2y^2) + (21y) = 6.15y^2 + 21y$$
$Q = \left(\frac{1.49}{n}\right) * A * R^{\frac{2}{3}} * S^{1/2}$ Manning's Equation (Equation 4)

$$1427 = \left(\frac{1.49}{0.03}\right) * (6.15y^2 + 21y) * (\frac{(6.15y^2 + 21y)}{(21 + 12.46y)})^{\frac{2}{3}} * (0.00153)^{0.5}$$

y=5.71 ft
A=320.43 ft^2
P= 92.022 ft
V= 4.46 ft/s

To determine slope needed to achieve a flow of 3 feet per second:

$$V = \left(\frac{1.49}{n}\right) * R^{\frac{2}{3}} * S^{1/2}$$
$$3.0 = \left(\frac{1.49}{0.03}\right) * (\frac{320.43}{92.022})^{\frac{2}{3}} * S^{1/2}$$

S = 0.000691

Height of Structure at King's Hwy Bridge:
Slope between Kings Hwy and Buckwalter structure- 0.00197
Distance- 2280 ft.

Height of Structure= (Existing Slope*Distance)-(Desired Slope*Distance)
Height= (0.00197*2280)-(0.000691*2280)

Height= 2.92 ft. ***Use height of structure of 3 ft.**

Phase 4:

Using USGS data at station on 38th St. and in putting it into Peak FQ software
The 100 yr flood at gage = 9028 ft^3/s
The 1.5 yr flood at gage = 1443 ft^3/s
Using regionalization curve equation from Iowa SWMM
The 100 yr flood at 250th St. = 1036 ft^3/s
The 1.5 yr flood at 250th St. = 238 ft^3/s
Design Flood = 100 yr, 1 hr storm event

Volumes:

$$1036\frac{\text{ft}}{\text{s}}\left(\frac{3600\text{ s}}{\text{hr}}\right)(1\text{ hr}) = 3.73 \text{ x } 10^6 \text{ ft}^3 \text{ (inflow)} \qquad \text{(Equation 2)}$$

$$238\frac{\text{ft}}{\text{s}}\left(\frac{3600\text{ s}}{\text{hr}}\right)(1\text{ hr}) = 0.86 \text{ x } 10^6 \text{ ft}^3 \text{ (outflow)}$$

Need total volume = 3.73-0.86 = 2.87 x 10^6 ft^3

Outlet Condit Equation

$Q = C_d A_o \sqrt{2gh}$ (Equation 3) where Q_o = 238 ft^3/s
C_d = 0.6 (WRE Book)
g = 32.2 ft/s^2
h = 6 ft

$$238\text{ ft}^3/\text{s} = (0.6)(A_o)\sqrt{2(32.2\frac{\text{ft}}{\text{s}^2})(6\text{ ft})}$$

A_o = 16.25 ft^2
Assume circular conduit

D_o = 4.05 ft. ***Use 4.5 ft. diameter pipe***

Phase 5:

Using USGS data at station on 38th St. and in putting it into Peak FQ software

The 100 yr flood at gage = 9028 ft^3/s

The 1.5 yr flood at gage = 1443 ft^3/s

Using regionalization curve equation from Iowa SWMM

The 100 yr flood at Forest Rd. = 720 ft^3/s

The 1.5 yr flood at Forest Rd. = 166 ft^3/s

Design Flood = 100 yr, 1 hr storm event

Volumes:

$$720\,\frac{\text{ft}}{\text{s}}\left(\frac{3600\text{ s}}{\text{hr}}\right)(1\text{ hr}) = 2.59 \text{ x } 10^6\text{ ft}^3\text{ (inflow)} \qquad \text{(Equation 2)}$$

$$166\,\frac{\text{ft}}{\text{s}}\left(\frac{3600\text{ s}}{\text{hr}}\right)(1\text{ hr}) = 0.60 \text{ x } 10^6\text{ ft}^3\text{ (outflow)}$$

Need total volume = 2.59-0.60 = 1.99 x 10^6 ft^3

Outlet Condit Equation

$Q = C_d A_o \sqrt{2gh}$ (Equation 3) where Q_o = 166 ft^3/s

C_d = 0.6 (WRE Book)

g = 32.2 ft/s^2

h = 9 ft

$$166\text{ ft}^3/\text{s} = (0.6)(A_o)\sqrt{2(32.2\,\frac{\text{ft}}{\text{s}^2})(9\text{ ft})}$$

A_o = 9.11 ft^2

Assume circular conduit

D_o = 3.02 ft. ***Use 3.5 ft. diameter pipe***

Detention Basins Cost Estimate

C= Cost

V= Volume needed to hold 10-year storm (cubic feet)

$C = 12.4 * V^{0.760}$ (Equation 5)

S. Ridge Rd. Dry Detention Basin

V= 9,489,600 cubic feet

$C = 12.4 * V^{0.760}$

$C = 12.4 * 9{,}489{,}600^{0.760}$

C= $2,498,603

Forest Rd. Dry Detention Basin

V= 1,659,600 cubic feet

$C = 12.4 * V^{0.760}$

$C = 12.4 * 1{,}659{,}600^{0.760}$

C= $661,644

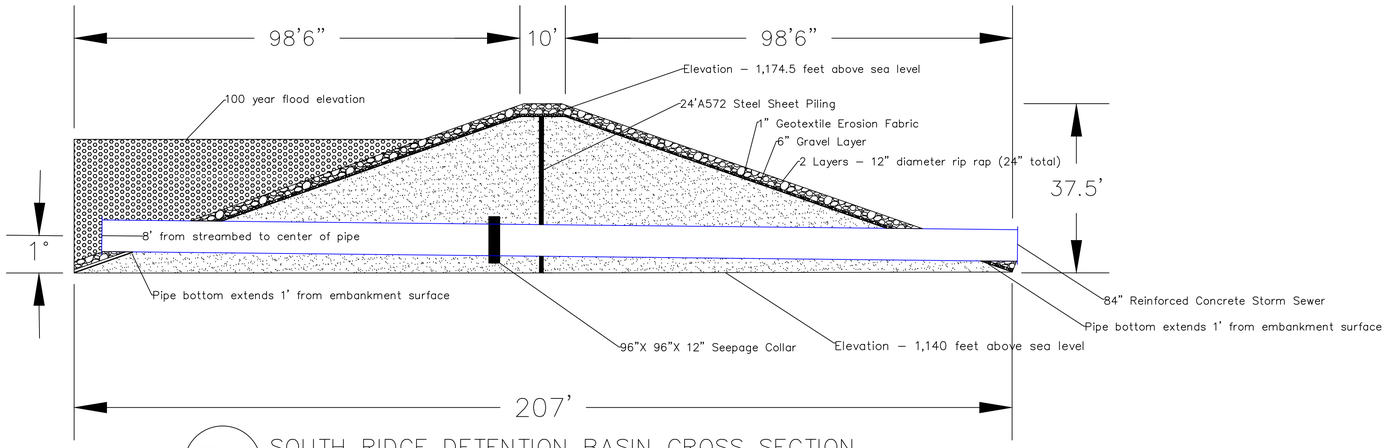
250th Street Dry Detention Basin

V= 2,383,200 cubic feet

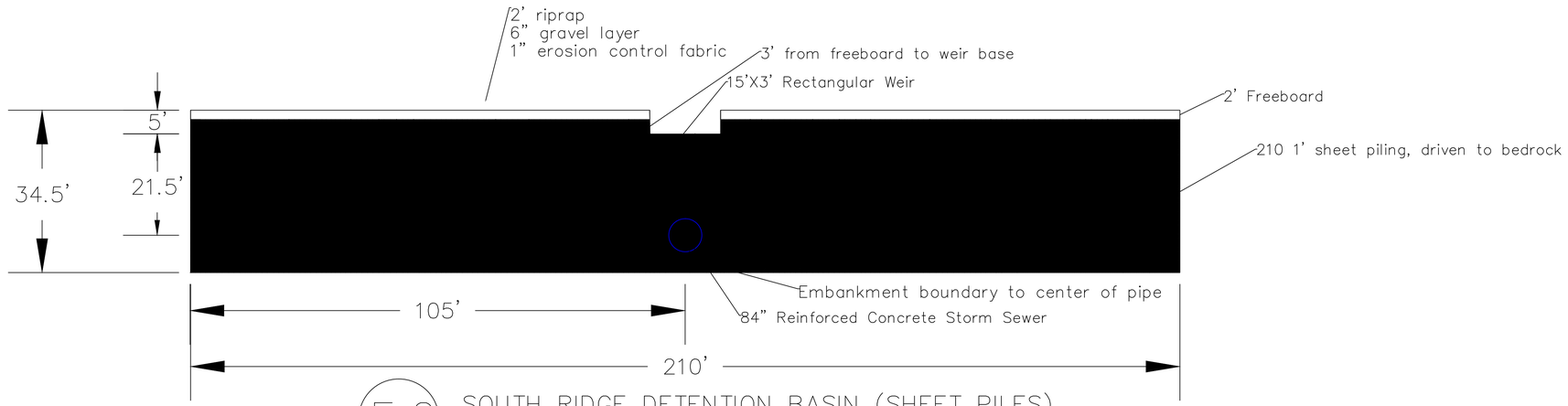
$C = 12.4 * V^{0.760}$

$C = 12.4 * 2{,}383{,}200^{0.760}$

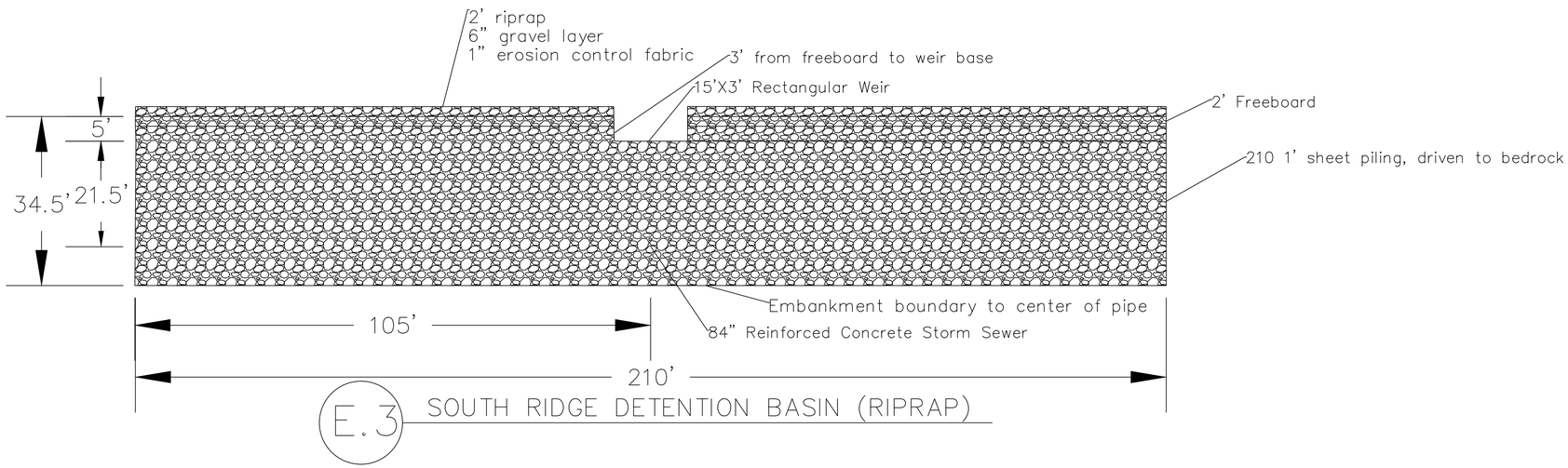
C= $871,091



E.1 SOUTH RIDGE DETENTION BASIN CROSS SECTION



E.2 SOUTH RIDGE DETENTION BASIN (SHEET PILES)



E.3 SOUTH RIDGE DETENTION BASIN (RIPRAP)

General Notes

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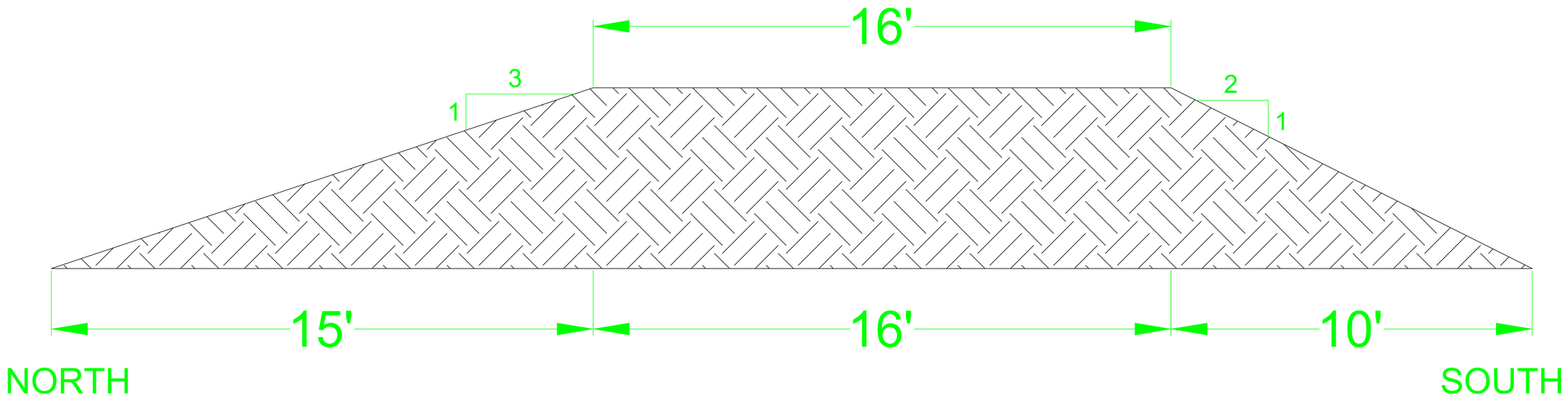

