VAN ALLEN DESIGN GROUP

Preliminary Regional Water Detention Plan and Environmental Assessment

For the City of Muscatine, IA

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5/2/2014

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Executive Summary

Van Allen Design Group, in conjunction with the University of Iowa's College of Engineering, provides a preliminary regional water detention plan for the undeveloped northeastern corridor of the City of Muscatine, IA. Existing conditions are largely forested areas and farmland, with plans to develop the plots into a mix of residential and commercial purposes. The detention plan is to maintain or improve conditions in and around Mad Creek, meet regulatory obligations for environmental and health concerns, and mitigate flooding in the area.

Several criteria were considered when selecting the locations and designing the proposed structure. Alternative uses for the land, difficulty of construction, hydrological contours of the sub-basin, available area, and client requests were involved in the decision of what to pursue and where. The subdivisions are expected to maintain any basins within their boundaries, so ease and expense of maintenance was also considered.

Possible alternative designs were based off of acceptable practices as outlined by the Stormwater management manual of Iowa. These include dams, wetlands, dry detention, and wet detention. Due to the size limits for acceptable dry detention basins compared to the area to be managed, the dry detention alternative was ruled out early in the process. A dam structure was considered based on an Army Corps of Engineers study that outlined but did not recommend a dam in upper Mad Creek. Due to recently built infrastructure the dam alternative was also dismissed, with investigations into alternative sites falling outside the scope of the project.

Wet pond and wetland detention were given the most in depth consideration. The investigation focused on the proposed Pond #8 near the southern tip of the area. Pond #8 was designed in greater detail while giving a more general evaluation of the other proposed sites to limit the scope of the project. Because of local conditions such as a nearby sewer extension and space requirements a wet pond with a forebay is recommended over a wetland. The remaining locations were evaluated for preliminary design of a wet detention basin, though further investigation of the feasibility of wetland and dam structures is not ruled out.

A single stage riser was chosen for the outlet structure on the wet pond. Weir length and pipe size were selected based on comparable structures in other basins and evaluated. A design that produced a reasonable outflow and drainage time was chosen, allowing for additions such as a trash guard to improve performance.

1. Introduction

The City of Muscatine, IA, has requested a preliminary regional water detention plan in order to aid their development of newly acquired land. The area to be protected is located to the northeast of downtown Muscatine and is bounded in part by Highway 38, Interstate 61, and 180th street. The planned development type is a mix of commercial and residential. This area was incorporated on the grounds that future expansion of the city is expected to occur into the area over the next several years. The City of Muscatine has coordinated with the University of Iowa's College of Engineering, placing the project as part of the Senior Design course. Van Allen Design Group has been selected to design the preliminary stage of the requested regional detention plan.

2. Problem Statement

2.1. Design Objectives

In the past the city has experienced both flooding from the Mississippi River and flash flooding from Mad Creek. The city has upgraded much of its downtown flood protection and mitigation, so current concerns are over mitigating flash flooding water quality and quantity impacts from future development of the Mad Creek area north of the city. A preliminary regional detention plan is to be designed to mitigate the flooding of properties south of 180th street. Potential sites are identified, with Pond 8 designed in detail to provide an example of possible future construction.

2.2. Approaches

2.2.1. Design Guidelines

Guidelines will be taken from the Iowa Department of Natural Resources (IDNR) Stormwater Manual, primarily sections 2G and 2H. Technical Bulletin No. 16 will also be used to build any dam structures.

2.2.2. Permits

A Section 401 (wetlands permitting) and Section 404 (Clean Water Act) permit will be required for navigable waters such as Mad Creek. A NPDES General Permit No. 2 is needed for the full project, with the potential for the IDNR to require an Individual Permit for construction of a specific drainage basin.

Dams, such as the earthen embankments that are part of wet detention ponds or wetlands, that hold back more than a specified volume or exceed a specified height require a Flood Plain Development Permit. Those constructed above sovereign state waters such as the Mississippi River require a Sovereign Lands permit.

2.3. Constraints

2.3.1. Hard Constraints

Design Guides: Parameter limits are listed in the IDNR Stormwater Manual and Technical Bulletin No. 16.

Permits: Permits required by the Clean Water Act, Section 401 and 404, as well as General Permit No. 2, are required before construction starts. Earthen embankments associated with wet detention ponds or wetlands, as well as the dam alternative designs, may require a Flood Plain Development Permit. All construction would potentially require a Sovereign Lands permit as Mad Creek connects to the Mississippi River.

Time: The design shall be completed and submitted no later than May 7th, 2014.

Environmental Considerations: Peak discharges of the 100-year and 2-year return storms are used as baselines for mitigation. The discovery of any endangered species in the area will necessitate a review of the proposal and a mitigation of any potential harm.

Safety: Any detention of water runs the risk of failure of the retaining structure, endangerment of the public and to infrastructure. The dam alternative would be classified as high hazard and require construction to the probable maximum flood. Depending on surrounding construction and terrain, earthen embankments for the wet detention and watershed alternatives would be likely classified as moderate hazards due to being associated with a public waterway and private development.

2.3.2. Soft Constraints

Costs: Costs of design, construction, and maintenance should be reasonable and economical.

Space: The design should intrude as little as possible on potential development and recreational areas. Undesirable land, such as flood plains and ravines, should be given precedence.

Aesthetics: The proposed designs should integrate with the existing landscape to provide additional aesthetic benefits to the community in addition to flood mitigation. Contours should be irregular to appear more natural.

Environmental Considerations: Mosquitos and other midges are a likely consequence of wetlands. Thermal impacts on the downstream should be mitigated. Wetlands can release nutrients in cold months.

Societal Impacts: Minimize foreseeable impediments to continued development. Input from residents and the city should be included to increase the acceptability of the detention plan.

2.4. Challenges

The drainage area for Mad Creek is significant. Depending on other currently installed detention practices and space constraints detention practices ranging from wet ponds to dams may be needed to adequately mitigate flooding both now and under future development scenarios. In addition, the bedrock is closer to the surface in several locations, potentially limiting excavation. The area is currently not well developed, possibly making access to the sites problematic. Private ownership of the land also poses potential problems for both siting and construction. A new sewer extension running along Mad Creek up to the Clearview Mobile Home Park may impede siting or feasible design options. An associated proposal of a Highway 38-Interstate 61 connector road in the same area may also pose restrictions on feasible designs. As there are no rain gauges with significant records within the design area, a synthetic storm is used to estimate runoff.

2.5. Societal Impacts

Historically Mad Creek has had problems with excessive agricultural runoff, resulting in overall poor health for the creek. Proper detention practices such as those proposed within this report should result in an improvement of water quality, partially cleaning much of the runoff before it enters the creek and reducing the velocity and peak quantity of water during storm events. Improved water quality and reduced flooding will improve environmental quality for residents and allow increased recreational opportunities. The proposed wet detention basins can attract wildlife such as waterfowl and provide habitat for plants and animals to improve green spaces in and around the new developments.

The addition of detention structures allows for better protection against the historical flash flooding of the creek. This can attract home owners and businesses to nearby areas and potentially improve property values. Further improvement in water quality and quantity coming from the area can also benefit the recent levee and channel improvements in the downtown area by reducing stress and sediment buildup.

3. Selection Process

3.1. Overall Alternatives

The Mad Creek watershed was analyzed as a whole, but the proposal responding to the RFP was more focused roughly one mile north of 180th St. to the corner of U.S. 61 and highway 38. This focused watershed was delineated into smaller sub-basins, as summarized in Table 3-1. All together there are six sub-basins south of 108th St. and one sub-basin north of 180th St, these sub-basins can be seen in Section 5. In the watershed basins of Mad creek, the contours all show depression into the creek. The direct runoff from the area therefore does not all flow in the same direction or pool into a big area. The majority of the runoff runs into the main channel of the creek or smaller links off of the main channel.

Table 3-1: Summary Table of Detention Ponds and Contributing Drainage Areas

Detention Pond	Drainage Area (acres)
1	92.5
2	92.5
3	106.8
4	81.5
5	133.5
6	106.8
7	63.5
8	155.2
9	249.6

3.1.1. Hydrologic Analysis

After the sub-basins were delineated, hydrologic analysis was necessary to design detention facilities. First, TR-55 Urban Hydrology for Small Watersheds software was utilized to calculate the runoff for the watershed. Several issues occurred during the trial of the simulation. Due to time constraints and lack of experience using the TR-55 software, no further analysis included TR-55. Further research would be needed and it is suggested for future studies to research and utilize TR-55 due to the resources and tools TR-55 possesses.

Because of the lack of rain gauges, the triangular unit hydrograph was utilized and suggested for the site; details can be seen in Section 5.1.

3.1.2. Wetlands

According to the US Army Corps of Engineers (USACE), wetlands are “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” Wetlands assist in flood mitigation and water quality enhancement as water runs through the comparatively dense plant cover. Plant growth allows for significant carbon storage. They provide habitat for a number of species year round including plants, waterfowl, amphibians, and fish. Wetlands can also serve as a public resource for aesthetic and recreational opportunities. Drainage of wetlands during previous development have greatly reduced the natural wetland cover of Iowa and other states, so preservation of existing wetlands and creation of new ones has been made a priority by the federal government and IDNR.

Based on the runoff calculation results and site situation, the detention facility location at Pond #7 would be the most feasible location for a wetland. A preliminary design for wetland size had been conducted. Details of the wetland design can be found in Appendix E, Table E-1. The calculation method was adapted from the Stormwater Management Manual Chapter 2H. Based on the site situation and the design criteria form the Manual, the most suitable wetland type would be an extended detention wetland. A schematic of the proposed wetland can be found in Appendix H, Figure H-1. An enlarged view of Pond #7 can be found in Appendix C, Figure C-5.

The location is a natural occurring wetland where two links of Mad Creek combine and flow south. The calculations in Appendix E show the necessary surface area needed for the wetlands alternative. It does not appear as though there are other locations that can provide suitable area for wetlands and maintain wetland conditions save for Pond #7. Further design would be necessary to determine if alternate proper locations are present.

The relatively new sewer extension to the Clearview Mobile Home Park also creates issues. Current manholes would be submerged and prevent maintenance on the sewer line. Wetlands are not recommended because the size constraint, limited suitable areas, and sewer extension issues.

3.1.3. Dam

The Dam alternative was acknowledged by the Army Corp of Engineers during flood mitigation design in 2002. The Army Corp did extensive research on potential risk and the benefit-cost analysis of a dam in the watershed south of 180th Street along with a second dam along Geneva creek to the west. They estimated the total cost of constructing the dams to be between 8 and 9.6 million dollars. The design of a dam is out of the scope of work for the preliminary designs for the regional detention plan. Further investigation is recommended for a dam in the locations along Mad Creek.

3.1.4. Detention Ponds

The design included the use of detention ponds to reduce the total direct runoff for the site. Two types of ponds were possible, a wet pond that has a permanent pool and a dry pond that only fills during storms. The watershed analyzed has multiple smaller basins and do not drain off into relatively large areas. Therefore, the design of one large detention pond is impractical and cannot properly reduce the runoff and pollution for the entire watershed. Multiple relatively smaller detention ponds were designed to control the direct runoff from the watershed.

3.1.4.1. Dry Detention Ponds

Dry detention and dry extended detention (ED) basins are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. These facilities temporarily detain stormwater runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events (IDNR). Since the dry pond drains completely, there is a size constraint on the drainage area.

The maximum contributing drainage area to be served by a single dry detention or dry ED basin is 75 acres (IDNR). This creates issues for the Mad Creek watershed because the smallest drainage area is 127 acres. Due to the extent of the watershed, the Dry Detention Pond alternative was not pursued or further designed for this project. Multiple storage ponds would be necessary for the smallest area. The largest area, 534 acres, would need roughly seven ponds to properly store and reduce the runoff. This excess of ponds is not considered economically feasible for this site.

3.1.4.2. Wet Detention Ponds

Stormwater ponds, also referred to as wet ponds, retention ponds, or wet extended duration [ED] ponds, are constructed stormwater retention basins that have a permanent pool of water throughout the year. They can be created by excavating an already existing natural depression, or through the construction of embankments (IDNR). Wet detention ponds can include both small and large ponds. Based on the watershed characteristics stated in subsection 3.1.1, smaller detention ponds were designed.

Because the elevations of the watershed and direct runoff calculations, nine detention ponds would be needed to properly detain all the runoff in the watershed, as seen in Section 5. Each of these ponds were designed according to the Iowa Stormwater Management Manual. The design meets all the requirements for the design project in a feasible manner. Contributing drainage area needs to be larger than 25 acres and is possible up to 300 acres depending on the type of areas drained. Sub-basins 1, 2, and 3 will require at least two ponds to achieve effective detention due to their size. The remaining sub-basins can be managed with only one detention structure.

The sewer extension mentioned in Section 2.4 creates issues with the alignment of the storage ponds because of the possibility of disturbing the underground pipe. With proper location the wet detention ponds can either route the water above the sewer or avoid the sewer all together.

Wet detention ponds built in accordance with the IDNR's specifications and properly maintained typically have a high rate of suspended solid and bacterial removal. Removal of nutrients, heavy metals, and other pollutants is also significant. They have a more compact structure than wetlands but remain able to effectively capture runoff from much larger areas than dry detention basins. These characteristics led to the wet detention pond being recommended for Pond #8, with greater detail given in Section 5.

3.1.5. Outlet Structures

Three potential outlet structure designs are available for this design; the single-stage weir, two-stage weir, and the single pipe outlet structure. The goal was to have outflow from the detention pond at the 25 year and 100 year return period. It was determined that the difference between these water level elevations was only 1.15 feet. The two-stage weir and the orifice and weir design were considered excessive.

The single stage weir is recommended because the single pipe outlet structure would only give outflow for the 100-year flood period. After deciding on the single-stage weir, a reasonable rectangular weir length was chosen. From this the bottom on the weir at the 25-year return period and the top of the weir at the elevation of the 100-year return period were determined. All the calculations for the outlet structure can be seen in Appendix H.

4. Environmental Assessment of Proposed Alternatives

The exploration and evaluation of alternative solutions is required by NEPA, including the No Action alternative for comparison. The No Action alternative and the Proposed Action are examined in reference to plausible environmental concerns. Detailed investigation of concerns and potential impacts is beyond the scope of the preliminary design, with more in depth study required to fully evaluate many of the possible impacts.

4.1. No Action

For the purposes of this subsection it is assumed that residential and commercial development will continue without the associated development of detention structures, allowing the runoff from rain events to flow into Mad Creek under the new conditions. The area is currently mostly wooded, grassy, and farmland terrain and the expected residential and commercial development would significantly increase the proportion of impervious surfaces.

4.2. Proposed Action

Wet detention ponds are proposed for all basins, with a more detailed analysis of Pond #8 provided in Section 5. The recommendation for all other sites is preliminary, with further investigation suggested. The wet detention pond alternative was chosen for Pond #8 due to the size of the sub-basin precluding dry detention practices, the excessive area needed for comparable wetland detention, and the requirements for drainage being more compatible with local obstacles and terrain.

4.3. Alternatives Considered and Dismissed

Wetland detention was considered, partially at the request of the City of Muscatine. The sub-basin chosen for more detailed exploration did not lend itself to wetland construction, though there was some indication that Pond #7 would be more appropriate. A major deciding factor for this location was the location of the recently laid sewer extension line running along Mad Creek in the same area. Proper sloping and elevation for the wetland and the outlet pipe would pass very near the existing sewer, leading to potential risk of damage during construction and unnecessary complication of maintenance on either structure. Further exploration of other proposed sites may result in more favorable conditions for this alternative.

Dam construction was also considered. The Army Corps of Engineers provided it as an ultimately dismissed alternative in their flood damage reduction study in 2002. The location they proposed for the dam on Mad Creek, located at the junction to the east southeast of the Clearview Mobile Home Park where the main northern and eastern arms of Mad Creek join to form the main channel, now runs very close to the sewer extension and could cause unnecessary problems. The option and location was dismissed for the preliminary plan due to concern over conflict with the sewer line and the restrictions involved with building upstream of a major population center and river. Further exploration of dam structures in other locations proved beyond the scope of this project. Future analysis of the watershed may provide a viable location for a dam structure.

4.4. Summary of Impacts and Mitigation

Environmental Resource	No Action	Proposed Action
Air Quality	No impact	No significant impact. Dust from construction activities would be temporary and local. Best Management Practices can be used to mitigate any effects.
Biological Resources	Adverse effect. Erosion and pollution transportation can degrade habitats in and around Mad Creek.	Potential adverse effect. Construction will replace current natural habitat with a built one.
Endangered or Threatened Species	Potential adverse effect. Any existing species may be negatively impacted by erosion and pollution.	Potential adverse effect. The presence of endangered or threatened species may require the selection of a new basin site.

Cultural Resources	Potential adverse effect. Any sites present may suffer from erosion.	Potential adverse effect. The discovery of a site of cultural significance could delay project completion or necessitate relocation of a basin.
Geology, Seismicity & Soils	Adverse effect. Uncontrolled increased runoff will likely result in erosion of soil.	No significant impact. BMP's can mitigate the short term exposure of soil during construction.
Land Use & Planning	No impact.	No impact. Zoning designation for residential and commercial development will allow for basin construction.
Hazardous Substances	Potential adverse effect. Undiscovered contaminated sites may suffer erosion, releasing contaminants into the environment.	No significant impact. Contaminated sites discovered before or during construction will necessitate contacting the IDNR for evaluation and mitigation. Work within the site must cease until IDNR concludes no more action is needed.
Noise	No impact.	No significant impact. Construction and maintenance activities will temporarily increase noise locally. Activity can be restricted to daylight hours to avoid undue disruption.
Transportation	Potential adverse effect. Erosion and sediment deposition may negatively impact roads, trails, etc. constructed in the area.	No significant impact. Temporary disruption of traffic may occur during construction and maintenance.
Water Resources	Adverse effect. Uncontrolled erosion and pollution from runoff will degrade existing conditions in and around Mad Creek.	No significant impact. Permit requirements and implementation of BMP will mitigate construction impacts, and normal operation will not harm water quality.
Cumulative Impacts	Adverse effect. Development without mitigation will result in overall degradation of environmental quality.	No impact. The retention and treatment of storm water runoff from the area will mitigate flooding and should maintain or improve water quality.

