Final Report

Stormwater BMP Master Plan
Volume 2: Appendixes

Submitted to

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CH2MHILL

with Howard R. Green Company

Wetland Permitting for Stormwater Management Facilities

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This memorandum is based on the Army Corps of Engineers (ACOE) guidance regarding their process to permit the siting of regional stormwater Best Management Practices (BMPs) in wetlands or waters of the United States (WOUS). The regional BMPs will provide both water quality and peak flow control through the use of techniques contained in the Sioux Falls Engineering Design Standards Chapter 11 *Drainage Improvements*, such as extended detention ponds (dry ponds) and retention ponds (wet ponds). Additional information has been included on the topics of cultural resources and listed species for the Sioux Falls area. The purpose of this Technical Memorandum (TM) is to educate future users on the permit process that may be triggered by the siting of stormwater BMPs.

The ways in which a South Dakota Department of Environment and Natural Resources (DENR) dam construction permit and a construction in the FEMA floodplain permit may influence the construction of a regional BMP facility are also discussed in this TM.

1. Introduction to the ACOE Wetland/WOUS Permit Process

Construction of regional stormwater BMPs in Sioux Falls is expected to initiate an ACOE permitting process in most, if not all, cases. The ACOE jurisdiction, potential permit requirements, and permitting options as related to wetlands and waters of the United States are described in Section 1.3.

It is important to consider other resource requirements, such as endangered species and cultural resources, early during the section 404 process. These are important issues, because as part of the wetland permitting and approval process, the ACOE must consider other resources. For example, one important consideration is the possibility that archaeological surveys may be required as part of the wetland permitting process for the project area and any proposed mitigation areas. Archaeological sites in the Sioux Falls area generally are found near perennial waters, especially in areas where bluffs are also present. The generalized distribution of unsurveyed areas that may contain archaeological sites is presented in the attached technical report. The attached report also contains information on areas already surveyed and known archaeological sites in the area. Archeological and endangered species issues are discussed further in Sections 3 and 4.

1.1 Purpose of a Department of the Army Section 404 Permit

The purpose of the Section 404 program is to insure that the physical, biological, and chemical quality of our nation's water are protected from irresponsible and unregulated discharges of dredged or fill material that could permanently alter or destroy these valuable resources.

1.2 What Work Requires a Section 404 Permit?

Section 404 of the Clean Water Act requires approval prior to discharging dredged or fill material into the waters of the United States. Typical activities requiring Section 404 permits include, but are not limited to:

- Depositing fill or dredged material in waters of the U.S. or adjacent wetlands.
- Site development fill for residential, commercial, or recreational developments.
- Construction of revetments, groins, breakwaters, levees, dams, dikes, and weirs.

Section 404 permits do not obviate the need to obtain other Federal, State, or local permits, approvals, or authorizations required by law. They do not grant any property rights or exclusive privileges. They do not authorize any injury to the property or rights of others, and they do not authorize interference with any existing or proposed Federal project.

Filling small amounts of wetlands/WOUS (i.e., less than 0.5 acre of wetland filled or less than 300 linear feet of stream bank altered) may qualify for a nationwide permit. Larger projects may require individual permits.

1.3 What are Wetlands and Waters of the United States?

The term "wetlands" means those areas that are inundated or saturated by surface or ground water 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 are areas characterized by growth of wetland vegetation (bulrush, cattails, rushes, sedges, willows, pickleweed, andiodine bush) and the development of hydric soils. The ACOE considers three elements to determine if an area is a wetland. These are hydrology, vegetation, and the presence of hydric soils. In normal circumstances, all three elements must be satisfied for an area to be identified as a wetland.

Waters of the United States include essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters. Perennial and intermittent streams (a.k.a. blue line streams), as shown through the use of blue lines on topographic maps prepared by the U.S. Geological Service, are considered to be within the jurisdiction of the ACOE regardless of the presence of adjacent wetlands.

The landward regulatory limit for waters (in the absence of adjacent wetlands) is the ordinary high water mark. The ordinary high water mark is the line on the shores established by the fluctuations of water and indicated by physical characteristics such as:

- a clear natural line impressed on the bank;
- shelving;
- changes in the character of the soil;
- destruction of terrestrial vegetation;
- the presence of litter and debris;
- or other appropriate means that consider the characteristics of the surrounding areas.

The regional BMPs will be located at sites that drain a large upstream area. Consequently, these facilities will often be in areas that are regulated by the ACOE.

1.4 How Are Wetlands Identified for Stormwater BMP Projects?

Given the large size of the City's future urbanizing area, the project team conducted a two-tiered desktop approach for wetland identification during the stormwater BMP Master Plan project planning. In the first tier, National Wetland Inventory (NWI) mapping was used and in the second tier, hydric soils information was considered.

The project team obtained NWI mapping for Lincoln and Minnehaha Counties from http://www.nwi.fws.gov/ accessed via the Internet February 3, 2003. Soils data were obtained from http://www.ftw.nrcs.usda.gov/ssur_data.html accessed via the Internet February 3, 2003.

The soils and wetland information for the Sioux Falls area is shown in Figure 1.

The NWI was prepared by the U.S. Fish & Wildlife Service (USFWS) through aerial photography interpretation. The USFWS used color infrared (CIR) aerial photographs interpreted by a trained professional. The NWI is considered by the South Dakota ACOE Regulatory Office to be a reliable indicator of overall wetland presence. However, the NWI is usually generated through the use of one year of aerial photographic coverage. The NWI is also heavily dependent upon the skill and experience of the aerial photograph interpreter and is, therefore, subject to an unquantified amount of error. Finally, NWI photointerpreted wetlands are not field-verified.

A hydric soil is one that is saturated, flooded, or ponded with water long enough during the growing season to develop anaerobic conditions in the upper horizon(s). The Natural Resource Conservation Service (NRCS) has developed local lists of hydric soils for each county or parish in the United States. These local lists are preferred for use in making preliminary wetland determinations. However, distinct soil areas of less than 3 acres are often not reported in the county soil surveys. Therefore, the absence of hydric soils data for a specific site does not necessarily mean that hydric soils are not present. Methods to verify hydric soils in the field are contained in the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual.

The NWI provides a strong indication as to the presence or absence of protected wetlands. When used together, the NWI information and the hydric soils information provide an even stronger predictor of the presence of wetland in a project area. The NWI and soils data provides a useful planning tool for identifying and avoiding large wetland areas or for minimizing impacts to wetlands. The use of such a planning tool allows for the avoidance and/or minimization of impacts to wetlands during the project planning phase. If NWI information indicates a wetland is present, a delineation survey using accepted Corps methodology is required during the permitting and design phase.

The project team obtained these data and considered them in conducting a first cut of regional BMP locations as a way of avoiding and minimizing wetland impacts. Criteria used in the siting evaluation was included in a separate TM titled *Criteria for Siting and Design of Regional BMP Facilities,* provided on February 18, 2003.

The City should use a planning horizon of no less than 2 to 3 years to select and schedule wetland and other appropriate resource surveys. This time frame is recommended to allow adequate time to conduct surveys, but to minimize the amount of time during which the circumstances in the project area can change (i.e. newly listed species). Project locations and rough estimates of their impacts (footprint) should be known prior to initiating surveys. The City should coordinate with the ACOE in order to ensure that the appropriate surveys are being planned and conducted. For example, if a project location is identified in an area known to be sensitive for archaeological resources, then the City should coordinate with the ACOE on the type of survey that appears to be required, survey methodology, the professional qualifications of the firm selected, and the expected results of the survey. This up front coordination will help to ensure that the ACOE will be able to accept the survey results when they become available. The City should coordinate the survey(s) results directly with the ACOE. Typically, the ACOE reviews the findings and forwards the survey information and its review findings to the State Historic Preservation Officer (SHPO) for SHPO review and comment. If the survey is being conducted in support of a Section 404 permit, then the survey results must be forwarded to the ACOE and not directly to other supporting agencies.

1.5 Who Should Obtain a Section 404 Permit?

Any person, firm, or agency (including Federal, state, and local government agencies) planning to work in waters of the United States, or place dredged or fill material in wetlands or waters of the United States, must first obtain a permit from the Corps of Engineers. Permits, licenses, variances, or similar authorization may also be required by other Federal, state and local statutes.

Since most, if not all regional BMP facilities will be located within waters of the United States, Sioux Falls should assume a permit will be required for these facilities until information is obtained and agreement with the ACOE shows otherwise.

1.6 Pre-application Consultation

To obtain permit requirements on a site specific basis, the ACOE is available for a consultation to discuss site specific permit requirements. The ACOE strongly encourages applicants to contact the Corps of Engineers as soon as reasonably possible to discuss proposed projects that would impact wetlands or WOUS. The ACOE South Dakota Regulatory Office is the first point of contact for such projects located in South Dakota. The ACOE South Dakota Regulatory Office is located at 28563 Powerhouse Road, Room 118, Pierre, SD 57501. Their phone number is 605-224-8531. Their fax number is 605-224-5945.

During the pre-application consultation, the ACOE will review the applicability of exemptions, nationwide, regional and individual permit requirements for the proposed project. They will also discuss what kinds of supporting studies (i.e., wetlands delineation, archaeological survey, listed species survey, etc.) they will require for an application to be considered complete. Individual project applications will be processed more efficiently when the ACOE has been engaged in a discussion of all information prior to application submittal.

A preliminary coordination meeting regarding establishment of stormwater BMPs in the future urbanizing area was held with the ACOE on January 29, 2003. Representatives from ACOE, USFWS, South Dakota Games Fish & Parks (SD GF&P), South Dakota Department of Environment and Natural Resources (SD DENR), and the South Dakota State Historic Preservation Officer (SD SHPO) were present.

The ACOE will also provide an official determination as to the need for a Department of the Army permit upon request. It is strongly recommended that an official determination be obtained in writing for all projects that do not require a Section 404 permit to ensure that the administrative record is complete in case the need for a permit is later challenged.

1.7 South Dakota Regional Conditions

South Dakota has specific conditions that are included and reviewed on Section 404 permit applications. These specific requirements must be considered by the ACOE for Section 404 permits in Sioux Falls.

The majority of Nationwide Permits, including Nationwide Permit 43 (Stormwater Management Facilities) are revoked for use in fens in South Dakota. Fens are defined as wetlands that are characterized by waterlogged spongy ground and contain (in all or in part) soils classified as histosols or mineral soils with a histic epipedon. To determine whether this provision applies, the entire wetland must be examined for the presence of histosols or histic epipedons. There is at least one report of a fen in the northeastern portion of the future urbanizing area. However, it is not known where this fen was located or if it remains in existence today.

Permittees must notify the Corps in accordance with General Condition No. 13 (Notification) for regulated activities located within 100 feet of the water source in natural spring areas in South Dakota. For purposes of this condition, a spring source is defined as any location where there is artesian flow emanating from a distinct point at any time during the growing season. Springs do not include seeps and other groundwater discharge areas where there is no distinct point source.

In order to further minimize adverse impacts in certain waters of the United States and to comply with General Condition No. 20 (Spawning Areas), projects authorized under all available Section 404 nationwide permits that would occur in South Dakota's cold water streams must comply with the following regional condition: in all South Dakota streams classified as cold water streams, when water flow is present, the discharge of dredged or fill material shall not take place between October 15 and April 1. Communication with the USFWS indicated streams designated as cold water streams only occur in the Black Hills region of South Dakota. Additional information on cold water streams in South Dakota can be obtained from the Corps of Engineers, the South Dakota Department of Game, Fish and Parks, or the South Dakota Department of Environment and Natural Resources.

2. Types of Section 404 Permits

There are three general types of Section 404 permits. They are:

- Nationwide General Permits
- Regional General Permits
- Individual Permits

Under 33 CFR Part 322.2(f) The term "general permit" means a Department of the Army authorization that is issued on a nationwide or regional basis for a category or categories of activities when:

1. those activities are substantially similar in nature and cause only minimal individual and cumulative environmental impacts; or
2. the general permit would result in avoiding unnecessary duplication of the regulatory control exercised by another Federal, state, or local agency provided it has been determined that the environmental consequences of the action are individually and cumulatively minimal.

Applicants qualifying for general permits prepare a simpler permit application and may receive permits with a lower regulatory burden.

One critical concept in Section 404 permitting is that of the “single and complete project.” This term is defined in 33 CFR 330.2(i) as the total project proposed or accomplished by one owner/developer or partnership or other association of owners/developers (see definition of independent utility). For linear projects, the “single and complete project” (i.e., a single and complete crossing) will apply to each crossing of a separate water of the United States (i.e., a single waterbody) at that location. Individual channels in a braided stream or river, or individual arms of a large, irregularly-shaped wetland or lake, etc., are not separate waterbodies. For stormwater BMPs, this means that there must be consideration of how multiple BMPs may or may not be considered to be one “single and complete project.” The key is whether or not the individual BMPs have independent utility and can operate in a stand-alone capacity. If they cannot operate independently and depend upon each other for function, then multiple BMP sites must be considered one single and complete project from a Section 404 permitting perspective.

2.1 Nationwide General Permits

Routinely referred to as nationwide permits, these are the simplest form of the Section 404 permits and authorize a category of activities throughout the nation. Assuming that a complete application is provided to the ACOE, a decision on a nationwide permit is possible in a relatively short time frame, often in less than 60 days. To apply for a nationwide permit, an application form must be completed and submitted to the ACOE. This application is available from all regulatory offices.

Nationwide permits are valid only if the applicable general conditions in Section 10.0 are met. If these conditions cannot be met, an individual permit will be required. There are a total of 43 Nationwide Permits that address activity in wetlands and WOUS in South Dakota. Examples of nationwide permits include:

- **Repair, rehabilitation, or replacement** of a structure or fill previously authorized and currently serviceable. The structure or fill must not be significantly changed.
- **Utility lines** placed across a waterway. Discharge of bedding and backfill material is permitted if bottom contours are not changed.
- **Single projects of less than 10 cubic yards** of fill. This could be used for riprap at a stormwater outfall, for example. Piecemeal work is not authorized.
- **Bank stabilization** projects less than 500 feet long containing less than an average of one cubic yard of material per running foot. The activity must be necessary for erosion protection and may not exceed the minimum amount needed for erosion protection. Fill

is not to be placed in wetland areas or in a manner that impairs water flow. Materials free of waste metal products and unsightly debris must be used and the activity must be a single and complete project.

- **Minor road crossing fills** (temporary or permanent) that place less than 200 cubic yards of fill below the ordinary high water mark. The crossing must be bridged or culverted to prevent restriction of high flows. The fill placed in waters of the US is limited to no more than one-third of an acre
- **Outfall structures**. See Nationwide Permit 7
- **Stormwater Management Facilities**. See Nationwide Permit 43

As discussed in Section 1.2, filling small amounts of wetlands/WOUS (i.e., less than 0.5 acre of wetland filled or less than 300 linear feet of stream bank altered) may qualify for a nationwide permit. Larger projects typically require individual permits.

2.2 Regional General Permits

Regional general permits are issued by the District Engineer for a general category of activities when two conditions are met. First, the activities are similar in nature and cause minimal environmental impact (both individually and cumulatively). Second, the regional permit reduces duplication of regulatory control by State and Federal agencies. The regional general permit has a 5-year duration.

There are no regional permits that are currently applicable to the construction of stormwater BMPs in the Sioux Falls area. Obtaining a regional permit may require more information and coordination, and cost more to prepare, than an individual permit. However, if multiple individual permit projects are anticipated over a 3- to 5-year period, then it may be more cost effective to develop a regional permitting system. This would streamline the permitting process for each separate and complete project that would required a Section 404 permit.

Thresholds are not applicable to regional general permits. Regional general permits are only triggered by projects that exceed nationwide permit thresholds and when the number of individual permits to be processed suggests that a regional general permit approach is advantageous. The regional general permit process is strongly advised if the City anticipates implementing multiple individual projects over a 5-year period.

2.3 Individual Permits

Individual permits and their associated review process are required when a project does not qualify for a nationwide or regional permit. They are issued following a full public interest review of an individual application for a Department of the Army permit. A public notice is distributed to all known interested persons. After evaluating all comments and information received, a final decision on the application is made. Processing time on a complete application usually takes 60 to 120 days unless a public hearing is required or an environmental statement must be prepared. Incomplete or complex applications can take much longer to process.

The permit decision is generally based on the outcome of a public process where the benefits of the project are balanced against the detriments. A permit will be granted unless the proposal is found to be contrary to the public interest.

To apply for an individual permit, an application form must be completed. This application is available from all regulatory offices. Depending upon the site, the application usually includes the following:

- Completed application form (required)
- Wetland delineation and jurisdictional determination for project area (required)
- Site plan and assessment of impacts to wetlands and WOUS
- Agency coordination letters or surveys for listed species
- Surveys or special studies of cultural resources
- Mitigation Plan and compensatory wetland mitigation
- Maintenance Plan for mitigation area(s) (required if mitigation is proposed)
- Conservation easement or deed restrictions to protect mitigation area (required if mitigation is proposed)

As discussed in Section 1.2, filling small amounts of wetlands/WOUS (i.e., less than 0.5 acre of wetland filled or less than 300 linear feet of stream bank altered) may qualify for a nationwide permit. Larger projects typically require individual permits.

2.4 Compensatory Mitigation

All three types of wetland permits may require compensatory mitigation. The ACOE defines compensatory mitigation as "the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved."

Permit applicants often seek permission to impact an existing wetland and promise to create a new wetland at the same site or elsewhere as compensation for the loss of the existing wetland. The ACOE and other regulatory agencies generally seek a replacement ratio in excess of 1:1 to account for the risk associated with wetland creation, and the fact that created wetlands may be of lower habitat value than the original wetland. The creation of compensatory mitigation does not guarantee that the applicant will be successful in creating a replacement wetland despite the fact that existing wetland would be destroyed. Thus, the ACOE uses a conservative approach by requiring the creation of more wetland than is destroyed with the overall goal of "no net loss" of wetland values through future replacement of existing wetlands.

Compensatory mitigation ratios are typically developed on a project-specific basis. A minimum of 1 acre of created wetland is required for each acre of existing wetland that is taken by a project. However, the replacement ratio for a created wetland typically is closer to 1.5 acres of created wetland for each acre taken because the created wetland does not exist and its creation cannot be guaranteed to be successful, however, the destruction of the existing wetland is assured. A replacement ratio in excess of 1 to 1 helps assure the ACOE will met its overall goal of "no net loss of wetlands." Additionally, consideration is given to the type of wetland lost (function, value, etc.) and the location of the proposed mitigation acreage. Impacts to forested wetlands typically require higher replacement ratios (2:1 or more) than impacts to grassland wetlands (1.5:1 or more) or ephemeral wetlands (1:1 or greater). Additionally, adjacent mitigation acreage is typically given more value than mitigation acreage that is not adjacent. As the distance between impacted and created wetland acreage increases, the replacement ratio also increases due to the localized loss of wetland value.

If replacement acreage already exists in a mitigation banking program, then the replacement ratios typically drop and can approach 1:1 because the replacement acreage already exists and has demonstrated wetland value. Consideration should be given to the establishment of a wetland mitigation bank to provide for replacement wetland acreage to take advantage of this relationship. Substantial savings may be achieved through mitigation banking programs because they remove the need to establish detailed mitigation plans for each impacted site.

3. Threatened and Endangered Species

All nationwide permit activity authorized by the ACOE must be in compliance with General Condition #7 (Endangered Species). The ACOE will not authorize any activity under any nationwide permit that is likely to jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Federal Endangered Species Act (ESA), or which will destroy or adversely modify the critical habitat of such species. Individual permits may be required for projects that would otherwise qualify for Nationwide Permit #43 (Stormwater Management Facilities), if General Condition #7 cannot be met.

A number of species are recognized by the federal government as threatened or endangered within South Dakota. They are presented in Table 1.

TABLE 1
Federally Listed Species in South Dakota

Status	Species Name		Notes
T	Bald Eagle	*Haliaeetus leucocephalus*	Bird. Known occurrence in Lincoln & Minnehaha counties Habitat: Wintering, breeding habitat in tall trees near lakes, reservoirs, or large rivers Nest tree reported on northeast side of City, near Big Sioux River, location reported by USFWS to be T 102 N, R 48 W, Section 30, unable to field verify due to the fact that the property was posted and access was not possible.
E	Topeka Shiner	*Notropis topeka*	Fish. Known occurrence in Lincoln & Minnehaha counties Habitat: Small, low order, prairie streams with high water quality and cool temperatures Reported in tributaries of Big Sioux River in Minnehaha County (Beaver Creek, Four-Mile Creek, Slip-up Creek, Split Rock Creek, Spring Water Creek, W. Pipestone Creek, and Willow Creek) and Vermillion River in Lincoln County (Blind Creek, Long Creek, and Saddle Creek)
T	Western Prairie Fringed Orchid	*Plantanthera praeclara*	Plant. Possible occurrence in Lincoln & Minnehaha counties Habitat: Wet grassland habitat, wet prairie remnants

Source: http://ecos.fws.gov/servlet/TESSWebpageUsaLists?state=SD, January 2003

Permit applicants are required to notify the District Engineer if any listed species or designated critical habitat might be affected by or is in the vicinity of a proposed project.

This means that surveys for listed species may be required prior to submittal of a permit to alter regulated waters and wetlands in certain cases. It is important to plan ahead if biological surveys are required; some species are seasonal in nature and fieldwork may be required during specific times of the year.

For activities that may affect Federally-listed endangered or threatened species or designated critical habitat, the preconstruction notification (General Condition 13) must include the name(s) of the endangered or threatened species that may be affected by the proposed work or that utilize the designated critical habitat that may be affected by the proposed work. The District Engineer may add species-specific regional endangered species conditions to the nationwide permits as a result of either formal or informal consultation with the USFWS. Projects are not permitted to begin until the District Engineer finds the requirements of the Endangered Species Act have been met.

There are also species that are listed at the state level that do not become listed at the federal level. Typically, these are known as "state-listed" species. The level of consideration for state listed species is dependent upon the type of permit being sought. For Individual Permits and General Permits, the ACOE will solicit comments from the resource agencies and take them under advisement in consideration of permit issuance. No consideration for state listed species is given by the ACOE for nationwide permits because the ACOE has not received a list of species from the state, or any special condition requests from the state (Oehlerking 2003).

If the ACOE is aware of a state-listed species and the project under consideration may affect the species, the ACOE would likely give it serious consideration under the Individual and/or General permit process as a public interest factor. However, it may not be an absolute "stopper" of a project. The level of consideration given a known state species, or its habitat, is the same as the level of consideration given other commentors and/or agencies on behalf of the public. The ACOE will also comply with the Fish and Wildlife Coordination Act, the Migratory Bird Treaty Act and other relevant Federal laws (Oehlerking 2003).

Authorization of an activity by a nationwide permit does not authorize the "take" of a threatened or endangered species as defined under the Federal Endangered Species Act. In the absence of separate authorization (e.g., an ESA Section 10 Permit, a Biological Opinion with "incidental take" provisions, etc.) from the USFWS, both lethal and non-lethal "takes" of protected species are in violation of the Endangered Species Act.

3.1 Species Specific Information

3.1.1 Bald Eagle. The threatened bald eagle is known to occur in Minnehaha and Lincoln Counties. During the winter, this species feeds on fish in the open water areas created by dam tailwaters, the warm water effluents of power plants and municipal and industrial discharges, or in power plant cooling ponds. The more severe the winter, the greater the ice coverage and the more concentrated the eagles become. They roost at night in groups in large trees adjacent to the river in areas that are protected from the harsh winter elements. They perch in large shoreline trees to rest or feed on fish. There is no critical habitat designated for this species.

Recommended management strategy: Bald eagles may not be harassed, harmed, or disturbed when present nor may nest trees be cleared. Close coordination between the City and the USFWS is recommended whenever a project is proposed to take place within one mile of the existing nest tree in the northeast portion of the City.

3.1.2 Topeka Shiner. The Topeka shiner is a small minnow, normally less than 3 inches long. The head is short, with a small mouth, large eyes, and a large dorsal fin. The Topeka shiner is silvery-green in color, with a distinct dark stripe preceding the dorsal fin and a dusky stripe along the entire length of the fish. The scales above this line are outlined with dark pigment, appearing cross-hatched, while the scales below this line have no pigment, appearing silvery-white in color (USFWS 2003).

Topeka shiners live in small to mid-size prairie streams in the central United States. These fish inhabit streams, which usually run continually and that have good water quality and cool to moderate temperatures. Occasionally, Topeka shiners have been found in larger streams, downstream of larger populations. They usually live in pools and run areas of streams. In Iowa, Minnesota and portions of South Dakota, the species also lives in oxbows and off-channel pools. The streams that the Topeka shiner inhabits must have plenty of aquatic or invertebrate food sources, and few competitive non-native species present. The Topeka shiner's historic range includes portions of Iowa, Kansas, Minnesota, Missouri, Nebraska, and South Dakota. It continues to exist in portions of these states (USFWS 2003).

Topeka shiners were historically reported to occur within the City of Sioux Falls in Willow Creek, however, they are not known to exist there today. They are reported to occur in the vicinity of Sioux Falls in Slip-up Creek, West Pipestone Creek, Split Rock Creek and one of its unnamed tributaries, Beaver Creek, and Four-Mile Creek, These creeks are all tributaries of Big Sioux River and are found north and east of the City in Minnehaha County. They are also reported to occur in Blind Creek, Long Creek, and Saddle Creek, which are tributaries of the Vermillion River in Lincoln County (USFWS 2003).

A recent study titled, *Topeka Shiner (Notropis topeka) Population Status and Habitat Conditions in South Dakota Streams*, was completed in 2001 (Wall et. al. 2001). This study included information on the known distribution of Topeka shiners and identified streams that could contain them based on the results of a model that utilized data on their distribution and habitat preferences. Copies of this report have been provided to the City of Sioux Falls. The report indicates that there are many streams that have the potential for Topeka shiner presence and that they are more widely found than was previously known. One of the potential locations is the Skunk Creek drainage, which is found on the west side of the City.

As of January 2003, the USFWS has proposed critical habitat for the Topeka shiner. As shown in Figures 3 and 4, the general locations of proposed critical habitat on the Lower Big Sioux Watershed in the Sioux Falls vicinity include Slip-up Creek, Split Rock Creek, West Pipestone Creek, Beaver Creek, and Four-Mile Creek. General locations of proposed critical habitat on the Vermillion River Watershed in the Sioux Falls vicinity include Camp Creek and Long Creek.

Recommended management strategy: Surveys for Topeka shiners should be conducted by a qualified wildlife biologist for proposed work in or adjacent to any of the streams where Topeka shiners are reported to be found, or streams that are proposed critical habitat. Plans should be made to incorporate riparian buffers that include trees, shrubs, and native grasses along streams that may be Topeka shiner habitat.

3.1.3 Western Prairie Fringed Orchid. The western prairie fringed orchid is listed as threatened and is considered to potentially occur based on historical records and habitat distribution. It occupies wet grassland habitats. There is no critical habitat designated for this species. Federal regulations prohibit any commercial activity involving this species or the destruction, malicious damage, or removal of this species from federal land or any other lands in knowing violation of state law or regulation, including state criminal trespass law.

Recommended management strategy: The western prairie fringed orchid should be searched for by a wildlife biologist or other qualified person whenever wet prairie remnants are encountered. Typically, wet prairie remnants are found in undisturbed areas inhabiting the transition zone between upland prairie and low-land wetlands.

4. Cultural Resources

The ACOE will not approve any activity that may affect historic properties listed, or eligible for listing, in the National Register of Historic Places until the District Engineer has complied with the ACOE's cultural resource procedures (found at 33 CFR part 325, Appendix C). There are many federal laws that address various aspects of our shared cultural heritage. Some of the more commonly encountered cultural resource laws are:

- American Indian Religious Freedom Act (AIRFA)
- Antiquities Act of 1906
- Archaeological Data Preservation Act of 1974
- Archaeological Resources Protection Act (ARPA)
- Historic Sites Act (HSA) of 1935
- National Historic Preservation Act (NHPA) of 1966
- Native American Graves Protection and Repatriation Act (NAGPRA)
- South Dakota State Law SDCL 1-19A-11.1

Of these, the National Historic Preservation Act (NHPA) is the law that is most likely to be triggered by a stormwater BMP project. The NHPA requires the federal government to consider the effects proposed actions would have on historic property[1] important to the nation's history. All cultural resource work is required to be performed under the supervision of a professional that meets the Secretary of the Interior's Professional Qualifications Standards. Due to the sensitive nature of archaeological site information, site-specific information is typically treated as confidential if the security of the information cannot be assured.

South Dakota state law 11.1 addresses the preservation of historic property. It states that the state or any political subdivision of the state may not undertake any project which would encroach upon, damage, or destroy any historic property included in the National Register of Historic Places or the State Register of Historic Places until the South Dakota State Historical Society has been given notice and an opportunity to investigate and comment on the proposed project. Unlike the NHPA, this law only applies to historic property that has been listed on the National Register.

[1] Historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria. The term eligible for inclusion in the National Register includes both properties formally determined as such in accordance with regulations of the Secretary of the Interior and all other properties that meet the National Register criteria [36 CFR 800.16.l].

The applicant must notify the District Engineer if the proposed activity may affect any historic properties listed, determined to be eligible, or which may be eligible for listing on the National Register of Historic Places. The applicant is not allowed to begin the activity until notified by the District Engineer that the requirements of the NHPA have been satisfied. For activities that may affect historic properties, the notification must state which historic property may be affected by the proposed work or include a vicinity map indicating the location of the historic property.

If an area has not previously been surveyed for archaeological resources and such a survey is required, then the first step is typically a Phase I Archaeological Reconnaissance Survey (a.k.a. Phase I Survey). The goal of the reconnaissance survey is the identification of archaeological resources. Reconnaissance surveys typically seek to identify all archaeological sites (both pre-contact and historic) in the project area of potential effect (APE), especially those that may meet the criteria of significance regarding eligibility for listing on the National Register of Historic Places.

An archaeological reconnaissance survey usually begins with a background records and literature search to determine the presence of any known sites in the project APE. The APE is considered to be any intact ground that will be impacted by the project within construction limits and staging areas. The background search typically includes inspection of state site files, previous archaeological work, topographic maps, aerial photographs, plat and other historic maps or atlases indicating the potential presence of archaeological resources. Any other relevant sources usually are included in the pre-field background work. The pre-fieldwork investigation summaries usually are limited to brief, basic descriptions unless subsequent fieldwork locates archaeological sites requiring detailed environmental or cultural context backgrounds.

An archaeological reconnaissance survey typically produces an inventory of archaeological resources (both pre-contact and historic) in the project APE. Specific portions of the APE are subjected to various archaeological survey methods based on a combination of factors including the location of known sites, the results of the background research, vegetation cover, landscape position, and the potential for deeply buried cultural resources.

For some projects involving archaeological resources, an intensive literature search may be required prior to a field survey. An intensive literature search usually is directed toward identifying areas where potentially significant archaeological resources are likely to survive intact within the project APE. This provides a detailed land use history of the specified project area in addition to providing the contextual background for any further analysis. The intensive literature search may include state site files, cultural resources reports, local histories, atlases, plat, insurance and real estate maps, census documents, City or local directories, historic photographs, early aerial photographs, assessor’s records, permitting records, and newspaper or oral accounts.

Information on the location and existence of historic resources can be obtained from the SHPO and the National Register of Historic Places. The SHPO reflects the interests of the State and its citizens in the preservation of their cultural heritage. The SHPO advises and assists Federal agencies in carrying out their Section 106 responsibilities to ensure that historic properties are taking into consideration at all levels of planning and development.

Assuming normal circumstances, a preliminary coordination meeting with the ACOE should be held as soon as is reasonable when siting individual BMPs. This meeting should include discussion of known historic property in the project area and the potential for unknown resources to also exist in the project area. The ACOE will consider the location of known resources and the probability for unknown resources to be present in their determination of whether or not to require a specific cultural resource survey. Typically, an archaeological reconnaissance survey is required if undeveloped or agricultural land is proposed for disturbance. These surveys typically require archival research, field research, and the laboratory analysis of artifacts, if recovered during field research, report preparation, and report review. This type of survey can require several months to complete, several more months to be reviewed by the ACOE and the State Historic Preservation Officer (SHPO). For an individual site, the cost for these types of studies ranges depending on the size and complexity of the project area.

Federal agencies are obliged to ensure that an agency official takes responsibility for Section 106 compliance. The agency official has approval authority for the undertaking and can commit the Federal agency to take appropriate action as a result of Section 106 compliance. The agency official has the authority to commit the Federal agency to any obligation it may assume in the implementation of a program alternative. Each federal agency is also responsible for the protection of historic resources and to ensure that all actions taken by employees or contractors of the agency shall meet the appropriate professional standards.

4.1 Data: Cultural Resources

The Archaeology Laboratory at Augustana College was retained to conduct a sensitivity analysis of the City's future urbanizing area. This analysis was based on the results of previously conducted surveys, known archaeological sites, previously mapped mound groups, the relationships between land forms (i.e., bluffs or perennial water) with known archaeological surveys, and the experience of the professional archaeologists that have worked in the area for approximately 2 decades. The results of this sensitivity analysis are contained in Attachment 1, *Draft Archaeological Sensitivity Analysis, Stormwater Best Management Practices (BMP) Project, Sioux Falls, South Dakota* and in a GIS layer that provides detailed spatial information on sensitive areas. Figure 2 shows areas of high sensitivity (potential) for archaeological resources. One of the most sensitive archaeological resources in the Sioux Falls vicinity is the Blood Run National Historic Landmark, which is located to the southeast of the City along the South Dakota/Iowa border on the Big Sioux River. Blood Run appears to be outside of the future urbanizing area.

If human remains are uncovered during construction activity, work must stop immediately and the appropriate City personnel must be notified immediately. It is important to remember that accidental disturbance of human remains is acceptable; however, intentional disturbance of human remains can result in criminal prosecution of the offending party. All construction personnel and all involved parties must be informed of and understand the process and the difference between accidental discovery and intentional disturbance.

5. DENR Dam Permit

The South Dakota Department of Environment and Natural Resources (DENR) requires that a permit be obtained for dam construction when a dam is either over 25 feet high or if it impounds 50 acre-feet or more of water. The detailed regulations of when a permit is required can be found in the South Dakota statutes, Chapter 74:02:08 Safety of Dams. On-line information on the dam safety program can be found at http://www.state.sd.us/denr/denr.html. The contact person at the DENR for dam permits is Tim Schaal, phone: (605) 773-3352, email: Tim.Schaal@state.sd.us.

Initial discussions with the DENR indicate that the type of permit necessary for a dam project requiring a permit could be either a Flood Control Permit or a Water Right Permit for Nonirrigated Water Use, depending upon the specific BMP situation. A dam permit review requires the review of plans and specifications. The review process includes:

- Receive plans and specifications (60 days to review and make report and recommendation)
- Advertise in paper for 2 weeks to receive any comments
- Review of the report and recommendations made by DENR staff by the water management board, which meets every other month
- The overall process can take 2 to 5 months to obtain approval once an application is received

BMP implementation should consider the dam permit requirements. The exact requirements of the permit application will depend upon the dam classification. The tables below list the dam classifications in South Dakota. The information is taken from Chapter 74:02:08.

As the tables indicate, the design standards could vary slightly depending upon the dam classification. A breach analysis report must be completed by the owner for the proposed dam if a preliminary risk assessment indicates that the dam is a category 1 or 2 dam and must be submitted to the Chief Engineer with the plans and specifications during the permit application. Exact plan requirements are detailed in Chapter 74:02:08.

DAM PERMIT TABLE 1
Dam Category Definition

Category	Loss of life potential	Economic Loss Potential
3	None expected	Minimal (undeveloped to occasional structures)
2	None expected	Extensive (community or industry)
1	Potential loss	Extensive (community or industry)

DAM PERMIT TABLE 2
Dam Size Definition

Size	Storage Capacity (acre-feet)	Height (feet)
Small	50 to 1000	25 to 40
Intermediate	1001 to 50,000	41 to 100
Large	Greater than 50,000	Greater than 100

DAM PERMIT TABLE 3
Spillway Design Criteria

Category	Size	Spillway Design Flood
3	Small	50-year frequency unless dam qualifies for § 74:02:08:07.01 exception
	Intermediate	100-year frequency
	Large	0.5 Probable Maximum Flood (PMF)
2	Small	100-year frequency
	Intermediate	0.5 PMF, unless dam qualifies for § 74:02:08:07.02 exception
	Large	PMF
1	Small	0.5 PMF
	Intermediate	0.5 PMF
	Large	PMF

6. FEMA Floodplain Issues

Some regional stormwater BMPs could be located within a floodplain. Consequently, certain requirements will have to be met in order to build a BMP within the floodplain. Floodplain jurisdiction within South Dakota is controlled through individual communities enrolled within the national flood insurance program (NFIP). Consequently, requirements will be limited to the local jurisdictional level, which will likely be the City of Sioux Falls. Floodplain management in Sioux Falls is controlled through the Planning and Building Services Department. If land is not annexed before constructing the regional BMPs, it is possible that Minnehaha and Lincoln Counties could be involved depending upon the location of the regional BMP. Minnehaha County is adopting very similar floodplain ordinance language to what is already in place in Sioux Falls. Consequently, the requirements will likely be very similar if not exactly the same.

GIS floodplain mapping available from the Sioux Falls GIS department will be used to determine when a regional BMP site is located within the 100-year floodplain.

Where construction is proposed within a delineated floodway, a no-rise certification is required. This means that any fill placed must not cause an increase in the water surface elevation. Where construction is proposed outside of the floodway, but within the floodplain, fewer requirements need to be met.

If a situation arises where the floodplain water surface elevation does increase within a FEMA mapped area, then a Conditional Letter of Map Revision (CLOMR) and a Letter of Map Revision (LOMR) of the revised floodplain should be coordinated with FEMA.

At the time of design, a CLOMR request would be initiated with FEMA to show the expected floodplain impact of the project. It is desirable to have the CLOMR approved prior to construction. Once the project is completed, a LOMR request to FEMA formally changes the mapped floodplain.

Any design within the floodplain should consider these requirements and coordinate with the appropriate organization (Sioux Falls Planning and Building Services, Minnehaha County Planning, or Lincoln County Planning).

7. Stormwater Permit for Construction Activities

For construction sites which disturb one or more acres, a stormwater permit for construction activities is required from the South Dakota Department of Environment and Natural Resources (DENR). A Notice of Intent (NOI) must be submitted to the DENR at least 15 days prior to the start of construction activity. As required under the general permit, a Stormwater Pollution Prevention Plan must be developed prior to construction activities. The Plan must include erosion and sediment control best management practices.

Additional permit requirements and NOI information can be obtained from the DENR via the Internet at http://www.state.sd.us/denr/DES/Surfacewater/stormcon.htm. The contact for the DENR stormwater program is Stacy Reed, phone: 1-800-737-8676.

8. Permitting Approach Summary

As discussed in Section 1.4, the City should use a planning horizon of no less than 2 to 3 years to select and schedule wetland and other appropriate resource surveys. Project locations and rough estimates of their impacts (footprint) should be known prior to initiating surveys. The City should coordinate with the ACOE at this time in order to ensure that the appropriate surveys are being planned and conducted. For example, if a project location is identified in an area known to be sensitive for biological or archaeological resources, then the City should coordinate with the ACOE on the type of survey that appears to be required, survey methodology, the professional qualifications of the firm selected, and the expected results of the survey. This up front coordination will help to ensure that the ACOE will be able to accept the survey results when they become available. The City should coordinate the survey(s) results directly with the ACOE. Typically, the ACOE reviews the findings and forwards the survey information and the ACOE's review findings to cooperating agencies for their review and comment. If the survey is being conducted in support of a Section 404 permit, then the survey results must be forwarded to the ACOE and not directly to other supporting agencies.

In general, a strategy employing nationwide permits for smaller projects on ephemeral streams and a Regional General permit to site larger projects either on or off of perennial streams would likely be the most cost effective permitting strategy. The more individual permits that would be required within a 5-year timeframe, the more cost effective a Regional General permit approach would be.

It can be advantageous to permit single sites if the sites qualify for a nationwide permit, while it can be advantageous to permit multiple sites together if they each would trigger an Individual Permit. The advantage of combining projects is that the permit process has to be navigated fewer times while the disadvantage is that some BMP sites may qualify for the less rigorous nationwide permit requirements.

TABLE 2
Permitting Strategy Matrix

Type of Section 404 Permit	Advantages	Disadvantages
Nationwide Permit	No public review, limited agency review results in quicker review cycle Complete application package requires less work than that required for Individual permit	Applicable only to projects that impact minimal amounts of wetland (less than 0.5 acre) or stream bed (less than 300 linear feet) Nationwide permit #43 (stormwater control features) cannot be used to establish stormwater control features in perennial streams
Individual Permit	Required for large impacts to wetlands (greater than 0.5 acres) or large impacts to stream beds (greater than 300 linear feet) Required if stormwater control feature is in perennial streams Required if not all of the 21 general conditions of a nationwide permit are met	Application package requires substantially more work than for a nationwide permit Mitigation plans and mitigation monitoring reports are typically required Mitigation ratios vary with the type of existing wetland to be impacted; ratios for impacts to wooded wetlands are higher than for emergent or grassland wetlands ACOE, public, and agency review cycle requires additional time to process permit request
Regional General Permit	Can provide substantially shorter review cycles for projects that would otherwise require Individual permits Can greatly streamline entire Section 404 permit process for large projects, especially when several large projects are proposed within a 5-year period Best overall approach if substantial numbers of Individual permit projects are anticipated to take place within a 5-year timeframe because it streamlines the review process and paperwork requirements	Typically requires substantial up-front work prior to gaining ACOE approval May require mitigation bank to be in-place prior to gaining ACOE approval Permit good for 5 years, then must be reauthorized or renewed

The City should also consider establishing a wetland mitigation bank. Established wetland mitigation areas can result in lower mitigation ratios and lower permitting costs. This is because, theoretically at least, only one mitigation plan and one annual mitigation monitoring report would be required; rather than mitigation plans and monitoring reports for each individual wetland permit site.

The following table lists several permits that are typically associated with constructing regional BMP facilities. A time duration range is provided for each activity. The actual duration could be shorter or longer depending upon the natural resource specifics of a particular site.

TABLE 3
Permit Action and Planning Time Considerations

Permit/Permit Action	Required Activity	Duration Range	Purpose
404 Permit/Application ACOE is lead agency and will typically complete without extensive outside involvement	Nationwide permit application	30-60 day ACOE review cycle; preparation of application package can require 15 days to 6 months depending upon complexity of project and site conditions	Permission to alter minor amount (less than 0.5 acres) of wetlands or minor amount of stream (less than 300 feet)
404 Permit/Delineation ACOE is lead agency, USFWS and NRCS provide input during development of delineation	Wetland delineation survey	15 to 30 days to prepare, typically conducted during growing season, can be conducted any time ground is not obscured by heavy snow cover	Identification of land that meets the definition of wetland according to the ACOE's 1987 Wetland Delineation Manual. Purpose is to obtain jurisdictional determination from the ACOE
404 Permit/Cultural Resources ACOE is lead agency for wetland permits and will coordinate with tribes, SHPO, and other interested parties	Cultural resources survey	Duration is highly dependent upon size of area and complexity of resources. Fieldwork cannot be conducted when the ground is frozen or obscured by heavy snow cover.	
		Reconnaissance surveys (Phase I) typically require 1–4 weeks of fieldwork, 1–2 months for report preparation, and 2–4 months of regulatory and/or tribal review	Identification of cultural resources (historic property) that must be considered during the review process.
		Evaluation of site significance (Phase II) typically requires 2–4 weeks of fieldwork, 2–3 months for report preparation, and 3–6 months of regulatory and/or tribal review (timing is highly variable depending on extent of resources)	Determination of significance of sites identified during Phase I, must answer question, "are sites eligible for inclusion in National Register of Historic Places?"
		Data recovery (Phase III) work is highly dependent upon the site situation and can require significant time to complete.	Recover important data when sites will be destroyed by proposed project to mitigate for loss of artifacts and/or data
404 Permit/Application ACOE is lead agency and will coordinate with other agencies and the public as appropriate	Individual permit application	60 – 120 day ACOE review cycle; preparation of application package can require 2 to 6 months depending upon complexity of project and site conditions	Permission to alter more than 0.5 acres of wetlands or more than 300 feet of stream
404 Permit/Endangered Species ACOE is lead agency for wetland permits and would typically involve USFWS, DENR, and SD Fish & Game as appropriate.	Endangered species survey	Duration varies depending upon type of species being surveyed. Can easily require one or more years to complete due to the need to conduct fieldwork during appropriate time of year.	Permit to impact listed species or critical habitat

TABLE 3
Permit Action and Planning Time Considerations

Permit/Permit Action	Required Activity	Duration Range	Purpose
Dam permit (DENR)	Meet South Dakota Chapter 74:02:08 requirements. Plan and specifications review.	2 to 5 months	Dam safety review for dams meeting minimum threshold of 25 feet high or 50 acre-feet storage. Requirements vary by dam classification category.
Floodplain (Sioux Falls, County)	Required when construction occurs in floodplain.	Estimated 30 to 60 days	No-rise certification if in mapped floodway or FEMA map revision.
Stormwater permit for construction activities (DENR)	Submit NOI, develop stormwater pollution prevention plan	NOI 15 days prior to construction	Meet erosion and sediment control requirements for construction sites.

The following table illustrates various phases of the BMP design, Section 404 permit application, and construction process, and typical tasks associated with the support and implementation of these processes.

TABLE 4
Permitting Actions Associated with BMP Project Phase

Phase	Tasks
BMP Alternatives Evaluation	Document alternatives sites that were considered and how impacts to wetlands and WOUS were avoided
Preliminary BMP Design	Review NWI wetlands and hydric soils GIS layers to get general idea of potential wetlands – seek to avoid impacts if practicable Consider archaeological sensitivity GIS layer and consider the need for archaeological surveys Consider other factors, such as listed species surveys
Secure site access	Consider possible need to survey outside of actual BMP footprint when securing access permission
Conduct wetland delineation	Incorporate field results (hydrology, hydric soil indicators, & wetland vegetation) with information on NWI wetlands, hydric soils, NRCS farmed wetlands, etc. Identify wetlands subject to ACOE jurisdiction according to ACOE 1987 Wetlands Delineation Manual. Prepare written report and submit to Corps for jurisdictional determination .
Consider need for other resource surveys	Review archaeological sensitivity analysis and listed species information; conduct surveys if appropriate
Precoordination meeting with ACOE	Review results of wetland delineation and other resource surveys with ACOE, develop overall permitting approach (individual or nationwide permit), develop appropriate mitigation ratio, discuss results of other resource surveys if available or need for other surveys if not yet conducted

TABLE 4
Permitting Actions Associated with BMP Project Phase

Phase	Tasks
Preconstruction Notification	Provide preconstruction notification information to ACOE. Depending on the site, this can include: Completed application form (required) Detailed description of proposed action design (plans and cross-sections, grading plans, design details, etc.)—this is required Wetland delineation for project area (required) Agency coordination letters or surveys for listed species as agreed-upon during precoordination meeting Surveys or special studies of various cultural resources as agreed-upon during precoordination meeting Mitigation Plan to provide compensatory wetland mitigation according to previously established ratio Maintenance Plan for mitigation area(s) (required if mitigation is proposed) Conservation easement or deed restrictions to protect mitigation area (required if mitigation is proposed)
Permit Review	ACOE leads review cycle, other agencies participate to the degree considered necessary by the ACOE ACOE will take lead on cultural resource issues and coordinate with SHPO and Native American tribes as appropriate ACOE will conduct their own public review of requests for individual permits
Receive Permit to Alter Wetlands	Conduct work as proposed in Preconstruction Notification
Construct BMP (and Mitigation Site if Required)	File as-builts with the ACOE upon completion of construction of mitigation site & BMP; conduct mitigation monitoring & submit annual report to ACOE

9. Nationwide Permit 43, Stormwater Management Facilities

The ACOE has provided Nationwide Permit #43 for the discharge of dredged or fill material into non-tidal waters of the United States for the construction and maintenance of stormwater management facilities. This permit includes activities for the excavation of stormwater ponds/facilities, detention basins, and retention basins; the installation and maintenance of water control structures, outfall structures and emergency spillways; and the maintenance dredging of existing stormwater management ponds/facilities and detention and retention basins.

Nationwide Permit #43 requires that the proposed activity meet all of the following criteria:

a. The discharge for the construction of new stormwater management facilities does not cause the loss of greater than 1/2 acre of non-tidal waters of the United States;

b. The discharge does not cause the loss of greater than 300 linear feet of a streambed, unless for intermittent streambeds this criterion is waived in writing pursuant to a determination by the District Engineer, as specified below, that the project complies with all terms and conditions of this nationwide permit and that any adverse impacts of the project on the aquatic environment are minimal, both individually and cumulatively;

c. For discharges causing the loss of greater than 300 linear feet of intermittent streambeds, the permittee notifies the District Engineer in accordance with General Condition 13 (Notification). In such cases, to be authorized the District Engineer must determine that the activity complies with the other terms and conditions of the nationwide permit, determine the adverse environmental effects are minimal both individually and cumulatively, and waive this limitation in writing before the permittee may proceed;

d. The discharge of dredged or fill material for the construction of new stormwater management facilities in perennial streams is not authorized;

e. For discharges or excavation for the construction of new stormwater management facilities or for the maintenance of existing stormwater management facilities causing the loss of greater than 1/10 acre of non-tidal waters, provided the permittee notifies the District Engineer in accordance with the General Condition 13 (Notification). In addition, the notification must include:

(1) A maintenance plan. The maintenance plan should be in accordance with State and local requirements, if any such requirements exist;

(2) For discharges in special aquatic sites, including wetlands and submerged aquatic vegetation, the notification must include a delineation of affected areas; and

(3) A compensatory mitigation proposal that offsets the loss of waters of the United States. Maintenance in constructed areas will not require mitigation provided such maintenance is accomplished in designated maintenance areas and not within compensatory mitigation areas (i.e., District Engineers may designate non-maintenance areas, normally at the downstream end of the stormwater management facility, in existing stormwater management facilities). (No mitigation will be required for activities which are exempt from Section 404 permit requirements);

f. The permittee must avoid and minimize discharges into waters of the United States at the project site to the maximum extent practicable, and the notification must include a written statement to the District Engineer detailing compliance with this condition (i.e., why the discharge must occur in waters of the United States and why additional minimization cannot be achieved);

g. The stormwater management facility must comply with General Condition 21 (Management of Water Flows) and be designed using BMPs and watershed protection techniques. Examples may include forebays (deeper areas at the upstream end of the stormwater management facility that would be maintained through excavation), vegetated buffers, and siting considerations to minimize adverse effects to aquatic resources. Another example of a BMP would be bioengineering methods incorporated into the facility design to benefit water quality and minimize adverse effects to aquatic resources from storm flows, especially downstream of the facility, that provide, to the maximum extent practicable, for long term aquatic resource protection and enhancement;

h. Maintenance excavation will be in accordance with an approved maintenance plan and will not exceed the original contours of the facility as approved and constructed; and

i. The discharge is part of a single and complete project.

10. General Conditions for Nationwide Permit 43

The following 21 general conditions must be met in order for any ACOE authorization by a nationwide permit to be valid. The ACOE also requires these general conditions be met on projects cleared under individual permits, although some general conditions may be modified or waived by the ACOE during the individual permit process.

1. Navigation. No activity may cause more than a minimal adverse effect on navigation.

2. Proper Maintenance. Any structure or fill authorized shall be properly maintained, including maintenance to ensure public safety.

3. Soil Erosion and Sediment Controls. Appropriate soil erosion and sediment controls must be used and maintained in effective operating condition during construction, and all exposed soil and other fills, as well as any work below the ordinary high water mark or high tide line, must be permanently stabilized at the earliest practicable date. Permittees are encouraged to perform work within waters of the United States during periods of low-flow or no-flow.

4. Aquatic Life Movements. No activity may substantially disrupt the necessary life-cycle movements of those species of aquatic life indigenous to the waterbody, including those species which normally migrate through the area, unless the activity's primary purpose is to impound water. Culverts placed in streams must be installed to maintain low flow conditions.

5. Equipment. Heavy equipment working in wetlands must be placed on mats, or other measures must be taken to minimize soil disturbance.

6. Regional and Case-By-Case Conditions. The activity must comply with any regional conditions that may have been added by the Division Engineer (see 33 CFR 330.4(e)) and with any case specific conditions added by the Corps or by the State or tribe in its Section 401 Water Quality Certification and Coastal Zone Management Act consistency determination.

7. Wild and Scenic Rivers. No activity may occur in a component of the National Wild and Scenic River System; or in a river officially designated by Congress as a “study river” for possible inclusion in the system, while the river is in an official study status; unless the appropriate Federal agency, with direct management responsibility for such river, has determined in writing that the proposed activity will not adversely affect the Wild and Scenic River designation, or study status. Information on Wild and Scenic Rivers may be obtained from the appropriate Federal land management agency in the area (e.g., National Park Service, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service).

8. Tribal Rights. No activity or its operation may impair reserved tribal rights, including, but not limited to, reserved water rights and treaty fishing and hunting rights.

The ACOE will coordinate project review with Native American tribes.

9. Water Quality.

(a) In certain States and tribal lands an individual 401 water quality certification must be obtained or waived (See 33 CFR 330.4(c)).

(b) Where the State or tribal 401 certification (either generically or individually) does not require or approve a water quality management measures, the permittee must provide water quality management measures that will ensure that the authorized work does not result in more than minimal degradation of water quality (or the Corps determines that compliance with state or local standards, where applicable, will ensure no more than minimal adverse effect on water quality). An important component of a water quality management includes stormwater management that minimizes degradation of the downstream aquatic system, including water quality (refer to General Condition 21 for stormwater management requirements). Another important component of a water quality management is the establishment and maintenance of vegetated buffers next to open waters, including streams (see General Condition 19 for vegetated buffer requirements for nationwide permits).

10. General Condition 10 is not applicable in South Dakota.

11. Endangered Species.

(a) No activity is authorized under any nationwide permit which is likely to jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, as identified under the Federal Endangered Species Act (ESA), or which will destroy or adversely modify the critical habitat of such species. Non-federal permittees shall notify the District Engineer if any listed species or designated critical habitat might be affected or is in the vicinity of the project, or is located in the designated critical habitat and shall not begin work on the activity until notified by the District Engineer that the requirements of the Endangered Species Act have been satisfied and that the activity is authorized. For activities that may affect Federally-listed endangered or threatened species or designated critical habitat, the notification must include the name(s) of the endangered or threatened species that may be affected by the proposed work or that utilize the designated critical habitat that may be affected by the proposed work. As a result of formal or informal consultation with the FWS or NMFS, the District Engineer may add species-specific regional endangered species conditions to the nationwide permits.

(b) Authorization of an activity by a nationwide permit does not authorize the “take” of a threatened or endangered species as defined under the Federal Endangered Species Act. In the absence of separate authorization (e.g., an ESA Section 10 Permit, a Biological Opinion with “incidental take” provisions, etc.) from the U.S. Fish and Wildlife Service or the National Marine Fisheries Service, both lethal and non-lethal “takes” of protected species are in violation of the Endangered Species Act.

12. Historic Properties. No activity which may affect historic properties listed, or eligible for listing, in the National Register of Historic Places is authorized, until the District Engineer has complied with the provisions of 33 CFR part 325, Appendix C. The prospective permittee must notify the District Engineer if the authorized activity may affect any historic properties listed, determined to be eligible, or which the prospective permittee has reason to believe may be eligible for listing on the National Register of Historic Places, and shall not begin the activity until notified by the District Engineer that the requirements of the National Historic Preservation Act have been satisfied and that the activity is authorized. Information on the location and existence of historic resources can be obtained from the State Historic Preservation Office and the National Register of Historic Places (see 33 CFR

330.4(g)). For activities that may affect historic properties listed in, or eligible for listing in, the National Register of Historic Places, the notification must state which historic property may be affected by the proposed work or include a vicinity map indicating the location of the historic property.

13. Notification. (a) Timing: Where required by the terms of the nationwide permit, the prospective permittee must notify the District Engineer with a preconstruction notification as early as possible. The District Engineer must determine if the notification is complete within 30 days of the date of receipt and can request additional information necessary to make the preconstruction notification complete only once. However, if the prospective permittee does not provide all of the requested information, then the District Engineer will notify the prospective permittee that the notification is still incomplete and the preconstruction notification review process will not commence until all of the requested information has been received by the District Engineer. The prospective permittee shall not begin the activity:

(1) Until notified in writing by the District Engineer that the activity may proceed under the nationwide permit with any special conditions imposed by the District or Division Engineer; or

(2) If notified in writing by the District or Division Engineer that an individual permit is required; or

(3) Unless 45 days have passed from the District Engineer's receipt of the complete notification and the prospective permittee has not received written notice from the District or Division Engineer. Subsequently, the permittee's right to proceed under the nationwide permit may be modified, suspended, or revoked only in accordance with procedure set forth in 33 CFR 330.5(d)(2).

(b) Contents of Notification: The notification must be in writing and include the following information:

(1) Name, address, and telephone numbers of the prospective permittee;

(2) Location of the proposed project;

(3) Brief description of the proposed project; the project's purpose; direct and indirect adverse environmental effects the project would cause; any other nationwide permit(s), regional general permit(s), or individual permit(s) used or intended to be used to authorize any part of the proposed project or any related activity. Sketches should be provided when necessary to show that the activity complies with the terms of the nationwide permit (sketches usually clarify the project and when provided result in a quicker decision);

(4) The preconstruction notification must include a delineation of affected special aquatic sites, including wetlands, vegetated shallows (e.g., submerged aquatic vegetation, seagrass beds), and riffle and pool complexes;

(5) The preconstruction notification must include a written statement to the District Engineer explaining how avoidance and minimization for losses of waters of the U.S. were achieved on the project site;

(6) The preconstruction notification must include, for the construction of new stormwater management facilities, a maintenance plan (in accordance with State and local requirements, if applicable) and a compensatory mitigation proposal to offset losses of waters of the United States. For discharges that cause the loss of greater than 300 linear feet of an intermittent streambed, to be authorized, the District Engineer must determine that the activity complies with the other terms and conditions of the nationwide permit, determine adverse environmental effects are minimal both individually and cumulatively, and waive the limitation on stream impacts in writing before the permittee may proceed;

(7) For activities that may adversely affect Federally-listed endangered or threatened species, the preconstruction notification must include the name(s) of those endangered or threatened species that may be affected by the proposed work or utilize the designated critical habitat that may be affected by the proposed work.

(8) For activities that may affect historic properties listed in, or eligible for listing in, the National Register of Historic Places, the preconstruction notification must state which historic property may be affected by the proposed work or include a vicinity map indicating the location of the historic property.

(c) Form of Notification: The standard individual permit application form (Form ENG 4345) may be used as the notification but must clearly indicate that it is a preconstruction notification and must include all of the information required by General Condition 13, Notification. A letter containing the requisite information may also be used.

(d) District Engineer's Decision: In reviewing the preconstruction notification for the proposed activity, the District Engineer will determine whether the activity authorized by the nationwide permit will result in more than minimal individual or cumulative adverse environmental effects or may be contrary to the public interest. The prospective permittee may submit a proposed mitigation plan with the preconstruction notification to expedite the process.

The District Engineer will consider any proposed compensatory mitigation the applicant has included in the proposal in determining whether the net adverse environmental effects to the aquatic environment of the proposed work are minimal. If the District Engineer determines that the activity complies with the terms and conditions of the nationwide permit and that the adverse effects on the aquatic environment are minimal, after considering mitigation, the District Engineer will notify the permittee and include any conditions the District Engineer deems necessary.

The District Engineer must approve any compensatory mitigation proposal before the permittee commences work. If the prospective permittee is required to submit a compensatory mitigation proposal with the preconstruction notification, the proposal may be either conceptual or detailed. If the prospective permittee elects to submit a compensatory mitigation plan with the preconstruction notification, the District Engineer will expeditiously review the proposed compensatory mitigation plan. The District Engineer must review the plan within 45 days of receiving a complete preconstruction notification and determine whether the conceptual or specific proposed mitigation would ensure no more than minimal adverse effects on the aquatic environment.

If the net adverse effects of the project on the aquatic environment (after consideration of the compensatory mitigation proposal) are determined by the District Engineer to be minimal, the District Engineer will provide a timely written response to the applicant. The response will state that the project can proceed under the terms and conditions of the nationwide permit.

If the District Engineer determines that the adverse effects of the proposed work are more than minimal, then the District Engineer will notify the applicant either: (1) That the project does not qualify for authorization under the nationwide permit and instruct the applicant on the procedures to seek authorization under an individual permit; (2) that the project is authorized under the nationwide permit subject to the applicant's submission of a mitigation proposal that would reduce the adverse effects on the aquatic environment to the minimal level; or (3) that the project is authorized under the nationwide permit with specific modifications or conditions.

Where the District Engineer determines that mitigation is required to ensure no more than minimal adverse effects occur to the aquatic environment, the activity will be authorized within the 45-day preconstruction notification period. The authorization will include the necessary conceptual or specific mitigation or a requirement that the applicant submit a mitigation proposal that would reduce the adverse effects on the aquatic environment to the minimal level. When conceptual mitigation is included, or a mitigation plan is required under item (2) above, no work in waters of the United States will occur until the District Engineer has approved a specific mitigation plan.

(e) Agency Coordination: The District Engineer will consider any comments from Federal and State agencies concerning the proposed activity's compliance with the terms and conditions of the nationwide permits and the need for mitigation to reduce the project's adverse environmental effects to a minimal level.

For activities requiring notification to the District Engineer that result in the loss of greater than 1/2 acre of waters of the United States, the District Engineer will provide immediately (e.g., via facsimile transmission, overnight mail, or other expeditious manner) a copy to the appropriate Federal or state offices (USFWS, State natural resource or water quality agency, EPA, and State Historic Preservation Officer (SHPO). These agencies will then have 10 calendar days from the date the material is transmitted to telephone or fax the District Engineer notice that they intend to provide substantive, site-specific comments. If so contacted by an agency, the District Engineer will wait an additional 15 calendar days before making a decision on the notification. The District Engineer will fully consider agency comments received within the specified time frame, but will provide no response to the resource agency, except as provided below. The District Engineer will indicate in the administrative record associated with each notification that the resource agencies' concerns were considered. As required by section 305(b)(4)(B) of the Magnuson-Stevens Fishery Conservation and Management Act, the District Engineer will provide a response to NMFS within 30 days of receipt of any Essential Fish Habitat conservation recommendations. Applicants are encouraged to provide the Corps multiple copies of notifications to expedite agency notification.

(f) Wetlands Delineations: Wetlands delineations must be prepared in accordance with the current method required by the Corps. The permittee may ask the Corps to delineate the special aquatic site. There may be some delay if the Corps does the delineation. Furthermore, the 45-day period will not start until the wetland delineation has been completed and submitted to the Corps, where appropriate.

14. Compliance Certification. Every permittee who has received a nationwide permit verification from the Corps will submit a signed certification regarding the completed work and any required mitigation. The certification will be forwarded by the Corps with the authorization letter. The certification will include: (a) A statement that the authorized work was done in accordance with the Corps authorization, including any general or specific conditions; (b) A statement that any required mitigation was completed in accordance with the permit conditions; and (c) The signature of the permittee certifying the completion of the work and mitigation.

15. Use of Multiple Nationwide permits. The use of more than one nationwide permit for a single and complete project is prohibited, except when the acreage loss of waters of the United States authorized by the nationwide permits does not exceed the acreage limit of the nationwide permit with the highest specified acreage limit.

16. Water Supply Intakes. No activity, including structures and work in navigable waters of the United States or discharges of dredged or fill material, may occur in the proximity of a public water supply intake except where the activity is for repair of the public water supply intake structures or adjacent bank stabilization.

17. Shellfish Beds. No activity, including structures and work in navigable waters of the United States or discharges of dredged or fill material, may occur in areas of concentrated shellfish populations.

18. Suitable Material. No activity, including structures and work in navigable waters of the United States or discharges of dredged or fill material, may consist of unsuitable material (e.g., trash, debris, car bodies, asphalt, etc.) and material used for construction or discharged must be free from toxic pollutants in toxic amounts (see Section 307 of the Clean Water Act).

19. Mitigation. The District Engineer will consider the factors discussed below when determining the acceptability of appropriate and practicable mitigation necessary to offset adverse effects on the aquatic environment that are more than minimal.

(a) The project must be designed and constructed to avoid and minimize adverse effects to waters of the United States to the maximum extent practicable at the project site (i.e., on site).

(b) Mitigation in all its forms (avoiding, minimizing, rectifying, reducing or compensating) will be required to the extent necessary to ensure that the adverse effects to the aquatic environment are minimal.

(c) Compensatory mitigation at a minimum one-for-one ratio will be required for all wetland impacts requiring a preconstruction notification, unless the District Engineer determines in writing that some other form of mitigation would be more environmentally appropriate and provides a project-specific waiver of this requirement. Consistent with National policy, the District Engineer will establish a preference for restoration of wetlands as compensatory mitigation, with preservation used only in exceptional circumstances.

(d) Compensatory mitigation (i.e., replacement or substitution of aquatic resources for those impacted) will not be used to increase the acreage losses allowed by the acreage limits of some of the nationwide permits. For example, 1/4-acre of wetlands cannot be created to change a 3/4-acre loss of wetlands to a 1/2-acre loss. However, 1/2-acre of created wetlands can be used to reduce the impacts of a 1/2-acre loss of wetlands to the minimum impact level in order to meet the minimal impact requirement associated with nationwide permits.

(e) To be practicable, the mitigation must be available and capable of being done considering costs, existing technology, and logistics in light of the overall project purpose. Examples of mitigation that may be appropriate and practicable include, but are not limited to: reducing the size of the project; establishing and maintaining wetland or upland vegetated buffers to protect open waters such as streams; and replacing losses of aquatic resource functions and values by creating, restoring, enhancing, or preserving similar functions and values, preferably in the same watershed.