E.4 LEVEE ON NORTHWEST SIDE OF BASIN

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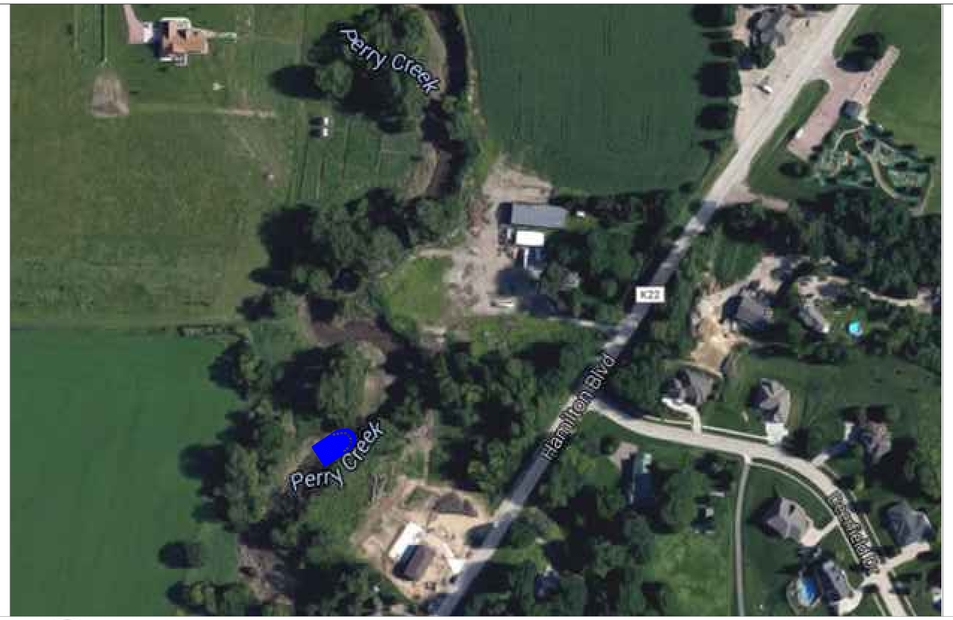
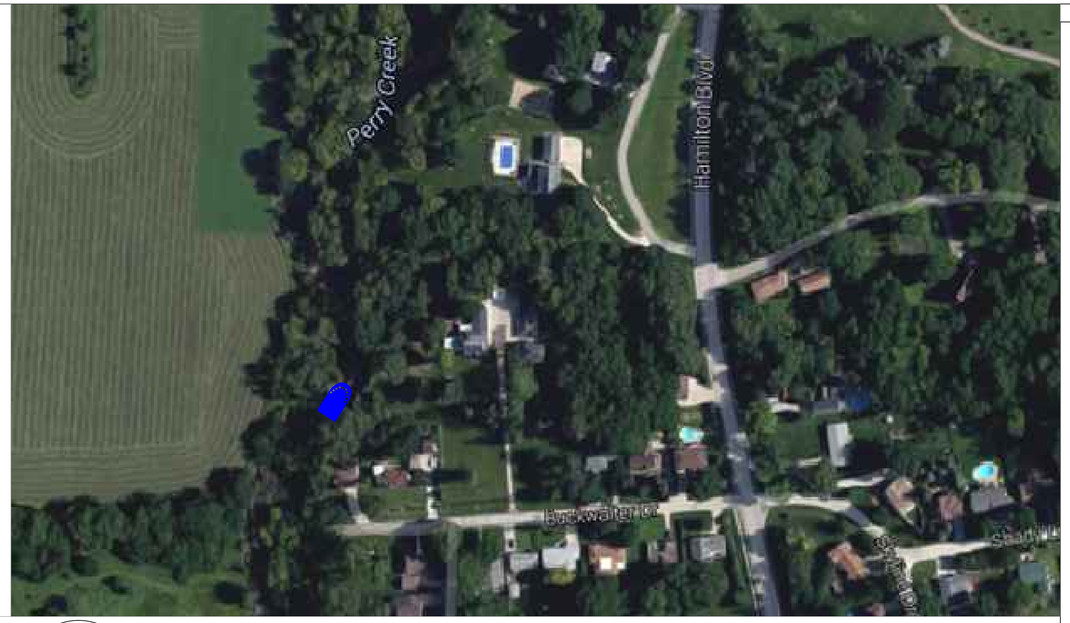
Appendix F: Final Design Phase 2- Grade Control Structures

Table F.1: Distance and slopes between structures

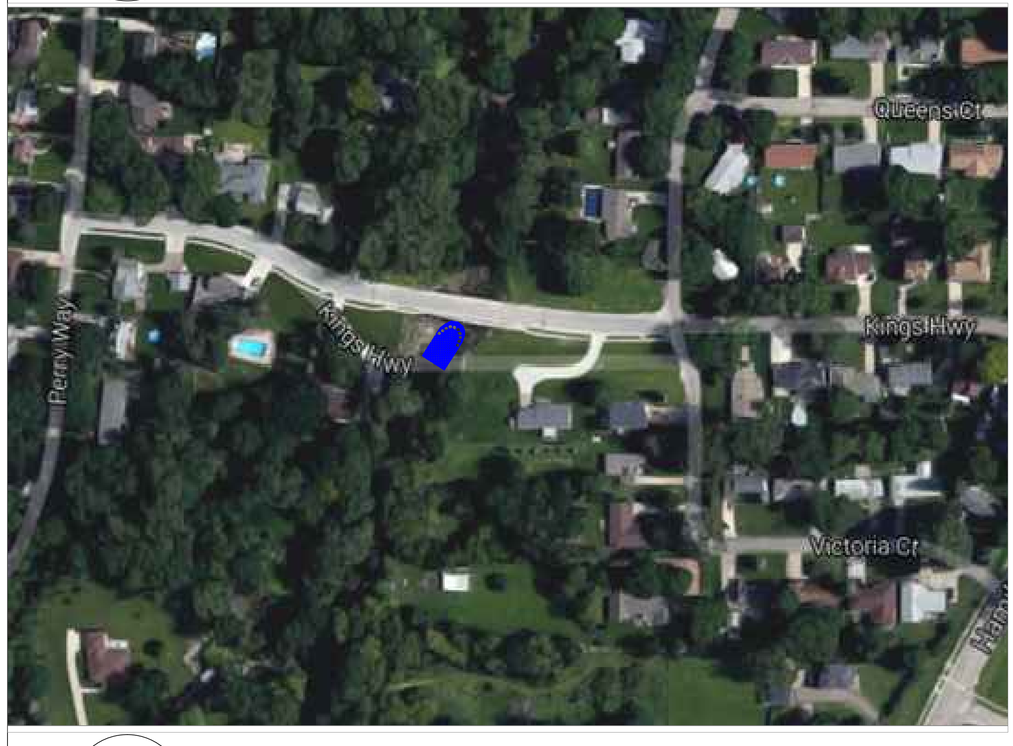
Location	Distance (ft.)	Slope	Height (ft)
West of Deerfield Drive	1430	0.00105	0.51337
West of Buckwalter Drive	2900	0.00086	0.4901
Kings Hwy Bridge	2280	0.00197	2.91612
Pedestrian Bridge (4209 Hamilton Blvd.)	2900	0.00129	1.7371
38th Street Bridge	3320	0.000828	0.45484
Hamilton Blvd. Bridge	1364	0.00256	2.549316
Dearborn Ave. Bridge	2736	0.00164	2.596464



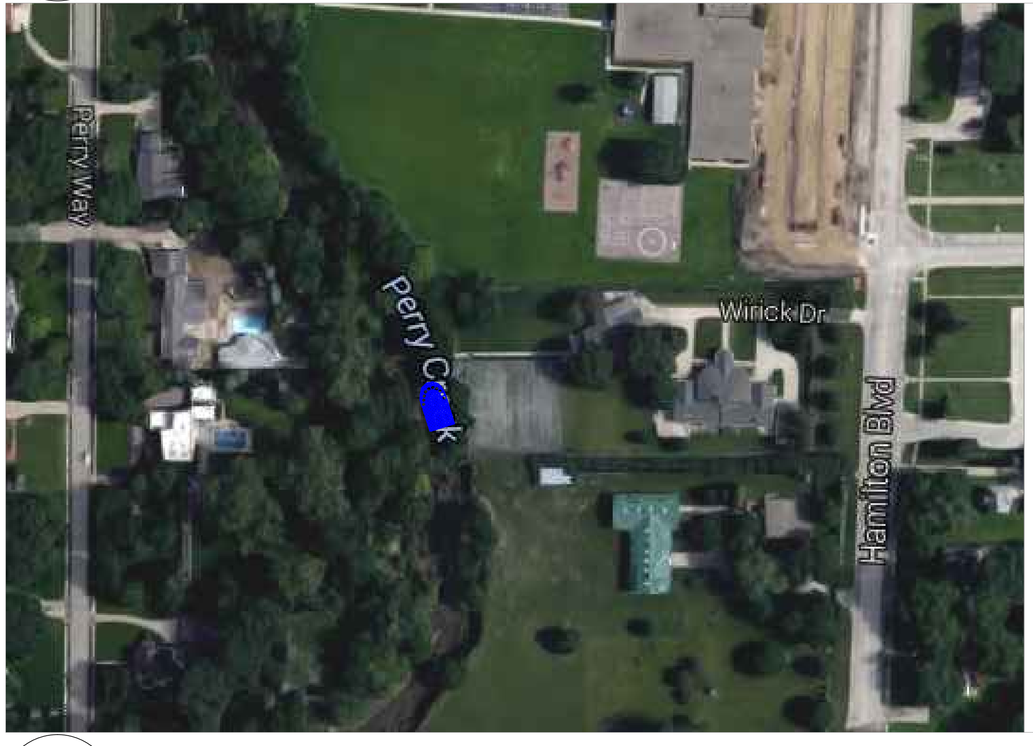
F.1 HAMILTON BLVD GRADE CONTROL



F.2 BUCKWALTER DR. GRADE CONTROL



F.3 KING'S HWY BRIDGE GRADE CONTROL



F.4 PEDESTRIAN BRIDE (4209 HAMILTON BLVD)

General Notes

No.	Revision/Issue	Date

å ENGINEERING, INC.
3100 SEAMANS CENTER
IOWA CITY, IA. 52242

CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA. 51102

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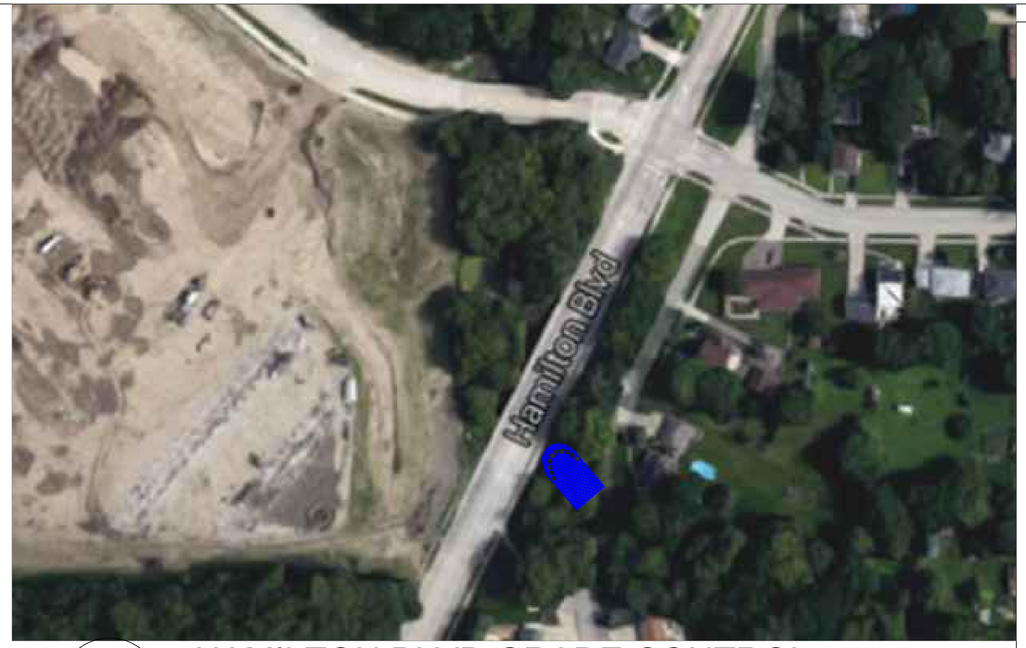
F.5 38TH ST. BRIDGE GRADE CONTROL



F.6 HAMILTON BLVD GRADE CONTROL

F.7 DEARBORN AVE. GRADE CONTROL

General Notes

No.	Revision/Issue	Date

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3100 SEAMANS CENTER
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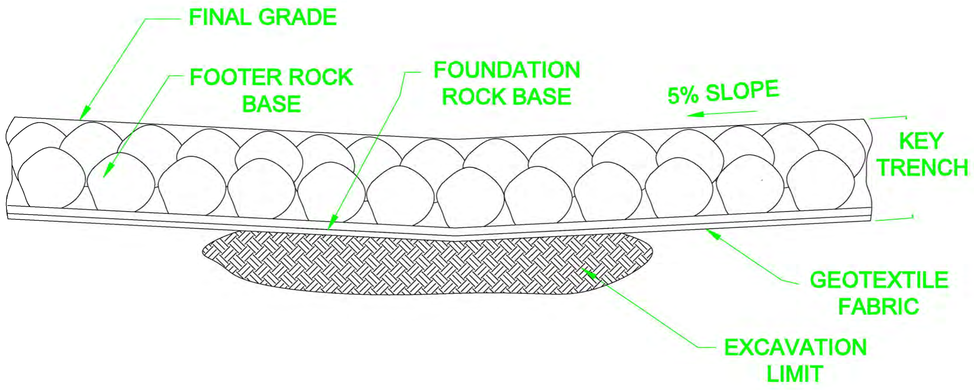
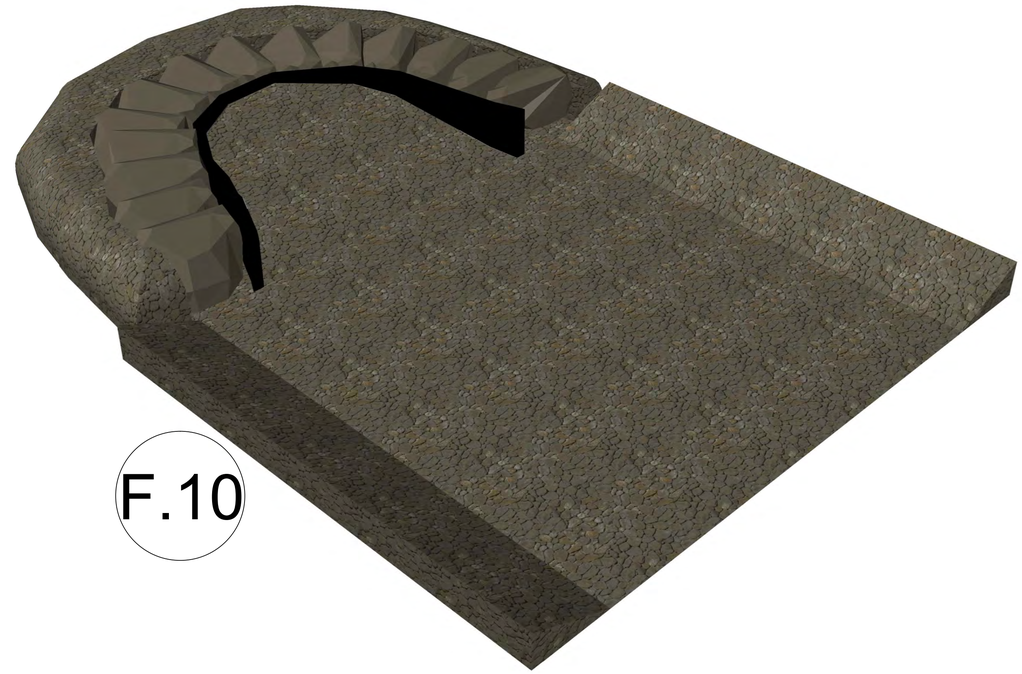
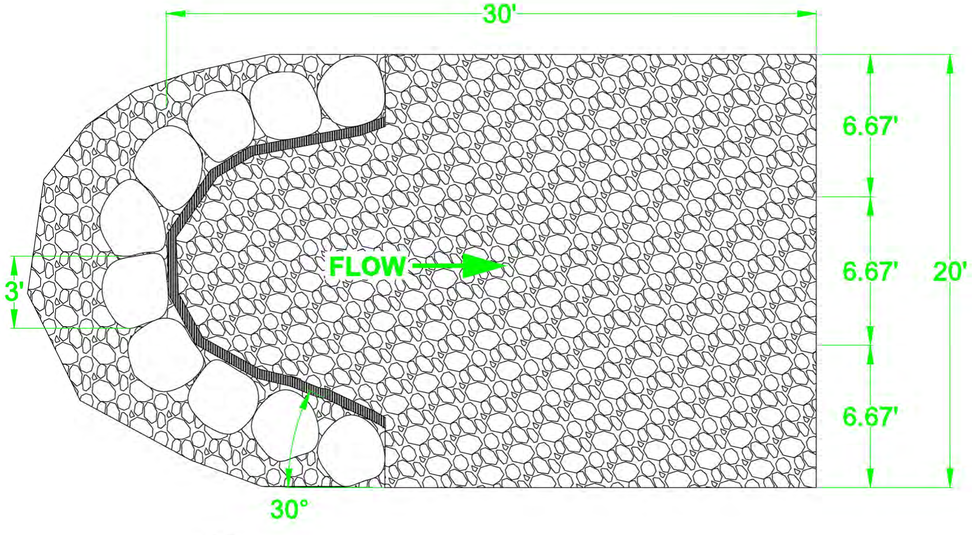