4.5. Affected Environment and Impacts

This section details the impacts of both the No Action Alternative and Proposed Action on specific areas of environmental concern. The No Action Alternative is evaluated based on the assumption that development still continues without appropriate detention practices put into place.

4.5.1. Air Quality

National Ambient Air Quality Standards (NAAQS), set by the EPA under the Clean Air Act, include six pollutants as criteria: Carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), particulate matter (PM), and lead (Pb). The intention is to limit human exposure to these pollutants to allowable concentrations or less over a given time period. This is done to protect human health and welfare and provide a reasonable margin of safety for those exposed.

Primary standards (health) and secondary standards (welfare) are set by the EPA. Failure to meet these standards will result in a 'nonattainment' designation and potential action by the agency to enforce compliance. These standards are preserved by the Ambient Air Quality division of the University of Iowa Hygienic Laboratory in partnership with the EPA and IDNR.

4.5.1.1. No Action

Air quality would be unaffected by the No Action Alternative, as there will be no construction of a detention structure.

4.5.1.2. Proposed Action

Under all proposed alternatives and for the various locations, air quality would be negatively impacted during construction of the detention structure(s) and during intermittent maintenance cleaning. The operation of excavation equipment and the movement of soil, both to build the structure(s) and to remove built up sediment, will generate exhaust emissions. Operation of excavation equipment over unpaved surfaces and the movement of removed soil during dry periods may result in particulate matter emissions. Both of these would be short term and localized during construction and regular maintenance and will not be a concern during regular operation.

Possible mitigation strategies as applicable to preparation, construction, and maintenance are as follows:

- Wetting soil where appropriate to prevent fugitive dust
- Taking appropriate steps to limit entrainment and trailing of soil out of the site by vehicles
- Minimizing the disturbance of land
- Covering trucks during the hauling of soil
- Stabilizing soil piles
- Placing wind breaks
- Re-vegetating disturbed land as per Executive Order 13112
- Removing unused soil from the site

4.5.2. Biological Resources

This section refers to the impact the Proposed and No Action alternatives may have on local flora and fauna.

4.5.2.1. Protected Species and Habitat

The protection and restoration of any species considered threatened or endangered is covered under Chapter 481B of the Code of Iowa, entitled Endangered Plants and Wildlife.

The US Fish and Wildlife Services (FWS) list multiple protected species as potentially inhabiting the area, including the Indiana bat (*Myotis sodalist*) and the sheepnose mussel (*Plethobasus cyphyus*). A more thorough study of the proposed locations for detention basins should be conducted to assess whether any endangered or threatened species would be displaced or harmed by the proposed actions.

Potential mitigations include restricting any tree clearing in the area to between October 1 and March 31. Indiana bats roost in the area during the summer using the loose bark of dead or dying trees, so clearing outside of this timeframe would mitigate any potential adverse effects.

4.5.2.2. No Action

Development of any sub basins without an appropriate detention structure would most likely result in an increase in the volume and velocity of water and higher concentrations of pollutants discharged to the environment. This would degrade the receiving bodies of water and increase erosion of soil and stream banks, compromising habitats in and around Mad Creek.

4.5.2.3. Proposed Action

Construction will require the removal of trees and ground cover in the local area, culminating in a new habitat type. The pond will be integrated into the existing landscape. Introducing appropriate native plant species for stability and cleaning will allow for repopulation by local fauna, reduce risk of invasive plants, and reduce maintenance needs.

4.5.3. Cultural Resources

Section 106 of the National Historic Preservation Act, including amendments in 36 CFR Part 800, mandates the consideration of impact on cultural resources. The identification of significant cultural resources, including prehistoric and historic sites, structures, buildings, artifacts, districts, objects, or other physical evidence of human activity that may have been important to a culture, subculture, or community for reasons such as science, tradition, religion, or others is required.

The National Park Service has established criteria for what is considered a significant cultural resource. If they meet the criteria they become eligible for inclusion in the National Register of Historic Places (NRHP). Sites not yet eligible but under examination for inclusion in the NRHP are considered equal with those currently listed in terms of regulatory protection.

Wapsi Valley Archaeology, Inc. performed a Phase 1 Intensive Archaeological Survey in 2012 in conjunction with the City of Muscatine Mad Creek Sewer Extension Project. The study covered the 12,250 foot length of the proposed sewer extension and a 75 foot width surrounding it. The results can be found in detail in their report, but the survey results did not appear to warrant further archaeological work. Due to the narrow width of the survey area investigated, further surveying is recommended even where the proposed basins intersect with the sewer line, such as in Ponds #7 and 8.

4.5.3.1. No Action

Potential undiscovered sites may suffer damage due erosion from increased uncontrolled runoff.

4.5.3.2. Proposed Action

A survey should be conducted to assess whether the selected basin site houses any relevant archaeological or historical sites of significance before construction begins. Potential significant finds must be relayed to the State and Federal Historic Preservation Office for evaluation.

4.5.4. Geology, Seismicity and Soils

4.5.4.1. No Action

As in section 4.5.2.2, the No Action Alternative would result in the erosion of soil in the area from the increased velocity and volume of runoff from the associated development.

4.5.4.2. Proposed Action

The area is largely a glacial loess and high in silt according to surveys by the National Resource Conservation Service (NRCS). Soil tests will need to be done to ascertain the exact nature of the soil at each proposed site should they be chosen for the final design. Hydrologic soil types as defined by the NRCS are used in the Stormwater management manual to recommend measures to maintain a permanent pool. Types C and D are typically considered suitable, with no further modification necessary. Type A commonly requires a liner and Type B may or may not, depending on the infiltration rate. As loess is high in silt it is likely to be Type B. Failure to maintain a permanent pool can severely impede the effectiveness of wet detention ponds and wetlands in cleaning and retaining sediment, nutrients, and pollution.

4.5.5. Land Use and Planning

The existing conceptual plan for development of the area includes high and low density residential, large lot residential, light industrial, mixed use, and large scale retail future land uses in addition to the commercial and residential uses already in place.

4.5.5.1. No Action

This alternative may negatively impact land use and planning. Lack of appropriate detention structures may impede development of the area and make proposed land uses infeasible, primarily near existing floodplain areas.

4.5.5.2. Proposed Action

There would be no significant impact on land use and planning. Management of stormwater runoff will assist in allowing current development plans to continue as intended.

4.5.6. Hazardous Substances

Hazardous substances are governed primarily by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), the RCRA Hazardous and Solid Waste Amendments, and the Toxic Substances Control Act (TSCA).

There are no currently registered contaminated sites in the area according to the IDNR and CERCLA database.

4.5.6.1. No Action

The No Action Alternative would not impact sites that were free of contamination. Unidentified hazardous substances could be washed into Mad Creek or exposed to the surface from the erosion precipitated by the lack of water detention.

4.5.6.2. Proposed Action

This alternative will have no impact on uncontaminated sites. Should a proposed site be discovered to contain a hazardous substance, the IDNR must be contacted to evaluate the danger and implement proper cleanup procedures if necessary.

4.5.7. Noise

In this case, noise is defined as any sounds which disrupt normal activities or otherwise diminish the quality of the environment. It can be continuous, intermittent, transient, or stationary. This includes construction vehicles and machinery. The U.S. Department of Housing and Urban Development sets regulations for acceptable noise levels in 24 CFR Part 51, Subpart B. Enforcement of these levels are a state and local concern.

4.5.7.1. No Action

The No Action Alternative would not result in any noise due to the lack of construction.

4.5.7.2. Proposed Action

Noise levels would be elevated during construction of the relevant structures and during regular maintenance. These would be short term and local. Normal operation of the structures may impose an increase in ambient noise levels should species such as waterfowl make use of the built habitat, but it is not expected to be unduly disruptive.

Mitigation of noise during construction and maintenance can include restricting the operation of vehicles to daylight hours and weekdays. Construction activities for the detention basins are expected to precede the construction of residential and commercial structures, so noise occurring as a result is not expected to be a major concern.

4.5.8. Socioeconomic Considerations

Should Federal funding or agencies become part of the project(s), Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" will govern at least in part the actions required. This order was signed by President Clinton on February 11, 1994, and directs federal agencies to consider the health and environmental conditions of minority and low-income populations. The intention is to avoid discriminatory results from actions taken by these agencies. A study of who could be displaced by the basins may be warranted, though the area is currently sparsely populated.

4.5.8.1. No Action

The likely resulting degradation of Mad Creek as it flows into the City of Muscatine and then into the Mississippi River will result in poorer waterfront conditions. Recreational activities, residents near the creek, and businesses stationed along it would suffer as a result. The increase in erosion would also negatively impact the effectiveness of the recently constructed flood control measures in the downtown area, potentially requiring extra maintenance expenditures or even redesign while also endangering residents and businesses. Future development along the creek would likely be constrained by poorer environmental conditions, and the lack of flood protection would likely depress property values.

4.5.8.2. Proposed Action

Mitigating runoff, silt, and pollution within the basins will help to maintain the quantity and enhance the quality of water in Mad Creek, allowing recreational and aesthetic enjoyment of the creek and the surrounding area to continue. Improved or maintained environmental conditions, along with flood protection, will likely enhance property values and the aesthetic appeal of homes and businesses constructed in the area. Maintaining or improving conditions in the stream will also ease the burden on downtown flood protection.

4.5.9. Transportation

The majority of the region under consideration is undeveloped. There are two proposed connector roads, one east/west and another north/south that would increase access should they be constructed. Current roads available include the boundary roads 180th street, Highway 38, and Interstate 61. Brookview Rd and Oak Dr. extend from Highway 38 but are paved residential county roads. Several paved roads extend from Interstate 61, including the access roads to Clearview Mobile Home Park and several in the southern section connecting much of the commercial businesses there to the main arterial. The construction and maintenance phases of the proposed detention structures would result in an increase of heavier traffic to and from the proposed sites, including construction materials and the transportation of sediments or personnel.

Should the proposed location north of 180th street be developed, there is the possibility of the road being elevated to meet the needs of the drainage basin. Such reconstruction would lead to a temporary restriction or redirection of traffic.

4.5.9.1. No Action

The No Action Alternative would likely result in no regular transportation impediments. However, the potential for erosion and sediment deposition could cause significant long term problems with the proposed connector roads crossing Mad Creek.

4.5.9.2. Proposed Action

The construction of wet detention ponds will allow for further development of the area. New homes and businesses will place increased burdens on existing infrastructure. Heavier traffic may result on Highway 38 and Interstate 61, necessitating construction to improve capacity or perform maintenance.

4.5.10. Water Resources

The US Army Corps of Engineers, in conjunction with the IDNR, is responsible for the enforcement of regulations pertaining to US waters, including permitting. Any potential impact on existing or planned wetlands, such as dredging or filling that could impact the water table within a wetland, must be approved through them. Executive Orders 11990 and 11988 cover federal mitigation of adverse impacts to and minimizing modifications to wetlands, respectively. EO 11988 also prohibits federal funding for construction within the 100 year flood plain, or the 500 year flood plain for structures deemed critical.

4.5.10.1. Wetlands

There is a known forested wetland contained within the design area, located south of 180th street as shown in Figure 4.5.10-1. Further analysis of the impact of detention structures on the existing wetland must be done to assure any potential changes to the water table will not directly or indirectly damage this wetland to any significant extent.

Figure 4.5.10-1: Forested Wetland south of 180th St.

4.5.10.1.1. No Action

The No Action Alternative may result in degradation of the conditions in the existing wetland from urban runoff. Changes in the water table from development may also put the wetland at risk.

4.5.10.1.2. Proposed Action

The construction of the wet pond at Pond #8 is not expected to impact the existing wetland. Development of Pond #7 would directly involve the wetland, as the site is connected to and partly overlaps this area. Construction activities will be governed by the Section 401 and 404 permits, so the movement of soil and fill should not negatively impact the wetland. A more thorough study of the cumulative impact of the regional plan will be needed to ensure the water table remains suitable for the existing wetland even if Pond #7 remains undeveloped.

4.5.10.2. Floodplain

The floodplain is defined by the flood caused by the 100 year or 500 year return storms. Certain activities are restricted within both boundaries, especially when federal funding is involved, such as construction of structures deemed non-critical like homes and businesses. The 500 year floodplain is less restricted, allowing exceptions for critical structures such as buildings for the police and fire departments if no other viable alternative is available. Building on the 100 year floodplain is typically discouraged through funding restrictions and regulations, with exceptions for structures that require a body of water to function.

4.5.10.2.1. No Action

The change in land use and surface caused by development can change the area impacted by the 100 and 500 year return storms. Due to the increase in runoff typically associated with development, these flood plains would likely expand and endanger residents and infrastructure should detention practices not be enacted.

4.5.10.2.2. Proposed Action

Several of the proposed locations are within the flood plain. This is not an uncommon practice throughout the country, but it can cause protection to suffer during significant storm events. Should a flood occur during construction, the exposed and loosened soil may cause increased turbidity and sediment buildup downstream. Proper flood protection practices and timely reseeding of the disturbed area once construction is complete can limit the potential for damage. Restricting construction to times of the year where flooding is historically rare can further reduce the risk.

4.5.11. Cumulative Impacts

Current conditions of Mad Creek are worsened by non-point agricultural runoff. The proposed structures are intended to detain and treat runoff in a more controlled manner, both before and after development of the area. The cumulative impact is expected to improve the quality of water in Mad Creek and provide a less flood prone area for development both in the proposal area and in downtown Muscatine. Economic impacts from such improvements include an increased draw for business and residents, and new and increased recreational opportunities.

4.5.12. Coordination

Coordination of activities must be done through their governing state and federal agencies such as the Iowa Department of Natural Resources, the Army Corps of Engineers, The US Fish and Wildlife Services, and the State Historical Preservation Office.

5. Final Design Details

A wet detention pond design is recommended as the best alternative for the regional water detention plan. Nine ponds are suggested to fully detain all the runoff for a storm event. Multiple ponds allows for a staggered implementation as development begins throughout the area. The results contained in this section are specified to Pond #8 in Sub-basin 6. This pond is used as a design example, with a reasonable approximation of the design and cost of the remaining ponds extrapolated from these results to match the differing drainage areas. The design consists of the detention pond, outlet structure, and small channel for routing the water that can be seen in detail in subsections 5.1-5.4.

5.1. Hydrology

The drainage area of Mad Creek encompasses the whole of the benefit district, and the total watershed is a large area that extends beyond the borders of Muscatine County. For this detention project only a partial drainage area was defined, containing the benefit district and those parts of the sub-basins that would impact it. Based on the existing contours of the site, 6 sub-drainage areas were delineated below 180th Street. The detailed watershed sub-basins are shown in Figure 5.1-1. Table 5.1-1 shows the detailed information of all six sub-basins. One sub-basin north of 180th street was also taking into consideration for detention of storm water.

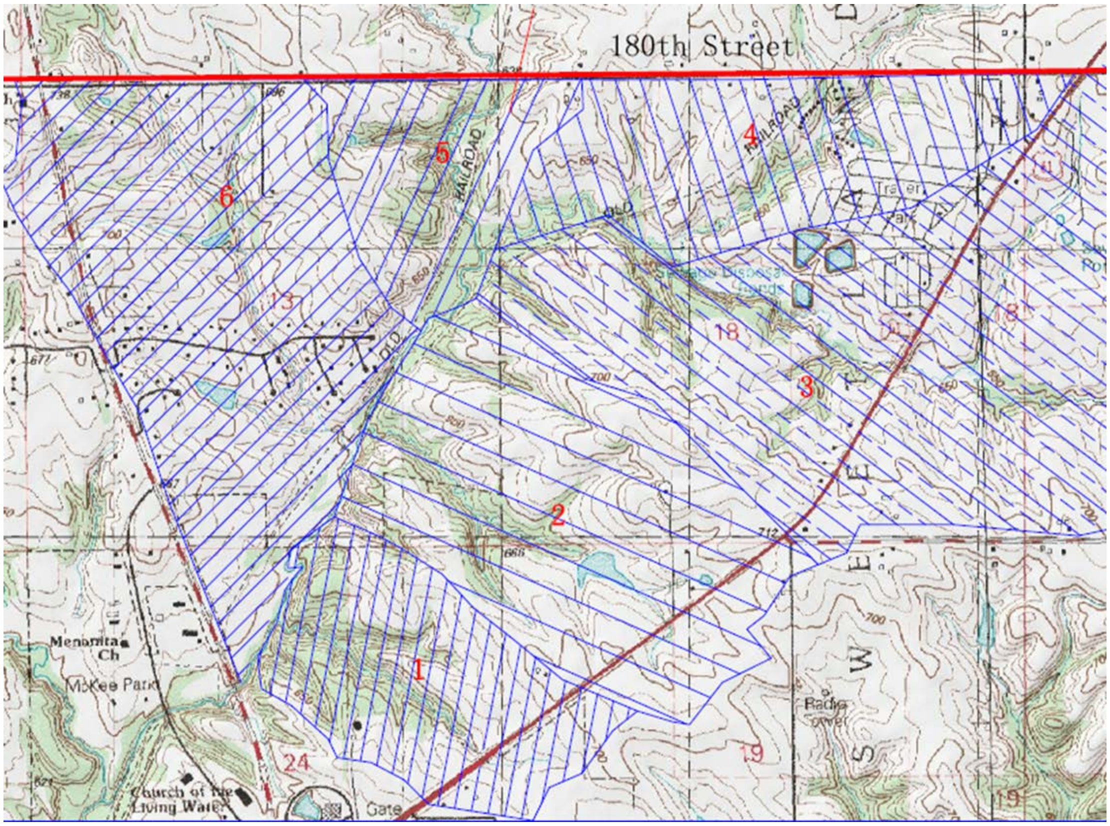

Figure 5.1-1: Watershed Delineated into six basins below 180th Street. The different hatching indicates separate sub-basins, the red numbers indicate the sub-basin number.