(f) Compensatory mitigation plans for projects in or near streams or other open waters will normally include a requirement for the establishment, maintenance, and legal protection (e.g., easements, deed restrictions) of vegetated buffers to open waters. In many cases, vegetated buffers will be the only compensatory mitigation required. Vegetated buffers should consist of native species. The width of the vegetated buffers required will address documented water quality or aquatic habitat loss concerns. Normally, the vegetated buffer will be 25 to 50 feet wide on each side of the stream, but the District Engineer may require slightly wider vegetated buffers to address documented water quality or habitat loss concerns. Where both wetlands and open waters exist on the project site, the Corps will determine the appropriate compensatory mitigation (e.g., stream buffers or wetlands compensation) based on what is best for the aquatic environment on a watershed basis. In cases where vegetated buffers are determined to be the most appropriate form of compensatory mitigation, the District Engineer may waive or reduce the requirement to provide wetland compensatory mitigation for wetland impacts.

(g) Compensatory mitigation proposals submitted with the notification may be either conceptual or detailed. If conceptual plans are approved under the verification, then the Corps will condition the verification to require detailed plans be submitted and approved by the Corps prior to construction of the authorized activity in waters of the United States.

(h) Permittees may propose the use of mitigation banks, in-lieu fee arrangements or separate activity-specific compensatory mitigation. In all cases that require compensatory mitigation, the mitigation provisions will specify the party responsible for accomplishing and/or complying with the mitigation plan.

20. Spawning Areas. Activities, including structures and work in navigable waters of the United States or discharges of dredged or fill material, in spawning areas during spawning seasons must be avoided to the maximum extent practicable. Activities that result in the physical destruction (e.g., excavate, fill, or smother downstream by substantial turbidity) of an important spawning area are not authorized.

21. Management of Water Flows. To the maximum extent practicable, the activity must be designed to maintain preconstruction downstream flow conditions (e.g., location, capacity, and flow rates). Furthermore, the activity must not permanently restrict or impede the

passage of normal or expected high flows (unless the primary purpose of the fill is to impound waters) and the structure or discharge of dredged or fill material must withstand expected high flows. The activity must, to the maximum extent practicable, provide for retaining excess flows from the site, provide for maintaining surface flow rates from the site similar to preconstruction conditions, and provide for not increasing water flows from the project site, relocating water, or redirecting water flow beyond preconstruction conditions. Stream channelization will be reduced to the minimal amount necessary, and the activity must, to the maximum extent practicable, reduce adverse effects such as flooding or erosion downstream and upstream of the project site, unless the activity is part of a larger system designed to manage water flows. In most cases, it will not be a requirement to conduct detailed studies and monitoring of water flow.

This condition is only applicable to projects that have the potential to affect water flows. While appropriate measures must be taken, it is not necessary to conduct detailed studies to identify such measures or require monitoring to ensure their effectiveness. Normally, the Corps will defer to state and local authorities regarding management of water flow.

22. Adverse Effects From Impoundments. If the activity creates an impoundment of water, adverse effects to the aquatic system due to the acceleration of the passage of water, and/or the restriction of its flow, shall be minimized to the maximum extent practicable. This includes structures and work in navigable waters of the United States, or discharges of dredged or fill material.

23. Waterfowl Breeding Areas. Activities, including structures and work in navigable waters of the United States or discharges of dredged or fill material, into breeding areas for migratory waterfowl must be avoided to the maximum extent practicable.

24. Removal of Temporary Fills. Any temporary fills must be removed in their entirety and the affected areas returned to their preexisting elevation.

25. Designated Critical Resource Waters. Critical resource waters include, NOAA-designated marine sanctuaries, National Estuarine Research Reserves, National Wild and Scenic Rivers, critical habitat for Federally listed threatened and endangered species, coral reefs, state natural heritage sites, and outstanding national resource waters or other waters officially designated by a state as having particular environmental or ecological significance and identified by the District Engineer after notice and opportunity for public comment. The District Engineer may also designate additional critical resource waters after notice and opportunity for comment.

(a) Except as noted below, discharges of dredged or fill material into waters of the United States are not authorized by Nationwide Permit 43 for any activity within, or directly affecting, critical resource waters, including wetlands adjacent to such waters. Discharges of dredged or fill materials into waters of the United States may be authorized by the above nationwide permits in National Wild and Scenic Rivers if the activity complies with General Condition 7. Further, such discharges may be authorized in designated critical habitat for Federally listed threatened or endangered species if the activity complies with General Condition 11 and the U.S. Fish and Wildlife Service or the National Marine Fisheries Service has concurred in a determination of compliance with this condition.

26. Fills Within 100-Year Floodplains. For purposes of this general condition, 100-year floodplains will be identified through the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps or FEMA-approved local floodplain maps.

(a) Discharges in Floodplain; Below Headwaters: Discharges of dredged or fill material into waters of the United States within the mapped 100-year floodplain, below headwaters (i.e. five cfs), resulting in permanent above-grade fills, are not authorized by Nationwide Permit 43.

(b) Discharges in Floodway; Above Headwaters: Discharges of dredged or fill material into waters of the United States within the FEMA or locally mapped floodway, resulting in permanent above-grade fills, are not authorized.

(c) The permittee must comply with any applicable FEMA-approved state or local floodplain management requirements.

27. Construction Period: For activities that have not been verified by the Corps and the project was commenced or under contract to commence by the expiration date of the nationwide permit (or modification or revocation date), the work must be completed within 12 months after such date (including any modification that affects the project).

For activities that have been verified and the project was commenced or under contract to commence within the verification period, the work must be completed by the date determined by the Corps.

For projects that have been verified by the Corps, an extension of a Corps approved completion date may be requested. This request must be submitted at least one month before the previously approved completion date.

11. Definitions

Best Management Practices: Best Management Practices (BMPs) are policies, practices, procedures, or structures implemented to mitigate the adverse environmental effects on surface water quality resulting from development. BMPs are categorized as structural or non-structural. A BMP policy may affect the limits on a development.

Compensatory Mitigation: For purposes of Section 10/404, compensatory mitigation is the restoration, creation, enhancement, or in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved.

Creation: The establishment of a wetland or other aquatic resource where one did not formerly exist.

Enhancement: Activities conducted in existing wetlands or other aquatic resources which increase one or more aquatic functions.

Ephemeral Stream: An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral stream beds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.

Flood Fringe: That portion of the 100-year floodplain outside of the floodway (often referred to as "floodway fringe."

Floodway: The area regulated by Federal, state, or local requirements to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as set by the National Flood Insurance Program) within the 100-year floodplain.

Groins: A barrier built out from a riverbank to protect the land from erosion and sand movements.

Historic Property: Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria. The term eligible for inclusion in the National Register includes both properties formally determined as such in accordance with regulations of the Secretary of the Interior and all other properties that meet the National Register criteria (36 CFR 800.16.l).

Hydric Soils: A soil that is saturated, flooded, or ponded with water long enough during the growing season to develop anaerobic conditions in the upper horizon(s). Hydric soils are one of three key components that demonstrate the presence of a wetland. Methods to verify hydric soils in the field are contained in the 1987 U.S. Army Corps of Engineers Wetlands Delineation Manual.

Independent Utility: A test to determine what constitutes a single and complete project in the Corps regulatory program. A project is considered to have independent utility if it would be constructed absent the construction of other projects in the project area. Portions of a multi-phase project that depend upon other phases of the project do not have independent utility. Phases of a project that would be constructed even if the other phases were not built can be considered as separate single and complete projects with independent utility.

Intermittent Stream: An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.

Loss of Waters of the United States: Waters of the United States that include the filled area and other waters that are permanently adversely affected by flooding, excavation, or drainage because of the regulated activity. Permanent adverse effects include permanent above-grade, at-grade, or below-grade fills that change an aquatic area to dry land, increase the bottom elevation of a waterbody, or change the use of a waterbody. The acreage of loss of waters of the United States is the threshold measurement of the impact to existing waters for determining whether a project may qualify for a nationwide permit; it is not a net threshold that is calculated after considering compensatory mitigation that may be used to offset losses of aquatic functions and values. The loss of stream bed includes the linear feet of stream bed that is filled or excavated. Impacts to ephemeral streams are not included in the linear foot measurement of loss of stream bed for the purpose of determining compliance with the linear foot limits of nationwide permits. Waters of the United States temporarily filled, flooded, excavated, or drained, but restored to preconstruction contours and elevations after construction, are not included in the measurement of loss of waters of the United States.

Non-tidal Wetland: A non-tidal wetland is a wetland (i.e., a water of the United States) that is not subject to the ebb and flow of tidal waters. The definition of a wetland can be found at 33 CFR 328.3(b).

Open Water: An area that, during a year with normal patterns of precipitation, has standing or flowing water for sufficient duration to establish an ordinary high water mark. Aquatic vegetation within the area of standing or flowing water is either non-emergent, sparse, or absent. Vegetated shallows are considered to be open waters. The term "open water" includes rivers, streams, lakes, and ponds. For the purposes of the nationwide permits, this term does not include ephemeral waters.

Perennial Stream: A perennial stream has flowing water year-round during a typical year. The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.

Permanent Above-Grade Fill: A discharge of dredged or fill material into waters of the United States, including wetlands, that results in a substantial increase in ground elevation and permanently converts part or all of the waterbody to dry land. Structural fills authorized by 404 Permits are not included.

Preservation: The protection of ecologically important wetlands or other aquatic resources in perpetuity through the implementation of appropriate legal and physical mechanisms. Preservation may include protection of upland areas adjacent to wetlands as necessary to ensure protection and/or enhancement of the overall aquatic ecosystem.

Restoration: Re-establishment of wetland and/or other aquatic resource characteristics and function(s) at a site where they have ceased to exist, or exist in a substantially degraded state.

Revetment: A facing made on a soil or rock embankment to prevent scour by water or weather.

Riffle and Pool Complex: Riffle and pool complexes are special aquatic sites under the 404(b)(1) Guidelines. Riffle and pool complexes sometimes characterize steep gradient sections of streams. Such stream sections are recognizable by their hydraulic characteristics. The rapid movement of water over a course substrate in riffles results in a rough flow, a turbulent surface, and high dissolved oxygen levels in the water. Pools are deeper areas associated with riffles. A slower stream velocity, a streaming flow, a smooth surface, and a finer substrate characterize pools.

Single and Complete Project: The term "single and complete project" is defined at 33 CFR 330.2(i) as the total project proposed or accomplished by one owner/developer or partnership or other association of owners/developers (see definition of independent utility). For linear projects, the "single and complete project" (i.e., a single and complete crossing) will apply to each crossing of a separate water of the United States (i.e., a single waterbody) at that location. An exception is for linear projects crossing a single waterbody several times at separate and distant locations: each crossing is considered a single and complete project. However, individual channels in a braided stream or river, or individual arms of a large, irregularly-shaped wetland or lake, etc., are not separate waterbodies.

Stormwater Management: Stormwater management is the mechanism for controlling stormwater runoff for the purposes of reducing downstream erosion, water quality degradation, and flooding and mitigating the adverse effects of changes in land use on the aquatic environment.

Stormwater Management Facilities: Stormwater management facilities are those facilities, including but not limited to, stormwater retention and detention ponds and BMPs, which retain water for a period of time to control runoff and/or improve the quality (i.e., by reducing the concentration of nutrients, sediments, hazardous substances and other pollutants) of stormwater runoff.

Stream Bed: The substrate of the stream channel between the ordinary high water marks. The substrate may be bedrock or inorganic particles that range in size from clay to boulders. Wetlands contiguous to the stream bed, but outside of the ordinary high water marks, are not considered part of the stream bed.

Stream Channelization: The manipulation of a stream channel to increase the rate of water flow through the stream channel. Manipulation may include deepening, widening, straightening, armoring, or other activities that change the stream cross-section or other aspects of stream channel geometry to increase the rate of water flow through the stream channel. A channelized stream remains a water of the United States, despite the modifications to increase the rate of water flow.

Vegetated Buffer: A vegetated upland or wetland area next to rivers, streams, lakes, or other open waters which separates the open water from developed areas, including agricultural land. Vegetated buffers provide a variety of aquatic habitat functions and values (e.g., aquatic habitat for fish and other aquatic organisms, moderation of water temperature changes, and detritus for aquatic food webs) and help improve or maintain local water quality. A vegetated buffer can be established by maintaining an existing vegetated area or planting native trees, shrubs, and herbaceous plants on land next to open waters. Mowed lawns are not considered vegetated buffers because they provide little or no aquatic habitat functions and values. The establishment and maintenance of vegetated buffers is a method of compensatory mitigation that can be used in conjunction with the restoration, creation, enhancement, or preservation of aquatic habitats to ensure that activities authorized by nationwide permits result in minimal adverse effects to the aquatic environment. (See General Condition 19.)

Vegetated Shallows: Vegetated shallows are special aquatic sites under the 404(b)(1) Guidelines. They are areas that are permanently inundated and under normal circumstances have rooted aquatic vegetation, such as seagrasses in marine and estuarine systems and a variety of vascular rooted plants in freshwater systems.

Waterbody: A waterbody is any area that in a normal year has water flowing or standing above ground to the extent that evidence of an ordinary high water mark is established. Wetlands contiguous to the waterbody are considered part of the waterbody.

Wetlands: Those areas that are inundated or saturated by surface or ground water 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.

12. References

U.S. Army Corps of Engineers, South Dakota Regulatory Office Website (http://www.nwo.usace.army.mil/html/od-rsd/frame.html)

General 404 Permit Information (http://www.nwo.usace.army.mil/html/od-rsd/regintro.html)

Hydric Soils of South Dakota. http://soils.usda.gov/soil_use/hydric/states/sd.htm

Nationwide Permits and Conditions (http://www.nwo.usace.army.mil/html/od-rsd/nwp2002.html)

National Historic Preservation Act of 1966. 16 U.S.C. 470 et seq.

National Resource Conservation Service (NRCS) Soil Survey for Minnehaha and Lincoln Counties, Accessed February 3, 2003. (http://www.nwi.fws.gov/)

National Wetland Inventory Information for Minnehaha and Lincoln Counties, Accessed February 3, 2003. (http://www.ftw.nrcs.usda.gov/ssur_data.html)

Oehlerking, James, Army Corps of Engineers, South Dakota Division Office, personal communication. April 2003

South Dakota Department of Environment and Natural Resources Dam Permit Information (http://www.state.sd.us/denr/des/waterrights/wr_dam.htm)

U.S. Army Corps of Engineers Wetlands Delineation Manual (http://www.nwo.usace.army.mil/html/od-rsd/87-manual.pdf)

U.S. Fish and Wildlife Service. Questions and Answers About Proposed Critical Habitat and the Topeka Shiner. 2003. http://www.r6.fws.gov/endspp/shiner/qanda082002.htm

U.S. Fish and Wildlife Service. General Locations of Proposed Critical Habitat for the Topeka Shiner (Notropis topeka) South Dakota – Lower Big Sioux Watershed. May 2003. http://www.r6.fws.gov/endspp/shiner/map11.pdf

U.S. Fish and Wildlife Service. General Locations of Proposed Critical Habitat for the Topeka Shiner (Notropis topeka) South Dakota – Vermillion River Watershed. May 2003. http://www.r6.fws.gov/endspp/shiner/map12.pdf

Wall, S., C. Blausey, and J. Jenks. Topeka Shiner (Notropis topeka) Population Status and Habitat Conditions in South Dakota Streams. South Dakota State University, 2001.

Winham, R. P., Draft Archaeological Sensitivity Analysis, Stormwater Best Management Practices (BMP) Project, Sioux Falls, South Dakota. Archaeology Laboratory, Augustana College, 2003.

For Figure 1, refer to Figure 2-1, "Soils and Wetland Information," in the main report.

For Figure 2, refer to Figure 2-2, "Cultural Resource Information," in the main report.

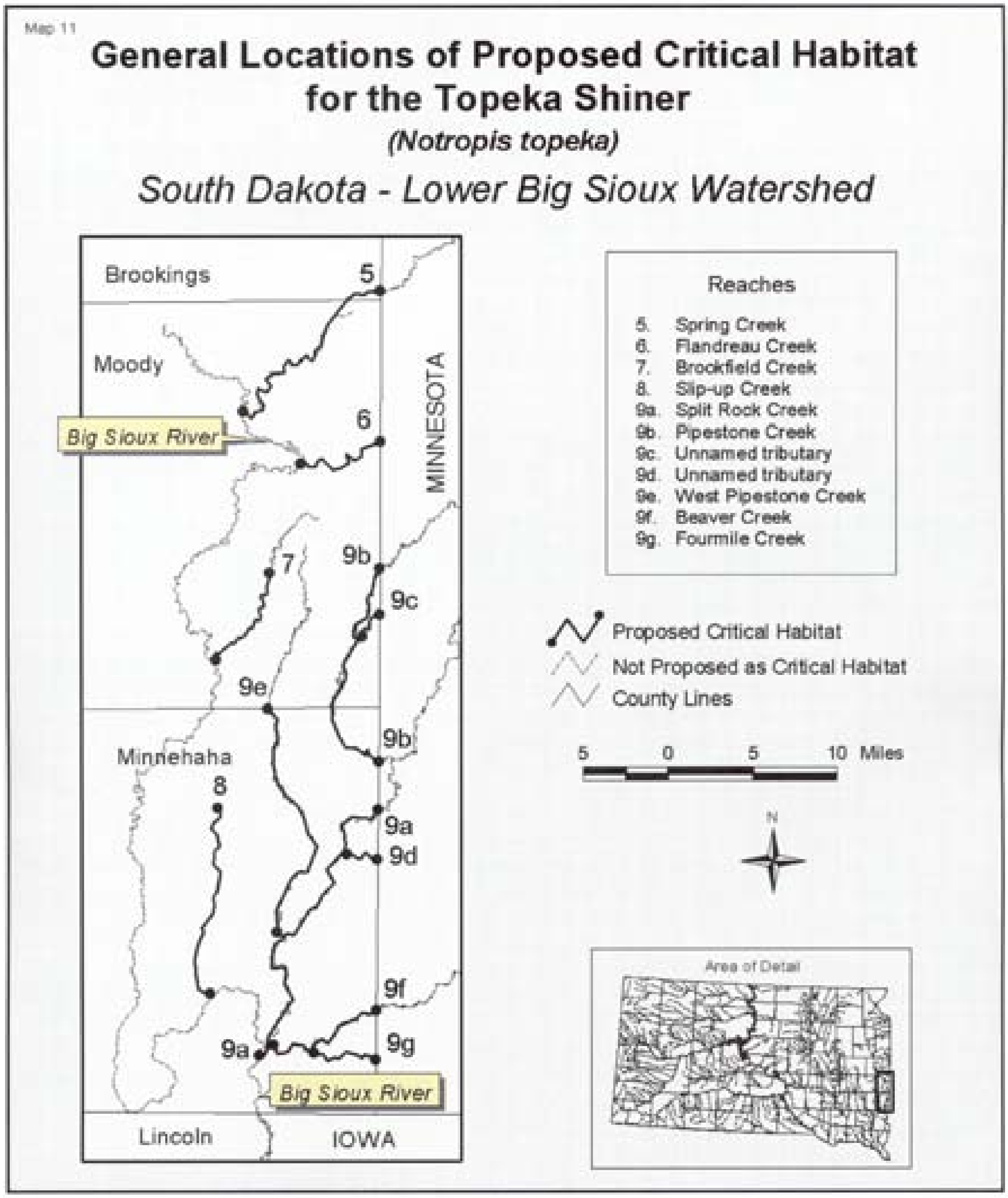

FIGURE 3
Proposed Topeka Shiner Critical Habitat Lower Big Sioux River Watershed
Source: http://www.r6.fws.gov/endspp/shiner/map11.pdf

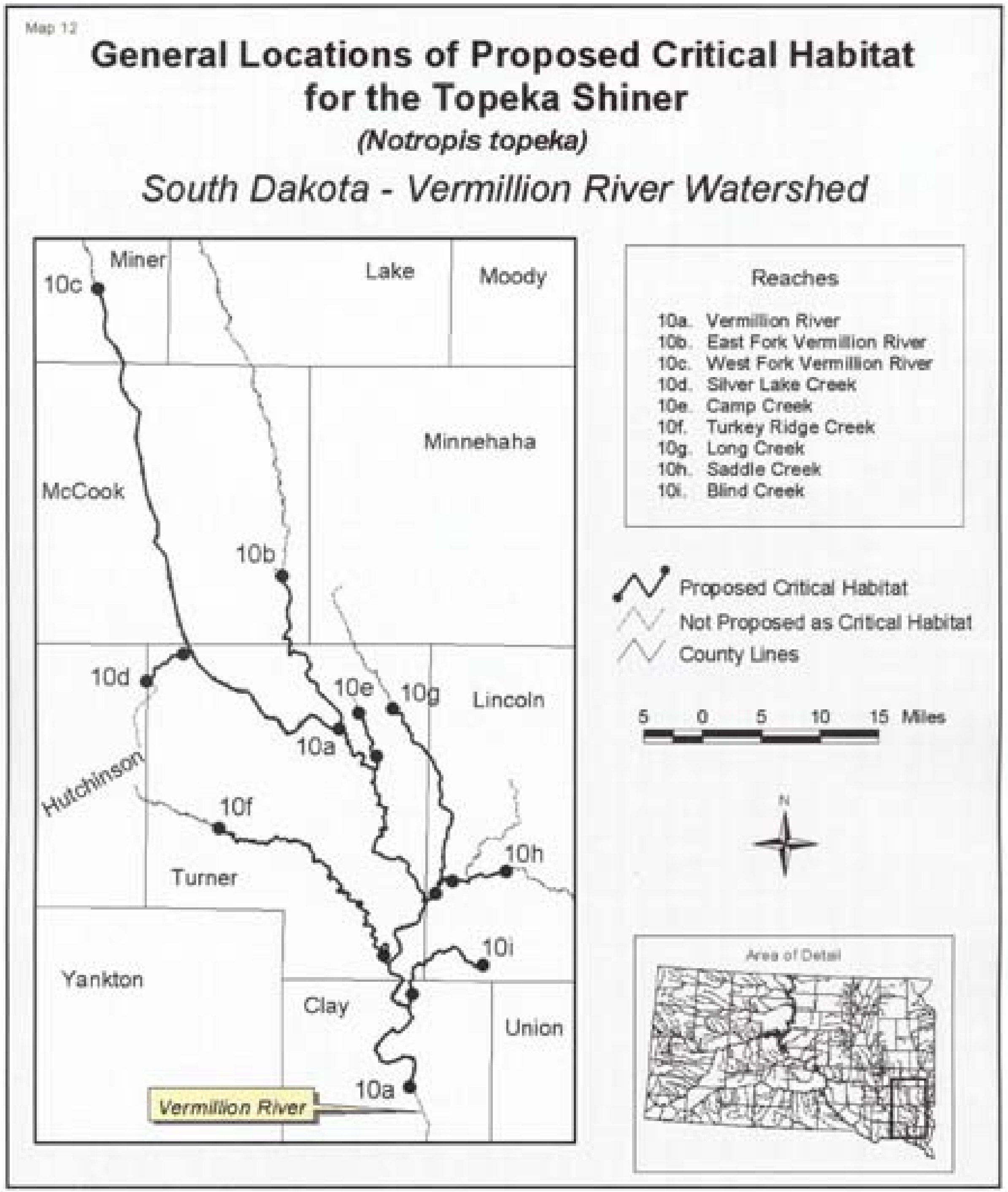

FIGURE 4
Proposed Topeka Shiner Critical Habitat Vermillion River Watershed
Source: http://www.r6.fws.gov/endspp/shiner/map12.pdf

Attachment 1
Cultural Resources Expert Report

Archeological Sensitivity Analysis for the Stormwater Best Management Practices (BMP) Project in Sioux Falls, South Dakota

by

R. Peter Winham

April 25, 2003

Prepared by
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Introduction

The City of Sioux Falls is finalizing its plan for establishing stormwater best management practices (BMPs) in the future urbanizing area of the city (Figure 1). The Archeology Laboratory, Augustana College, Sioux Falls, South Dakota, was requested to provide a sensitivity analysis to identify those portions of the future urbanizing area that are considered to have high sensitivity as potential archeological site locations. The goal of this effort is to predict the need for archeological reconnaissance (Phase 1) surveys during the design phase and prior to final siting of stormwater BMPs in the future urbanizing area. This project may require close coordination among the City of Sioux Falls, the South Dakota Division Office of the U.S. Army Corps of Engineers, the South Dakota State Historic Preservation Officer (SD SHPO), and the appropriate Native American tribes at some time in the future.

Scope-of-Work

The scope-of-work defined for this project was two-fold. It included a site record and literature search to determine the present pattern of known sites in the future urbanizing area as well as the preparation of a GIS shapefile layer that contains polygons of areas that are considered highly sensitive with respect to archeological resources.

Methodology

Initially, a project database was created in ArcView. Digital Raster Graphic (DRGs) 7.5' USGS quadrangle maps covering the project area were obtained and imported into ArcView. Nine maps comprise the database: Brandon, Crooks, Garretson West, Harrisburg, Klondike, Renner, Sioux Falls East, Sioux Falls West and Tea.

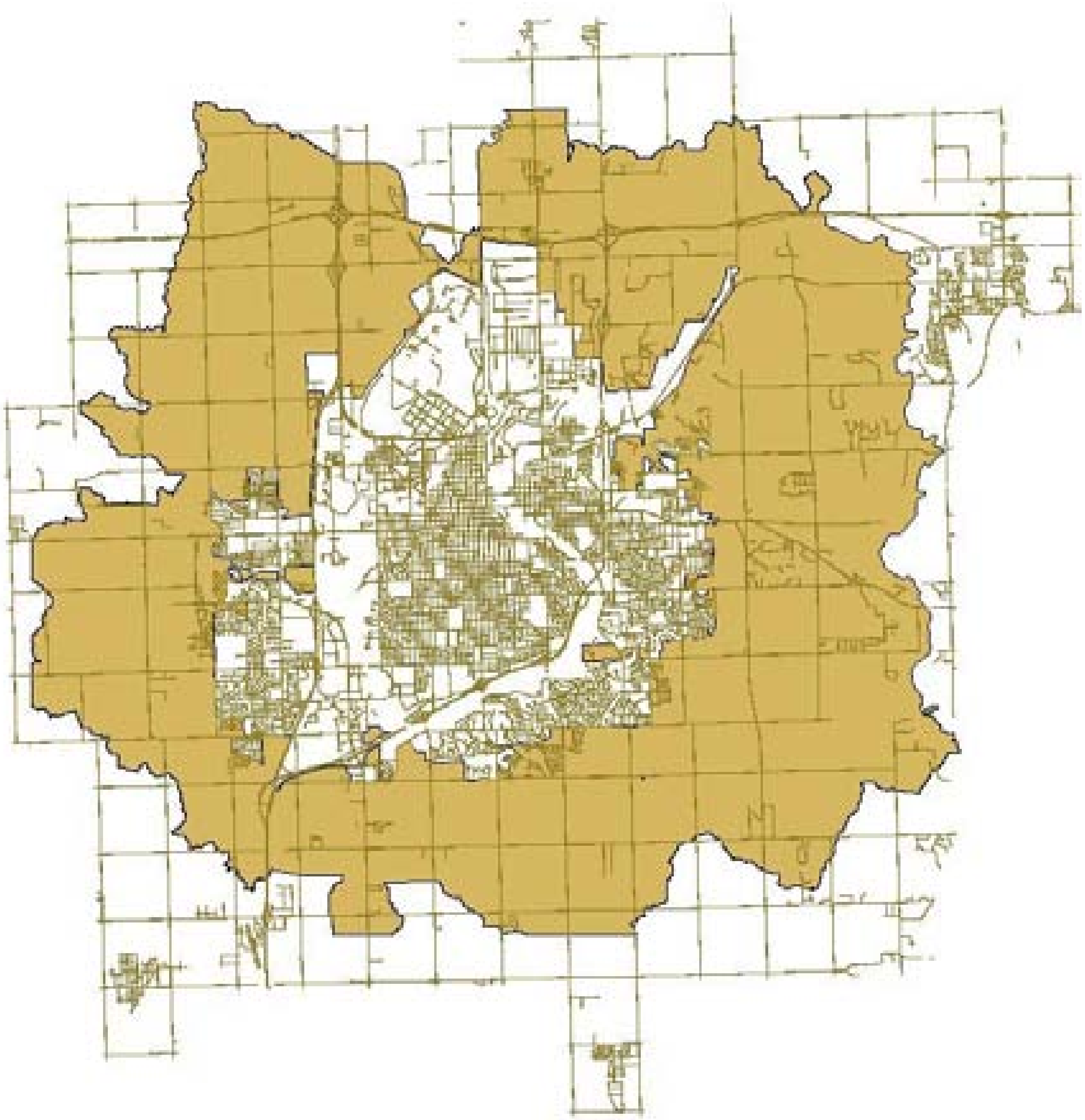

Figure 1. Future urbanizing area (shown in gold) of the City of Sioux Falls [map supplied by Howard Green Company].

A GIS shapefile and hard copy map of the future urbanizing area were provided by Howard Green Company (Figure 1). Unfortunately, the GIS file was not compatible with the DRGs in ArcView and it was necessary to manually input the project boundaries. The resulting shapefile was simplified from the original (by expansion only) and includes all of the future urbanizing area (Figure 2).

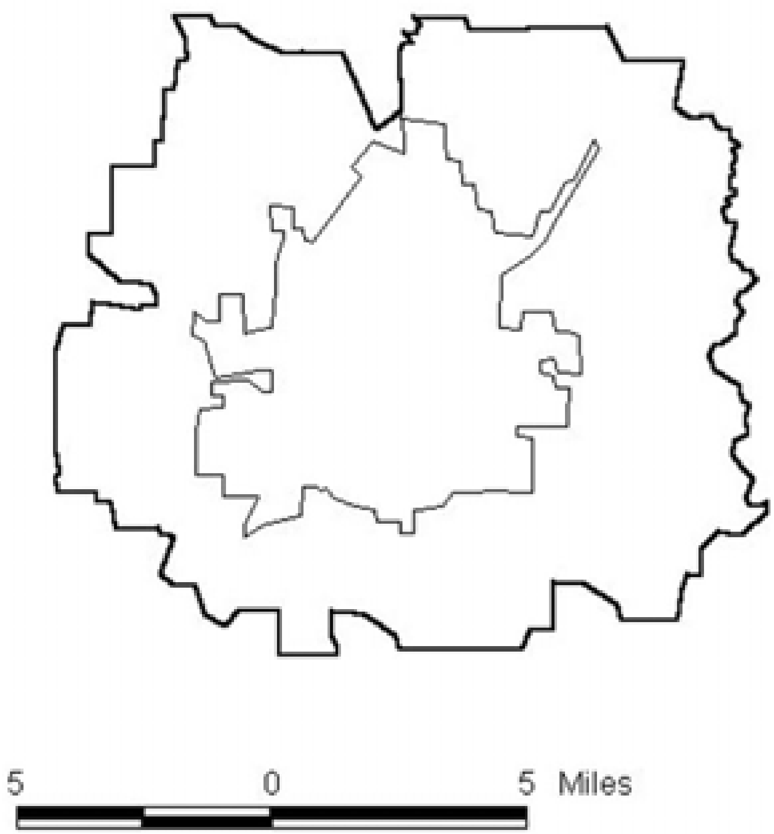

Figure 2. Simplified project area shapefile used for the sensitivity analysis.

Once the project area was defined and the base maps were added, additional GIS layers were developed showing a) archeological sites previously recorded and b) archeological surveys previously conducted. These data were derived from an examination of master site and survey record maps maintained at the State Archaeological Research Center in Rapid City and from the archives of the

Archeology Laboratory, Augustana College. *Site* data are limited to the project area (Figure 4; Table 1). The *survey* data cover the entire project area and a surrounding buffer zone of at least one mile, as well as all of the City of Sioux Falls (Figure 3). Surveys and reports applicable to this region are listed in the References Cited:Surveys section at the conclusion of this report.

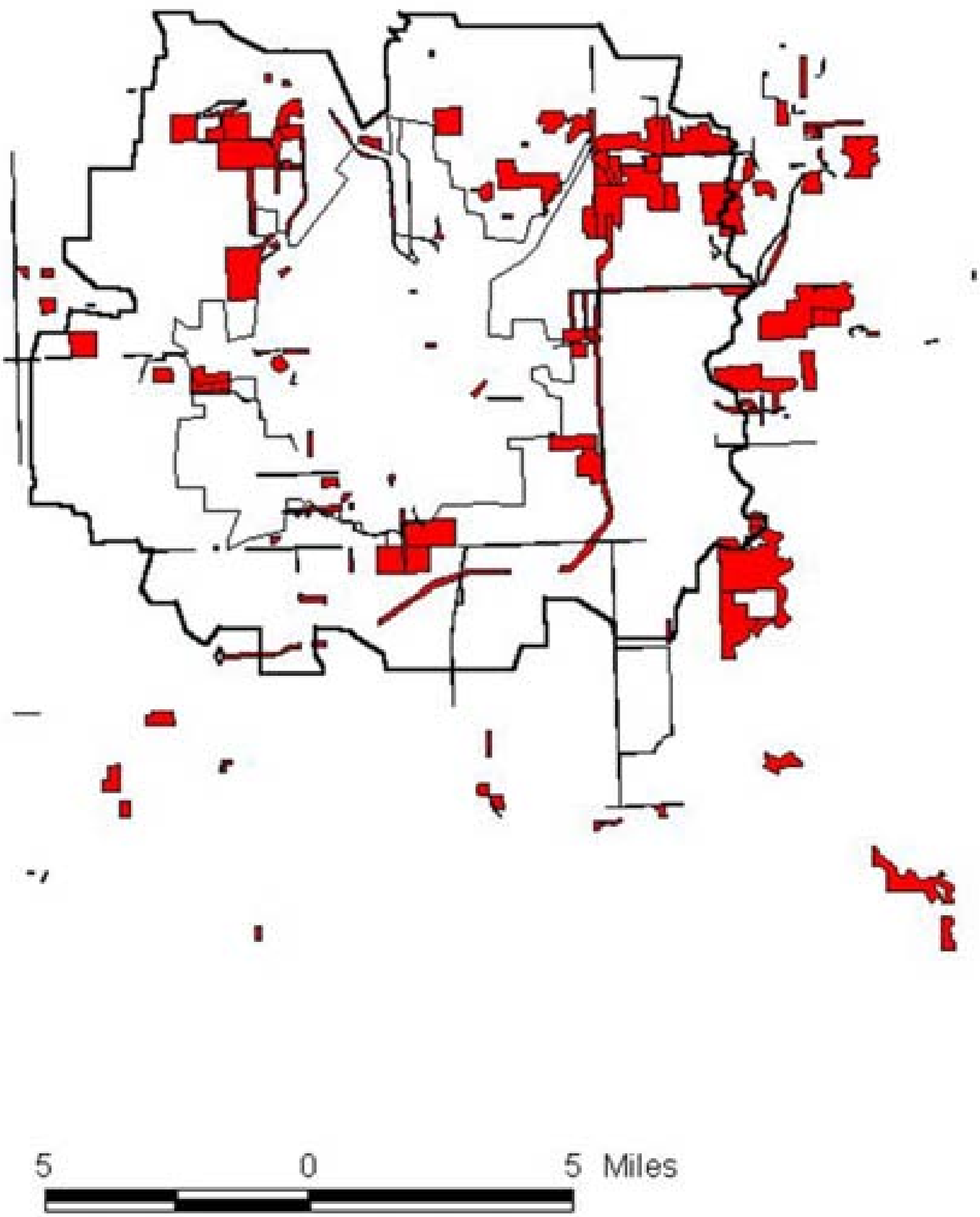

Figure 3. Previous surveys in and near the project area.

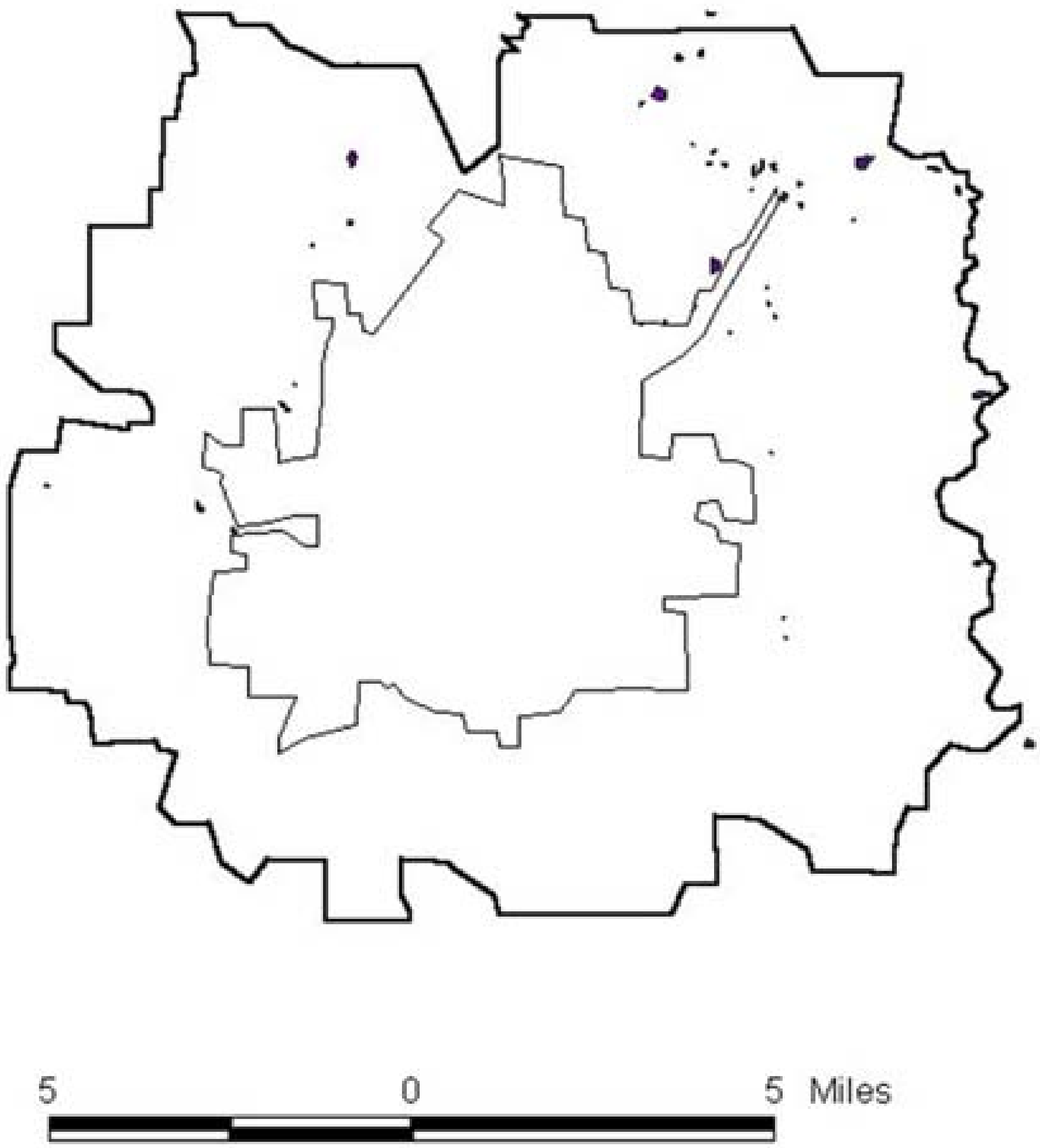

Figure 4. Previously recorded sites within the project area.

Table 1. Archeological Sites Documented Within the Project Area.

Site Number (39-XX-XXX)	Comments	NRHP Eligibility*	Quadrangle Map
LN036	Artifact Scatter-Prehistoric	Unknown	Klondike
LN062	Artifact Scatter-Prehistoric	Unknown	Tea
MH008	Artifact Scatter-Prehistoric	Unknown	Renner
MH019	Historic Foundation	Unknown	Sioux Falls East
MH025	Historic Village	Unknown	Sioux Falls East
MH027	Mound-Prehistoric	Unknown	Renner
MH070	Artifact Scatter-Prehistoric	Not Eligible	Renner
MH083	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls West
MH086	Artifact Scatter-Prehistoric	Unknown	Sioux Falls West
MH095	Artifact Scatter-Prehistoric	Not Eligible	Sioux Falls East
MH096	Artifact Scatter-Prehistoric	Not Eligible	Sioux Falls East
MH097	Artifact Scatter-Prehistoric	Not Eligible	Sioux Falls East
MH098	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH100	Artifact Scatter-Prehistoric and Historic	Unknown	Sioux Falls East
MH101	Artifact Scatter-Prehistoric and Historic	Unknown	Brandon
MH102	Village-Prehistoric	Not Eligible	Brandon
MH104	Isolated Find-Prehistoric	Not Eligible	Sioux Falls West
MH105	Artifact Scatter-Prehistoric and Historic	Not Eligible	Brandon
MH136	Artifact Scatter-Prehistoric	Not Eligible	Brandon
MH143	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH144	Artifact Scatter-Prehistoric and Historic	Not Eligible	Sioux Falls East
MH145	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH146	Artifact Scatter-Prehistoric	Not Eligible	Sioux Falls East
MH147	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH148	Artifact Scatter-Prehistoric	Not Eligible	Sioux Falls East
MH149	Artifact Scatter-Prehistoric	Unknown	Sioux Falls East
MH150	Artifact Scatter-Prehistoric	Unknown	Brandon
MH154	Artifact Scatter-Prehistoric	Not Eligible	Sioux Falls East
MH155	Artifact Scatter-Prehistoric	Unknown	Brandon
MH161	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH162	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH163	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH166	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH167	Isolated Find-Prehistoric	Unknown	Sioux Falls East
MH169	Isolated Find-Prehistoric	Unknown	Sioux Falls East
MH170	Artifact Scatter-Prehistoric	Potentially Eligible	Sioux Falls East
MH171	Isolated Find-Prehistoric	Not Eligible	Sioux Falls East
MH185	Artifact Scatter and Farm	Unknown	Sioux Falls West
MH186	Artifact Scatter and Farm	Not Eligible	Sioux Falls West
MH187	Farm	Potentially Eligible	Sioux Falls West
MH190	Artifact Scatter-Historic	Not Eligible	Sioux Falls West
MH206	Isolated Find-Prehistoric	Not Eligible	Sioux Falls East
MH207	Isolated Find-Prehistoric	Not Eligible	Sioux Falls East
MH210	Farm	Not Eligible	Sioux Falls East
MH215	Artifact Scatter-Historic	Not Eligible	Sioux Falls West
MH216	Isolated Find-Prehistoric	Not Eligible	Sioux Falls West
MH2003	Railroad	On Register	Sioux Falls East

* NRHP = National Register of Historic Places

In addition to those sites officially recorded in the project area, a GIS layer was prepared that shows the mounds recorded by T. H. Lewis (Figure 5) as well as the current and proposed boundaries of the Blood Run National Historic Landmark (Figure 5). All of these GIS layers form one project database that is tied to the 7.5' USGS quadrangle maps using the 1927 North American Datum and projected to UTM Zone 14 with measurement units in meters. The site distribution layer contains restricted information and has not been distributed with the other files at this time.

Historic architectural sites are not currently included in the database. However, we have compiled a list of atlases and plat maps that could be reviewed (see References Cited:Maps/Plats/Atlases). The project area includes the townships listed in Table 2. Several State Register or National Register Historic Properties are within, or in the vicinity of, the project area. Figure 6 reflects the distribution of historic properties (architectural) currently listed on the state database for Minnehaha and Lincoln Counties. This distribution shows sites eligible, not eligible and unevaluated for the National Register of Historic Places.

Table 2. Townships included within the Project Area.

Minnehaha County		
Benton	T102N	R50W
Mapleton	T102N	R49W
Brandon	T102N	R48W
Wayne	T101N	R50W
Sioux Falls	T101N	R49W
Splitrock	T101N	R48W
Lincoln County		
Delapre	T100N	R51W
Delapre	T100N	R50W
Springdale	T100N	R49W

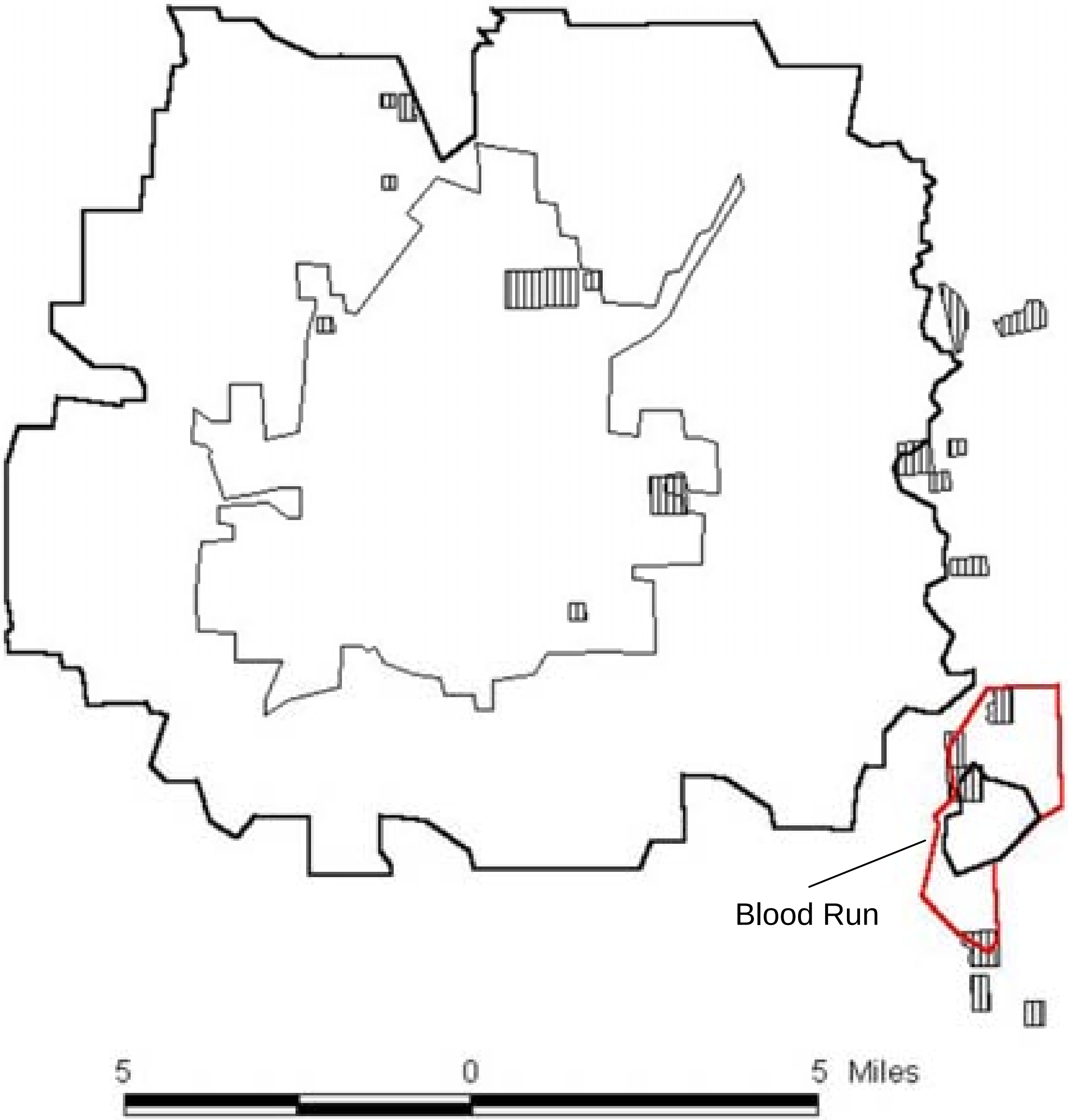

Figure 5. Distribution of the mound groups reported by T. H. Lewis and the current and proposed (red) boundaries of the Blood Run National Historic Landmark.

Lincoln and Minnehaha Counties

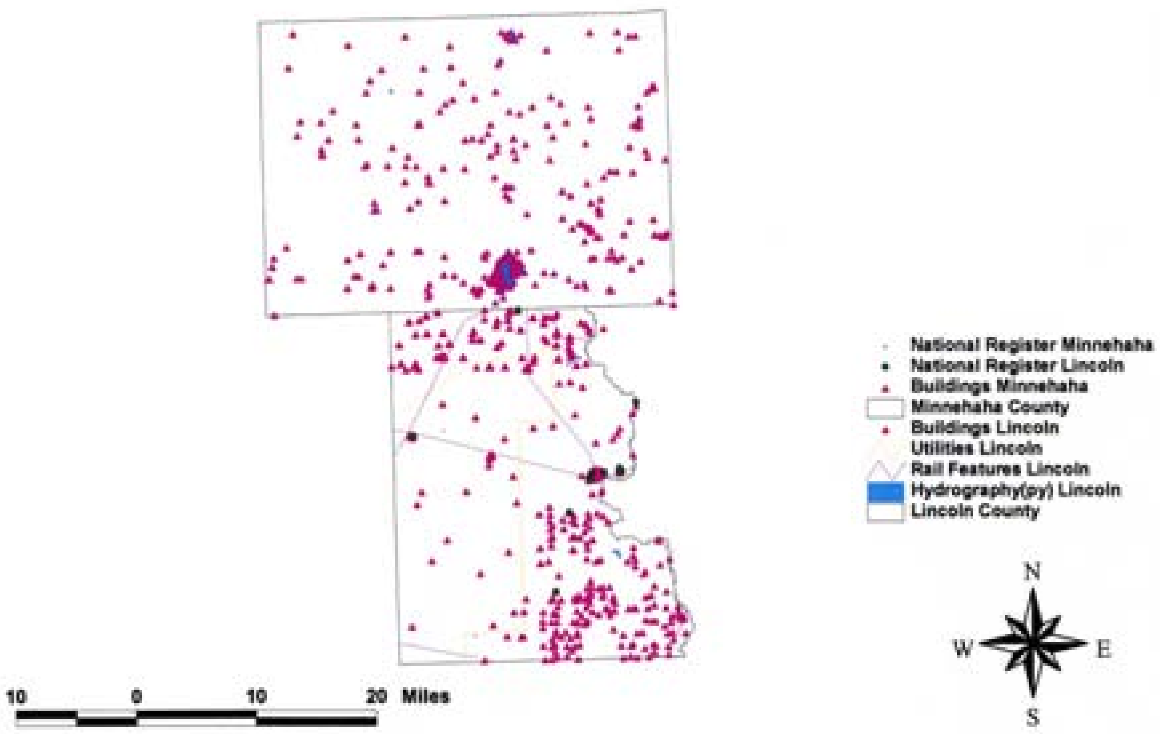

Figure 6. Distribution of all historic (architectural) properties currently (April 2003) on the state database whether eligible, not eligible or unevaluated for the National Register of Historic Places.

Sensitivity Analysis

Figure 7 presents the GIS layer that illustrates those areas considered highly sensitive with respect to archeological resources. It must be stated at the outset that archeological resources per se could be located almost anywhere within the project area. However, the areas outlined in Figure 7 have been judged most sensitive for significant archeological resources, i.e., resources that have the potential for nomination to the National Register of Historic Places.

These areas are drawn in a general fashion that is based on three main aspects considered critical to archeological site location: 1) significant water sources; 2) slope/ topography; and 3) distance to critical resources. The major water source in the project area is the Big Sioux River. Five additional named drainages are present: Slip Up Creek, Silver Creek, Willow Creek, Spring Creek and Skunk Creek. In general terms, the closer a project is to a major water source, the higher the potential for archeological sites. Exceptions to the latter statement, relating primarily to landform changes and topography, do occur. Sites can be destroyed by rivers that meander across their floodplains. Such recent floodplains often have no potential for significant resources. Similarly, steep slopes are generally not suitable site locations. On the other hand, many sites have been identified on high terraces, bluffs, hilltops and ridge tops. Again, the further such landforms are from water sources, the less likely they are to be the location of significant sites.

The high sensitivity areas shown on Figure 7 were drawn based on the above considerations as well as reviews of a series of planning documents and archeological syntheses of the region (see References Cited:Planning Documents). These depictions are general in nature and the boundaries should not be interpreted literally. The USGS quadrangle maps which form the base maps for the project were themselves compiled over 25 years ago. Housing tracts and other developments have encroached on some of the high sensitivity areas, and have likely destroyed numerous archeological sites.

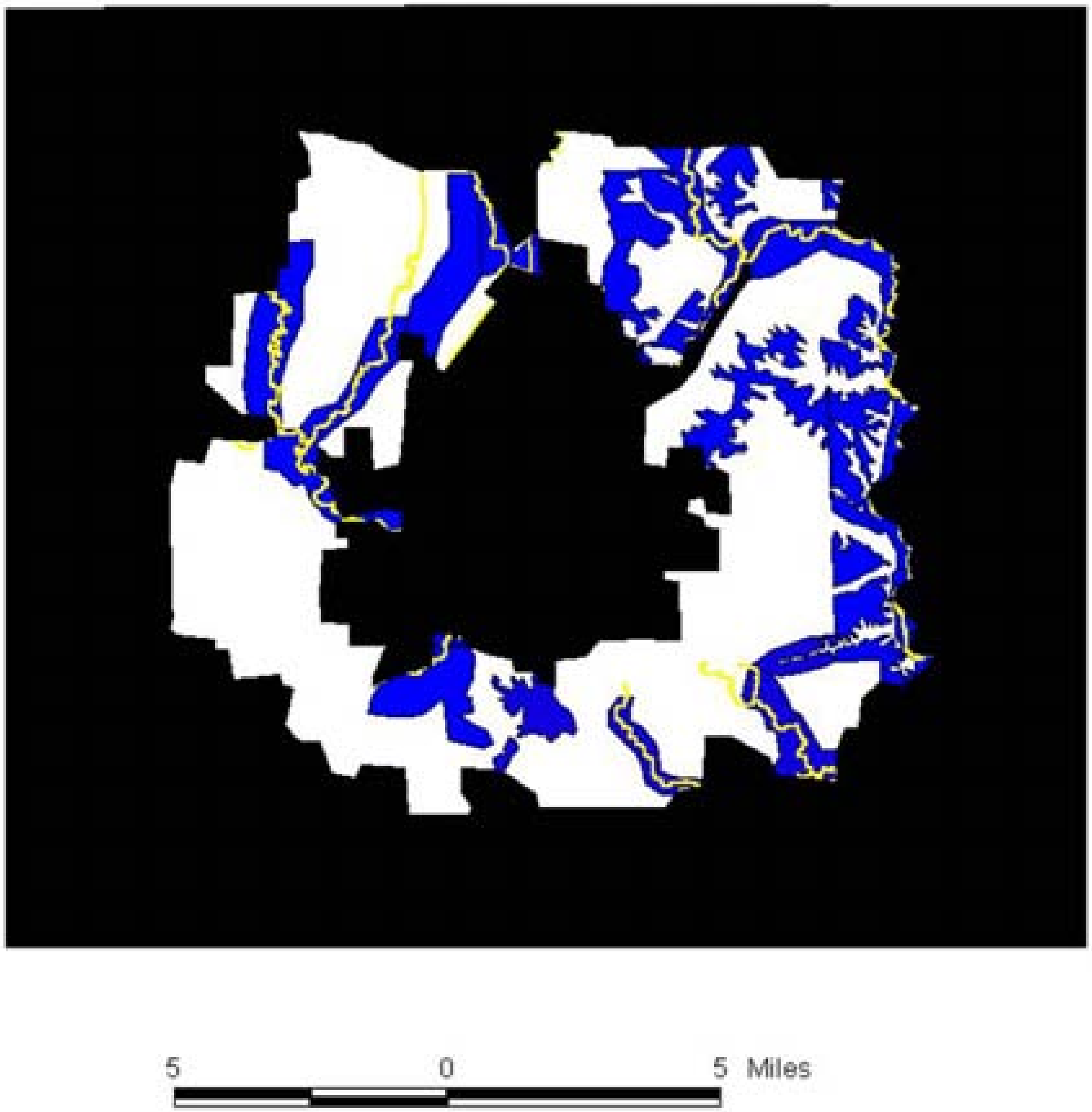

Figure 7. Areas of high sensitivity (potential) for archeological resources with major drainages superimposed.

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(Survey numbers indicated - see Figure 8)

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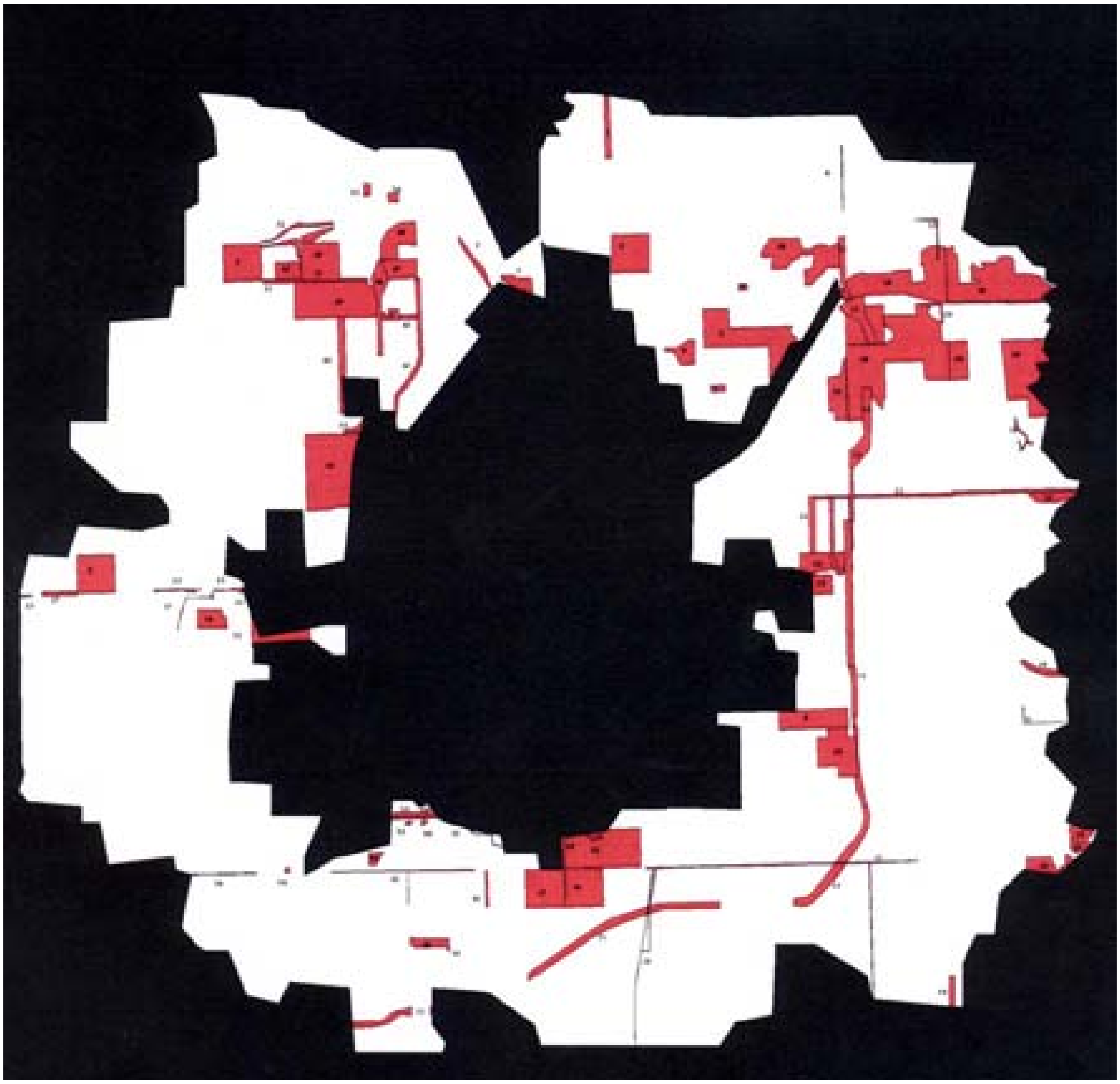

Figure 8. Surveys within project boundaries (Numbered 1-56).

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Criteria for Siting and Design of Regional BMP Facilities

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RESPOND BY: February 28, 2003

DATE: February 18, 2003

This memorandum summarizes the criteria that will be used for siting and designing Best Management Practices (BMPs) for the Regional Stormwater BMP Master Plan for Sioux Falls, South Dakota. The *purpose of the criteria* is to guide the design of BMPs by integrating information from the modeling task with site and watershed characteristics (e.g. topography and land use information). The focus of this memorandum is on conventional structural BMPs, as defined in the City's Chapter 11 design standards, such as:

- Extended Detention Basin
- Constructed Wetlands Basin
- Retention Pond

In addition, a companion memorandum has been prepared to address nonstructural or vegetative BMPs. These two memorandums should be considered in an integrated fashion.

1. Objectives of the Regional BMP Master Plan

The objectives of the Master Plan were discussed with the City 's Master Plan project team. The following Vision and Purpose were developed as key objectives of the Master Plan.

1.1. Project Vision

To develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. The stormwater plan will:

- Establish Sioux Falls as a leader in South Dakota
- Provide a template of how to manage stormwater discharges
- Be endorsed by the development community
- Be understood by the general public
- Facilitate planned growth
- Support water quality

- Enhance natural resources
- Be affordable

1.2. Project Purpose Statement

To create a Stormwater BMP Master Plan that charts the future of stormwater management in the new development areas of Sioux Falls. Provide an overall assessment of the City's water quality and quantity BMP needs in new development areas that is prioritized to meet expected development patterns. We will achieve this purpose by:

- Identifying BMP locations and storm drainageways (for land purchases and planning)
- Estimating BMP cost for financial planning purposes
- Developing conceptual design examples to educate stakeholders on BMP purpose, function and appearance
- Developing a BMP implementation plan, which will identify ordinance needs and permitting requirements
- Identifying operation and maintenance needs
- Achieving City and stakeholder communication, awareness, and involvement in the program

1.3. Water Quality Program

The City established water quality best management practices (BMPs) as part of the City's Phase I stormwater permit program. The water quality BMPs are contained within the *Sioux Falls Engineering Design Standards* Chapter 11, Drainage Improvements. The water quality BMPs are patterned after the Urban Drainage and Flood Control District (UDFCD) stormwater program in Denver. A water quality capture volume (WQCV) is specified for various types of BMPs. The WQCV is based upon the runoff for a given percent imperviousness in the watershed and the 80th percentile storm. Flood storage for a given design storm is provided above the WQCV level.

2. Types of BMP Facilities to be Considered

The BMP facilities to be considered will be located and designed to ensure the aforementioned objectives can be met, while gaining regulatory approval and developer buy-in.

The selected BMPs will perform the following functions:

- Take advantage of different pollutant removal mechanisms (storage and settling, physical and biological filtration of runoff, chemical and biological processes, and infiltration) to improve stormwater quality.

- Maximize preservation of sensitive natural features

- Control runoff peak velocities and volumes to minimize erosion and damage to aquatic and riparian habitat in downstream areas.

Implementable regional (watershed-level) facilities will be considered in the preparation of the Regional BMP Master Plan. Onsite facilities will only be considered to the extent necessary if regional facilities prove infeasible due to regulatory or other constraints.

2.1. Regional (Watershed-Level) BMPs

Watershed-level BMPs will facilitate replication of the runoff characteristics of the watershed and will minimize wetlands impacts. Watershed-level BMPs will be evaluated using the hydrologic watershed models.

The following watershed-level facilities will be evaluated. With the exception of the riparian buffer, these BMPs have been taken from Chapter 11.

- **Extended Detention Basin.** A sedimentation basin designed to totally drain dry over an extended time after stormwater runoff ends. It is an adaptation of a detention basin used for flood control.
- **Constructed Wetlands Basin.** A shallow retention pond that requires a perennial base flow to permit the growth of rushes, willows, cattails, and reeds to slow down runoff and allow time for sedimentation, filtering, and biological uptake.
- **Retention Pond.** A sedimentation basin that has a permanent pool of water that is replaced with stormwater, in part or in total, during stormwater runoff events. In addition, a temporary detention volume is provided above this permanent pool to capture stormwater runoff and enhance sedimentation. Retention ponds differ from extended detention basins because the influent water mixes with the permanent pool water as it rises above the permanent pool level.
- **Riparian Buffers.** A riparian buffer is land adjoining and immediately up-gradient from rivers or streams that is vegetated with native vegetation. Additional information on buffers is available in the accompanying companion memorandum on nonstructural BMPs. The U.S. Corps of Engineers is likely to require a buffer with native vegetation around any BMP which needs a permit from the Corps

2.2. Onsite Level BMPs

Typically, a watershed master plan will identify areas of the watershed that need to be served by onsite facilities as opposed to regional facilities. Certain types of onsite facilities will be beneficial in achieving water quality goals, but criteria needs to be developed to ensure that critical runoff-peak timing effects do not aggravate flood and erosion conditions. It is assumed that the water quality benefits of onsite BMPs will be provided if they are designed according to the WQCV requirements of Chapter 11 or by using other water quality practices if WQCV requirements cannot be met. The onsite BMPs will not be included in the hydrologic model.

The following onsite facilities are being considered by the City and could be implemented for onsite BMPs:

- Sand Filters
- Infiltration Trenches
- Bioretention
- Grass Swales
- Grass Buffers
- Porous Landscape Detention
- Water Quality Catch Basins
- Ponds
- Retrofitting Existing Ponds and BMPs

Onsite BMPs will be recommend for select areas within the 2015 Growth Plan. Locations where onsite BMPs are anticipated include:

- Locations that are part of a watershed which is predominately developed already such that a regional BMP would likely be an individual development anyway.
- Areas which are part of the 2015 Growth Plan but which are remote and not directly connected to the Growth Area will also be best served by site-specific BMPs.
- Areas where the sanitary sewer basin overlaps a small portion of a watershed where the majority of development will not occur in that watershed until beyond the 2015 planning horizon.
- Areas where existing development and local topography limit the types of BMPs appropriate to the watershed.

3. BMP Selection Approach

The watershed models will be used to evaluate the reduction in peak discharge rates from regional BMPs. Note that retention facilities ("wet ponds") are generally recognized to be more effective for pollutant removal than detention facilities ("dry ponds"). However, review of past drainage studies and discussions with City staff have indicated that the local preference is for detention facilities. For the purposes of this study, an extended detention basin ("dry-pond") will be presumed for WQCV sizing purposes. In some instances, such as for larger watersheds with regular baseflows, wet ponds will be recommended.