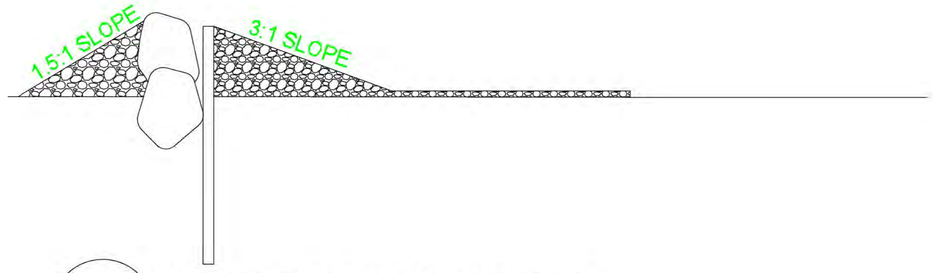
F.8 BOULDER CROSS SECTION



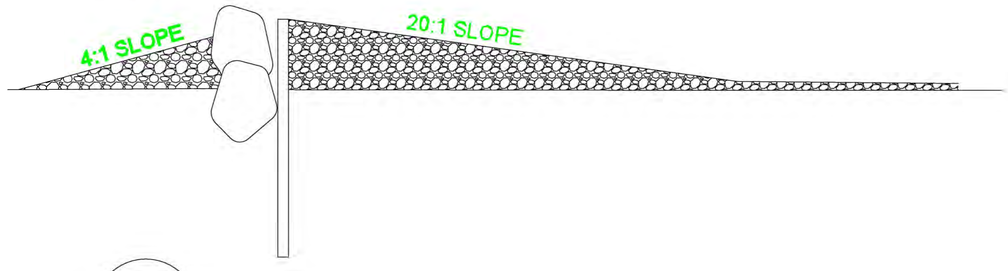
F.10



F.9 BOULDER CROSS SECTION



F.11 SIDE VIEW OF GRADE CONTROL



F.12 SIDE VIEW OF GRADE CONTROL (FISH PASSAGE)

General Notes

No.	Revision/Issue	Date

å ENGINEERING, INC.
3100 SEAMANS CENTER
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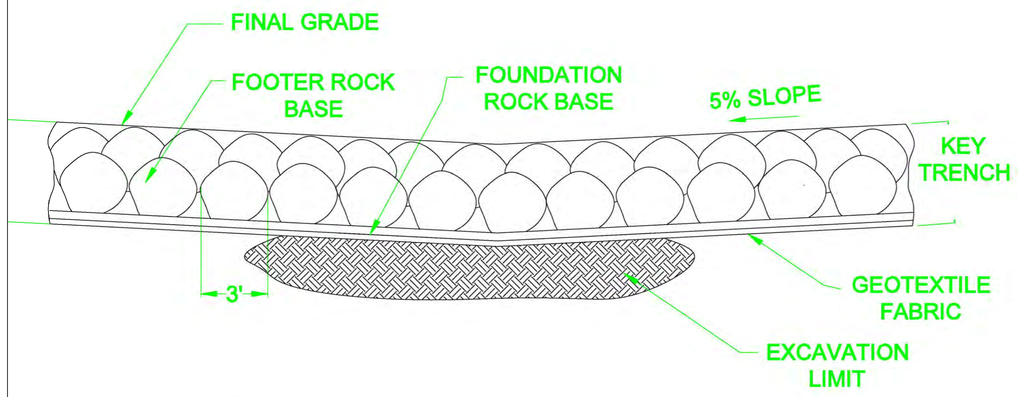
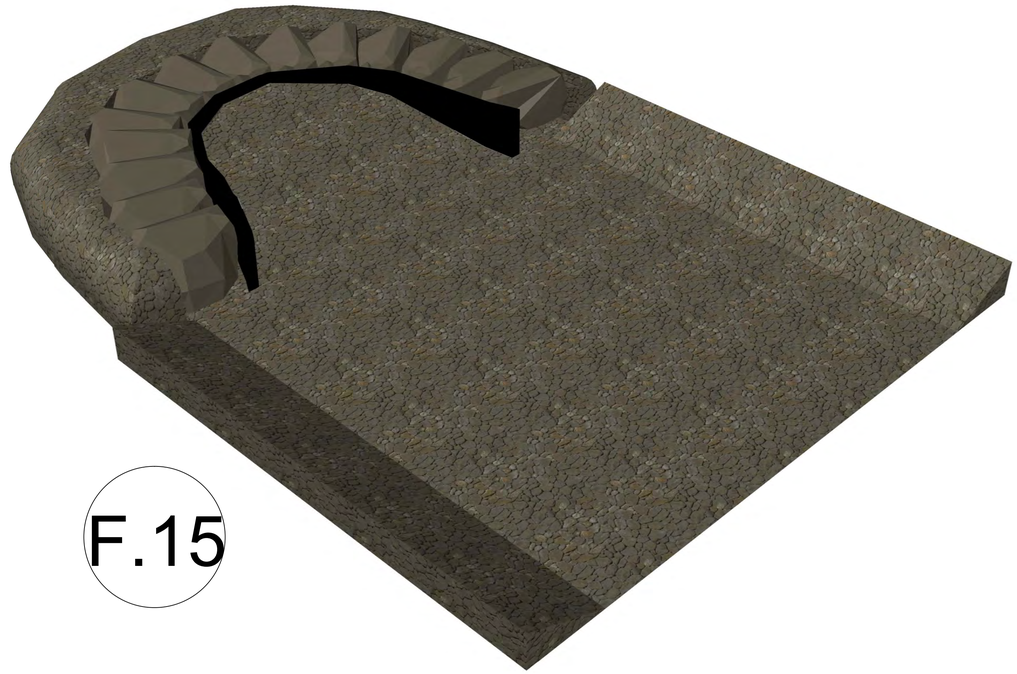


F.13 BOULDER CROSS SECTION



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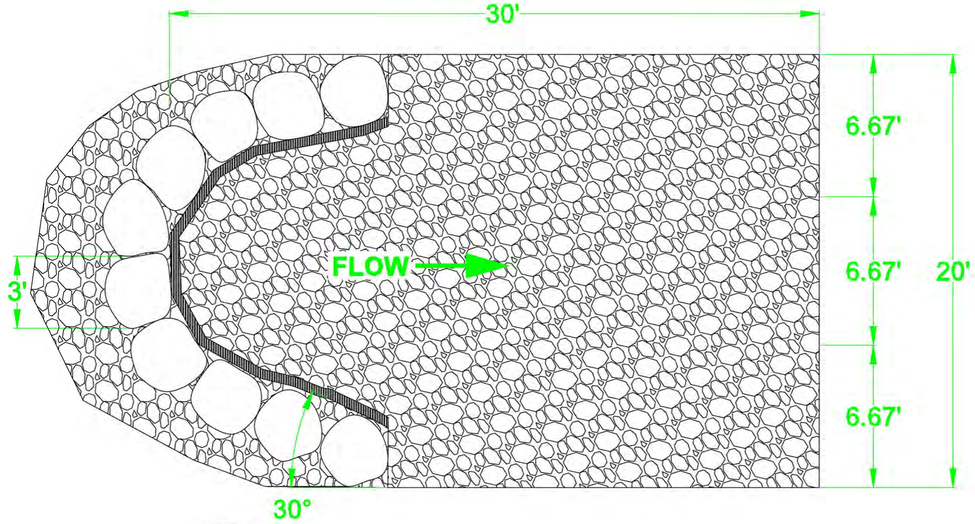
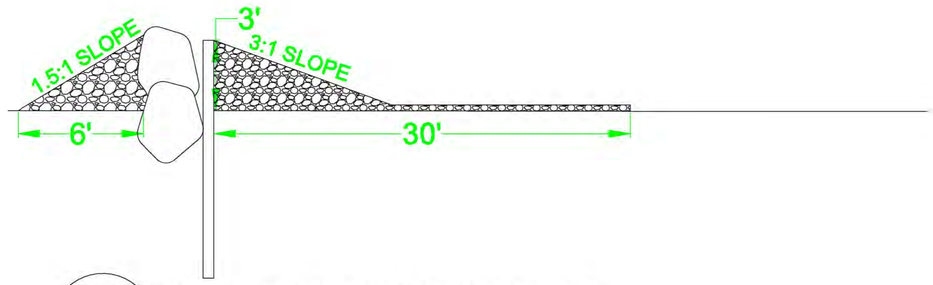
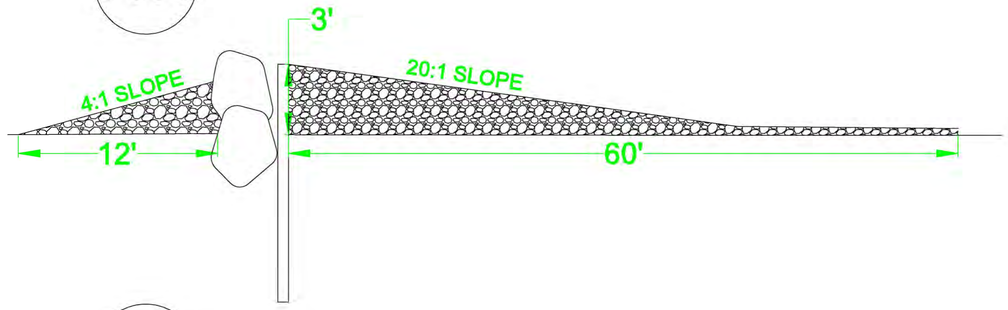


F.14 BOULDER CROSS SECTION



F.16 SIDE VIEW OF GRADE CONTROL



F.17 SIDE VIEW OF GRADE CONTROL (FISH PASSAGE)

General Notes

No.	Revision/Issue	Date

å ENGINEERING, INC.
3100 SEAMANS CENTER
IOWA CITY, IA. 52242

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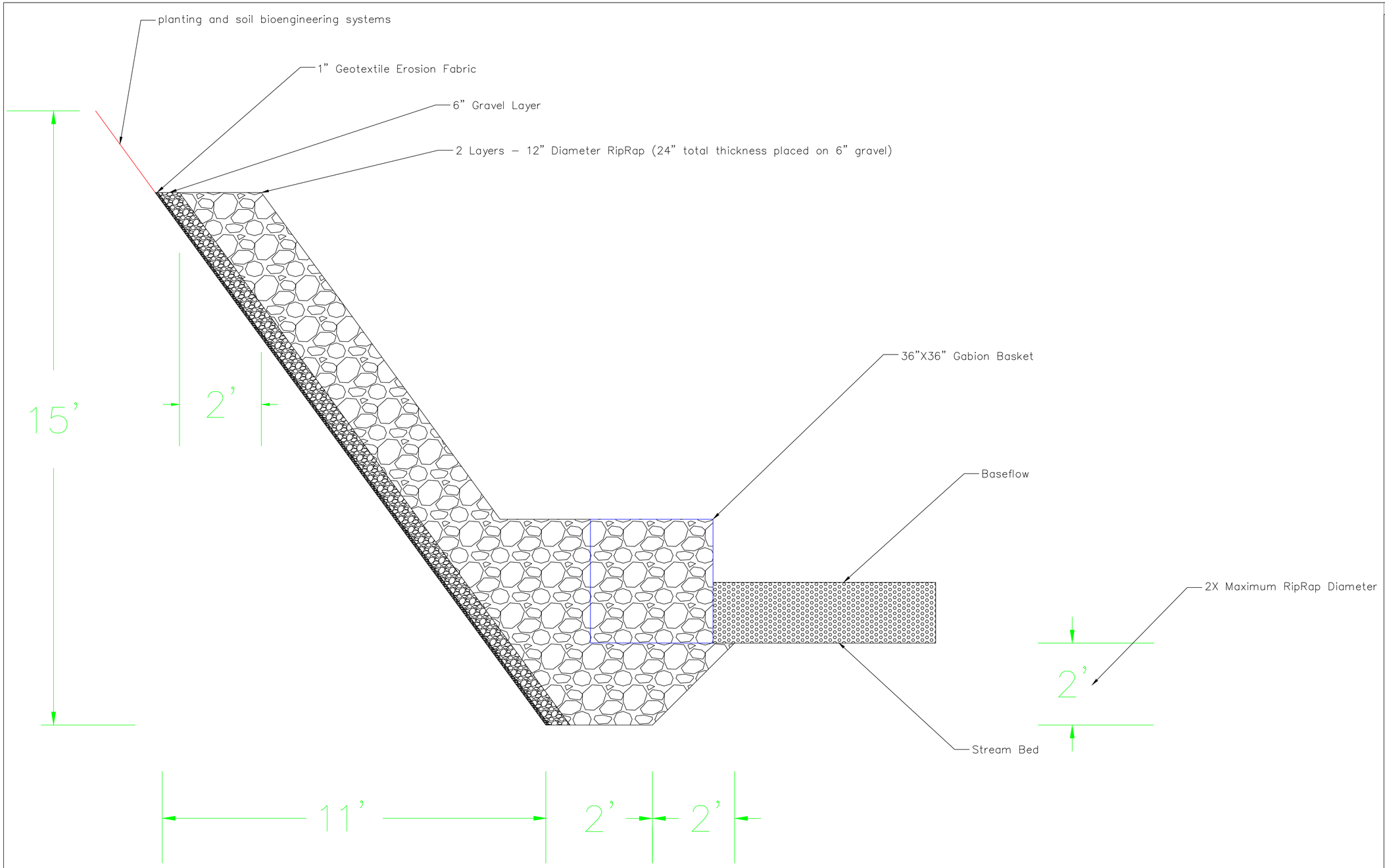

G.1 RIPRAP DESIGN

General Notes

No.	Revision/Issue	Date

ā ENGINEERING, INC.
3100 SEAMANS CENTER

IOWA CITY, IA. 52242

CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA.