Area	Direct Peak Runoff (cfs)				Total Runoff (acre-ft)			
	2yr-Pre	2yr-Post	100yr-Pre	100yr-Post	2yr-Pre	2yr-Post	100yr-Pre	100yr-Post
1	51	151	377	860	25	62	183	284
2	88	176	673	924	46	92	310	426
3	88	185	709	1053	58	121	461	685
4	18	56	248	456	10	32	144	264
5	21	52	193	356	11	26	100	183
6	**57**	**111**	**470**	**716**	**39**	**75**	**326**	**424**
N180	84	168	523	758	51	102	316	398
Total Area	304	557	2468	3393	186	306	1520	1866

Table 5.1-1: Runoff Summary for Mad Creek Northeast corridor

The NRCS method was used for the runoff calculations. According to the Iowa Stormwater Management Manual Chapter 2C-1, the NRCS Urban Hydrology method has wide application for existing and developing urban water sheds up to 2000 acres. This method can be used for estimating peak direct runoff flows and hydrographs for all design applications. The various curve numbers used as part of this analysis can be seen in Appendix A, Table A-2.

Due to the lack of adequate rain gages at the Mad Creek site locations, the National Oceanic and Atmospheric Administration (NOAA) website was used for PDS-based precipitation frequency for the regional Muscatine area. Detailed precipitation data adapted from NOAA is in Appendix A, Table A-4. The City of Muscatine lies in Region 6 as defined by the Stormwater management manual and has a typical rainfall of 2.5 inches. Peak intensities correspond to 60 minute precipitation data intervals from NOAA. Appendix A, Table A-3 shows the synthetic typical 6 hour duration rainfall data with 2-year and 100-year return period for the Mad Creek watershed.

The NRCS triangular method was used to create unit hydrographs for the area. The sample calculations for a 2-year storm in sub-basin 6 under current conditions is shown in Appendix B. Table B-1 and Figure B-1 show the summary of triangular unit hydrograph data and the triangular hydrograph. Table B-2 shows the details of the one hour unit S curve with the time lag defined as 0.25 hours. For the excess precipitation hyetograph, Table B-3 and Figure B-2 lay out the details. Table B-4 shows the direct runoff hydrograph corresponding to excess rainfall and its peak runoff. Figure B-3 is the average direct runoff hydrograph. The calculations for both 2-year and 100-year return period storm at pre and post development situation were conducted for all the sub-basin areas. As part of the design of Pond #8 the 25-year return storm condition was also considered.

Sub-basins 2 and 3 are the main contributors to the Mad Creek runoff values, as shown in Table 5.1-1. Sub-basins 4 and 5 had less runoff partly because the existing ponds at the Clearview Mobile Home Park mitigate the runoff speed. Based on the runoff summary, we proposed several locations for detention facilities. The detailed locations of the detention facilities will be discussed in subsection 5.2.

5.2. Locations of Detention Facilities

A total number of nine feasible locations for detention facilities were selected. The locations chosen take the path of a water droplet, contours, and existing ongoing projects (road, sewer, etc.) into account. Figure 5.2-1 shows the overview of all the proposed detention facilities locations. According to the runoff calculations, those detention facilities would mitigate the possible flood due to development. Two inline wet detention ponds, Ponds #1 and 2, were proposed in sub-basin 1. One inline pond, Pond #3, and one offline wet detention basin, Pond #4, were proposed to sub-basin 2. Two offline ponds, Pond #5 and 6, were proposed to sub-basin 3. One large detention pond or wetland, Pond #7, was proposed to take runoff for sub-basins 4 and 5. Pond eight was designed for taking partial runoff for Area 6. Finally, Pond nine was designed for the area north of 180th street. Figure C-1 to C-7 in Appendix C show the detailed locations with two-foot contours.

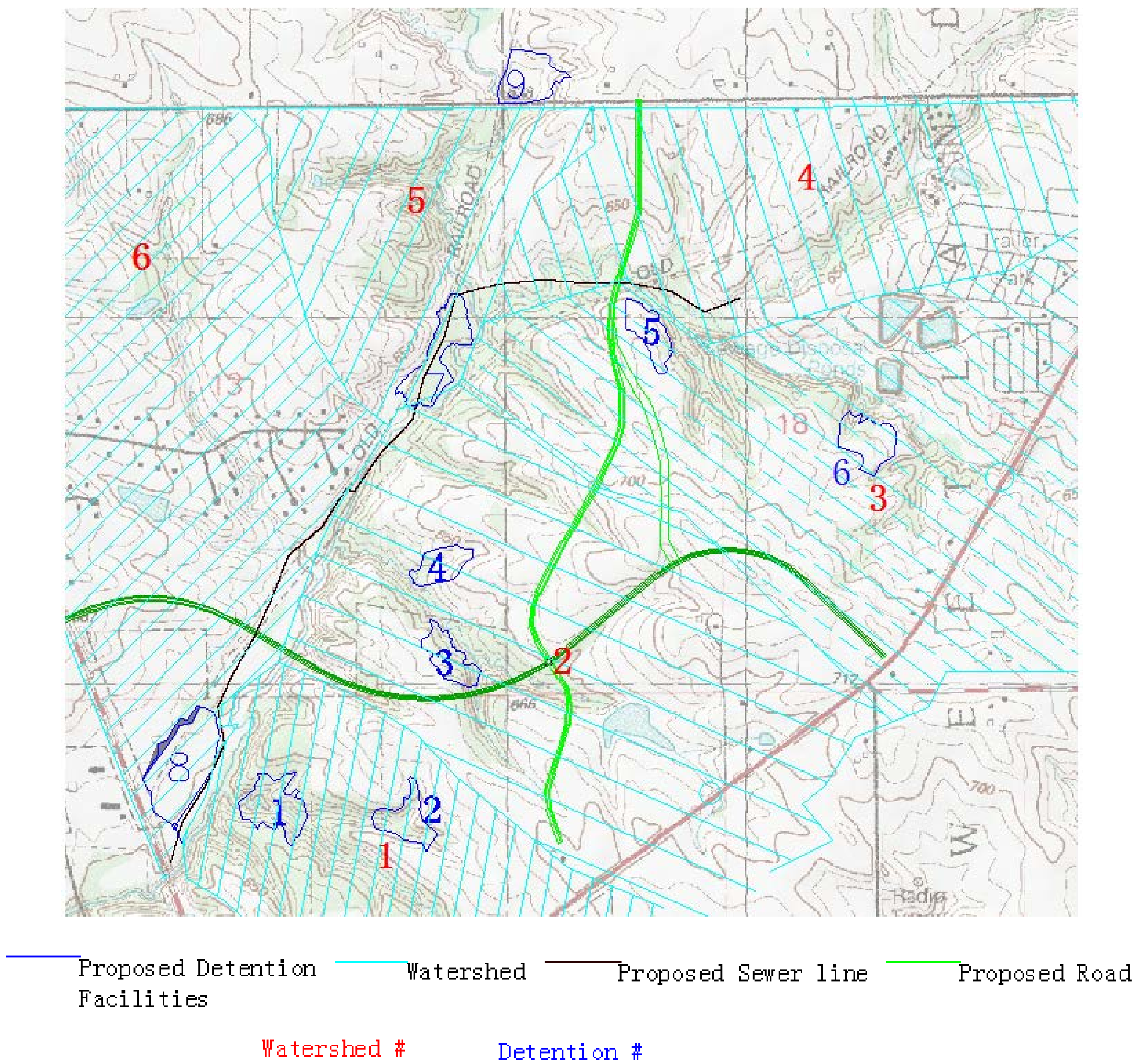

Figure 5.2-1: Proposed locations of wet detention basins

5.3. Detention Pond

The design calculations for the wet detention ponds can be found in Appendix E, modeled after the process found in the Iowa Stormwater Management Manual. The contributing drainage area for the design example, Pond #8, was calculated using AutoCad and found to be 155.2 acres as seen in Table 5.3-1, along with a summary of all the ponds with respect to basin length and width. The surface area of each pond is considered as a percentage of the total drainage area. In this design, the surface area is consider to be 5% of the total drainage area. The length to width ratio is 3:1, including the permanent pool, to maximize sedimentation.

Table 5.3-1: Summary Table of Detention Ponds and respective pond sizes

Detention Pond	Drainage Area (Acres)	Surface Area (Acres)	Surface Area (ft.^{2})	Drainage Basin Length(ft.)	Drainage Basin Width (ft.)
1	92.5	4.63	201465	777	259
2	92.5	4.63	201465	777	259
3	106.8	5.34	232610	835	278
4	81.5	4.08	177507	730	243
5	133.5	6.68	290763	934	311
6	106.8	5.34	232610	835	278
7	63.5	3.18	138303	644	215
8	155.2	7.76	338026	1007	336
9	249.6	12.48	543629	1277	426

Several parameters are used to design the size of a detention pond's stages. Water Quality volume is defined as the storage needed to capture and treat the runoff from 90% of the average annual rainfall (IDNR). In Iowa the corresponding depth of rainfall is equivalent to 1.25 inches. The permanent pool is the volume of water at the bottom of the pond that should always be filled even during dry periods. A reasonable detention time for wet detention pond needs to be 2 weeks or more (IDNR). Appendix E contains the calculations used to derive these values where appropriate. Water Quality volume was found to be 2.26 acre-feet, the permanent pool to be 4.5 acre-feet, and the detention time was chosen as 2 weeks.

To reduce the frequency of major cleanout activities within the pool area, a sediment forebay with hardened bottom should be constructed near the inlet to trap coarse sediment particles. A frequently-used value for the forebay storage capacity is approximately ten percent of the permanent pool volume (IDNR). A sediment forebay works as a “filter” and reduces incoming sediment. The example detention basin’s sediment forebay is 0.45 acre-feet and can be seen in a plan view in Figure 5.3-1 and in the contour view of the pond in Figure 5.3-2. The sediment forebay becomes essential in pond eight’s location because of the current farm field draining into the pond. The schematic section view with elevations are shown in Figure 5.2-3.

The total volume of the pond was derived from the geometry of the pond. The volume of the pond is 90 acre-feet. This is derived from the total direct runoff for the sub-basin and used as a safety factor. The volume needed with the outlet structure that is discussed in Section 5.4 is 32 acre-feet. The storage-depth relationship can be seen in Figure F-1 in Appendix F.

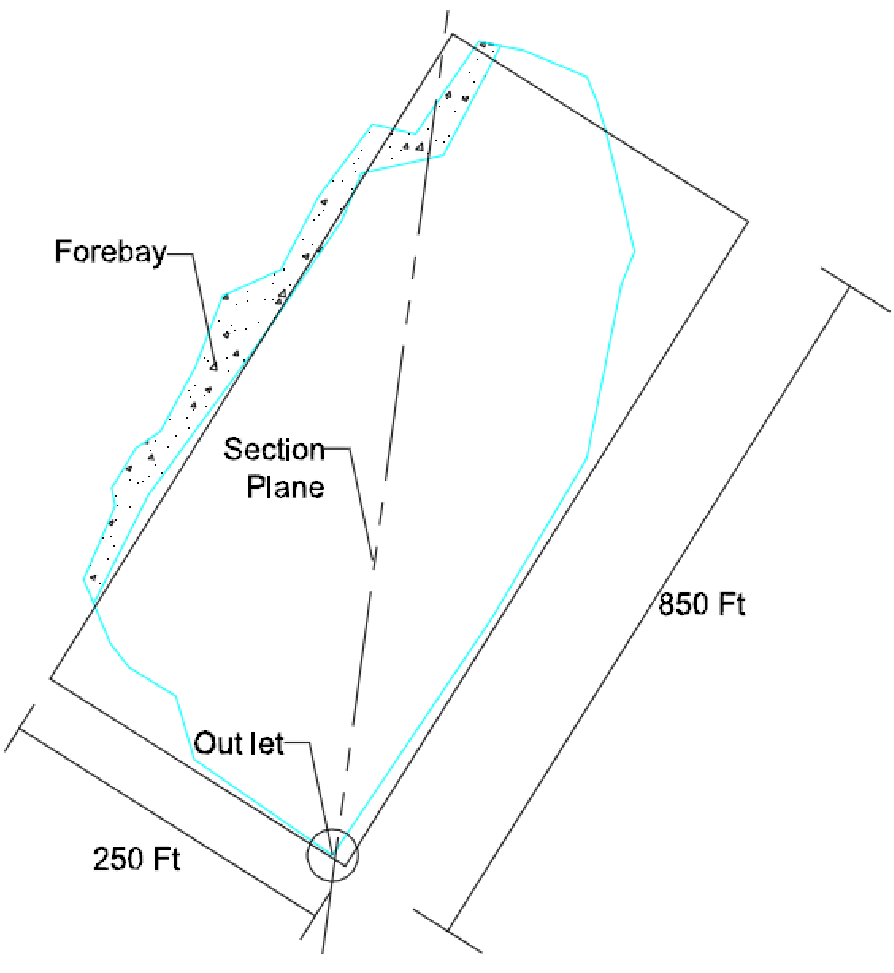

Figure 5.3-1: Plan view of Pond #8

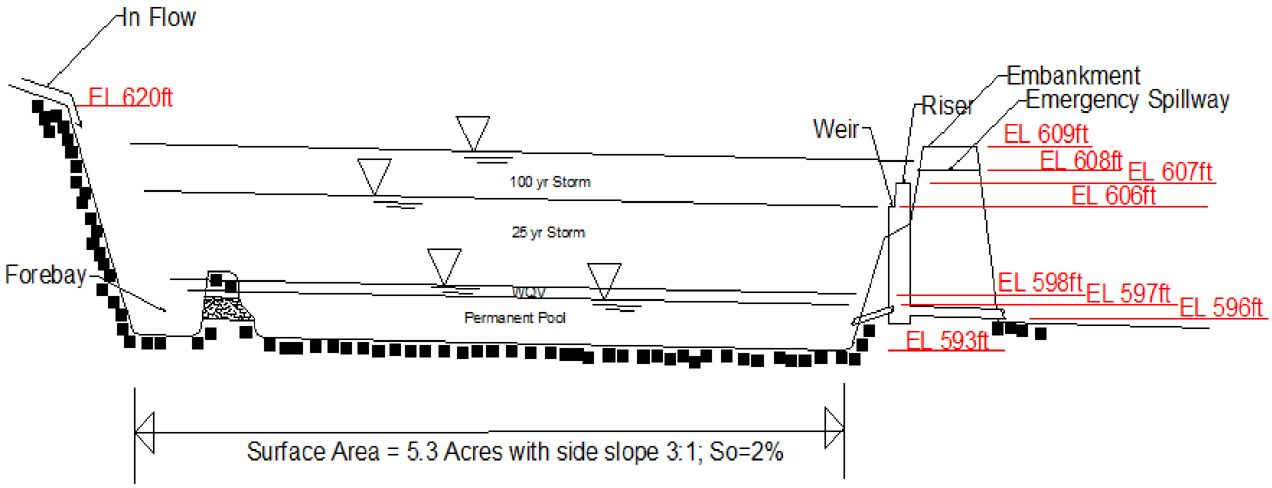

Figure 5.3-2: Section view of Pond #8

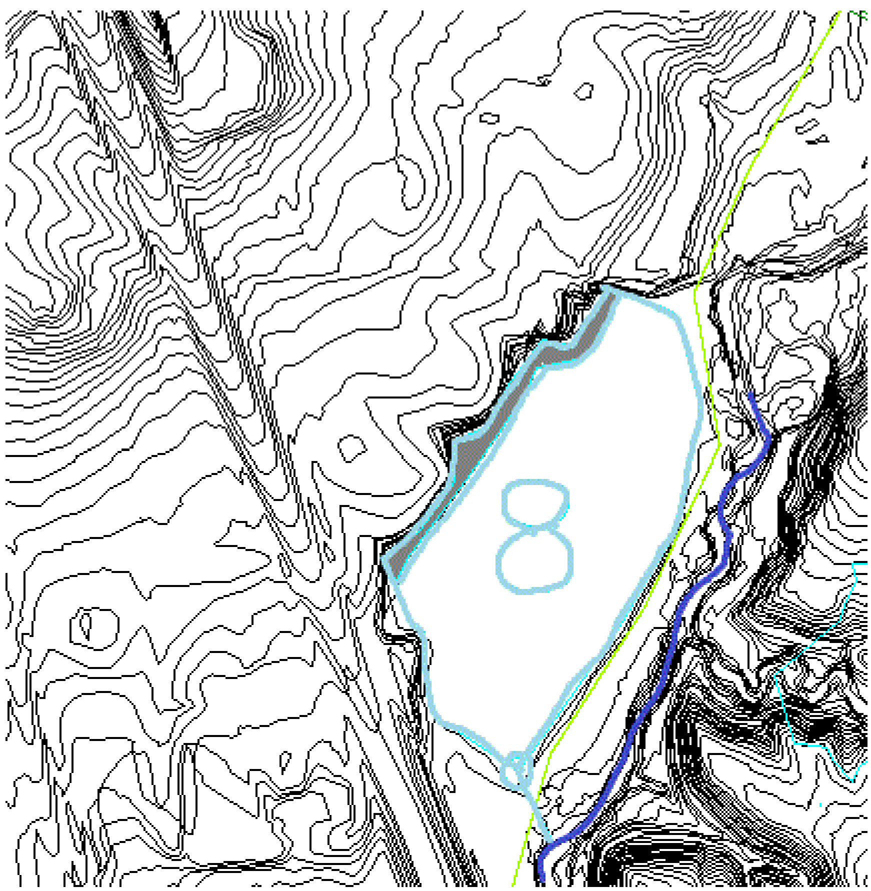

Figure 5.3-3: Pond #8 site view

5.4. Outlet Structure

When designing the Single Stage rectangular weir, we found the weir length and contacted Oldcastle Precast in Topeka, Kansas. Their outlet structure specialist Bill Keithley took our numbers and gave us the dimensions needed to complete the design. It stands 5 feet tall with 6 inch walls and has an outlet pipe diameter of 12 inches. The length and width of the box are both 4 feet with #4 bars for reinforcement 12 inches from the center. Figure 5.4-1 gives a 2D frontal view of the resulting shape. The 3D views of the structure can be seen in Figure 5.4-2. An optional trash gate can be placed over the top of the weir box to prevent trash clogging the pipe. For protection against stagnant water in the pond, a pipe is to be placed at the level of the permanent pool connecting to the outlet structure to keep water flowing even in non-storm periods. This pipe can be seen in the Figure 5.4-2. All the outlet structure calculations can be found in Appendix H.