If there is a baseflow it means that the pond and stream channel upstream intersect the groundwater level so wet ponds are more appropriate. A dry pond in such area would definitely have a persistent wet area, in the "low-flow" channel and likely in areas near the sediment forebay and/or the outlet.

Onsite BMPs such as those listed in Section 2.2 are recommended for subwatersheds that can not be "served" by regional BMPs.

4. Siting and Layout Criteria

The siting criteria is presented in the Table 1. The siting process includes six steps:

1. The end of each sub-basin will be examined as a potential BMP location. A qualitative decision will be made by viewing the wetlands at the end of the basin to determine if it would have a relatively high wetland impact or low wetland impact. If a high wetland impact is anticipated, a different location will be chosen for the BMP and the qualitative screening process will be documented.
2. Once sub-basin and BMP sites have been selected, estimates of the BMP footprint will be made and the associated wetland impacts will be quantified.
3. If at the time of the site screening, known threatened and endangered species are at a BMP site location, consideration will be given to an alternative BMP location. A change in sites will be documented.
4. If known cultural resources are presented, consideration will be given to an alternative BMP location.

5. For instances where additional information becomes available for threatened and endangered species or cultural resources after site selections have been made, at a minimum, permitting considerations will be documented.

6. Other factors listed in Table 1 will be considered in the siting process.

TABLE 1
Siting Criteria for Watershed-Level BMP Facilities

BMP Applicability	Criteria
All	Take advantage of existing topography and maintain natural vegetation
All	Use the known wetlands and threatened and endangered species information to screen sites
All	Minimize impacts to known cultural resources
Ponds	Maximize use of man-made infrastructure (road-crossings)
Ponds	Maximize use of existing ponds (including BMPs and farm ponds)
Ponds	Consider small sub-basin confluences for BMP sites.
Ponds	Keep drainage area for ponds within 100 to 300 acres. Evaluate larger drainage areas on main streams to maximize BMP coverage. Balance critical habitat with drainage area size.
All	Land-use appropriateness and watershed shape
All	Minimize interference with utility easements.
All	Balance water quality benefits, permitting requirements, and costs

Design elements. The following is a list of the typical layout components or design elements of BMP facilities. Incorporating these components in the design of BMP facilities will extend the life of the facility, minimize maintenance costs, and maximize pollutant removal.

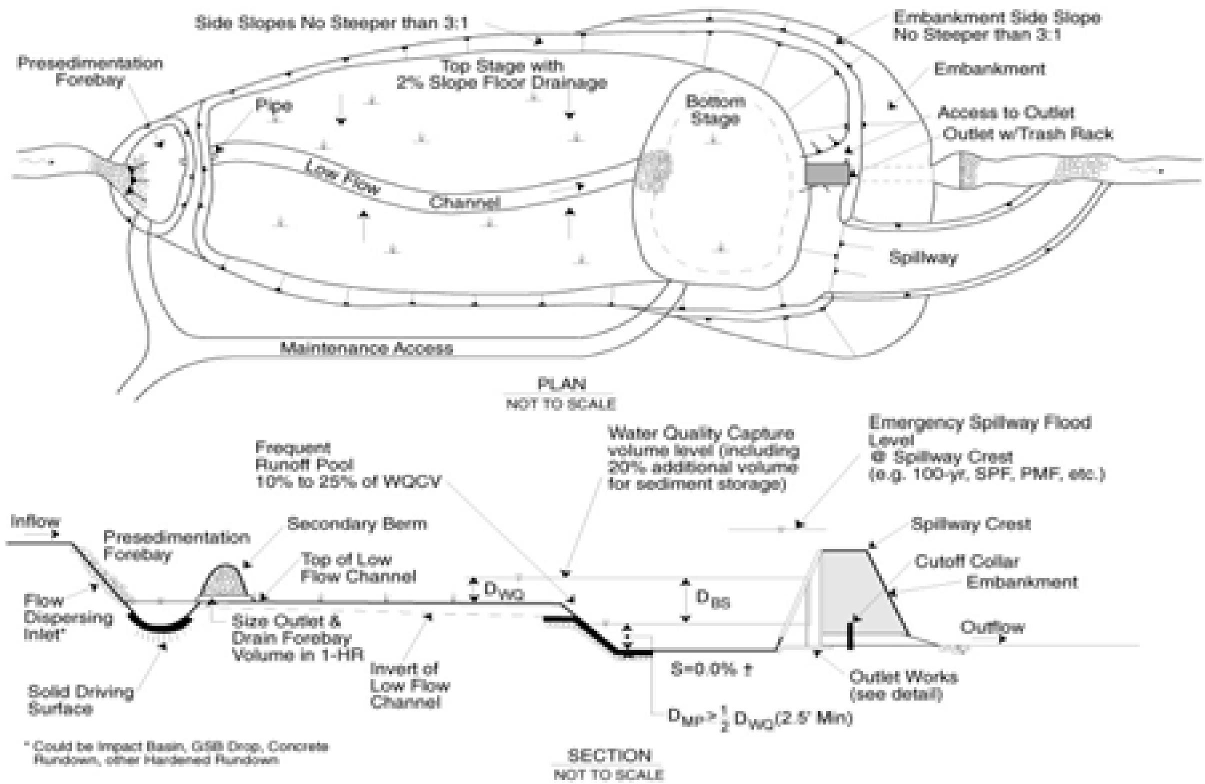
- Prevent concentrated flow from reaching buffers and streams
- Forebays
- Pond side slopes
- Outlet structures (risers, weirs, low level outlets, etc.)
- Trash racks
- Access for maintenance activities
- Outlet pipes and energy dissipation
- Constructability

Layout of regional ponds. A sediment forebay can be constructed near the inlet to trap coarse sediment. Because the forebay acts like a sediment basin or trap, the sediment will need to be removed periodically. To create the forebay, a baffle can be introduced to restrict hydraulic communication between the inlet and the remainder of the pond. Baffles can be constructed from stone, rip rap, gabions, or similar materials.

Short-circuiting of the stormwater should be minimized. The most direct way of minimizing short-circuiting stormwater is to maximize the distance between the inlet and the outlet. A minimum length-to-width ratio between 2:1 and 3:1 is recommended. Wet ponds with long, narrow, and irregular shapes also have reduced surface area exposed to wind and, therefore, a reduced tendency to resuspend previously settled material. Irregularly shaped ponds also appear more natural, or less "engineered." If local site conditions inhibit constructing a relatively long, narrow facility, baffles constructed from gabions or other materials should be placed in the pond to "lengthen" the stormwater flow path as much as possible.

An example Extended Detention Basin BMP is shown in Figure 1.

FIGURE 1
Example BMP – Extended Detention Basin



In wet ponds, aquatic benches can be introduced to provide a shallow-water environment for emergent wetland vegetation (littoral zone). Vegetated aquatic benches can:

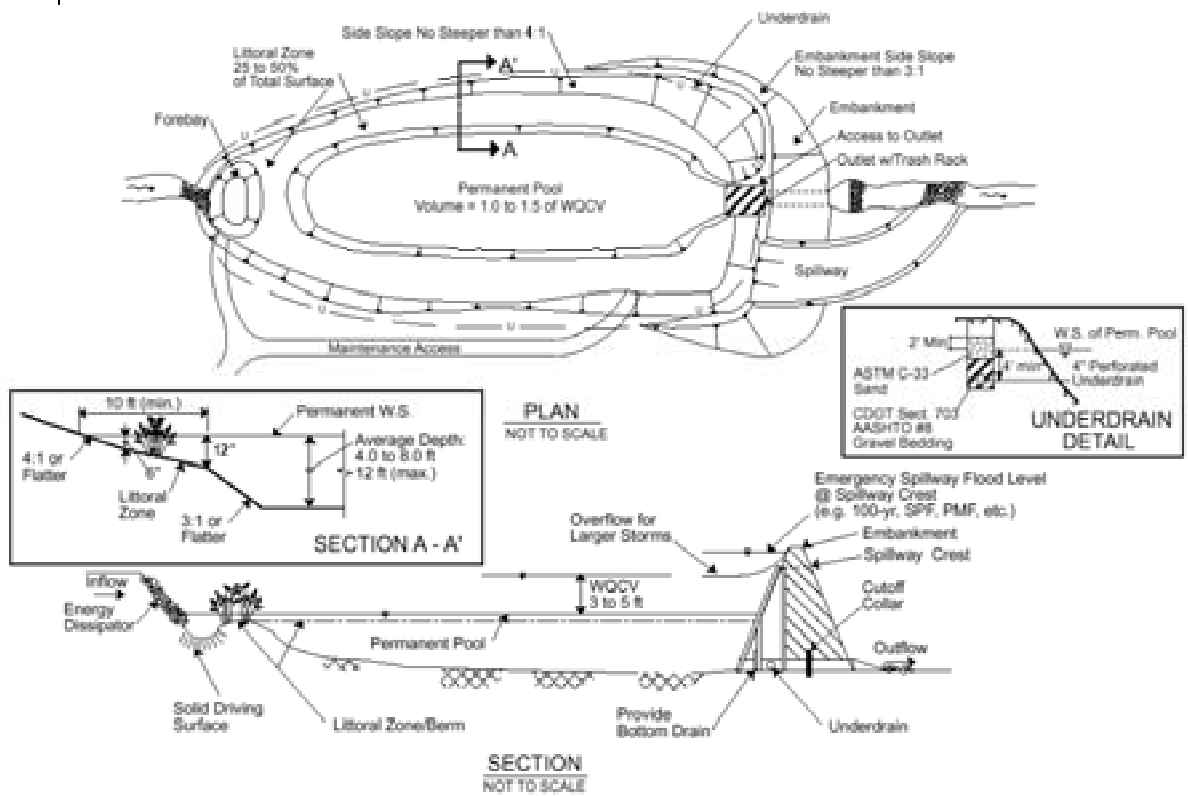
- Enhance biological pollutant removal
- Provide a habitat for wildlife and waterfowl
- Protect the shoreline from erosion
- Improve sediment trap efficiency

In some designs, that portion of the pond devoted to peak attenuation storage will incorporate a nearly level terrestrial bench. Unlike an aquatic bench that is submerged at all times, this bench is only inundated during large storms. It can be planted with shrubs and trees that will shade the pool for wet ponds and help reduce warming effects. The terrestrial bench also introduces the following benefits:

- Enhances wildlife habitat
- Leaf litter provides an additional carbon source for aquatic macro-invertebrates
- Contributes to aesthetic value of the BMP
- Improves safety by providing a buffer separating the pond edge from the permanent pool.
- Reduces currents during large storms, thereby minimizing the potential for the resuspension of sediment

Figure 2 illustrates the layout criteria for wet ponds.

FIGURE 2
Example BMP – Retention Pond



5. BMP Sizing Criteria

It is proposed to size the watershed-level BMPs according to three levels. In order of increasing magnitude, the design storms are:

1. Water quality capture volume
2. Runoff peak attenuation design storm - match existing peak flows for developed peak flows for the 5-year storm
3. Runoff peak attention design storm - match existing peak flows for developed peak flows for the 100-year storm

Peak attenuation can be done through either a structure or a spillway. The standard approach assumed for the Master Plan is to have both the 5- and 100-year storms entirely contained within the same structure while the berm spillway will be an "emergency spillway" which is only activated for events larger than the 100-year storm.

These criteria will be applied to the 2015 Growth Plan area analyzed as part of the Master Plan. One exception to the peak flow attenuation criteria is drainage study basin 40. This basin has been previously identified through City studies as not requiring peak flow detention. Consequently, only water quality capture volume will be analyzed for this basin.

It is necessary to obtain a permit from the DENR for BMPs which have a 25-foot or higher dam or which contain 50 acre-feet or more of water at the top of the berm. Emergency spillway design requirements vary depending upon the dam classification, but it is expected that the typical design criteria will be for the 100-year design flood.

Land Use. Existing land use provided by the City will be used for the predevelopment peak flow determination. The 2015 Growth Plan landuse provided by the City will be used to determine postdevelopment peak flows. The existing land use and 2015 Growth Plan landuse are shown in Attachments 1 and 2. For existing conditions, nonresidential areas outside of the City will assume an agricultural landuse.

Water quality capture volume is used to size BMPs that are intended to achieve specific quality treatment objectives. The 80th percentile storm (the storm at which 80 percent of storms is equal to or less than this storm) is used for the water quality capture volume.

Water quality BMPs usually will continue to provide benefits during runoff events larger than the 80th percentile storm, however, water quality treatment will not be at the same level for these events.

Design for the **attenuation of runoff peaks** is based on the 5- and 100-year return-frequency storms. These large storm events are capable of producing significant downstream flooding and streambank erosion. The design criteria requires that the predicted postdevelopment peak runoff rate for the runoff peak attenuation design storm does not exceed the peak associated with existing conditions. A wide variety of BMPs can be used to control peaks. Example BMPs include:

- Extended Detention Basin
- Retention pond

For this project, we will use the HEC-HMS program with the NRCS methodology. Existing landuse will be used to model predevelopment condition. The relative magnitude of design storm events is summarized in Table 2.

TABLE 2
Rainfall Depths (in.) for Specified Durations and Frequencies Sioux Falls, South Dakota

Frequency	5-Min	15-Min	1-Hour	2-Hour	3-Hour	6-Hour	12-Hour	24-Hour
2-Year	0.417	0.825	1.450	1.660	1.800	2.100	2.328	2.688
5-Year	0.517	1.050	1.910	2.280	2.340	2.640	3.060	3.600
10-Year	0.575	1.175	2.300	2.740	2.760	3.180	3.540	4.200
100-Year	0.841	1.775	3.400	3.720	4.350	4.560	5.160	6.000

From Chapter 11, Figure 11.1

Nonstructural and Vegetative BMP Controls

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RESPOND BY: March 5, 2003

DATE: February 24, 2003

The City of Sioux Falls has requested that nonstructural BMPs be identified to meet the planning requirements of the City and to promote water quality. CH2M HILL conducted an evaluation of nonstructural and vegetative management measures identified based on current planning and engineering practice, including buffer zones, open space preservation, river greenways in-line with the 2015 Growth Plan, and vegetative BMPs. This evaluation provides information to the City on the feasibility of implementing nonstructural management measures in development projects, with emphasis on the 2015 Growth Area.

The categories of management measures evaluated in this technical memorandum are riparian corridor management, vegetative BMPs, transportation best management practices (BMPs), and alternative structural BMPs.

Definitions

Riparian Corridor Management includes structural measures and management policies designed to restore or enhance the beneficial hydrologic properties of natural stream corridors. Stream corridors include the floodplain and adjacent riparian buffer areas. A riparian buffer is land adjoining and immediately upgradient from rivers or streams that is vegetated with a native vegetation, often a combination of trees, shrubs, and herbaceous plants.

Vegetative BMPs are nonstructural management measures implemented as an alternative to storm sewers and to complement or, in some cases, replace traditional BMPs (ponds). Vegetative BMPs will treat and filter the stormwater runoff as it moves through the site. Traditional conveyance systems will "pipe" the stormwater towards a detention or retention facility that will treat the pollutants. Vegetative BMPs will also reduce the rate of runoff by slowing flows and increasing the time of concentration of the watershed. The types of vegetative BMPs evaluated in this memorandum are grass swales, modified grass swales, filter strips, and bioretention.

Transportation BMPs are nonstructural management measures associated with the construction of new roads. Treatment in such facilities is achieved mainly through settling out of sediments and other particles that contain pollutants. In addition, these measures include reducing impervious surfaces. The types of transportation BMPs evaluated in this memorandum are grass shoulders and grass swales.

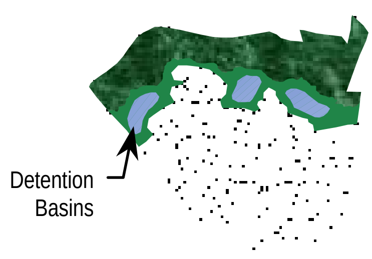
Applicability

The City is developing a watershed management approach to control storm water discharges to address water quality control objectives established in the City's Engineering Design Standards. This approach can be best achieved by implementation of a *runoff reduction hierarchy* in all site designs. The intent of this hierarchy is to minimize runoff volumes and pollutant loads at the source and to mitigate uncontrollable runoff increases using accepted practices like detention/retention.

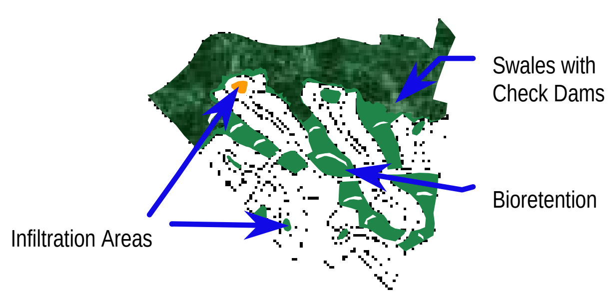
The following are some of the key elements of the runoff reduction hierarchy:

- Minimize impervious surfaces
- Attenuate flows in vegetated swales and depressional (bioretention) storage areas, including buffers
- Infiltrate runoff onsite (depending on soil characteristics)
- Detain/retain excess stormwater
- Construct storm sewers

Nonstructural management measures can be utilized in several elements of the runoff reduction hierarchy. These measures can be used to *pretreat* stormwater before it discharges into traditional BMPs. Pretreatment of stormwater will enhance the pollutant removal efficiency of the system and will reduce the maintenance requirements of the traditional BMPs. The nonstructural measures, such as those listed in this TM, can also be used to *replace* traditional BMPs if the entire subdivision is designed to drain into nonstructural BMPs located throughout the site and the subdivision layout makes use of the natural drainage and storage features of the site, as illustrated below. A nonstructural approach to replace traditional BMPs would have to be shown to be capable of treating the water quality capture volume required in Chapter 11.

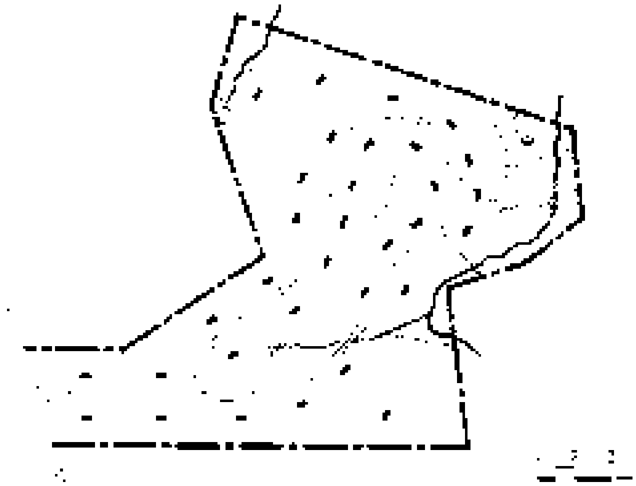


Conventional Development Approach



Hydrologic Approach

Similarly, good site planning procedures are essential to achieve preservation of open space and to promote the use of riparian buffers and greenways, as illustrated below.



Conventional Development Approach **Conservation Subdivision**

(Yield Plan showing 32 lots with 1-acre zoning) (32 lots, with open space, and buffers)

A successful watershed management program will include structural and source control (nonstructural) measures to reduce pollutants that are discharged through the storm sewer system in storm water runoff from commercial and residential areas. The City currently has requirements for structural storm water measures for all new development and this technical memorandum provides information on nonstructural measures. Other nonstructural management measures that were not evaluated, but are part of the City's program, include public education, control of illicit discharges, integrated pest management practices, household hazardous waste program, erosion and sediment control from construction sites, and floodplain management.

Nonstructural management measures are applicable to most sites. However, these types of measures are not widely used. The following are some of the reasons why these measures are not widely used:

- Existing design manuals are not detailed and sample facilities are not practical
- Nonstructural measures are perceived as having large area requirements
- Implementation of nonstructural measures requires changes in traditional construction and development practices (e.g. reduce mass grading, use natural drainage system, reduce the use of concrete pipes to convey storm water, etc.). Workshops with developers and contractors may be useful to identify constraints and obtain input to improve the existing design guidelines
- Lack of definitive monitoring data

Developing jurisdictions, like the City of Sioux Falls, are realizing the need to continue to find new types of BMPs that can be used to meet their water quality goals. Nonstructural BMPs provide an alternative to traditional BMPs and can be effective in reducing pollutant loads because they maximize the area treated and are located as close as possible to the pollutant source. Nonstructural BMPs, if properly designed, will also improve the aesthetics of the site and will provide numerous environmental benefits. Therefore, we recommend that nonstructural BMPs continue to be implemented in Sioux Falls.

Pollutant Removal

The mechanisms for removing pollutants in the nonstructural BMPs being evaluated are infiltration during small storms and adsorption and filtration of pollutants as the storm water runoff travels across the BMP. Other important pollutant removal mechanisms include settling and biological uptake (biofiltration). Bioretention facilities also remove pollutants through ion exchange, evapotranspiration, decomposition, and microbial soil processes.

Traditionally, the control of storm water has been based on managing one or more design storms, such as the 2-, 5-, and 100-year storms for solving "quantity" problems. In the 1980's, controlling the first half-inch of runoff was the standard for solving water "quality" problems. Watershed managers have identified problems with these "standards" and are working on nontraditional approaches to meet the needs of the watersheds (Watershed Protection Techniques, Vol. 1, No.2, Summer 1994).

Nontraditional approaches include focusing the design of BMPs on small storms (less than a 2-year storm) rather than large storms, since the "bulk" of the annual pollutant loads will be carried by these small storms. Sioux Falls has recently updated its Engineering Standards Manual (Chapter 11) to include the control of a Water Quality Capture Volume, which addresses these smaller, more frequent storms. The nonstructural management measures evaluated in this study will be effective in reducing pollutant loads from small storms and controlling erosion of the natural drainage system.

Monitoring

There is a limited amount of data currently available to make detailed determinations on the pollutant removal efficiencies of most nonstructural BMPs. Therefore, there is a need to continue monitoring these facilities to refine the design guidelines and to increase their use as the science and experience of stormwater management continue to develop.

We recommend that if nonstructural BMPs are proposed in lieu of traditional BMPs, the City should look for examples of successful implementation of the approach elsewhere and consider requiring monitoring to judge the success of the nonstructural BMP only approach.

BMP Matrix

A BMP matrix to aid in evaluating the feasibility of implementing nonstructural measures was developed and is found attached.

This matrix summarizes the evaluation of nonstructural BMPs and provides information on pollutant removal, applicability to the City, environmental benefits and concerns, and capital and maintenance costs. The matrix also provides a priority ranking for implementation based on functional, environmental, and funding issues.

Attachments

Figure 2-1 in the main report shows hydrologic soil groups in the Sioux Falls vicinity. Many of these vegetative BMPs function more effectively in soils with higher permeabilities. As the map indicates, there are ample opportunities within the Sioux Falls area to take benefit from these BMPs.

Each management measure is discussed in an attachment to this technical memorandum. The attachments are listed below:

Attachment A—Riparian Buffers
Attachment B—Grass Swales
Attachment C—Modified Grass Swales
Attachment D—Filter Strips
Attachment E—Bioretention
Attachment F—Transportation: Grass Shoulders
Attachment G—Transportation: Grass Swales

Note that Grass Swales and Bioretention are specifically included in Chapter 11. Additional information and perspectives on these BMPs are presented in the attachments. The techniques included in the other BMPs could fit into the openspace and greenways efforts of the City.

The following information is provided for each management measure:

- Functional issues (pollutant removal reliability and efficiency, factors influencing pollutant removal, longevity, and applicability to the City)
- Recommended design criteria
- Maintenance requirements
- Environmental issues (environmental benefits and concerns)
- Funding (estimated construction and maintenance costs)
- Addressing common concerns
- Conclusions
- References

Attachment A—Riparian Buffers

Buffers can be used to provide peak flow attenuation and stream valley detention, reduce nonpoint source loads and to meet the City of Sioux Falls land use planning objectives. Buffer areas may include wetlands and sensitive habitats, steep slopes, floodplains and other important resource areas. The 2015 Growth Plan identifies Greenway and park areas that can be used as buffers without reducing the availability of land for development or infringing on property rights.

Under some circumstances, an urban stream buffer can be used as a vegetative filter to treat the quality of stormwater runoff. The term buffer is also sometimes referred to as a riparian buffer, a forested buffer, a stream buffer, or simply a buffer strip. The riparian buffer should not to be confused with grass buffers and grass filter strips, because the target vegetation is the native riparian plant community, which generally is mature forest, though in parts of the Midwest, including some areas of Sioux Falls, prairie grass and shrub vegetation may be appropriate. (Much of this discussion on riparian buffers comes from *Site Planning for Urban Stream Protection - Chapter 5: The Architecture of Stream Buffers,* prepared by Tom Schueler and the Center for Watershed Protection, December 1995).

Functional Issues

Pollutant Removal Reliability

Riparian buffers rely primarily on sediment deposition, soil adsorption, plant uptake, and infiltration. Performance monitoring have shown that these mechanisms can be very effective at removing pollutants, as long as even and uniform sheet flow is maintained across the buffer. However, while urban stream buffers provide many benefits, it must be emphasized that they often have limited capability to remove pollutants borne in stormwater runoff, and must be used in combination with other BMPs.

Most runoff in urban areas concentrates too quickly to be effectively treated by a buffer. Typically, runoff from about 75 to 150 ft landward of a buffer will concentrate into a gully or ditch, or be conveyed in a drainage pipe directly to the stream, thus short-circuiting the benefit of the buffer.

Design Considerations

- ✓ **Soil**
- ✓ **Area Required**
- ✓ **Slope**
- ✓ **Flow Velocity**
- Water Availability
- Aesthetics
- Hydraulic Head
- Permitting

Key
✓ Most Important Consideration

Targeted Constituents

- ● Sediment
- ⊙ Nutrients
- ● Heavy Metals
- ⊙ Toxic Materials
- ⊙ Floatable Materials
- ⊙ Oxygen-Demanding Substances
- ⊙ Oil and Grease
- ○ Bacteria and Viruses

Key
- ● Likely to Have a Significant Impact
- ⊙ Medium Impact
- ○ Probably Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ⊙ O&M Costs
- ⊙ Maintenance
- ○ Training

Key
- ● High Requirement
- ⊙ Medium Requirement
- ○ Low Requirement

Based on the area treated landward of each buffer and typical stream densities, it has been estimated that buffers typically can treat only 10 percent of the total drainage area. Therefore, other BMPs must still be installed. The buffer watershed treatment is constrained by the limited distance sheet flow occurs into the buffer and by the traditional practice of piping outfalls directly to the channel. The treatment area is conceptually shown in Figure A-1.

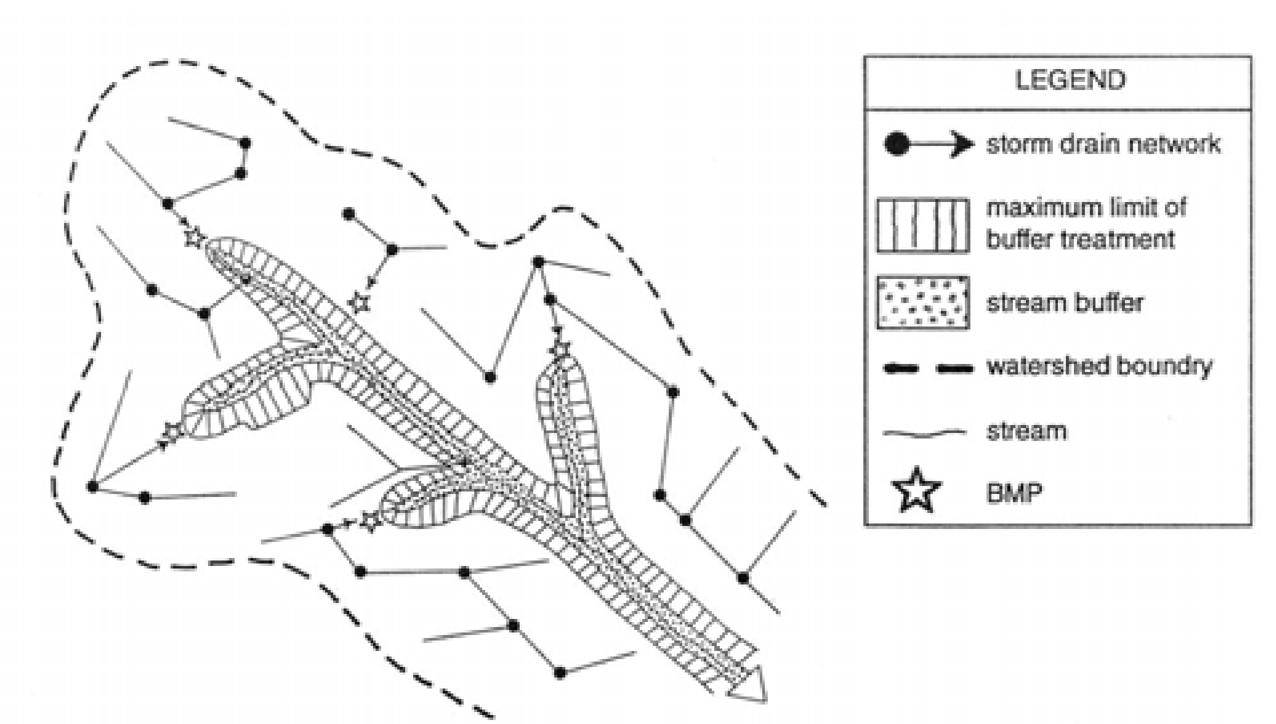


Figure A-1. Conceptual buffer treatment area *(Center for Watershed Protection 1995)***.**

Pollutant Removal Efficiency

Relatively few monitoring studies are available to determine the pollutant removal efficiency of riparian buffers.

According to one paper (Uusi-Kamppa et al. 1996) increased buffer width led to increased removal of total phosphorus in studies in Virginia and Maryland. The Virginia study indicated that a buffer with a width of 9 m (30.2 ft) producing an average phosphorus reduction of 79% verses 67% with a buffer width of 4.6 m (15.1 ft). The removal rates increased by 12% as a result of essentially doubling the buffer width. The Maryland study produced similar results.

The Center for Watershed Protection cites the potential for achieving the following pollutant removal rates, for the narrow strip of land immediately upstream of a buffer that is effectively treated, i.e. for which flow is not channelized:

- Sediment 75%
- Total Nitrogen 40%
- Total Phosphorus 50%
- Trace Metals 60 to 70%
- Hydrocarbons 75%

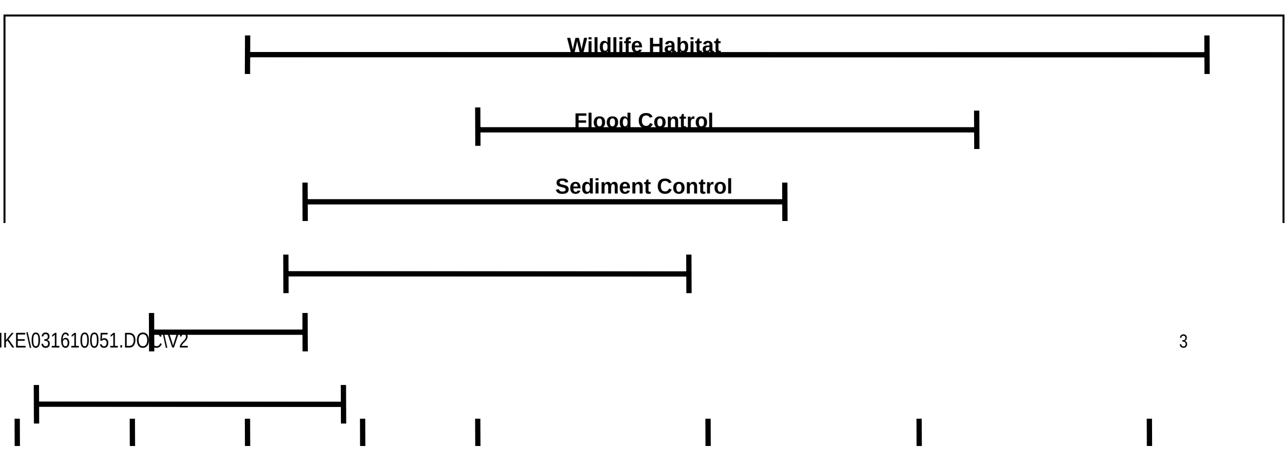
Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal. The four most important factors for buffers, especially those surrounding first and second order streams, are:

- buffer width (flow path length);
- buffer structure (plant types, maturity, coverage);
- buffer slope; and
- the presence or absence of concentrated (channelized) flow.

Increasing buffer width improves removal efficiency up to a point. Buffers comprised of trees and undergrowth are more efficient than grass (particularly lawns). Buffer efficiency rapidly declines with increasing slope. Channelized flow acts as a bypass, routing water from the area upslope of the buffer to the stream, eliminating the effectiveness of the buffer. Both the amount of area contributing flow to the buffer and the buffer slope contribute to whether channelized flows will form to bypass the buffer.

The optimum width for buffers (landward from the stream) will depend on the functions assigned to them (see Figure A-2).



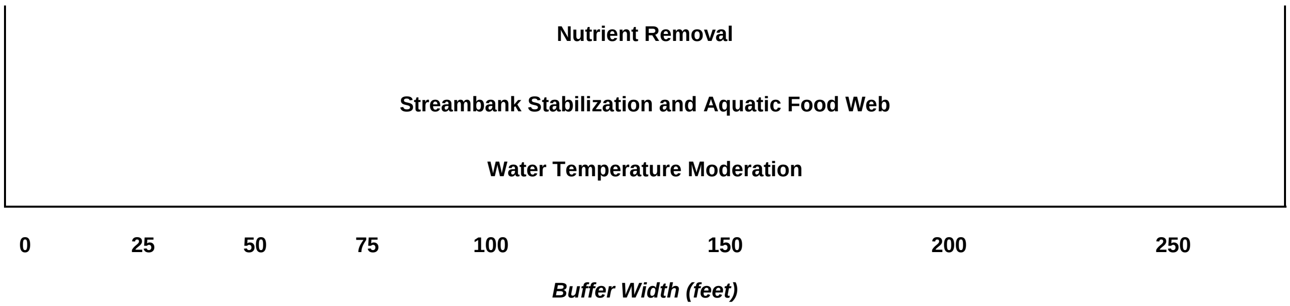


Figure A-2. *Range of minimum width for meeting specific buffer objectives* (Palone and Todd, draft).

Factors with a Positive Influence

- Slopes less than 5%
- Contributing flow length less than 150 ft
- Water table close to the surface
- Check dams and level spreaders to promote sheet flow
- Permeable but not sandy soil
- Growing season
- Buffer width (long flow path)
- Organic matter, humus or mulch layer
- Small runoff events
- Entry velocity less than 1.5 ft/sec
- Dense vegetative cover, deep roots

Factors with a Negative Influence

- Slopes greater than 5%
- Overland flow paths over 300 ft
- Groundwater far below the surface
- Contact times less than 5 minutes
- Compacted soils
- Non-growing season
- Buffers less than 10 ft
- Snowmelt conditions, ice cover
- Runoff events greater than 2 year frequency
- Entry velocity more than 5 ft/sec
- Sparse vegetative cover, shallow root systems

Longevity

Surveys indicate that most riparian buffers operate as designed, requiring only minor maintenance such as sediment removal (Horner 1988; Schueler 1992). The main maintenance problem is the gradual buildup of soil, which causes runoff to concentrate and short-circuit the buffer. In addition, encroachment by homeowners can cause loss of vegetation and function. Factors influencing longevity are:

- Runoff velocity that is consistently high (that is, more than 5 fps) will increase the tendency of the buffer to erode and experience short-circuiting
- Accumulation of sediment in the upper portions of the buffer can lead to concentrated flow channels

Applicability to City

The location of riparian buffers and lots should be based on site topography and natural features. Where buffers are planned, they should be designed according to the guidelines in this section, and carefully planned as part of the site planning and review process. This best management practice (BMP) works best in conjunction with other BMPs.

Slope

Buffers are well suited to either flat or rolling terrain typical of the City of Sioux Falls. However, they can also be used to limit development on steep slopes adjacent to streams, in floodplains and environmentally sensitive areas.

Soil

Buffers are not restricted in their applicability by soil type. However, the target vegetation for a given buffer will likely be impacted by soils and precipitation.

Contributing Drainage Area and Required Area

Buffers are applicable to all streams, but are particularly valuable to protect headwater streams (first and second order streams). The Army Corps of Engineers has recognized the value of headwater streams in a Regulatory Guidance Letter on October 31, 2001. This letter notes the value the preservation of stream and open water vegetated buffers and recommends the acceptance of these (including upland areas) for mitigation credit. The letter also stresses the importance of evaluating the mitigation with a watershed approach in mind.

Buffers typically take up about 5 percent of the watershed area, land that may not be developable anyway. The contributing area that is treated is the area immediately upgradient about 150 ft from the buffer, representing a total of 10% of the watershed area (including the buffer area itself). Some buffer design criteria include a variable width, with buffer width increasing downstream. However, because of decreasing stream density (fewer stream miles per watershed area) downstream, the increasing buffer width design does not take up a greater proportion of watershed area.

Level of Applicability

In conclusion, buffers are an appropriate nonstructural BMP for development sites in many areas of the City. Major constraints in using buffers are:

- Slope–Steep slopes reduce pollutant removal rates and increase the potential for short-circuiting.
- Area served- the contributing drainage area served by buffers is generally less than 10 percent of the watershed area, so additional stormwater BMPs are needed to treat stormwater from the entire watershed.

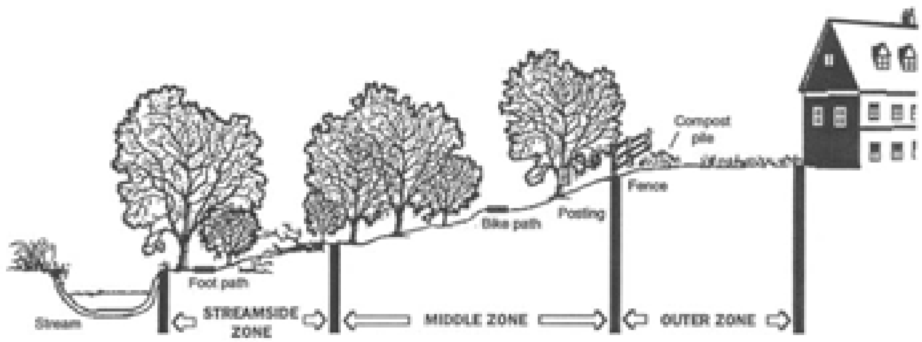
Recommended Design Criteria

The following subsection discusses some critical design considerations. There are ten design criteria that are recommended for buffers:

1. **Minimum total width –** In general, a minimum buffer width of 100 feet is recommended. Most communities require that buffers fully incorporate lands within the

100-year floodplain, and others may extend the buffer to include adjacent wetlands, steep slopes or other critical habitat.

2. **Three-zone buffer system –** Effective stream buffer systems are recommended to include three lateral zones, each with a different function and width, as shown in Figure A-3: a *streamside zone* (typically 25 ft, plus wetlands and critical habitats), a *middle zone* (50 to 100 ft, depending on stream order, slope, plus the 100-year floodplain), and an *outer zone* (25 ft setback to structures).
3. **Mature forest, or pre-development native vegetation, as a vegetative target –** the ultimate target is to establish or maintain pre-development natural vegetation.
4. **Conditions for buffer expansion or contraction –** allows for expansion to encompass the 100-year floodplain, steep slopes, or adjacent wetlands or critical habitats, or to increase with stream order. Similarly, allows the buffer width to contract to accommodate unusual circumstances (e.g. shallow lots, stream crossings, or stormwater BMPs), provided the average buffer width is maintained.
5. **Physical delineation requirements –** buffers should be mapped for citywide planning purposes and should appear on development plans submitted for review.



CHARACTERISTICS	STREAMSIDE ZONE	MIDDLE ZONE	OUTER ZONE
FUNCTION	Protect the physical integrity of the stream ecosystem	Provide distance between upland development and streamside zone	Prevent encroachment and filter backyard runoff
WIDTH	Min. 25 feet, plus wetlands and critical habitats	50 to 100 feet, depending on stream order, slope, and 100 year floodplain	25 foot minimum setback to structures
VEGETATIVE TARGET	Undisturbed mature forest. Reforest if grass	Managed forest, some clearing allowable	Forest encouraged, but usually turfgrass
ALLOWABLE USES	*Very Restricted* e.g., flood control, utility right of ways, footpaths, etc.	*Restricted* e.g., some recreational uses, some stormwater BMPs, bike paths, tree removal by permit	*Unrestricted* e.g., residential uses including lawn, garden, compost, yard wastes, most stormwater BMPs

Figure A-3. *The Three-Zone Urban Stream Buffer System (Center for Watershed Protection 1995). Three lateral zones comprise the foundation of an effective urban stream buffer zone. The width, function, management and vegetative target vary by zone.*

6. **Conditions where the buffer can be crossed –** criteria should be established to limit the number buffer crossings in order to maintain habitat value of the buffer, including an unbroken corridor of riparian vegetation and maintain upstream/downstream fish passage. In practice, however, some crossings should be allowed. Criteria should be set for maximum right-of-way width, crossing angle (right angles are preferred), frequency (1 crossing per subdivision is a recommended goal), and elevation (utility crossings should be a minimum of 3 ft below the stream invert or deeper as otherwise required)

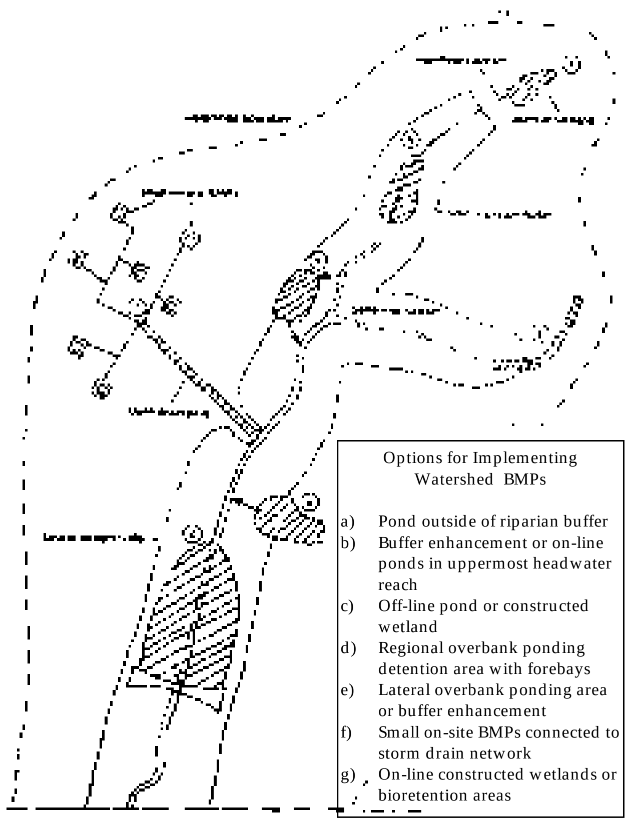


Figure A-4. Options for locating watershed BMPs in riparian corridors (adapted from *Site Planning for Urban Stream Protection*, Center for Watershed Protection 1995).

7. **Integrating stormwater and BMPS within the buffer –** buffers are a desirable location to locate BMPs. Given the effectiveness of stormwater ponds and wetlands in removing pollutants, it is generally not advisable to prohibit their use within the buffer. Figure A-4 shows some of the options for locating ponds within the stream buffer.

   In order to maximize the effectiveness of the buffers, it is suggested that concentrated flow discharges be minimized using "systems" like the one shown on Figure A-5.

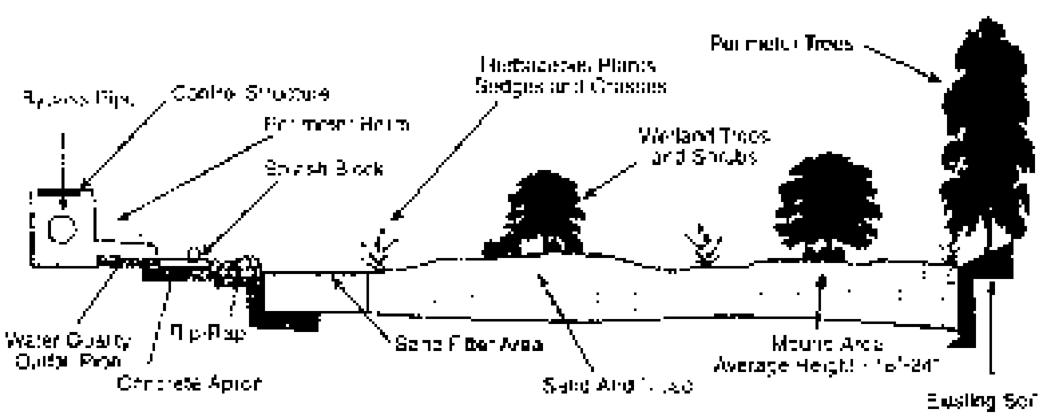


Figure A-5. Small storm treatment/Bioretention cross section: Runoff from large storms (greater than the WQCV) is bypassed through the main drainage system. Runoff from small storms is **diverted** *at the control structure (manhole). The* *splash block or the rip rap* **dissipates** *the energy of the stormwater flow. The stormwater is* **filtered** *through an open sand filter. Excess stormwater is* **treated** *in the bioretention area.*

8. **Buffer limit review –** The limits and uses of stream buffers should be well defined during each stage of the development review process, from initial plan review through construction.

9. **Buffer education, inspection, and enforcement –** to maintain the future integrity of the buffer, a strong education and enforcement program should be implemented, including mark the buffer boundaries with permanent signs, educating buffer owners, and providing appropriate enforcement options through establishment of a buffer ordinance.

10. **Buffer flexibility –** because of legitimate concerns that stream buffer requirements could be viewed as uncompensated taking of private property, it is important to build flexibility in the buffer program, including 1. Maintaining buffers in private property; 2. Allowing for buffer averaging; 3. Allowing for density compensation; 4. Allowing for variances; and 5. Allowing for conservation easements that can reduce property taxes on land set aside as a buffer.

The City of Sioux Falls has several existing programs (floodplain management, stormwater management) that provide the basis for developing a ***riparian corridor management*** program, including riparian buffer application for the 2015 Growth Areas. Some of the options for using these corridors are illustrated in Figure A-4. In addition, buffers contained within these corridors can be enhanced to ensure that they perform the required functions.

Maintenance Requirements

Maintenance of buffers is limited to maintaining the vegetation and occasional trash and sediment removal. Where native vegetation is used rather than groomed turf, vegetation need only be monitored seasonally to ensure adequate growth of woody vegetation and removal of invasive species. The frequency of trash and sediment removal will depend on the location.

Excessive sediments should not accumulate if adequate soil and erosion controls are in practice upstream. However, should excessive siltation occur, it will be necessary to remove the excess sediment.

Environmental Issues

Environmental Benefits

Environmental benefits of riparian buffers include:

- Reduces small drainage problems and complaints
- Allows for lateral movements of stream
- Provides flood control
- Protects from stream erosion, especially if forested and deep rooted vegetation
- Increases property values
- Enhances pollutant removal

- Provides a foundation for present or future greenways
- Provides food and habitat for wildlife
- Protects associated wetlands
- Prevents disturbances of steep slopes
- Mitigates stream warming, if forested
- Preserves important terrestrial habitat
- Supplies corridors for conservation
- Essential habitat for amphibians
- Fewer barriers to fish migration
- Discourages excessive storm drain enclosures/channel hardening
- Provides space for stormwater ponds
- Allows for future restoration

Environmental Concerns

Environmental concerns associated with riparian buffers include:

- Buffers sometimes viewed as a breach of property rights
- Natural buffer vegetation may not be what is preferred by the community
- Buffers may result in reduced lot yields for development, especially smaller subdivisions

Funding

Estimated Construction and Implementation Costs

Little information is available on the implementation costs of riparian buffers. Limits on utility crossings could increase some construction costs, and potential reductions in lot yields might occur. But a national survey of 36 stream buffer programs has shown that buffers are either neutral or lead to increased property values (Heraty 1993).

Estimated Operation and Maintenance Costs

Regular maintenance costs for stream buffers are minimal. Costs for periodic replanting, trash and sediment removal should be considered. In residential subdivisions, adjacent homeowners will manage this responsibility. Also, inspection after large storms for erosion failures and special maintenance should occur regularly.

Conclusions

Based on the benefits that buffers present, it is recommend that the City work closely with the development community to implement a buffer ordinance for new development areas within the 2015 Growth Plan for Sioux Falls.

Attachment B—Grass Swales

Grass swales are constructed open-channel drainageways. They are used as an alternative to, or an enhancement of, conventional storm sewers. Swales vegetated with grass or other suitable vegetation are useful both as runoff conveyance facilities and as pollutant filtering and infiltration devices.

Design information for grassed swales is included in the City of Sioux Falls Engineering Design Standards Chapter 11. The information contained in this TM provides additional discussion on this BMP and comparison to other nonstructural BMPs.

Functional Issues

Pollutant Removal Reliability

Grass swales increase infiltration opportunities and filter pollutants as stormwater runoff moves through the swale drainage system. Where possible, natural drainageways on the site should be maintained and used as part of the swale drainage system. The main mechanism for removing dissolved pollutants will be infiltration during small events. Removal rates will be reduced substantially if the vegetation in the swale is not maintained or if the sediment load is sufficiently high that it buries the vegetation and is readily resuspended during subsequent events (that is, where uncontrolled runoff from the construction site discharges to the swale).

Pollutant Removal Efficiency

On many sites, vegetated swales are a practical, efficient, cost-effective alternative to curb and gutter or storm sewer systems for stormwater conveyance. Vegetated swales remove pollutants through filtration and infiltration. For small storms during which flow in the swale is less than 1 to 2 inches deep, the vegetated swale acts as a long, vegetated filter. For large storms, the low velocities in the swale facilitate the removal of particulate pollutants through settling.

Use of vegetated swales rather than conventional storm sewers can generally reduce peak runoff rates because of the swale's greater roughness and greater storage capacity relative to storm sewers. Swales also can reduce the annual volume of surface runoff by infiltrating runoff from typical storm events.

Design Considerations

- ✓ **Soil**
- ✓ **Area Required**
- ✓ **Slope**
- ✓ **Flow Velocity**
- Water Availability
- Aesthetics
- Hydraulic Head
- Permitting

Key
✓ Most Important Consideration

Targeted Constituents

- ● Sediment
- ⊙ Nutrients
- ⊙ Heavy Metals
- ⊙ Toxic Materials
- ⊙ Floatable Materials
- ⊙ Oxygen-Demanding Substances
- ⊙ Oil and Grease
- ○ Bacteria and Viruses

Key

- ● Likely to Have a Significant Impact
- ⊙ Medium Impact
- ○ Probably Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ⊙ O&M Costs
- ⊙ Maintenance
- ○ Training

Key

- ● High Requirement
- ⊙ Medium Requirement
- ○ Low Requirement

Grass swales are effective in reducing the "flashiness" of small storms that cause much of the habitat disruption and bank erosion usually associated with urbanization.

The effectiveness of the swale for both reducing the volume of runoff and removing pollutants is a function of the drainage area, the level of imperviousness, the slope and cross section of the channel, the permeability of the soil, and the density and type of vegetation in the swales. Broad swales on flat slopes with dense vegetation are most effective. Pollutant removal will be highest for pollutants associated with sediments and lowest for dissolved constituents. Removal rates for settleable solids may approach 70 percent for swales designed according to the recommendations of this section. The expected removal efficiency of a well-designed, well-maintained conventional swale is projected to 30 percent for total phosphorus and 25 percent for total nitrogen (Schueler 1992).

Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal:

Factors with a Positive Influence

- Check dams
- Low slopes
- Permeable subsoil
- Dense grass cover
- Long contact time
- Smaller storm events
- Coupling swales with plunge pools, infiltration trenches, or pocket wetlands
- Swale length greater than 200 feet

Factors with a Negative Influence

- Compacted subsoil
- Short duration, high intensity (short duration of contact with swale) storms
- Large storm events
- Snow melt events
- Short grass heights
- Steep slopes (6 percent or greater)
- Runoff velocities (1.5 feet per second [fps] or more)
- Peak discharge (5 cubic feet per second or more)
- Dry-weather flow

Longevity

Surveys indicate that most conventional swales operate as designed, requiring only minor maintenance such as grass mowing (Horner 1988; Schueler 1992). The main maintenance problem is the gradual buildup of soil and grass adjacent to roads, which prevents entry of runoff in swales. Factors influencing longevity are:

- Runoff velocity that is consistently high (that is, more than 5 fps) will increase the tendency of the swale to erode

- Rate of erosion decreases as side slopes become flatter

Applicability to City

The location of drainage structures and lots should be based on site topography and natural features. Where man-made swales are installed, they should be designed according to the guidelines in Chapter 11 and supplemented with information in this section. This BMP works best in conjunction with other structural or nonstructural BMPs.

Slope

Vegetated swales are well suited to either flat or rolling terrain typical of the City of Sioux Falls. They can be used as an alternative to conventional storm sewers within common areas of residential subdivisions and along back lot lines and property boundaries. Swales also can be used as internal depressed islands within large parking lots.

Swales should be located to conform with and make use of natural drainageways to the extent that site constraints allow. It will be easier to maintain the existing topsoil and vegetation in a natural drainageway than to establish vegetation in a constructed swale.

Soil

Sandy soils are appropriate for grass swale BMPs. Although grass swales are less efficient in clayey soil because infiltration rates are lower, a properly designed and maintained grass swale should provide some phosphorus removal and, therefore, is also appropriate for use in the City of Sioux Falls.

Contributing Drainage Area

Swales are suitable for many types of development, but they probably are most practical for large-lot residential sites (that is, 1/2-acre lots or larger, or 1/4-acre lots with swales established in common areas) and campus-type developments. A swale serving a tributary area less than 10 to 20 acres will provide significant water quality benefits. A swale serving a larger tributary area will provide some water quality benefits, but would be expected to serve mainly as conveyance, depending on the design. Figure B-1 shows examples of vegetated swales for primary drainage of residential subdivisions, parking lots, and commercial developments. Figure B-2 provides a more detailed sketch of swales within a parking lot. In this example, the optional use of raised storm sewer inlets is shown.

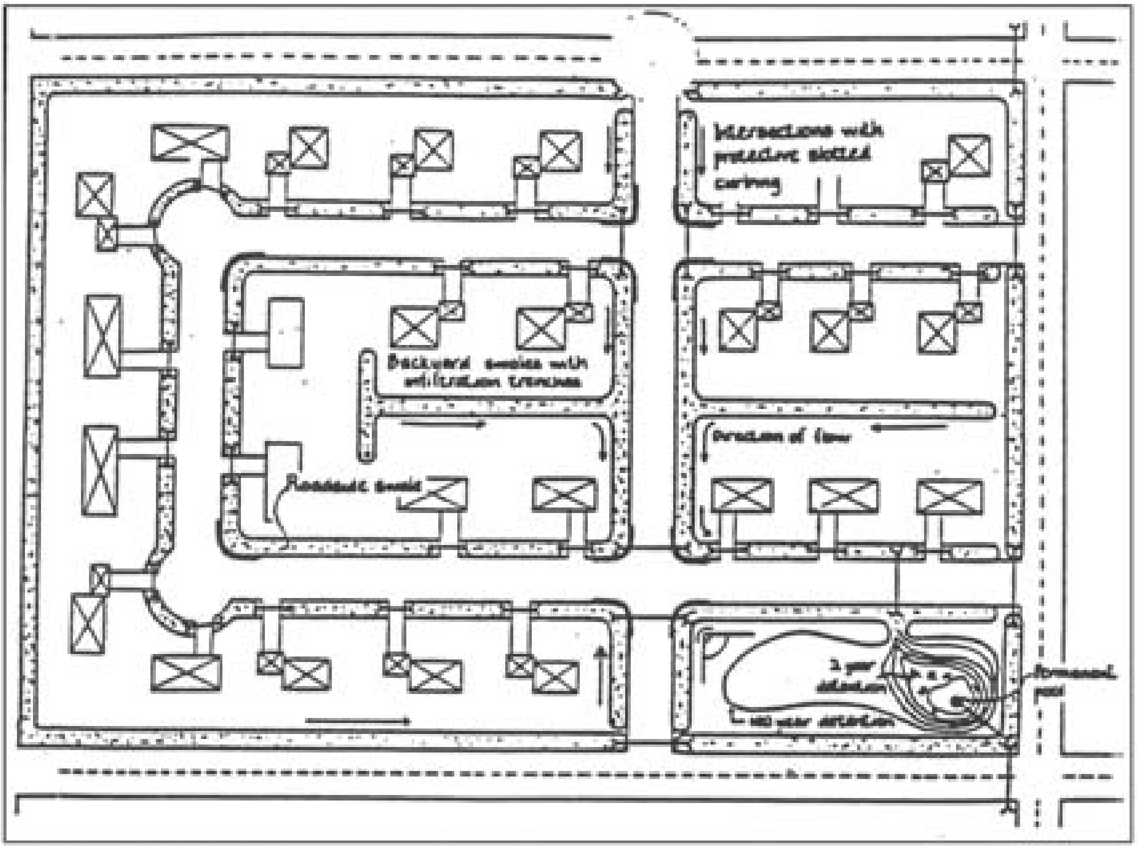
Required Area

When swales are on private property, easements should be provided to prevent alteration and to allow access for inspection and maintenance by the City or a homeowner association as applicable.

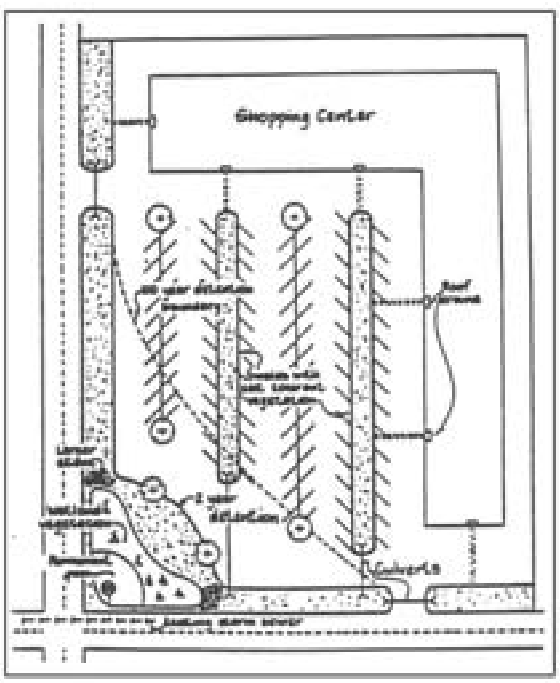
Level of Applicability

In conclusion, grass swales are an appropriate BMP for development sites in many areas of the City. Major constraints in using grass swales are:

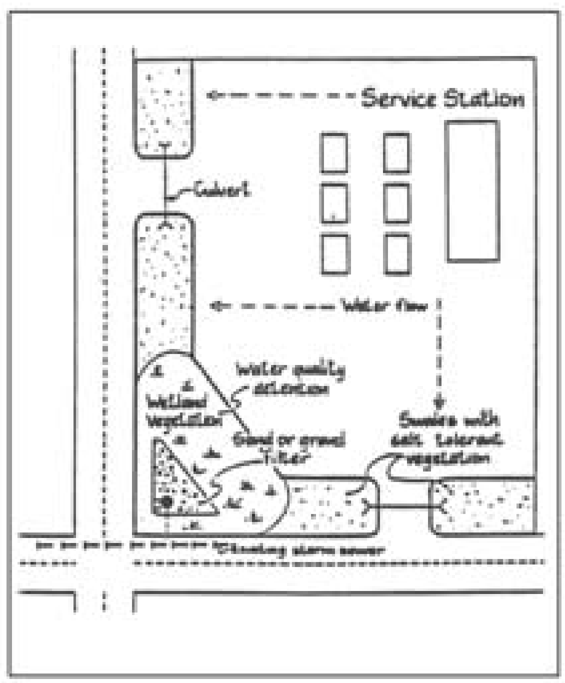
- Slope–Steep slopes reduce pollutant removal rates and increase the potential for erosion; flat slopes promote ponding of water.
- Soil–Soil with a higher infiltration rate provides a higher pollutant removal rate. Grass swales in clayey soil will still provide some pollutant removal through filtering mechanisms.



Single Family Residential Schematic.



Commercial Site Schematic.



Small Commercial Site Schematic.

Figure B-1. Example Uses of Swales for Primary Drainage (Northeast Illinois Planning Commission 1993)

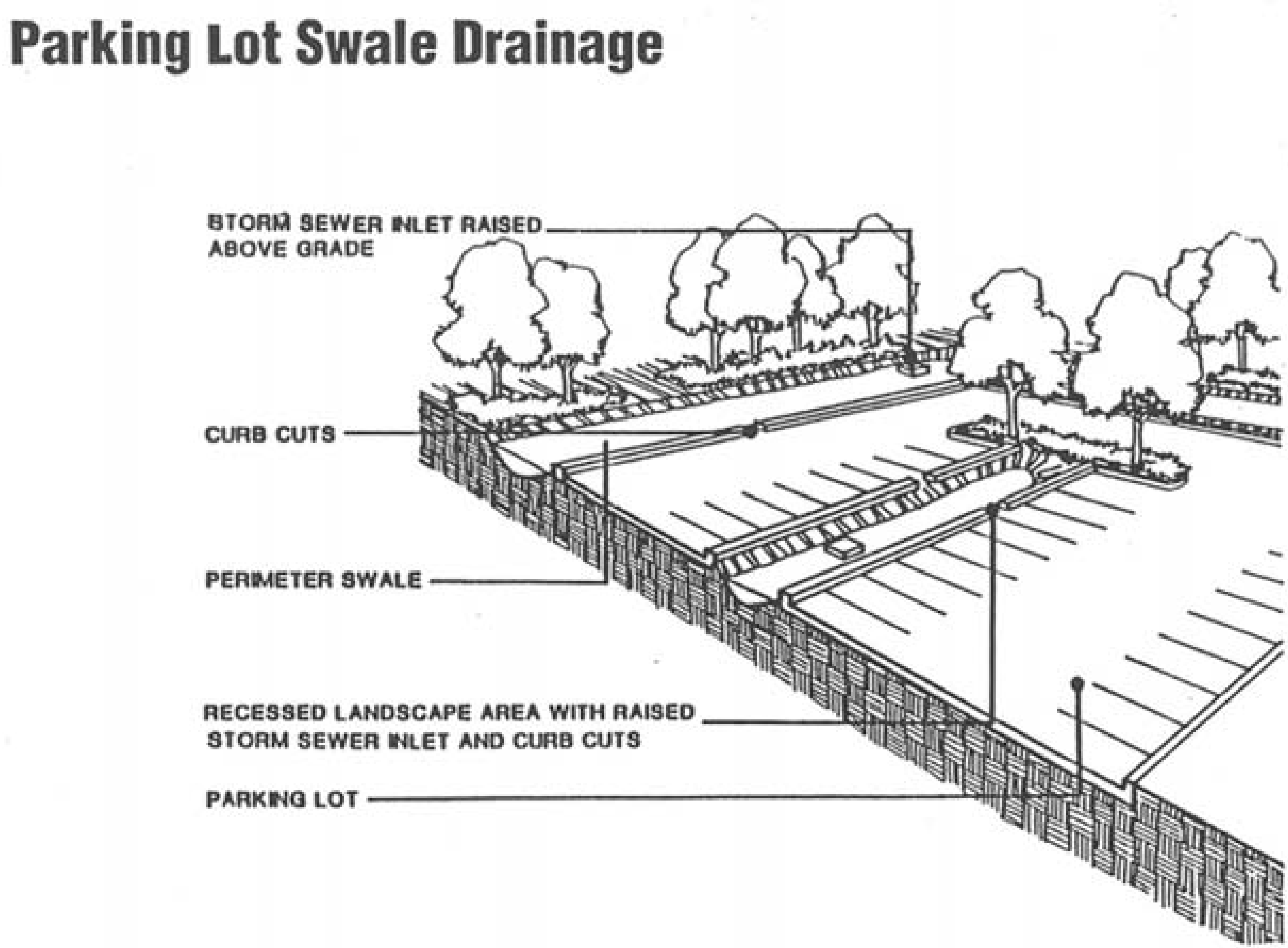


Figure B-2. Parking Lot Swale Drainage (Northeast Illinois Planning Commission 1993).

- Required Area– Grass swales require more surface area than a traditional storm drain system. However, grass swales can typically be incorporated into design plans for residential subdivision common areas.

Recommended Design Criteria

The following subsection discusses some critical design considerations. There are two design conditions that must be considered for swales: the water quality design and the conveyance design. The swale should be designed to promote low velocities for water quality. However, the swale should also be able to pass the flow from the design conveyance event without overtopping or causing erosive velocities. Figure B-3 shows a schematic of a typical grass swale. As shown in Figure B-4, grass swales can be designed in four different ways, depending on function: a drainage channel, a grassed channel, a dry swale, or a wet swale.

Underdrains. The underdrain system can have many different configurations and typically includes a gravel layer surrounding a horizontal, perforated discharge pipe, 4 to 6 inches in diameter. Filter fabric is used to protect the underdrain from blockage. This underdrain design guidance is taken from the North Carolina BMP manual.

Swale Slope. The longitudinal slope of the swale should be as flat as possible to minimize velocities and improve pollutant filtering. However, with slopes much flatter than 1 to 2 percent, ponding may occur in minor depressions, which may be objectionable to some residents. Where slopes are flatter than 1 percent, underdrains or bioretention areas, as discussed in Attachment C, "Modified Grass Swales/Biofilters" may be used to ensure a dry swale between storm events. Another alternative is to place an infiltration trench in the bottom of the swale to store subsurface runoff that will not drain along the slope. If ponding is not a concern to residents, then vegetation that is suited to more wet conditions should be used.

Where longitudinal slopes are greater than 2 to 4 percent, check dams should be considered to reduce velocities, improve pollutant removal, and prevent scour. Vegetated swales should generally be avoided for slopes greater than 10 percent to 12 percent unless it is only for a short distance, there is little flow, and permissible velocities are not exceeded or unless special construction measures are used such as stone riprap in the bottom or drop structures are used.