51102

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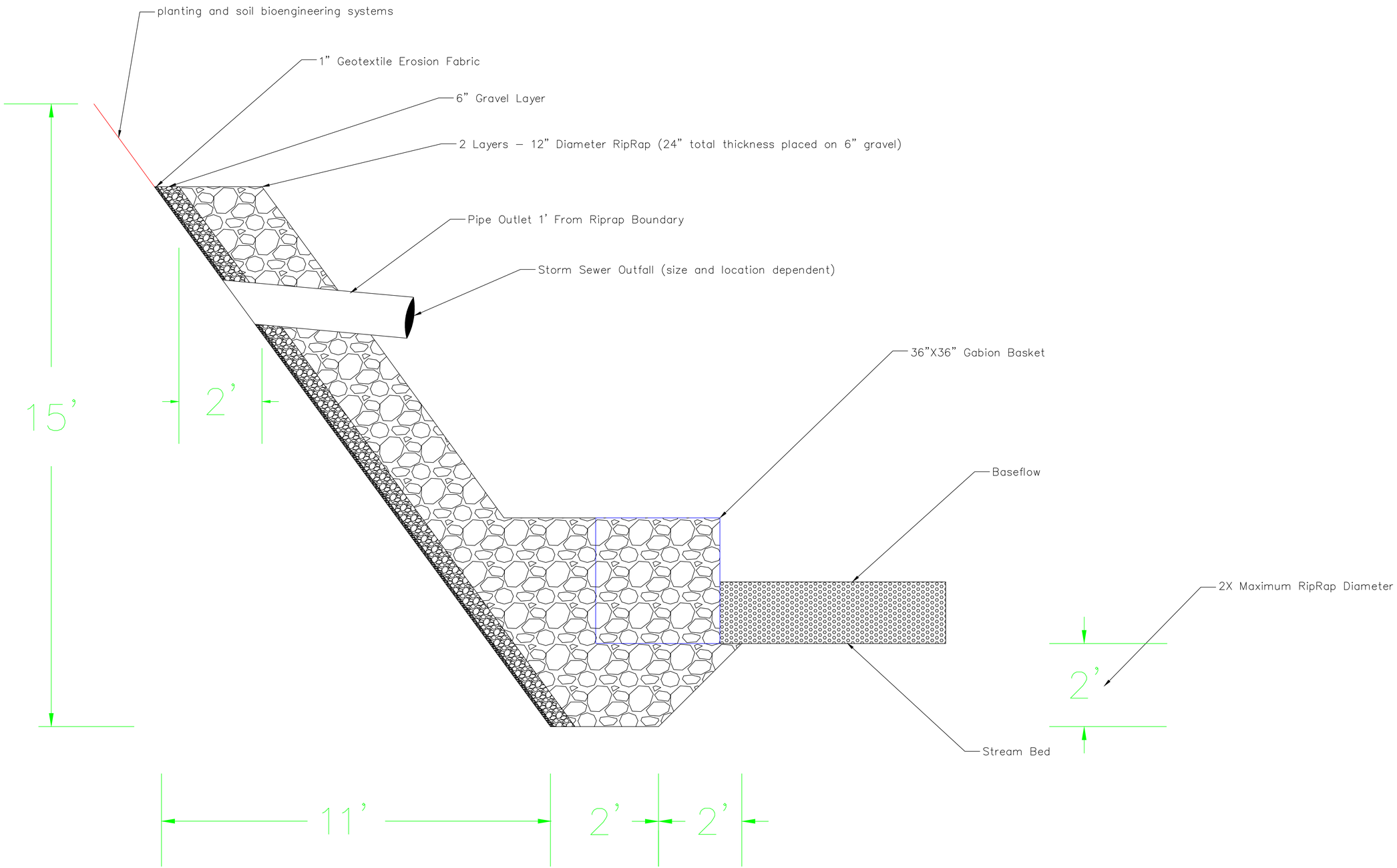

G.2 STORM OUTFALL DESIGN

General Notes

No.	Revision/Issue	Date

ā ENGINEERING, INC.
3100 SEAMANS CENTER

IOWA CITY, IA. 52242

CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA.

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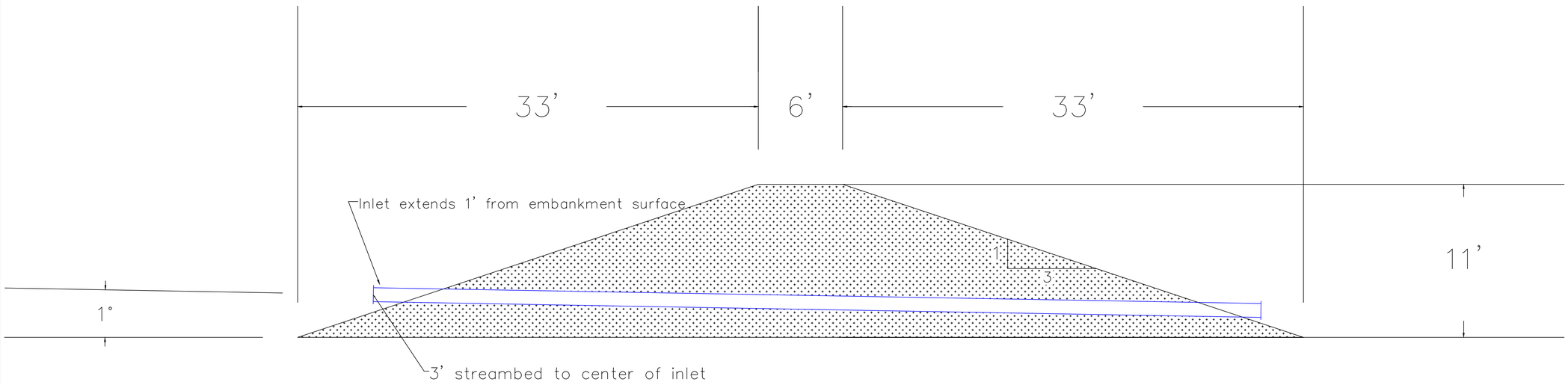

H.1 250TH ST. DETENTION BASIN CROSS SECTION

General Notes

No.	Revision/Issue	Date

å ENGINEERING, INC.
3100 SEAMANS CENTER
IOWA CITY, IA. 52242

CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA.
51102

5/1/15
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SEDIMENTATION FORBAY (INLET)
EMERGENCY SPILLWAY
OUTLET
EMBANKMENT
H.2
250TH ST. DETENTION BASIN
Revised Dates
No.
Revisions/Issues
Date
ENGINEERING, INC.
3100 SEAMANS CENTER
IOWA CITY, IA. 52242
CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA. 51102
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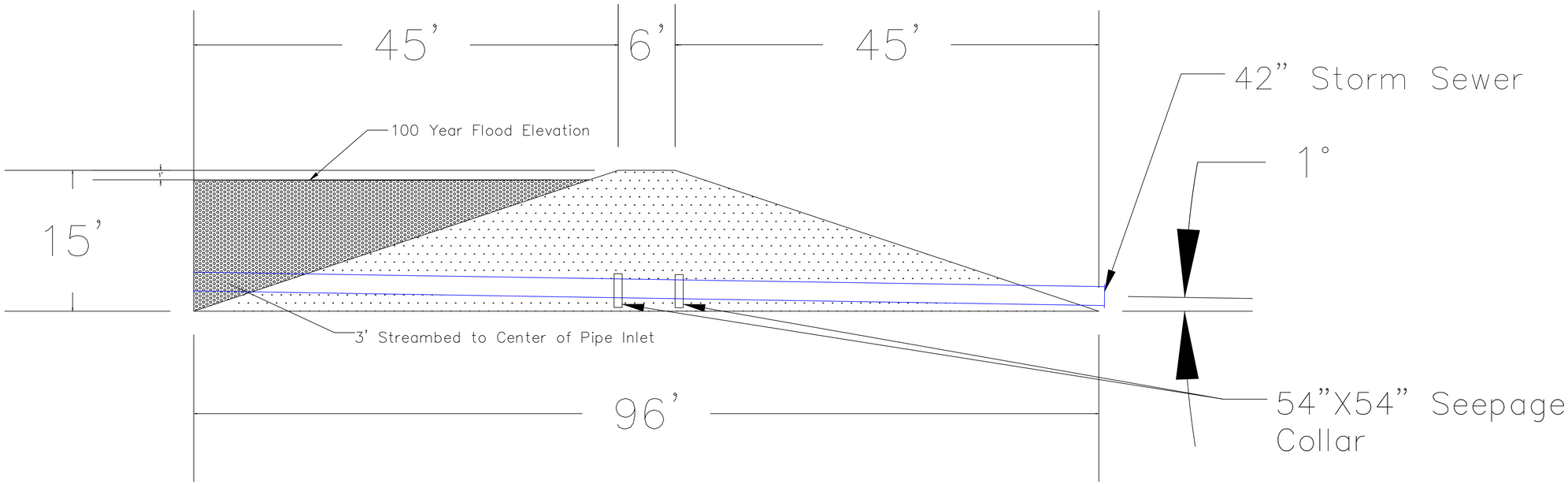

1.1 FOREST AVE DETENTION BASIN

General Notes

No.	Revision/Issue	Date

å ENGINEERING, INC.
3100 SEAMANS CENTER

IOWA CITY, IA. 52242

CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA.

51102

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SEDIMENTATION FORBAY (INLET)

OUTLET

EMERGENCY SPILLWAY

EMBANKMENT

1.2 FOREST AVE DETENTION BASIN

8 ENGINEERING, INC.
3100 SEAMANS CENTER
IOWA CITY, IA 52242

CITY OF SIOUX CITY
405 6TH STREET
SIOUX CITY, IA 51102

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Appendix J

Permits to be completed in order to implement design solution:

1. U.S. Army Corps of Engineers: Application for Department of the Army Permit
2. Iowa DNR NPDES: Notice of Discontinuation of a Storm Water Discharge
3. Iowa DNR: Flood Plain Permit for Low Head Dams
4. Iowa DNR NPDES: Notice of Intent

U.S. ARMY CORPS OF ENGINEERS

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT

33 CFR 325. The proponent agency is CECW-CO-R.

Form Approved - OMB No. 0710-0003 Expires: 30-SEPTEMBER-2015

Public reporting for this collection of information is estimated to average 11 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of the collection of information, including suggestions for reducing this burden, to Department of Defense, Washington Headquarters, Executive Services and Communications Directorate, Information Management Division and to the Office of Management and Budget, Paperwork Reduction Project (0710-0003). Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. Please DO NOT RETURN your form to either of those addresses. Completed applications must be submitted to the District Engineer having jurisdiction over the location of the proposed activity.

PRIVACY ACT STATEMENT

Authorities: Rivers and Harbors Act, Section 10, 33 USC 403; Clean Water Act, Section 404, 33 USC 1344; Marine Protection, Research, and Sanctuaries Act, Section 103, 33 USC 1413; Regulatory Programs of the Corps of Engineers; Final Rule 33 CFR 320-332. Principal Purpose: Information provided on this form will be used in evaluating the application for a permit. Routine Uses: This information may be shared with the Department of Justice and other federal, state, and local government agencies, and the public and may be made available as part of a public notice as required by Federal law. Submission of requested information is voluntary, however, if information is not provided the permit application cannot be evaluated nor can a permit be issued. One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and/or instructions) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

(ITEMS 1 THRU 4 TO BE FILLED BY THE CORPS)

1. APPLICATION NO.	2. FIELD OFFICE CODE	3. DATE RECEIVED	4. DATE APPLICATION COMPLETE

(ITEMS BELOW TO BE FILLED BY APPLICANT)

5. APPLICANT'S NAME	8. AUTHORIZED AGENT'S NAME AND TITLE (agent is not required)
First - Middle - Last -	First - Middle - Last -
Company -	Company -
E-mail Address -	E-mail Address -
6. APPLICANT'S ADDRESS:	9. AGENT'S ADDRESS:
Address-	Address-
City - State - Zip - Country -	City - State - Zip - Country -
7. APPLICANT'S PHONE NOs. w/AREA CODE	10. AGENTS PHONE NOs. w/AREA CODE
a. Residence b. Business c. Fax	a. Residence b. Business c. Fax

STATEMENT OF AUTHORIZATION

11. I hereby authorize, _____ to act in my behalf as my agent in the processing of this application and to furnish, upon request, supplemental information in support of this permit application.

_____ _____

SIGNATURE OF APPLICANT DATE

NAME, LOCATION, AND DESCRIPTION OF PROJECT OR ACTIVITY

12. PROJECT NAME OR TITLE (see instructions)

13. NAME OF WATERBODY, IF KNOWN (if applicable)	14. PROJECT STREET ADDRESS (if applicable)
	Address
15. LOCATION OF PROJECT Latitude: ◦N Longitude: ◦W	City - State- Zip-

16. OTHER LOCATION DESCRIPTIONS, IF KNOWN (see instructions)

State Tax Parcel ID Municipality

Section - Township - Range -

17. DIRECTIONS TO THE SITE

18. Nature of Activity (Description of project, include all features)

19. Project Purpose (Describe the reason or purpose of the project, see instructions)

USE BLOCKS 20-23 IF DREDGED AND/OR FILL MATERIAL IS TO BE DISCHARGED

20. Reason(s) for Discharge

21. Type(s) of Material Being Discharged and the Amount of Each Type in Cubic Yards:

Type Amount in Cubic Yards	Type Amount in Cubic Yards	Type Amount in Cubic Yards

22. Surface Area in Acres of Wetlands or Other Waters Filled (see instructions)

Acres

or

Linear Feet

23. Description of Avoidance, Minimization, and Compensation (see instructions)

24. Is Any Portion of the Work Already Complete? ☐ Yes ☐ No IF YES, DESCRIBE THE COMPLETED WORK

25. Addresses of Adjoining Property Owners, Lessees, Etc., Whose Property Adjoins the Waterbody (if more than can be entered here, please attach a supplemental list).

a. Address-

City - State - Zip -

b. Address-

City - State - Zip -

c. Address-

City - State - Zip -

d. Address-

City - State - Zip -

e. Address-

City - State - Zip -

26. List of Other Certificates or Approvals/Denials received from other Federal, State, or Local Agencies for Work Described in This Application.

AGENCY	TYPE APPROVAL*	IDENTIFICATION NUMBER	DATE APPLIED	DATE APPROVED	DATE DENIED

* Would include but is not restricted to zoning, building, and flood plain permits

27. Application is hereby made for permit or permits to authorize the work described in this application. I certify that this information in this application is complete and accurate. I further certify that I possess the authority to undertake the work described herein or am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT DATE SIGNATURE OF AGENT DATE

The Application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in block 11 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up any trick, scheme, or disguises a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statements or entry, shall be fined not more than $10,000 or imprisoned not more than five years or both.

NOTICE OF DISCONTINUATION

OF A STORM WATER DISCHARGE COVERED UNDER IOWA NPDES GENERAL PERMIT NO. 2 FOR CONSTRUCTION ACTIVITIES

Name of the owner or facility to which the storm water discharge general permit coverage was issued.

_____

List the complete permit authorization number for the discharge. This number is provided on the bottom of the authorization sheet for General Permit No. 2.

IA - _____---_____

List the date the construction site reached final stabilization.

_____

The following certification signed in accordance with the signatory requirements of the general permit: (see back side)

I certify under penalty of law that disturbed soils at the identified facility have been finally stabilized and temporary erosion and sediment control measures have been removed or will be removed at an appropriate time. I understand that by submitting this Notice of Discontinuation, that I am no longer authorized to discharge storm water associated with industrial activity for construction activities by Iowa Department of Natural Resources NPDES General Permit No. 2, and that discharging pollutants from storm water associated with industrial activity to waters of the United States is unlawful under the Clean Water Act where the discharge is not authorized by a NPDES permit.