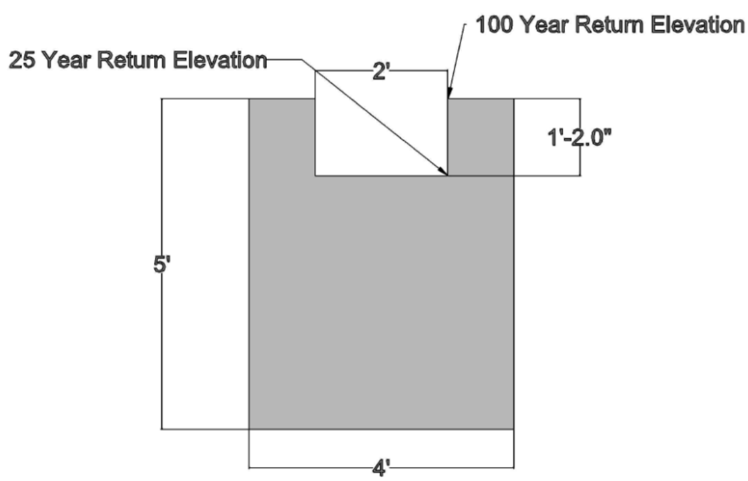

Figure 5.4-1: Front weir view of single stage structure

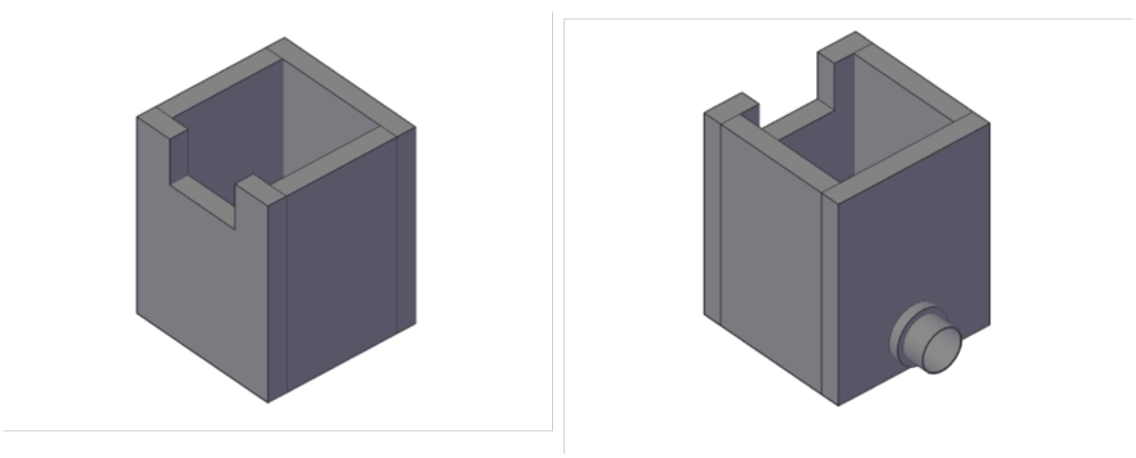

Figure 5.4-2: 3D Views of the front and back of the single stage rectangular weir

Based on the detention pond detailed design information and runoff calculation, the routing computation was completed using the Modified Puls Method. The weir length from the design was chosen to be two feet and used in the design calculations seen in Appendix F. A detailed sample calculation for routing computation is in Appendix F. Figure 5.4-3 shows the inflow and outflow of Pond #8 for a 25-year return storm. The peak runoff rate from Pond #8 for 25-year storm in the post-development situation was less than the predevelopment condition, 42 cfs compared to 91 cfs respectively.

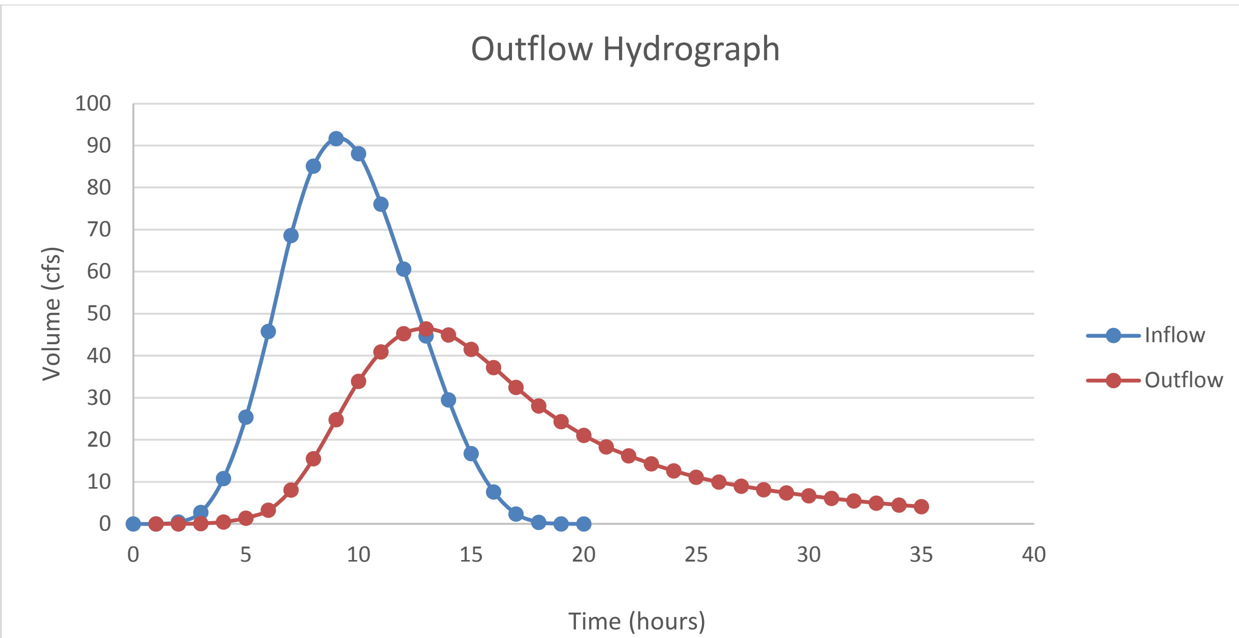

Figure 5.4-3: Inflow & outflow hydrograph for Pond #8

5.5. Channel

The water routed from the example detention pond has the sewer extension line between the pond and Mad Creek. To avoid routing the water in a pipe and possibly run into the sewer line, an overland channel is to be used to route the water into Mad Creek. A trapezoidal channel is common and is recommended as used in the calculations. Manning's equation for open channel flow was used to calculate the appropriate size of the channel, as seen in Appendix I.

The max flow rate (Q) during a 100-year flood event is 46.4cfs out of the outlet structure. The calculation can be found in Appendix A and with the max flow rate, assuming a bottom width of 4 feet, side slopes of 3:1, and land slope the Channel Geometry can be seen in Table 5.5-1. The channel is lined with Riprap for simplicity and to reduce the scour from the routed water leaving the pipe. Riprap also requires minimal maintenance unlike grass or soil linings. Riprap is relatively cheap compared to synthetic sheet liners. The total channel length is 120 feet from the pond to the creek. At the 100-year Design Storm, the depth in the channel will be 1.7 feet.

Table 5.5-1 Channel Dimensions

Depth (ft.)	1.707
Top Width (ft.)	14.24
Bottom Width (ft.)	4
Area(ft^2)	15.57

6. Cost and Construction Estimates

The cost estimation was determined in part by using old project costs from the Harrison street detention pond given to us by the City of Muscatine and also from various other detention pond project costs designed by HDR. The weir outlet structure was estimated by Oldcastle Precasting Company in Topeka Kansas. The total cost estimate for all 9 ponds comes to $2,253,202.17, as shown in Table 6.1. The cost estimate of Pond #8 is detailed in Table 6-2, totaling $249,815.03 with the majority of the costs coming from earthwork, clearing, and grubbing the land.

Table 6-1: Total cost of proposed ponds

Summary Cost	
Pond	Cost
1	$249,815.94
2	$249,815.94
3	$249,815.94
4	$249,815.94
5	$249,815.94
6	$249,815.94
7	$152,763.13
8	$249,815.90
9	$351,727.50
Total Cost for All Ponds	$2,253,202.17

Table 6-2: Bid Tabulation for Pond 8

Bid Tabulation Pond 8					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 155.2 acres				

7. Conclusions

The Van Allen Design Group developed preliminary design for regional water detention plan for the northeastern corridor of the City of Muscatine, Iowa. Possible alternatives were evaluated such as detention ponds, wetlands, and Dams. Due to the numerous criteria such as hydrologic land contours, existing infrastructure, and estimated costs. Wet Detention pond was found to be the most feasible method to reduce the runoff for pre-existing and post development conditions.

The suggested preliminary design consists of 9 ponds to detain and treat the runoff to meet requirements. Because the scope of the project, not all 9 ponds could be fully designed. Pond #8 was fully designed as an example, reflecting intentions for the remaining ponds. The Iowa Stormwater management manual was utilized as a design guide paired with hydrologic analysis for the watershed. Pond #8 was evaluated to contain a roughly 91 acre-feet pond with a depth of 14 feet. The detention pond will settle out pollutants from the nearby farm field and highway such as suspended solids, nutrients, heavy metals, and hydrocarbons. Along with the pollutants, the detention pond will also handle the increase in runoff from future industrial and residential development.

A Single Stage outlet structure is suggested based on the ability to handle 25- and 100-year return periods. Peak discharge out of the outlet was calculated to be 42 cfs, which is reduced from the current peak of 91 cfs. The outflow is routed by a small channel into Mad Creek. The Van Allen Design Group recommends this preliminary design as the most feasible option for the City of Muscatine.

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Appendices

Appendix A: Runoff Information

Table A-1: Watershed information

# of watershed	Area	Creek Width (ft)	Land Slope %	Surface Length (ft)	Watercourse Slope%	Shallow Length (ft)	Channel Slope%	Channel Length (ft)	Sum	Average Slope%
1	185	16.15	4.86	2338	2.95	2034	0.34	1800	4372	3.97
2	326	18.93	3.66	2154	2.24	2228	0.38	4300	4382	2.94
3	534	15.65	3.82	1850	1.04	2876	0.34	8085	4726	2.13
4	223	14.23	3.60	1775	1.08	930	0.36	7600	2705	2.73
5	127	14.27	4.50	1736	1.33	1500	0.32	7686	3236	3.03
6	388	18.55	4.08	2642	1.92	3132	0.31	3786	5774	2.91
N180	307	13.85	2.72	6000	--	--	--	--	6000	272.00%

Table A-2: Curve Number Calculations

	Percent of land coverage				
	Commercial and Business Areas	Residential: 1/4 lots	Row Crops: Straight Row	Woods: Fair	Meadow
Areas	92	75	78	60	58
1	0.3	0	0.1	0.5	0.1
2	0.2	0.05	0.3	0.2	0.25
3	0	0.6	0	0.2	0.2
4	0	0.1	0	0.55	0.35
5	0	0.05	0.3	0.45	0.2
6	0	0.5	0.05	0.25	0.2

Areas	Areas(acres)	Area Weight					Total
1	185	55.5	0	18.5	92.5	18.5	185
2	326	65.2	16.3	97.8	65.2	81.5	326
3	534	0	320.4	0	106.8	106.8	534
4	223	0	22.3	0	122.65	78.05	223
5	127	0	6.35	38.1	57.15	25.4	127
6	388	0	194	19.4	97	77.6	388

Areas	Area Weighted Curve Number					Sum	Composite Curve Number
1	5106	0	1443	5550	1073	13172	**71.2**
2	5998.4	1222.5	7628.4	3912	4727	23488.3	**72.05**
3	0	24030	0	6408	6194.4	36632.4	**68.6**
4	0	1672.5	0	7359	4526.9	13558.4	**60.8**
5	0	476.25	2971.8	3429	1473.2	8350.25	**65.75**
6	0	14550	1513.2	5820	4500.8	26384	**68**
					Total	121585.4	
				Total Composite CN=		68.19	

Table A-3: Synthetic rainfall data for mad creek (6 hour duration)

Time (hr)	Intencity I (in/h)	
	2-yr	100-yr
0.00		
	0.05	0.50
1.00		
	0.35	1.06
2.00		
	0.99	1.31
3.00		
	0.55	2.43
4.00		
	0.33	0.51
5.00		
	0.04	0.10
6.00		