Side Slopes and Bottom Width. The swale should be parabolic or trapezoidal in cross section for ease of construction and maintenance and for reducing the potential for scour. The side slopes should generally be 4 horizontal to 1 vertical (4H:1V) or flatter to minimize velocities and ease maintenance. However, side slopes of 3H:1V may be used where space is constrained. The bottom width should consider the maintenance needs and be no less than 2 feet (Chapter 11: 10 feet) to ease maintenance and prevent scour.

Vegetation. Native grasses and wetland vegetation, where they already exist or where they can be established prior to substantial discharge rates, are preferred for their improved ability to filter pollutants. Native vegetation also encourages lower velocities because of greater roughness. Flat slopes, intentional creation of minor depressions, and sufficient runoff volumes will improve the ability of the swale to support wetland vegetation. Swales that are ideally suited for wetland vegetation include those that experience routine backwater, have bottoms at or near the groundwater table, or receive sustained base flows.

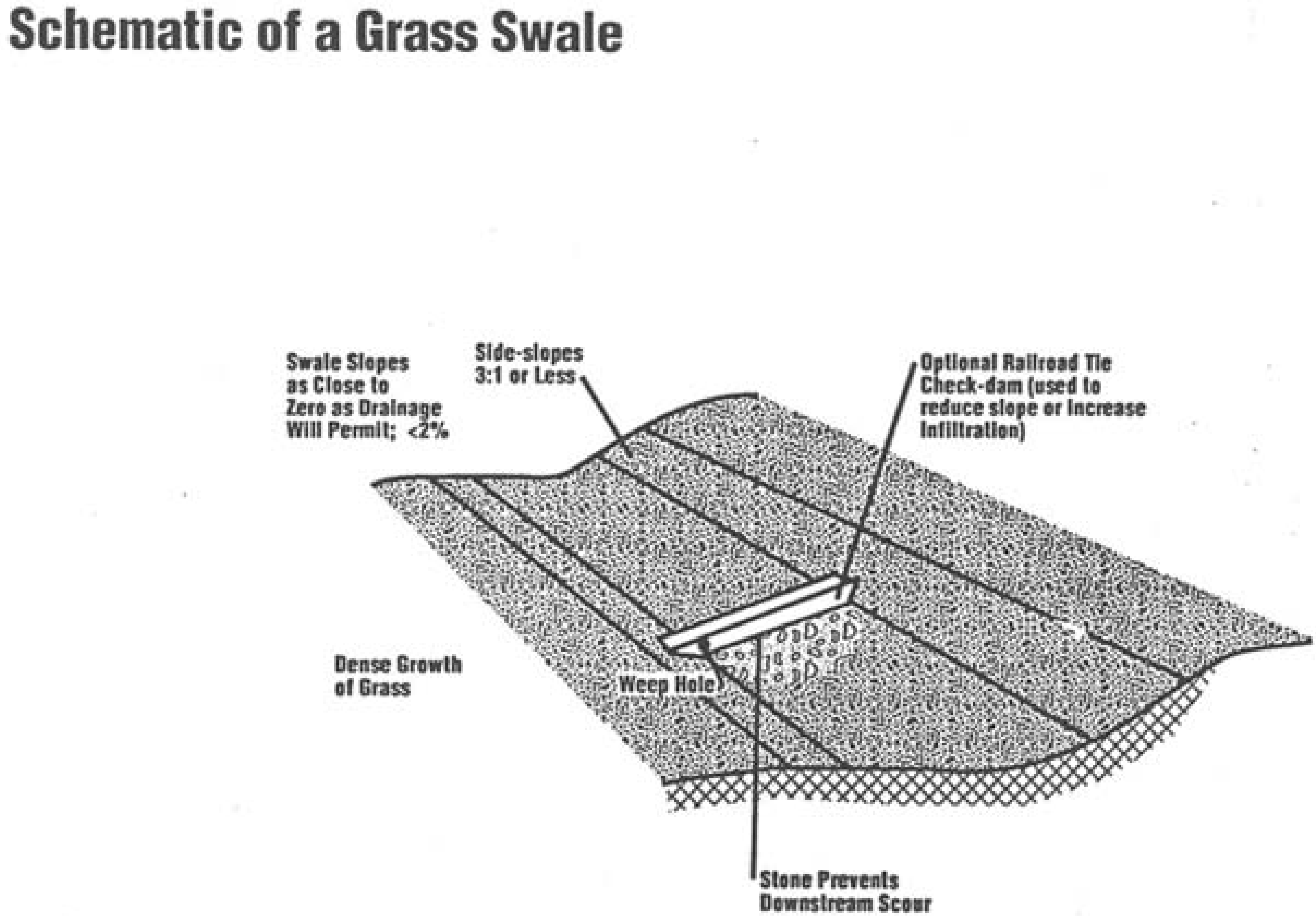
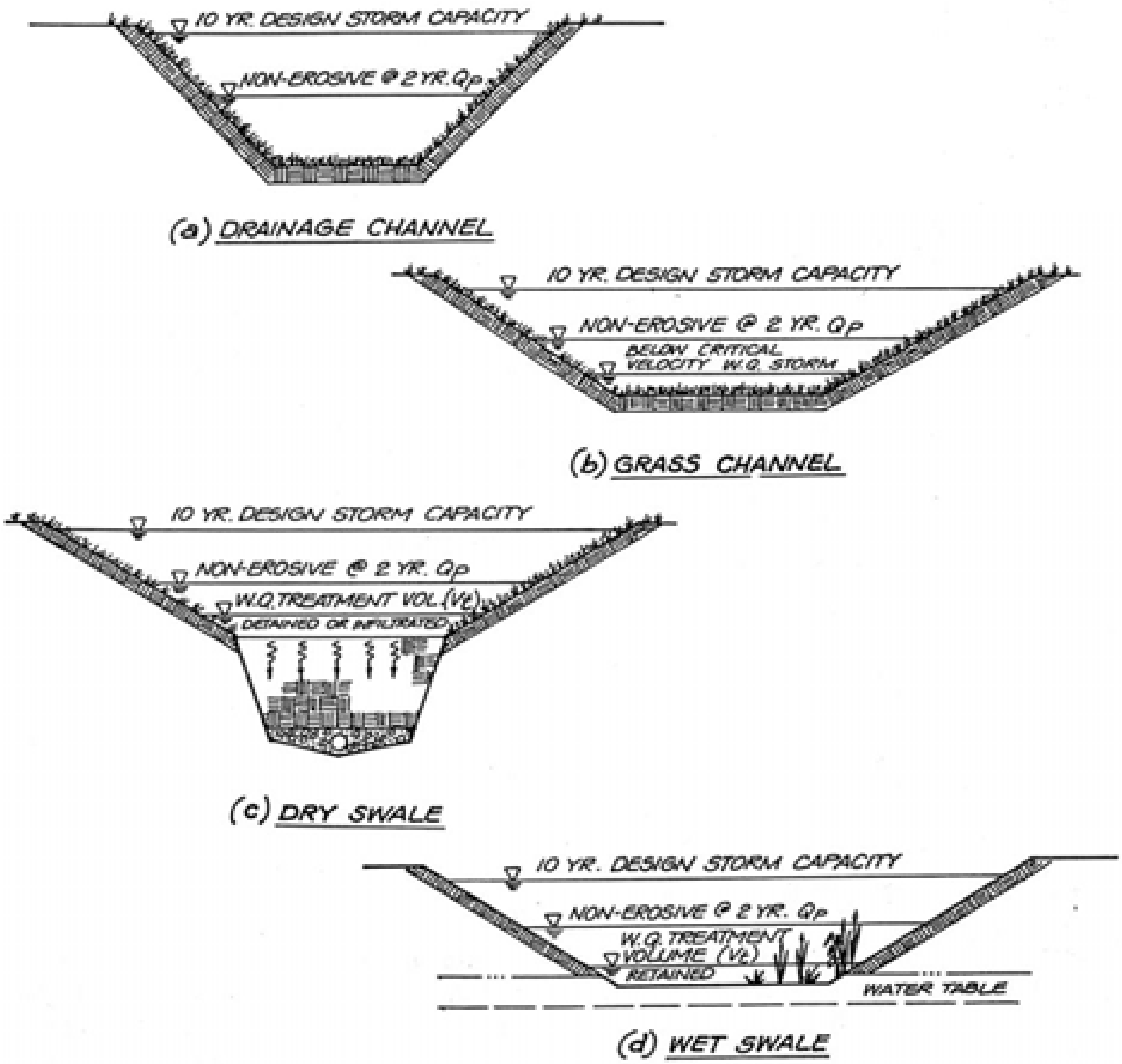


Figure B-3. Schematic of a typical grass swale.



Open channels can be designed in one of four ways—as either (a) a drainage channel, (b) a grassed channel, (c) a dry swale, or (d) a wet swale. All open channels are typically designed to convey the ten year design storm, and prevent critical erosive velocities during the two year design storm. The grass channel is designed to achieve a critical velocity during a water quality design storm. The dry swale is designed to capture and treat the entire water quality volume in the swale. The same is true for the wet swale, except that the storage is provided by a pool of water, due to the presence of a high water table.

Figure B-4. Schematic of a four design alternatives for grass swales (Center for Watershed Protection, 2001).

Standard turf grasses may be used where a more manicured appearance is required. These include standard mixtures such as those recommended by South Dakota Department of Transportation (SDDOT) or the Extension Service. Otherwise, it is recommended to use longer growing grasses such as buffalo grass and tall fescue. Grasses with wider spacing between individual plants such as alfalfa are not recommended. Bluegrass should be avoided in areas of high salt loading.

Design Flow. Because vegetated swales are used to provide both pollutant removal and stormwater conveyance, design flows must be considered for both water quality and conveyance.

Water Quality. The design flow for water quality should be based upon the WQCV in Chapter 11 where a volume is detained or infiltrated . Most rainfall events and pollutant loads are from the WQCV and smaller storms. Thus, if a swale is designed to provide good pollutant removal for the WQCV storm, then annual pollutant removal rates should be relatively high.

Conveyance. Swales should be designed to convey the peak flow as required by Chapter 11 except in those areas with higher consequences from flooding. In more flood-prone areas, a 100-year design event may be more appropriate.

Design Velocity. The design velocity for the swale should be less than 1.5 fps for the 2-year event to provide reasonable pollutant removal. Some jurisdictions have applied the velocity rate of 1.5 fps to the 6-month storm. Lower velocities will improve pollutant removal. The design velocity for the conveyance event depends on the erodability of the soil, the vegetation, and the slope of the swale. The design velocities must take into account water quality and conveyance.

Water Quality. The swale slope, bottom width, and side slopes should be selected so that the velocity for the 2-year event does not exceed 1.5 fps. This should be done using the appropriate retardance factor for the vegetation selected.

For swales serving larger drainage areas that mainly convey flows from upstream, the recommended water quality velocity of 1.5 fps may be difficult to achieve. However, because much of the runoff will have already been treated in the upstream portions of the swale, the swales may be designed with conveyance considerations alone. Along highways and other areas where space is sufficient, a flatter vegetated area between the edge of pavement and the swale could serve as a filter strip to provide greater pollutant removal where the tributary area of the swale is larger.

Conveyance. For the swale shape selected for water quality purposes, the maximum velocity for the design conveyance flow rate should be checked to ensure that the velocity does not exceed permissible velocities to prevent scour.

If driveway and road crossing culverts determine the depth of flow under the design event rather than Manning’s equation on the basis of steady uniform flow, the velocity for the depth of flow dictated by the culverts should be checked. The velocity should also be checked using the maximum flow rate for which the culverts provide minimal or no backwater.

If the maximum permissible velocity is exceeded, the bottom width should be increased, the side slopes flattened, or check dams used to reduce the effective longitudinal slope or smaller culverts used to decrease velocity.

Swale Capacity. The swale should be sized to convey the design flow without overtopping the banks of the swale. The capacity should be checked using the highest expected retardance factor.

Special Water Quality Features. Swales can be effective particularly at reducing pollutant loads and minimizing increases in surface-runoff volumes if special features are incorporated into the swales to maximize infiltration. The special features include check dams already discussed, slightly raised driveway culverts, and slightly raised drop inlets. All of these features are designed to promote ponding of water so that additional time is provided for infiltration. These features are described further in Attachment C, "Modified Grass Swales/Biofilters."

Construction. To prevent loss of soil infiltration capacity, construction should avoid compacting the soil underlying the swale. For example, backhoe excavation from the side of the swale is preferred over grading from within the swale.

Vegetation must be established in the swale as soon as possible to prevent erosion and scour. Swales should be constructed and vegetated early in the construction schedule, preferably before mass grading and paving increase the rate of runoff.

Geotextile erosion blanket or special mulch protection such as fiberglass roving or straw and netting should be used to provide stability until the vegetation becomes established. Where flow rates and velocities are high, the swale should be sodded and staked or the runoff should be diverted in the early stages of vegetation establishment. Stabilization measure guidelines are found in Chapter 12.

An alternative method is to base selection of appropriate stabilization measures on swale slopes as follows:

- Zero percent to 4 percent longitudinal slope: seed and erosion blanket
- 4 percent to 8 percent slope: staked sod or rock bottom with vegetated sides for high flow rates
- Greater than 8 percent slope: rock bottom unless flow rates are low and vegetation can be established

Vegetation should be inspected and replaced as necessary during the first year after construction.

Maintenance Requirements

Maintenance of grass swales is limited to maintaining the vegetation and occasional trash removal. Where native vegetation is used rather than groomed turf, vegetation need only be mowed seasonally to retard the growth of woody vegetation. The frequency of trash removal will depend on the location.

Routine mowing will be required where turf grasses are used. However, this can generally be done by homeowners and groundskeepers as part of their normal mowing activities. It is recommended to cut grass no lower than about 3 to 5 inches. In addition, the grass should be allowed to grow to the maximum height consistent with the species and aesthetic requirements. Periodic watering and fertilizing may be needed to maintain a dense growth.

Excessive sediments should not accumulate if adequate soil and erosion controls are in practice upstream. However, should excessive siltation occur, it will be necessary to remove the excess sediment.

Environmental Issues

Environmental Benefits

Environmental benefits of grassed swales include:

- When grassed swales are substituted for curbs and gutters, they can slightly reduce impervious area, and more importantly, eliminate a very effective pollutant collection and delivery system.
- Low slope swales can create wetland areas.
- Unmowed swale systems that are not adjacent to roadways can provide valuable “wet meadow” habitat.
- Swales can partially infiltrate runoff from small storm events if underlying soil is not compacted.

Environmental Concerns

Environmental concerns associated with grassed swales include:

- Driveway culverts may leach trace metals into runoff.
- Lawn fertilization may increase the level of nutrients in runoff. Public education efforts can address this concern.
- The quality of local groundwater may be affected.
- Standing water in residential swales will not be popular with adjacent residents for aesthetic reasons and because of potential safety, odor, and mosquito problems.

Funding

Estimated Construction and Implementation Costs

Vegetated swales are usually less expensive to construct than conventional storm sewers. Construction costs include excavation by backhoe, grading, erosion protection, and establishment of the vegetation. Excavation costs should allow for specifications to prevent soil compaction. In some cases, costs will also include the installation of check dams or other special water quality features.

Estimated Operation and Maintenance Costs

Regular maintenance costs for conventional swales are minimal. Sediments trapped behind check dams may need to be cleaned out and spot repairs to vegetation may be required. Grassed swales also require general lawn maintenance such as mowing, watering, and chemical application. In nonresidential areas, this burden will fall on either SDDOT or the City. In residential subdivisions, adjacent homeowners will manage this responsibility. Also, inspection after large storms for erosional failures and special maintenance should occur regularly.

Addressing Common Concerns

Mosquitoes

Extended periods of standing water caused by flat slopes or improper grading of vegetated swales may result in nuisance conditions and can potentially be a source of mosquitoes. However, mosquitoes should generally not be a problem because of the frequent flushing of the ponded water. Standing water will result in the development of wetland vegetation that encourages the presence of mosquito predators such as other insects, dragon flies, and birds. In this case, the potential for mosquitoes will be even less of a concern. If wetland vegetation and standing water are persistent concerns, these problems can be reduced by maintaining more uniform steeper slopes in the swale invert or by installing underdrains or gravel trenches.

Traffic Safety

Traffic safety is sometimes a concern with roadside swales. However, in residential subdivisions, where low velocity traffic is expected, shallow swales with 3H:1V or flatter side slopes should not present an excessive traffic hazard.

Conclusions

The use of grass swales, particularly in the common areas of residential subdivisions, is appropriate for the City of Sioux Falls. Although clay soil will allow less infiltration than sandy soil, filtering the flows through grass will remove some pollutants. This BMP should typically be used in conjunction with other BMPs. It is recommended that grass swales should be a medium priority BMP.

References

CH2M HILL. 2001. *Stormwater Best Management Practices*. Prepared for the North Carolina Department of Environment and Natural Resources Division of Water Quality.

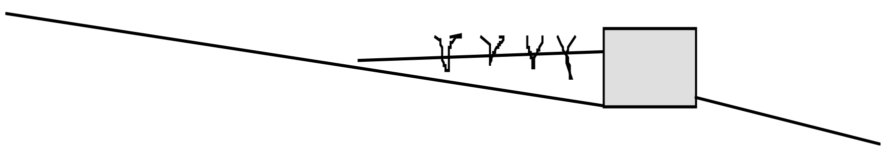
Horner, R.R. 1988. *Biofiltration Systems for Storm Runoff Water Quality Control*. Prepared for the Washington State Department of Ecology.

Schueler, T.R., P.A. Kumble, and M. A. Hearaty. 1992. *A Current Assessment of Urban Best Management Practices*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C.

Attachment C—Modified Grass Swales/Biofilters

Modified grass swales or biofilters are swales designed to "treat" stormwater in runoff in addition to conveying it. Two types of modified grass swales have been used. The first type of modified grass swale or biofilter was developed by Rich Horner of the University of Washington. The Center for Watershed Protection defines biofilters as passive, technically simple, and flexible methods of treating runoff in developing areas. Biofiltration is a process whereby stormwater is treated by contact with vegetation and soil surfaces along a long and broad grass swale (Reeves 1994).

A second type of modified grass swales involves adding a *bioretention area* to the grass swale as a means of enhancing pollutant removal and reducing slope. The figure below illustrates the basic components of this type of modified grass swale.



Functional Issues

Pollutant Removal Reliability

Modified grass swales increase infiltration opportunities and filter pollutants as stormwater runoff moves through the swale/ biofilter system. The primary mechanism for removing dissolved pollutants will be infiltration during small events. For biofilters, pollutants are also removed by settling if check dams are included in the design. For the swale/bioretention system, the pollutants also will be removed through adsorption and filtration that occurs in the bioretention area.

Pollutant Removal Efficiency

Studies done in Washington State indicate that well-maintained biofilters have high rates of removal for sediment, hydrocarbons,

Design Considerations

- ✓ **Soil**
- ✓ **Area Required**
- ✓ **Slope**
- ✓ **Flow Velocity**
- Water Availability
- Aesthetics
- Hydraulic Head
- Permitting

Key
✓ Most Important Consideration

Targeted Constituents

- ● Sediment
- ⊙ Nutrients
- ● Heavy Metals
- ⊙ Toxic Materials
- ○ Floatable Materials
- ○ Oxygen-Demanding Substances
- ● Oil and Grease
- ○ Bacteria and Viruses

Key
- ● Likely to Have a Significant Impact
- ⊙ Medium Impact
- ○ Probably Low or Unknown Impact

Implementation Requirements

- ● Capital Costs
- ⊙ O&M Costs
- ⊙ Maintenance
- ○ Training

Key
- ● High Requirement
- ⊙ Medium Requirement
- ○ Low Requirement

and particulate trace metals. Phosphorus removal was typically around 30 percent, and nitrogen concentrations actually were increased downstream of the system.

No data currently are available to make final determinations on the efficiency of pollutant removal of swales with bioretention areas. However, it is expected that well-established bioretention areas will increase pollutant removal rates.

Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal:

Factors with a Positive Influence

- Low-flow velocities
- Gentler slopes
- Longer residence times
- Check dams or bioretention areas along the swale

Factors with a Negative Influence

- High-flow velocities
- Steep slopes
- Lack of maintenance causing erosion along the swale
- Residents' potential concern with ponded water

Longevity

The Center for Watershed Protection summarized a survey of 44 biofilters conducted by Rich Horner of the University of Washington. To improve the longevity of biofilters, the study indicated that the construction and maintenance practices need to be improved. For example, approximately 40 percent of the biofilters had a vegetative cover that was in poor condition or had bare spots. Also, approximately 70 percent of the biofilters had steep side slopes (greater than 3H:1V).

No data are available on the longevity of modified grass swales with bioretention areas. However, the bioretention areas will slow down the flow velocities and this will reduce long-term erosion problems.

Applicability to the City

Modified grass swales can be applied to most development situations. They can be used along back lot lines and property boundaries, preferably in common areas. The use of grass swales and bioretention areas presents an opportunity to the City to develop an innovative BMP that will meet the water quality goals in the different watersheds.

Slopes

Modified grass swales are well suited to either flat or rolling terrain typical in Sioux Falls. However, they are not applicable in steep slope areas, unless numerous check dams or bioretention areas are included along the length of the swale.

Contributing Drainage Area

Modified grass swales are suitable for many types of development, but they probably are most practical for large-lot residential sites (that is, 1/2-acre lots or larger, or 1/4-acre lots with swales established in common areas) and campus-type developments. A modified grass swale system serving a tributary area less than 10 to 20 acres will provide significant water quality benefits. Modified grass swales are not recommended as a treatment device for larger drainage areas.

Recommended Design Criteria

Chapter 11 contains design information for both grass swales and bioretention with supplemental information contained in this TM. The following are general design considerations for modified grass swales (Schueler 1995):

- Velocity not greater than:
  - 1.5 fps for 2-year design storm
- Minimum residence time of 10 to 20 minutes
- Dense turf exceeding the elevation of the water quality design storm
- Minimum length of 200 feet
- Use check dams or bioretention areas for slopes 4 percent or greater
- Underdrains may be needed for slopes less than 2 percent
- WQCV approximated by Chapter 11 Porous Landscape Detention

Check Dams. A check dam is simply an earthen, stone, or timber dam 3 to 6 inches high to retain runoff from routine events. A weep hole may be provided to allow slow drainage of the area behind an earthen or timber dam. However, the weep hole may be subject to clogging.

Drop Inlets. A drop inlet can be used when a combined system of swales and storm sewers is being used. The swales would serve as the collector system and the inlet into the main storm sewer system would be elevated slightly to retain runoff from routine events. The height of elevation would depend on the soil, the slope of the swale, and the tolerance for ponding.

Elevated Culverts. The elevated culverts are used for the same purpose as the check dams and drop inlets, to retain runoff from routine events. In areas with A or B soil in good condition, these features are consistent with turf grass. In areas with C or D soil, wetland vegetation may be required in the ponded areas.

Maintenance Requirements

Maintenance of grass swales is limited to maintaining the vegetation and occasional trash removal. Where native vegetation is used rather than groomed turf, vegetation need only be mowed seasonally to retard the growth of woody vegetation. The frequency of trash removal will depend on the location.

Routine mowing will be required where turf grasses are used. However, this can generally be done by homeowners and groundskeepers as part of their normal mowing activities. It is recommended to cut grass no lower than about 3 to 5 inches. In addition, the grass should be allowed to grow to the maximum height consistent with the species and aesthetic requirements. Periodic watering and fertilizing may be needed to maintain a dense growth.

Excessive sediments should not accumulate if adequate soil and erosion controls are in practice upstream. However, should excessive siltation occur, it will be necessary to remove the excess sediment.

Environmental Issues

Environmental Benefits

Environmental benefits of modified grassed swales include:

- Modified grass swales can partially infiltrate runoff from small storm events if underlying soil is not compacted
- Provide a promising technique to improve water quality

Environmental Concerns

Environmental concerns include the following:

- Possible takeover by invasive nuisance plants in bioretention areas
- Lawn fertilization may increase runoff nutrient levels
- Possible impact on local groundwater quality
- Contamination of soil in heavily polluted areas

Funding

Estimated Construction and Implementation Costs

Modified grass swales are usually less expensive than conventional storm sewers. Construction costs include excavation by backhoe, grading, erosion protection, and establishment of the vegetation, and installation of check dams, bioretention areas, and other water quality features. Excavation costs should allow for specifications to prevent soil compaction.

Estimated Operation and Maintenance Costs

Regular maintenance costs for modified swales are minimal. Sediments trapped behind check dams may need to be cleaned out and spot repairs to vegetation may be required. Grassed swales also require general lawn maintenance such as mowing and watering. In residential subdivisions, adjacent homeowners will manage this responsibility. Also, inspection after large storms for erosional failures and special maintenance should occur regularly.

No reliable maintenance cost data are available for swales with bioretention areas. These type of systems will require more maintenance in the first 2 years until the plants are established. Thereafter, the maintenance burden may be similar to other swale systems.

Addressing Common Concerns

Aesthetics

People living next to a modified grass swale may be concerned about its “unkept” or “natural” components. Proper signage explaining the purpose of the modified grass swale will lessen the concerns.

Conclusions

Modified grass swales provide opportunities for more infiltration and filtration than traditional grass swales. Some additional maintenance is required, and the use of this BMP is limited to areas where standing water is acceptable. Modified grass swales with bioretention areas will significantly reduce standing water problems. Although clay soil in the City of Sioux Falls will allow less infiltration than sandy soil, filtering the flows through vegetation and bioretention areas, and the increased contact time, will remove more pollutants than traditional grass swales. This BMP is recommended as a medium priority.

References

Northeastern Illinois Planning Commission (NIPC). 1993. *Urban Stormwater Best Management Practices for Northeastern Illinois*.

Reeves, E. 1994. “Performance and Condition of Biofilters in the Pacific Northwest.” *Watershed Protection Techniques*, Vol. 1, No. 3, Fall 1994.

Schueler, T.R. 1995. “How to Design Urban Stormwater Best Management Practices,” Seminar Notebook.

Attachment D—Filter Strips

Vegetated filter strips are used to convey sheet runoff from impervious surfaces to drainage swales or other conveyance devices. A well-vegetated lawn can function as a filter strip. Filter strips are a recommended measure to "disconnect" impervious surfaces from storm sewers and channels.
Filter strips can provide effective infiltration and filtration of runoff if the flow is distributed uniformly over the length of the strip. Filter strips of native vegetation also can serve as effective buffers between developments and sensitive features such as streams, lakes, and wetlands.

Functional Issues

Pollutant Removal Reliability

Filter strips rely primarily on three mechanisms to remove pollutants from stormwater: settling, biofiltration, and infiltration.

Filter strips facilitate the settling of particles from stormwater by slowing the runoff, thereby enabling heavier particles to settle out. The filter strip reduces flow velocity because its vegetation provides resistance to flow.

Biofiltration removes pollutants by incorporating trapped pollutants, particularly nutrients and some metals, into the plant structure. When the plant material is harvested (mowed), the pollutants are removed from the system.

Filter strips also provide a mechanism to reduce the volume of surface runoff by infiltrating runoff into the ground. In addition to reducing runoff volumes, pollutants also are removed by infiltration when they are trapped in the soil. Infiltration in the filter strip is maximized by slow velocities, pervious soil, and increased permeability associated with the root structure of the vegetation in the strip (Northeastern Illinois Planning Commission [NIPC] 1993).

Pollutant Removal Efficiency

The pollutant removal efficiency of filter strip systems, relative to curb and gutter or storm sewer systems, is greatest for small runoff events. With a traditional drainage system, pollutants are washed from impervious surfaces directly into storm sewers with no opportunity for infiltration or pollutant filtering.

Design Considerations

- ✓ **Soil**
- ✓ **Area Required**
- ✓ **Slope**
- ✓ **Flow Velocity**
- Water Availability
- Aesthetics
- Hydraulic Head
- Permitting

Key
✓ Most Important Consideration

Targeted Constituents

- ● Sediment
- ⦿ Nutrients
- ⦿ Heavy Metals
- ⦿ Toxic Materials
- ○ Floatable Materials
- ○ Oxygen-Demanding Substances
- ⦿ Oil and Grease
- ○ Bacteria and Viruses

Key
- ● Likely to Have a Significant Impact
- ⦿ Medium Impact
- ○ Probably Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ⦿ O&M Costs
- ⦿ Maintenance
- ○ Training

Key
- ● High Requirement
- ⦿ Medium Requirement
- ○ Low Requirement

If impervious runoff is disconnected from the storm sewer system and routed across a filter strip or swale system, small storms (that is, up to 0.5 inches of rainfall) are literally soaked up in the soil and effective pollutant removal approaches 100 percent (NIPC 1993).

Properly designed and maintained filter strips can remove up to 90 percent of the settleable solids and associated pollutants from urban impervious areas. Pollutant removal is lower for dissolved constituents. Monitoring studies documenting the effectiveness of removing nutrients are limited. Studies of the effectiveness of filter strips in controlling agricultural runoff report phosphorus removal efficiencies ranging from 26 percent to 79 percent (Haan, Barfield, and Hayes 1994). Poorly maintained filter strips will not be effective in removing pollutants.

Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal:

Factors with a Positive Influence

- Gentler slopes reduce velocity and increase settling
- Longer lengths increase contact time with vegetation
- Soil with a higher permeability increases runoff capture rates
- Health and density of vegetation

Factors with a Negative Influence

- Lack of proper design and maintenance
- Concentrated inflows without energy dissipaters or level spreaders
- Steep slopes (that is, greater than 15 percent)

Longevity

No detailed studies have been conducted on the longevity of filter strips. Proper maintenance of filter strips will ensure increased pollutant removal effectiveness and longer life.

Applicability to City

In general, filter strips are used to disconnect or partially disconnect impervious areas. Filter strips are particularly well suited for residential developments and campus-type commercial and industrial developments. Because these developments usually have large expanses of grassed areas that can be used to accept runoff from impervious surfaces, the strips can be incorporated into the site layout and landscaping designs. Use of filter strips for parking lots and residential roofs is shown in Figures D-1 and D-2.

Soil

For low-permeability soil, the estimated removal rates are usually calculated for settling and filtration alone and assume no infiltration. However, even for the low-permeability soil areas in the City of Sioux Falls, some infiltration will occur in filter strips, particularly for the small routine events that occur many times throughout the year but represent most of the annual rainfall volume. Where the soil is more permeable, actual removal rates may be higher.

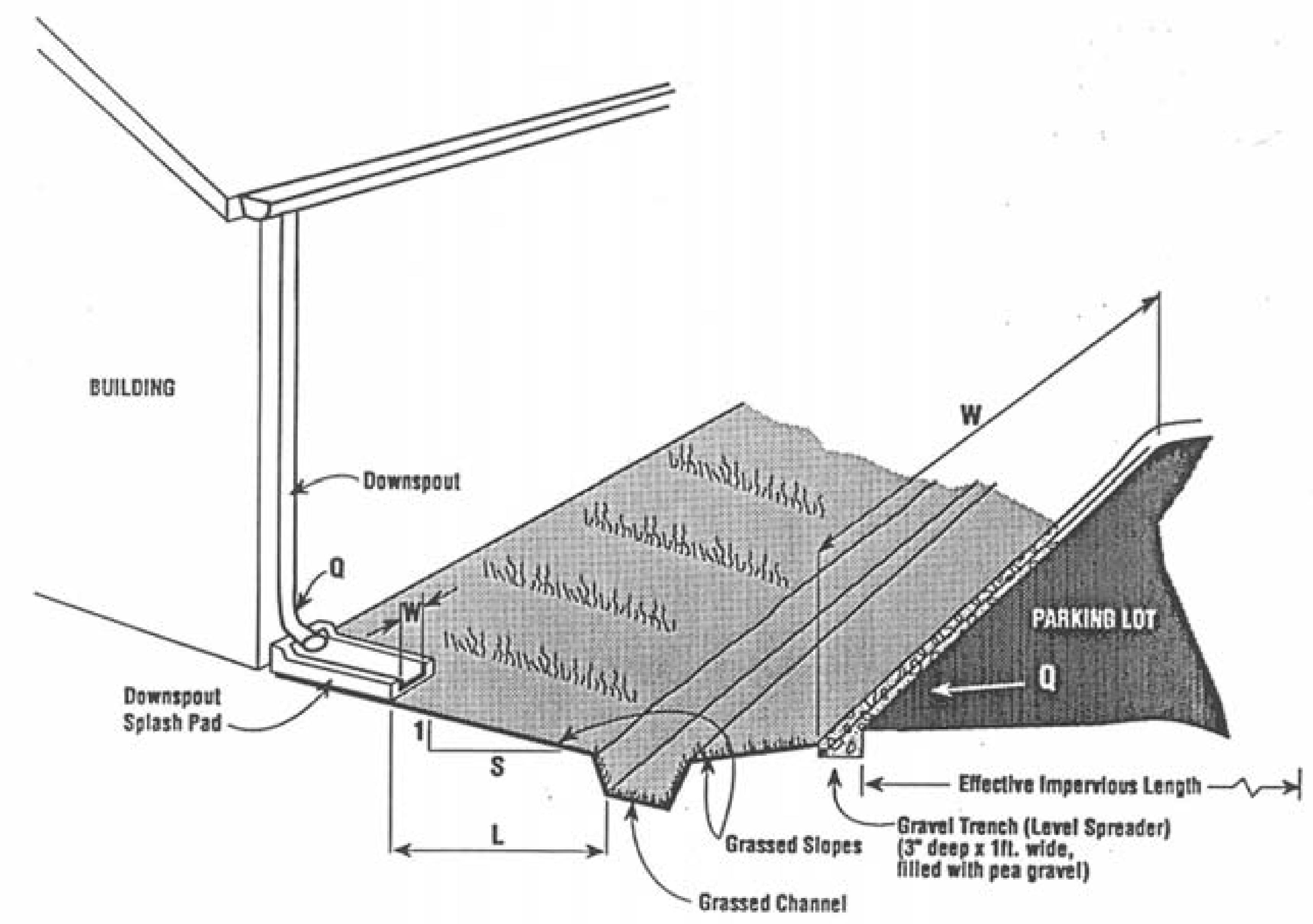


Figure D-1. Filter Strip Applications.

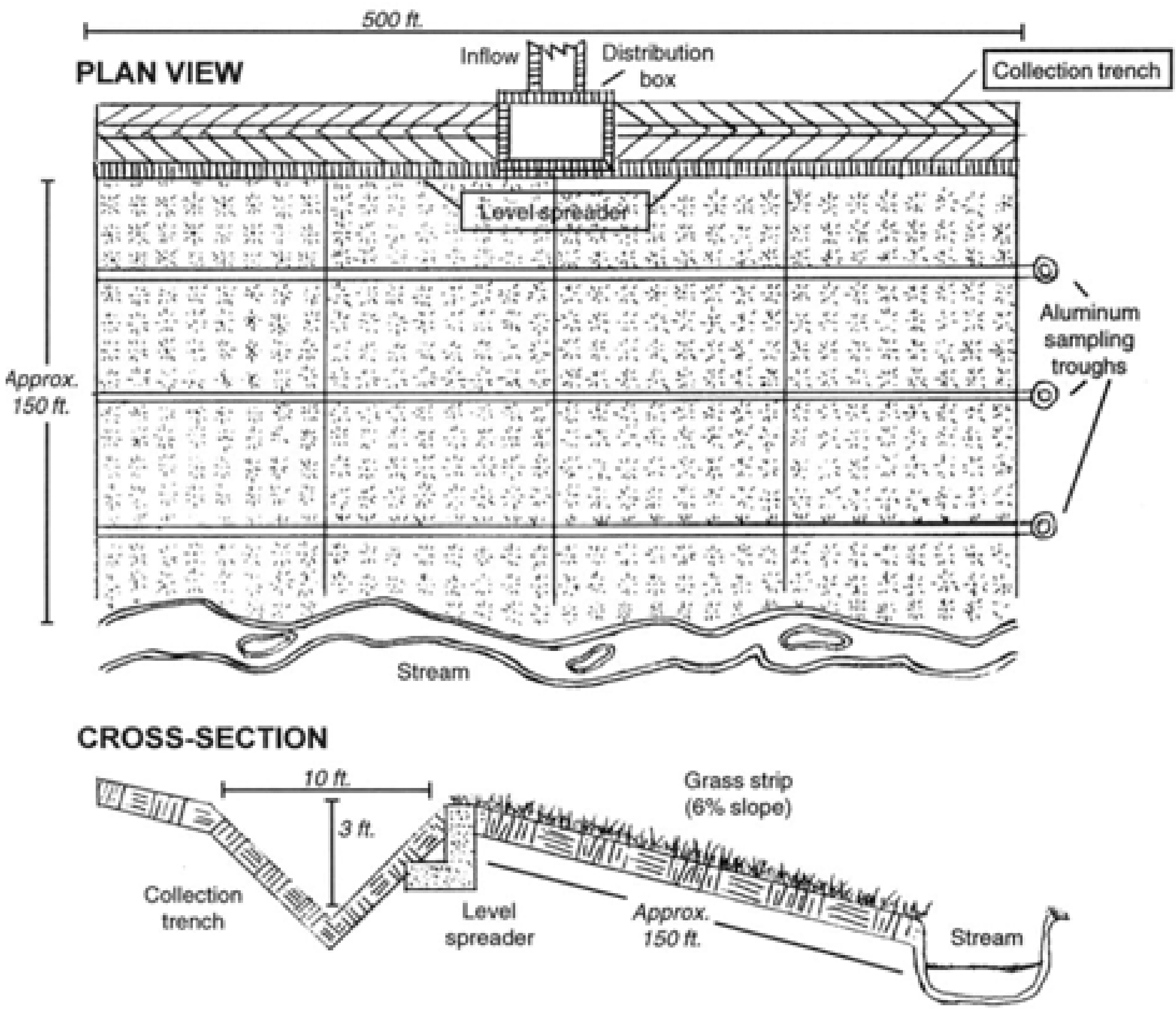


Figure D-2. Filter Strip Design Schematic (Yu 1999).

Contributing Drainage Area

For optimal effectiveness, filter strips should drain relatively small tributary areas. Too large a tributary area will result in concentration of flows difficult to overcome even with the use of a sophisticated level spreader. Filter strips can be used for larger areas by interspersing filter strips between impervious surfaces (for example, incorporating filter strips between parking lanes).

Slopes

In general, filter strips will be most effective on sites with flat slopes (for example, flatter than 5 percent). However, steeper slopes will generally be acceptable as filter strips if healthy, deep-rooted native vegetation is present and the flow is well distributed over the width of the strip. For roadways, where the drainage area per unit width of filter strip is quite small, steeper slopes may also be acceptable.

Recommended Design Criteria

Design Factors

The most important design factors for a filter strip are the drainage area, the dimensions of the strip, and the permeability of the soil.

The following variables are used to size filter strips and check for erosion potential (NIPC 1993):

- Slope of the filter strip
- Width over which the flow is distributed
- Effective impervious length (drainage area and width)
- Length of the flow path through the filter strip
- Unit flow per foot of filter strip
- Allowable peak velocity
- Type of vegetative cover
- Permeability of the underlying soil

Figure D-2 shows a filter strip design that incorporates a level spreader to minimize short-circuiting. Filter strips with good vegetation stand can effectively filter pollutants even on very tight soil, but the effectiveness will be enhanced if the underlying soil retains its natural permeability. Compaction of filter strip soil by equipment or vehicles during construction should be minimized. Over time, the permeability of compacted soil will be restored through the action of vegetation root systems. However, this may take 5 to 10 years and the vegetation may be difficult to establish without a good layer of topsoil.

Maintenance Requirements

The filter strip should be kept free of litter. The vegetation should be maintained with normal landscape maintenance activities. Irrigation and fertilization needs on the filter strip may be less than normal because the runoff from the adjacent areas will provide both water and nutrients. Periodic aeration of the soil may be helpful if the underlying soil is particularly tight and there is difficulty in maintaining a good vegetative cover caused by compaction.

During the first 1 or 2 years, filter strips and level spreaders should be inspected for proper distribution of flows and signs of erosion during and after major storm events. After the first 1 or 2 years, the strip may be inspected annually or biannually. If erosion is discovered, the eroded areas should be filled in and reseeded. Then, the cause for the erosion should be determined and, if possible, prevented from recurring.

Environmental Issues

Environmental Benefits

Wildlife habitat value is possible in vegetated filter strips and in grass filter strips if a no-mow zone is incorporated in the design. Filter strips can partially infiltrate runoff from small storm events if the underlying soil is not compacted. Infiltration of runoff will enhance pollutant removal efficiency and will reduce the volume of runoff.

Environmental Concerns

Most of the grass filter strips are maintained as lawn area (Metropolitan Washington Council of Governments [MWCOG] 1992). Environmental concerns include the following:

- No wildlife habitat value in short grass areas
- Lawn fertilization may increase the level of nutrients in runoff
- Possible impact on local groundwater quality

Funding

Estimated Construction and Implementation Costs

Construction costs for filter strips are usually included in the normal landscaping of the site. Incorporation of filter strips should add little or no cost to the site development with the exception of additional erosion protection.

Estimated Operation and Maintenance Costs

Maintenance costs for filter strips are limited primarily to those normally required for good ground maintenance and inspection. In residential subdivisions, this cost would typically be assumed by the homeowner’s association. New designs and landscaping will result in better acceptance by homeowners and reduced maintenance requirements.

Addressing Common Concerns

Aesthetics

People living next to a filter strip may be concerned about its “unkept” or “natural” components. Proper signage explaining the purpose of the filter strip will reduce the concerns and will allow the strip to be distinguished from other lawn-type areas.

Conclusions

The use of filter strips is an appropriate BMP for the City of Sioux Falls. This BMP should be used in conjunction with other BMPs. Because of their lower expected removal efficiencies compared to other BMPs, it is recommended that filter strips should be a low priority BMP at this time.

References

Haan, C. T., B. J. Barfield, J. C. Hayes. 1994. *Design Hydrology and Sedimentology for Small Catchments*. New York: Academic Press.

Metropolitan Washington Council of Governments (MWCOG). 1992. *Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland.*

Northeastern Illinois Planning Commission (NIPC). 1993. *Urban Stormwater Best Management Practices for Northeastern Illinois*.

Attachment E—Bioretention

Bioretention is an innovative best management practice (BMP) developed by Prince George's County, Maryland, that improves runoff quality by "treating" stormwater in a sand and soil mixture planted with native plants.

Bioretention areas were used initially as off-line systems in urban and suburban areas. Modifications to Prince George's County guidelines, as outlined in *Design Manual for Use of Bioretention in Stormwater Management,* are being tested in Jurisdictions throughout the US. The new configurations and designs include diverting the first flush from drainage pipes into a bioretention area, incorporating on-line bioretention concepts to swales, and adding collector pipe systems in areas with underlying clay soil.

Bioretention facilities are most effective if they receive runoff as close as possible to the source. A site designer needs to look for opportunities to incorporate bioretention facilities throughout the site and minimize using inlets, pipes, and downstream controls. Prince George's County reports saving up to 50 percent on drainage infrastructure costs in developments that incorporate bioretention facilities. Similar savings have been achieved in Prince William County, Virginia, in sections of developments with bioretention facilities.

Functional Issues

Pollutant Removal Reliability

Bioretention areas remove pollutants through adsorption, filtration, ion exchange, and decomposition. Microbial soil processes, evapotranspiration, and nutrient uptake in plants also influence pollutant removal rates (Bitter and Bowers 1994).

Pollutant removal rates will increase as the plants become established and reach maturity. Bioretention areas have to be constructed when development in the site is near completion to prevent construction sediments from entering the facility.

Pollutant Removal Efficiency

No data are currently available to make final determinations on the pollutant removal efficiency of bioretention areas. However, Prince George's County estimates that annual phosphorus

Design Considerations

- ✓ **Soil**
- ✓ **Area Required**
- Slope
- ✓ **Flow Velocity**
- ✓ **Water Availability**
- ✓ **Aesthetics**
- Hydraulic Head
- Permitting

Key
✓ Most Important Consideration

Targeted Constituents

- ● Sediment
- ● Nutrients
- ⊙ Heavy Metals
- ⊙ Toxic Materials
- ⊙ Floatable Materials
- ⊙ Oxygen-Demanding Substances
- ⊙ Oil and Grease
- ○ Bacteria and Viruses

Key
- ● Likely to Have a Significant Impact
- ⊙ Medium Impact
- ○ Probably Low or Unknown Impact

Implementation Requirements

- ⊙ Capital Costs
- ⊙ O&M Costs
- ⊙ Maintenance
- ○ Training

Key
- ● High Requirement
- ⊙ Medium Requirement
- ○ Low Requirement

removal rates from a typical 1-acre commercial site would be approximately 0.3 to 1.2 pounds of phosphorus. This would correspond to approximately 18.4 to 73.5 percent removal of phosphorus.

Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal:

Factors with a Positive Influence

- Range of microtopography within the bioretention area
- Grass buffer strip or sediment forebay
- Periodic removal of leaf litter would reduce the amount of nutrients reaching the groundwater
- Mature forest community

Factors with a Negative Influence

- Low removal rate during nongrowing season
- Concentrated inflows without energy dissipators
- Compacted soil during construction
- Use of non-native plants

Longevity

No data are available on the longevity of bioretention areas. However, if stable forest community ecosystems are established, the longevity of the bioretention areas is expected to be comparable to structural BMPs.

Applicability to City

Bioretention facilities can be applied to most development situations. They are particularly applicable in urban areas where the opportunities and the land available to provide reliable stormwater controls are scarce. Bioretention facilities may be installed in median strips, parking lot islands, or lawn areas of commercial developments. They also can be used in residential subdivisions with open drainage systems.

Soil

A homogenous soil mix of 50 percent construction sand; 20 to 30 percent topsoil with less than 5 percent clay content, and 20 to 30 percent organic leaf compost provides a planting medium with adequate infiltration capacity. Soil amendments can be added according to the plant species selected. This soil guidance is taken from the North Carolina BMP manual.

In areas where clay contents are higher and the soil is not conducive to infiltration, the bioretention facility can be modified with a collector pipe system installed beneath the basin to form a bioretention filter. The City of Alexandria has developed design guidelines for bioretention filters (City of Alexandria 1995). As a standard practice, a collector pipe system is now used on all bioretention applications.

Contributing Drainage Area

Bioretention areas can be used successfully in a wide range of drainage areas. Median strips, ramp loops, and parking lot islands are examples of small drainage areas (less than 1 acre). In large drainage areas (less than 10 acres), diversion structures and energy dissipation devices need to be incorporated into the design to preserve the integrity of the bioretention area.

Required Area

The Prince George's County's Design Manual recommends that the size of the bioretention area be 5 percent to 7 percent of the drainage area multiplied by the "c" coefficient of the rational formula. Smaller and larger ranges are currently being constructed in Virginia. Monitoring data will provide better guidance on the design of these facilities. The land requirements of bioretention facilities can be reduced by partially substituting vertical-extended detention storage for horizontal storage.

Recommended Design Criteria

Facility Description

There are six major components to the bioretention area: (1) the grass buffer strip or energy dissipation area; (2) the ponding or treatment area; (3) the planting soil; (4) the sand bed (optional); (5) the organic layer; and (6) the plant material.

The grass buffer strip or energy dissipation area filters particles from the runoff and reduces its velocity. The sand bed further slows the velocity of the runoff, spreads the runoff over the basin, filters part of the water, provides positive drainage to prevent anaerobic conditions in the planting soil, and enhances exfiltration from the basin. The ponding area functions as storage of runoff awaiting treatment and as presettling basin for particulates that have not been filtered out by the grass buffer. The organic or mulch layer acts as a filter for pollutants, protects the soil from eroding, and provides an environment for microorganisms to degrade petroleum-based compounds and other pollutants. The planting soil layer nurtures the plants with stored water and nutrients. Clay particles in the soil adsorb heavy metals, nutrients, hydrocarbons, and other pollutants. The plant species are selected based on their documented ability to cycle and assimilate nutrients, pollutants, and metals through the interaction among plants, soil, and organic layer (Bitter and Bowers 1994).

As with any experimental BMP, sizing rules are continually changing. Although the site requirements will determine the actual dimensions, the following dimensions are recommended for bioretention areas:

- Minimum width is 15 feet
- Minimum length is 40 feet
- The ponded area should have a maximum depth of 6 inches
- The planting soil should have a minimum depth of 4 feet
- Water quality volume should be at listed in Chapter 11

Figure E-1 shows the original bioretention concept. Bioretention filters incorporate an underdrain under the facility, where local soils are poorly drained. Incorporating underdrains into bioretention areas is now a standard practice regardless of the local soil conditions. Figures E-2 and E-3 show bioretention areas in the edge of parking areas and in traffic islands, respectively.

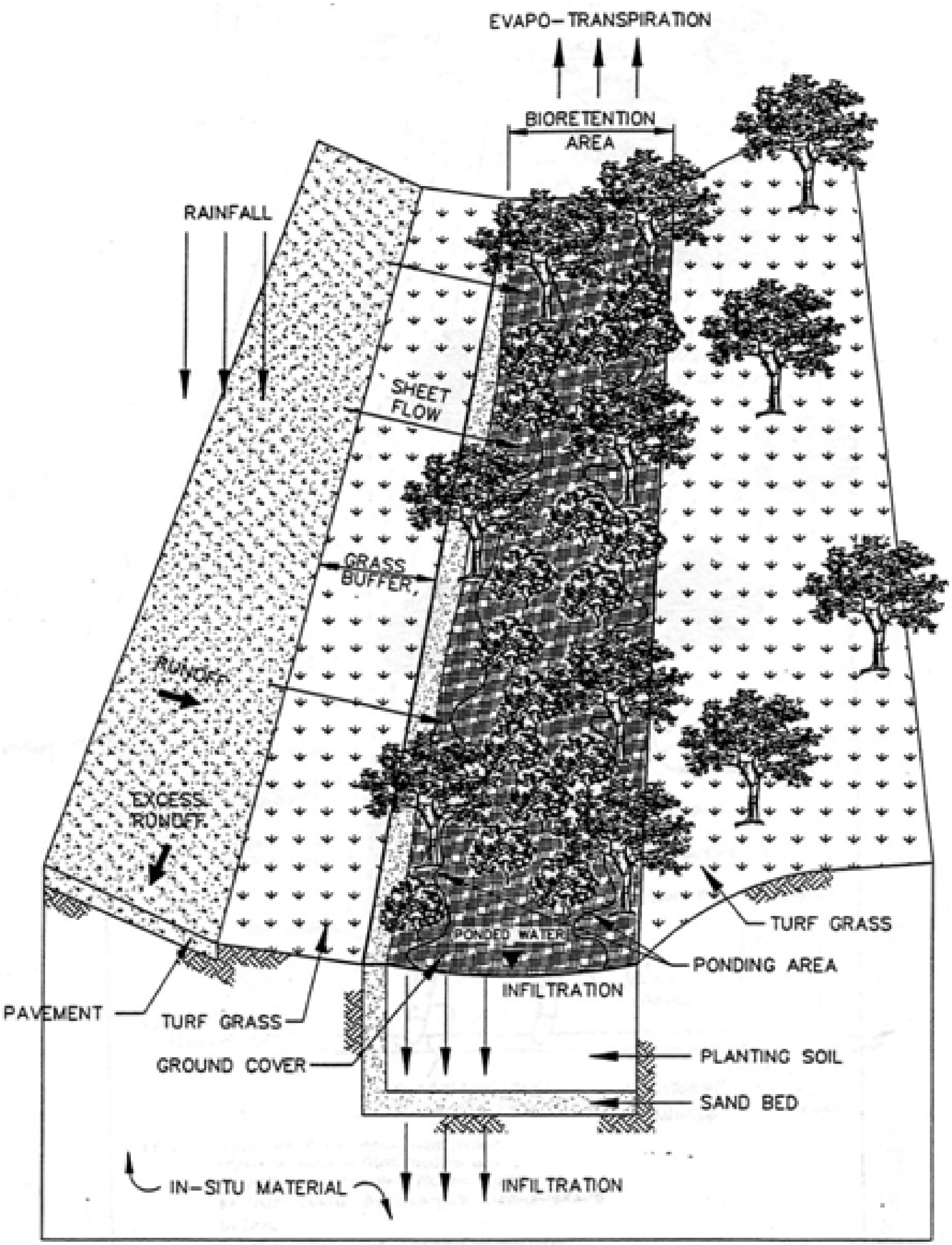


Figure E-1. Bioretention Area Conceptual Layout (Prince Georges County 1993)

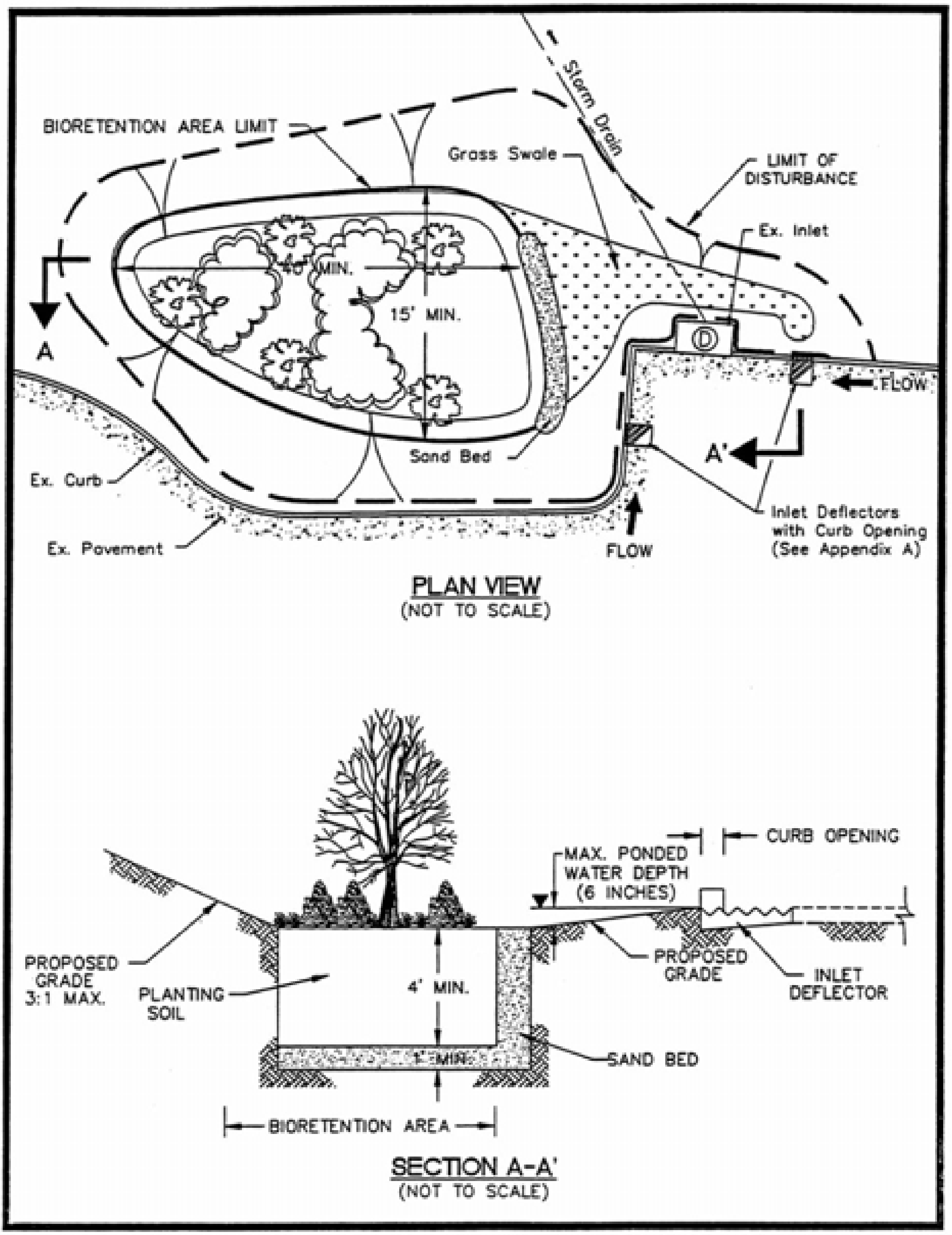


Figure E-2. Bioretention in Parking Edge and Perimeter Curb (Prince Georges County 1993)

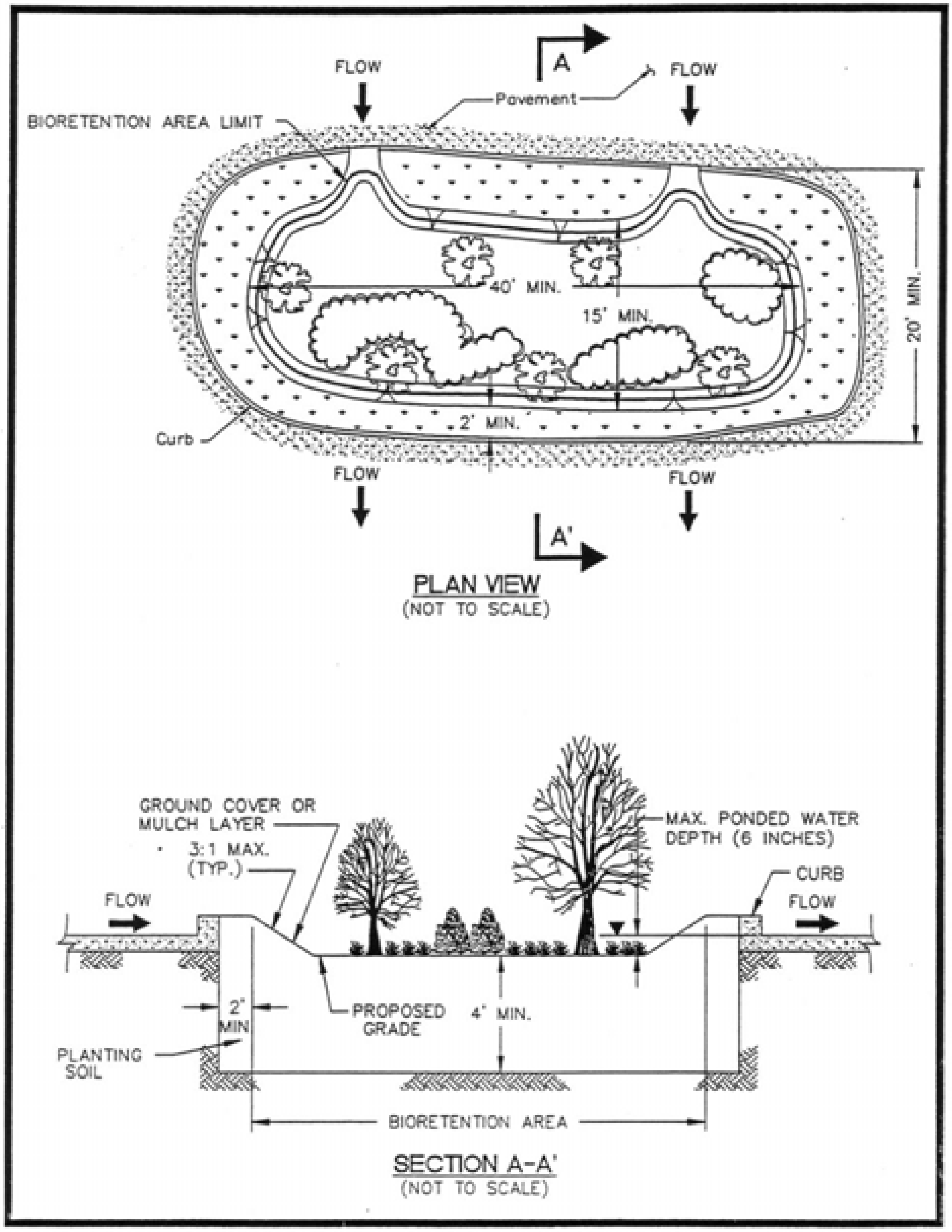


Figure E-3. Bioretention Traffic Island (Prince Georges County 1993)

Underdrains. The underdrain system can have many different configurations and typically includes a gravel layer surrounding a horizontal, perforated discharge pipe, 4 to 6 inches in diameter. Filter fabric is used to protect the underdrain from blockage. This underdrain design guidance is taken from the North Carolina BMP manual.

Maintenance Requirements

Monthly inspections are recommended until the plants are established. Annual inspections should then be adequate.

Environmental Issues

Environmental Benefits

Careful design of bioretention areas will replicate a forest community where monoculture susceptibilities to insect and disease infestation are avoided and evapotranspiration is enhanced.

Environmental Concerns

If a forest community is not replicated because of site constraints, the bioretention area or filter will not have the same benefits of larger well-established facilities. Environmental concerns include the following:

- Possible introduction of invasive nuisance plants
- Contamination of soil in heavily polluted areas

Funding

Estimated Construction and Implementation Costs

Very little cost data are available on the construction of bioretention facilities. The prevailing viewpoint is that bioretention construction costs are lower than those of dry and wet ponds. Also, the drainage infrastructure costs are reduced as reported by Prince George's County.

Estimated Operation and Maintenance Costs

No reliable data on maintenance costs are available. Bioretention areas will require more maintenance in the first 2 years until the plants are established. Thereafter, the maintenance burden may be similar to other pond systems.

Addressing Common Concerns

Clogging

Clogging of collector pipe systems in bioretention areas with underlying clay soil is possible. Pipe cleanouts are recommended for underdrain systems to be included in the design to facilitate unclogging of the pipes without disturbing the bioretention areas.

Conclusions

Bioretention facilities can be applied to most development situations. They may be installed in residential subdivisions, median strips, parking lot islands, or lawn areas of commercial developments. Performance data are limited because this is a relatively new practice. Bioretention is particularly useful in waterfront situations where limited space and small contributing areas eliminate other BMP options. Capital cost savings on developments incorporating bioretention areas have been substantial in Prince George's County. Bioretention is recommended as a high priority BMP for new development and redevelopment in the City of Sioux Falls.

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City of Alexandria, Virginia. 1995. Alexandria Supplement to the *Northern Virginia BMP Handbook*. Draft "Section XIII Bioretention and Bioretention Filters."

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Attachment F—Transportation: Grass Shoulders

Roads are a major source of stormwater pollution because of pollutant loadings from vehicles and impervious areas. If a roadway's storm drain system is designed so that stormwater runs overland off the pavement across a grass shoulder before entering a grass swale or a traditional storm drain system, the grass shoulders serve as filter strips for the stormwater. The use of grass shoulders along roadways is described in this section; filter strips for other types of development are discussed in Attachment D.

Functional Issues

Pollutant Removal Reliability

Grass shoulders increase infiltration opportunities and filter pollutants as stormwater runoff travels across the shoulder. The main mechanism for removing dissolved pollutants will be infiltration during small events. Other mechanisms include settling and biofiltration.

Grass shoulders reduce surface runoff volumes by infiltrating runoff into the ground. In addition to reducing runoff volumes, infiltration removes pollutants by trapping them in the soil. Infiltration in the grass shoulder is maximized by slow velocities, pervious soil, and increased permeability associated with the root structure of the vegetation in the strip (NIPC 1993).

Grass shoulders facilitate the settling of particles from stormwater by slowing the runoff, thereby providing an opportunity for heavier particles to settle out. The vegetation in the shoulder also reduces flow velocities by providing resistance to flow.

Biofiltration removes pollutants by incorporating trapped pollutants, particularly nutrients and some metals, into the plant structure. When the shoulders are mowed and the clippings are removed, the pollutants are removed from the system.

Design Considerations

- ✓ **Soil**
- ✓ **Area Required**
- ✓ **Slope**
- ✓ **Flow Velocity**
- Water Availability
- Aesthetics
- Hydraulic Head
- Permitting

Key

✓ Most Important Consideration

Targeted Constituents

- ● Sediment
- ⊙ Nutrients
- ⊙ Heavy Metals
- ⊙ Toxic Materials
- ○ Floatable Materials
- ○ Oxygen-Demanding Substances
- ⊙ Oil and Grease
- ○ Bacteria and Viruses

Key

- ● Likely to Have a Significant Impact
- ⊙ Medium Impact
- ○ Probably Low or Unknown Impact

Implementation Requirements

- ○ Capital Costs
- ⊙ O&M Costs
- ⊙ Maintenance
- ○ Training

Key

- ● High Requirement
- ⊙ Medium Requirement
- ○ Low Requirement

Pollutant Removal Efficiency

Along many roads, grass shoulders are a practical, efficient, cost-effective method to provide pollutant removal through filtering and infiltration. The pollutant removal efficiency of grass shoulders, relative to traditional curb and gutter or storm sewer systems, is highest for small runoff events. With a traditional drainage system, pollutants are washed directly from impervious surfaces into storm sewers with no opportunity for reducing flow quantities or pollutant concentrations.

The effectiveness of the shoulder for both reducing the volume of runoff and removing pollutants is a function of the drainage area, the slope of the shoulder, the permeability of the soil, and the density and type of vegetation in the shoulders. Wide shoulders on flat slopes with dense vegetation are the most effective. These design considerations must be balanced against safety concerns to ensure that water does not back up onto the roadway.

If runoff from impervious areas is disconnected from the storm sewer system and routed across a filter strip or swale system, small storms (that is, up to 0.5 inches of rainfall) are literally soaked up in the soil and effective pollutant removal efficiencies approach 100 percent (NIPC 1993).

Properly designed and maintained grass shoulders can remove up to 90 percent of the settleable solids and associated pollutants from urban impervious areas. Pollutant removal is lower for dissolved constituents. Monitoring data documenting the effectiveness of nutrient removal are limited and focus on agricultural areas. One study indicates a phosphorus removal efficiency of 26 percent to 79 percent (Haan, Barfield, and Hayes 1994). In an urban setting, the efficiency is likely to be at the lower end of this range, due to high runoff velocities. In addition, poorly maintained shoulders will not be effective in removing pollutants.

Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal:

Factors with a Positive Influence

- Gentler slopes reduce velocity and increase settling
- Wider shoulders increase contact time with vegetation
- Soil with higher permeability increases runoff capture rates
- Health and density of vegetation

Factors with a Negative Influence

- Lack of proper design and maintenance
- Concentrated inflows without energy dissipaters or level spreaders
- Steep slope (for example, greater than 5 percent)

Longevity

Surveys indicate that most filter strips operate as designed, requiring only minor maintenance such as grass mowing (Horner 1988; Schueler 1992). The main maintenance problem is the gradual buildup of soil and grass adjacent to roads, which prevents entry of runoff to shoulders.