I further certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

_____Name (print) _____Title

_____Signature _____Date

Return to:

Storm Water Coordinator
Department of Natural Resources
502 E. 9th Street
Des Moines, IA 50319-0034

Print Form

Iowa Department of Natural Resources
Flood Plain Management Program

FPID# _____

Applying for a Flood Plain Permit
Low Head Dams

To obtain a DNR Flood Plain Permit for your project, you must submit to this Department two copies of the application, the following checklist and the supporting documentation itemized on this checklist. **Applications submitted without this information will be considered incomplete and will not be reviewed.**

- ☐ Completed DNR form 542-1016 - "Determining If a Flood Plain Permit is Required – Low Head Dams".
- ☐ Completed and signed DNR Form 36, *Joint Application Form – Protecting Iowa Waters*.
- ☐ Completed document- "Gaining Approval for Low Head Dams" - attached
- ☐ Two sets of engineering plans for the project. Please note that the plans must be prepared and certified by a professional engineer licensed in the State of Iowa.
- ☐ Summary of hydrologic and hydraulic design information. Include the hydraulic modeling as appropriate.
- ☐ Summary of Engineering Data Worksheet.
- ☐ Names and mailing addresses of the immediate upstream, downstream and adjacent property owners and tenants, if applicable.

Reviewer's Notes:

Gaining Approval for
Low Head Dams

Date: _____
Completed By: _____

1. Application: Completed and signed Joint Application Form Submitted? ☐ Yes ☐ No

Please indicate if the project site is within the incorporated limits of a city by using the word 'in' when listing the city in Item 7 of the application. The application can be found online at the following link. http://floodplain.iowadnr.gov/

A copy of the application and supporting documentation must be sent to:

- Iowa DNR, Flood Plain Permit Program
- Iowa DNR, Sovereign Lands (Submit with the copy for the Flood Plain Management Program)
- U.S. Army Corps of Engineers (Submit to the address listed in the instructions)

Applicant Name:					
Location (in Quarter-Section-Tier-Range format) :	Qtr.	Sec.	T N	R	
County:		Stream(s):			

2. Engineering Plans: Two sets of certified plans submitted? ☐ Yes ☐ No

At minimum the plans must include the following information.

- ☐ Cover page showing general vicinity map with indicated project location and description of location in Section, Township and Range. IDOT maps available at: http://www.iowadotmaps.com/msp/index.html. Location map (topographic maps available at: *http://ortho.gis.iastate.edu/).*
- ☐ A site plan showing the proposed structure, work limits, the stream, property lines and ownership, the borrow site (if on the flood plain), roads, buildings and any other pertinent physical features.
- ☐ Elevation reference datum: _____ (NGVD29, NAVD88, other – explain). Provide Benchmark reference description.
- ☐ To-scale site weir situation plan showing the proposed low head dam/weir. Show elevation contour lines of existing natural ground and natural channel, and proposed contours. Extend contours to beyond improvements to show surrounding area contours, show riprap, the location of property lines, roads, houses, buildings, other pertinent physical features, and north arrow.
- ☐ Longitudinal profile of the weir structure and natural channel, showing slopes, elevations and distances.
- ☐ Cross section of the weir showing v-notch, width of weir at base and width at top of weir.
- ☐ Cross section and plan view through the weir structure, showing v-notch, upstream and downstream weir slope and large rock placement for fish navigation. Show stilling basin, and label pertinent cross section stations.
- ☐ Cross section detail views of the structure at referenced stations showing channel bank stabilization sections, grouted riprap, rock-filled cutoff trenches, and natural ground.
- ☐ At least one stream valley cross-section taken perpendicular to the direction of flow through the project area representing typical conditions. The structure, obstruction or deposit should be depicted on the cross-section. Provide elevation data beyond impact of project i.e. extend cross section beyond project boundaries where natural ground will be undisturbed. Additional cross sections may be required depending on the lineal extent of the project and whether there are natural or artificial control sections on the flood plain. Include the survey in tabular form in a distance/elevation table.

Note: A pre-application consultation with the Iowa DNR can be scheduled where, among other

items, the number and location of the required stream valley cross sections can be determined.

☐ A stream slope based on a minimum of two survey shots taken on the water surface at least 500-feet apart.

☐ Two sets of Construction specifications, when applicable.

3. Hydrology and Hydraulics:

☐ Weir Flow Calculations worksheet where the 100 year flood frequency stage is greater than the flow at bankfull stage. Include justifications for Mannings values used, show rating curve that includes top of bank elevation. Please note that if the top of bank elevations for each side of the channel cross section are not the same, the lesser elevation should be used for the rating curve flow.

Does the community have a detailed Flood Insurance Study (FIS)? ☐ Yes ☐ No (*If "Yes" continue with Section **3.a**. If "No", Skip to Section **3.b**, for the situation where No Detailed FIS exists for the Stream)*

a. Detailed FIS Exists for This Stream

Does study include detailed information (floodway and 100 yr. flood) information for this stream?

☐ Yes ☐ No *(If "No", Skip to Section **3.b**, for the situation where no detailed FIS exists for the stream).*

If the proposed project is located within the floodway as delineated in the FIS, it will be necessary to provide hydraulic modeling showing that the project will not cause a rise (0.00 feet) in the 100-year flood elevation. To that end, you will have to follow the steps below for hydraulic modeling.

Was original hydraulic model obtained from FEMA library? (*For instructions on how to order study data from the FEMA Library, see http://www.fema.gov/plan/prevent/fhm/st_order.shtm)*

☐ Yes ☐ No

If "No", Explain: _

If "No", what is source of information? _

When analyzing the effects of a project where a detailed Flood Insurance Study (FIS) exists, the following series of hydraulic models should normally be performed in the specified order to create a "base" condition. Please check that these runs were done in the order listed:

Step #1) ☐ Original hydraulic model as received from FEMA.

Step #2) ☐ Original hydraulic model with corrections made.

Step #3) ☐ Corrected model with additional cross-section(s) located at the project site.

Step #4) ☐ Model from Step #3 with the project included.

The model resulting from Step #3 will be the "base" condition and will be used to determine the effects of the project on flood stages (e.g., backwater). *(Note: The hydraulic models specified above are the minimum needed to analyze the effects of the project on flood stages when a project is located within the delineated floodway. Additional modeling may be required.)*

NFIP " No-Rise Certification Criteria:

On a stream with a detailed FIS, FEMA requires that any structure, obstruction or deposit that is located within the delineated floodway must result in "no-rise" (i.e., 0.00 ft. increase) in the 100 year flood profile when compared to the "base condition" model (see modeling process previously outlined in Section 3.a.). A certification of "no-rise" must be included in with the application if the project is within the delineated floodway.

Have all of the referenced hydraulic models been submitted on disk or electronically?

☐ Yes ☐ No

After completion of the Above Section, Skip to Section 4, "Approval"

b. If No Detailed FIS Exists for This Stream

Hydrology: Design flood, e.g., 100-yr flood, other

Frequency_____Discharge _____

Source of discharge information (Check One):

- ☐ USGS Regional Equations Report 87-4732
- ☐ USGS Regional Equations Report 00-4233
- ☐ Corps Study
- ☐ WRC 17B analysis of Gage Data
- ☐ Nearby Flood Insurance Study
- ☐ Other (Explain) _____

Stream Slope: _____ ft. /ft. _____ ft. /mi.
Source (topo map, *survey, other): _____

**(Note: If a surveyed profile is used to determine stream slope, the profile should be of sufficient length (at least 500 feet) to represent the stream slope within the reach.)*

Method of Hydraulic Analysis (Check One):

☐ HEC-RAS/HEC2 (Disk with input/output included? ☐ Yes ☐ No)
☐ Iowa DOT Bridge Backwater (Disk with input/output included? ☐ Yes ☐ No)
☐ Other (list) _____
☐ Rating curve included? ☐ Yes ☐ No
☐ Backwater (surcharge) calculations included? ☐ Yes ☐ No

4. Approval:

General Requirements for Low Head Dam Structures

- ☐ Downstream weir slope is not to exceed a 15:1 ratio.
- ☐ The crest of the weir is to be "V" shaped, this shape is to extend the length of the downstream slope.
- ☐ The side elevation of the weir to center "V" elevation is not to exceed one foot.
- ☐ The weir crest elevation from the base of the "V" to the original stream bottom or to the top of the downstream rock-filled cutoff trench is not to exceed four feet.
- ☐ The downstream weir slope will be constructed with riprap. Grouted riprap will be permitted.
- ☐ Larger rock will be put to one side and placed on the slope surface. A minimum of nine (9) large rocks (greater than 2 feet in diameter) shall be randomly placed in the center 1/3 of the weir slope and fitted into the smaller rock and extend approximately half way above the adjoining rock.

As outlined in Iowa Administrative Code 567-72.3(3) and 72.3(5), low head dams must be designed to meet the following criteria.

72.3(3) *Low head dams.*

a. The location and design of a low head dam shall not adversely affect the fisheries or recreational use of the stream.

b. The pool created by a low head dam shall not adversely affect drainage on lands not owned or under easements by the applicant.

c. The structure shall be hydraulically designed to submerge before bankfull stage is reached in the stream channel in order that increased or premature overbank flooding does not occur. Where this IAC 7/2/08 Environmental Protection[567] Ch 72, p.5 cannot be reasonably accomplished in order for the structure to fulfill its intended purpose, the applicant shall demonstrate that any increased flooding will affect only lands owned or controlled by the applicant.

d. For projects which include significant appurtenant structures or works outside the stream channel, the combined effect of the total project shall not create more than 1 foot of backwater during floods which exceed the flow capacity of the channel, unless the proper lands, easements, or rights-of-way are obtained.

e. The structure shall be capable of withstanding the effects of normal and flood flows across its crest and against the abutments, and adjacent channel or bank areas shall be protected against erosion as needed.

72.3(5) *Encroachment on a confinement feeding operation structure.* A dam shall not be constructed or modified so that the ordinary high water of the lake, pond or reservoir created by the dam is closer than the following distances from a confinement feeding operation structure unless a secondary containment barrier according to 567—subrule 65.15(17) is in place. Measurement shall be from the closest point of the confinement feeding operation structure to the water edge of the lake, pond or reservoir for a pool level at the elevation of the crest of the emergency spillway or at the top of dam elevation should the dam not have an emergency spillway.

a. Minimum separation between a water source other than a major water source and a confinement feeding operation structure is 500 feet.

b. Minimum separation between a major water source and a confinement feeding operation structure is 1,000 feet or such distance that the structure is not located on land that would be inundated by Q100, whichever is greater. This rule is intended to implement Iowa Code sections 455B.262, 455B.264, 455B.270, 455B.275 and 455B.277.

The list of major water sources can be accessed in Tables 1 and 2 on page 116 of Chapter 65 Iowa Administrative Code, Animal Feeding Operations.
http://www.legis.state.ia.us/aspx/ACODocs/DOCS/4-8-2009.567.65.pdf

☐ Statement describing distance from the nearest animal feeding facility.
☐ Aerial Image depicting the site location and the nearest animal feeding facility location to scale.

Does the Project Satisfy All Criteria? ☐ Yes ☐ No

Summary of Engineering Data
Low Head Dams/Weirs

Applicant(s): _____

Location: Qtr _____ Sec _____ T _____ N R _____ County _____

Stream: _____

Drainage: _____ sq. mi.

Topography

Typical Width of Floodplain _____ Ft.

Typical Width of Stream _____ ft.

Stream Slope and Source: Reach ___ ft./ ft. _____ ft./ mi. Main-Channel Slope

_____ ft./ mi.

Elevation Data: (ft., _____) Local Datum - _____ ft.

Channel Bottom _____ ft.

Average Floodplain ___ ft. Record High

Water _____ ft.

Natural Channel Hydraulics

Bankfull Discharge: _____ cfs

Bankfull Elevation _____ ft.

Bankfull Velocity _____ ft./sec.

Low Head Dam Hydraulics

Dam Height _____ ft.

Downstream Slope _____ : 1

Standard Design ☐ Sheetpile ☐ riprap

Set D/H = _____ 0.7

Set D+ _____ h (worst case scenario)

Discharge (bankfull with weir, cfs) _____ cfs @ elevation _____ ft.

"HOW TO FILE A COMPLETE NOTICE OF INTENT"

For

NPDES General Permit No.1
for "Storm Water Discharge
Associated With Industrial Activity"

or

NPDES General Permit No.2
for " Storm Water Discharge
Associated with Industrial Activity
for Construction Activities"

or

NPDES General Permit No.3
for "Storm Water Discharge Associated with Industrial Activity for Asphalt Plants, Concrete Batch Plants, Rock Crushing Plants and Construction Sand and Gravel Facilities"

In accordance with the Clean Water Act, all industrial facilities that discharge storm water meeting the definition of storm water associated with industrial activity must apply for coverage under a National Pollutant Discharge Elimination System (NPDES) permit.

These instructions are provided to assist activities that need to notify the Iowa Department of Natural Resources (IDNR) of their storm water discharge to be covered under Iowa's NPDES General Permit No. 1, General Permit No. 2 or General Permit No. 3.

The instructions are the same for all general permits. When a discharger provides a complete Notice of Intent to the IDNR, its storm water discharges will be subject to the terms and conditions of the appropriate general permit unless notified by the IDNR.

A pollution prevention plan is required for all storm water permits. The plan must be completed before submittal of the Notice of Intent. The plan should be kept on-site at the facility or construction site that generates the storm water discharge. Do not send the pollution prevention plan with the Notice of Intent.

To file a complete Notice of Intent you must provide the following items:

1. The completed Form 542-1415 entitled *"Notice of Intent for NPDES Coverage Under General Permit"*,
2. Proof of Public notification from the newspaper in the area with the highest circulation and,
3. Permit fee.

Each of these items is discussed in detail below and on the back side of this page.

Mail the completed application form 542-1415 with the proof of public notice and permit fee to the following address. **DO NOT** send the Pollution Prevention Plan with your Notice of Intent. **DO NOT** send the application form, fee payment or proof of public notice separately. Send them all together.

Storm Water Coordinator
Department of Natural Resources
502 E. 9th Street
Des Moines, Iowa 50319-0034

1. Proof of Public Notification

Iowa law requires dischargers to make public notice for seeking coverage under a general permit. The public notice must be published at least one day at your own expense in the newspaper with the largest circulation in the area where the discharge is located.

The wording to use in the public notice is specified as a rule of the IDNR and is included as a separate page for your convenience. This wording contains the minimum information that must be provided in the public notice. You must complete the blank portions with the specified information. You may add more information to the notice if you wish.

To determine which newspapers have the largest circulation, ask your local newspaper or call the Iowa Newspaper Association (INA) at (515) 244-2145 for circulation information. The INA is located at 319 E. Fifth Street, Des Moines, Iowa 50309.

When your Notice of Intent is sent to the IDNR, you **MUST** enclose a clipping the public notice with the name of the newspaper and date published, or an affidavit from the newspaper with the clippings attached to demonstrate your public notification requirement. If the proof of public notice is not included with your application, the storm water permit authorization will **NOT** be issued.

2. Form 542-1415

In filling out the form, type or print legibly and complete both sides of the form.

Permit Information and Fee Options

Give permit information on the general permit for which you are applying and select a fee option.

Facility or Project Information

Enter the official or legal name of the facility or site. Enter the complete street address. If no street address exists, provide a geographic description (e.g., Intersection of 5th Street and 2nd Avenue or, at a minimum, the name of the street or road nearest the site), city, county, state and zip code. Do not use a P.O. box number. This is the address of the facility or construction site not the address of the owner or contact.

For General Permits No. 1 and No. 3, provide a four-digit SIC code that best represents the principal products or activities provided by the facility.