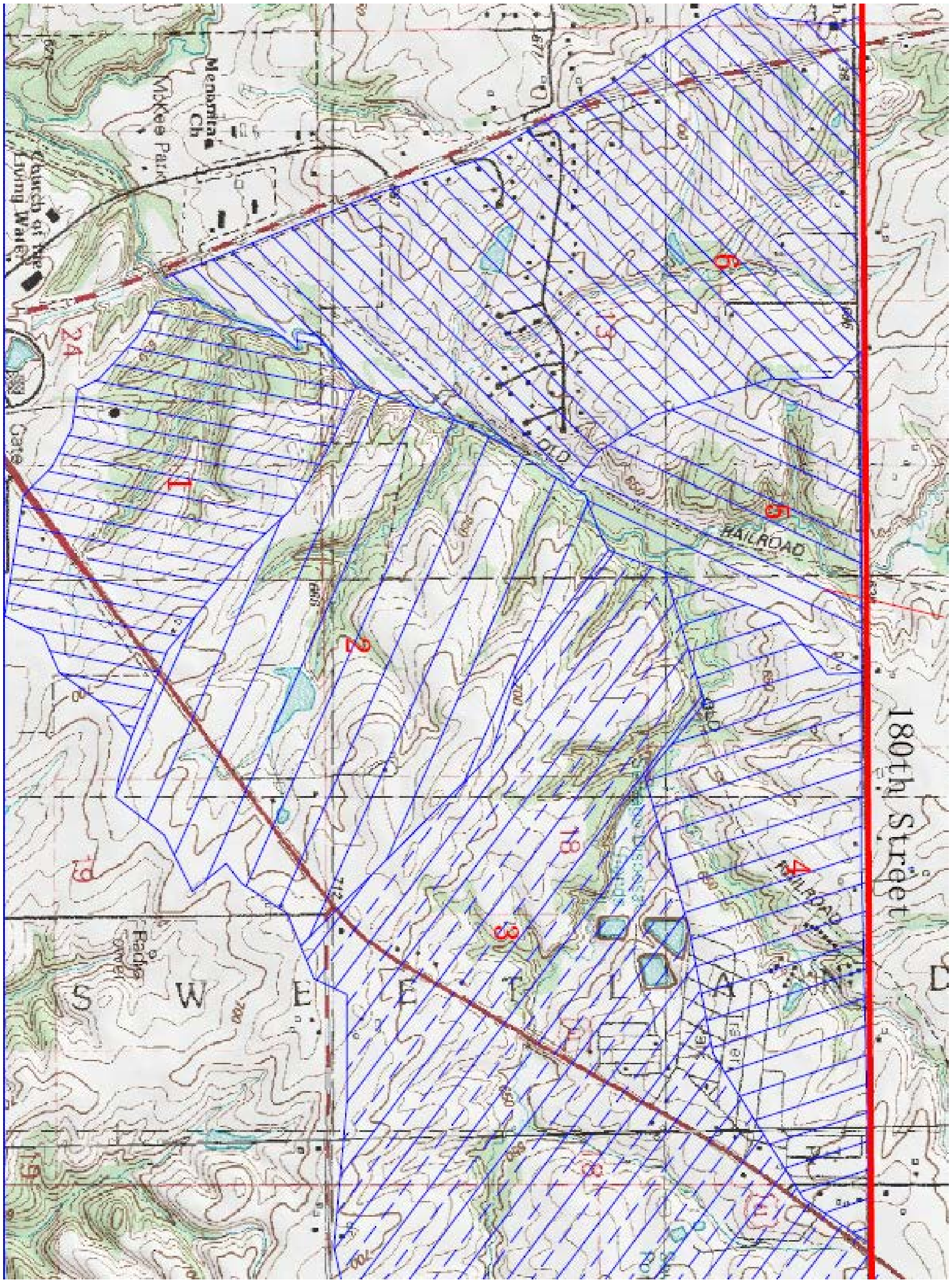


Figure A-1: Watershed Delineation

Table A-4: NOAA Precipitation frequency for Muscatine, Iowa

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.362** (0.290-0.459)	**0.422** (0.338-0.536)	**0.525** (0.418-0.668)	**0.613** (0.486-0.782)	**0.739** (0.565-0.968)	**0.84** (0.626-1.11)	**0.944** (0.677-1.27)	**1.05** (0.721-1.44)	**1.2** (0.788-1.67)	**1.32** (0.839-1.85)
10-min	**0.53** (0.425-0.672)	**0.618** (0.495-0.785)	**0.768** (0.613-0.977)	**0.897** (0.711-1.15)	**1.08** (0.828-1.42)	**1.23** (0.916-1.62)	**1.38** (0.991-1.85)	**1.54** (1.05-2.10)	**1.76** (1.15-2.45)	**1.93** (1.23-2.70)
15-min	**0.646** (0.518-0.820)	**0.754** (0.604-0.958)	**0.937** (0.747-1.19)	**1.09** (0.867-1.40)	**1.32** (1.01-1.73)	**1.5** (1.12-1.98)	**1.69** (1.21-2.26)	**1.88** (1.29-2.56)	**2.15** (1.41-2.98)	**2.36** (1.50-3.30)
30-min	**0.937** (0.751-1.19)	**1.1** (0.878-1.39)	**1.36** (1.09-1.74)	**1.6** (1.27-2.04)	**1.93** (1.48-2.53)	**2.19** (1.64-2.90)	**2.47** (1.77-3.31)	**2.75** (1.89-3.76)	**3.15** (2.06-4.37)	**3.46** (2.20-4.84)
60-min	**1.23** (0.985-1.56)	**1.43** (1.15-1.82)	**1.79** (1.43-2.27)	**2.1** (1.67-2.68)	**2.58** (1.98-3.39)	**2.96** (2.21-3.93)	**3.38** (2.43-4.55)	**3.82** (2.62-5.23)	**4.44** (2.92-6.19)	**4.94** (3.14-6.91)
2-hr	**1.52** (1.23-1.90)	**1.77** (1.43-2.21)	**2.21** (1.78-2.77)	**2.61** (2.09-3.28)	**3.22** (2.51-4.21)	**3.73** (2.83-4.90)	**4.29** (3.12-5.72)	**4.88** (3.39-6.63)	**5.73** (3.81-7.92)	**6.42** (4.13-8.90)
3-hr	**1.69** (1.38-2.10)	**1.96** (1.60-2.43)	**2.46** (2.00-3.05)	**2.92** (2.36-3.64)	**3.63** (2.86-4.72)	**4.24** (3.24-5.54)	**4.91** (3.60-6.52)	**5.63** (3.94-7.62)	**6.67** (4.47-9.19)	**7.53** (4.87-10.4)
6-hr	**1.99** (1.64-2.43)	**2.31** (1.91-2.82)	**2.9** (2.39-3.56)	**3.47** (2.84-4.26)	**4.34** (3.46-5.58)	**5.09** (3.94-6.58)	**5.91** (4.40-7.77)	**6.82** (4.83-9.13)	**8.12** (5.50-11.1)	**9.18** (6.01-12.6)
12-hr	**2.29** (1.92-2.76)	**2.68** (2.24-3.23)	**3.39** (2.82-4.09)	**4.04** (3.35-4.89)	**5.03** (4.05-6.36)	**5.87** (4.59-7.47)	**6.78** (5.09-8.78)	**7.76** (5.56-10.3)	**9.17** (6.29-12.4)	**10.3** (6.83-14.0)
24-hr	**2.63** (2.23-3.11)	**3.07** (2.60-3.64)	**3.85** (3.25-4.59)	**4.57** (3.83-5.45)	**5.63** (4.58-7.00)	**6.52** (5.15-8.17)	**7.47** (5.67-9.54)	**8.49** (6.15-11.1)	**9.94** (6.88-13.3)	**11.1** (7.44-14.9)
2-day	**3.03** (2.61-3.54)	**3.48** (2.99-4.07)	**4.29** (3.67-5.02)	**5.01** (4.26-5.90)	**6.11** (5.04-7.48)	**7.03** (5.63-8.68)	**8.01** (6.16-10.1)	**9.07** (6.65-11.7)	**10.6** (7.42-14.0)	**11.8** (7.99-15.7)
3-day	**3.34** (2.89-3.86)	**3.78** (3.27-4.38)	**4.58** (3.94-5.31)	**5.3** (4.54-6.18)	**6.4** (5.32-7.77)	**7.32** (5.91-8.98)	**8.31** (6.44-10.4)	**9.39** (6.94-12.0)	**10.9** (7.71-14.3)	**12.2** (8.29-16.1)
4-day	**3.59** (3.13-4.13)	**4.04** (3.51-4.65)	**4.84** (4.20-5.58)	**5.57** (4.80-6.45)	**6.67** (5.57-8.04)	**7.59** (6.16-9.25)	**8.58** (6.68-10.7)	**9.65** (7.16-12.3)	**11.2** (7.92-14.6)	**12.4** (8.50-16.3)
7-day	**4.21** (3.71-4.78)	**4.73** (4.16-5.37)	**5.62** (4.92-6.40)	**6.39** (5.56-7.31)	**7.52** (6.32-8.91)	**8.44** (6.90-10.1)	**9.4** (7.38-11.5)	**10.4** (7.79-13.1)	**11.8** (8.46-15.3)	**12.9** (8.96-16.9)
10-day	**4.79** (4.24-5.39)	**5.37** (4.76-6.05)	**6.36** (5.60-7.18)	**7.19** (6.30-8.16)	**8.38** (7.07-9.80)	**9.31** (7.65-11.1)	**10.3** (8.11-12.5)	**11.3** (8.48-14.1)	**12.6** (9.08-16.2)	**13.7** (9.54-17.8)
20-day	**6.55** (5.88-7.25)	**7.32** (6.56-8.11)	**8.57** (7.66-9.52)	**9.6** (8.53-10.7)	**11** (9.40-12.7)	**12.1** (10.1-14.1)	**13.2** (10.5-15.8)	**14.3** (10.9-17.6)	**15.7** (11.4-19.9)	**16.8** (11.9-21.7)
30-day	**8.05** (7.29-8.83)	**8.99** (8.14-9.88)	**10.5** (9.47-11.6)	**11.7** (10.5-13.0)	**13.4** (11.5-15.2)	**14.6** (12.3-16.9)	**15.9** (12.8-18.8)	**17.1** (13.1-20.8)	**18.6** (13.6-23.4)	**19.8** (14.1-25.3)
45-day	**9.96** (9.10-10.8)	**11.2** (10.2-12.1)	**13.1** (11.9-14.3)	**14.6** (13.2-16.0)	**16.6** (14.3-18.6)	**18** (15.2-20.5)	**19.4** (15.7-22.7)	**20.7** (15.9-25.0)	**22.3** (16.4-27.8)	**23.5** (16.8-29.9)
60-day	**11.6** (10.6-12.5)	**13.1** (12.0-14.1)	**15.3** (14.0-16.6)	**17.1** (15.5-18.6)	**19.4** (16.8-21.5)	**21** (17.7-23.7)	**22.5** (18.2-26.1)	**23.8** (18.4-28.6)	**25.5** (18.8-31.5)	**26.6** (19.2-33.7)

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Appendix B: Runoff Calculations

Sub-basin 6 predevelopment 2-year storm runoff calculation:

$$T_l = \frac{L^{0.8}(\mathrm{S}+1)^{0.7}}{1900 * AverageSlope^{0.5}} = \frac{6000^{0.8}(4.71+1)^{0.7}}{1900 * 2.5^{0.5}} = 1.19s \quad \text{(Eq. B-1)}$$

Traveling Time

$$Tc = \frac{5}{3}T_l = \frac{5}{3} * 1.19 = 1.98s \quad \text{(Eq. B-2)}$$

Time of Concentration

$$Tp = 0.5 * Tr + Tl = 0.5 * 0.25 + 1.19 = 1.31s \quad \text{(Eq. B-3)}$$

Time to peak

$$Tb = 2.67 * Tp = 2.67 * 1.31 = 3.5s \quad \text{(Eq. B-4)}$$

Base Time

$$Qp = \frac{484 * Area}{Tp} = \frac{484 * 0.6}{3.5} = 221.45cfs \quad \text{(Eq. B-5)}$$

Peak Flow

Table B-1: Summary of Triangular UH data

NRCS Triangular UH	
CN (AMC II) =	68.00
Average slope	2.50
L (ft.)	6000
Area (mi^2)	0.60
S	4.71
Tl (s)	1.19
Tc (s)	1.98
Tr (s)	0.25
Tp (s)	1.31
Tb (s)	3.50
Qp (cfs)	221.45

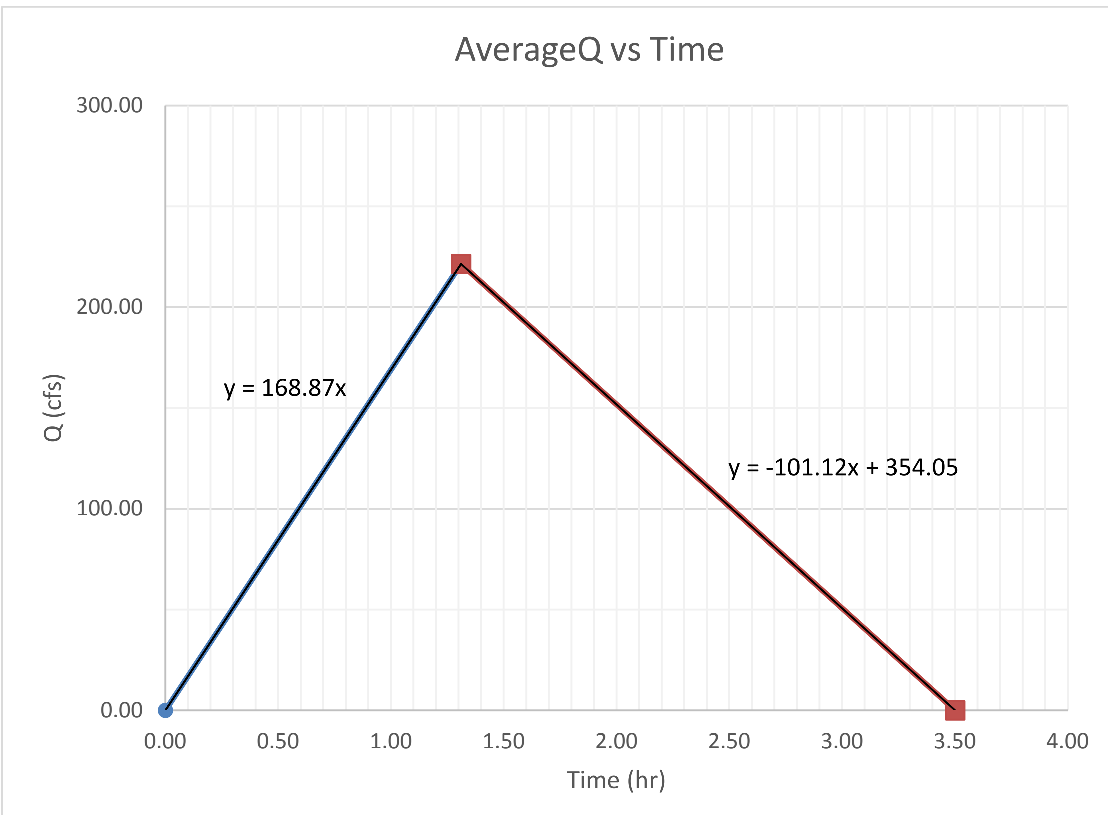


Figure B-1: NRCS Triangular hydrograph

Table B-2: CN Average 1-hr UH S Hydrograph, Time Lag (T_l) = 0.25 hour

	0.25hr - UH	Unit Hydro leged by							Derived S graph	S graph lagged by 4	Derived 1-hr S graph	1-hr UH
t (hr)	q (cfs)	1	2	3	…	17	18	19				
0	0.0				…							
0.25	41.8	0.0			…				0.0		0.0	0.0
0.5	83.6	41.8	0.0		…				41.8		41.8	10.5
0.75	125.4	83.6	41.8	0.0	…				125.4		125.4	31.4
1	167.2	125.4	83.6	41.8	…				250.8		250.8	62.7
1.25	209.0	167.2	125.4	83.6	…				418.0	0.0	418.0	104.5
1.5	202.1	209.0	167.2	125.4	…				627.0	41.8	585.2	146.3
1.75	177.1	202.1	209.0	167.2	…				829.2	125.4	703.8	175.9
2	152.1	177.1	202.1	209.0	…				1006.3	250.8	755.5	188.9
2.25	127.0	152.1	177.1	202.1	…				1158.3	418.0	740.3	185.1
2.5	102.0	127.0	152.1	177.1	…				1285.4	627.0	658.3	164.6
2.75	77.0	102.0	127.0	152.1	…				1387.4	829.2	558.2	139.6
3	52.0	77.0	102.0	127.0	…				1464.4	1006.3	458.1	114.5
3.25	26.9	52.0	77.0	102.0	…				1516.3	1158.3	358.0	89.5
3.5	1.9	26.9	52.0	77.0	…				1543.2	1285.4	257.9	64.5
3.75	0.0	1.9	26.9	52.0	…				1545.1	1387.4	157.7	39.4
4		0.0	1.9	26.9	…				1545.1	1464.4	80.8	20.2
4.25		0.0	0.0	1.9	…	0.0			1545.1	1516.3	28.8	7.2
4.5		0.0	0.0	0.0	…	41.8	0.0		1545.1	1543.2	1.9	0.5
4.75		0.0	0.0	0.0	…	83.6	41.8	0.0	1545.1	1545.1	0.0	0.0
5		0.0	0.0	0.0	…	125.4	83.6	41.8			0.0	0.0
5.25		0.0	0.0	0.0	…	167.2	125.4	83.6			0.0	0.0
5.5		0.0	0.0	0.0	…	209.0	167.2	125.4			0.0	0.0
5.75		0.0	0.0	0.0	…	202.1	209.0	167.2			0.0	0.0
6		0.0	0.0	0.0	…	177.1	202.1	209.0			0.0	0.0
6.25		0.0	0.0	0.0	…	152.1	177.1	202.1			0.0	0.0
6.5		0.0	0.0	0.0	…	127.0	152.1	177.1			0.0	0.0
6.75		0.0	0.0	0.0	…	102.0	127.0	152.1			0.0	0.0
7		0.0	0.0	0.0	…	77.0	102.0	127.0			0.0	0.0
7.25		0.0	0.0	0.0	…	52.0	77.0	102.0			0.0	0.0
7.5		0.0	0.0	0.0	…	26.9	52.0	77.0			0.0	0.0
7.75		0.0	0.0	0.0	…	1.9	26.9	52.0			0.0	0.0
8		0.0	0.0	0.0	…	0.0	1.9	26.9			0.0	0.0
8.25		0.0	0.0	0.0	…	0.0	0.0	1.9			0.0	0.0
Check: Sum=	1545.128											1545.13

For excess precipitation hyetograph, Table B-3 and Figure B-2 shows the detail. Table B-4 shows the direct runoff hydrograph corresponding to excess rainfall and its peak runoff. Figure B-3 is the average direct runoff hydrograph.

$$\sum Pe = \frac{(\sum P - 0.2*S)^2}{\sum P + 0.8*S} = \frac{(1.92-0.2*4.71)^2}{1.94+0.8*4.71} = 0.71in \qquad \text{(Eq. B-6)}$$

Accumulated Excess

Table B-3: Excess Precipitation Hyetograph for Mad Creek, Sub-basin 6

Excess Precipitation Hyetograph for Mad Creek North (6-hr-Duration;100-yr-Return)					
Time (hr.)	Intensity I (in/h)	Increment Rainfall P (in)	Accumulated rainfall ∑P (in)	Accumulated Excess ∑Pe (in) avg	Increment Pe (in)
0.00			0.00	0.00	
	0.50	0.50			0.00
1.00			0.50	0.00	
	1.06	1.06			0.00
2.00			1.56	0.00	
	1.31	1.31			0.56
3.00			2.87	0.56	
	2.43	2.43			1.54
4.00			5.30	2.10	
	0.51	0.51			0.38
5.00			5.81	2.48	
	0.10	0.10			0.08
6.00			5.91	2.55	

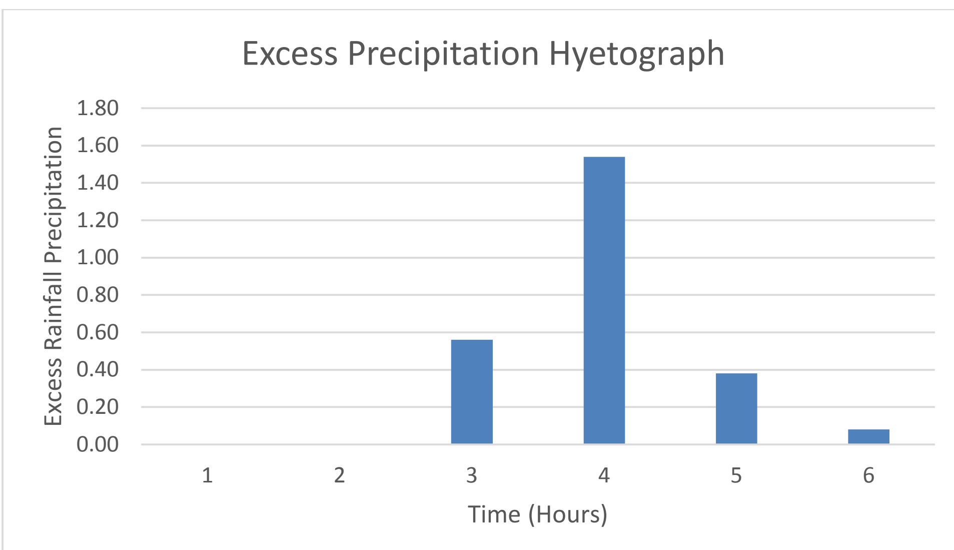


Figure B-2: Excess Precipitation Hyetograph for Specific Design Pond Eight

Table B-4: The direct runoff hydrograph corresponding to excess rainfall

Time (h)	1 hr - UH (cfs)	Direct runoff hydrograph cooresponding to excess rainfall (cfs)						Direct run off (cfs)
		0 in	0 in	0.04in	0.14n	0.12n	0.02 in	
0.00	0.00							0.00
1.00	10.45							0.00
2.00	31.35			0.00				0.00
3.00	62.70			0.41	0.00			0.41
4.00	104.51			1.23	1.42	0.00		2.64
5.00	146.31			2.45	4.26	1.23	0.00	7.94
6.00	175.94			4.08	8.52	3.69	0.17	16.46
7.00	188.86			5.72	14.19	7.38	0.50	27.79
8.00	185.08			6.88	19.87	12.30	0.99	40.04
9.00	164.59			7.38	23.89	17.22	1.66	50.15
10.00	139.56			7.23	25.65	20.71	2.32	55.91
11.00	114.53			6.43	25.13	22.23	2.79	**56.59**
12.00	89.49			5.45	22.35	21.79	2.99	52.58
13.00	64.47			4.48	18.95	19.38	2.93	45.73
14.00	39.44			3.50	15.55	16.43	2.61	38.09
15.00	20.19			2.52	12.15	13.48	2.21	30.36
16.00	7.20			1.54	8.75	10.54	1.81	22.64
17.00	0.47			0.79	5.36	7.59	1.42	15.15
18.00	0.00			0.28	2.74	4.64	1.02	8.69
19.00	0.00			0.02	0.98	2.38	0.62	4.00
20.00	0.00			0.00	0.06	0.85	0.32	1.23
21.00	0.00			0.00	0.00	0.06	0.11	0.17
22.00	0.00				0.00	0.00	0.01	0.01
23.00	0.00				0.00	0.00	0.00	0.00
24.00	0.00				0.00	0.00	0.00	0.00