Applicability to City

In general, grass shoulders are used to disconnect or partially disconnect impervious areas. Many major roads in the City are maintained by the South Dakota Department of Transportation (SDDOT). SDDOT's rules and regulations will apply to most rights-of-way and will govern the design of roadside ditches along these roads.

Grass shoulders are particularly appropriate when combined with a roadside grass swale. This practice is easily adaptable to median areas of major roads and to residential subdivision areas where grass swales can be placed in front lawns. Residential subdivisions with grass shoulders and grass swales along roadways maintain a more rural character than subdivisions with traditional curb and gutter systems.

Slope

Grass shoulders are well suited to either flat or rolling terrain typical of the City of Sioux Falls. Grass shoulders will be most effective on sites with flat slopes (for example, flatter than 5 percent).

Soil

Areas containing soils with higher infiltration in the City are very appropriate for grass shoulder best management practices (BMPs). Although grass shoulders are less efficient in clayey soil because infiltration rates are lower, a properly designed and maintained grass shoulder should provide some pollutant removal and, therefore, is also appropriate for use in Sioux Falls.

Contributing Drainage Area

A shoulder serving a tributary area containing only the roadway will provide significant water quality benefits. Most grass shoulders serving road and highway areas will serve a tributary area smaller than 1 acre.

Required Area

Grass shoulders are well suited to highway construction. A paved shoulder adjacent to the traveled way will be required for some SDDOT classes of highways and freeways. An additional grass shoulder area can be added to act as a filter strip.

Level of Applicability

In conclusion, grass shoulders are an appropriate BMP for roadways in many areas of the City. Major constraints for using grass shoulders are:

- Slope–Steep slopes reduce pollutant removal rates and increase the potential for erosion; flat slopes encourage ponding of water.
- Soil–Soil with a higher infiltration rate provides a higher pollutant removal rate.
- Required Area–Roadside grass shoulders require land area adjacent to the road. A wider right-of-way will typically be required than if a traditional storm drain system is used.

Recommended Design Criteria

Many major roads in the City are maintained by SDDOT. SDDOT's rules and regulations will apply to most rights-of-way and will govern the design of roadside ditches along these roads.

The most important design factors for a grass shoulder are the drainage area, the dimensions of the shoulder, and the permeability of the soil. The following variables are used to size grass shoulders and check for erosion potential (NIPC 1993):

- Slope of the shoulder
- Effective impervious length (drainage area and width)
- Unit flow per foot of shoulder
- Allowable peak velocity
- Type of vegetative cover
- Permeability of the underlying soil

Grass shoulders with dense vegetation can effectively filter pollutants even in soil with low permeability, but the effectiveness will be enhanced if the underlying soil retain its natural permeability. Compaction of shoulder strip soil by equipment or vehicles after the shoulder is graded should be minimized. Over time, the permeability of compacted soil will be restored through the action of vegetation root systems. However, this may take 5 to 10 years and the vegetation may be difficult to establish without a good layer of topsoil.

Maintenance Requirements

Maintenance of grass shoulders is limited to maintaining the vegetation and occasional trash removal. Where native vegetation is used rather than groomed turf, vegetation need only be mowed seasonally to retard the growth of woody vegetation. The frequency of trash removal will depend on the location and the level of littering from motorists.

Routine mowing will be required where turf grasses are used. In some situations, this can be done by homeowners and groundskeepers as part of their normal mowing activities. For highways, it would be conducted by SDDOT. It is recommended to cut grass no lower than about 3 to 5 inches. In addition, the grass should be allowed to grow to the maximum height consistent with the aesthetic requirements and safety concerns. Periodic watering and fertilizing may be needed to maintain a dense growth.

Environmental Issues

Environmental Benefits

Environmental benefits of grass shoulders include:

- When grass shoulders are substituted for paved, they can slightly reduce impervious area and provide a filtering and infiltration mechanism to the storm drain system.
- Grass shoulders can partially infiltrate runoff from small storm events if the underlying soil is not compacted.

Environmental Concerns

Environmental concerns associated with grass shoulders include:

- Fertilization may increase the level of nutrients in the runoff
- Local groundwater quality may be affected

Funding

Estimated Construction and Implementation Costs

Grass shoulders are typically less expensive to construction than conventional paved shoulders. Additional right-of-way costs, if necessary, need to be factored into the construction cost estimates. Other construction costs include grading, erosion protection, and establishment of vegetation. Grading costs should allow for specifications to prevent soil compaction. In some cases, costs will also include the installation of check dams or other special water quality features.

Estimated Operation and Maintenance Costs

The cost for regular maintenance of grass shoulders is minimal. Cleanup of sediments along the roadside may be required. Grass shoulders also require general maintenance such as mowing, watering, and chemical application. Depending on the road, this burden will fall to either SDDOT, the City, or a homeowner association. Inspection for erosion failures after large storms and special maintenance to address erosion early on should occur regularly.

Addressing Common Concerns

Traffic Safety

Traffic safety is sometimes a concern with grass shoulders. Regular maintenance of the shoulders will prevent a buildup of sediment along the roadway. A buildup of sediment can cause stormwater to back up on the roadway.

Conclusions

The use of grass shoulders along roadways is an appropriate BMP for the City of Sioux Falls. This BMP should be used in conjunction with other BMPs. It is recommended that grass shoulders along roadways should be encouraged for major new SDDOT roadways to reduce pollutants entering the City’s BMPs. For reconstruction of City owned roads, this BMP is recommended as a low priority BMP for the City of Sioux Falls at this time.

References

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Attachment G—Transportation: Grass Swales

Grass swales are constructed open-channel drainageways. They are used as an alternative to, or an enhancement of, conventional storm sewers or traditional curb and gutter systems. One popular location for grass swales is within existing medians. Swales vegetated with grass or other suitable vegetation are useful as both runoff conveyance facilities and as pollutant filtering and infiltration devices.

Functional Issues

Pollutant Removal Reliability

Grass swales increase infiltration opportunities and filter pollutants as stormwater runoff moves through the swale drainage system. Where possible, natural drainageways on the site should be maintained and used as part of the swale drainage system. The main mechanism for removing dissolved pollutants will be infiltration during small events. Removal rates will be reduced substantially if the vegetation in the swale is not maintained or if the sediment load is sufficiently high that it buries the vegetation and is readily resuspended during subsequent events (that is, where uncontrolled runoff from the construction site discharges to the swale).

Pollutant Removal Efficiency

Along many roads, vegetated swales are a practical, efficient, cost-effective alternative to curb and gutter or storm sewer systems for stormwater conveyance. Vegetated swales remove pollutants through filtration and infiltration. For small storms during which flow in the swale is less than 1 to 2 inches deep, the vegetated swale acts as a long, vegetated filter. For large storms, the low velocities in the swale facilitate the removal of particulate pollutants through settling.

Design Considerations

✓ **Soil**
✓ **Area Required**
✓ **Slope**
✓ **Flow Velocity**
Water Availability
Aesthetics
Hydraulic Head
Permitting

Key
✓ Most Important Consideration

Targeted Constituents

● Sediment
⊙ Nutrients
⊙ Heavy Metals
⊙ Toxic Materials
○ Floatable Materials
○ Oxygen-Demanding Substances
⊙ Oil and Grease
○ Bacteria and Viruses

Key
● Likely to Have a Significant Impact
⊙ Medium Impact
○ Probably Low or Unknown Impact

Implementation Requirements

○ Capital Costs
⊙ O&M Costs
⊙ Maintenance
○ Training

Key
● High Requirement
⊙ Medium Requirement
○ Low Requirement

Use of vegetated swales rather than conventional curb and gutter systems can generally reduce peak runoff rates because of the swale's greater roughness and greater storage capacity relative to gutters. Swales can also reduce annual surface runoff volumes by infiltrating runoff from typical storm events. Grass swales are effective in reducing the "flashiness" of small storms that cause much of the habitat disruption and bank erosion usually associated with urbanization.

The effectiveness of the swale for both reducing the volume of runoff and removing pollutants is a function of the drainage area, the level of imperviousness, the slope and cross section of the channel, the permeability of the soil, and the density and type of vegetation in the swales. Broad swales on flat slopes with dense vegetation are most effective. Pollutant removal will be highest for pollutants associated with sediments and lowest for dissolved constituents. Removal rates for settleable solids may approach 70 percent for swales designed according to the recommendations of this section. The expected removal efficiency of a well-designed, well-maintained conventional swale is projected to 30 percent for total phosphorus and 25 percent for total nitrogen (Schueler 1992).

Factors Influencing Pollutant Removal

A variety of factors can influence the level and reliability of pollutant removal:

Factors with a Positive Influence

- Check dams
- Low slopes
- Permeable subsoil
- Dense grass cover
- Long contact time
- Smaller storm events
- Coupling swales with plunge pools, infiltration trenches, or pocket wetlands
- Swale length greater than 200 feet

Factors with a Negative Influence

- Compacted subsoil
- Short runoff contact storms
- Large storm events
- Snow melt events
- Short grass heights
- Steep slopes (6 percent or greater)
- Runoff velocities (1.5 feet per second [fps] or more)
- Peak discharge (5 cubic feet per second [cfs] or more)
- Dry-weather flow

Longevity

Surveys indicate that most conventional swales operate as designed, requiring only minor maintenance such as grass mowing (Horner 1988; Schueler 1992). The main maintenance problem is the gradual buildup of soil and grass adjacent to roads, which prevents entry of runoff in swales. Factors influencing longevity are:

- Rate of erosion decreases as side slopes become flatter
- Runoff velocity that is consistently high (that is, more than 5 fps) will increase the tendency for the swale to erode

Applicability to City

Most major roads in the City are maintained by South Dakota Department of Transportation (SDDOT). SDDOT's rules and regulations will apply to most rights-of-way and will govern the design of roadside ditches along the roads.

Slope

Vegetated swales are well suited to either flat or rolling terrain typical of the City of Sioux Falls. They can be used as an alternative to conventional storm sewers along streets and highways, particularly in locations with few roadway or driveway crossings. Headwater elevations at culverts and backwater conditions need to be checked during design, especially in flatter areas.

In addition to being located along streets, swales should be located to conform with and use natural drainageways to the extent that site constraints allow. It will be easier to maintain the existing topsoil and vegetation in a natural drainageway than to establish vegetation in a constructed swale.

Soil

The higher infiltration soils in the City are appropriate for grass swale best management practices (BMPs). Although grass swales are less efficient in clayey soil because infiltration rates are lower, a properly designed and maintained grass swale should provide some pollutant removal and, therefore, is also appropriate for use in the City of Sioux Falls.

Contributing Drainage Area

The contributing drainage area for a grass swale along a road typically consists of the roadway area sloped towards it and some surrounding pervious areas. The contributing area should not be higher than 10 acres or the pollutant removal efficiencies will be decreased substantially.

Required Area

Swales are well suited to highway construction. Swales typically require more area than a traditional curb and gutter system. The typical configuration for a four-lane highway is to have swales on either side of the highway and between the divided lanes. However, where space is a constraint or where there is a large embankment, the pavement may be pitched so that the stormwater runs off to the center swale, eliminating the need for side swales.

Level of Applicability

In conclusion, grass swales are an appropriate BMP for roadways in many areas of the City. Major constraints in using grass swales are:

- Slope–Steep slopes reduce pollutant removal rates and increase the potential for erosion; flat slopes encourage ponding of water.
- Soil–Soil with a higher infiltration rate provides a higher pollutant removal rate.
- Required Area–Roadside swales require land area adjacent to the road. A wider right-of-way will typically be required than if a traditional storm drain system is used.

Recommended Design Criteria

The following subsection discusses some critical design considerations. There are two design conditions that must be considered for swales: the water quality design and the conveyance design. The swale should be designed to promote low velocities for water quality. However, the swale should also be able to pass the flow from the design conveyance event without overtopping or causing erosive velocities. Figure F-1 shows a schematic of a typical grass swale. More detail on design criteria is included in Attachment B, “Grass Swales” of this report. As stated above, SDDOT criteria will govern for the roads maintained by SDDOT.

Edge Treatment. Measures to prevent cars from driving on the grass swale may be required. These measures may include gravel shoulders, boulders, railroad ties, or other decorative elements. Safety design requirements should govern any edge treatment approach.

Swale Slope. The longitudinal slope of the swale should be as flat as possible to minimize velocities and improve pollutant filtering. However, with slopes much flatter than 1 to 2 percent, ponding may occur in minor depressions, which may be objectionable to some residents. Where slopes are flatter than 1 percent, underdrains, bioretention areas, or an infiltration trench in the bottom of the swale may be used to ensure a dry swale between storm events. If ponding is not a concern to residents, then vegetation that is suited to more wet conditions should be used.

Where longitudinal slopes are greater than 2 to 4 percent, check dams should be considered to reduce velocities, improve pollutant removal, and prevent scour. Vegetated swales should generally be avoided for slopes greater than 10 percent to 12 percent.

Underdrains. The underdrain system can have many different configurations and typically includes a gravel layer surrounding a horizontal, perforated discharge pipe, 4 to 6 inches in diameter. Filter fabric is used to protect the underdrain from blockage. This underdrain design guidance is taken from the North Carolina BMP manual.

Side Slopes and Bottom Width. The swale should be parabolic or trapezoidal in cross section for ease of construction and maintenance and to reduce the potential for scour. The side slopes should generally be 4 horizontal to 1 vertical (4H:1V) or flatter to minimize velocities and ease maintenance. However, side slopes of 3H:1V may be used where space is constrained. The bottom width should be no less than 2 feet to ease maintenance and prevent scour.

Vegetation. Native grasses and wetland vegetation are preferred for their improved ability to filter pollutants. Flat slopes, intentional creation of minor depressions, and sufficient runoff volumes will improve the ability of the swale to support wetland vegetation. Swales that are ideally suited for wetland vegetation include those that experience routine backwater, have bottoms at or near the groundwater table, or receive sustained baseflows.

Standard turf grasses may be used where a more manicured appearance is required. These include standard mixtures such as those recommended by SDDOT or the local Extension Service. Grasses with wider spacing between individual plants such as alfalfa are not recommended.

Design Flow. Because vegetated swales are used to provide both pollutant removal and stormwater conveyance, design flows must be considered for both water quality and conveyance.

Schematic of a Grass Swale

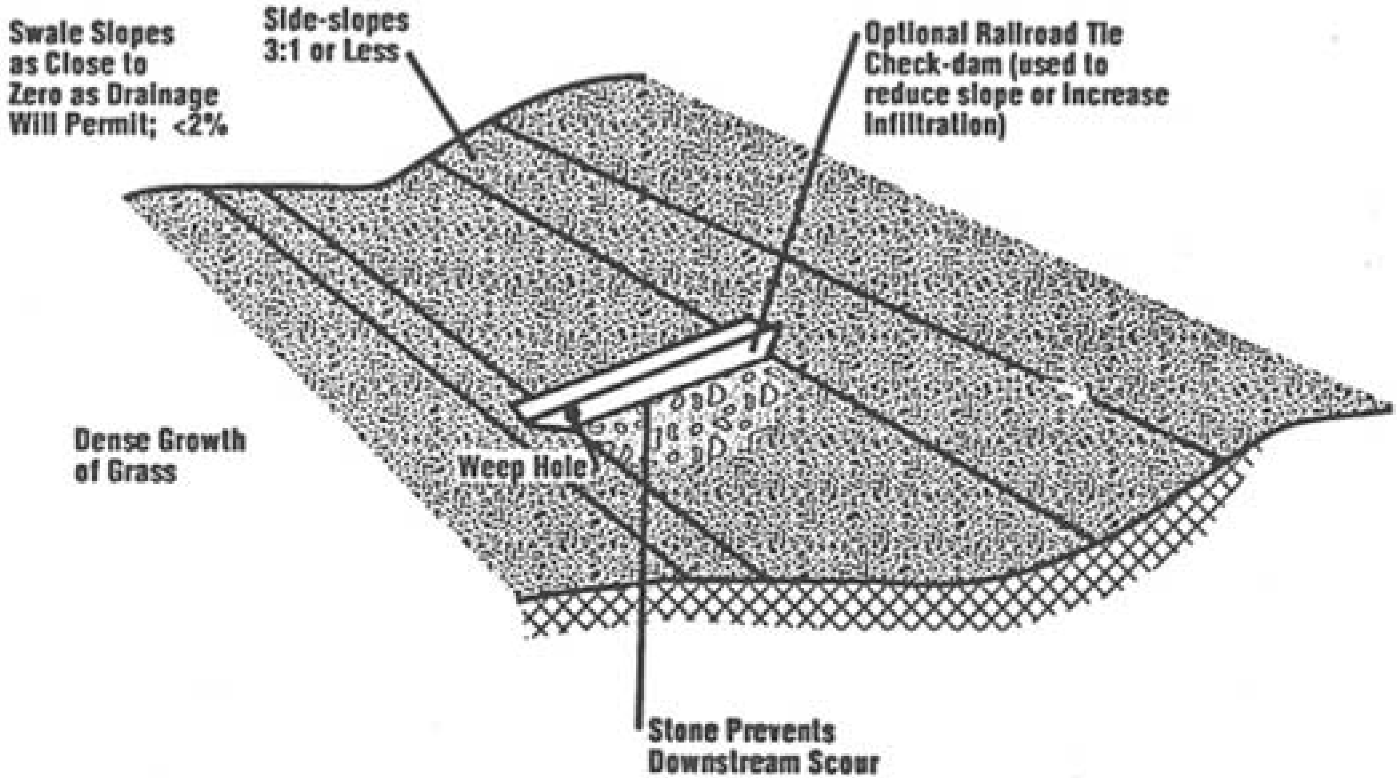

Figure F-1. Schematic of a typical grass swale.

Water Quality. The design flow for water quality should be based upon the WQCV in Chapter 11 where a volume is detained or infiltrated. Most rainfall events and pollutant loads are from the WQCV and smaller storms. Thus, if a swale is designed to provide good pollutant removal for the WQCV storm, then annual pollutant removal rates should be relatively high.

Conveyance. Swales should be designed to convey the peak flow from the design storm designated by SDDOT for the type of road. The planner and designer should consider City requirements.

Design Velocity. The design velocity for the swale should be less than 1.5 fps for the 2-year event to provide reasonable pollutant removal. Some jurisdictions have applied the velocity rate of 1.5 fps to the 6-month storm. Lower velocities will improve pollutant removal. The design velocity for the conveyance event depends on the erodability of the soil, the vegetation, and the slope of the swale. The design velocities must take into account water quality and conveyance.

Water Quality. The swale slope, bottom width, and side slopes should be selected such that the velocity for the 2-year event does not exceed 1.5 fps. This should be done using the appropriate retardance factor for the vegetation selected.

For swales serving larger drainage areas that mainly convey flows from upstream, the recommended water quality velocity of 1.5 fps may be difficult to achieve. However, since much of the runoff will have already been treated in the upstream portions of the swale, the swales may be designed with conveyance considerations alone. Along highways and other roads where space is sufficient, a flatter vegetated area between the edge of pavement and the swale could serve as a filter strip to provide greater pollutant removal where the tributary area of the swale is larger.

Conveyance. For the swale shape selected for water quality purposes, the maximum velocity for the design conveyance flow rate should be checked to ensure that the velocity does not exceed permissible velocities to prevent scour. Velocities should also be checked near culverts.

If the maximum permissible velocity is exceeded, the bottom width should be increased, the side slopes flattened, or check dams used to reduce the effective longitudinal slope or smaller culverts used to decrease velocity.

Swale Capacity. The swale should be sized to convey the design flow without overtopping the banks of the swale. The capacity should be checked using the highest expected retardance factor.

Special Water Quality Features. Swales can be particularly effective at reducing pollutant loads and minimizing increases in surface-runoff volumes if special features are incorporated into the swales to maximize infiltration. These special features include check dams already discussed, slightly raised driveway culverts, and slightly raised drop inlets. All of these features are designed to promote ponding of water so that additional time is provided for infiltration. These features are described further in Attachment C, “Modified Grass Swales.”

Construction. To prevent loss of soil infiltration capacity, construction should avoid compacting the soil underlying the swale during final grading. In addition, backhoe excavation from the side of the swale is preferred over grading from within the swale.

Vegetation must be established in the swale as soon as possible to prevent erosion and scour. Swales should be constructed and vegetated early in the construction schedule, preferably before mass grading and paving increase the rate of runoff.

Maintenance Requirements

Maintenance of grass swales is limited to maintaining the vegetation and occasional trash removal. Where native vegetation is used rather than groomed turf, vegetation need only be mowed seasonally to retard the growth of woody vegetation. The frequency of trash removal will depend on the location and "attractiveness" of the swale as a disposal site.

Routine mowing will be required where turf grasses are used. It is recommended that grass be cut no lower than about 3 to 5 inches. In addition, the grass should be allowed to grow to the maximum height consistent with the species and aesthetic requirements. Periodic watering and fertilizing may be needed to maintain a dense growth.

Excessive sediments should not accumulate if adequate soil and erosion controls are in practice upstream. However, should excessive siltation occur, it will be necessary to remove the excess sediment.

Environmental Issues

Environmental Benefits

Environmental benefits of grassed swales include:

- When grassed swales are substituted for curbs and gutters, they can slightly reduce impervious area, and more importantly, eliminate a very effective pollutant collection and delivery system.
- Low slope swales can create wetland areas.
- Unmowed swale systems that are not adjacent to roadways can provide valuable “wet meadow” habitat.
- Swales can partially infiltrate runoff from small storm events if the underlying soil is sandy.

Environmental Concerns

Environmental concerns associated with grassed swales include:

- Culverts may leach trace metals into runoff.
- Fertilization may increase runoff nutrient levels.
- The quality of local groundwater may be affected.

Funding

Estimated Construction and Implementation Costs

Vegetated swales are usually less expensive to construct than conventional storm sewers. Additional right-of-way costs, if necessary, need to be factored into the construction cost estimates. Other construction costs include excavation by backhoe, grading, erosion protection, and establishment of vegetation. Excavation costs should allow for specifications to prevent soil compaction. In some cases, costs will also include the installation of check dams or other special water quality features.

Estimated Operation and Maintenance Costs

Regular maintenance costs for conventional swales are minimal. Sediments trapped behind check dams may need to be cleaned out and spot repairs to vegetation may be required. Grassed swales also require general maintenance such as mowing, watering, and chemical application. Depending on the road, this burden will fall to either SDDOT or the City. Also, inspection after large storms for erosion failures and special maintenance should occur regularly.

Addressing Common Concerns

Mosquitoes

Extended periods of standing water caused by flat slopes or improper grading of vegetated swales may result in nuisance conditions and can potentially be a source of mosquitoes. However, mosquitoes should generally not be a problem because of the frequent flushing of the ponded water. Standing water will result in the development of wetland vegetation that encourages the presence of mosquito predators such as other insects, dragonflies, and birds. In this case, the potential for mosquitoes will be even less of a concern. If wetland vegetation and standing water are persistent concerns, these problems can be reduced by maintaining more uniform steeper slopes in the swale invert or by installing underdrains or gravel trenches.

Traffic Safety

Traffic safety is sometimes a concern with roadside swales. For major roadways, such as highways and arterials, roadway safety is usually addressed by providing a sufficient setback between the roadway and the swale to allow sufficient distance between stray traffic and the swale. The design of setbacks are standard practices of transportation designers. Gravel shoulders should also be used to provide a buffer between the roadway pavement and the grassed area in high-traffic areas. In addition, visual barriers can be used to mark the edge of pavement and warn vehicles to avoid the vegetated swale. Where low velocity traffic is expected, such as in residential subdivisions, shallow swales with 3H:1V or flatter side slopes should not present an excessive traffic hazard.

Conclusions

The use of grass swales along roadways is an appropriate BMP for the City of Sioux Falls. This BMP should typically be used in conjunction with other BMPs. It is recommended that grass swales along roadways should be a medium priority BMP.

References

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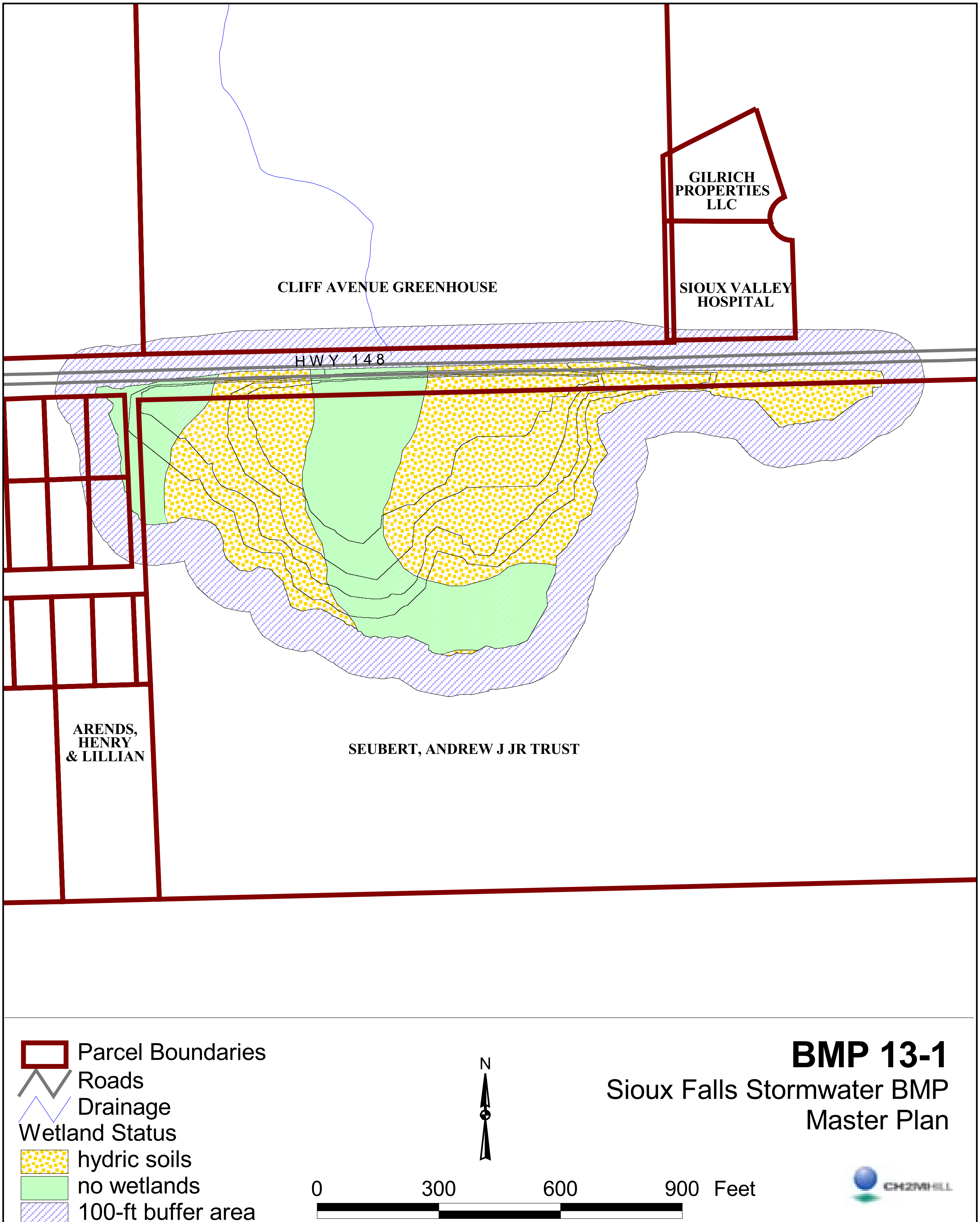
Schueler, T.R., P. A. Kumble, and M. A. Hearaty. 1992. *A Current Assessment of Urban Best Management Practices*. Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C.

APPENDIX D

BMP Information

BMP ID	Location Description
13-1	2,100 ft west of 41st St. and Sertoma Ave. intersection, on south side of 41st
13-2	850 ft east of Tea Ellis Rd. and 41st intersection, on north side of 41st
13-3	2,700 ft north of Tea Ellis Rd. and 41st St. intersection, on west side of Tea Ellis Rd.
11-1	East of Tallgrass Ave. and south of 69th Street, Pond 17C of Prairieview Study
11-2	750 ft west of Crane St. and 77th St. intersection, Pond 17B of Prairieview Study
40-1	1,200 ft east and 700 ft north of Marion Rd. and W 34th St. N intersection
51-2	1,500 ft north of Cliff Ave. and 85th Street intersection, on west side of Cliff Ave.
7-4	600 ft east of intersection of Sycamore and 69th St., on north side of 69th St.
51-1	1,850 ft east of Cliff Ave. and 85th St. intersection, on north side of 85th St.
7-5	1,600 ft west and 1,000 ft north of Rushmore and 69th St. intersection, extends upstream and downstream of future East Side Corridor
25-3	Southeast corner of Six Mile Rd. and 10th St.
303-2	1,600 ft east of Powderhouse and 26th, on south side of 26th Street
25-1	1,600 ft east of Madison St. and Powder House intersection, on north side of Madison St.
25-2	1,600 ft south of Madison St. and Powder House intersection, on west side of Powder House
41A	1,500 ft north of I-29 and 12th St. intersection, on west side of I-29
401-1	4,000 ft east of Six Mile Rd., on south side of 57th St.
401-2	1,800 ft south of Six Mile Rd. and 57th St. intersection, west side of Six Mile Rd. (Tisdale).
40-2	Northeast corner of Madison St. and LaMesa Dr. intersection
304	2,600 ft southeast of intersection of Six Mile Road and STH 42 (Minnehaha Rd.), on south side of STH 42
312	2,750 ft east of I-229, on north side of Benson Rd.
400	7,200 ft east of Six Mile Rd., on north side of 41st St.
303-4	1,300 ft southeast of Six Mile Rd. and STH 42 (Minnehaha Road) intersection, on south side of STH 42
22	2,600 ft east of Bahnson Ave., between Rice St. and the railroad tracks
317	1,300 ft south of Maple Rd. and Six Mile Rd. intersection, on west side of Six Mile Rd.
40-3	Northwest corner of I-90 and I-229 interchange
305	East side of Rice St., 400 ft northeast of Lawrence Pl, north of Great Bear.
306	Northeast of intersection of Rice St. and Timberline, upstream of East Side Corridor
316	4,700 ft east of I-90 and I-229 interchange, on south side of I-90

Wetland Impacts



BMP 13-1

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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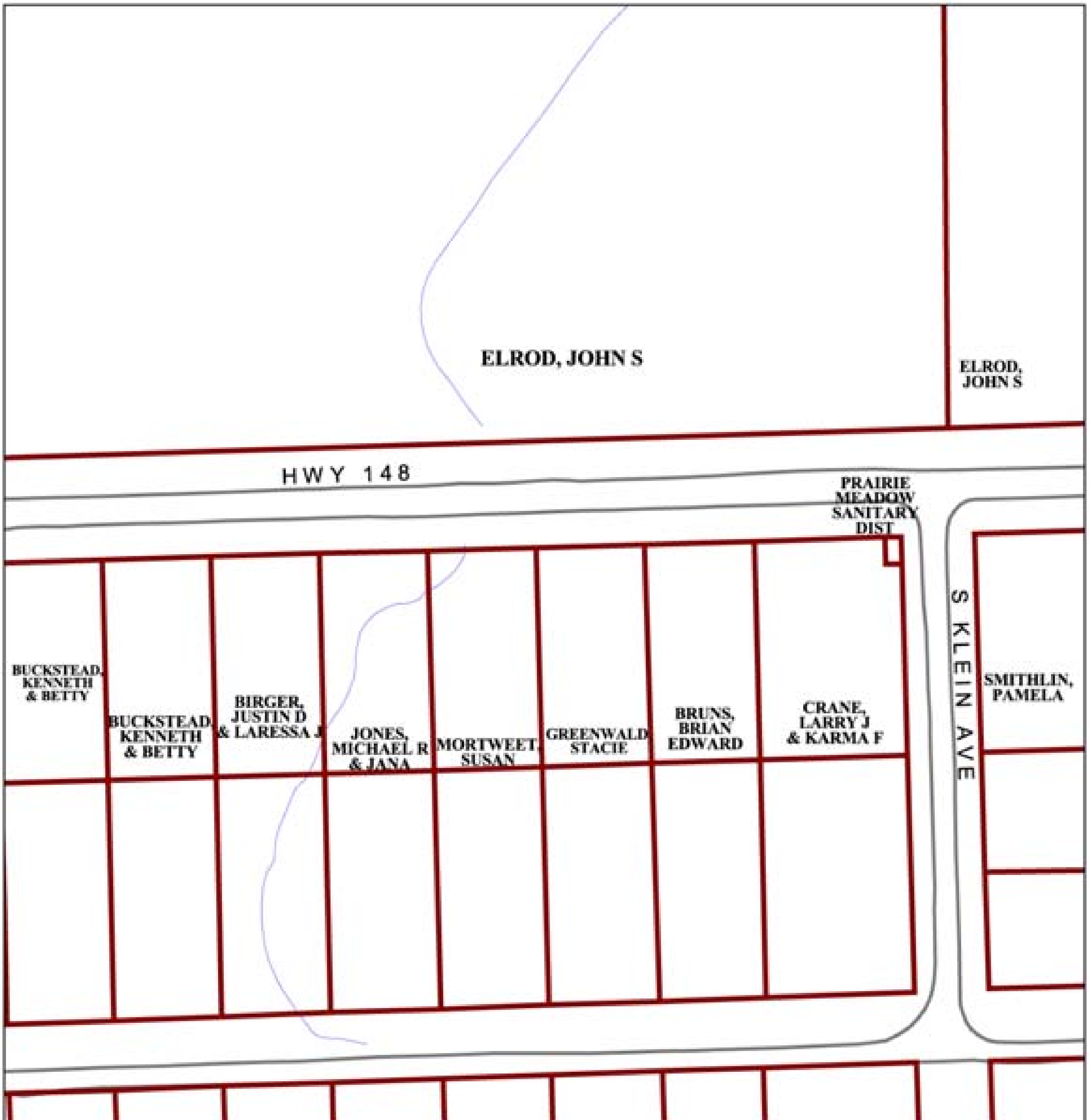

Parcel Boundaries
Roads
Drainage

There are no wetlands or hydric soils in this area.

N

0 125 250 Feet

BMP 13-2

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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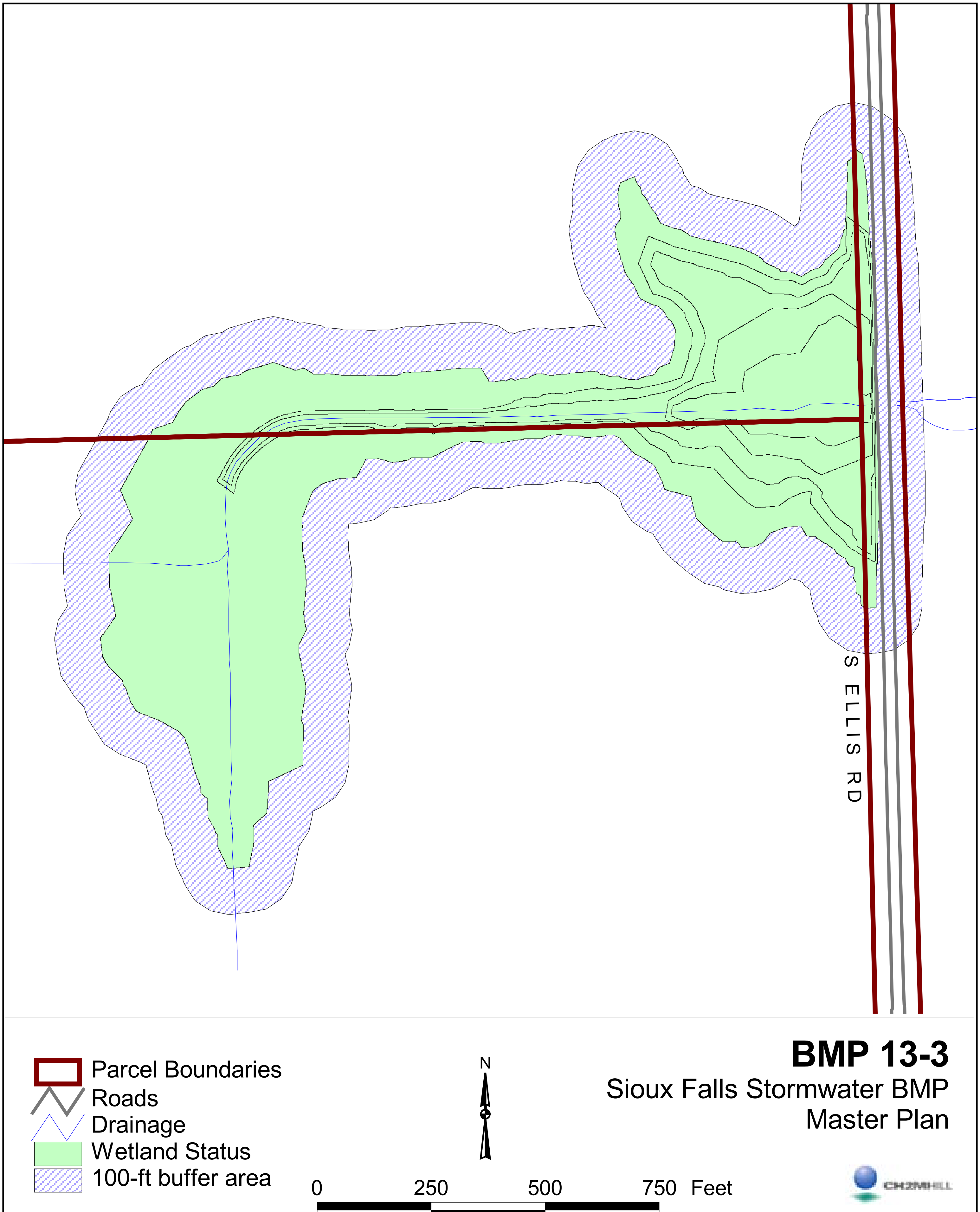


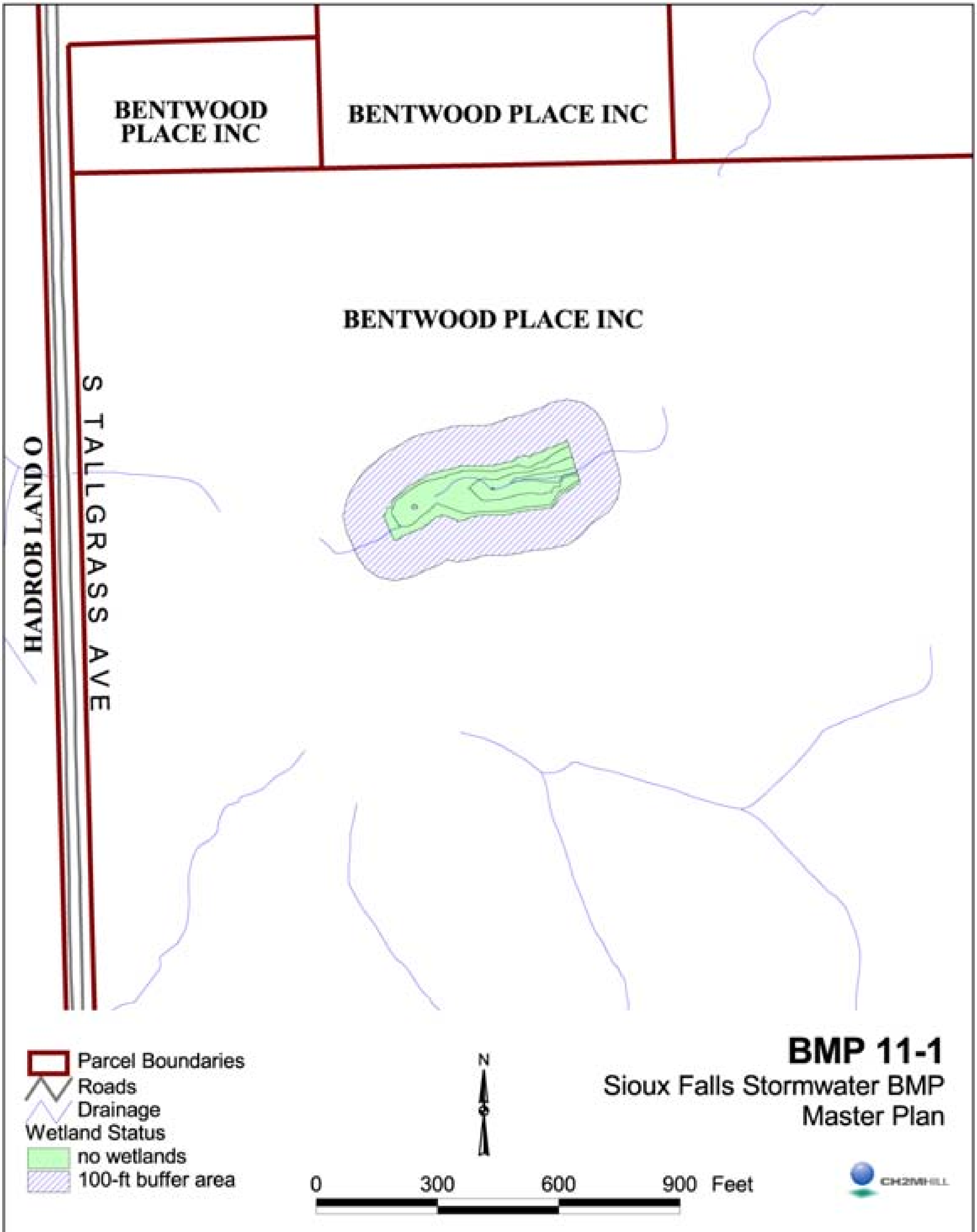
BMP 13-3

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

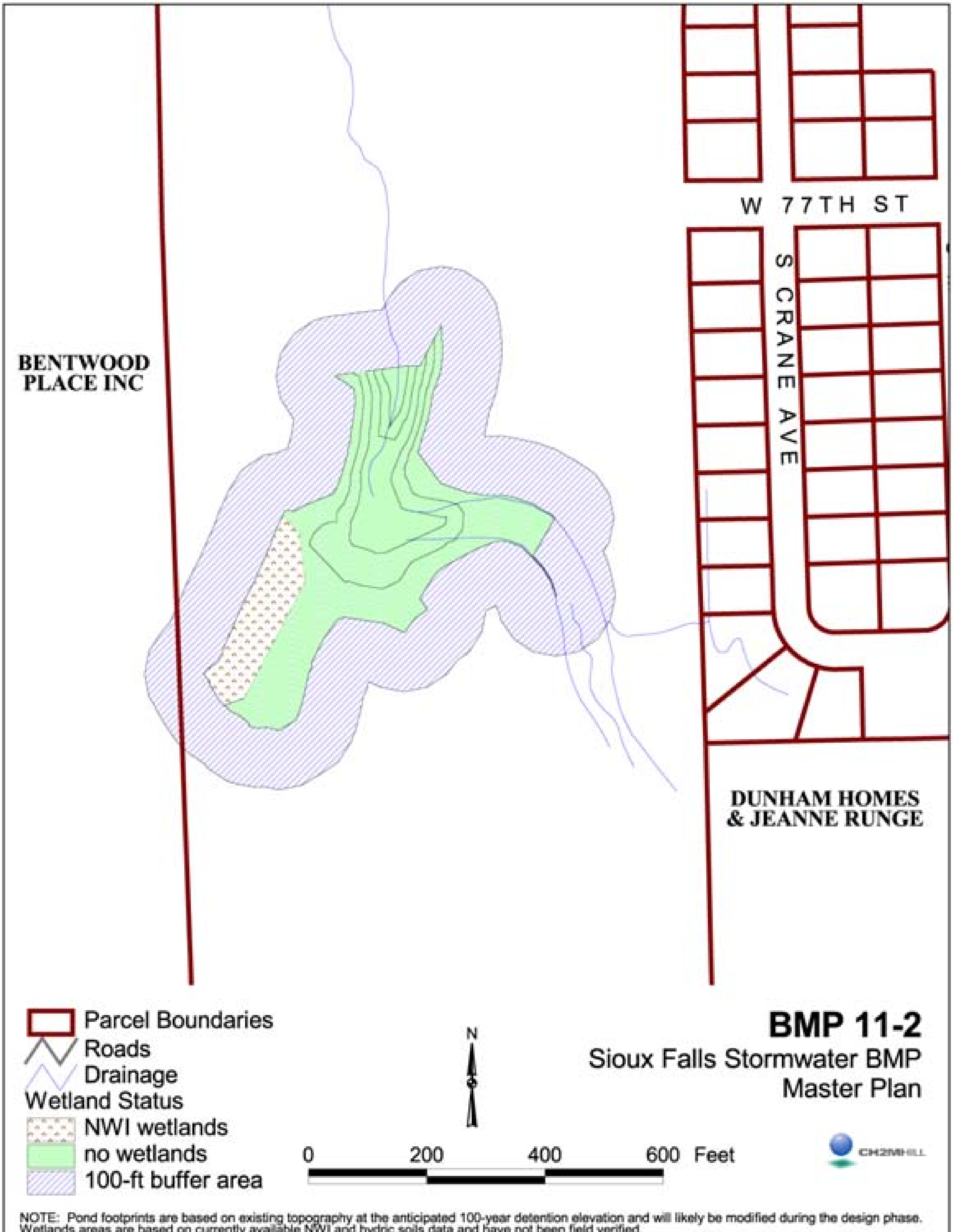
NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr

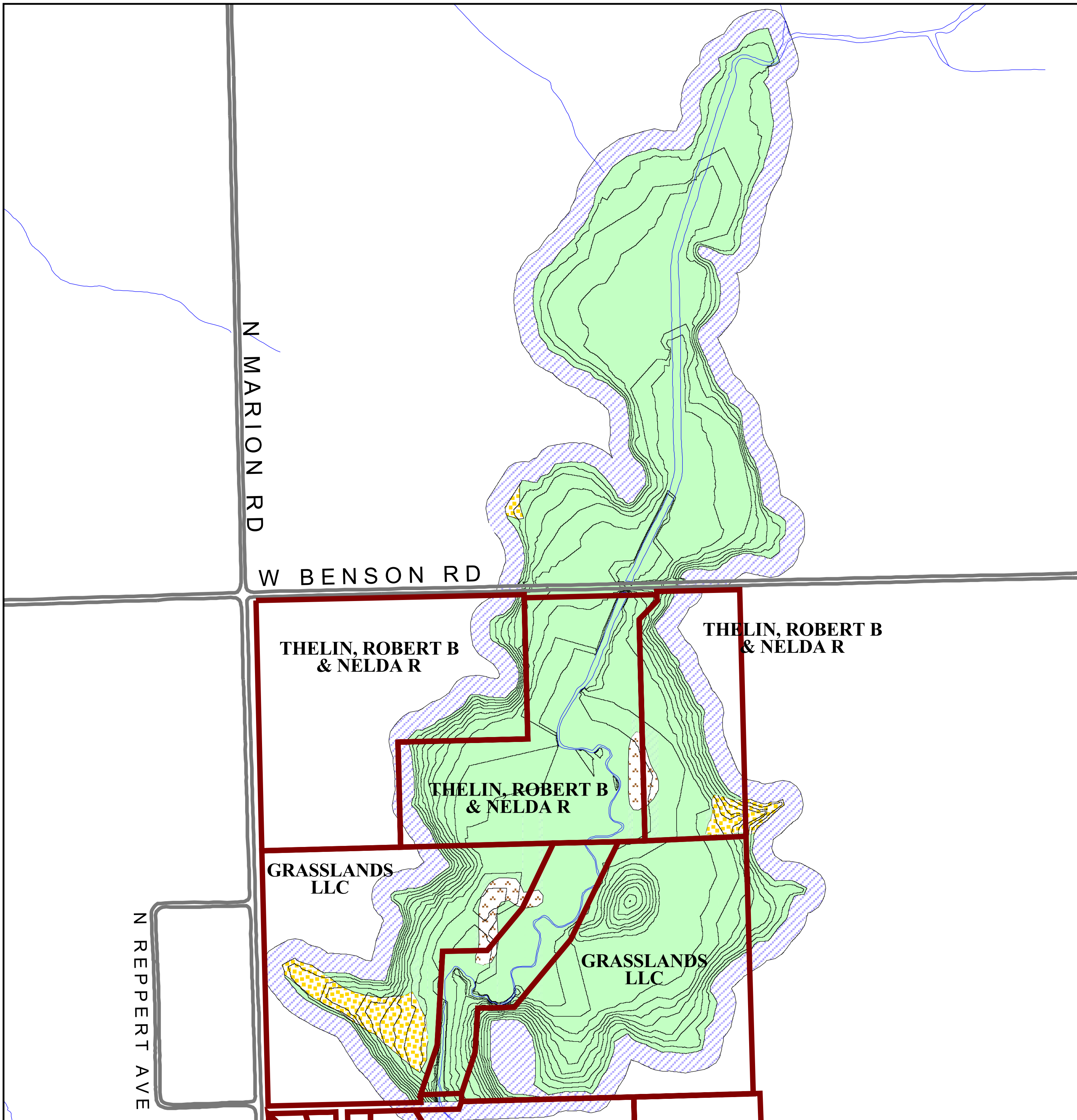


NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr



\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr



Parcel Boundaries
Roads
Drainage
Wetland Status
NWI wetlands
hydric soils
no wetlands
100-ft buffer area

N

0 700 1400 2100 Feet

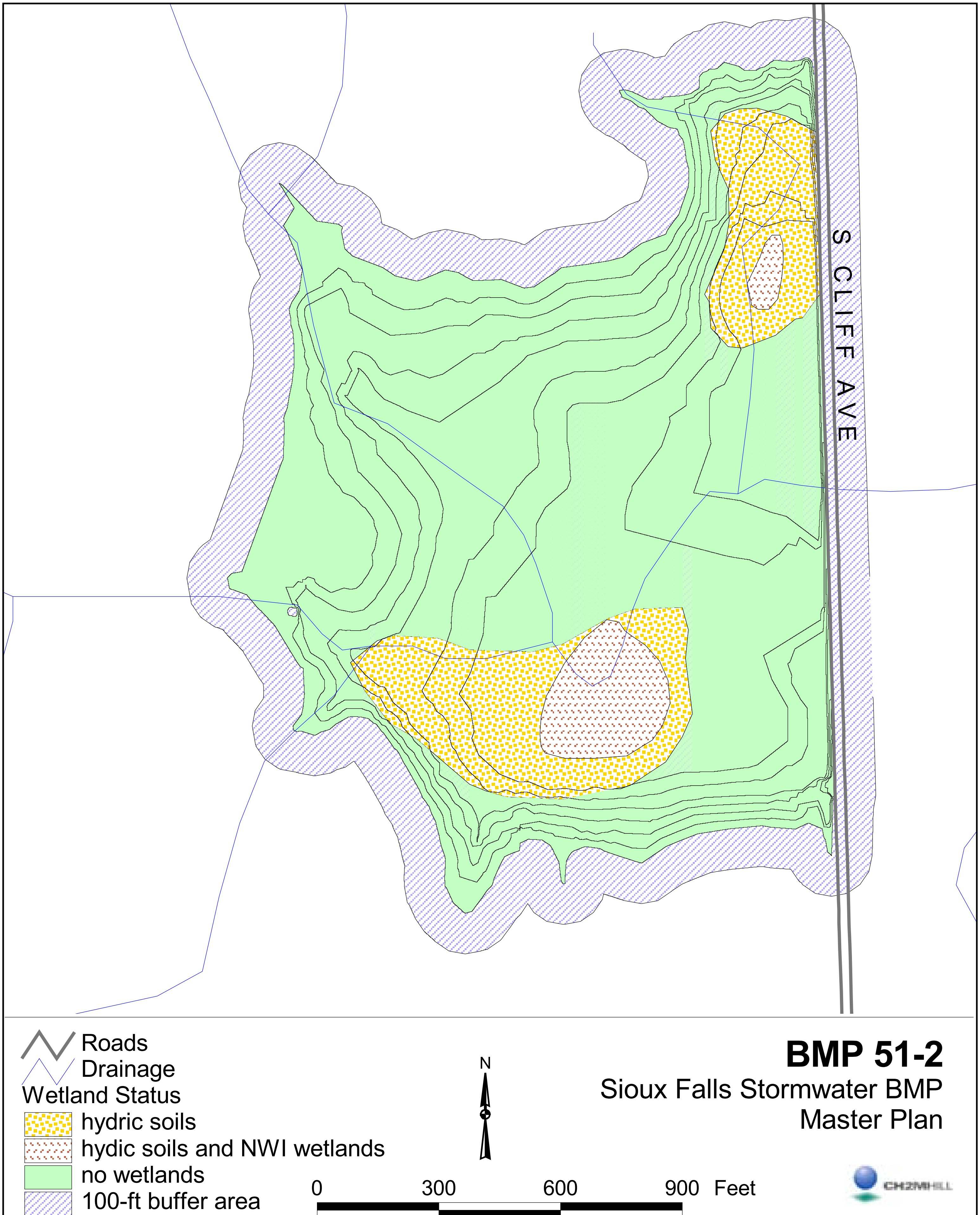
BMP 40-1

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr

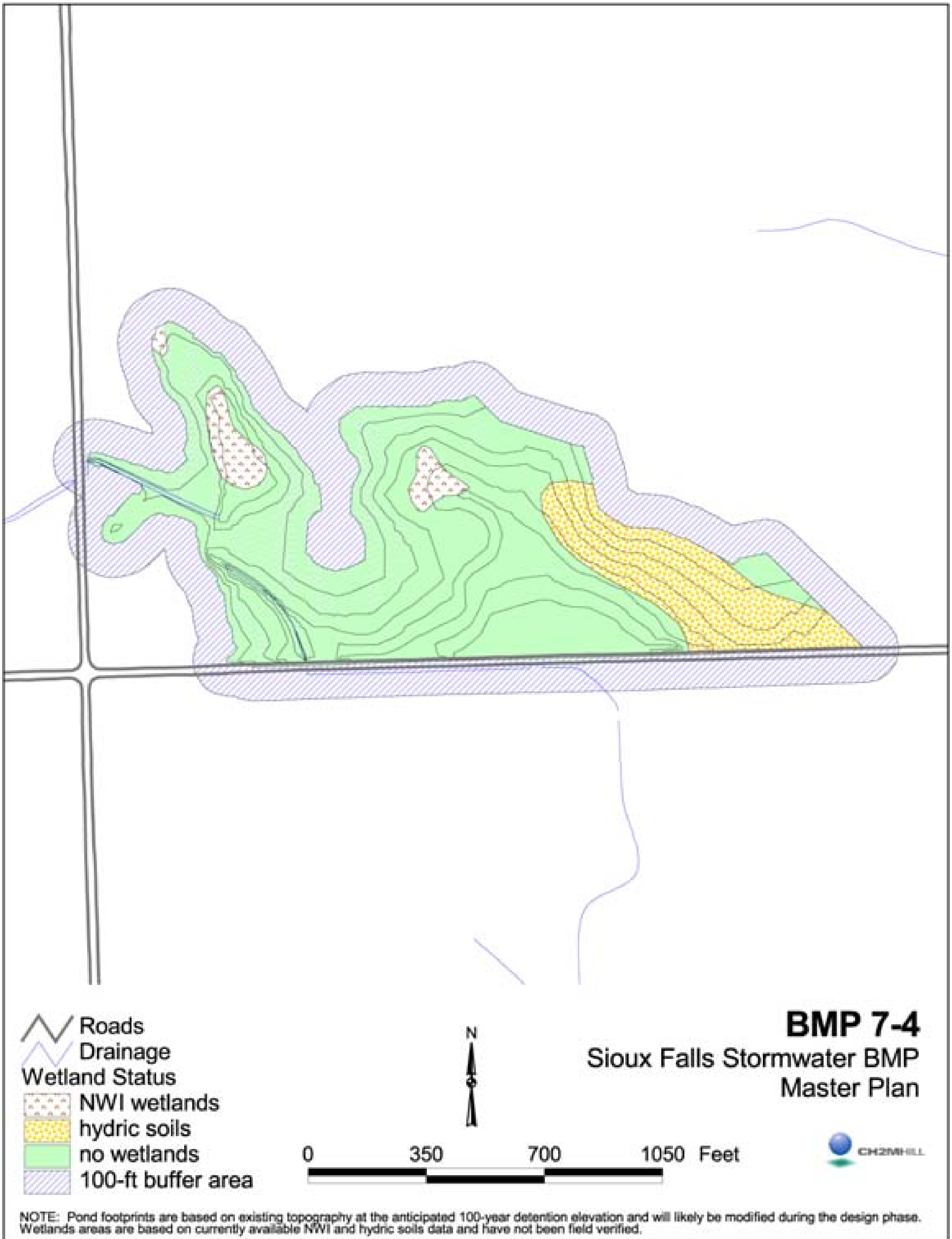


BMP 51-2

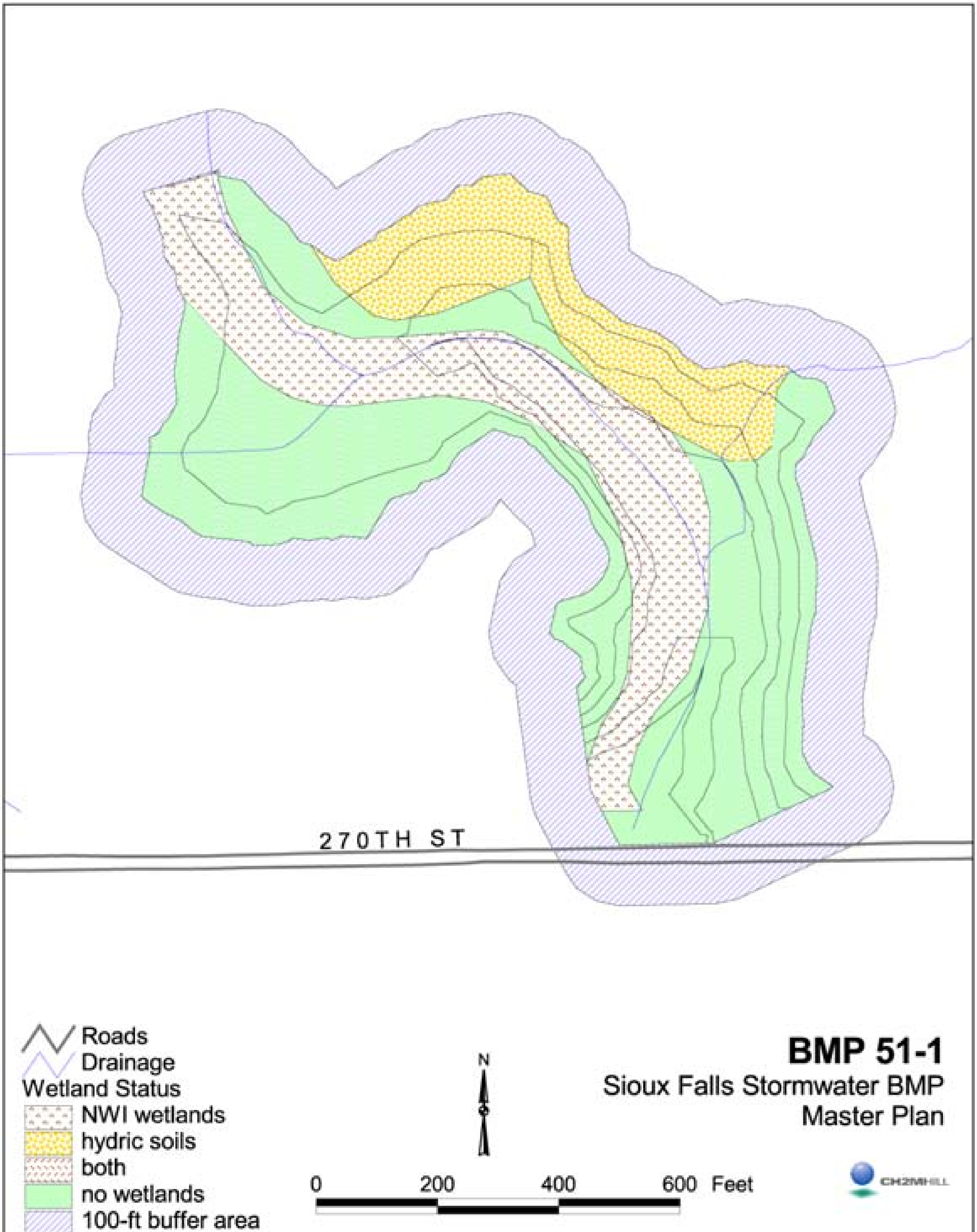
Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr

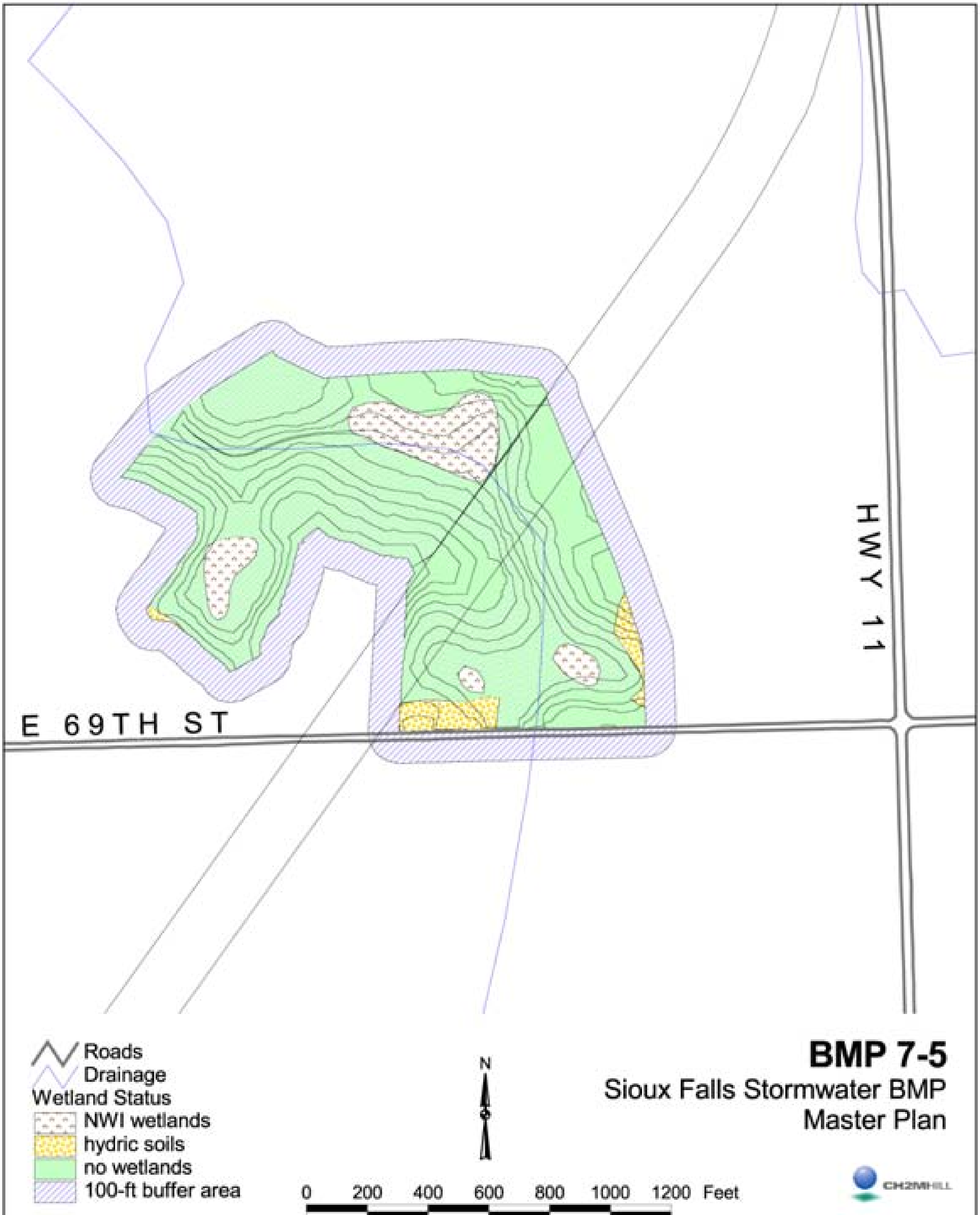


\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr



NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr

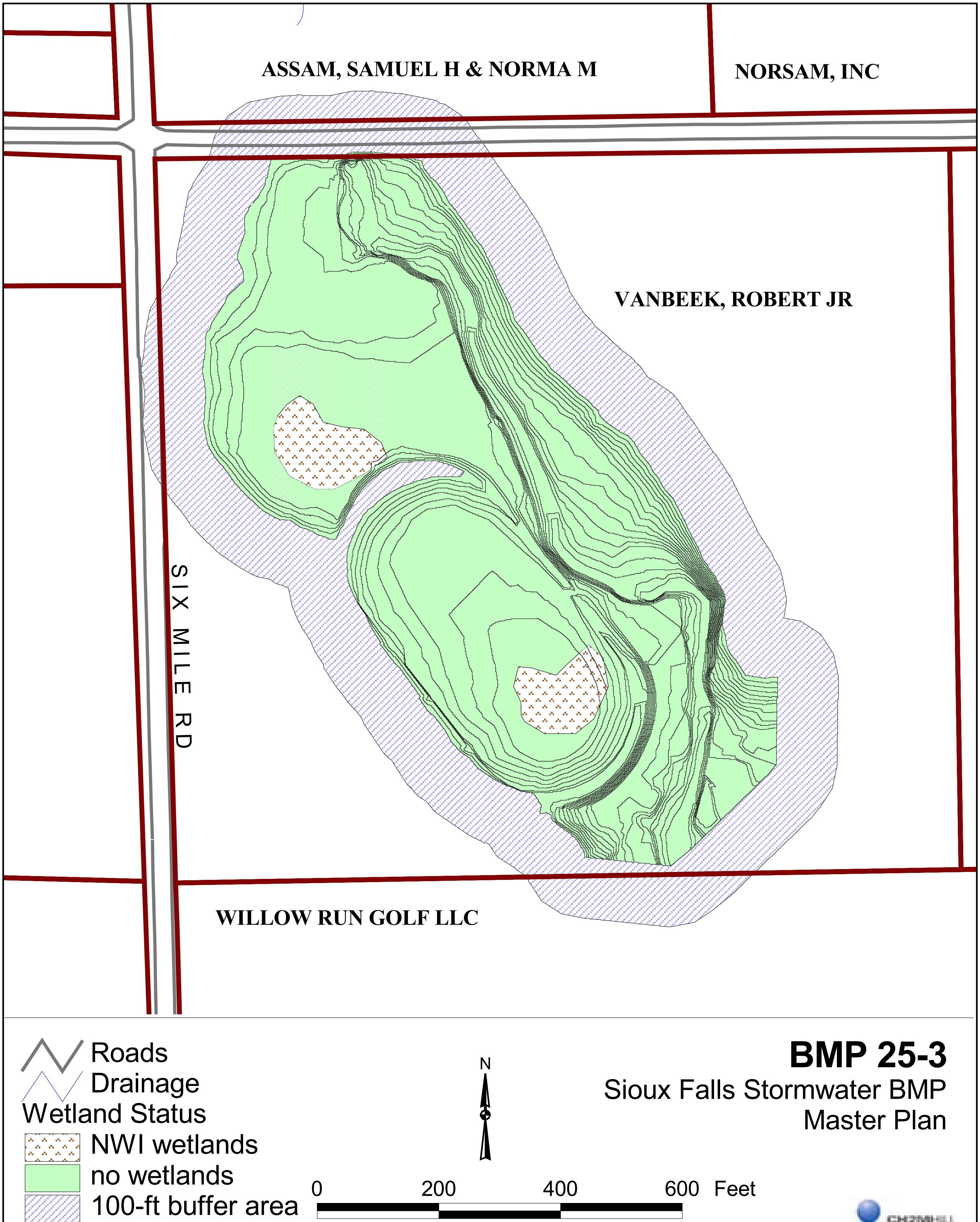


BMP 7-5

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr

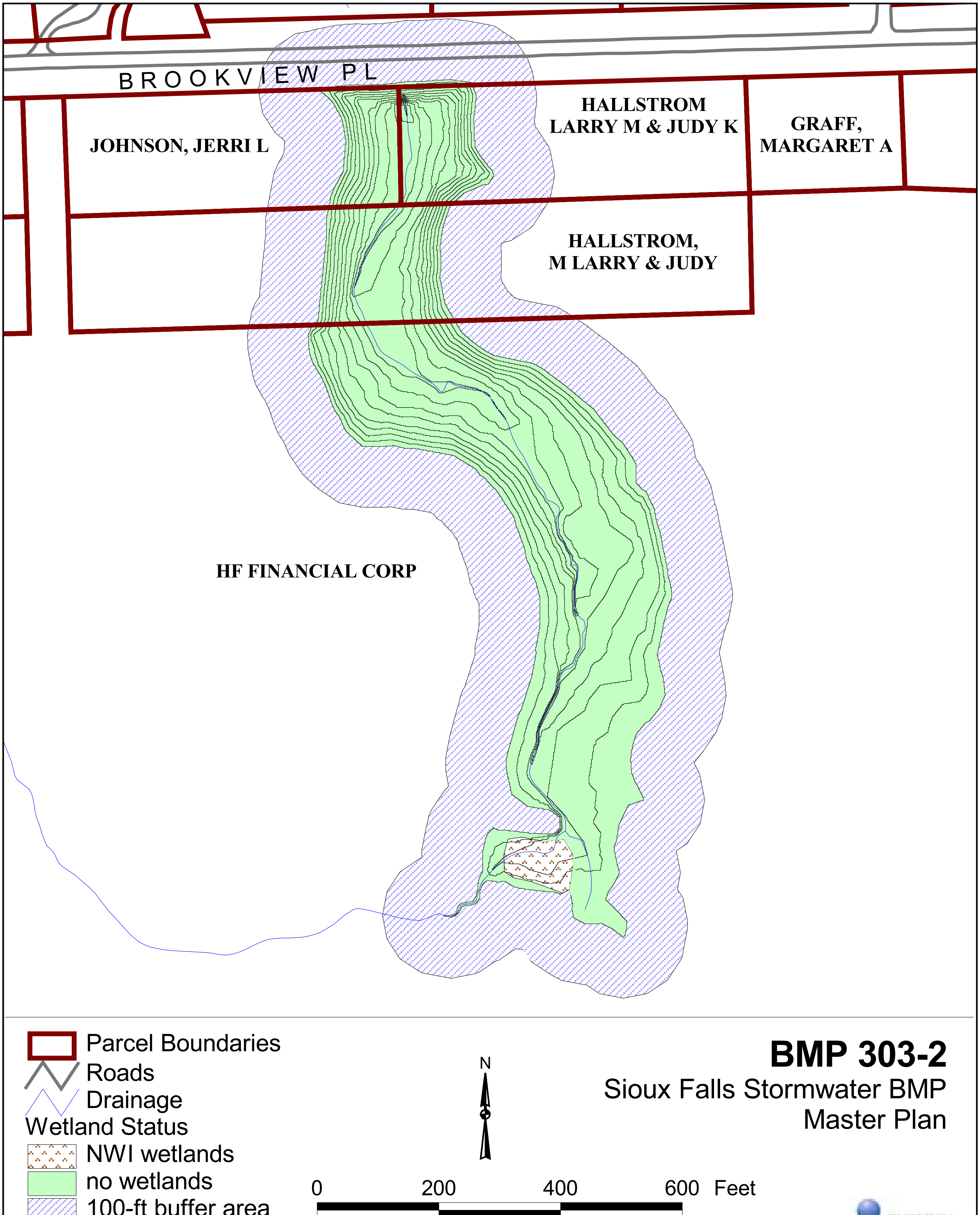


BMP 25-3

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\philpond.apr

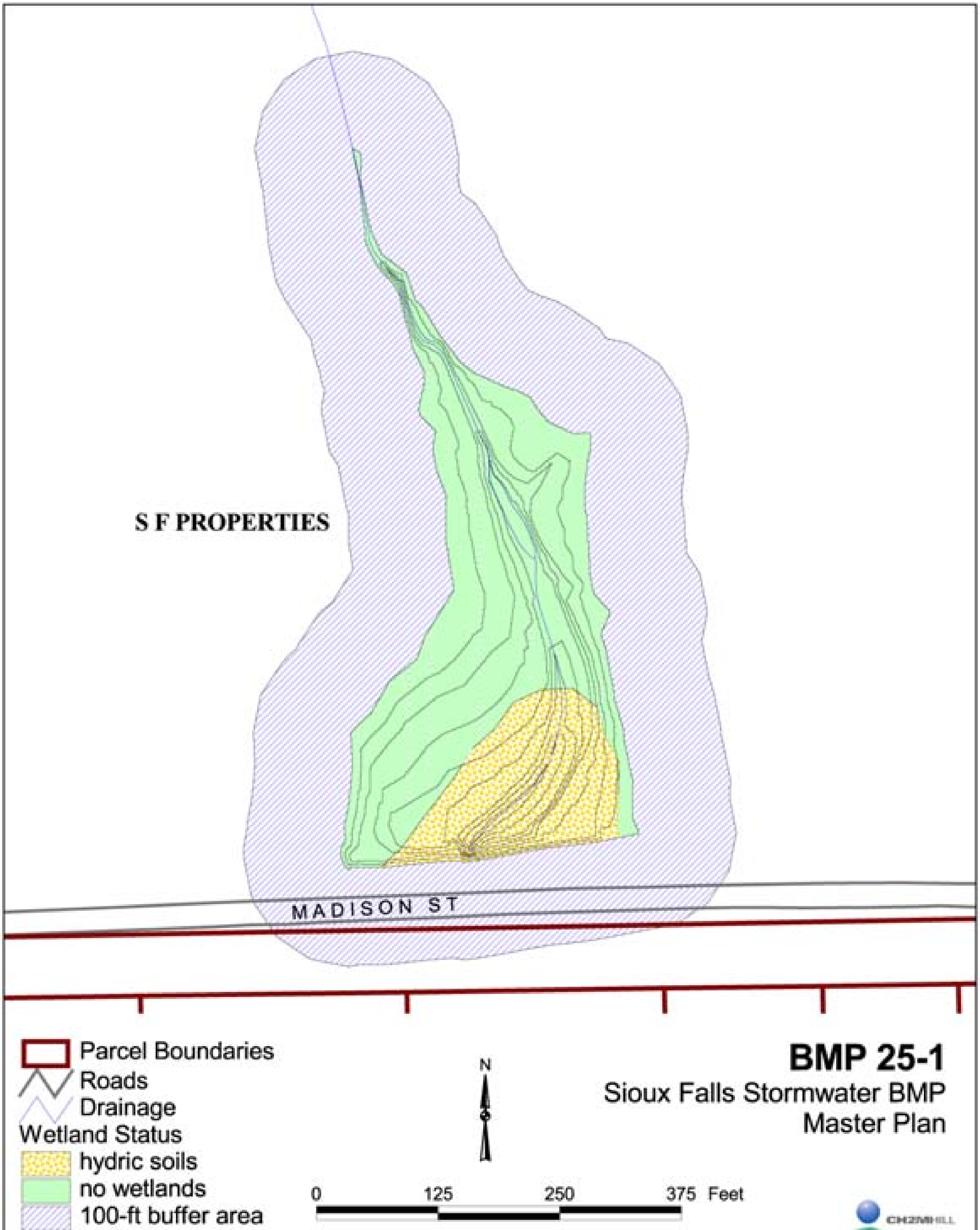


BMP 303-2

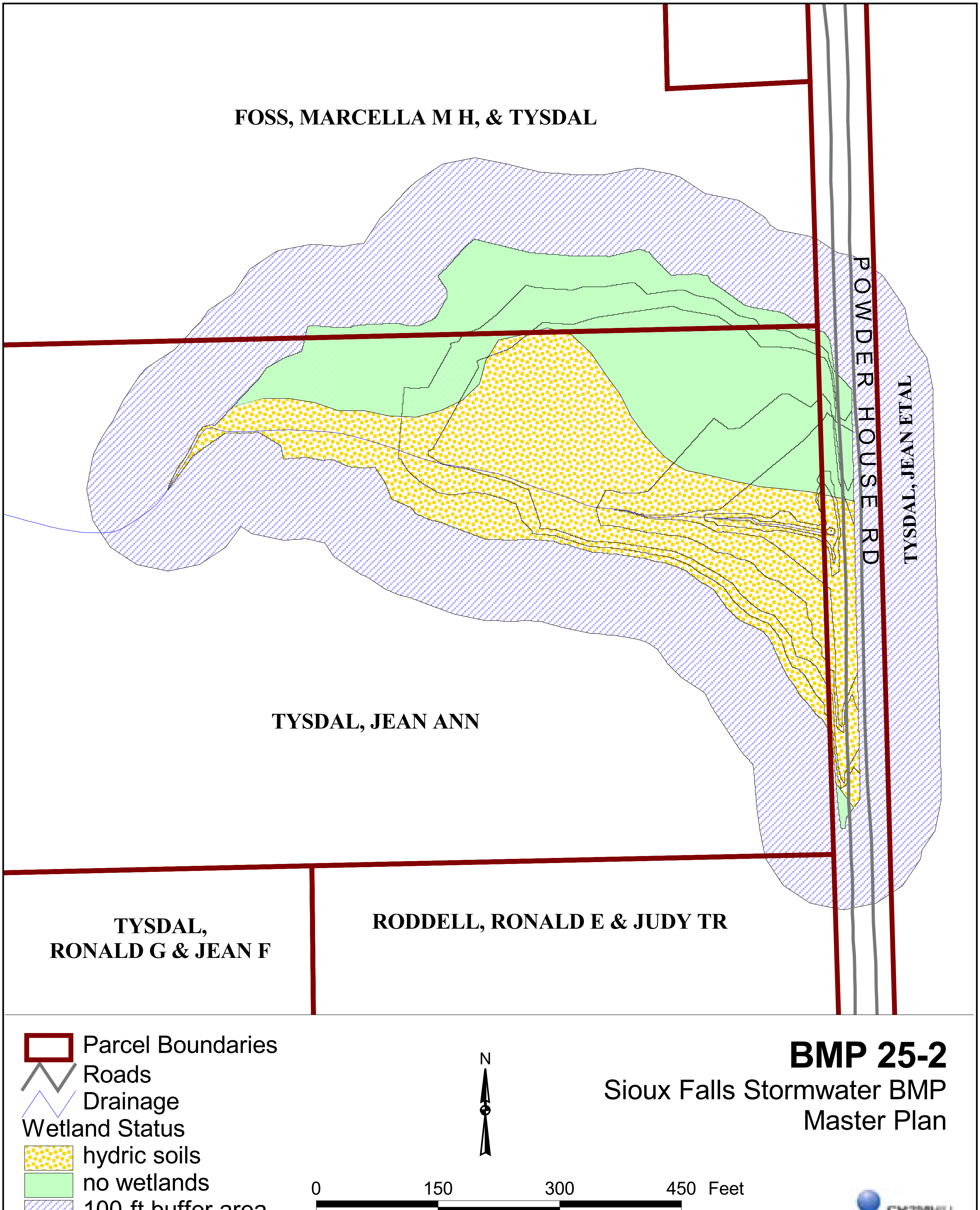
Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\philpond.apr



NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.



BMP 25-2

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\philpond.apr

Parcel Boundaries
Roads
Drainage
Wetland Status
no wetlands
100-ft buffer area

N

0 450 900 1350 Feet

BMP 41A

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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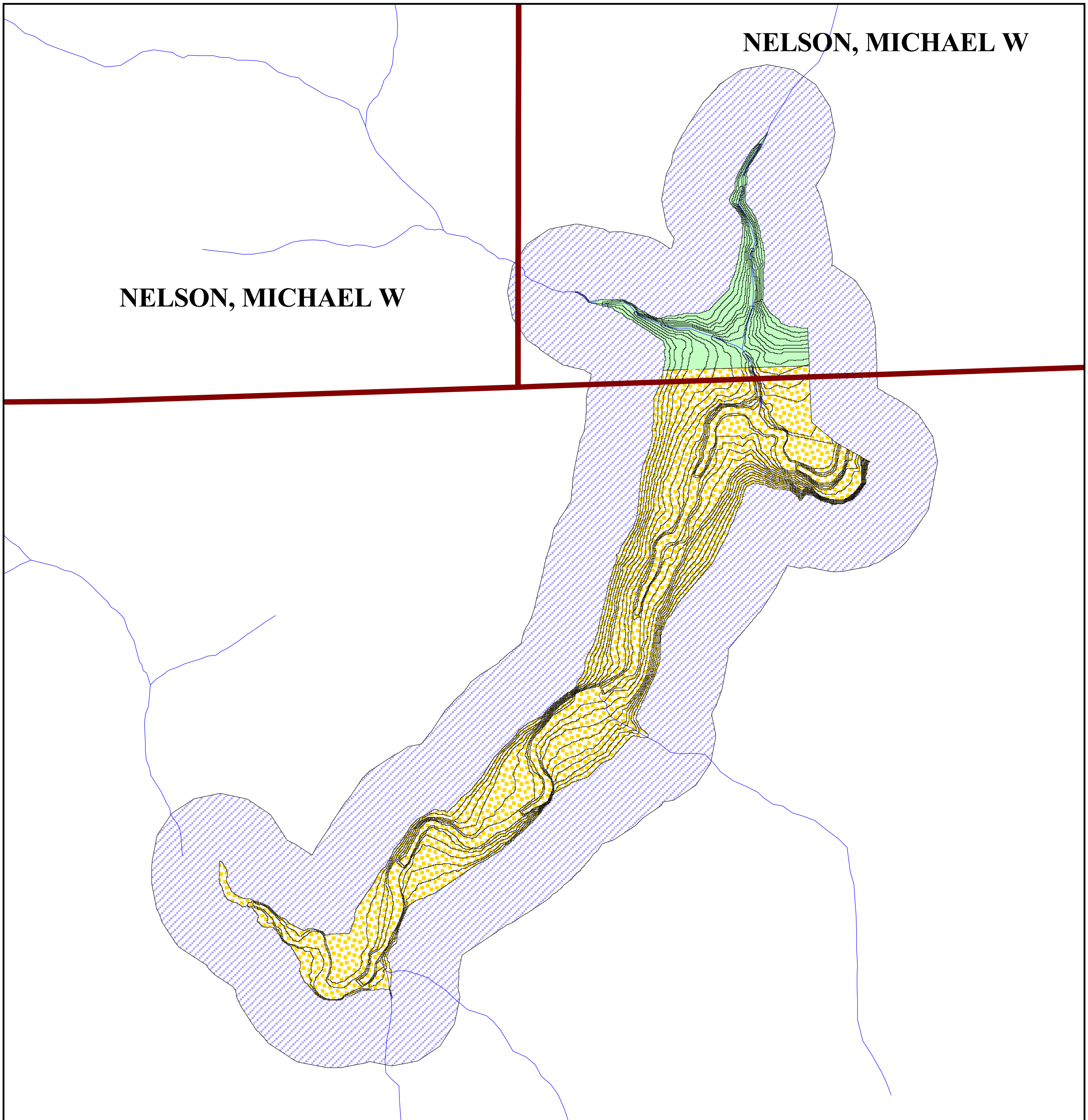


Parcel Boundaries
Drainage
Wetland Status
hydric soils
no wetlands
100-ft buffer area

N

0 200 400 600 Feet

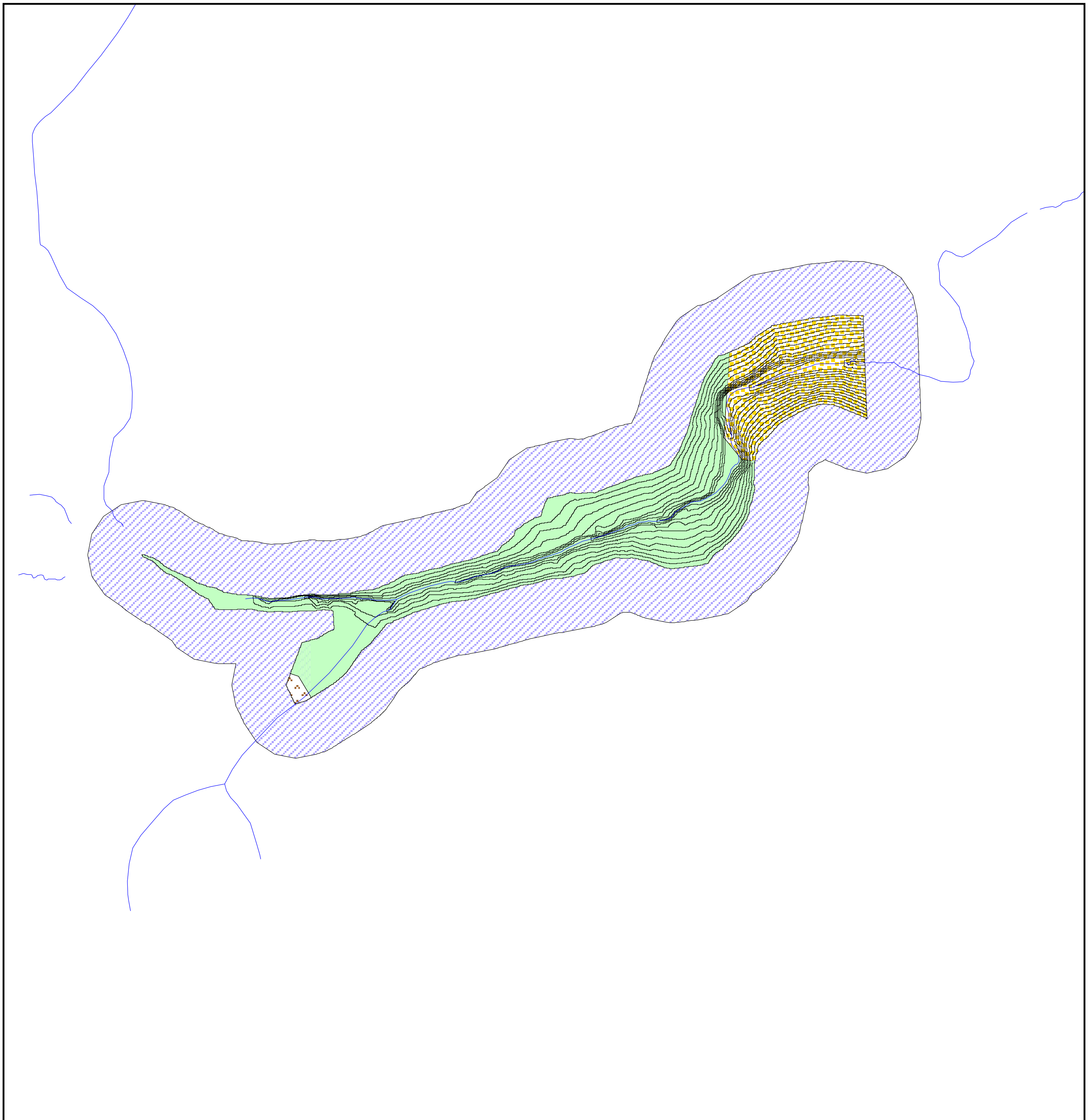
BMP 401-1

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr



Drainage
Wetland Status
NWI wetlands
hydric soils
no wetlands
100-ft buffer area

N

0 250 500 750 Feet

BMP 401-2

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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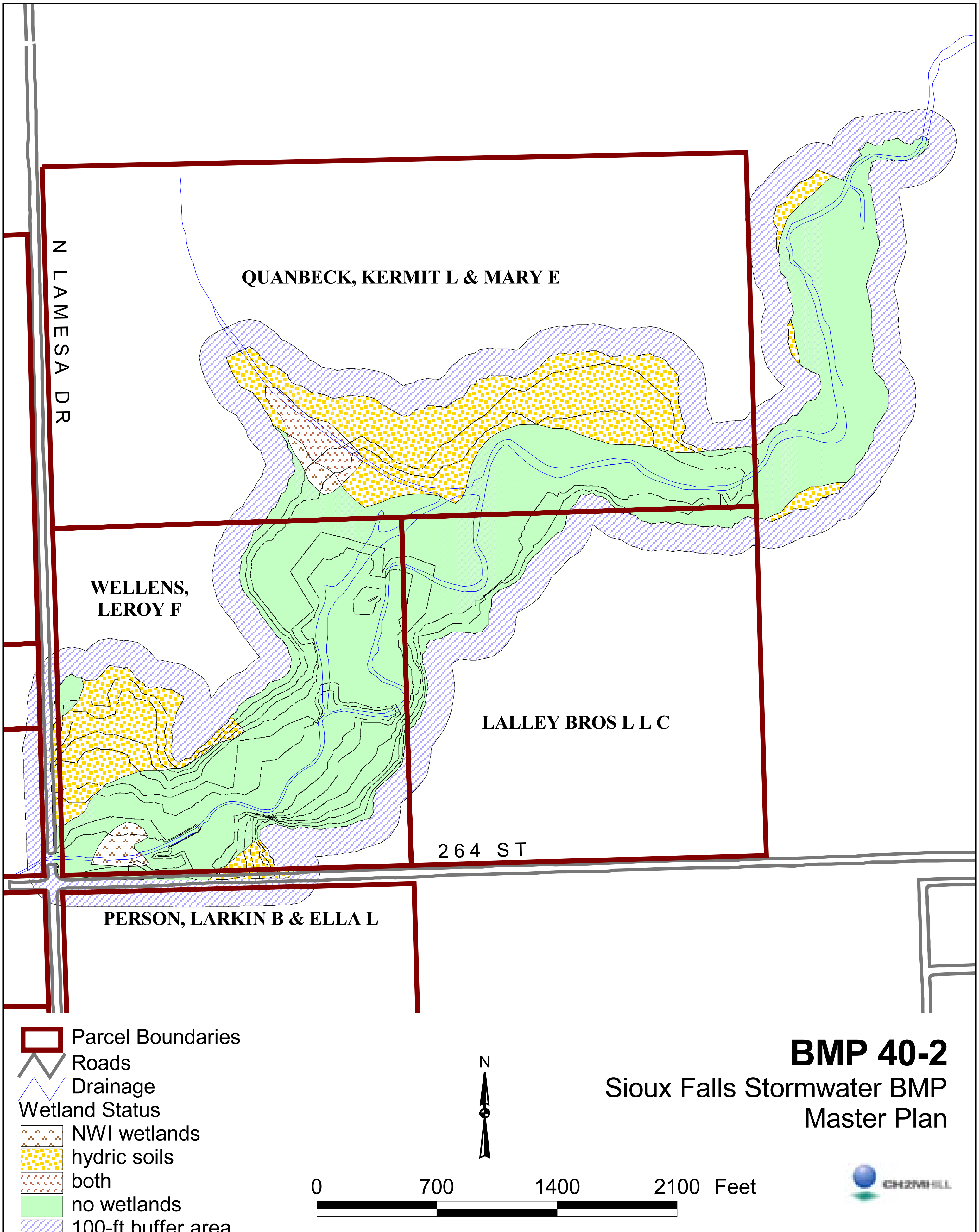

BMP 40-2

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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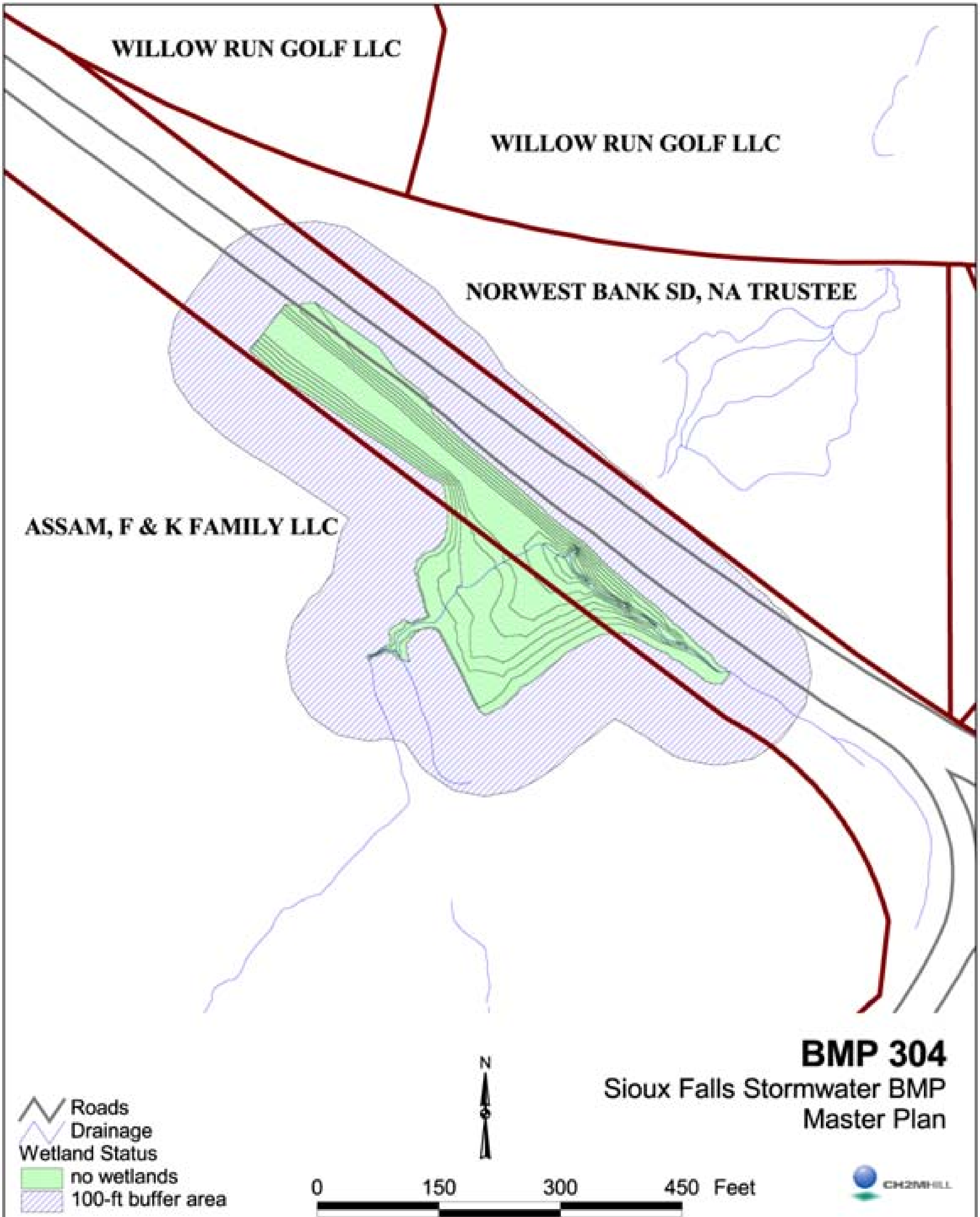

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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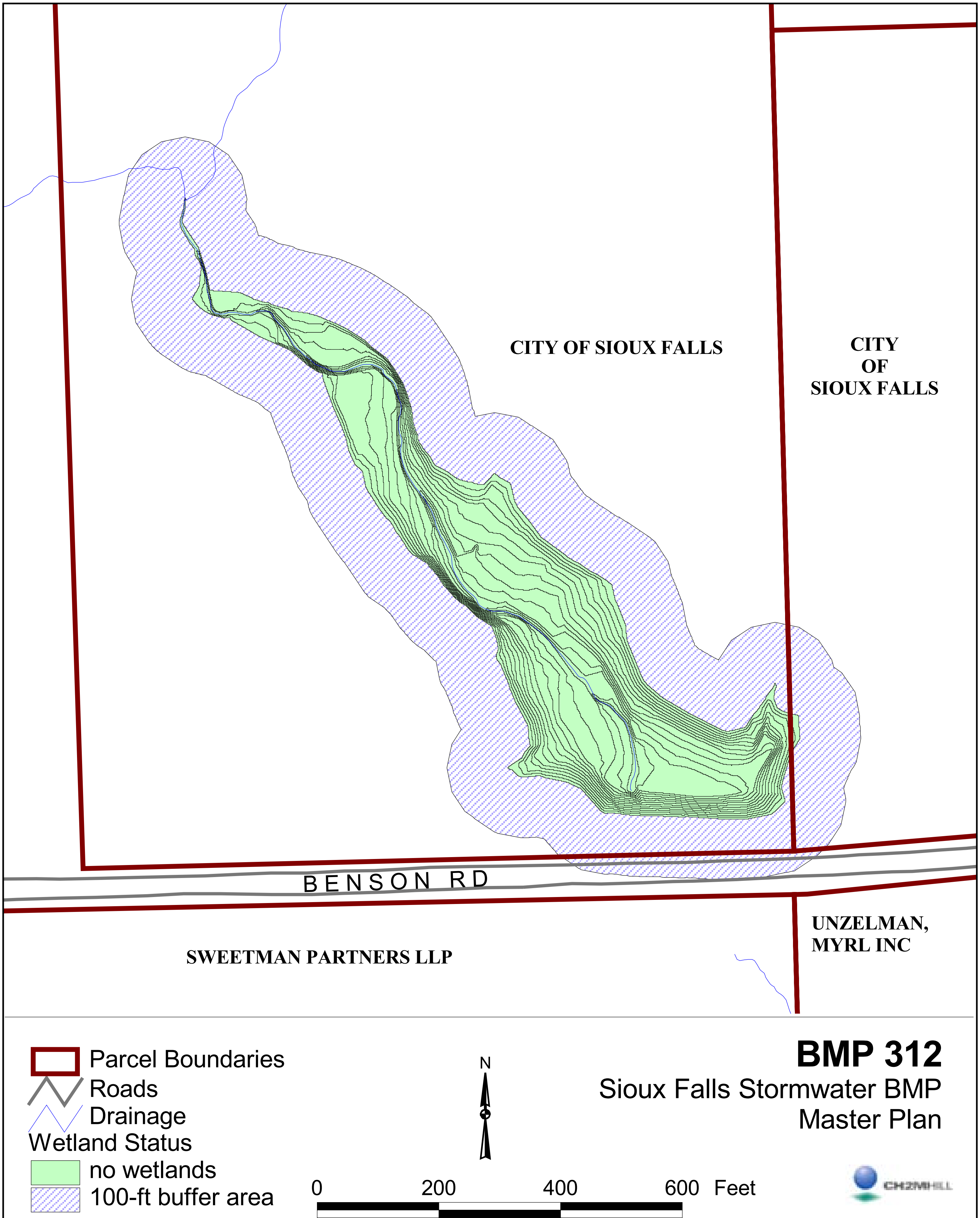

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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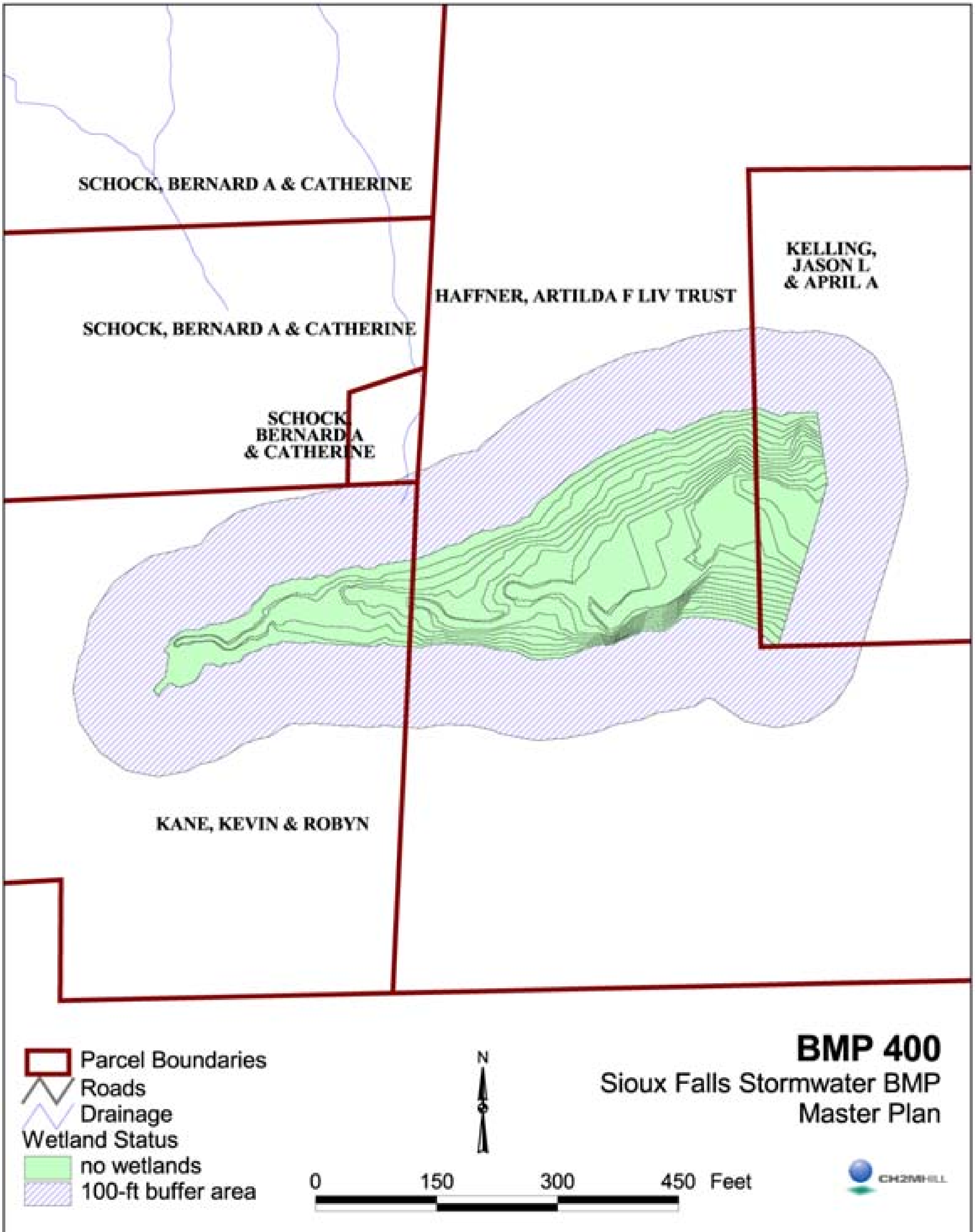

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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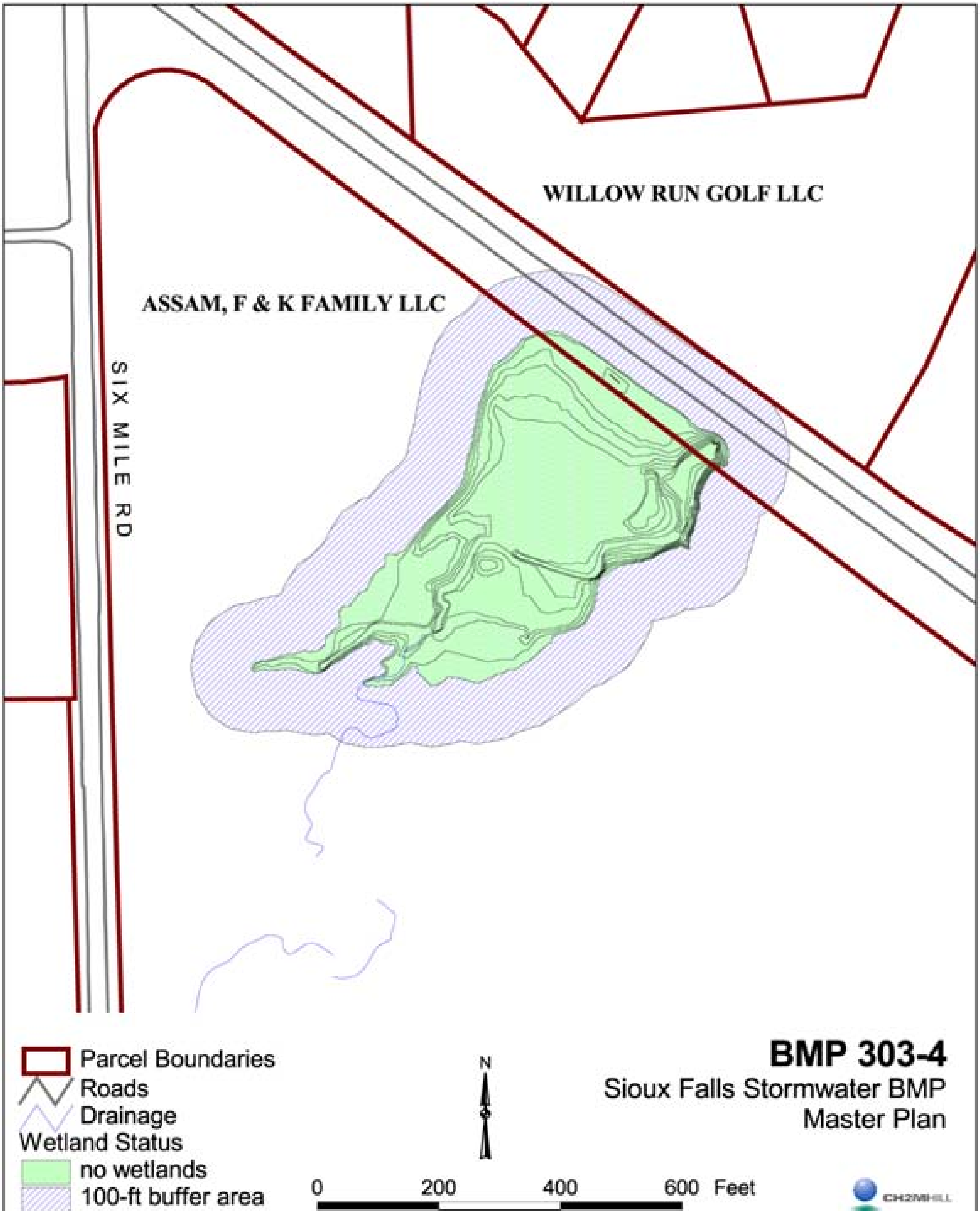

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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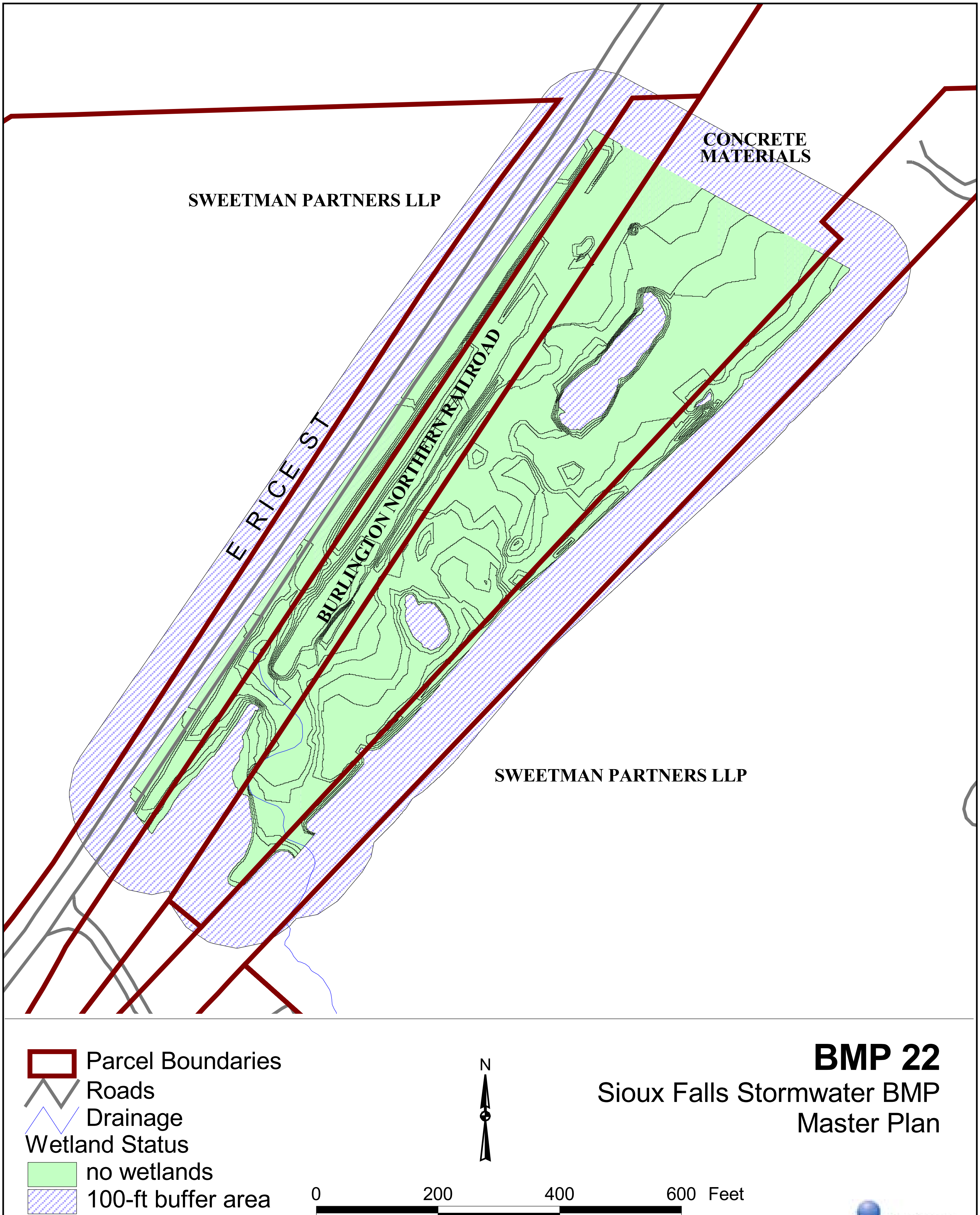

BMP 22

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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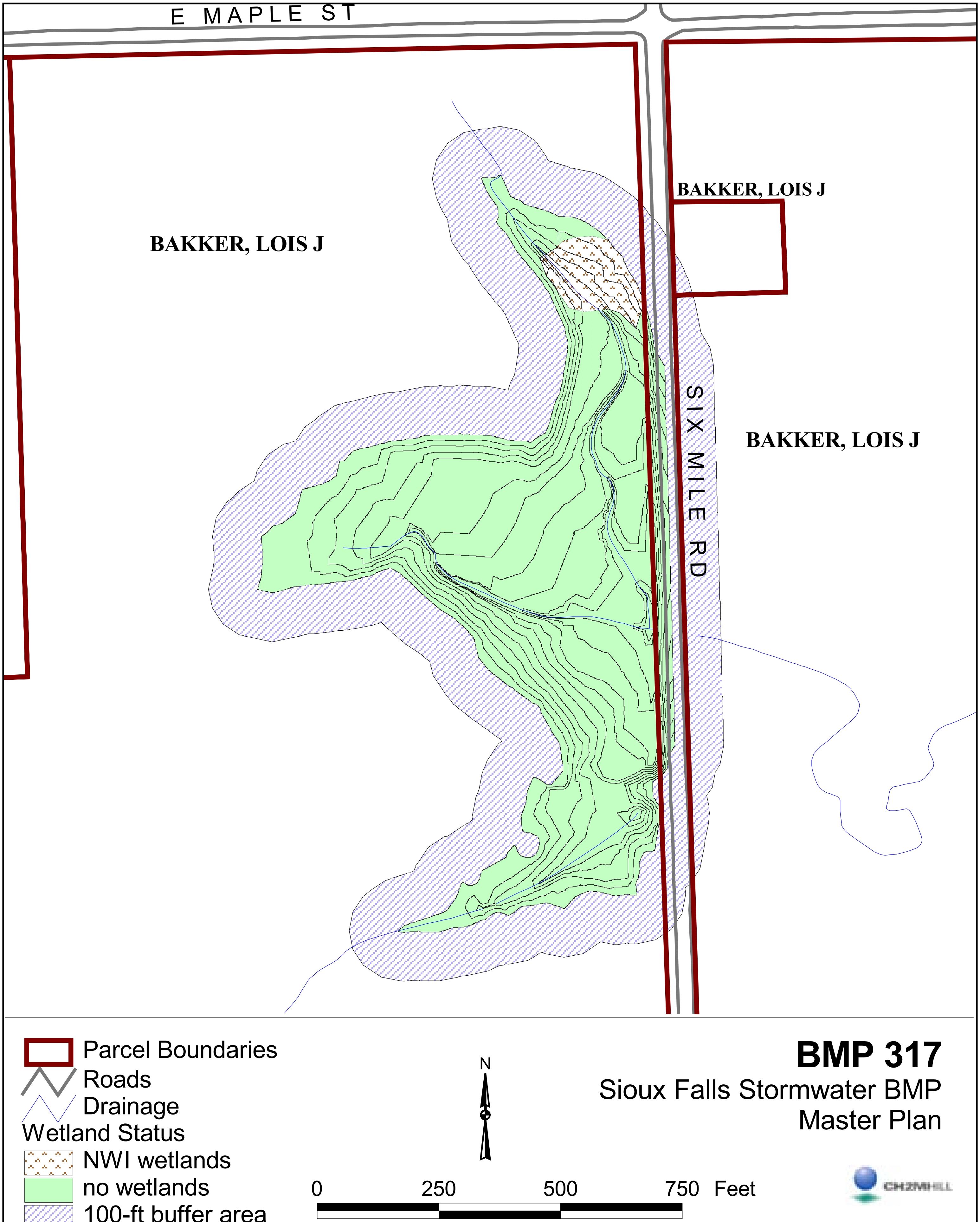

BMP 317

Sioux Falls Stormwater BMP Master Plan

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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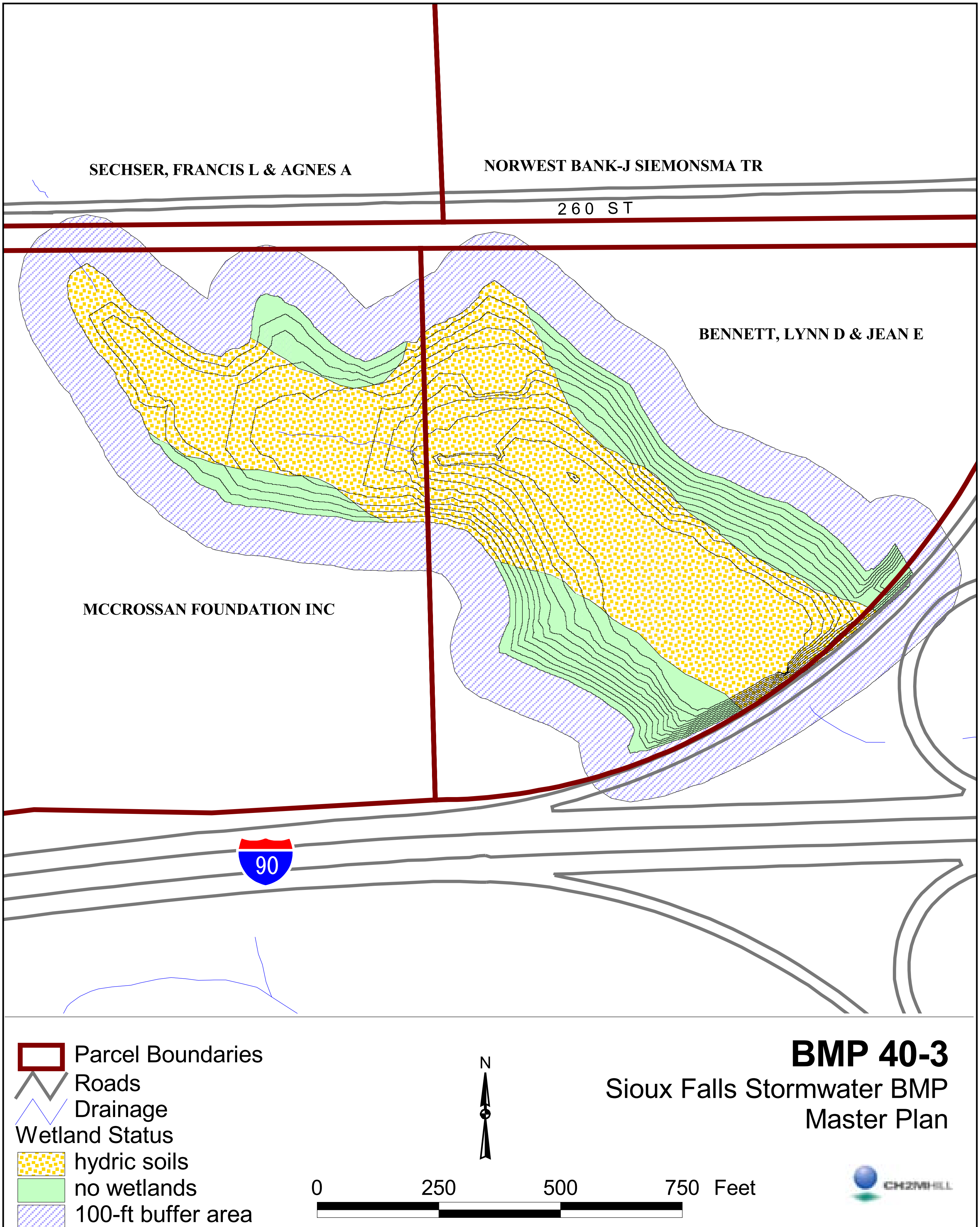


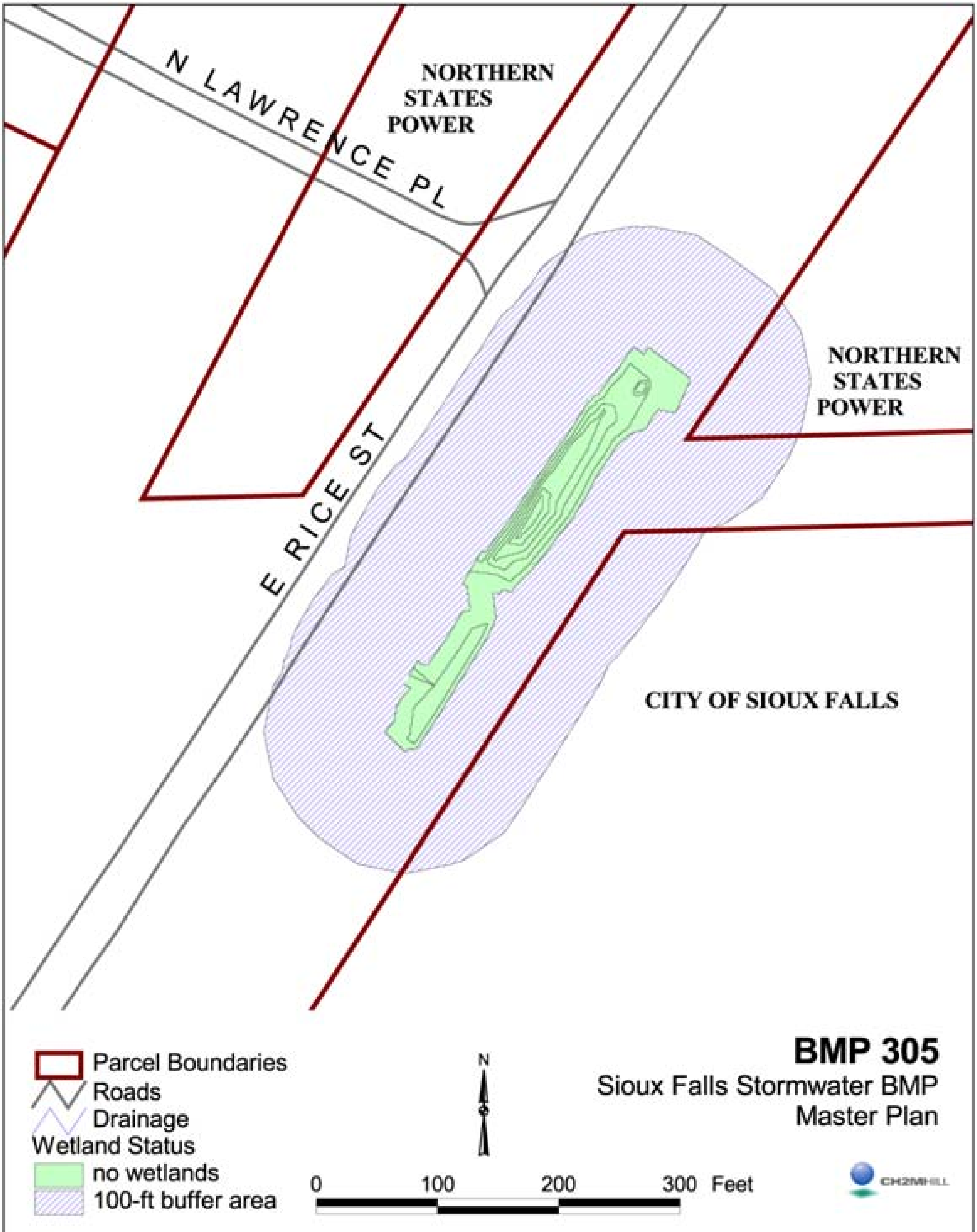
BMP 40-3

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

\\perseus\groups\gis_is\marku\sioux_falls\proj1.apr



NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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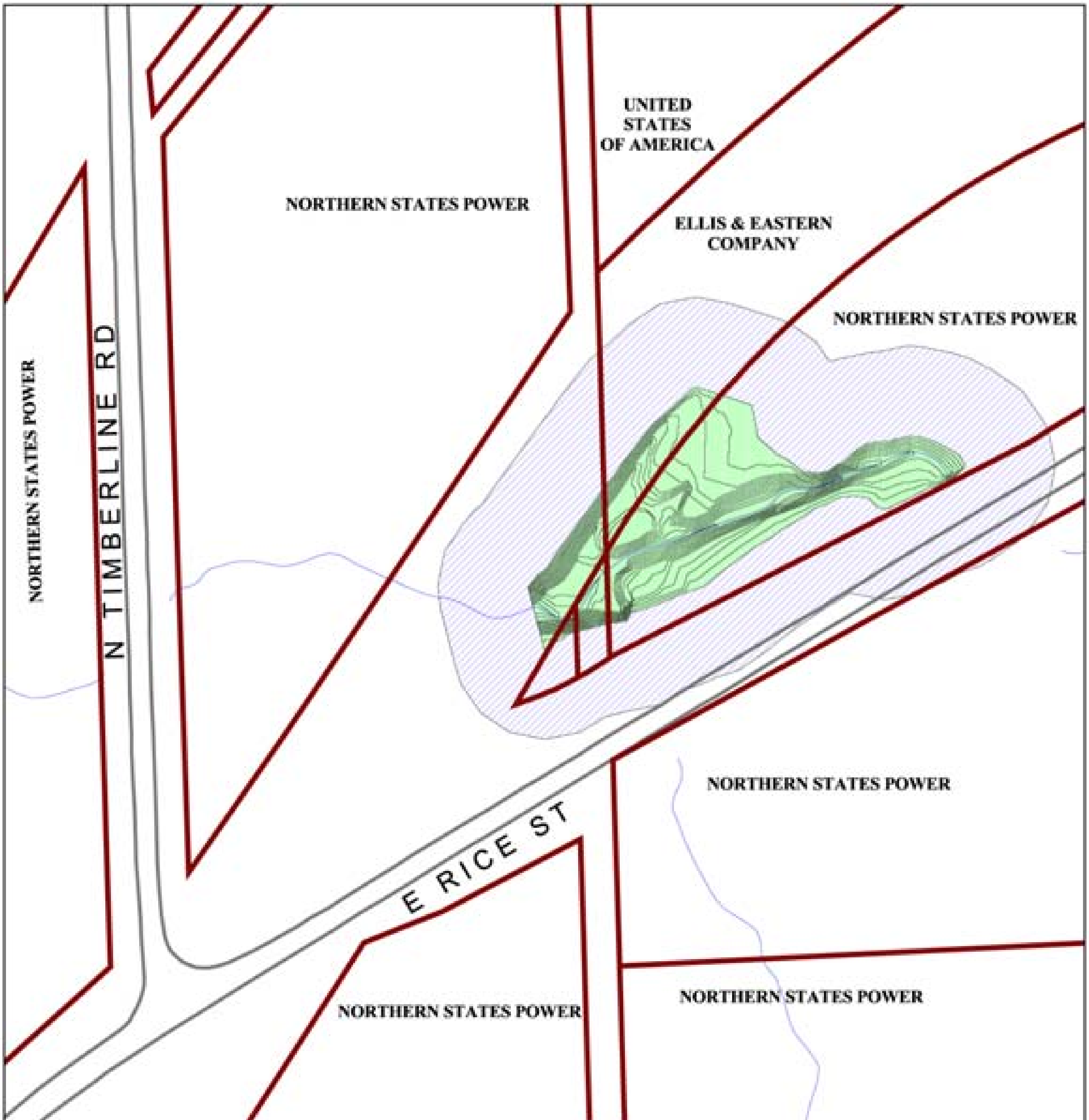

Parcel Boundaries
Roads
Drainage
Wetland Status
no wetlands
100-ft buffer area

N

0 150 300 450 Feet

BMP 306

Sioux Falls Stormwater BMP Master Plan

CH2MHILL

NOTE: Pond footprints are based on existing topography at the anticipated 100-year detention elevation and will likely be modified during the design phase. Wetlands areas are based on currently available NWI and hydric soils data and have not been field verified.