Contact Information

Provide the legal name of a contact person, firm, public organization or any other entity that owns or operates the facility or site. The name of the operator or contact may or may not be the same as the name of the facility. The operator is the legal entity that controls the facility's operation. Provide a mailing address (P.O. box numbers may be used). Include the city, state, zip code and telephone number for a contact person. All correspondence relating to the storm water permit, including the storm water permit authorization, will be sent to this address.

Facility Location or Location of Construction Site

Give the location by ¼ section (e.g., NW), section number, township number (e.g., T78N) and range number (e.g., R4W). The location information can be obtained from United States Geological Survey topographic maps, by calling 1-(888) ASK-USGS.

Owner Information

Enter the name, mailing address and telephone number of the owner of the facility.

Outfall Information

Provide an estimated start date the discharge did or is to commence, the name(s) of the receiving water(s), and check compliance conditions. All applicable compliance conditions listed must be met for the Notice of Intent to be considered complete.

The discharge start date is the date storm water discharge from industrial activity or construction activity (from a construction site that disturbs one acre or more or is part of a larger common plan of development that disturbs one acre or more) began or will begin to leave the property. If the discharge start date is before 10/1/92, the correct date to place in the blank is 10/1/92. This is the date the State of Iowa implemented the storm water permit requirements.

If an industrial facility was not initially required to obtain a storm water permit but changed operations so that later a storm water permit was or will be required, the discharge start date is the date that the change was made that necessitated the need for a storm water permit.

Provide the name(s) of the receiving water(s) to the first uniquely named river. Explain to where the storm water runoff will drain (e.g., unnamed waterway to road ditch to unnamed tributary to Mud Creek to Skunk River).

Compliance conditions

Check the compliance conditions that apply. A pollution prevention plan is required for all storm water permits. For General Permit No. 3 (if no soil disturbing activities will take place) and General Permit No. 1, the question regarding state or local sediment and erosion control plans does not apply. If you check no to any of the applicable compliance conditions, your application will not be approved.

General Permits No. 2 and No. 3

For construction sites that need a storm water discharge permit, in addition to the information required above, include a brief description of the project, estimated timetable for major activities and an estimate of the number of acres of the site on which soil will be disturbed.

For General Permit No. 3, identify if the facility is a portable plant.

Certification

The completed form must be signed by a qualified official. A qualified official is any of the following: owner, principal executive officer of at least the level of vice-president, general partner, general contractor (for construction sites), principal executive officer or ranking elected official (for publicly owned facilities).

The Notice of Intent will be returned and no permit issued if information on the form is incomplete.

3. Fees

There is a permit fee for each general permit. The fee schedule is the same for General Permit No. 1, No. 2 and No. 3.

The applicant has the option of paying an annual permit fee or a multi-year permit fee.

annual permit fee	$175
3-year permit fee	$350
4-year permit fee	$525
5-year permit fee	$700

IMPORTANT - The storm water permit authorization will not be issued unless the proof of public notice and permit fee accompany the completed Notice of Intent.

If you need assistance contact the IDNR at (515) 281-6782 or (515) 281-7017.

IOWA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

IDNR CASHIER'S USE ONLY
0253-542-SW08-0581

NOTICE OF INTENT FOR NPDES COVERAGE UNDER GENERAL PERMIT

No. 1 FOR "STORM WATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY"

or

No. 2 FOR "STORM WATER DISCHARGES ASSOCIATED WITH INDUSTRIAL ACTIVITY FOR CONSTRUCTION ACTIVITIES"

or

No. 3 FOR "STORM WATER DISCHARGE ASSOCIATED WITH INDUSTRIAL ACTIVITY FOR ASPHALT PLANTS, CONCRETE BATCH PLANTS, ROCK CRUSHING PLANTS, AND CONSTRUCTION SAND AND GRAVEL FACILITIES."

PERMIT INFORMATION

Has this storm water discharge been previously permitted? ☐ Yes ☐ No

If yes, please list authorization number _____

Under what General Permit are you applying for coverage?

General Permit No. 1 ☐ General Permit No. 2 ☐ General Permit No. 3 ☐

PERMIT FEE OPTIONS

For coverage under the NPDES General Permit the following fees apply:

- ☐ Annual Permit Fee $175 (per year) Maximum coverage is one year.
- ☐ 3-year Permit Fee $350 Maximum coverage is three years.
- ☐ 4-year Permit Fee $525 Maximum coverage is four years.
- ☐ 5-year Permit Fee $700 Maximum coverage is five years.

Checks should be made payable to: Iowa Department of Natural Resources.

FACILITY OR PROJECT INFORMATION

Enter the name and full address/location (not mailing address) of the facility or project for which permit coverage is requested.

NAME:		STREET ADDRESS OF SITE:	
CITY:	COUNTY:	STATE:	ZIP CODE:

CONTACT INFORMATION Give name, mailing address and telephone number of a contact person (Attach additional information on separate pages as needed). This will be the address to which all correspondence will be sent and to which all questions regarding your application and compliance with the permit will be directed.

NAME:		ADDRESS:	
CITY:	STATE:	ZIP CODE:	TELEPHONE ( )
Check the appropriate box to indicate the legal status of the operator of the facility. ☐ Federal ☐ State ☐ Public ☐ Private ☐ Other (specify) _____			

SIC CODE (General Permit No. 1 & 3 Applicants Only) ☐

SIC code refers to Standard Industrial Classification code number used to classify establishments by type of economic activity.

Be sure to complete both sides of this form.

542-1415 (Rev. 7/08)

FACILITY LOCATION OR LOCATION OF CONSTRUCTION SITE

Give the location by ¼ section, section, township, range, (e.g., NW, 7, T78N, R3W).

1/4 SECTION	SECTION	TOWNSHIP	RANGE

MAIL TO:

STORM WATER COORDINATOR
IOWA DEPARTMENT OF
NATURAL RESOURCES
502 E. 9TH STREET
DES MOINES, IA 50319-0034

OWNER INFORMATION Enter the name and full address of the owner of the facility.

NAME:		ADDRESS:	
CITY:	STATE:	ZIP CODE:	TELEPHONE: ( )

OUTFALL INFORMATION

Discharge start date, i.e., when did/will the site begin operation or 10/1/92, whichever is later: _____

Is any storm water monitoring information available describing the concentration of pollutants in storm water discharges? ☐ Yes ☐ No

NOTE: Do not attach any storm water monitoring information with the application.

Receiving water(s) to the first uniquely named waterway in Iowa, (e.g., road ditch to unnamed tributary to Mud Creek to South Skunk River):

Compliance With The Following Conditions:

	Yes	No
Has the Storm Water Pollution Prevention Plan been developed prior to the submittal of this Notice of Intent and does the plan meet the requirements of the applicable General Permit? (do not submit the SWPPP with the application)		
Will the Storm Water Pollution Prevention Plan comply with approved State (Section 161A.64, Code of Iowa) or local sediment and erosion plans? (for General Permit 2 only)		
Has one public notice been published for at least one day, in the newspaper with the largest circulation in the area where the discharge is located, and is the proof of notice attached? (new applications only)		

GENERAL PERMIT NO. 2 AND GENERAL PERMIT NO. 3 APPLICANTS COMPLETE THIS SECTION.

Description of Project (describe in one sentence what is being constructed):

For General Permit No. 3 - Is this facility to be moved this year? ☐ Yes ☐ No

Number of Acres of Disturbed Soil: _____ (Construction Activities Only)

Estimated Timetable For Activities / Projects, i.e., approximately when did/will the project begin and end:

CERTIFICATION – ALL APPLICATIONS MUST BE SIGNED

Only the following individuals may sign the certification: owner of site, principal executive officer of at least the level of vice-president of the company owning the site, a general partner of the company owning the site, principal executive officer or ranking elected official of the public entity owning the site, any of the above of the general contracting company for construction sites.

I certify under penalty of law that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified people properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, this information is to the best of my knowledge and belief, true, accurate, and complete. I further certify that the terms and conditions of the general permit will be met. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

NAME: (print or type)	TITLE:
SIGNATURE:	DATE:

Instructions - To complete the public notice, fill in the blanks with the required information or select the appropriate response and send to the newspapers.

The public notice must be published at least one day each in the newspaper with the highest circulation in the area of the discharge at your own expense.

PUBLIC NOTICE OF STORM WATER DISCHARGE

_____ plans to submit a Notice of Intent to the
(*applicant name*)

Iowa Department of Natural Resources to be covered under the NPDES General Permit

_____
(select the appropriate general permit - No. 1 "Storm Water Discharge Associated with Industrial Activity", General Permit No. 2 "Storm Water Discharge Associated with Industrial Activity for Construction Activities, or General Permit No. 3 "Storm Water Discharge Associated With Industrial Activity From Asphalt Plants, Concrete Batch Plants, Rock Crushing Plants, And Construction Sand And Gravel Facilities")

The storm water discharge will be from _____
(description of industrial activity)

located in _____
(1/4 section, section, township, range, county)

Storm water will be discharged from _____ point source(s) and will be discharged to
(number)

the following streams: _____
(stream name(s))

Comments may be submitted to the Storm Water Discharge Coordinator, Iowa Department of Natural Resources, Environmental Protection Division, 502 E. 9th Street, Des Moines, IA 50319-0034. The public may review the Notice of Intent from 8 a.m. to 4:30 p.m., Monday through Friday, at the above address after it has been received by the department.

CHAPTER 466B

SURFACE WATER PROTECTION, FLOOD MITIGATION, AND WATERSHED MANAGEMENT

Referred to in §461.34

SUBCHAPTER I

SURFACE WATER PROTECTION AND FLOOD MITIGATION

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466B.2 Definitions.
466B.3 Water resources coordinating council.
466B.4 Legislative findings and marketing campaign.
466B.5 Regional watershed assessment, planning, and prioritization.
466B.6 Community-based subwatershed improvement plans.
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WATERSHED MANAGEMENT AUTHORITIES

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466B.22 Watershed management authorities created.
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SUBCHAPTER III

WATERSHED PLANNING ACTIVITIES

466B.31 Watershed planning advisory council.
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WATER QUALITY INITIATIVE — NUTRIENTS

466B.41 Definitions.
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466B.46 Reserved.
466B.47 Iowa nutrient research center — establishment and purpose.
466B.48 Iowa nutrient research center advisory council — establishment and purpose.
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SUBCHAPTER I

SURFACE WATER PROTECTION AND FLOOD MITIGATION

466B.1 Short title.

This chapter shall be known and may be cited as the *"Surface Water Protection and Flood Mitigation Act"*.

2008 Acts, ch 1034, §1; 2009 Acts, ch 146, §7

466B.2 Definitions.

For the purposes of **this chapter**, unless the context otherwise requires:

1. *"Council"* means the water resources coordinating council created in **section 466B.3**.
2. *"Department"* means the department of natural resources.
3. *"Political subdivision"* means a city, county, or soil and water conservation district.
4. *"Regional watershed"* means a watershed of hydrologic unit code scale 8.
5. *"Subwatershed"* means a watershed of hydrologic unit code scale 12 or smaller.
6. *"Watershed"* means a geographic area in which surface water is drained by rivers, streams, or other bodies of water.

2008 Acts, ch 1034, §2; 2013 Acts, ch 132, §57

466B.3 Water resources coordinating council.

1. *Council established.* A water resources coordinating council is established within the department of agriculture and land stewardship.

2. *Purpose.* The purpose of the council shall be to preserve and protect Iowa's water resources, and to coordinate the management of those resources in a sustainable and fiscally responsible manner. In the pursuit of this purpose, the council shall use an integrated approach to water resource management, recognizing that insufficiencies exist in current approaches and practices, as well as in funding sources and the utilization of funds. The integrated approach used by the council shall attempt to overcome old categories, labels, and obstacles with the primary goal of managing the state's water resources comprehensively rather than compartmentally.

3. *Accountability.* The success of the council's efforts shall ultimately be measured by the following outcomes:

a. Whether the citizens of Iowa can more easily organize local watershed projects.

b. Whether the citizens of Iowa can more easily access available funds and water quality program resources.

c. Whether the funds, programs, and regulatory efforts coordinated by the council eventually result in a long-term improvement to the quality of surface water in Iowa.

d. Whether the potential for flood damage in each watershed in the state has been reduced.

4. *Membership.* The council shall consist of the following members:

a. The director of the department of natural resources or the director's designee.

b. The director of the soil conservation division of the department of agriculture and land stewardship or the director's designee.

c. The director of the department of public health or the director's designee.

d. The director of the department of homeland security and emergency management or the director's designee.

e. The dean of the college of agriculture and life sciences at Iowa state university or the dean's designee.

f. The dean of the college of public health at the university of Iowa or the dean's designee.

g. The dean of the college of natural sciences at the university of northern Iowa or the dean's designee.

h. The director of the department of transportation or the director's designee.

i. The director of the economic development authority or the director's designee.

j. The executive director of the Iowa finance authority or the executive director's designee.

k. The secretary of agriculture, who shall be the chairperson, or the secretary's designee. As the chairperson, and in order to further the coordination efforts of the council, the secretary may invite representatives from any other public agency, private organization, business, citizen group, or nonprofit entity to give public input at council meetings, provided the entity has an interest in the coordinated management of land resources, soil conservation, flood mitigation, or water quality. The secretary shall also invite and solicit advice from the following:

(1) The director of the Iowa water science center of the United States geological survey or the director's designee.

(2) The state conservationist from the Iowa office of the United States department of agriculture's natural resources conservation service or the state conservationist's designee.

(3) The executive director for Iowa from the United States department of agriculture's farm services agency or the executive director's designee.

(4) The state director for Iowa from the United States department of agriculture's office of rural development or the state director's designee.

(5) The director of region seven of the United States environmental protection agency or the director's designee.

(6) The corps commander from the United States army corps of engineers' Rock Island district or the commander's designee.

l. The dean of the college of engineering at the university of Iowa or the dean's designee.

5. *Meetings and quorum.*

a. The council shall be convened by the secretary of agriculture at least quarterly.

b. A majority of the members fixed by statute shall constitute a quorum, and any action taken by the council must be adopted by a majority of the voting membership.

6. *Duties and powers.*

a. The council shall engage in the regular coordination of water resource-related functions, including protection strategies, planning, assessment, prioritization, review, concurrence, advocacy, and education.

b. In coordinating water resource-related functions, the council may do all of the following:

(1) Consider the steps necessary to address the planning, management, and implementation of water resource improvement.

(2) Identify ways to facilitate communication and participation among all water resource stakeholders, including owners of land in Iowa whether they are residents or not.

(3) Identify inefficiencies in current programs and recommend ways to eliminate duplicative services.

(4) Improve the availability and management of water resource information.

(5) Provide incentives for, and recognition of, environmental excellence.

(6) Regularly assess and identify measurable improvements in water quality.

(7) Oversee the complete, statewide regional watershed assessment, prioritization, and planning process described in **section 466B.5**, including a short-term interim program and a long-term comprehensive state water quality and quantity plan updated every five years as provided in **sections 466B.5** and **466B.6**.

(8) Develop a protocol which identifies high-priority watersheds, including local and community-based subwatersheds, and which appropriately directs resources to those watersheds.

(9) Review best available technologies on a regular basis, so that investments of time and program resources can be prioritized and directed to projects that will best and most effectively improve water quality and reduce flood damage within regional and community subwatersheds.