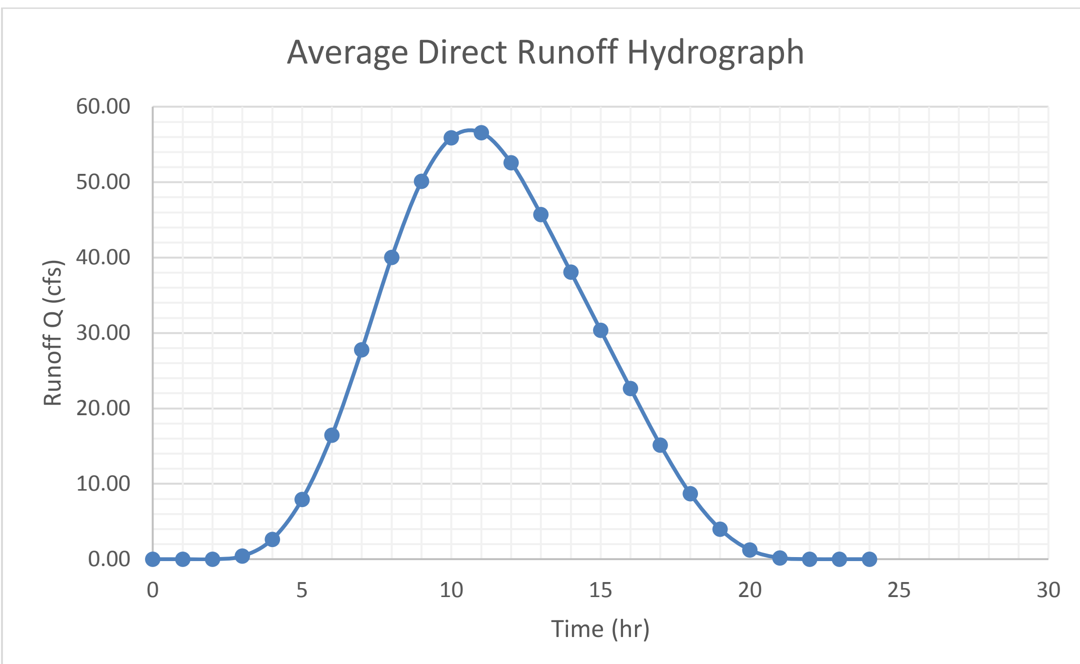


Figure B-3: Average Direct Runoff Hydrograph

Appendix C: Locations for Detention Facilities

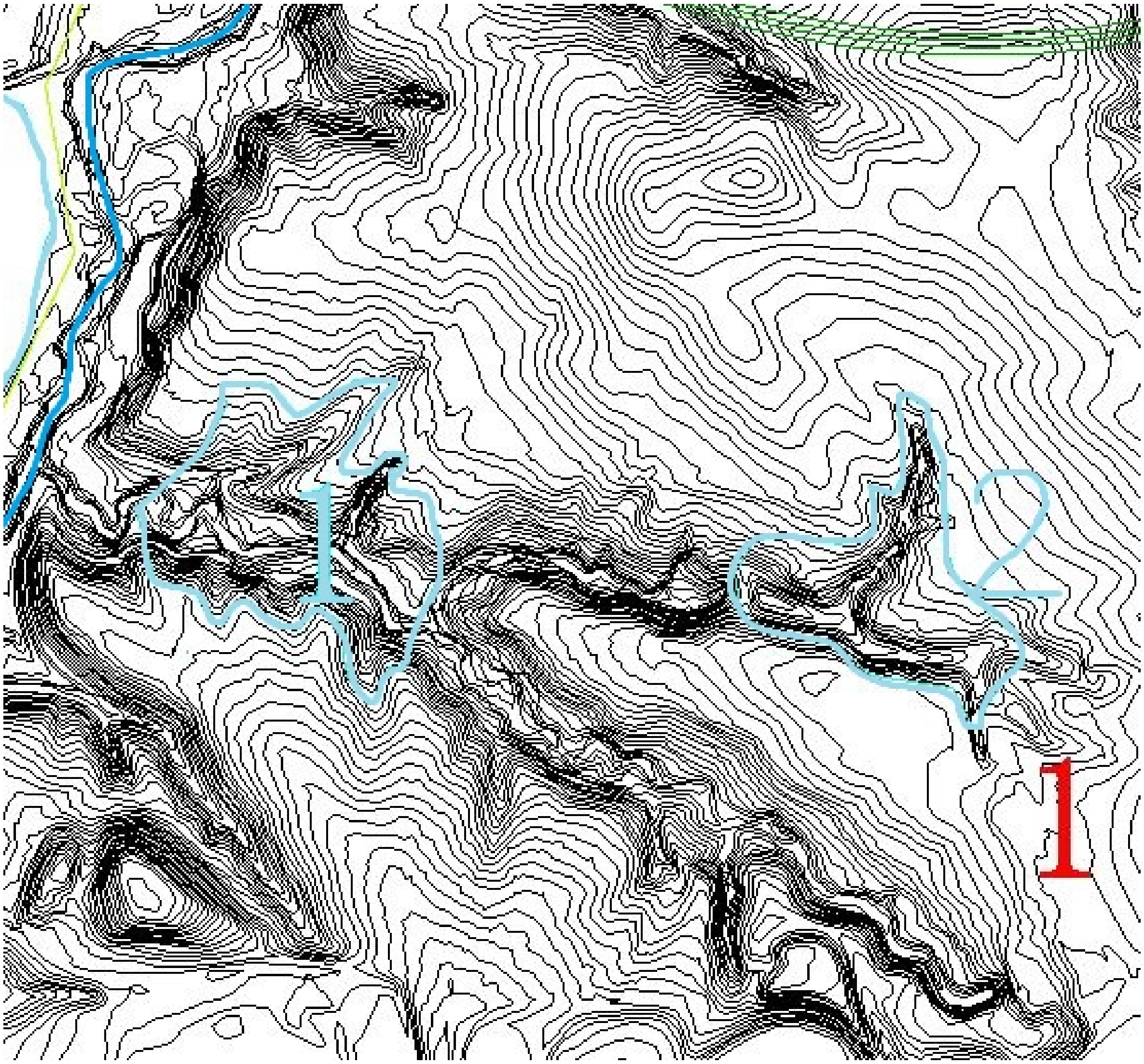


Figure C-1: Detention Facilities Pond #1 and 2

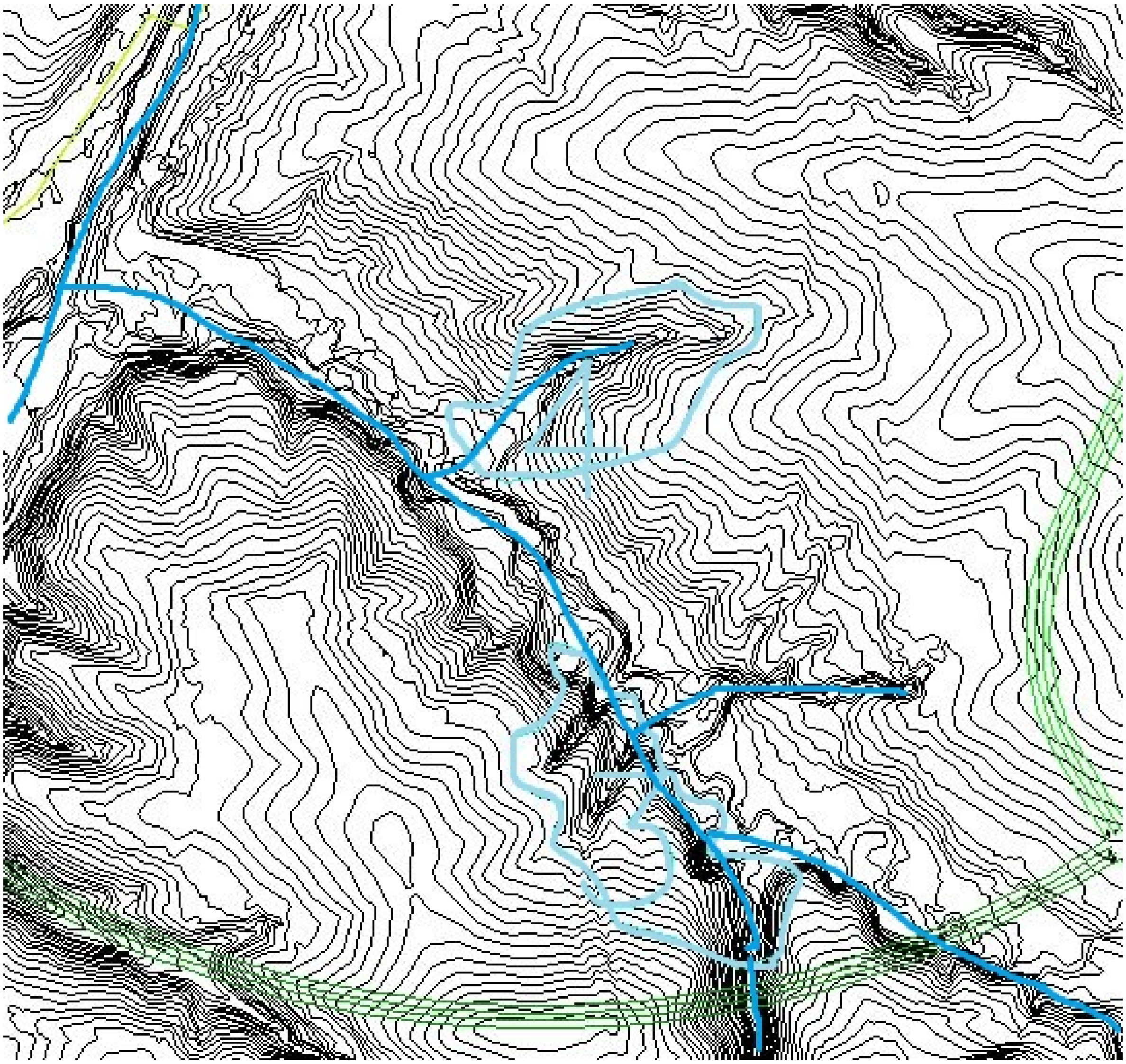


Figure C-2: Detention Facilities Pond #3 and 4

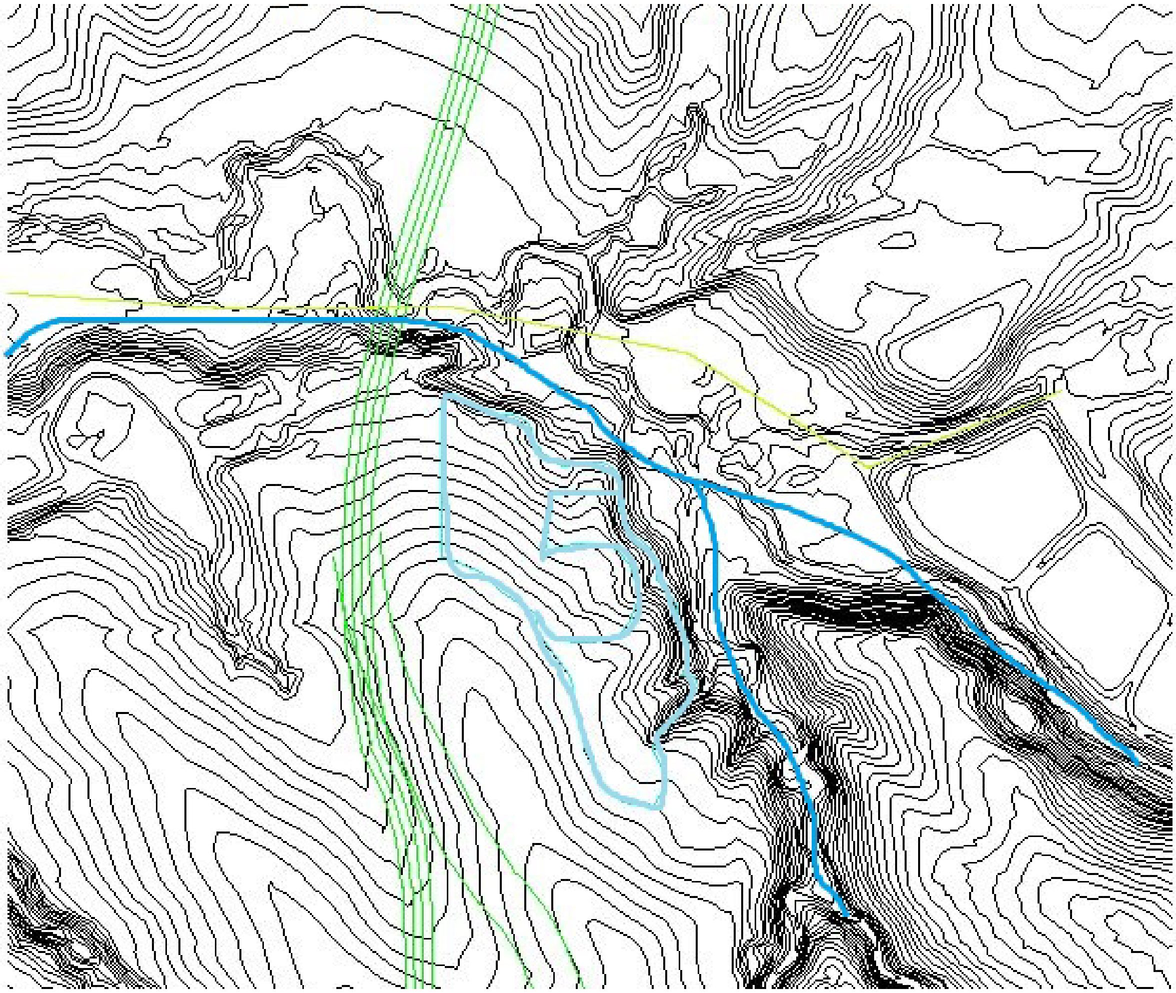


Figure C-3: Detention Facilities Pond #5

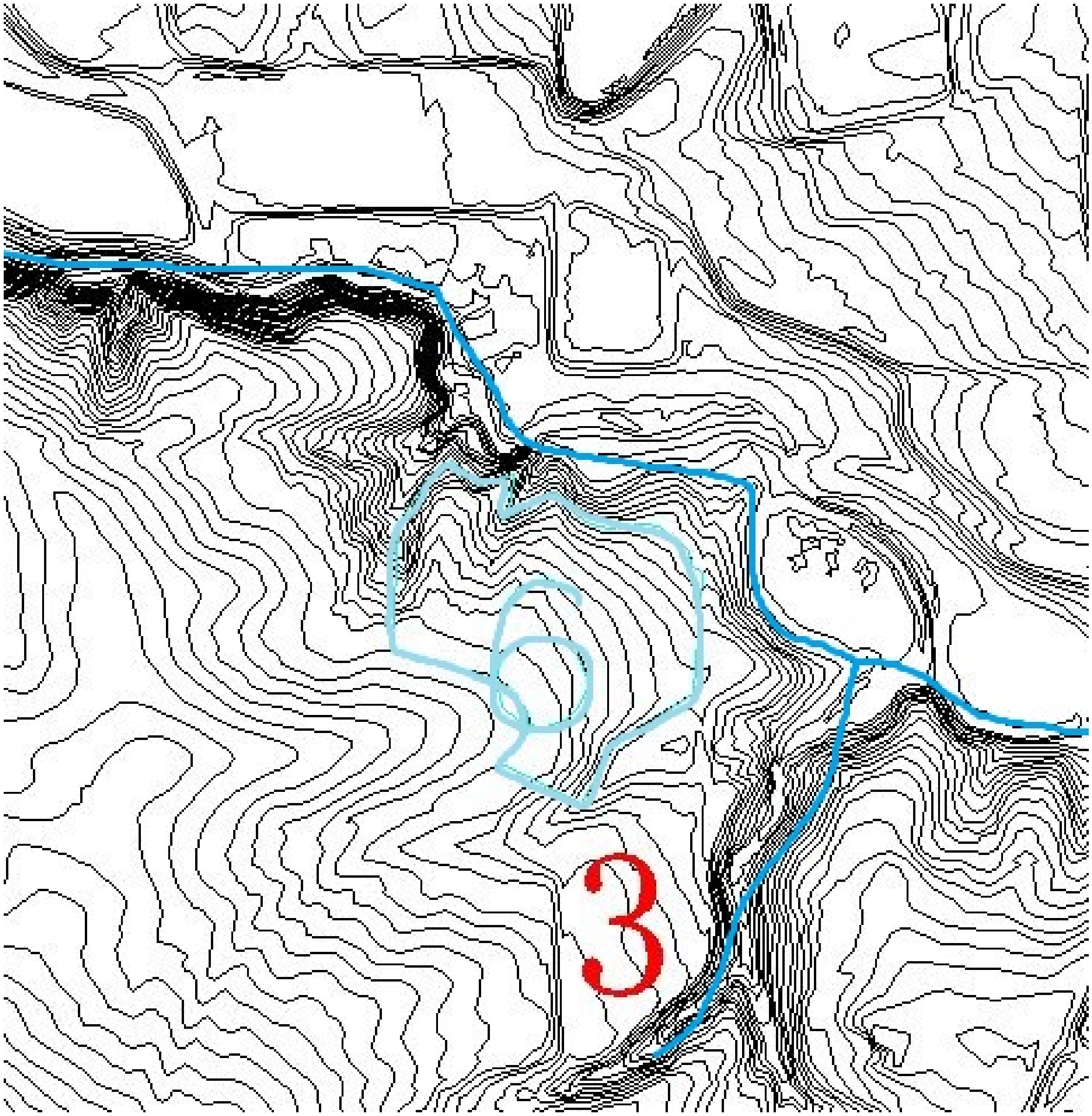


Figure C-4: Detention Facilities Pond #6

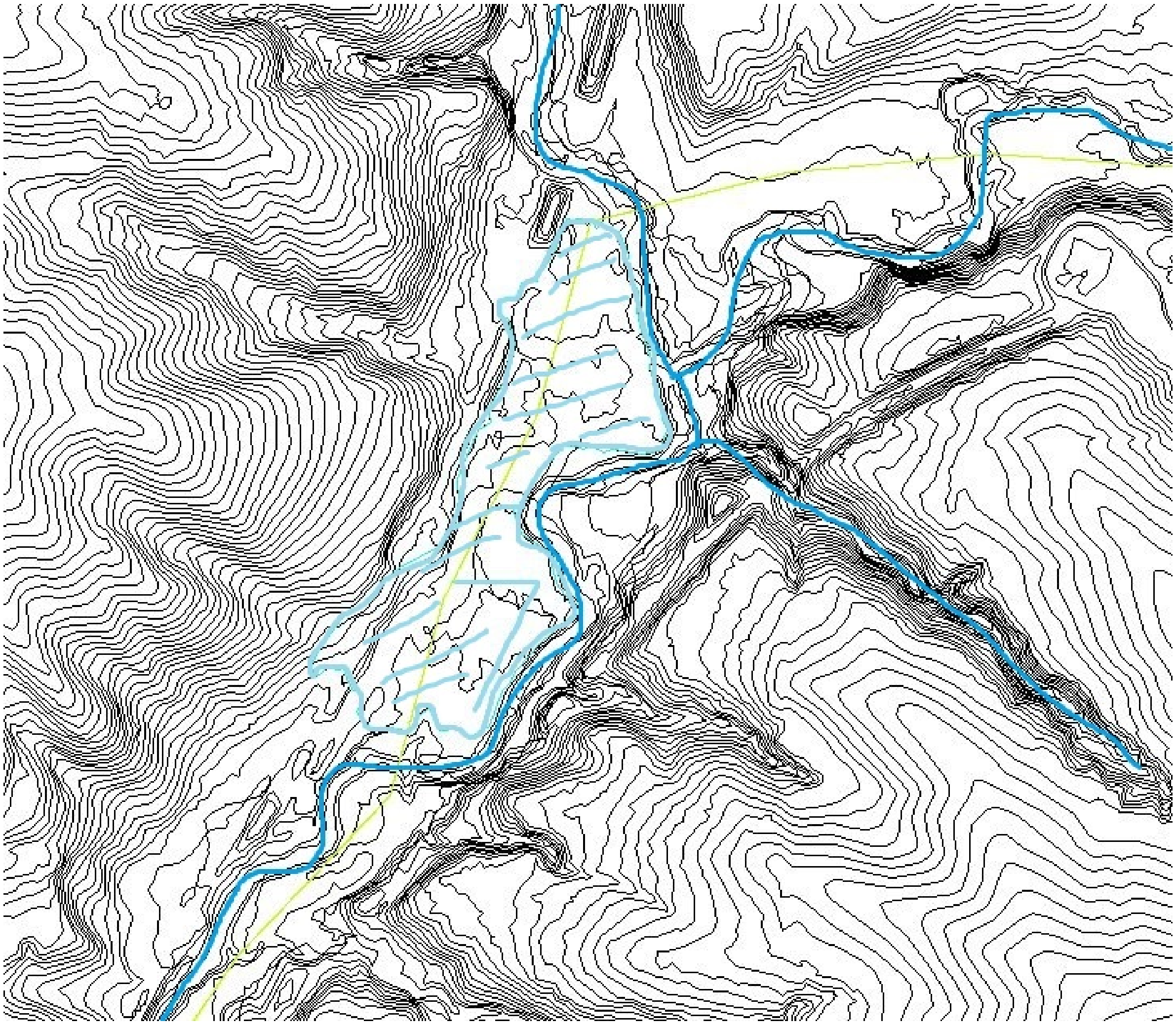


Figure C-5: Detention Facilities Pond #7

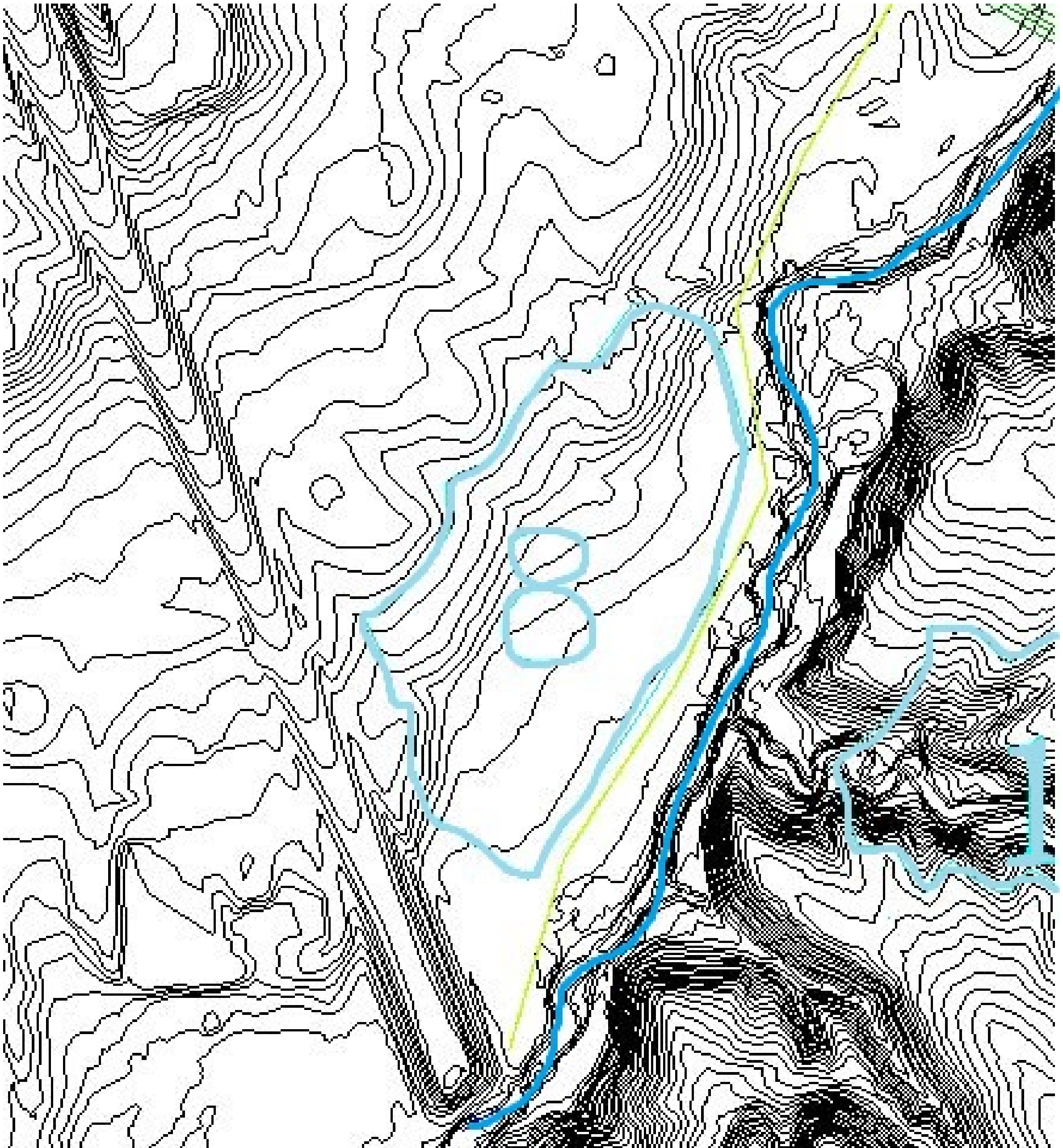


Figure C-6: Detention Facilities Pond #8

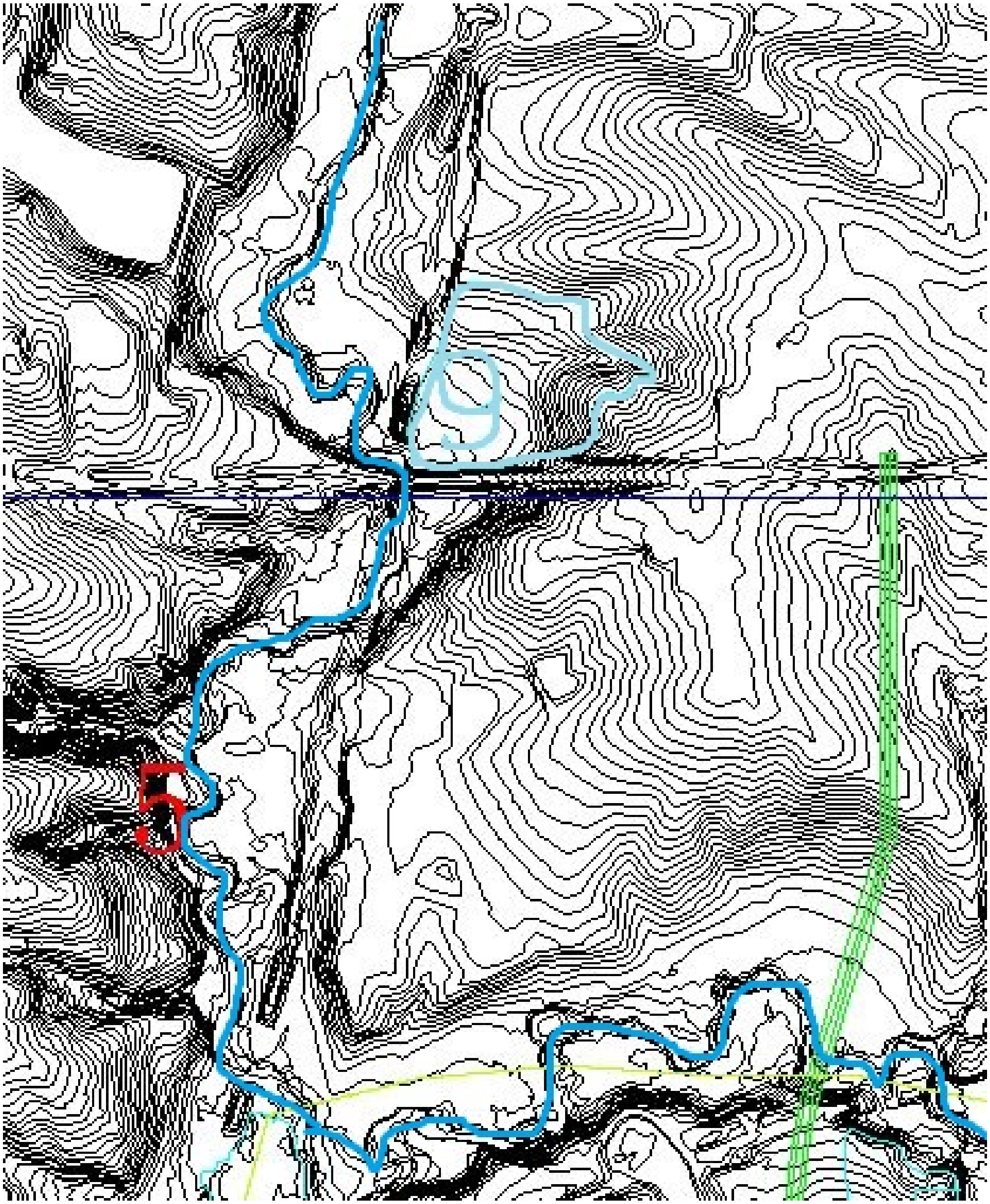


Figure C-7: Detention Facilities Pond #9

Appendix D: Wetlands

Table D-1: Stormwater Wetland Design Form

Watershed Data			
Total upstream drainage area		350	acres
% Imperviousness of DA		37.1	%
Total impervious area		129.84	acres
Watershed CN		CN =	67.3
Time of Concentration, tc		tc (hours) =	0.8928
Compute WQv requirements			
Compute Runoff Coefficient, Rv	Rv	0.38	
Compute WQv requirements	WQv	14	acres-ft
Compute Channel Protection Storage	CPv =	---	acres-ft
Compute average release rate	release rate	---	ft3/sec
Compute Qp-25	Qp-25 =	76.8	acres-ft