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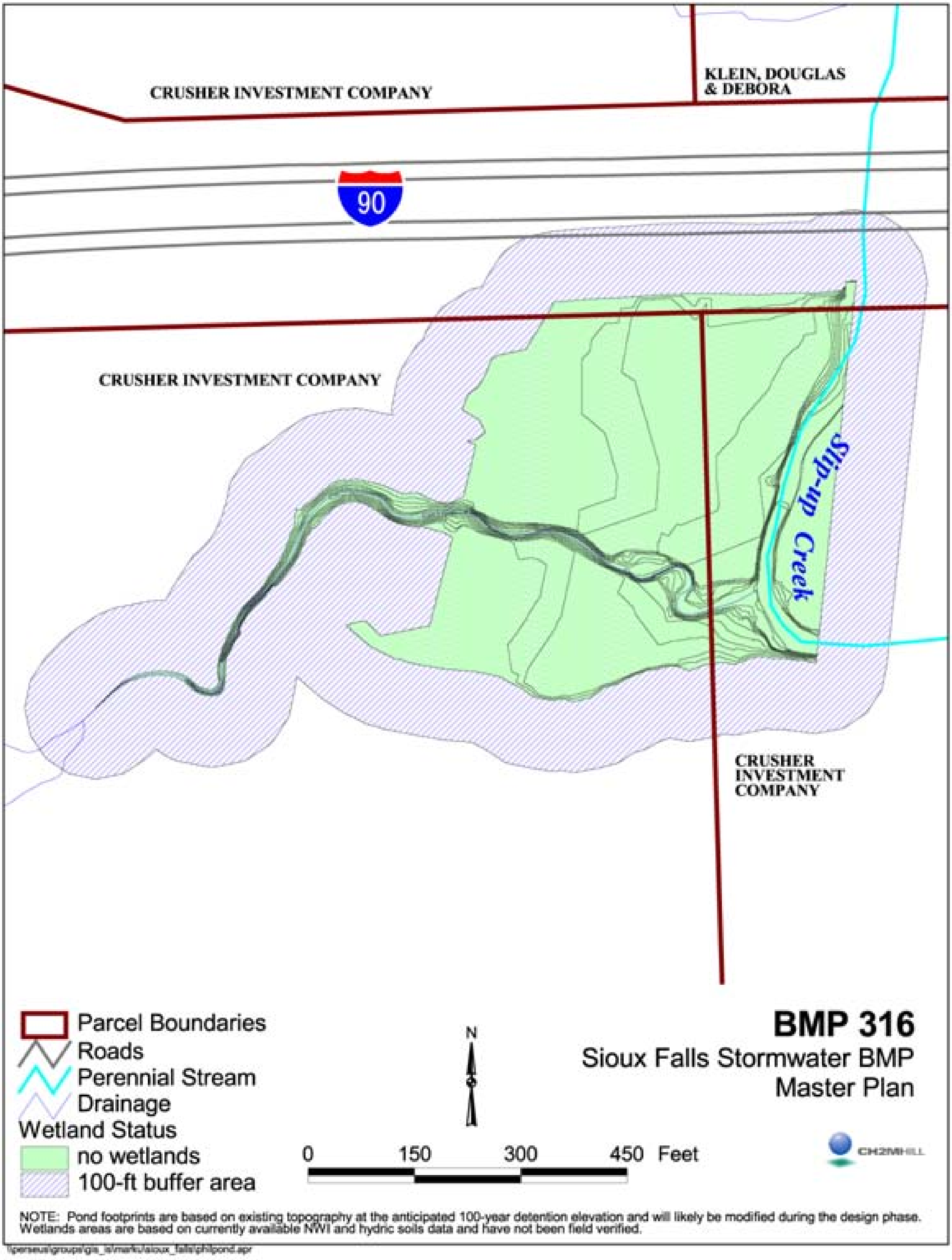

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BMP Site Field Data Sheets

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **13-1**
2. Location description: **41st and Tea Ellis (E)**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership: **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: Y / **N**
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Long grasses**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **6.0 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Yes**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000′ of Channel
   - 7.4. Existing Outlet Pipe Shape: **Double 36″ RCP**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **N/A**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **None pronounced, flood plain is wide**

7.5.1.3. Side Slopes **N/A**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
13-3 #1	BMP Area	u/s Lt.	
13-3 #2	BMP Area	u/s	
13-3 #3	BMP Area	u/s Rt.	
13-3 #4	Downstream Channel	d/s Lt.	
13-3 #5	Downstream Channel	d/s	
13-3 #6	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **13-2**
2. Location description: **41st and Tea Ellis (W)**
3. Current Land Use: **Vacant Lot**
4. Land Ownership: **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: Y / **N**
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Long grasses**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **Buildings**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **No Culvert**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Yes**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width , Composition: **Silt**
       - 7.5.1.2. Bank Height: **None pronounced, flood plain is wide**

7.5.1.3. Side Slopes **N/A**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High Moderate **Minimal** Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required: **Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
13-2 #1	BMP Area	u/s Lt.	
13-2 #2	BMP Area	u/s	
13-2 #3	BMP Area	u/s Rt.	
13-2 #4	Downstream Channel	d/s Lt.	
13-2 #5	Downstream Channel	d/s	
13-2 #6	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **13-3**
2. Location description: **Tea Ellis, midway between 41st and 22nd**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):

   5.1. Baseflow Present: **Y** / N

   5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only

   5.3. Vegetation Type(s): **Long grasses**

   5.4. Wetlands coverage: **None** , Description:

   5.5. Physical constraints present: Utilities Buildings Limited Acreage

   Describe: **None**

   5.6. Other:

6. Potential Capacity

   6.1. Existing height from outlet invert to top of roadway: **7.5 feet**

   6.2. Maximum height of feasible berm (from outlet invert):

   6.3. Maximum 100-yr footprint constraints:

   6.4. Other:

7. BMP Construction

   7.1. Access feasible for construction: **Yes**

   7.2. Fill areas available for excavated material (above high water elevation): **No**

   7.3. Existing Outlet and Downstream 1000' of Channel

   7.4. Existing Outlet Pipe Shape: **Double 48" RCP**

   7.5. Downstream Conveyance: **Open Channel**

   7.5.1. Average size and composition (vegetated, gravel, concrete, etc)

   7.5.1.1. Bottom Width **2 to 10 feet**, Composition: **Silt**

   7.5.1.2. Bank Height: **None pronounced, flood plain is wide**

7.5.1.3. Side Slopes **N/A**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Outlet**

7.6.4. Other:

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
13-3 #1	**BMP Area**	**u/s Lt.**	
13-3 #2	**BMP Area**	**u/s**	
13-3 #3	**BMP Area**	**u/s Rt.**	
13-3 #4	**Downstream Channel**	**d/s Lt.**	
13-3 #5	**Downstream Channel**	**d/s**	
13-3 #6	**Downstream Channel**	**d/s Rt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **11-1, Preliminary Design**
2. Location description: **East of Tallgrass, south of 69th, Pond 17C of Prairieview Study**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Cattails, Pasture**
   - 5.4. Wetlands coverage: **0.2 Acre**, Description: **Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None seen**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway:
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Moderate, in the middle of agric. operation**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **3 feet ,** Composition: **Silt**
       - 7.5.1.2. Bank Height: **1 feet**
       - 7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High Moderate **Minimal** Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**,

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
11-1 #1	**BMP Area**	**u/s Lt.**	
11-1 #2	**BMP Area**	**u/s**	
11-1 #3	**BMP Area**	**u/s Rt.**	
11-1 #4	**Downstream Channel**	**d/s Lt.**	
11-1 #5	**Downstream Channel**	**d/s**	
11-1 #6	**Downstream Channel**	**d/s Rt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **11-2, Preliminary Design**
2. Location description: **West of 77th Street, Pond 17B of Prairieview Study**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**:** **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):

   5.1. Baseflow Present: **Y** / N

   5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only

   5.3. Vegetation Type(s): **Cattails, Long Grass**

   5.4. Wetlands coverage: **0.5 Acres** , Description: **Cattails and Long Grass**

   5.5. Physical constraints present: Utilities Buildings Limited Acreage

   Describe: **None seen**

   5.6. Other:

6. Potential Capacity

   6.1. Existing height from outlet invert to top of roadway:

   6.2. Maximum height of feasible berm (from outlet invert):

   6.3. Maximum 100-yr footprint constraints:

   6.4. Other:

7. BMP Construction

   7.1. Access feasible for construction: **Yes**

   7.2. Fill areas available for excavated material (above high water elevation): **Yes**

   7.3. Existing Outlet and Downstream 1000' of Channel

   7.4. Existing Outlet Pipe Shape:

   7.5. Downstream Conveyance: **Open Channel**

   7.5.1. Average size and composition (vegetated, gravel, concrete, etc)

   7.5.1.1. Bottom Width **3 feet,** Composition: **Silt**

   7.5.1.2. Bank Height: **1 feet**

   7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other: **N/A**

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High Moderate **Minimal** Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
11-2 #1	**BMP Area**	**u/s Lt.**	
11-2 #2	**BMP Area**	**u/s**	
11-2 #3	**BMP Area**	**u/s Rt.**	
11-2 #4	**Downstream Channel**	**d/s Lt.**	
11-2 #5	**Downstream Channel**	**d/s**	
11-2 #6	**Downstream Channel**	**d/s Rt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **40-1**

2. Location description: **W 34th at Creek Crossing**

3. Current Land Use: **Agricultural/Slough**

4. Land Ownership**: Private** / City / Easement

5. BMP Site Topography and Hydrology (baseflow, etc.):

    5.1. Baseflow Present: **Y** / N

    5.2. Most suitable BMP (circle): Detention (dry-pond) Retention (wet-pond) **Constr._Wetland** WQ Only

    5.3. Vegetation Type(s): **Cattails, long grasses**

    5.4. Wetlands coverage: **12 acres**, Description:**Cattails and Long Grass**

    5.5. Physical constraints present: Utilities Buildings Limited Acreage

    Describe**: Flood Plain Apparent**

    5.6. Other: **Large Base Flow, High water table**

6. Potential Capacity

    6.1. Existing height from outlet invert to top of roadway: **Not Constructed**

    6.2. Maximum height of feasible berm (from outlet invert): **5 feet**

    6.3. Maximum 100-yr footprint constraints:**200 feet wide**

    6.4. Other:

7. BMP Construction

    7.1. Access feasible for construction: **Yes**

    7.2. Fill areas available for excavated material (above high water elevation): **No**

8. Existing Outlet and Downstream 1000' of Channel

    8.1. Existing Outlet Pipe Shape: **N/A**

    8.2. Downstream Conveyance: **Open Channel**

        8.2.1. Average size and composition (vegetated, gravel, concrete, etc)

            8.2.1.1. Bottom Width **5ft,** Composition: **Silt**

            8.2.1.2. Bank Height: **None pronounced, flood plain is wide**

            8.2.1.3. Side Slopes **N/A**

8.2.1.4. Overbank **N/A**

8.2.1.5. Overbank Slopes **N/A**

8.2.1.6. Other: **N/A**

8.3. Open Channel Bank Erosion Observations

8.3.1. Bank Erosivity: High Moderate **Minimal** Stable

8.3.2. Bank Length Needing Stabilization: **N/A**

8.3.3. Erosion Protection Required:**Riprap at Oultet**

8.3.4. Other: **N/A**

8.4. Longitudinal Slope Analysis

8.4.1. Existing grade control structures present: **N**,

8.4.2. Headcutting present: **N**

8.4.3. Grade control needed: **N**

8.4.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

9. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
40-1 #1	**BMP Area**	**u/s Lt.**	
40-1 #2	**BMP Area**	**u/s**	
40-1 #3	**BMP Area**	**u/s Rt.**	
40-1 #4	**Downstream Channel**	**d/s Rt.**	
40-1 #5	**Downstream Channel**	**d/s**	
40-1 #6	**Downstream Channel**	**d/s Lt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **51-2**
2. Location description: **1500 feet north of Cliff Ave./85th Street intersection**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** **Constr._Wetland** WQ Only
   - 5.3. Vegetation Type(s): **Tall Grasses and Cattails**
   - 5.4. Wetlands coverage: **18 Acres** , Description: **Tall Grasses and Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None Noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **7.5 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Land Purchase and wetland mitigation**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Good**
   - **7.2.** Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape: **Double 36" RCP, one pipe lower than other**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - **7.5.1.1.** Bottom Width **5 feet,** Composition: **Silt**
       - **7.5.1.2.** Bank Height: **2 feet**
       - 7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other: **N/A**

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**,

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
51-1 #1	**BMP Area**	**u/s Lt.**	
51-1 #2	**BMP Area**	**u/s**	
51-1 #3	**BMP Area**	**u/s Rt.**	
51-1 #4	**Outlet**	**u/s end**	
51-1 #5	**Downstream Channel**	**d/s Lt.**	
51-1 #6	**Downstream Channel**	**d/s**	
51-1 #7	**Downstream Channel**	**d/s Rt.**	
51-1 #8	**Outlet**	**d/s end**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **7-4**
2. Location description: **1000 East of intersection of Sycamore and 69th**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership: **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) Retention (wet-pond) **Constr._Wetland** WQ Only
   - 5.3. Vegetation Type(s): **Tall Grasses and Cattails**
   - 5.4. Wetlands coverage: **9 Acres** , Description: **Tall Grasses and Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None Noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **6.5 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Land Purchase and wetland mitigation**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Good**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000′ of Channel
   - 7.4. Existing Outlet Pipe Shape: **5′ x 3′ RCB**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **2 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **5 feet**

7.5.1.3. Side Slopes **3:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required: **Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**,

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:______________________________

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
7-4 #1	**BMP Area**	**u/s Lt.**	
7-4 #2	**BMP Area**	**u/s**	
7-4 #3	**BMP Area**	**u/s Rt.**	
7-4 #4	**Outlet**	**Looking d/s**	
7-4 #5	**D/s Channel**	**d/s Lt.**	
7-4 #6	**D/s Channel**	**d/s**	
7-4 #7	**D/s Channel**	**d/s Rt.**	
7-4 #8	**Outlet**	**Looking u/s**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **51-1**
2. Location description: **1,900 feet east of Cliff Ave./85th Street intersection of 85th**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership: **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** **Constr._Wetland** WQ Only
   - 5.3. Vegetation Type(s): **Tall Grasses and Cattails**
   - 5.4. Wetlands coverage: **18 Acres** , Description: **Tall Grasses and Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None Noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **5 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Land Purchase and wetland mitigation**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Good**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape: **Double 24" CMP**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **5 feet,** Composition: **Silt**
       - 7.5.1.2. Bank Height: **2 feet**
       - 7.5.1.3. Side Slopes **2:1**
       - 7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other: **N/A**

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**,

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
51-2 #1	**BMP Area**	**u/s Lt.**	
51-2 #2	**BMP Area**	**u/s**	
51-2 #3	**BMP Area**	**u/s Rt.**	
51-2 #4	**Outlet**	**u/s end**	
51-2 #5	**Downstream Channel**	**d/s Lt.**	
51-2 #6	**Downstream Channel**	**d/s**	
51-2 #7	**Downstream Channel**	**d/s Rt.**	
51-2 #8	**Outlet**	**d/s end**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **7-5**
2. Location description: **3200 East of intersection of Sycamore and 69th**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) Retention (wet-pond) **Constr._Wetland** WQ Only
   - 5.3. Vegetation Type(s): **Tall Grasses and Cattails**
   - 5.4. Wetlands coverage: **13 Acres** , Description: **Tall Grasses and Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None Noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway:
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Land Purchase and wetland mitigation**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Below Average**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **N/A**, Composition: **Silt**
       - 7.5.1.2. Bank Height:

7.5.1.3. Side Slopes

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
7-5 #1	**BMP Area**	**u/s Lt.**	
7-5 #2	**BMP Area**	**u/s**	
7-5 #3	**BMP Area**	**u/s Rt.**	
7-5 #4	**D/s Channel**	**d/s Lt.**	
7-5 #5	**D/s Channel**	**d/s**	
7-5 #6	**D/s Channel**	**d/s Rt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **25-3 (Formerly 303-3)**
2. Location description: **SE Quad of Intersection of Linden and 6 Mile**
3. Current Land Use: **Slough**
4. Land Ownership**:** **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Low grass in wet conditions**.
   - 5.4. Wetlands coverage: **5 Acres** , Description: **Low grass in wet conditions**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **Possible conflict with future high intensity land use**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway:
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Adajcent Roadway Elevations**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Adequate**
   - 7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **6 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **2 feet, 12 feet**

7.5.1.3. Side Slopes **2:1, 3:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
303-3 #1	BMP Area	u/s Lt.	
303-3 #2	BMP Area	u/s	
303-3 #3	BMP Area	u/s Rt.	
303-3 #4	D/s Channel	d/s Lt.	
303-3 #5	D/s Channel	d/s	
303-3 #6	D/s Channel	d/s Rt.	
303-3 #7	D/s Channel	d/s	Further Downstream

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **303-2, Preliminary Design**

2. Location description: **1150' East of intersection of Powderhouse and 26th**

3. Current Land Use: **Agricultural/Slough**

4. Land Ownership**: Private** / City / Easement

5. BMP Site Topography and Hydrology (baseflow, etc.):

   5.1. Baseflow Present: **Y (very little)**

   5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only

   5.3. Vegetation Type(s): **Low grass in wet conditions**.

   5.4. Wetlands coverage: **2 Acres** , Description: **Low grass in wet conditions**

   5.5. Physical constraints present: Utilities Buildings Limited Acreage

   Describe: **None seen**

   5.6. Other:

6. Potential Capacity

   6.1. Existing height from outlet invert to top of roadway: **20 feet**

   6.2. Maximum height of feasible berm (from outlet invert):

   6.3. Maximum 100-yr footprint constraints: **None**

   6.4. Other:

7. BMP Construction

   7.1. Access feasible for construction: **Adequate**

   7.2. Fill areas available for excavated material (above high water elevation): **Yes**

   7.3. Existing Outlet and Downstream 1000' of Channel

   7.4. Existing Outlet Pipe Shape: **6 foot dia. RCP**

   7.5. Downstream Conveyance: **Open Channel**

      7.5.1. Average size and composition (vegetated, gravel, concrete, etc)

         7.5.1.1. Bottom Width **4 feet,** Composition: **Silt**

         7.5.1.2. Bank Height: **3 feet**

         7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes **N/A**

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:______________________________

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
303-2 #1	BMP Area	u/s Lt.	
303-2 #2	BMP Area	u/s	
303-2 #3	BMP Area	u/s Rt.	
303-2 #4	Outlet	At u/s end	
303-2 #5	Downstream Channel	d/s Lt.	
303-2 #6	Downstream Channel	d/s	
303-2 #7	Downstream Channel	d/s Rt.	
303-2 #8	Outlet	At d/s end	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **25-1**
2. Location description: **Madison, east of Powderhouse**
3. Current Land Use: **Farmstead**
4. Land Ownership**:** **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   5.1. Baseflow Present: Y / **N**
   5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   5.3. Vegetation Type(s): **Ag., Grasses, Timber**
   5.4. Wetlands coverage: **None** , Description:
   5.5. Physical constraints present: Utilities Buildings Limited Acreage
   Describe: **None**
   5.6. Other:
6. Potential Capacity
   6.1. Existing height from outlet invert to top of roadway: **9 feet**
   6.2. Maximum height of feasible berm (from outlet invert):
   6.3. Maximum 100-yr footprint constraints:
   6.4. Other:
7. BMP Construction
   7.1. Access feasible for construction: **Acceptable**
   7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   7.3. Existing Outlet and Downstream 1000′ of Channel
   7.4. Existing Outlet Pipe Shape: **Double 36" RCP**
   7.5. Downstream Conveyance: **Open Channel via future roadway culvert**
      7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
         7.5.1.1. Bottom Width **3 feet**, Composition: **Silt**
         7.5.1.2. Bank Height: **2 feet**

7.5.1.3. Side Slopes **3:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other

Other Field Notes: **None Noted**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
25-1 #1	BMP Area	u/s Lt.	
25-1 #2	BMP Area	u/s	
25-1 #3	BMP Area	u/s Rt.	
25-1 #4	Outlet	Looking d/s	
25-1 #5	Outlet	Looking d/s	
25-1 #6	Downstream Channel	d/s Lt.	
25-1 #7	Downstream Channel	d/s	
25-1 #8	Downstream Channel	d/s Rt.	
25-1 #9	Downstream Channel	d/s Rt.	
25-1 #10	Outlet	Looking u/s	
25-1 #4	Outlet	Looking u/s	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **25-2**
2. Location description: **Powderhouse, midway between 6th and Madison**
3. Current Land Use: **Agriculture**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   5.1. Baseflow Present: Y / **N**
   5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr. Wetland WQ Only
   5.3. Vegetation Type(s): **Grassland**
   5.4. Wetlands coverage: **None** , Description:
   5.5. Physical constraints present: Utilities Buildings Limited Acreage

   Describe: **None**
   5.6. Other:
6. Potential Capacity
   6.1. Existing height from outlet invert to top of roadway: **4.5 feet**
   6.2. Maximum height of feasible berm (from outlet invert):
   6.3. Maximum 100-yr footprint constraints:
   6.4. Other:
7. BMP Construction
   7.1. Access feasible for construction: **Acceptable**
   7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   7.3. Existing Outlet and Downstream 1000′ of Channel
   7.4. Existing Outlet Pipe Shape: **36″ RCP & 36″ CMP**
   7.5. Downstream Conveyance: **Open Channel via future roadway culvert**
      7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
         7.5.1.1. Bottom Width **3 feet**, Composition: **Silt**
         7.5.1.2. Bank Height: **1 foot**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Outlet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other

Other Field Notes: **None Noted**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
25-2 #1	BMP Area	u/s Lt.	
25-2 #2	BMP Area	u/s	
25-2 #3	BMP Area	u/s Rt.	
25-2 #4	Outlet	Looking d/s	
25-2 #5	Outlet	Looking d/s	
25-2 #6	Downstream Channel	d/s Lt.	
25-2 #7	Downstream Channel	d/s	
25-2 #8	Downstream Channel	d/s Rt.	
25-2 #9	Outlet	Looking u/s	
25-2 #10	Outlet	Looking u/s	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **41A**
2. Location description: **NW intersection of EERR and I-29**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **N**
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Ag**
   - 5.4. Wetlands coverage: **8 acres**, Description: **Agriculture**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe**: Flood Plain Apparent, Fiber Optics Cable**
   - 5.6. Other: **Railroad grade limits pond depth, outlet structure elevation very high**
   - 5.7. Potential Capacity:
   - 5.8. Existing height from outlet invert to top of roadway: **6.5 feet to top of rail**
   - 5.9. Maximum height of feasible berm (from outlet invert):
   - 5.10. Maximum 100-yr footprint constraints: **200 feet wide**
   - 5.11. Other: **Poorly draining to east**
6. BMP Construction
   - 6.1. Access feasible for construction: **Moderate**
   - 6.2. Fill areas available for excavated material (above high water elevation): **No**
7. Existing Outlet and Downstream 1000' of Channel
   - 7.1. Existing Outlet Pipe Shape: **36" RCP**
   - 7.2. Downstream Conveyance: **Open Channel**
     - 7.2.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.2.1.1. Bottom Width **5ft**, Composition: **Silt**
       - 7.2.1.2. Bank Height: **None pronounced, flood plain is wide**

7.2.1.3. Side Slopes **N/A**

7.2.1.4. Overbank **N/A**

7.2.1.5. Overbank Slopes **N/A**

7.2.1.6. Other: **N/A**

7.3. Open Channel Bank Erosion Observations

7.3.1. Bank Erosivity: High Moderate **Minimal** Stable

7.3.2. Bank Length Needing Stabilization: **N/A**

7.3.3. Erosion Protection Required:**Riprap at Oultet**

7.3.4. Other: **N/A**

7.4. Longitudinal Slope Analysis

7.4.1. Existing grade control structures present: **N**,

7.4.2. Headcutting present: **N**

7.4.3. Grade control needed: **N**

7.4.4. Other: **None**

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
41A #1	BMP Area	u/s Lt.	
41A #2	BMP Area	u/s Lt.	
41A #3	BMP Area	u/s Lt.	
41A #4	BMP Area	u/s Lt.	
41A #5	BMP Area	u/s	
41A #6	BMP Area	u/s Rt.	
41A #7	Downstream Channel	d/s Lt.	
41A #8	Downstream Channel	d/s	
41A #9	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **401-1**
2. Location description: **8000' directly east and south of intersection of 57th and Sycamore**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership: **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Tall Grasses and Cattails**
   - 5.4. Wetlands coverage: **13 Acres** , Description: **Tall Grasses and Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None Noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway:
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Channel constrained**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Below Average**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width , Composition: **Silt**
       - 7.5.1.2. Bank Height:

7.5.1.3. Side Slopes

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
401-1 #1	BMP Area	u/s Lt.	
401-1 #2	BMP Area	u/s	
401-1 #3	BMP Area	u/s Rt.	
401-1 #4	BMP Area	u/s Rt.	At Confluence
401-1 #5	D/s Channel	d/s Lt.	
401-1 #6	D/s Channel	d/s Lt.	
401-1 #7	D/s Channel	d/s	
401-1 #8	D/s Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 6/12/03

1. BMP ID: **401-2**
2. Location description: **Approximately 4000 feet east of Hwy. 11 and 2000 feet south of 57th St. This site was located further downstream of the original 401-2 to avoid wetland impacts.**
3. Current Land Use: **Agricultural**
4. Land Ownership**:** **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** Constr. Wetland WQ Only
   - 5.3. Vegetation Type(s): **Tall Grasses**
   - 5.4. Wetlands coverage: **8 Acres** , Description: **Tall Grasses**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None Noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway:
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **Channel constrained**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Below Average**
   - **7.2.** Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - **7.5.1.1.** Bottom Width **,** Composition: **Silt**
       - **7.5.1.2.** Bank Height:
       - 7.5.1.3. Side Slopes

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:____

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
401-2 #1	**BMP Area**	**u/s Lt.**	
401-2 #2	**BMP Area**	**u/s**	
401-2 #3	**BMP Area**	**u/s Rt.**	
401-2 #4	**BMP Area**	**u/s**	**Close-up of Channel**
401-2 #5	**D/s Channel**	**d/s Lt.**	
401-2 #6	**D/s Channel**	**d/s**	
401-2 #7	**D/s Channel**	**d/s Rt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **40-2**
2. Location description: **W Madison ans La Mesa**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   5.1. Baseflow Present: **Y** / N
   5.2. Most suitable BMP (circle): Detention (dry-pond) Retention (wet-pond) **Constr._Wetland** WQ Only
   5.3. Vegetation Type(s): **Cattails, long grasses**
   5.4. Wetlands coverage: **19 acres**, Description:**Cattails and Long Grass**
   5.5. Physical constraints present: Utilities Buildings Limited Acreage
   Describe**: Flood Plain Apparent**
   5.6. Other: **Large Base Flow, High water table**
6. Potential Capacity
   6.1. Existing height from outlet invert to top of roadway: **7.3 feet to top of bridge**
   6.2. Maximum height of feasible berm (from outlet invert): **roads are 1 to 2 foot lower than top of bridge**
   6.3. Maximum 100-yr footprint constraints:**200 feet wide**
   6.4. Other:
7. BMP Construction
   7.1. Access feasible for construction: **Yes**
   7.2. Fill areas available for excavated material (above high water elevation): **No**
8. Existing Outlet and Downstream 1000′ of Channel
   8.1. Existing Outlet Pipe Shape: **N/A**
   8.2. Downstream Conveyance: **Open Channel**
      8.2.1. Average size and composition (vegetated, gravel, concrete, etc)
         8.2.1.1. Bottom Width 5ft, Composition: **Silt**

8.2.1.2. Bank Height: **None pronounced, flood plain is wide**

8.2.1.3. Side Slopes **N/A**

8.2.1.4. Overbank **N/A**

8.2.1.5. Overbank Slopes **N/A**

8.2.1.6. Other: **N/A**

8.3. Open Channel Bank Erosion Observations

8.3.1. Bank Erosivity: High Moderate **Minimal** Stable

8.3.2. Bank Length Needing Stabilization: **N/A**

8.3.3. Erosion Protection Required:**Riprap at Oultet**

8.3.4. Other: **N/A**

8.4. Longitudinal Slope Analysis

8.4.1. Existing grade control structures present: **N**,

8.4.2. Headcutting present: **N**

8.4.3. Grade control needed: **N**

8.4.4. Other:____

Other Field Notes: **Area is flat and poorly draining**

9. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
40-2 #1	BMP Area	u/s Lt.	
40-2 #2	BMP Area	u/s	
40-2 #3	BMP Area	u/s Rt.	
40-2 #4	Outlet	d/s Lt.	
40-2 #5	Outlet	d/s	
40-2 #6	Outlet	d/s Rt.	
40-2 #7	Downstream Channel	d/s Lt.	
40-2 #8	Downstream Channel	d/s	
40-2 #9	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **304 (Formerly 303-5)**
2. Location description: **2600' SE of intersection of 6 Mile and 42 along 42**
3. Current Land Use: **Agricultural**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   5.1. Baseflow Present: **Y**
   5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** Constr._Wetland WQ Only
   5.3. Vegetation Type(s): **Low grass in wet conditions**.
   5.4. Wetlands coverage: **4 Acres** , Description: **Low grass in wet conditions**
   5.5. Physical constraints present: Utilities Buildings Limited Acreage

   Describe: **Small area between roadway intersections. Possible conflict with future high intensity land uses.**
   5.6. Other:
6. Potential Capacity
   6.1. Existing height from outlet invert to top of roadway: **20 feet**
   6.2. Maximum height of feasible berm (from outlet invert):
   6.3. Maximum 100-yr footprint constraints: **None**
   6.4. Other:
7. BMP Construction
   7.1. Access feasible for construction: **Adequate**
   7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   7.3. Existing Outlet and Downstream 1000' of Channel
   7.4. Existing Outlet Pipe Shape: **5 ft dia. RCP**
   7.5. Downstream Conveyance: **Open Channel via roadway culvert**
      7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
         7.5.1.1. Bottom Width **3 feet**, Composition: **Silt**

7.5.1.2. Bank Height: **2 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:**Outlet flowline 10 feet above channel**

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
303-5 #1	BMP Area	u/s Lt.	
303-5 #2	BMP Area	u/s	
303-5 #3	BMP Area	u/s Rt.	
303-5 #4	Outlet	Looking d/s	
303-5 #5	D/s Channel	d/s Lt.	
303-5 #6	D/s Channel	d/s	
303-5 #7	D/s Channel	d/s Rt.	
303-5 #8	D/s Channel	d/s Rt.	
303-5 #9	Outlet	Looking u/s	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **312**
2. Location description: **Benson Road, north and east of I-29**
3. Current Land Use: **Agriculture, Slough**
4. Land Ownership**:** Private / **City** / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y** / N
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): Grasses
   - 5.4. Wetlands coverage: **0.2 Acre** , Description: **Cattails**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **38 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Acceptable**
   - 7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   - 7.3. Existing Outlet and Downstream 1000′ of Channel
   - 7.4. Existing Outlet Pipe Shape: **60" RCP**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **4 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **3 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
312 #1	BMP Area	u/s Lt.	
312 #2	BMP Area	u/s	
312 #3	BMP Area	u/s Rt.	
312 #4	BMP Area	u/s Rt.	
312 #5	BMP Area	u/s Rt.	
312 #6	Outlet	Looking d/s	
312 #7	Downstream Channel	d/s Lt.	
312 #8	Downstream Channel	d/s	
312 #9	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **400 B**
2. Location description: **Location per CH2M Hill, noted as 400 on original BMP Plan**
3. Current Land Use: **Agriculture**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Grasses**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe:
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway:
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Inadequate, private access**
   - 7.2. Fill areas available for excavated material (above high water elevation):
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape: **30" RCP**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **3 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **3 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other:

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
400B #1	BMP Area	u/s Lt.	
400B #2	BMP Area	u/s	
400B #3	BMP Area	u/s Rt.	
400B #4	BMP Area	u/s Rt.	
400B #5	BMP Area	u/s Rt.	
400B #6	D/s Channel	d/s Lt.	
400B #7	D/s Channel	d/s	
400B #8	D/s Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **303-4**
2. Location description: **1500' SE of intersection of 6 Mile and 42 along 42**
3. Current Land Use: **Agricultural**
4. Land Ownership**:** **Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y**
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Low grass in wet conditions**.
   - 5.4. Wetlands coverage: **2 Acres** , Description: **Low grass in wet conditions**
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None noted**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **20 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints: **None**
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Adequate**
   - 7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape: **8' x 7' RCB**
   - 7.5. Downstream Conveyance: **Open Channel via roadway culvert**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **4 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **2 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other:____

Other Field Notes: **Very steep conditions on side slopes**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
303-4 #1	**BMP Area**	**u/s Lt.**	
303-4 #2	**BMP Area**	**u/s**	
303-4 #3	**BMP Area**	**u/s Rt.**	
303-4 #4	**Outlet**	**Looking d/s**	
303-4 #5	**D/s channel**	**d/s Lt.**	
303-4 #6	**D/s channel**	**d/s**	
303-4 #7	**D/s channel**	**d/s Rt.**	
303-4 #8	**Outlet**	**Looking u/s**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **22**
2. Location description:
3. Current Land Use: **Agricultural/Timber**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y** / N
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr. Wetland WQ Only
   - 5.3. Vegetation Type(s): **Timber**
   - 5.4. Wetlands coverage: **None** Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **Buildings**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **11.5 feet to top of Rail**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Moderate**
   - 7.2. Fill areas available for excavated material (above high water elevation): **No**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width: **3 to 5 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **1 ft**.
       - 7.5.1.3. Side Slopes **2:1**
       - 7.5.1.4. Overbank
       - 7.5.1.5. Overbank Slopes
       - 7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: High **Moderate** Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**,

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other:____

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
22 #1	BMP Area	u/s Lt.	
22 #2	BMP Area	u/s Lt.	
22 #3	BMP Area	u/s	
22 #3a	BMP Area	u/s	
22 #4	BMP Area	u/s	
22 #5	BMP Area	u/s Rt.	
22 #6	At RR Bridge	d/s Lt.	
22 #7	At RR Bridge	d/s	
22 #8	At RR Bridge	d/s Rt.	
22 #9	At RR Bridge	u/s Lt.	
22 #10	At RR Bridge	u/s	
22 #11	At RR Bridge	u/s Rt.	
22 #12	Downstream Channel	d/s	
22 #13	Downstream Channel	d/s	
22 #14	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **317**
2. Location description: **4000 feet north of 6 mile and E Madison along 6 mile**
3. Current Land Use: **Farmstead**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y** / N
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Grasses**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **10 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Acceptable**
   - 7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   - 7.3. Existing Outlet and Downstream 1000′ of Channel
   - 7.4. Existing Outlet Pipe Shape: **8′ x 6′ RCB**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **2 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **1 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other

Other Field Notes: **Farmhouse in close proximity to outlet structure.**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
317 #1	**BMP Area**	**u/s Lt.**	
317 #2	**BMP Area**	**u/s**	
317 #3	**BMP Area**	**u/s Rt.**	
317 #4	**Outlet**	**Looking d/s**	
317 #5	**Downstream Channel**	**d/s Lt.**	
317 #6	**Downstream Channel**	**d/s**	
317 #7	**Downstream Channel**	**d/s Rt.**	
317 #8	**Outlet**	**Looking u/s**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/16/03

1. BMP ID: **40-3**
2. Location description: **NW corner intersecion of I-90 and I-229**
3. Current Land Use: **Agricultural/Slough**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y** / N
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Long Grass**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe**: Buildings**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **15 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Yes**
   - 7.2. Fill areas available for excavated material (above high water elevation): **Yes**
8. Existing Outlet and Downstream 1000′ of Channel
   - 8.1. Existing Outlet Pipe Shape: **8′ x 6′ RCB**
   - 8.2. Downstream Conveyance: **Open Channel**
     - 8.2.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 8.2.1.1. Bottom Width **Area Between Loop and Ramp** Composition: **Silt**
       - 8.2.1.2. Bank Height:

8.2.1.3. Side Slopes

8.2.1.4. Overbank

8.2.1.5. Overbank Slopes

8.2.1.6. Other:

8.3. Open Channel Bank Erosion Observations

8.3.1. Bank Erosivity: High Moderate **Minimal** Stable

8.3.2. Bank Length Needing Stabilization:

8.3.3. Erosion Protection Required:**Riprap at Oultet**

8.3.4. Other:

8.4. Longitudinal Slope Analysis

8.4.1. Existing grade control structures present: **N**

8.4.2. Headcutting present: **N**

8.4.3. Grade control needed: **N**

8.4.4. Other:____

Other Field Notes:

9. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
40-3 #1	**BMP Area**	**u/s Lt.**	
40-3 #2	**BMP Area**	**u/s**	
40-3 #3	**BMP Area**	**u/s Rt.**	
40-3 #4	**Outlet**	**Looking Downstream**	
40-3 #5	**Downstream Channel**	**d/s Lt.**	
40-3 #6	**Downstream Channel**	**d/s**	
40-3 #7	**Downstream Channel**	**d/s Rt.**	
40-3 #8	**Outlet**	**Looking Upstream**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **305**
2. Location description: **Rice Street, north of Great Bear**
3. Current Land Use: **Agriculture**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: Y / **N**
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Grasses**
   - 5.4. Wetlands coverage: **None**, Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **None**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **3.5 feet to top of Rail**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Difficult due to RR**
   - 7.2. Fill areas available for excavated material (above high water elevation): **Yes**
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **2 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **1 foot**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other

Other Field Notes: **Railroad Embankment not permitted for pond**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
305 #1	**BMP Area**	**u/s Lt.**	
305 #2	**BMP Area**	**u/s**	
305 #3	**BMP Area**	**u/s Rt.**	
305 #4	**At RR Outlet**	**Looking d/s**	
305 #5	**At RR Outlet**	**Looking u/s**	
305 #6	**Downstream Channel**	**d/s Lt.**	
305 #7	**Downstream Channel**	**d/s**	
305 #8	**Downstream Channel**	**d/s Rt.**	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **306**
2. Location description: **Intersection of Rice and Timberline**
3. Current Land Use: **Vacant**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y** / N
   - 5.2. Most suitable BMP (circle): **Detention (dry-pond)** Retention (wet-pond) Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Timber**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **Rice Street, Railroad**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **17 feet**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Acceptable**
   - 7.2. Fill areas available for excavated material (above high water elevation):
   - 7.3. Existing Outlet and Downstream 1000′ of Channel
   - 7.4. Existing Outlet Pipe Shape: **10 feet Dia. CMP**
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **3 to 5 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **2 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other: **N/A**

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present: **N**

7.7.2. Headcutting present: **N**

7.7.3. Grade control needed: **N**

7.7.4. Other

Other Field Notes: **Railroad Embankment not permitted for pond**

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
306 #1	BMP Area	u/s Lt.	
306 #2	BMP Area	u/s	
306 #3	BMP Area	u/s Rt.	
306 #4	Outlet	Looking d/s	
306 #5	Downstream Channel	d/s Lt.	
306 #6	Downstream Channel	d/s	
306 #7	Downstream Channel	d/s Rt.	
306 #8	Outlet	Looking u/s	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Site Investigator: **Dunn/Ellis** Date: 4/15/03

1. BMP ID: **316**
2. Location description: **South of I-90, end of future Sycamore extension to interstate**
3. Current Land Use: **Farmstead**
4. Land Ownership**: Private** / City / Easement
5. BMP Site Topography and Hydrology (baseflow, etc.):
   - 5.1. Baseflow Present: **Y** / N
   - 5.2. Most suitable BMP (circle): Detention (dry-pond) **Retention (wet-pond)** Constr._Wetland WQ Only
   - 5.3. Vegetation Type(s): **Timber, Grasses**
   - 5.4. Wetlands coverage: **None** , Description:
   - 5.5. Physical constraints present: Utilities Buildings Limited Acreage

     Describe: **I-90**
   - 5.6. Other:
6. Potential Capacity
   - 6.1. Existing height from outlet invert to top of roadway: **N/A**
   - 6.2. Maximum height of feasible berm (from outlet invert):
   - 6.3. Maximum 100-yr footprint constraints:
   - 6.4. Other:
7. BMP Construction
   - 7.1. Access feasible for construction: **Access substandard, easement required**
   - 7.2. Fill areas available for excavated material (above high water elevation):
   - 7.3. Existing Outlet and Downstream 1000' of Channel
   - 7.4. Existing Outlet Pipe Shape:
   - 7.5. Downstream Conveyance: **Open Channel**
     - 7.5.1. Average size and composition (vegetated, gravel, concrete, etc)
       - 7.5.1.1. Bottom Width **10 feet**, Composition: **Silt**
       - 7.5.1.2. Bank Height: **4 feet**

7.5.1.3. Side Slopes **2:1**

7.5.1.4. Overbank **N/A**

7.5.1.5. Overbank Slopes

7.5.1.6. Other:

7.6. Open Channel Bank Erosion Observations

7.6.1. Bank Erosivity: **High** Moderate Minimal Stable

7.6.2. Bank Length Needing Stabilization: **Riprap**

7.6.3. Erosion Protection Required:**Riprap at Oultet**

7.6.4. Other:

7.7. Longitudinal Slope Analysis

7.7.1. Existing grade control structures present:

7.7.2. Headcutting present:

7.7.3. Grade control needed:

7.7.4. Other

Other Field Notes:

8. Photo Log (BMP area, outlet, downstream channel, etc.)

Photo #	Item	Direction (u/s,d/s,RB,LB)	Notes
316 #1	BMP Area	u/s Lt.	
316 #2	BMP Area	u/s	
316 #3	BMP Area	u/s Rt.	
316 #4	BMP Area	u/s	
316 #5	BMP Area	u/s towards I-90	
316 #6	At Confluence	Looking d/s	
316 #7	Downstream Channel	d/s	
316 #8	Downstream Channel	d/s Rt.	

u/s = upstream; d/s = downstream; RB, LB = right bank and left bank (when looking d/s)

Master Plan Pond Modeling Summary

Watershed 13, Pond 13-1 Output Summary

Water Quality Capture Volume: 3.66 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	370	cfs
Post-Development Peak Outflow:	184	cfs
Pre-Development Peak Flow:	204	cfs
Total Volume:	43.0	Ac-ft
Peak Storage:	17.8	Ac-ft

100-Year Storm Event Summary

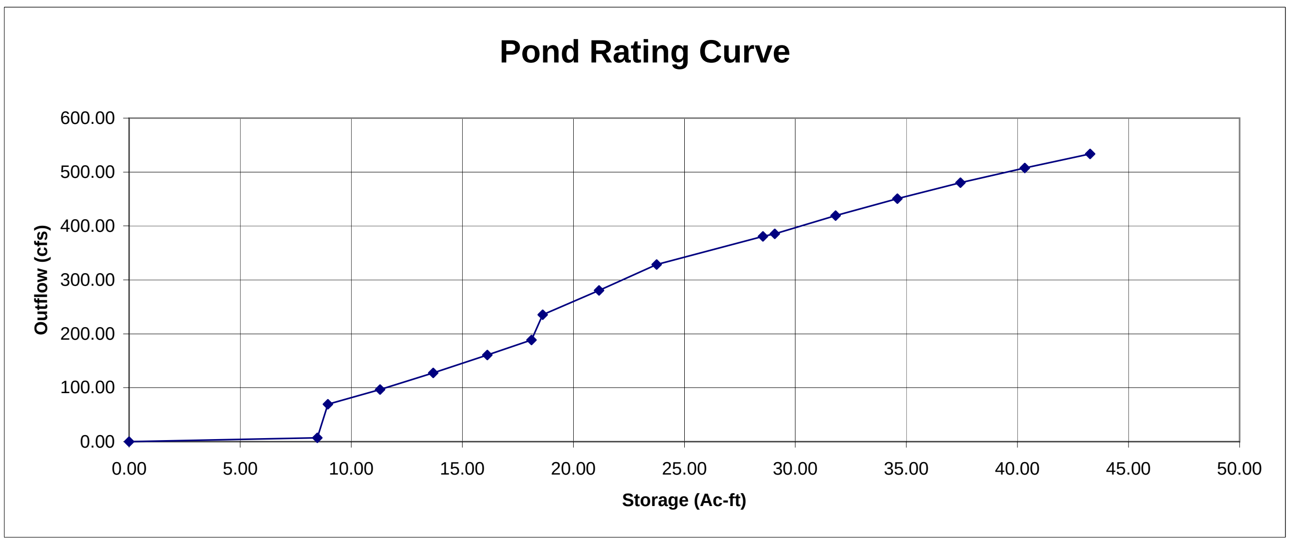
Post-Development Peak Inflow:	734	cfs
Post-Development Peak Outflow:	407	cfs
Pre-Development Peak Flow:	467	cfs
Total Volume:	83.0	Ac-ft
Peak Storage:	30.8	Ac-ft

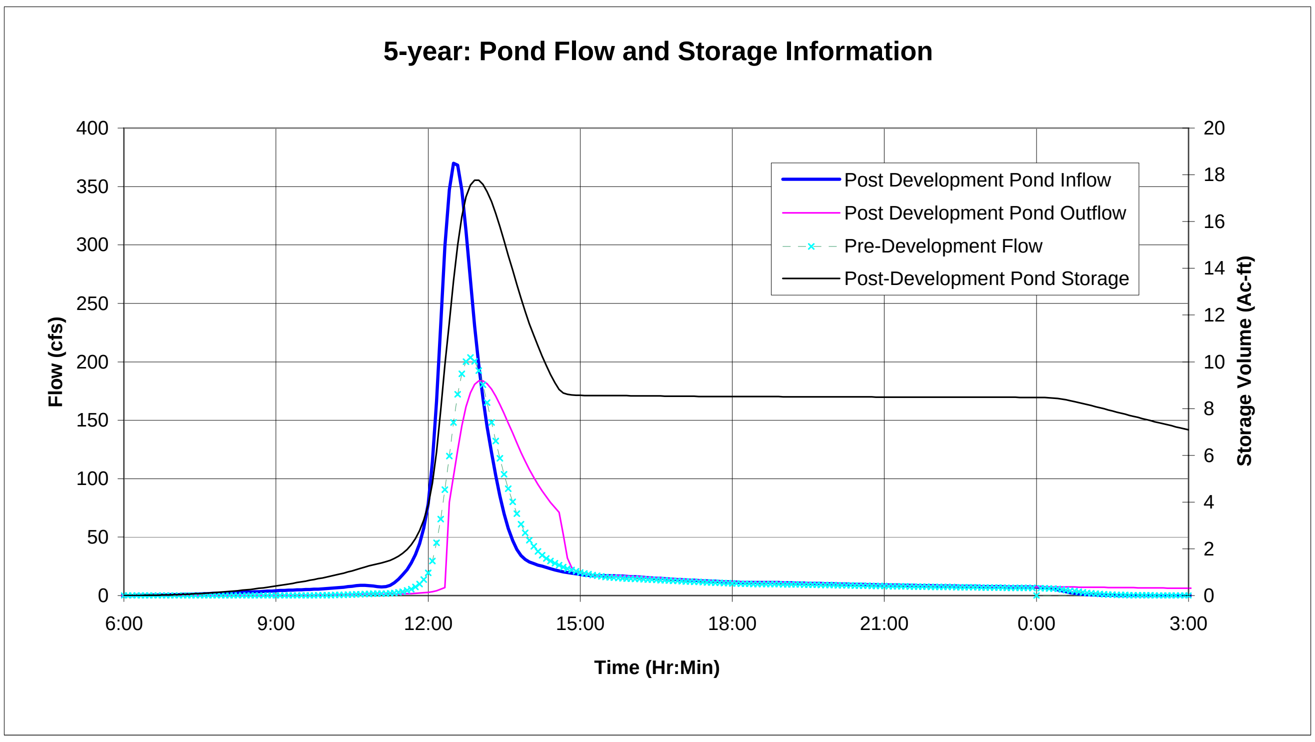
Detention Pond 13-1 Rating Curve

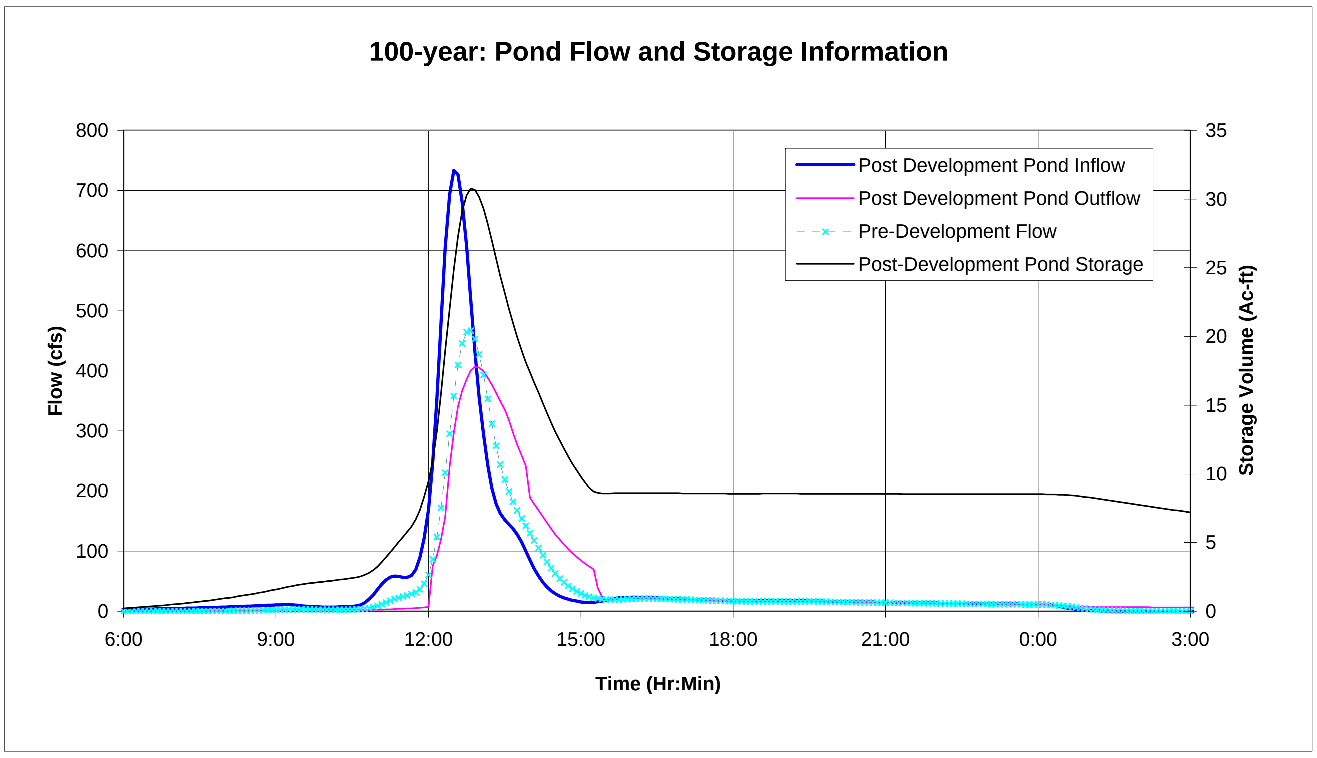
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	8.48	7.38
2	8.95	69.30
2.5	11.29	96.85
3	13.69	127.31
3.5	16.13	160.43
3.9	18.12	188.71
4	18.62	235.22
4.5	21.16	280.67
5	23.75	328.72
5.9	28.53	380.35
6	29.07	385.61
6.5	31.81	419.44
7	34.60	450.74
7.5	37.44	480.00
8	40.33	507.58
8.5	43.27	533.73

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	2.20		Pond Bottom Length	673	ft
Max Pond Depth	7.5	ft	Pond Bottom Width	278	ft
Side Slope (H:1)	4		Pond Top Length	725	ft
Pond Volume at Max. Depth	31.81	Ac-ft	Pond Top Width at Max Depth	330	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x10	ft	100-yr control opening size	4x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	4	ft	100-yr water surface elevation	6.5	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	5.49	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	11.25	Ac







Watershed 13, Pond 13-2 Output Summary

Water Quality Capture Volume: 1.00 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	92	cfs
Post-Development Peak Outflow:	39	cfs
Pre-Development Peak Flow:	56	cfs
Total Volume:	7.6	Ac-ft
Peak Storage:	3.4	Ac-ft

100-Year Storm Event Summary

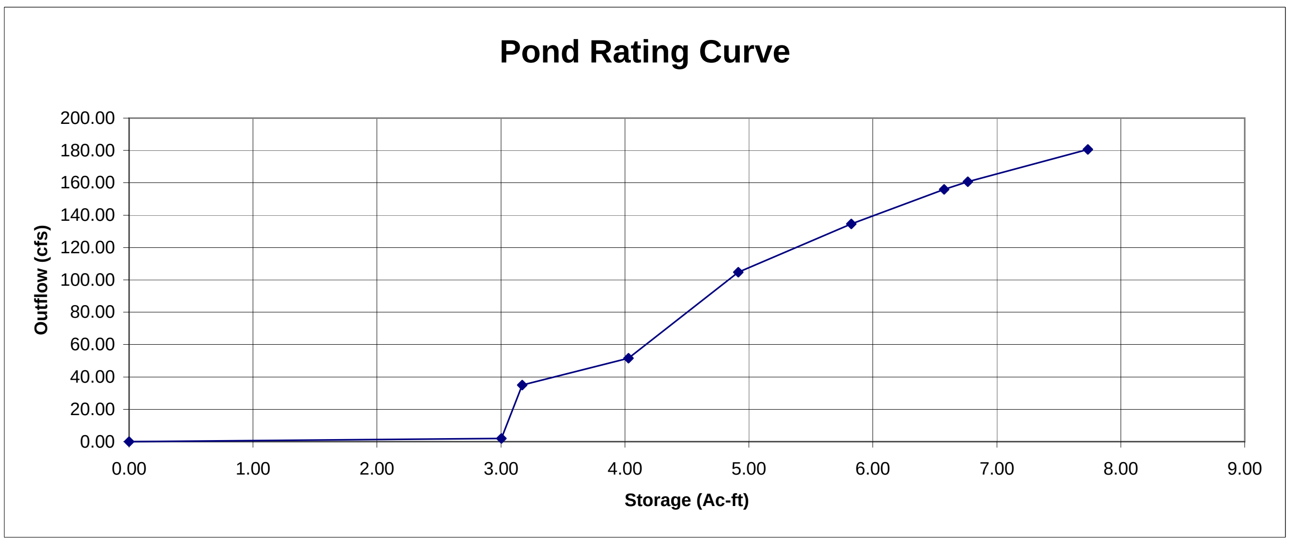
Post-Development Peak Inflow:	229	cfs
Post-Development Peak Outflow:	144	cfs
Pre-Development Peak Flow:	148	cfs
Total Volume:	18.0	Ac-ft
Peak Storage:	6.2	Ac-ft

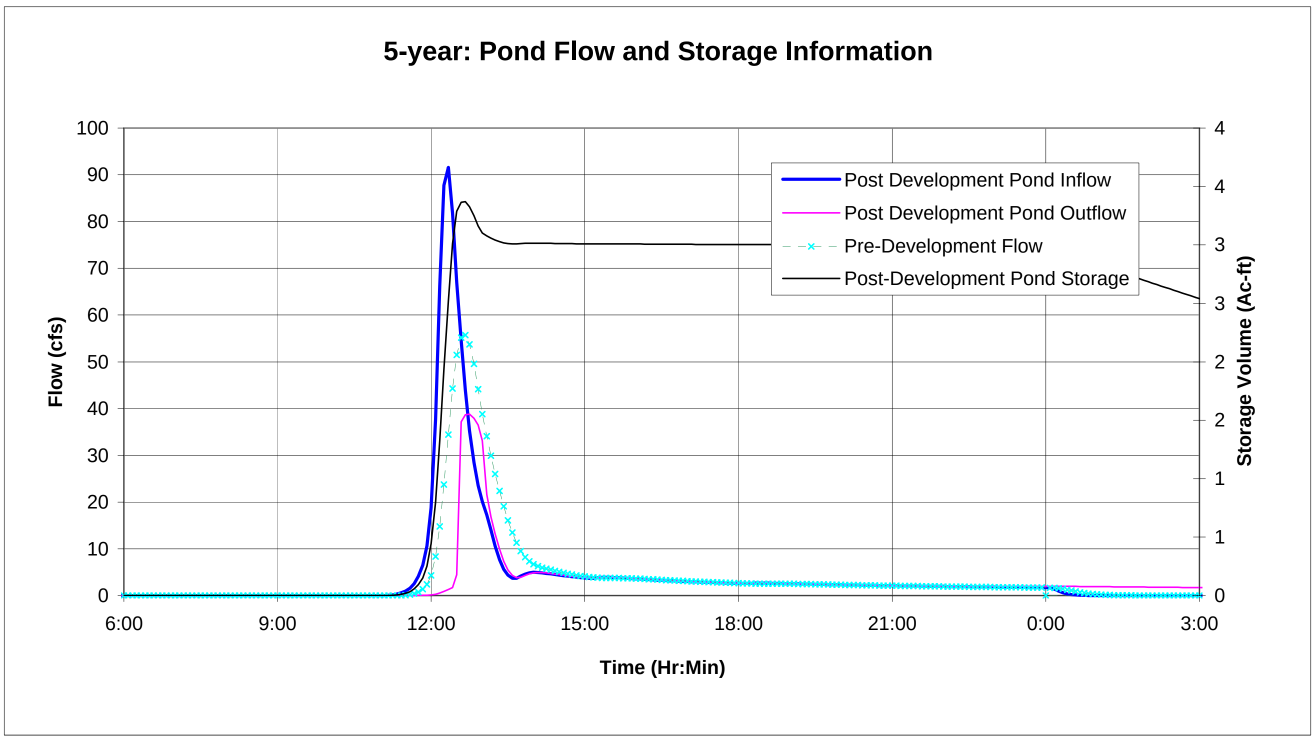
Detention Pond 13-2 Rating Curve

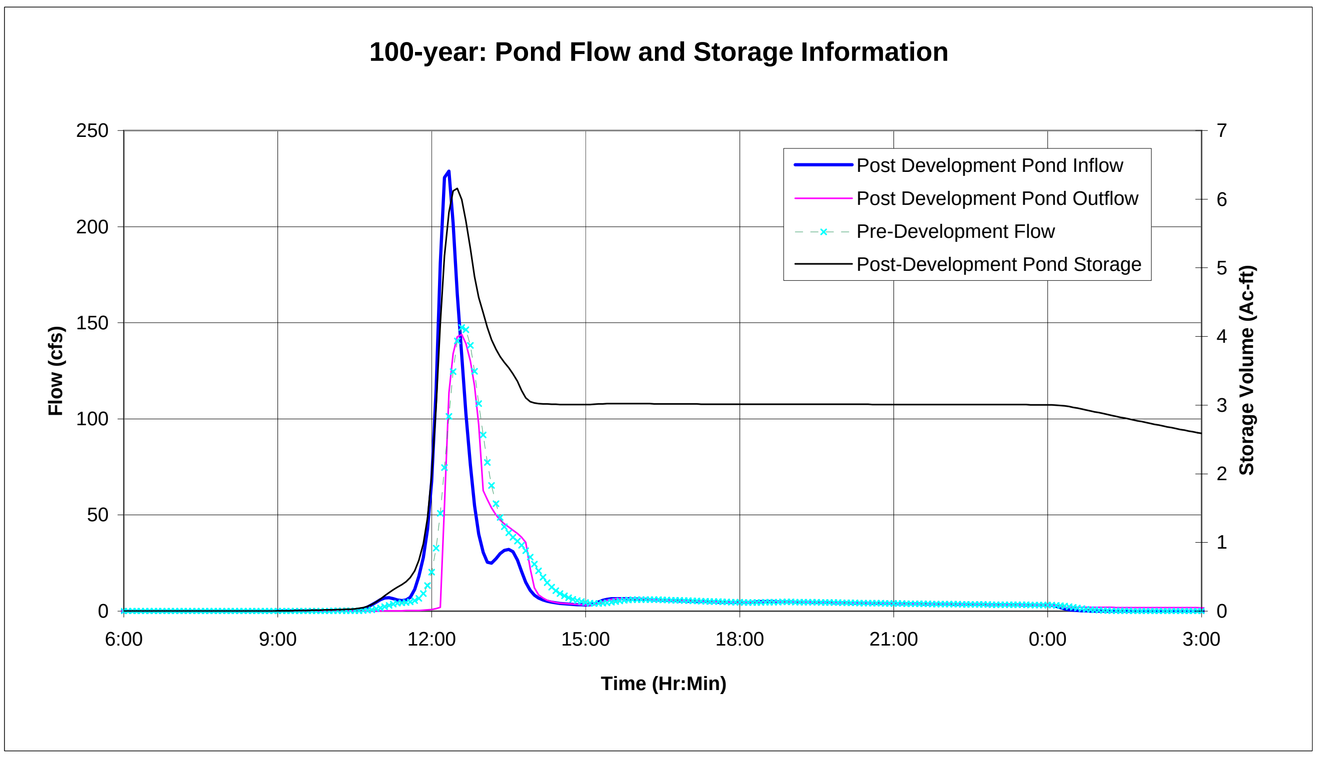
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	3.00	2.01
2	3.17	34.90
2.5	4.03	51.58
3	4.91	104.82
3.5	5.83	134.49
3.9	6.58	155.91
4	6.77	160.77
4.5	7.73	180.54

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.66		Pond Bottom Length	337	ft
Max Pond Depth	4.5	ft	Pond Bottom Width	192	ft
Side Slope (H:1)	4		Pond Top Length	365	ft
Pond Volume at Max. Depth	5.83	Ac-ft	Pond Top Width at Max Depth	220	ft
5-yr control opening type	Pipe		100-yr control opening type	Pipe	
5-yr control opening size	3	ft	100-yr control opening size	3	ft
Number of parallel 5-yr openings	2		Number of parallel 100-yr structures	3	
5-yr top control height	3	ft	100-yr water surface elevation	3.5	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	1.84	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	5.45	Ac







Watershed 13, Pond 13-3 Output Summary

Water Quality Capture Volume: 10.59 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	702	cfs
Post-Development Peak Outflow:	261	cfs
Pre-Development Peak Flow:	345	cfs
Total Volume:	109.4	Ac-ft
Peak Storage:	53.6	Ac-ft

100-Year Storm Event Summary

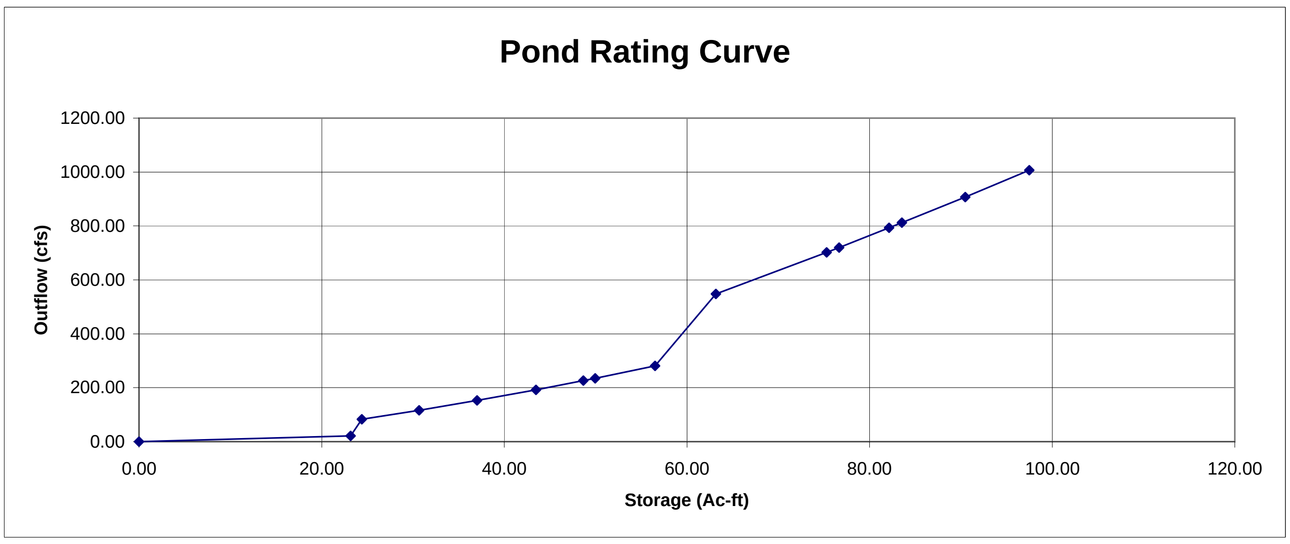
Post-Development Peak Inflow:	1453	cfs
Post-Development Peak Outflow:	848	cfs
Pre-Development Peak Flow:	864	cfs
Total Volume:	219.8	Ac-ft
Peak Storage:	86.1	Ac-ft

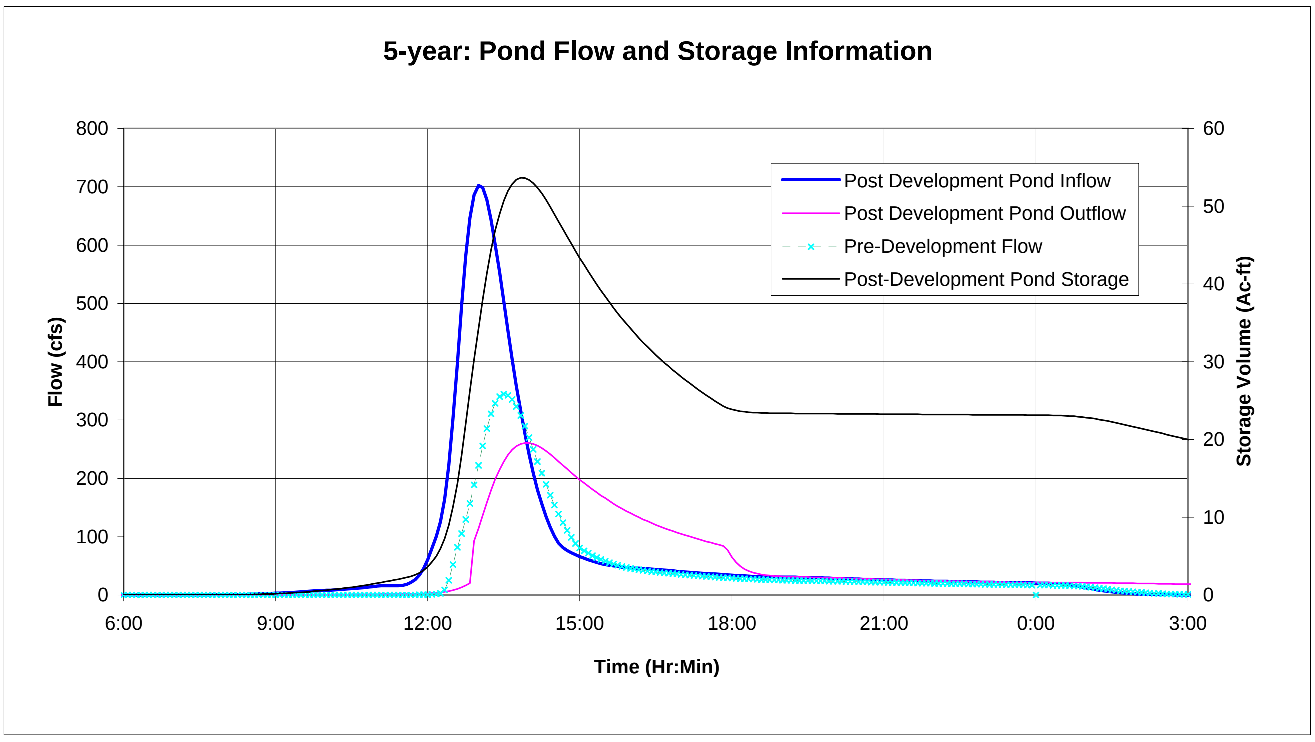
Detention Pond 13-3 Rating Curve

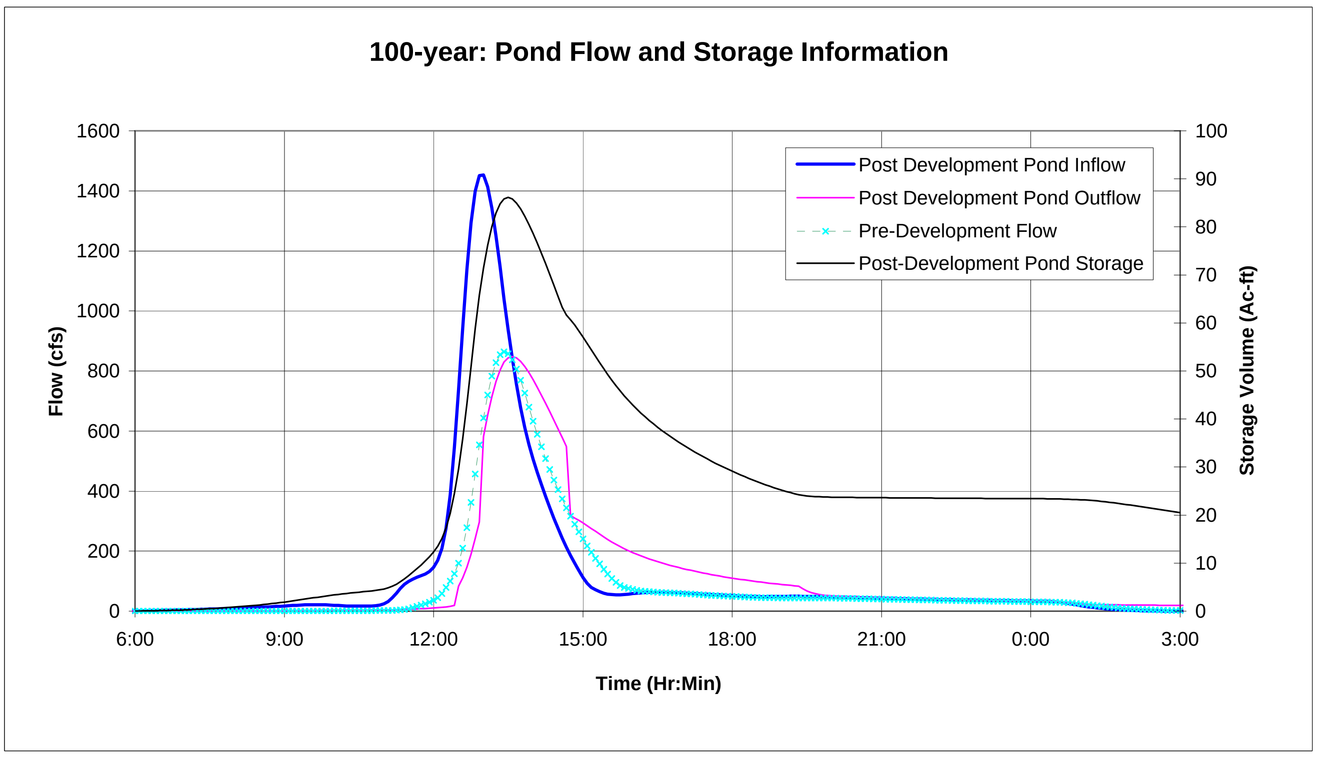
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	23.16	21.37
2	24.41	83.16
2.5	30.69	116.22
3	37.03	152.78
3.5	43.46	192.52
3.9	48.65	226.45
4	49.95	235.22
4.5	56.52	280.67
5	63.16	547.87
5.9	75.30	702.27
6	76.66	720.20
6.4	82.15	793.41
6.5	83.53	812.07
7	90.47	907.55
7.5	97.48	1006.51

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.67		Pond Bottom Length	948	ft
Max Pond Depth	7.5	ft	Pond Bottom Width	548	ft
Side Slope (H:1)	4		Pond Top Length	1000	ft
Pond Volume at Max. Depth	83.53	Ac-ft	Pond Top Width at Max Depth	600	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x12	ft	100-yr control opening size	6x20	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	5	ft	100-yr water surface elevation	6.5	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	13.77	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	22.04	Ac







Watershed 11, Pond 11-1 Output Summary

Water Quality Capture Volume: 14.46 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1167	cfs
Post-Development Peak Outflow:	342	cfs
Pre-Development Peak Flow:	712	cfs
Total Volume:	163.0	Ac-ft
Peak Storage:	90.6	Ac-ft