(10) Review voluntary, performance-based standards for water resource management, land management, and soil conservation.

(11) Develop a protocol for assigning multiagency teams to regional watersheds and local subwatersheds and guide those teams in the coordination of citizen and agency activities within those watersheds.

(12) Engage in dialogue with, and pursue efforts to make cooperative agreements with, other states when a watershed extends beyond borders of this state.

(13) Enter into agreements and make contracts with third parties for the performance of duties imposed by **this chapter**.

(14) Prepare a memorandum of understanding identifying the roles and responsibilities of council members in the coordination of the implementation of community-based subwatershed improvement plans. The memorandum shall be a commitment by the agencies participating in council meetings to reach consensus regarding communications with subwatershed planning units.

c. The council shall develop recommendations for policies and funding promoting a watershed management approach to reduce the adverse impact of future flooding on this state's residents, businesses, communities, and soil and water quality. The council shall consider policies and funding options for various strategies to reduce the impact of flooding including but not limited to additional floodplain regulation; wetland protection, restoration, and construction; the promulgation and implementation of statewide storm water management standards; conservation easements and other land management; perennial ground cover and other agricultural conservation practices; pervious pavement, bioswales, and other urban conservation practices; and permanent or temporary water retention structures. In developing recommendations, the council shall consult with hydrological and land use experts, representatives of cities, counties, drainage and levee districts, agricultural interests, and soil and water conservation districts, and other urban and regional planning experts.

2008 Acts, ch 1034, §3; 2009 Acts, ch 41, §139; 2009 Acts, ch 146, §8 – 12; 2010 Acts, ch 1061, §62; 2011 Acts, ch 118, §85, 89; 2011 Acts, ch 119, §1 – 5; 2012 Acts, ch 1021, §86; 2012 Acts, ch 1023, §65; 2013 Acts, ch 29, §58

Referred to in **§28N.3**, **§466B.2**

466B.4 Legislative findings and marketing campaign.

1. *Findings.* The general assembly finds all of the following:

a. Most Iowans desire to have improved water quality throughout the state, but many Iowans do not understand the problems with local water quality.

b. Most Iowans believe that the protection of fish and wildlife benefits all Iowans.

c. The benefits of improving water quality could far outweigh the costs of implementing mechanisms to improve it.

d. Most Iowans look to some level of government for the protection of water resources rather than to themselves and their own actions. However, it is not possible or desirable for state government to take complete control and responsibility for water quality.

e. In addition to the use of Iowa land for agriculture and economic development, the land in watersheds and floodplains should be managed to reduce flooding, reduce flood damage, ameliorate the effects of drought, improve water quality, improve habitat and the natural environment, increase renewable energy production, and enhance recreational opportunities.

2. *Marketing campaign.* The water resources coordinating council shall develop a marketing campaign to educate Iowans about the need to take personal responsibility for the quality and quantity of water in their local watersheds. The emphasis of the campaign shall be that not only is everyone responsible for clean water, but that everyone benefits from it as well, and that everyone is responsible for and benefits from reducing the risk for flooding and mitigating possible future flood damage. The goals of the campaign shall be to convince Iowans to take personal responsibility for clean water and reducing the risk of flooding and to equip them with the tools necessary to effect change through local water quality improvement projects and better flood plain management and flood risk programs.

3. *Contingent on funding.* The duties imposed in **subsection 2** are contingent upon the receipt of funding sufficient to cover the costs associated with the marketing campaign.

2008 Acts, ch 1034, §4; 2009 Acts, ch 146, §13; 2010 Acts, ch 1193, §127

466B.5 Regional watershed assessment, planning, and prioritization.

1. *Regional watershed assessment program.* The department of natural resources shall create a regional watershed assessment program. The program shall assess all the regional watersheds in the state.

a. The statewide assessment shall be conducted at the rate of approximately one-fifth of the watersheds per year, and an initial full assessment shall be completed within five years. Thereafter, the department of natural resources shall review and update the assessments on a regular basis.

b. Each regional watershed assessment shall provide a summary of the overall condition of the watershed. The information provided in the summary may include land use patterns, soil types, slopes, management practices, stream conditions, and both point and nonpoint source impairments.

c. In conducting a regional watershed assessment, the department of natural resources may provide opportunities for local data collection and input into the assessment process.

2. *Planning and prioritization.* In conducting the regional watershed assessment program, the department of natural resources shall provide hydrological and geological information sufficient for the water resources coordinating council to prioritize watersheds statewide and for the various communities in those watersheds to plan remedial efforts in their local communities and subwatersheds.

3. *Report to council.* Upon completion of the statewide assessment, and upon updating the assessments, the department of natural resources shall report the results of the assessment to the council and the general assembly, and shall make the report publicly available.

2008 Acts, ch 1034, §5; 2011 Acts, ch 119, §6

Referred to in **§466B.3**, **§466B.9**

466B.6 Community-based subwatershed improvement plans.

1. *Facilitation of community-based subwatershed plans.* After the department of natural resources' completion of the initial regional watershed assessment, and after the council's

prioritization of the regional watersheds, the council shall designate one or more of the agencies represented on the council to facilitate the development and implementation of local, community-based subwatershed improvement plans.

2. *Assessment, planning, prioritization, and implementation.* In facilitating the development of community-based subwatershed improvement plans, the agency or agencies designated by the council shall, based on the results of the regional watershed assessment program, identify critical subwatersheds within priority regional watersheds and recruit communities, citizen groups, local governmental entities, or other stakeholders to engage in the assessment, planning, prioritization, and implementation of a local community-based subwatershed improvement plan. The agency or agencies designated by the council may assist in the formation of a group of initial local community-based subwatershed improvement plans that can be implemented as pilot projects, in order to develop an effective process that can be replicated across the state.

2008 Acts, ch 1034, §6; 2011 Acts, ch 119, §7
Referred to in §466B.3

466B.7 Community-based subwatershed monitoring.

1. *Monitoring assistance.* After completion of the statewide regional watershed assessment and prioritization, and throughout the implementation of local community-based subwatershed improvement plans, the department of natural resources shall assist communities with the monitoring and measurement of local subwatersheds. The monitoring and measurement shall be designed for the particular needs of individual communities.

2. *Data collection and use.* Local communities in which the department of natural resources conducts subwatershed monitoring shall use the information to support subwatershed planning activities, do local data collection, and identify priority areas needing additional resources. Local communities shall also collect data over time and use the data to evaluate the impacts of their management efforts.

2008 Acts, ch 1034, §7; 2011 Acts, ch 119, §8

466B.8 Wastewater and storm water infrastructure assessment.

The department of natural resources shall assess and prioritize communities within a watershed presenting the greatest level of risk to water quality and the health of residents. This prioritization shall include both sewered and unsewered communities.

2008 Acts, ch 1034, §8; 2011 Acts, ch 119, §9

466B.9 Rulemaking authority.

The department of natural resources and the department of agriculture and land stewardship shall have the power and authority reasonably necessary to carry out the duties imposed by **this chapter**. As to the department of natural resources, this includes rulemaking authority to carry out the regional watershed assessment program described in **section 466B.5**. As to the department of agriculture and land stewardship, this includes rulemaking authority to assist in the implementation of community-based subwatershed improvement plans.

2008 Acts, ch 1034, §9; 2011 Acts, ch 119, §10

466B.10 Floodplain managers.

The council shall encourage and support the formation of a chapter of the association of state floodplain managers in Iowa that would provide a vehicle for local floodplain managers and floodplain planners to further pursue professional educational opportunities.

2010 Acts, ch 1193, §128

466B.11 Flood education.

The Iowa state university agricultural extension service, the council, and agency members of the council shall, to the extent feasible, work with floodplain and hydrology experts to educate the general public about floodplains, flood risks, and basic floodplain management

principles. This educational effort shall include developing educational materials and programs in consultation with floodplain experts.

2010 Acts, ch 1193, §129

466B.12 through 466B.20 Reserved.

SUBCHAPTER II

WATERSHED MANAGEMENT AUTHORITIES

466B.21 Definitions.

As used in **this subchapter**, unless the context otherwise requires:

1. *"Authority"* means a watershed management authority created pursuant to a **chapter 28E** agreement as provided in **this subchapter**.
2. *"Board"* means a board of directors of a watershed management authority.

2010 Acts, ch 1116, §3; 2013 Acts, ch 132, §58

466B.22 Watershed management authorities created.

1. Two or more political subdivisions may create, by **chapter 28E** agreement, a watershed management authority pursuant to **this subchapter**. The participating political subdivisions must be located in the same United States geological survey hydrologic unit code 8 watershed. All political subdivisions within a watershed must be notified within thirty days prior to organization of any watershed management authority within the watershed, and provided the opportunity to participate.
2. The **chapter 28E** agreement shall include a map showing the area and boundaries of the authority.
3. A political subdivision may participate in more than one authority created pursuant to **this subchapter**.
4. A political subdivision is not required to participate in a watershed management authority or be a party to a **chapter 28E** agreement under **this subchapter**.

2010 Acts, ch 1116, §4

466B.23 Duties.

A watershed management authority may perform all of the following duties:

1. Assess the flood risks in the watershed.
2. Assess the water quality in the watershed.
3. Assess options for reducing flood risk and improving water quality in the watershed.
4. Monitor federal flood risk planning and activities.
5. Educate residents of the watershed area regarding water quality and flood risks.
6. Allocate moneys made available to the authority for purposes of water quality and flood mitigation.
7. Make and enter into contracts and agreements and execute all instruments necessary or incidental to the performance of the duties of the authority. A watershed management authority shall not acquire property by eminent domain.

2010 Acts, ch 1116, §5

466B.24 Board of directors.

1. An authority shall be governed by a board of directors. Members of a board of directors of an authority shall be divided among the political subdivisions comprising the authority and shall be appointed by the respective political subdivision's elected legislative body.
2. A board of directors shall consist of one representative of each participating political subdivision. **This subsection** shall not apply if a **chapter 28E** agreement under **this subchapter** provides an alternative board composition method.
3. The directors shall serve staggered terms of four years. The initial board shall determine, by lot, the initial terms to be shortened and lengthened, as necessary, to achieve

staggered terms. A person appointed to fill a vacancy shall be appointed in the same manner as the original appointment for the duration of the unexpired term. A director is eligible for reappointment. **This subsection** shall not apply if a **chapter 28E** agreement under **this subchapter** provides an alternative for the length of term, appointment, and reappointment of directors.

4. A board may provide procedures for the removal of a director who fails to attend three consecutive regular meetings of the board. If a director is so removed, a successor shall be appointed for the duration of the unexpired term of the removed director in the same manner as the original appointment. The appointing body may at any time remove a director appointed by it for misfeasance, nonfeasance, or malfeasance in office.

5. A board shall adopt bylaws and shall elect one director as chairperson and one director as vice chairperson, each for a term of two years, and shall appoint a secretary who need not be a director.

6. A majority of the membership of a board of directors shall constitute a quorum for the purpose of holding a meeting of the board. The affirmative vote of a majority of a quorum shall be necessary for any action taken by an authority unless the authority's bylaws specify those particular actions of the authority requiring a greater number of affirmative votes. A vacancy in the membership of the board shall not impair the rights of a quorum to exercise all the rights and perform all the duties of the authority.

2010 Acts, ch 1116, §6

466B.25 Activities coordination.

In all activities of a watershed management authority, the authority may coordinate its activities with the department of natural resources, the department of agriculture and land stewardship, councils of governments, public drinking water utilities, and soil and water conservation districts.

2010 Acts, ch 1116, §7

466B.26 through 466B.30 Reserved.

SUBCHAPTER III

WATERSHED PLANNING ACTIVITIES

466B.31 Watershed planning advisory council.

1. A watershed planning advisory council is established for purposes of assembling a diverse group of stakeholders to review research and make recommendations to various state entities regarding methods to protect water resources in the state, assure an adequate supply of water, mitigate and prevent floods, and coordinate the management of those resources in a sustainable, fiscally responsible, and environmentally responsible manner. The advisory council may seek input from councils of governments or other organizations in the development of its recommendations. The advisory council shall meet once a year and at other times as deemed necessary to meet the requirements of **this section**. The advisory council may appoint a task force to assist the advisory council in completing its duties.

2. The watershed planning advisory council shall consist of all of the following members:

a. The voting members of the advisory council shall include all of the following:

(1) One member selected by the Iowa association of municipal utilities.
(2) One member selected by the Iowa league of cities.
(3) One member selected by the Iowa association of business and industry.
(4) One member selected by the Iowa water pollution control association.
(5) One member selected by the Iowa rural water association.
(6) One member selected by growing green communities.
(7) One member selected by the Iowa environmental council.
(8) One member selected by the Iowa farm bureau federation.
(9) One member selected by the Iowa corn growers association.

(10) One member selected by the Iowa soybean association.
(11) One member selected by the Iowa pork producers council.
(12) One member selected by the soil and water conservation districts of Iowa.
(13) One person representing the department of agriculture and land stewardship selected by the secretary of agriculture.
(14) One person representing the department of natural resources selected by the director.
(15) Two members selected by the Iowa conservation alliance.
(16) One member selected by the Iowa drainage district association.
(17) One member selected by the agribusiness association of Iowa.
(18) One member selected by the Iowa floodplain and stormwater management association.
(19) One member selected by Iowa rivers revival.

b. The nonvoting members of the advisory council shall include all of the following:

(1) Two members of the senate. One senator shall be appointed by the majority leader of the senate and one senator shall be appointed by the minority leader of the senate.

(2) Two members of the house of representatives. One member shall be appointed by the speaker of the house of representatives and one member shall be appointed by the minority leader of the house of representatives.

3. By December 1 of each year, the watershed planning advisory council shall submit a report to the governor, the general assembly, the department of agriculture and land stewardship, the department of natural resources, and the water resources coordinating council. The report shall include recommendations regarding all of the following:

a. Improving water quality and optimizing the costs of voluntarily achieving and maintaining water quality standards.

b. Creating economic incentives for voluntary nonpoint source load reductions, point source discharge reductions beyond those required by the federal Water Pollution Control Act, implementation of pollution prevention programs, wetland restoration and creation, and the development of emerging pollution control technologies.

c. Facilitating the implementation of total maximum daily loads, urban storm water control programs, and nonpoint source management practices required or authorized under the federal Water Pollution Control Act. This paragraph shall not be construed to obviate the requirement to develop a total maximum daily load for waters that do not meet water quality standards as required by section 303(d) of the federal Water Pollution Control Act or to delay implementation of a total maximum daily load that has been approved by the department and the director.

d. Providing incentives, methods, and practices for the development of new and more accurate and reliable pollution control quantification protocols and procedures, including but not limited to development of policy based on information and data that is publicly available and that can be verified and evaluated.

e. Providing greater flexibility for broader public involvement through community-based, nonregulatory, and performance-driven watershed management planning.

f. Assigning responsibility for monitoring flood risk, flood mitigation, and coordination with federal agencies.

g. Involving cities, counties, and other local and regional public and private entities in watershed improvement including but not limited to incentives for participation in a watershed management authority created under **this chapter**.

4. Each year, the voting members of the advisory council shall designate one voting member as chairperson.

2010 Acts, ch 1116, §1; 2011 Acts, ch 131, §98, 158

466B.32 Watershed demonstration pilot projects.