Add 15% to the required Qp-25 volume	Qp-25 * 0.15 =	11.52	acres-ft
Compute Qf (100-yr)	Qf =	240	acres-ft
Stormwater Wetland Design			
Pre-treatment volume			
VPRE = AIMP *(0.1-inches) * (1-ft/12 in)	VPRE =	1.08	acre-ft
Allocation of pool, marsh, and ED volumes			
Shallow wetland	VOLpool = 0.2*(WQv)	2.80	acre-ft
	VOLmarsh = 0.7*(WQv)	9.80	acre-ft
Shallow ED wetland	VOLpool = 0.1*(WQv)	1.40	acre-ft
	VOLmarsh = 0.3*(WQv)	4.20	acre-ft
	VOLED = 0.5*(WQv)	7.00	acre-ft
Allocation of surface area			
Pool/deep water wetland zone(1.5-6ft)	A pool=	**0.47**	acre
Low marsh wetland zone(0.2-1.5ft)	A marsh=	**2.80**	acre
ED zone	A ED=	**3.50**	acre

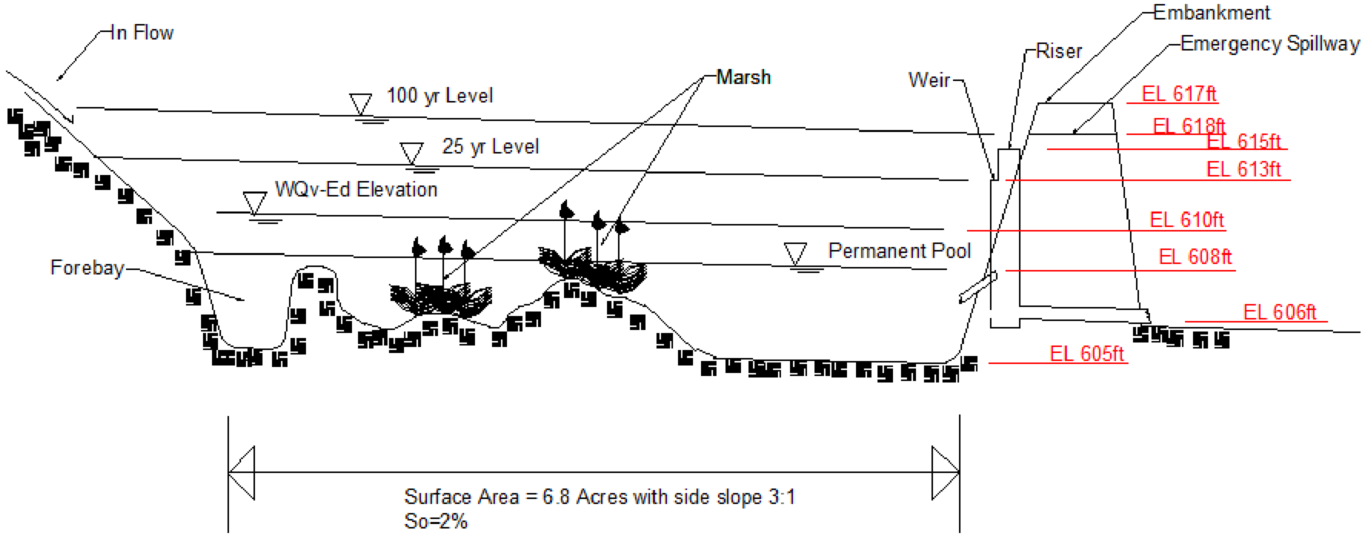


Figure D-1: Wetlands section schematic

Appendix E: Wet Detention Pond Calculations

$$\text{WQv}=\frac{(P)(R_v)(A)}{12}=\frac{(1.25)(0.14)(126.49)}{12}=\textbf{2.26 acre-feet} \qquad \text{(Eq. E-1)}$$

Water Quality Volume

V_B= 2*WQv = 2*2.26 = **4.53 acre-feet** (Eq. E-2)

Permanent pool volume

T = V_b/V_r = 4.53 acre-feet/126.45 acre-feet*(365 days/year) = **14 days** (Eq. E-3)

Detention Time

Depth of Pool = Direct Runoff/Surface Area=158 acre-feet/11.3 acres=**14 feet** (Eq. E-4)

Appendix F: Routing Calculations

Weir equation for Puls Method

The weir equation, take the weir length from the design b= 2 ft.

$Q=1.83\ bh^{3}/2 = 1.83\ (2)\ h^{3/2} = 3.66h^{3}/2$ (Eq. F-1)

The post development runoff hydrograph can be routed through the detention pond using time step=1 hour. The storage and out flow characteristics of the detention pond can be put in the following form:

Table F-1: Storage and Elevation Relationship

Storage (ft^3)	Elevation (ft.)	Outflow (ft^3/s)	2S/dT+O (ft^3/s)
0	0	0	0
237137	1	3.66	135.40
481096	2	10.35204	277.63
731949	3	19.01792	425.66
989768	4	29.28	579.15
1254625	5	40.92004	737.93
1526592	6	53.79079	901.90
1805741	7	67.78415	1070.97
2092144	8	82.81635	1245.12
2385873	9	98.82	1424.31
2687000	10	115.7394	1608.52
2995597	11	133.5273	1797.75
3311736	12	152.1433	1992.00
3635489	13	171.5521	2191.27
3966928	14	191.7225	2395.57

Table F-2: Modified Puls Method

Time (hr.)	Inflow ,I (cfs)	Inflow ,I (factored)	2S/dT-O (ft^3/s)	2S/dT+O (ft^3/s)	O (ft^3/s)
0	0.00	0.000	0.000	0.000	
1	0.00	0.000	0.000	0.000	0.000
2	3.42	0.437	0.414	0.437	0.012
3	21.72	2.780	3.434	3.631	0.098
4	84.44	10.809	16.103	17.023	0.460
5	198.46	25.403	49.486	52.314	1.414
6	357.79	45.797	114.161	120.686	3.262
7	536.23	68.637	212.506	228.595	8.045
8	665.11	85.135	335.194	366.277	15.542
9	**716.44**	91.704	462.447	512.032	24.793
10	688.11	88.078	574.421	642.229	33.904
11	594.26	76.065	656.625	738.564	40.970
12	474.00	60.672	702.821	793.363	45.271
13	349.66	44.756	715.370	808.250	**46.440**
14	230.68	29.527	699.694	789.653	44.980
15	130.72	16.732	662.853	745.952	41.549
16	59.71	7.643	612.821	687.227	37.203
17	18.71	2.395	557.891	622.859	32.484
18	3.28	0.420	504.612	560.706	28.047
19	0.35	0.045	456.421	505.077	24.328
20	0.00	0.000	414.311	456.466	21.078
21			377.603	414.311	18.354
22			345.194	377.603	16.205
23			316.579	345.194	14.307
24			291.314	316.579	12.632
25			269.007	291.314	11.153
26			249.115	269.007	9.946
27			231.094	249.115	9.010
28			214.769	231.094	8.163
29			199.980	214.769	7.394
30			186.583	199.980	6.699
31			174.447	186.583	6.068
32			163.452	174.447	5.497
33			153.493	163.452	4.980
34			144.470	153.493	4.511
35			136.297	144.470	4.087
			128.893	136.297	3.702

Appendix G: Outlet Structure Drawings

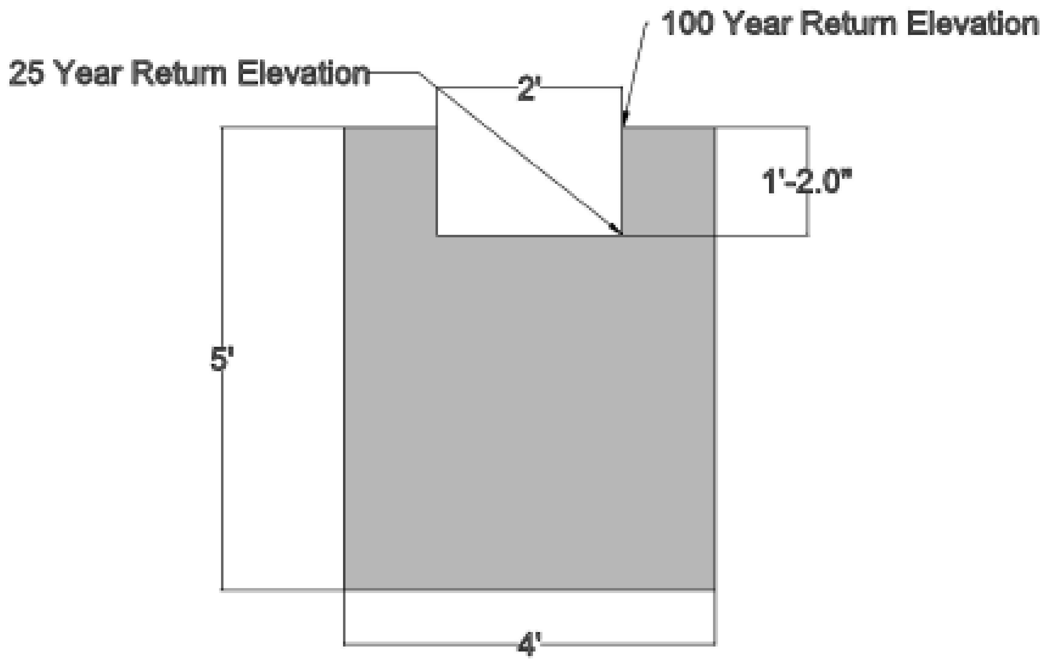


Figure G-1: Front Weir View of Outlet Structure

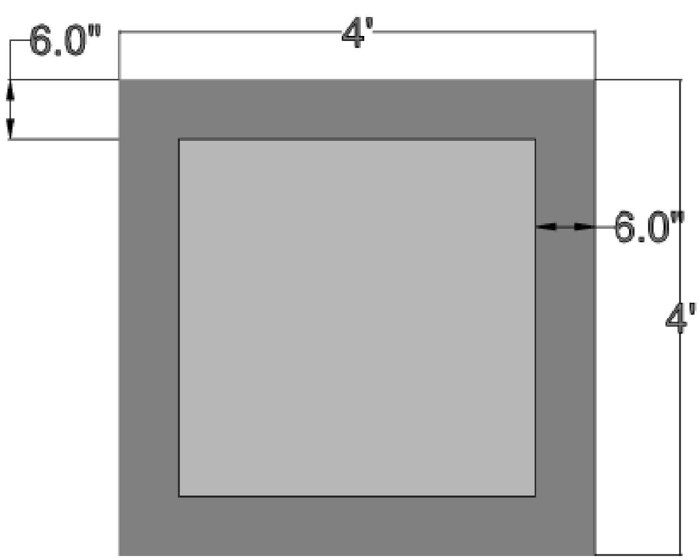


Figure G-2: Bottom View of Outlet Structure

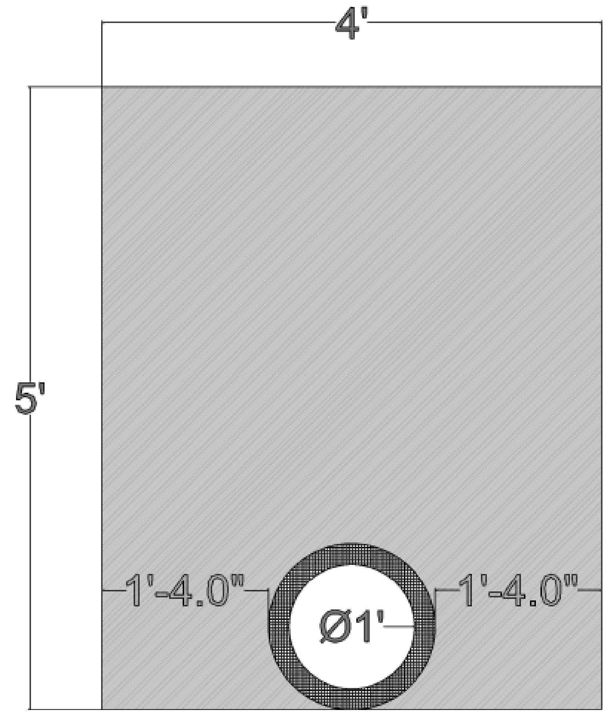


Figure G-3: Back Pipe View of Outlet Structure

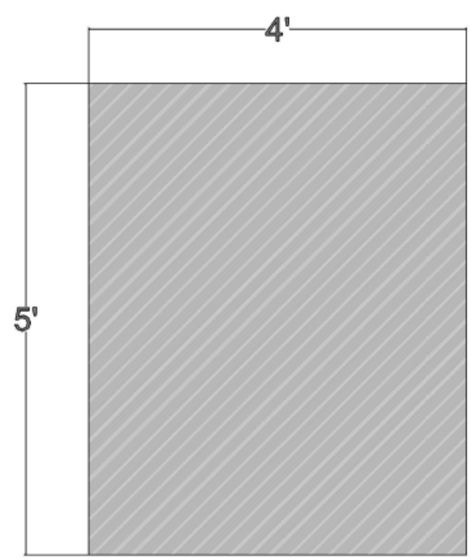


Figure G-4: Side Wall of Outlet Structure

Appendix H: Outlet Structure Sample Calculations

Single Stage Weir

$q_{pb} = Flow\ Rate\ into\ Weir$

$L_W = Weir\ Length$

$C_W = Weir\ Coefficient$

$h = Weir\ Height$

$$L_W = q_{pb}/(C_W h^{1.5}) \quad \text{(Eq. H-1)}$$

Lw= Qw/(Cw*(h^2/3)) = 1.284/(1.81*(1.15^3/2))=0.6 Feet

Single Pipe Outlet

$D = Pipe\ diameter$

$L = Pipe\ Length$

$Es = Water\ elevation\ at\ design\ Volume$

$Ec = Pipe\ Centerline\ elevation$

$q_{pb} = Runoff\ Rate$

$n = Mannings\ roughness\ coefficient$

$$C = 0.456 + 0.047(LK_p) - 0.0024(LK_p)^2 + 0.00006(LK_p)^3 \quad \text{(Eq. H-2)}$$

$$K_p = 5087\, n^2\, D^{-\frac{4}{3}} \quad \text{(Eq. H-3)}$$

$$D = 12C\, q_{pb}^{1/2}\, (Es - Ec)^{-\frac{1}{4}} \quad \text{(Eq. H-4)}$$

Diameter = 12*C*($L^{0.5}$)*(Es-Ec) $^{(-.25)}$ = 12*.5*($10^{0.5}$)*(595.23-594.73) $^{(-.25)}$ = 8.4 in.

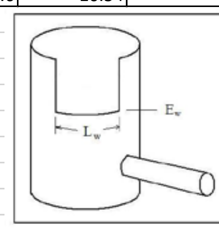
$$Q=\frac{1}{n}\frac{A^{5/3}}{P^{2/3}}S^{1/2} = 46.4=\frac{1}{0.06}\frac{(4*y+y^2)^{5/3}}{(4+2*y*10^2)^{2/3}}(0.02985)^{1/2}$$, **y=1.707 ft.** (Eq. H-5)

Appendix I: Outlet Structure Data

Table I-1: Outlet Structure

Single +A1:G33Stage Weir	25 and 100 Year	
Qo	1.284	
Cw	1.81	
Qw	1.284	
Lw	3.23	
h	1.15	
Hw	10.34	
Cd	0.6	Typical Value
Ao	0.40	
g	32.2	
Elev Ground	583.54	

Cw	Lw (ft)	Hw (ft)	Total Height of Structure (ft)
1.8	0.6	10.54	11.69



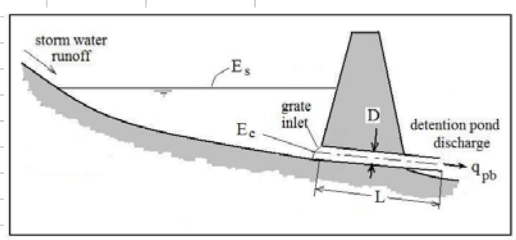
Weir Outlet Flow Control Parameters

Double Stage (Weir/ Orifice) 2,25,100 year		
Z	694.23	ft
Z0	593.45	ft
Z1	594.08	ft
Z2	595.23	ft
H0	0.5	ft
Q	1.284	cfs
Ao	0.25	ft^2
Cd	0.6	
Orifice Elev	652.96	ft

Z1 < Z

Cw	Lw (ft)	Hw	Total Height of Structure (ft)
1.8	0.6	9.91	11.69

Single Pipe outlet		
Ec, Outlet Pipe Elev.	594.73	ft
Es, Water Elevation (100 yr)	595.23	ft
Pre-Development peak	1.284	cfs
Pipe Length	10	ft
Mannings roughness	0.022	Metal-Corrugated
	0.012	Concrete
Trial Diameter	8.4	inches
Kp	0.1	
C	0.5	
Final Diameter	**8.4**	Inches



Storm Water Detention Pond with Pipe Outlet Control

Appendix J: Cost Estimations for Wet Detention Ponds

Table J-1: Bid Tabulation for Pond #1

Bid Tabulation Pond 1					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 92.5 acres				

Table J-2: Bid Tabulation for Pond #2

Bid Tabulation Pond 2					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improveme	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 92.5 acres				

Table J-3: Bid Tabulation for Pond #3

Bid Tabulation Pond 3					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 106.8 acres				

Table J-4: Bid Tabulation for Pond #4

Bid Tabulation Pond 4					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 81.5 acres				

Table J-5: Bid Tabulation for Pond #5

Bid Tabulation Pond 5					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 25%					
Total Costs					**$249,815.94**
	Drainage Area = 133.5 acres				

Table J-6: Bid Tabulation for Pond #6

Bid Tabulation Pond 6					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 106.8 acres				

Table J-7: Bid Tabulation for Pond #7

Bid Tabulation Pond 7					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	5,000	C.Y	$6.00	$30,000.00
2	Saftey Fencing	1,000	L.F.	$3.00	$3,000.00
3	Sodding	250	SQUARE	$50.00	$12,500.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	4	ACRE	$7,600.00	$30,400.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	500	L.F.	$2.50	$1,250.00
10	Import and Place Topsoil	350	S.Y.	$6.00	$2,100.00
11	Pond Lining	150	S.Y.	$11.25	$1,687.50
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	75	C.Y.	$25.00	$1,875.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	250	SQ	$13.50	$3,375.00
Total Construction Cost					$132,837.50
Contingency - 15%					
Total Costs					**$152,763.13**
	Drainage Area = 63.5 acres				

Table J-8: Bid Tabulation for Pond #8

Bid Tabulation Pond 8					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	10,000	C.Y	$6.00	$60,000.00
2	Saftey Fencing	2,000	L.F.	$3.00	$6,000.00
3	Sodding	500	SQUARE	$50.00	$25,000.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	8	ACRE	$7,600.00	$60,800.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,000	L.F.	$2.50	$2,500.00
10	Import and Place Topsoil	750	S.Y.	$6.00	$4,500.00
11	Pond Lining	225	S.Y.	$11.25	$2,531.25
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	100	C.Y.	$25.00	$2,500.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	500	SQ	$13.50	$6,750.00
Total Construction Cost					$217,231.25
Contingency - 15%					
Total Costs					**$249,815.94**
	Drainage Area = 155.2 acres				

Table J-9: Bid Tabulation for Pond #9

Bid Tabulation Pond 9					
General Work Items					
Item No	Description	Estimated Quantity	Units	Unit Price	Item Price
1	Class A Earthwork	15,000	C.Y	$6.00	$90,000.00
2	Saftey Fencing	3,000	L.F.	$3.00	$9,000.00
3	Sodding	750	SQUARE	$50.00	$37,500.00
4	Stabilized Construction Entrance	1	L.S.	$1,300.00	$1,300.00
5	Clearing and Grubbing	12	ACRE	$7,600.00	$91,200.00
6	Urban Temporary Seeding	1	ACRE	$1,700.00	$1,700.00
7	Field Office	1	EA	$5,500.00	$5,500.00
8	Detention Basin Area Improvements	1	L.S.	$7,900.00	$7,900.00
9	Silt Fencing	1,500	L.F.	$2.50	$3,750.00
10	Import and Place Topsoil	1,000	S.Y.	$6.00	$6,000.00
11	Pond Lining	700	S.Y.	$11.25	$7,875.00
12	Weir Outlet structure	1	EA	$4,000.00	$4,000.00
13	Pollution Control	1	L.S.	$5,000.00	$5,000.00
14	Mobilization and Demobilization	1	L.S.	$5,000.00	$5,000.00
15	Erosion Control Plan	1	EA	$5,000.00	$5,000.00
16	Riprap	150	C.Y.	$25.00	$3,750.00
17	12 Inch Pipe (Weir)	150	L.F	$75.00	$11,250.00
18	Slope Protection, Wood Excelsior	750	SQ	$13.50	$10,125.00
Total Construction Cost					$305,850.00
Contingency - 15%					
Total Costs					**$351,727.50**
	Drainage Area = 249.6 acres				

Appendix K: Cost Estimation Sample Calculations

Single Stage Weir

$q_{pb} = Flow\ Rate\ into\ Weir$

$L_W = Weir\ Length$

$C_W = Weir\ Coefficient$

$h = Weir\ Height$

$$L_W = q_{pb}/(C_W h^{1.5}) \quad \text{(Eq 1)}$$

Lw= Qw/(Cw*(h^2/3)) = 1.284/(1.81*(1.15^3/2))=0.6 Feet

Single Pipe Outlet

$D = Pipe\ diameter$

$L = Pipe\ Length$

$Es = Water\ elevation\ at\ design\ Volume$

$Ec = Pipe\ Centerline\ elevation$

$q_{pb} = Runoff\ Rate$

$n = Mannings\ roughness\ coefficient$

$$C = 0.456 + 0.047(LK_p) - 0.0024(LK_p)^2 + 0.00006(LK_p)^3 \quad \text{(Eq 2)}$$

$$K_p = 5087\, n^2\, D^{-\frac{4}{3}} \quad \text{(Eq 3)}$$

$$D = 12C\, q_{pb}^{1/2}\, (Es - Ec)^{-\frac{1}{4}} \quad \text{(Eq 4)}$$

Diameter = 12*C*(L^0.5)*(Es-Ec) ^(-.25)= 12*.5*(10^0.5)*(595.23-594.73)^(-.25) = 8.4 in.