The department of natural resources and the department of agriculture and land stewardship, in collaboration with the United States department of agriculture's natural resources conservation service and the Iowa flood center established pursuant to **section 466C.1**, and in cooperation with the council, shall seek funding to plan, implement, and monitor one or more watershed demonstration pilot projects for urban and rural areas

involving a twelve-digit hydrologic unit code subwatershed as defined by the United States geological survey. The pilot projects shall include features that seek to do all of the following:

1. Maximize soil water holding capacity from precipitation.
2. Minimize severe scour erosion and sand deposition during floods.
3. Manage water runoff in uplands under saturated soil moisture conditions.
4. Reduce and mitigate structural and nonstructural flood damage.

2010 Acts, ch 1116, §2

466B.33 through 466B.40 Reserved.

SUBCHAPTER IV

WATER QUALITY INITIATIVE — NUTRIENTS

466B.41 Definitions.

As used in this subchapter, unless the context otherwise requires:

1. *"Center"* means the Iowa nutrient research center established pursuant to **section 466B.47**.
2. *"Council"* means the Iowa nutrient research center advisory council established pursuant to **section 466B.48**.
3. *"Division"* means the division of soil conservation within the department of agriculture and land stewardship as established in **section 161A.4**.
4. *"Fund"* means the water quality initiative fund created in **section 466B.45**.
5. *"Nutrient"* includes nitrogen and phosphorus.

2013 Acts, ch 132, §59

466B.42 Water quality initiative.

The division shall establish a water quality initiative in order to assess and reduce nutrients in this state's watersheds, including subwatersheds, and regional watersheds. The division shall establish and administer projects to reduce nutrients in surface waters from nonpoint sources in a scientific, reasonable, and cost-effective manner. The division shall utilize a pragmatic, strategic, and coordinated approach with the goal of accomplishing reductions over time.

2013 Acts, ch 132, §60

466B.43 and 466B.44 Reserved.

466B.45 Water quality initiative fund.

1. A water quality initiative fund is created in the state treasury under the management and control of the division.
2. The fund shall include moneys appropriated by the general assembly. The fund may include other moneys available to and obtained or accepted by the division, including moneys from public or private sources.
3. Moneys in the fund are appropriated to the division and shall be used exclusively to carry out the provisions of this subchapter as determined by the division, and shall not require further special authorization by the general assembly.
4. *a.* Notwithstanding **section 12C.7**, interest or earnings on moneys in the fund shall be credited to the fund.

b. Notwithstanding **section 8.33**, moneys appropriated or otherwise credited to the fund for a fiscal year shall not revert to the fund from which appropriated at the close of the fiscal year for which the appropriation was made but shall remain available for expenditure for the purposes designated until the close of the fiscal year that begins three years from the beginning date of the fiscal year for which the appropriation was made.

2013 Acts, ch 132, §61

Referred to in **§466B.41**

466B.46 Reserved.

466B.47 Iowa nutrient research center — establishment and purpose.

1. The state board of regents shall establish and maintain in Ames as part of Iowa state university of science and technology an Iowa nutrient research center.

2. The purpose of the center shall be to pursue a science-based approach to nutrient management research that may include but is not limited to evaluating the performance of current and emerging nutrient management practices, and using an adaptive management framework for providing recommendations for the implementation of nutrient management practices and the development of new nutrient management practices.

3. The center shall be administered by a director who shall be appointed by the dean of the college of agriculture and life sciences of Iowa state university of science and technology.

4. The center shall facilitate collaboration among appropriate institutions of higher education governed by the state board of regents, including but not limited to institutes, departments, and centers.

5. Any information collected or received by the center that identifies a person holding a legal interest in agricultural land or specific agricultural land shall be a confidential record under **section 22.7**.

2013 Acts, ch 132, §62
Referred to in **§466B.41**, **§466B.48**

466B.48 Iowa nutrient research center advisory council — establishment and purpose.

1. The state board of regents shall establish and maintain in Ames as part of Iowa state university of science and technology an Iowa nutrient research center advisory council.

2. The council shall consist of the following members:

a. The dean of the college of agriculture and life sciences of Iowa state university of science and technology, or the dean's designee.

b. The director of the Iowa state university of science and technology extension service, or the director's designee.

c. A representative of the IIHR — hydroscience and engineering within the college of engineering of the university of Iowa who shall be appointed by the president of the university.

d. A person knowledgeable in an area related to nutrient research who shall be appointed by the president of the university of northern Iowa.

e. A person knowledgeable in an area related to nutrient research who shall be appointed by the state association of private colleges and universities.

f. The secretary of agriculture or the secretary's designee.

g. The administrative director of the soil conservation division of the department of agriculture and land stewardship as provided in **chapter 161A**, or the administrative director's designee.

h. The director of the department of natural resources, or the director's designee.

3. *a.* An appointed or designated member of the council shall serve at the pleasure of the person making the appointment or designation.

b. A majority of the members of the council as provided in **subsection 2** constitutes a quorum. Any action taken by the council must be adopted by the affirmative vote of a majority of its members present, except that a lesser number may adjourn a meeting. The majority shall not include any member who has a conflict of interest and a statement by a member of a conflict of interest shall be conclusive for this purpose.

c. The council shall elect a chairperson and any other officers from the membership of the council as the council determines necessary. An officer shall serve for a term required by rules adopted by the council. A vacancy in the membership does not impair the right of a quorum to exercise all rights and perform all duties of the council.

d. The council shall adopt rules that it determines are necessary for the conduct of business.

e. Only the member appointed by the state association of private colleges and universities is eligible for reimbursement of actual expenses as provided in **section 7E.6**. However, no member is eligible for a payment of a per diem.

4. The council shall function on a continuing basis for the study and recommendation of solutions for consideration by the Iowa nutrient research center in carrying out its purpose as provided in **section 466B.47**.

2013 Acts, ch 132, §63
Referred to in **§466B.41**

466B.49 Confidentiality.

Any information received, collected, or held under **this subchapter** is a confidential record, and is exempted from public access as provided in **section 22.7**, if all of the following apply:

1. The information is received, collected, or held by a nonprofit organization that conducts nutrient management research, including but not limited to conducting evaluations, assessments, or validations.

2. The information identifies any of the following:

a. A person who holds a legal interest in agricultural land or who has previously held a legal interest in agricultural land.

b. A person who is involved or who has previously been involved in managing the agricultural land or producing crops or livestock on the agricultural land.

c. The identifiable location of the agricultural land.

2014 Acts, ch 1139, §28, 29
NEW section

Appendix L: Final Cost Analysis

Table L.1: Cost estimate for Phase 1

S. Ridge Rd. Basin				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
Land	Ea	1.00	$100,000.00	$100,000.00
Mobilization, 5%	Ea	1.00	$80,000.00	$80,000.00
Site Preparation				
Clearing and Grubbing	Acre	15.00	$3,800.00	$57,000.00
Tree Removal	Acre	18.00	$4,900.00	$88,200.00
Site Development				
Sedimentation Forebay	Ea	1.00	$50,000.00	$50,000.00
Riprap, Embankment	CY	3,387.00	$63.00	$213,381.00
Conduit, 84" Diameter	LF	210.00	$550.00	$115,500.00
Landscape	Acre	15.00	$3,000.00	$45,000.00
Levee	CY	713.00	$21.00	$14,973.00
Sheet Pile	SF	7,245.00	$34.50	$249,952.50
Embankment	CY	28,700.00	$21.00	$602,700.00
Anti-Seepage Collar	Ea	1.00	$500.00	$500.00
Subtotal				**$1,617,206.50**
Contingency, 10%				$161,720.65
Other Costs, 15% (Engineering Costs, permitting, etc)				$242,580.98
Total Cost				**$2,021,508.13**

Table L.2: Cost estimate for Phase 2- West of Deerfield Ave grade control structure

West of Deerfield Ave				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	134.35	$100.00	$13,435.00
Grade Control Structure Riprap	CY	32.83	$63.00	$2,068.29
Geotextile Fabric, 105 mm Thick Non-woven	SY	69.93	$2.50	$174.83
Sheet Pile, 20' deep extraction	SF	700.35	$34.50	$24,162.08
Creek Bank Riprap	CY	310.8	$63.00	$19,580.40
Soil Excavation, Excavator, 1 C.Y. cap=100 C.Y./hr	BCY	644.91	$2.48	$1,599.38
Gravel,6" Layer	SF	4200	$0.43	$1,806.00
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	466.2	$117.98	$55,002.28
Contingency				$11,782.82
Total Cost				**$129,611.07**

Table L.3: Cost estimate for Phase 2- West of Buckwalter grade control structure

West of Buckwalter Drive				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	134.35	$100.00	$13,435.00
Grade Control Structure Riprap	CY	32.83	$63.00	$2,068.29
Geotextile Fabric, 105 mm Thick Non-woven	SY	76.59	$2.50	$191.48
Sheet Pile, 20' deep extraction	SF	700.35	$34.50	$24,162.08
Creek Bank Riprap	CY	512.08	$63.00	$32,261.04
Soil Excavation, Excavator, 1 C.Y. cap=100 C.Y./hr	BCY	1047.47	$2.48	$2,597.73
Gravel,6" Layer	SF	6920	$0.43	$2,975.60
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	768.12	$117.98	$90,622.80
Contingency				$16,831.40
Total Cost				**$185,145.40**

Table L.4 Cost estimate for Phase 2- Kings Hwy Bridge grade control structure

Kings Hwy Bridge				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	268.70	$100.00	$26,870.00
Grade Control Structure Riprap	CY	177.05	$63.00	$11,154.15
Geotextile Fabric, 105 mm Thick Non-woven	SY	73.26	$2.50	$183.15
Sheet Pile, 20' deep extraction	SF	767.05	$34.50	$26,463.23
Creek Bank Riprap	CY	322.84	$63.00	$20,338.92
Soil Excavation, Excavator, 1 C.Y. cap=100 C.Y./hr	BCY	670.81	$2.48	$1,663.61
Gravel,6" Layer	SF	4360	$0.43	$1,874.80
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	483.96	$117.98	$57,097.60
Contingency				$14,564.55
Total Cost				**$160,210.00**

Table L.5: Cost estimate for Phase 2- Pedestrian Bridge grade control structure

Pedestrian Bridge (4209 Hamilton Blvd)				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	268.70	$100.00	$26,870.00
Grade Control Structure Riprap	CY	86.91	$63.00	$5,475.33
Geotextile Fabric, 105 mm Thick Non-woven	SY	69.93	$2.50	$174.83
Sheet Pile, 20' deep extraction	SF	733.7	$34.50	$25,312.65
Creek Bank Riprap	CY	455.84	$63.00	$28,717.92
Soil Excavation, Excavator, 1 C.Y. cap=100 C.Y./hr	BCY	936.1	$2.48	$2,321.53
Gravel,6" Layer	SF	6160	$0.43	$2,648.80
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	683.76	$117.98	$80,670.00
Contingency				$17,219.11
Total Cost				**$189,410.16**

Table L.6: Cost estimate for Phase 2- 38th Street Bridge grade control structure

38th Street Bridge				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	134.35	$100.00	$13,435.00
Grade Control Structure Riprap	CY	32.83	$63.00	$2,068.29
Geotextile Fabric, 105 mm Thick Non-woven	SY	75.69	$2.50	$189.23
Sheet Pile, 20' deep extraction	SF	700.35	$34.50	$24,162.08
Creek Bank Riprap	CY	370	$63.00	$23,310.00
Soil Excavation, Excavtor, 1 C.Y. cap=100 C.Y./hr	BCY	763.31	$2.48	$1,893.01
Gravel,6" Layer	SF	5000	$0.43	$2,150.00
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	555	$117.98	$65,478.90
Contingency				$13,268.65
Total Cost				**$145,955.15**

Table L.7 Cost estimate for Phase 2- Hamilton Blvd. Bridge grade control structure

Hamilton Blvd. Bridge				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	268.70	$100.00	$26,870.00
Grade Control Structure Riprap	CY	177.05	$63.00	$11,154.15
Geotextile Fabric, 105 mm Thick Non-woven	SY	75.69	$2.50	$189.23
Sheet Pile, 20' deep extraction	SF	767.05	$34.50	$26,463.23
Creek Bank Riprap	CY	312.58	$63.00	$19,692.54
Soil Excavation, Excavator, 1 C.Y. cap=100 C.Y./hr	BCY	650.68	$2.48	$1,613.69
Gravel,6" Layer	SF	4224	$0.43	$1,816.32
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	468.86	$117.98	$55,316.10
Contingency				$14,311.52
Total Cost				**$157,426.77**

Table L.8: Cost estimate for Phase 2- Dearborn Ave. Bridge grade control structure

Dearborn Ave. Bridge				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
3' Diameter Boulders	TON	268.70	$100.00	$26,870.00
Grade Control Structure Riprap	CY	177.05	$63.00	$11,154.15
Geotextile Fabric, 105 mm Thick Non-woven	SY	75.69	$2.50	$189.23
Sheet Pile, 20' deep extraction	SF	767.05	$34.50	$26,463.23
Creek Bank Riprap	CY	361.12	$63.00	$22,750.56
Soil Excavation, Excavtor, 1 C.Y. cap=100 C.Y./hr	BCY	747.77	$2.48	$1,854.47
Gravel,6" Layer	SF	4880	$0.43	$2,098.40
Gabion Baskets, 36" deep, galvanized steel mesh boxes	SY	541.68	$117.98	$63,907.41
Contingency				$15,528.74
Total Cost				**$170,816.18**

Table L.9: Cost estimate for Phase 4

Forest Rd. Dry Detention Basin				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
Land	Ea	1.00	$60,000.00	$60,000.00
Mobilization, 5%	Ea	1.00	$32,000.00	$32,000.00
Site Preparation				
Clearing and Grubbing	Acre	34.00	$3,800.00	$129,200.00
Tree Removal	Acre	9.00	$4,900.00	$44,100.00
Site Development				
Sedimentation Forebay	Ea	1.00	$50,000.00	$50,000.00
Riprap, Embankment	CY	2,960.00	$63.00	$186,480.00
Orifice, 42" Diameter	LF	96.00	$107.00	$10,272.00
Landscape	Acre	5.00	$3,000.00	$15,000.00
Embankment	CY	5,100.00	$21.00	$107,100.00
Anti-Seepage Collar	Ea	1.00	$500.00	$500.00
Subtotal				**$634,652.00**
Contingency, 10%				$63,465.20
Other Costs, 15% (Engineering Costs, permitting, etc)				$95,197.80
Total Cost				**$793,315.00**

Table L.10: Cost estimate for Phase 5

250th St. Dry Detention Basin				
Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**
Land	Ea	1.00	$75,000.00	$75,000.00
Mobilization, 5%	Ea	1.00	$20,000.00	$20,000.00
Site Preparation				
Clearing and Grubbing	Acre	27.00	$3,800.00	$102,600.00
Tree Removal	Acre	0.50	$4,900.00	$2,450.00
Site Development				
Sedimentation Forebay	Ea	1.00	$50,000.00	$50,000.00
Riprap, Embankment	CY	1,125.00	$63.00	$70,875.00
Conduit, 60" Diameter	LF	74.00	$215.00	$15,910.00
Landscape	Acre	5.00	$3,000.00	$15,000.00
Embankment	CY	1,200.00	$21.00	$25,200.00
Anti-Seepage Collar	Ea	1.00	$500.00	$500.00
Subtotal				**$377,535.00**
Contingency, 10%				$37,753.50
Other Costs, 15% (Engineering Costs, permitting, etc)				$56,630.25
Total Cost				**$471,918.75**