100-Year Storm Event Summary

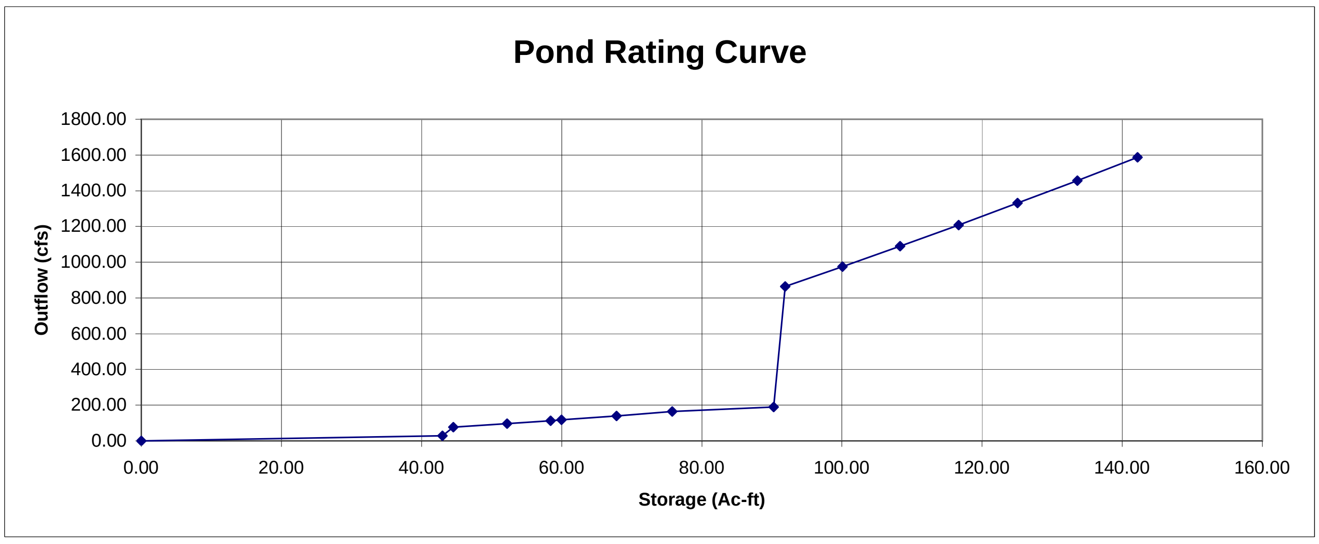
Post-Development Peak Inflow:	2463	cfs
Post-Development Peak Outflow:	1312	cfs
Pre-Development Peak Flow:	1550	cfs
Total Volume:	333.8	Ac-ft
Peak Storage:	123.8	Ac-ft

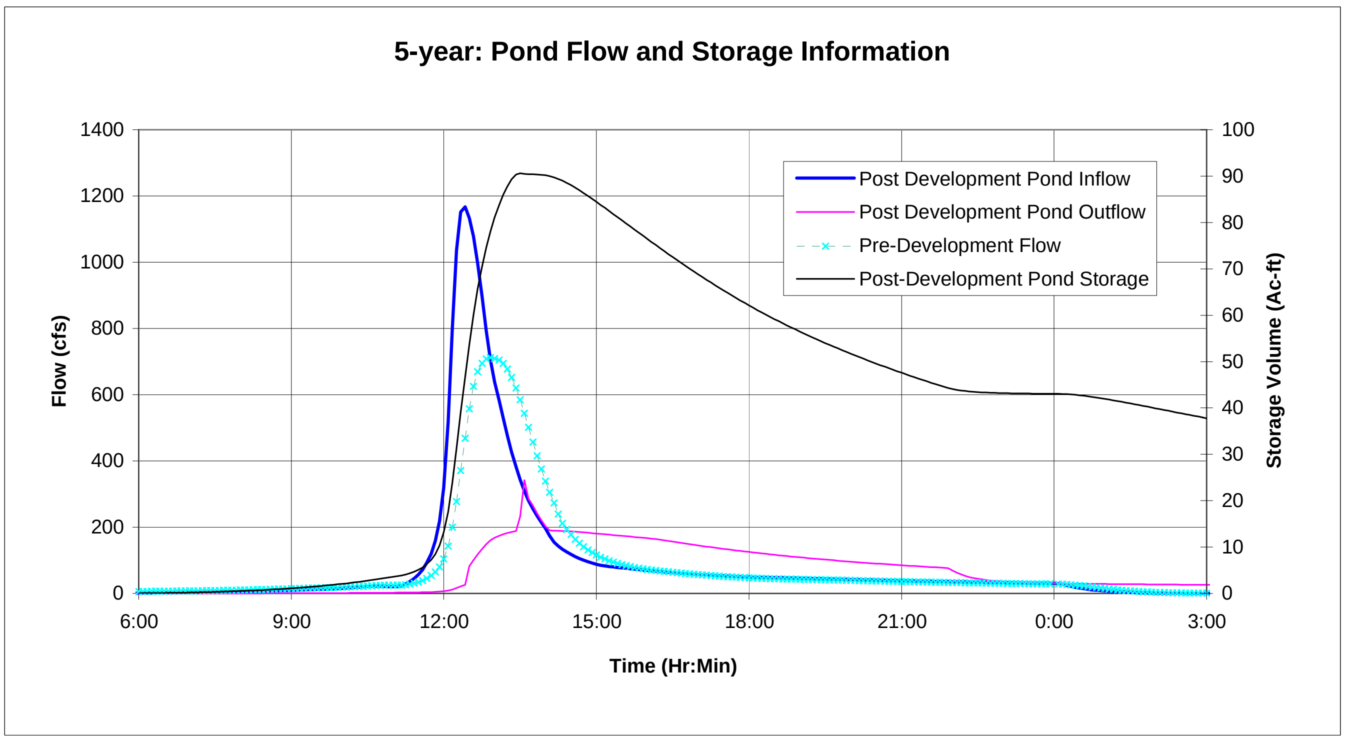
POND GEOMETRY

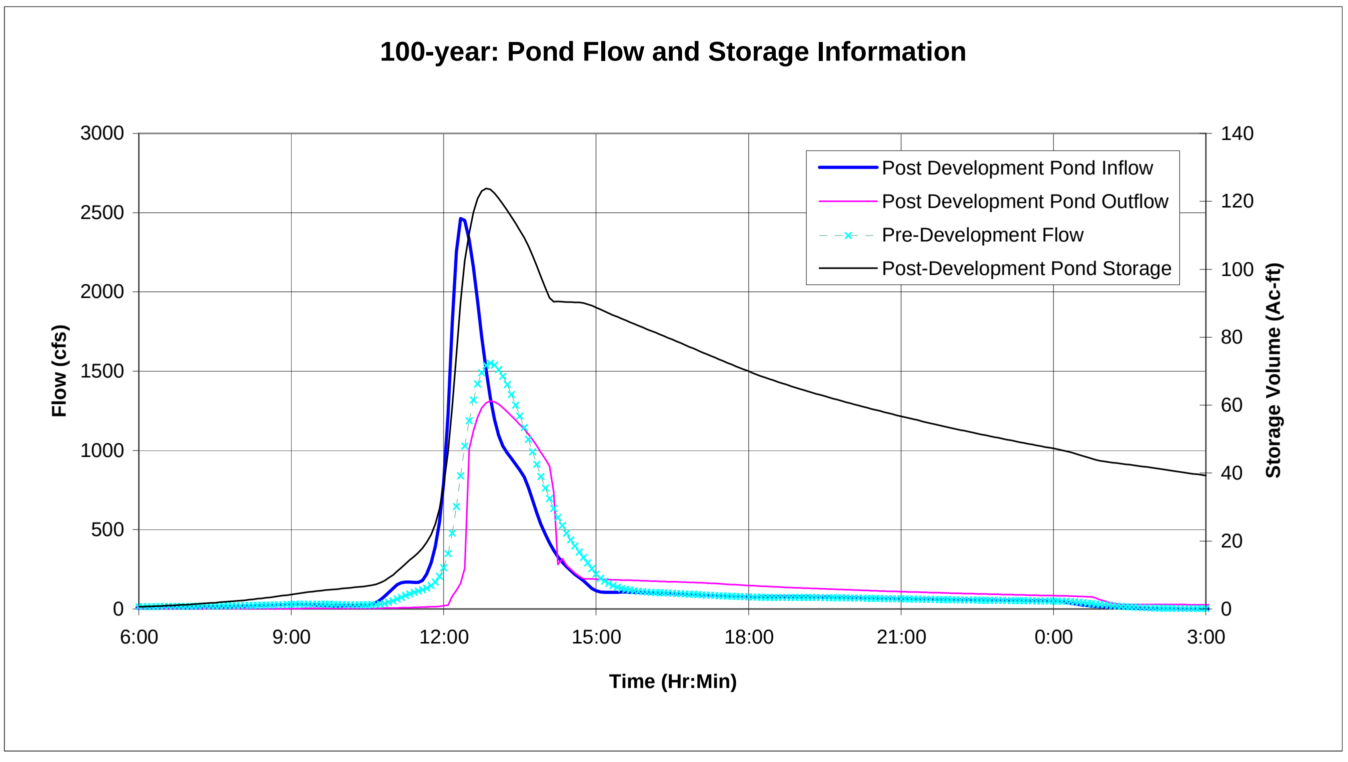
Pond Length to Width Ratio (xL:1W)	1.64		Pond Bottom Length	1035	ft
Max Pond Depth	8.1	ft	Pond Bottom Width	605	ft
Side Slope (H:1)	4		Pond Top Length	1100	ft
Pond Volume at Max. Depth	126.77	Ac-ft	Pond Top Width at Max Depth	670	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x6	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	2	
5-yr top control height	6	ft	100-yr water surface elevation	8.1	ft
WQCV top control height	3	ft			
Estimated impoundment area for 100-year detention				16.92	Ac
Estimated footprint area for 100-year detention (includes riparian area)				25.96	Ac

Detention Pond 11-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
2.9	42.99	29.16
3	44.52	76.39
3.5	52.22	96.26
3.9	58.43	113.23
4	59.99	117.61
4.5	67.84	140.33
5	75.77	164.36
5.9	90.25	190.17
6	91.88	864.24
6.5	100.05	974.48
7	108.31	1089.06
7.5	116.65	1207.82
8	125.08	1330.58
8.5	133.59	1457.26
9	142.18	1587.70







Watershed 11, Pond 11-2 Output Summary

Water Quality Capture Volume: 5.39 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	422	cfs
Post-Development Peak Outflow:	200	cfs
Pre-Development Peak Flow:	254	cfs
Total Volume:	50.6	Ac-ft
Peak Storage:	24.8	Ac-ft

100-Year Storm Event Summary

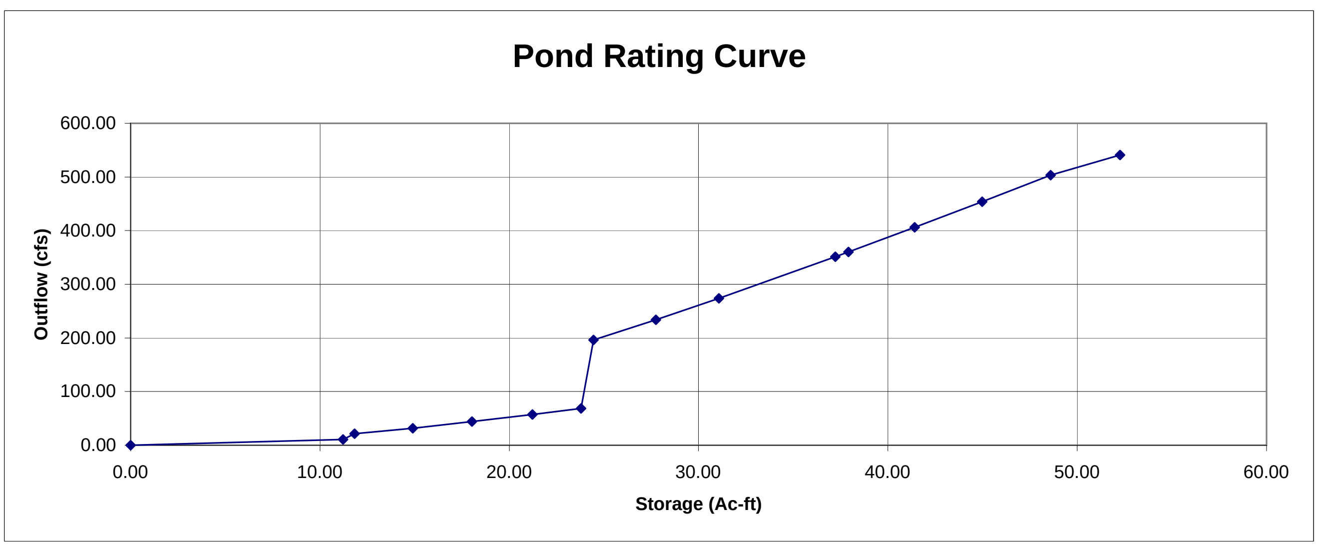
Post-Development Peak Inflow:	919	cfs
Post-Development Peak Outflow:	450	cfs
Pre-Development Peak Flow:	551	cfs
Total Volume:	105.9	Ac-ft
Peak Storage:	44.7	Ac-ft

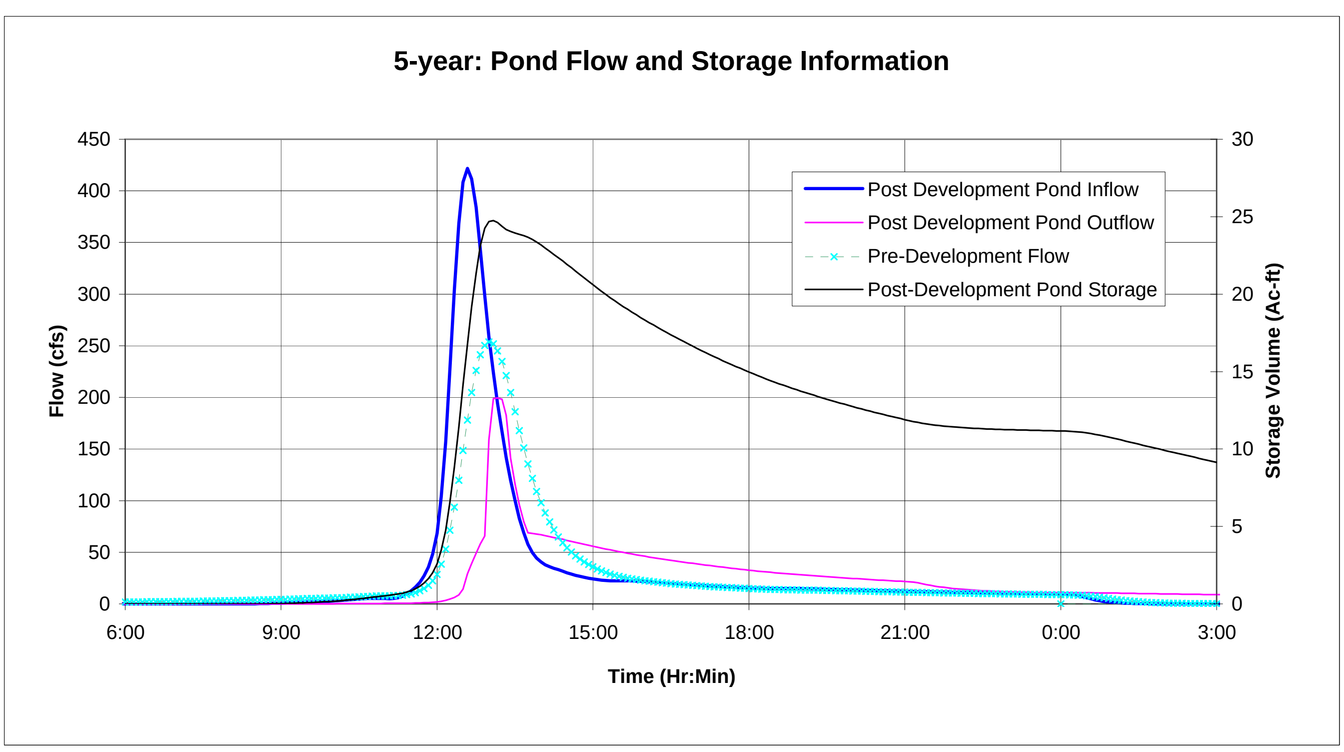
POND GEOMETRY

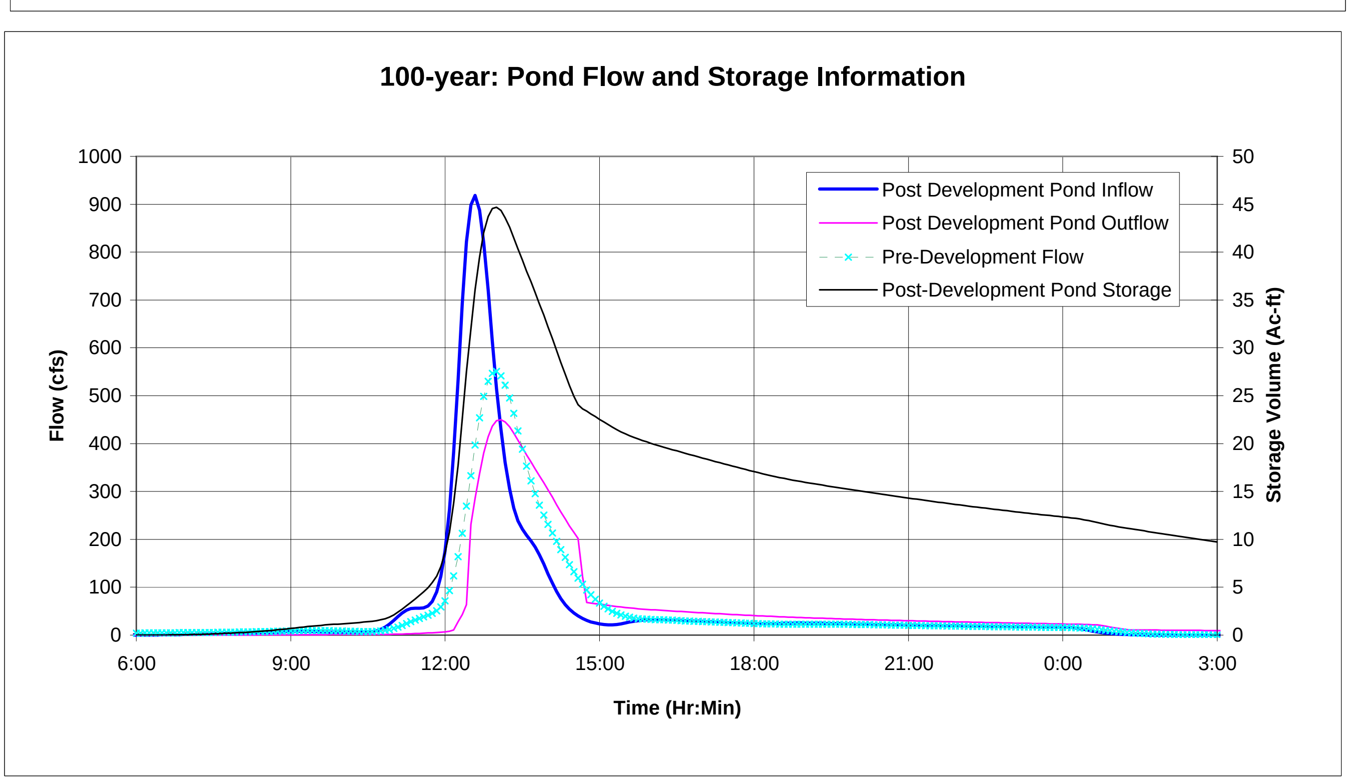
Pond Length to Width Ratio (xL:1W)	1.76		Pond Bottom Length	684	ft
Max Pond Depth	8	ft	Pond Bottom Width	364	ft
Side Slope (H:1)	4		Pond Top Length	740	ft
Pond Volume at Max. Depth	44.98	Ac-ft	Pond Top Width at Max Depth	420	ft
5-yr control opening type	Pipe		100-yr control opening type	Box	
5-yr control opening size	4	ft	100-yr control opening size	6x10	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	4	ft	100-yr water surface elevation	7	ft
WQCV top control height	2	ft			
Estimated impoundment area for 100-year detention				7.13	Ac
Estimated footprint area for 100-year detention (includes riparian area)				13.38	Ac

Detention Pond 11-2 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	11.21	10.87
2	11.82	21.19
2.5	14.90	31.89
3	18.03	44.13
3.5	21.22	57.53
3.9	23.80	68.83
4	24.45	196.01
4.5	27.74	233.89
5	31.08	273.94
5.9	37.22	351.13
6	37.92	360.10
6.5	41.42	406.04
7	44.98	453.78
7.5	48.59	503.25
8	52.26	541.22







Watershed 40, Pond 40-1 Output Summary

Water Quality Capture Volume: 48.96 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1625	cfs
Post-Development Peak Outflow:	1333	cfs
Pre-Development Peak Flow:	1459	cfs
Total Volume:	1218.8	Ac-ft
Peak Storage:	252.1	Ac-ft

100-Year Storm Event Summary

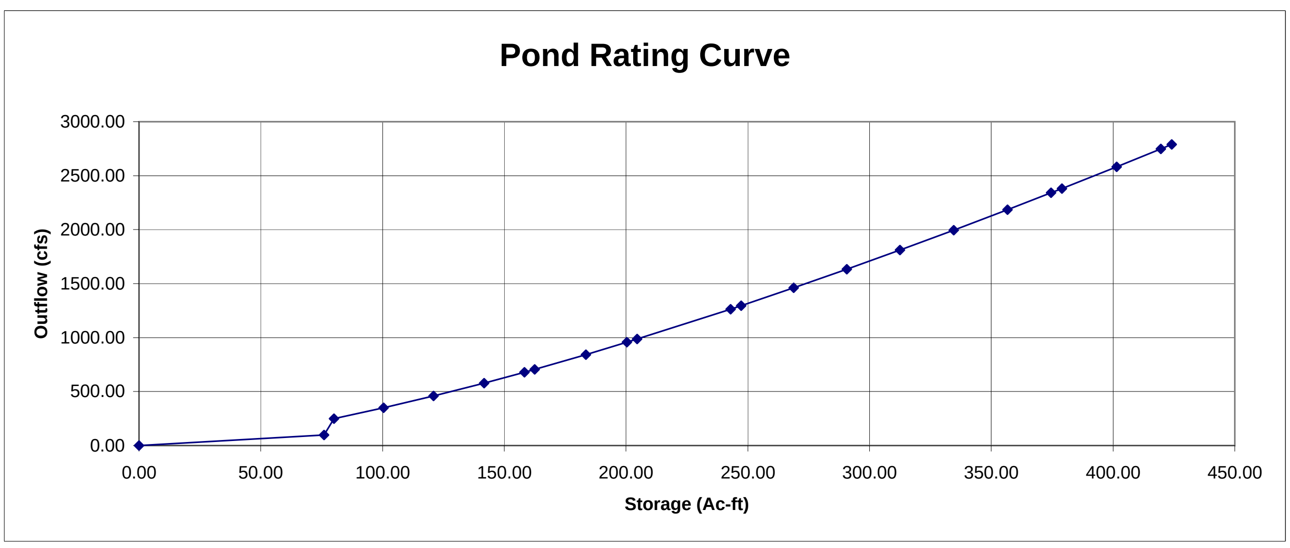
Post-Development Peak Inflow:	3330	cfs
Post-Development Peak Outflow:	2628	cfs
Pre-Development Peak Flow:	3824	cfs
Total Volume:	2581.7	Ac-ft
Peak Storage:	406.5	Ac-ft

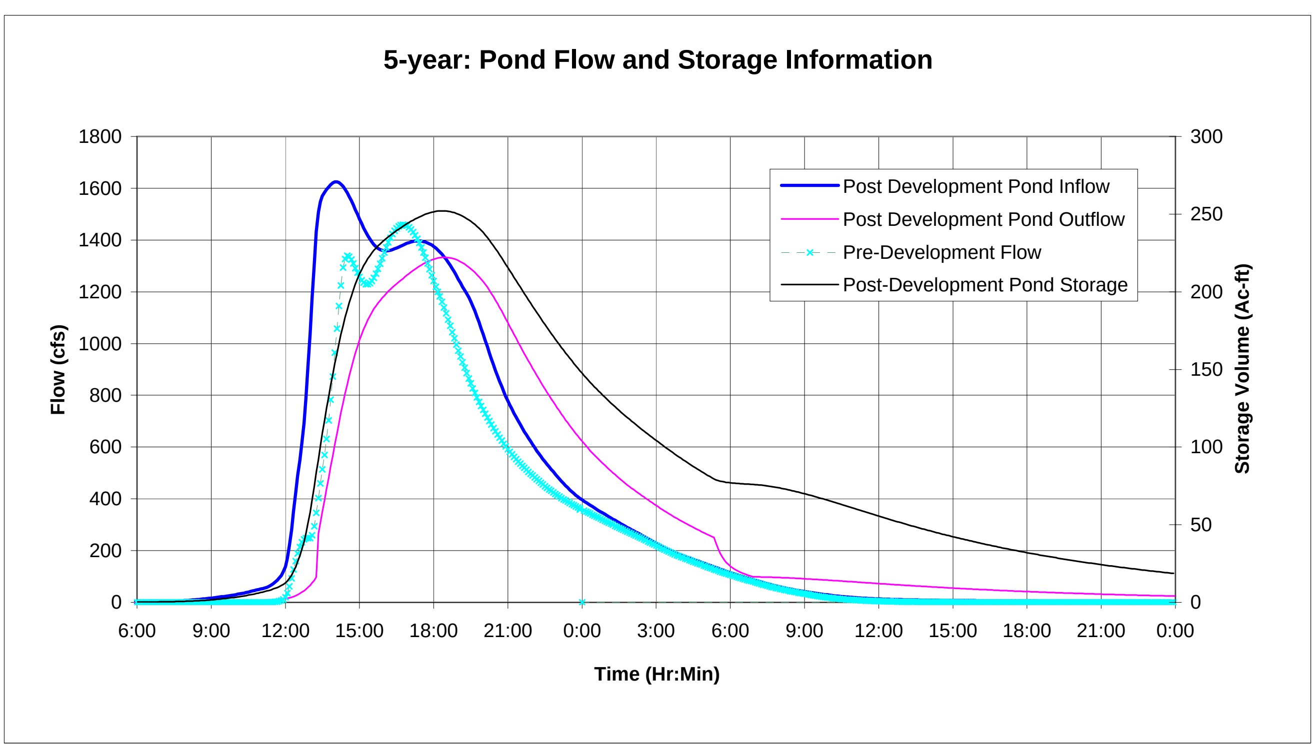
POND GEOMETRY

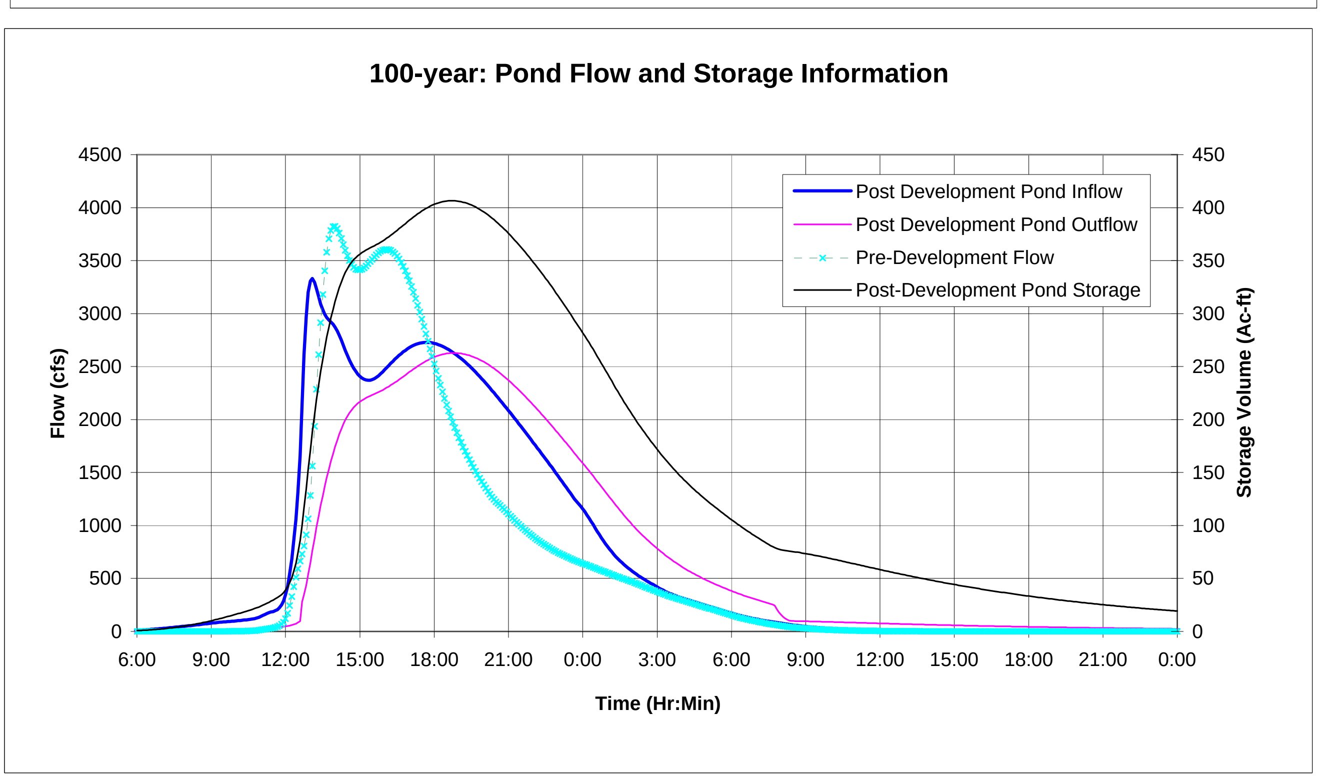
Pond Length to Width Ratio (xL:1W)	3.21		Pond Bottom Length	2428	ft
Max Pond Depth	10	ft	Pond Bottom Width	708	ft
Side Slope (H:1)	4		Pond Top Length	2500	ft
Pond Volume at Max. Depth	379.03	Ac-ft	Pond Top Width at Max Depth	780	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	8x12	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	3		Number of parallel 100-yr structures	3	
5-yr top control height	6	ft	100-yr water surface elevation	9	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	44.77	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	60.74	Ac

Detention Pond 40-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	76.02	98.73
2	80.08	249.48
2.5	100.47	348.66
3	121.00	458.34
3.5	141.68	577.56
3.9	158.33	679.35
4	162.51	705.66
4.5	183.48	842.01
4.9	200.37	956.73
5	204.61	986.16
5.9	243.01	1264.08
6	247.31	1296.36
6.5	268.88	1461.72
7	290.61	1633.59
7.5	312.48	1811.73
8	334.51	1995.87
8.5	356.70	2185.89
8.9	374.55	2341.98
9	379.03	2381.55
9.5	401.52	2582.76
9.9	419.62	2747.58
10	424.17	2789.31







Watershed 51, Pond BMP 51-2 Output Summary

Water Quality Capture Volume: 9.03 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	852	cfs
Post-Development Peak Outflow:	282	cfs
Pre-Development Peak Flow:	455	cfs
Total Volume:	89.9	Ac-ft
Peak Storage:	43.8	Ac-ft

100-Year Storm Event Summary

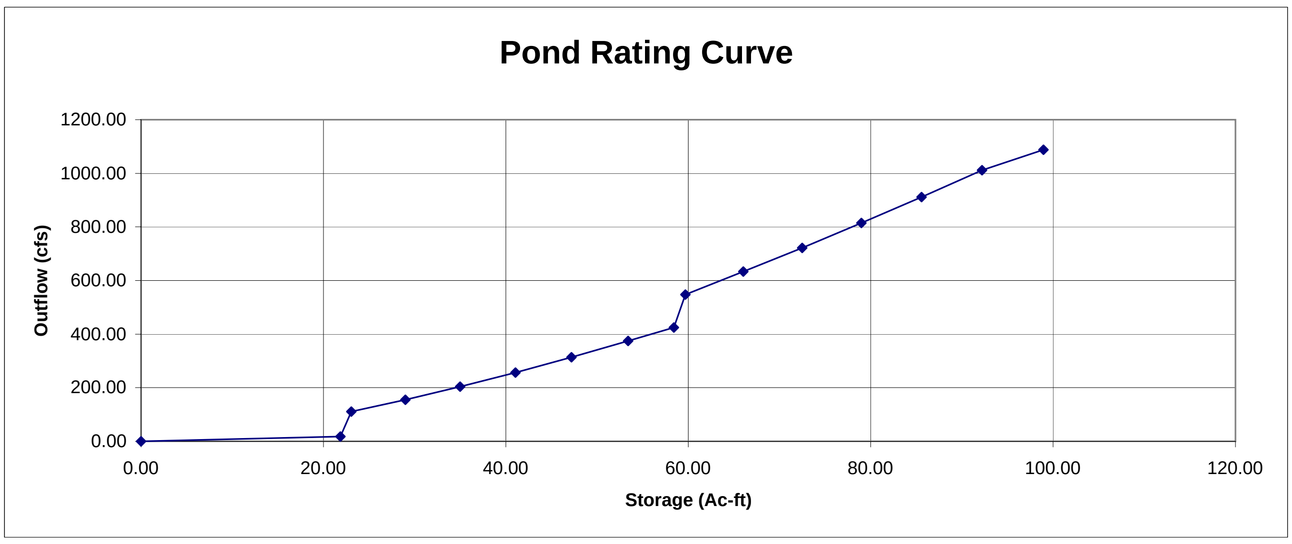
Post-Development Peak Inflow:	1910	cfs
Post-Development Peak Outflow:	910	cfs
Pre-Development Peak Flow:	1212	cfs
Total Volume:	194.7	Ac-ft
Peak Storage:	85.6	Ac-ft

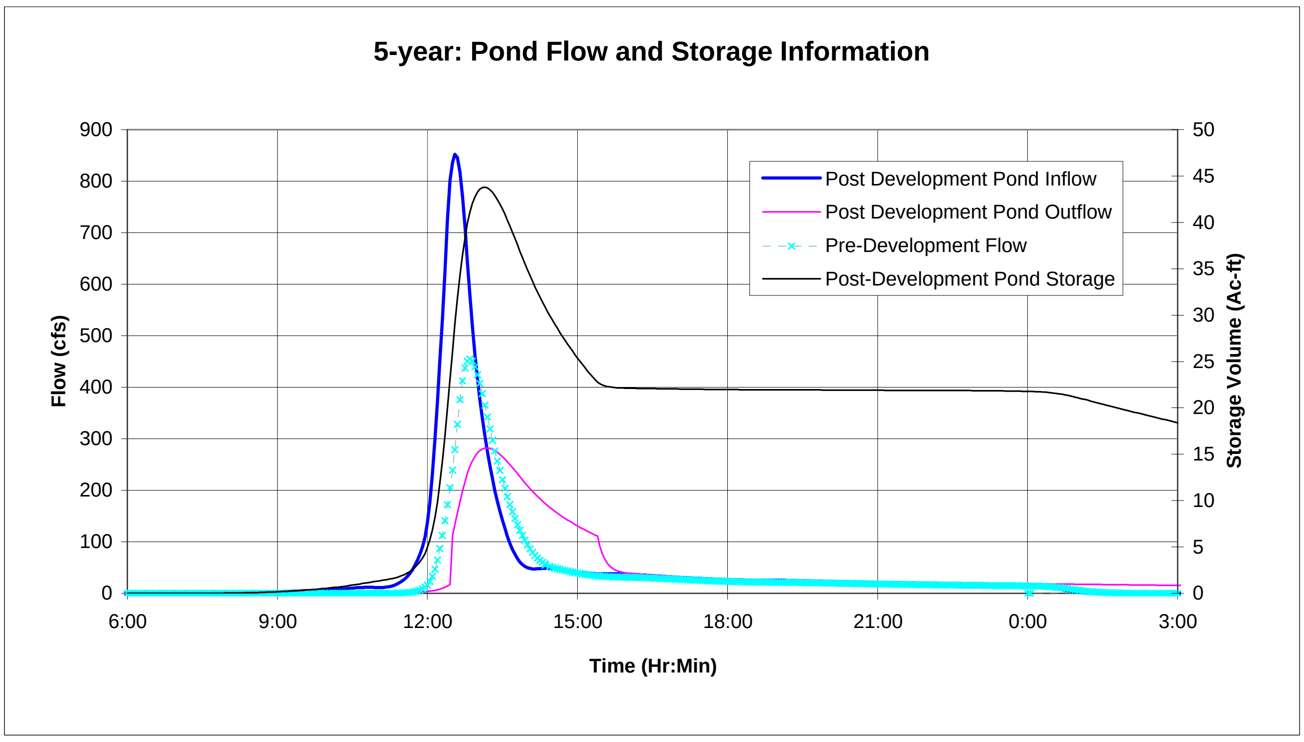
Detention Pond BMP 51-2 Rating Curve

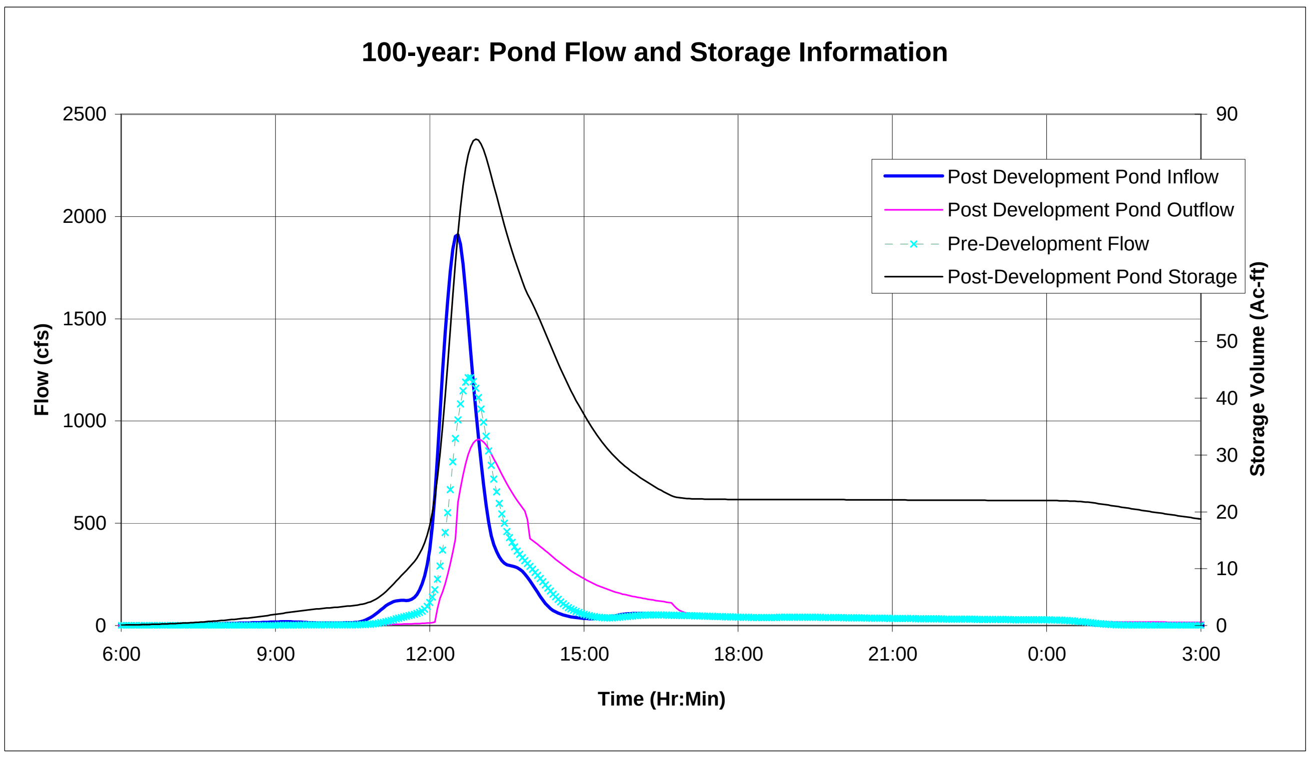
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	21.86	18.22
2	23.04	110.88
2.5	28.97	154.96
3	34.97	203.70
3.5	41.04	256.69
4	47.19	313.62
4.5	53.40	374.23
4.9	58.42	425.22
5	59.69	547.87
5.5	66.05	633.08
6	72.48	722.20
6.5	78.99	815.07
7	85.57	911.55
7.5	92.22	1011.51
8	98.95	1088.44

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.74		Pond Bottom Length	944	ft
Max Pond Depth	8	ft	Pond Bottom Width	519	ft
Side Slope (H:1)	4		Pond Top Length	1000	ft
Pond Volume at Max. Depth	85.57	Ac-ft	Pond Top Width at Max Depth	575	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x16	ft	100-yr control opening size	6x20	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	5	ft	100-yr water surface elevation	7	ft
WQCV top control height	2	ft			
Estimated impoundment area for 100-year detention				13.20	Ac
Estimated footprint area for 100-year detention (includes riparian area)				21.35	Ac







Watershed 7, Pond 7-4 Output Summary

Water Quality Capture Volume: 16.31 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1273	cfs
Post-Development Peak Outflow:	164	cfs
Pre-Development Peak Flow:	906	cfs
Total Volume:	161.1	Ac-ft
Peak Storage:	100.9	Ac-ft

100-Year Storm Event Summary

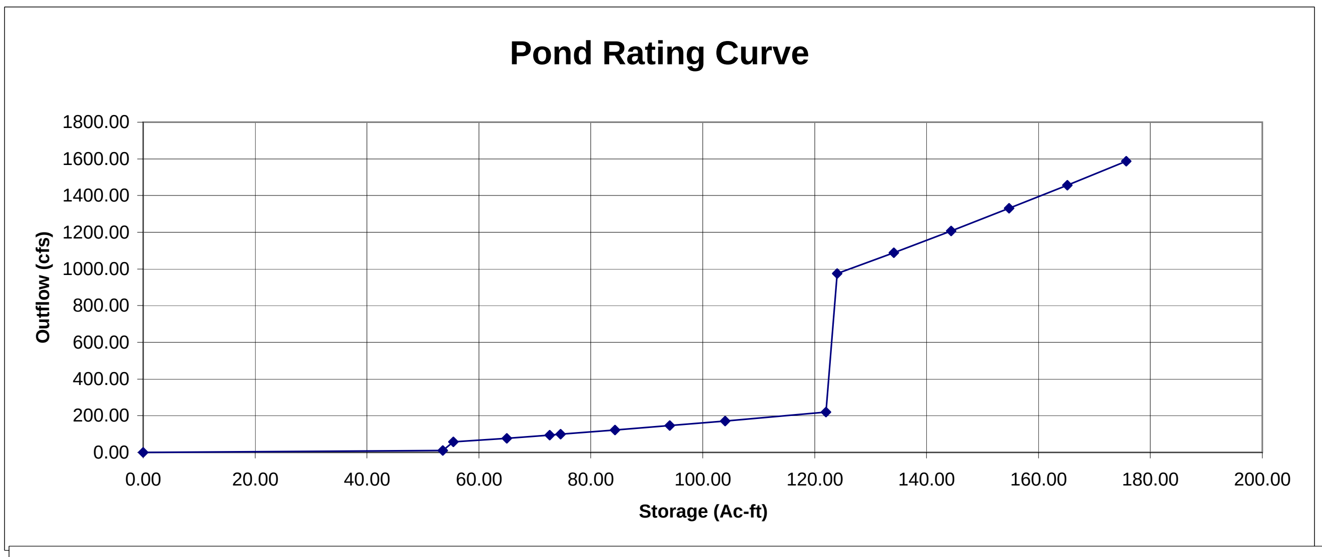
Post-Development Peak Inflow:	2644	cfs
Post-Development Peak Outflow:	1302	cfs
Pre-Development Peak Flow:	1940	cfs
Total Volume:	326.2	Ac-ft
Peak Storage:	150.7	Ac-ft

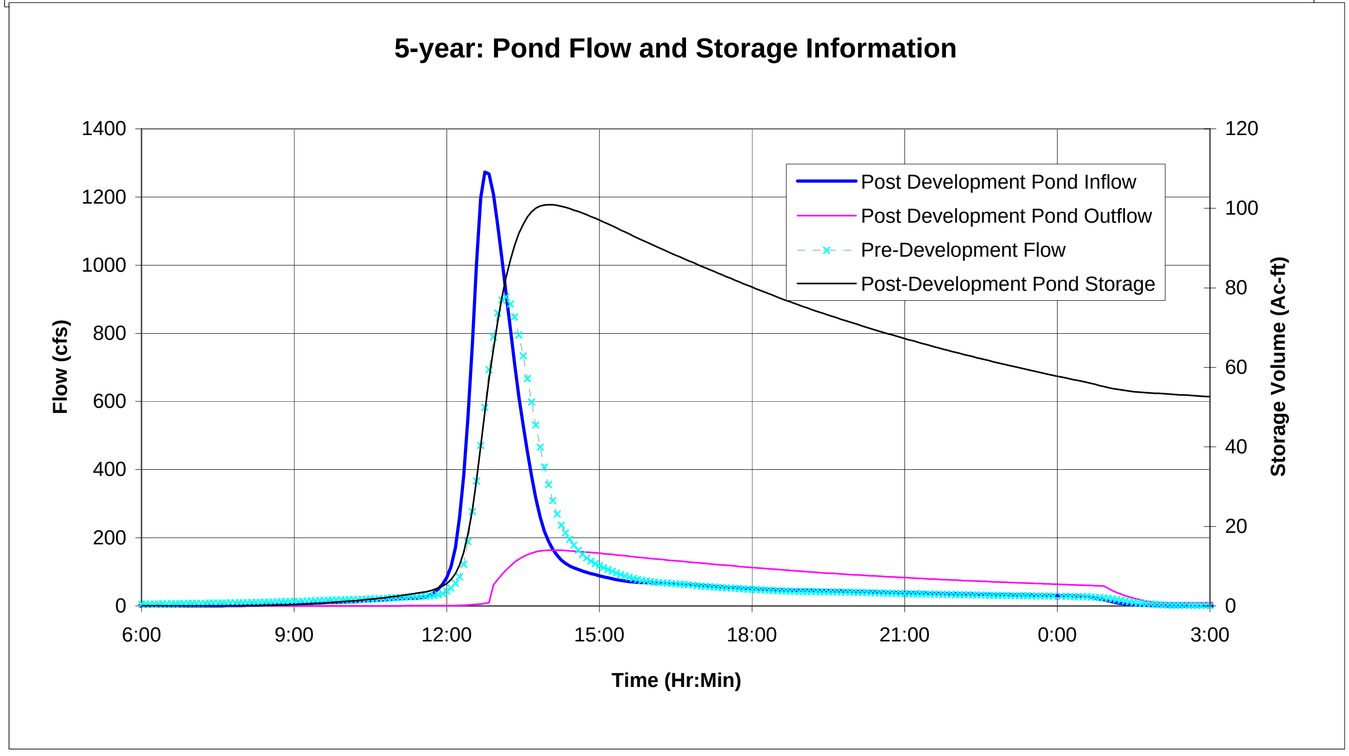
Detention Pond 7-4 Rating Curve

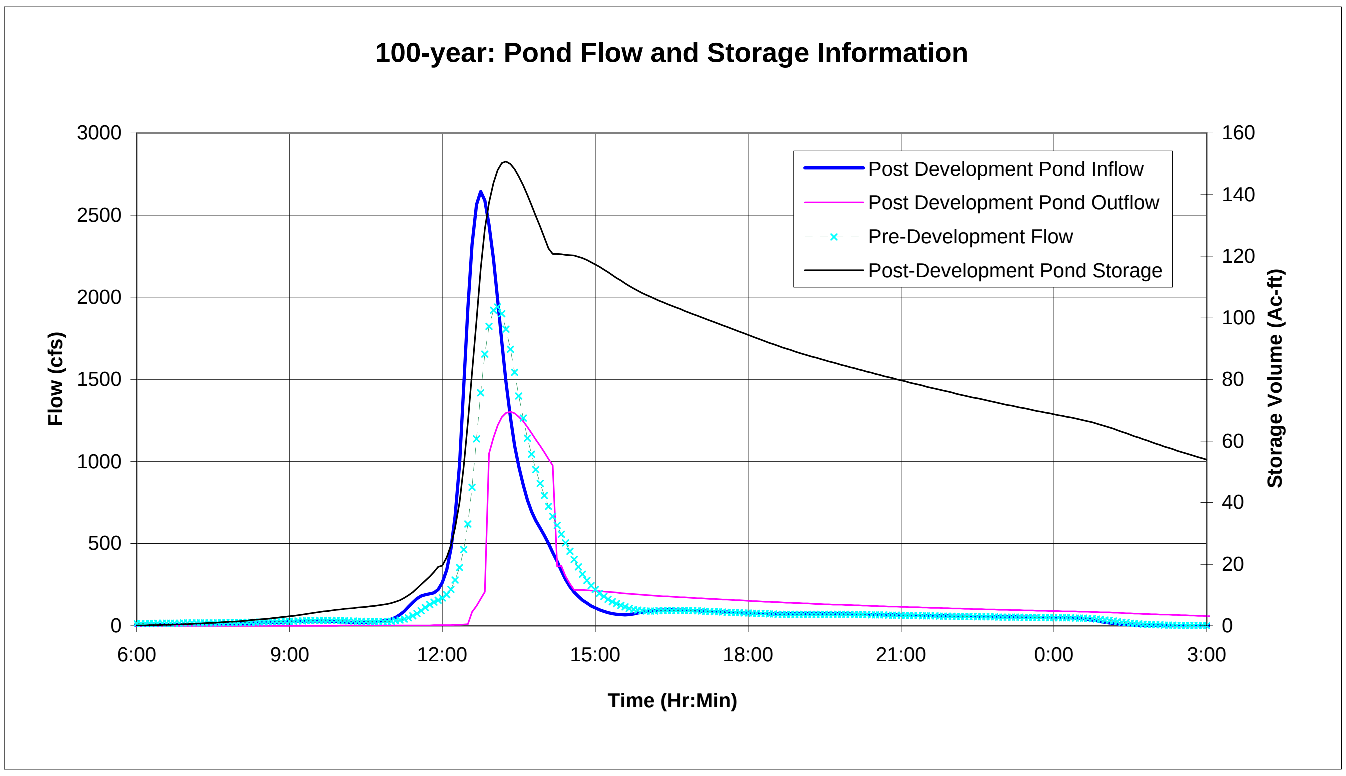
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
2.9	53.54	9.87
3	55.44	58.38
3.5	64.98	77.54
3.9	72.67	94.32
4	74.60	98.70
4.5	84.31	121.59
5	94.11	145.92
5.5	103.99	171.37
6.4	122.01	219.02
6.5	124.03	974.48
7	134.18	1089.06
7.5	144.42	1207.82
8	154.75	1330.58
8.5	165.17	1457.26
9	175.69	1587.70

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.34		Pond Bottom Length	1036	ft
Max Pond Depth	9	ft	Pond Bottom Width	756	ft
Side Slope (H:1)	4		Pond Top Length	1100	ft
Pond Volume at Max. Depth	154.75	Ac-ft	Pond Top Width at Max Depth	820	ft
5-yr control opening type	Pipe		100-yr control opening type	Box	
5-yr control opening size	6	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	2	
5-yr top control height	6.5	ft	100-yr water surface elevation	8	ft
WQCV top control height	3	ft			
			Estimated impoundment area for 100-year detention	20.71	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	30.44	Ac







Watershed 51, Pond BMP 51-1 Output Summary

Water Quality Capture Volume: 7.65 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	452	cfs
Post-Development Peak Outflow:	421	cfs
Pre-Development Peak Flow:	569	cfs
Total Volume:	162.9	Ac-ft
Peak Storage:	15.1	Ac-ft

100-Year Storm Event Summary

Post-Development Peak Inflow:	1258	cfs
Post-Development Peak Outflow:	1170	cfs
Pre-Development Peak Flow:	1565	cfs
Total Volume:	356.6	Ac-ft
Peak Storage:	25.1	Ac-ft

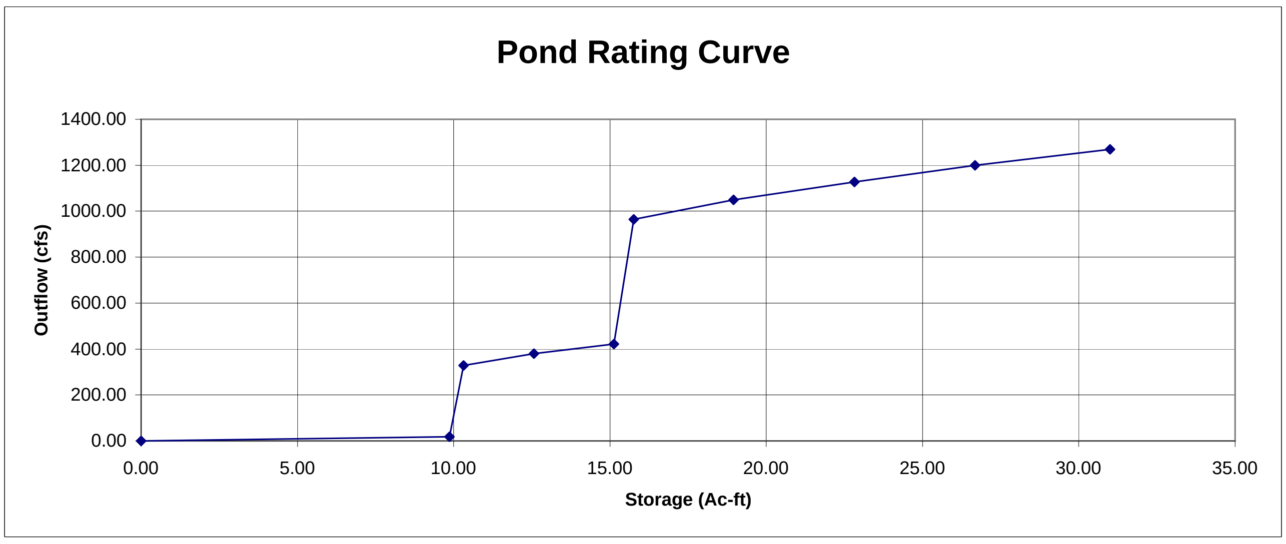
Detention Pond BMP 51-1 Rating Curve

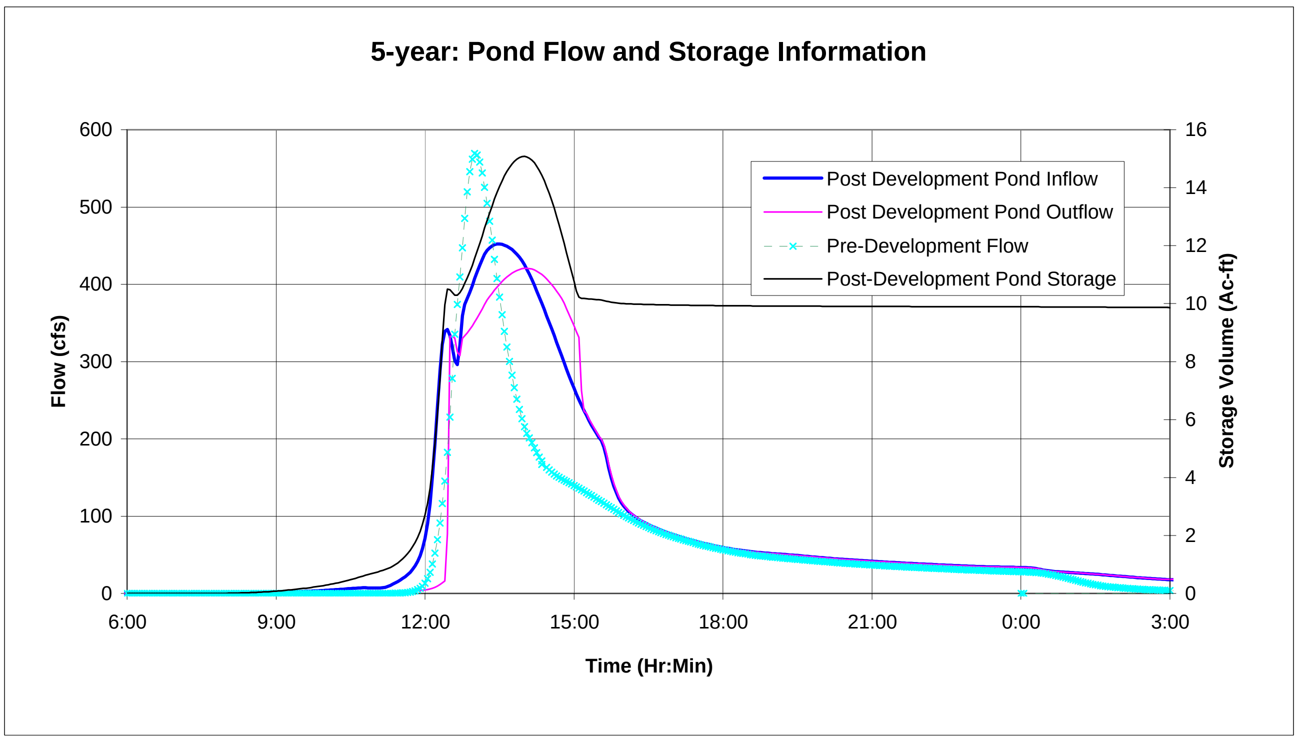
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
4.9	9.87	18.22
5	10.32	328.72
5.5	12.57	379.25
5.9	15.12	421.36
6	15.76	964.02
6.5	18.96	1048.62
7	22.82	1126.86
7.5	26.68	1200.00
8	31.00	1268.94

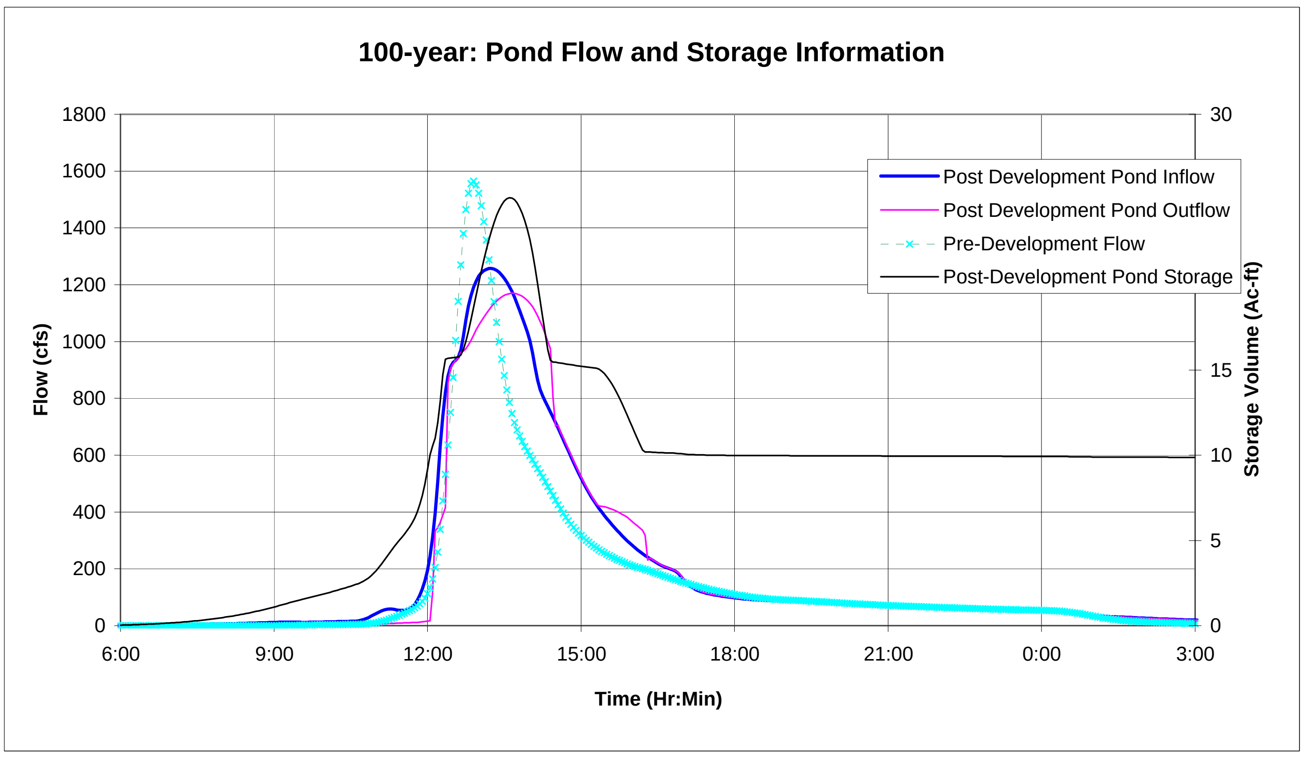
POND GEOMETRY

Pond is sized using existing topography with minimal or no excavation

Pond Volume at Max. Depth	35.31	Ac-ft			
5-yr control opening type	Box				
5-yr control opening size	6x12	ft	100-yr control opening type	Box	
Number of parallel 5-yr openings	1		100-yr control opening size	4x10	ft
5-yr top control height	6	ft	Number of parallel 100-yr structures	3	
WQCV top control height	5	ft	100-yr water surface elevation	7	ft
			Estimated impoundment area for 100-year detention	40.68	Ac







Watershed 7, Pond 7-5 Output Summary

Water Quality Capture Volume: 13.01 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	576	cfs
Post-Development Peak Outflow:	100	cfs
Pre-Development Peak Flow:	549	cfs
Total Volume:	118.3	Ac-ft
Peak Storage:	74.7	Ac-ft

100-Year Storm Event Summary

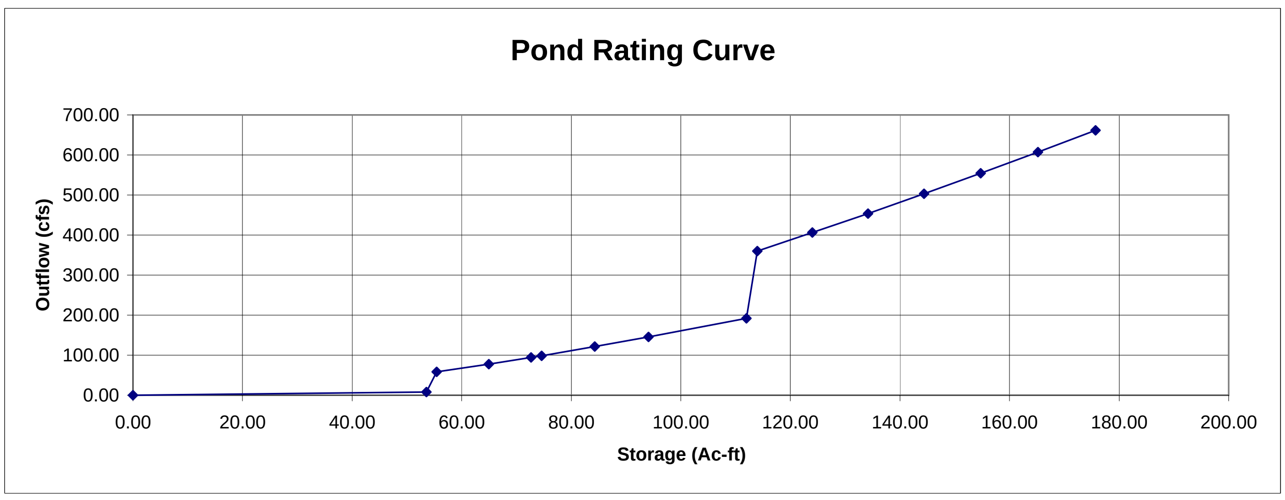
Post-Development Peak Inflow:	1251	cfs
Post-Development Peak Outflow:	482	cfs
Pre-Development Peak Flow:	1075	cfs
Total Volume:	249.9	Ac-ft
Peak Storage:	140.0	Ac-ft

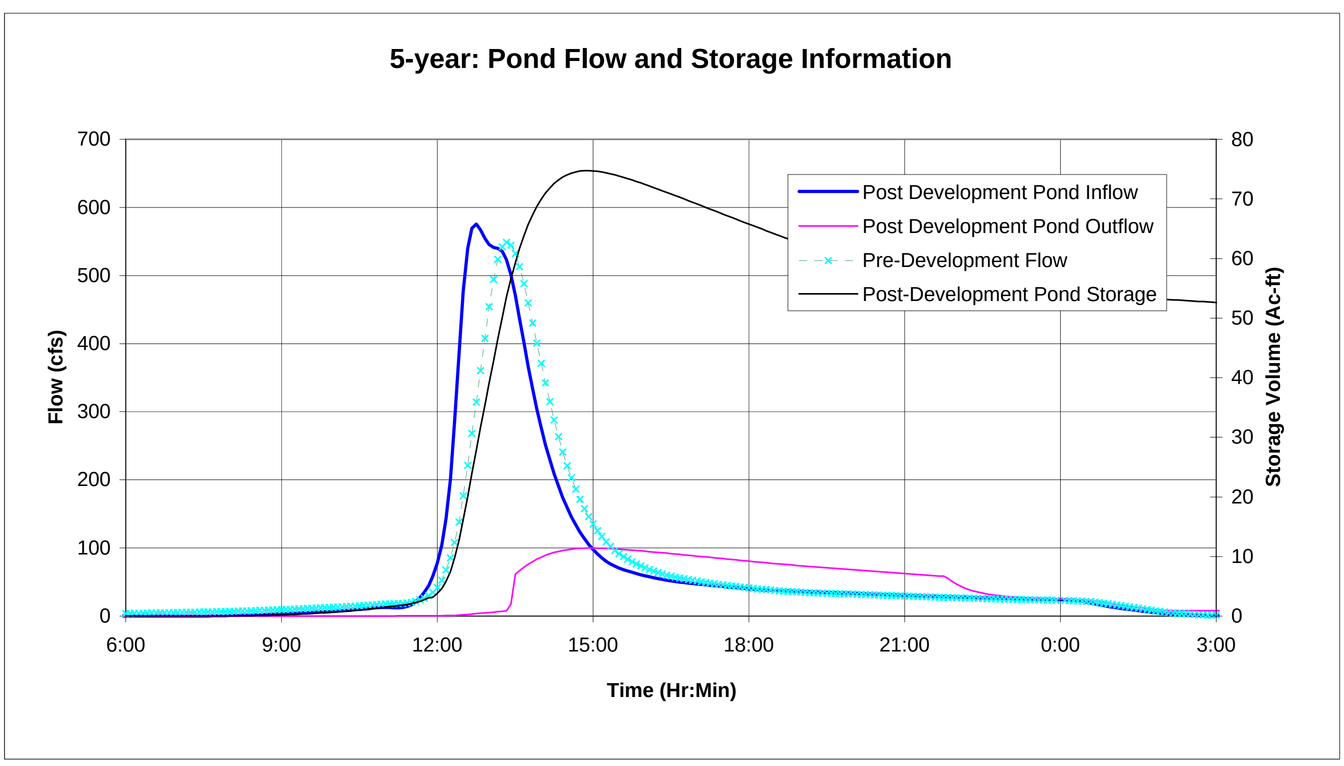
Detention Pond 7-5 Rating Curve

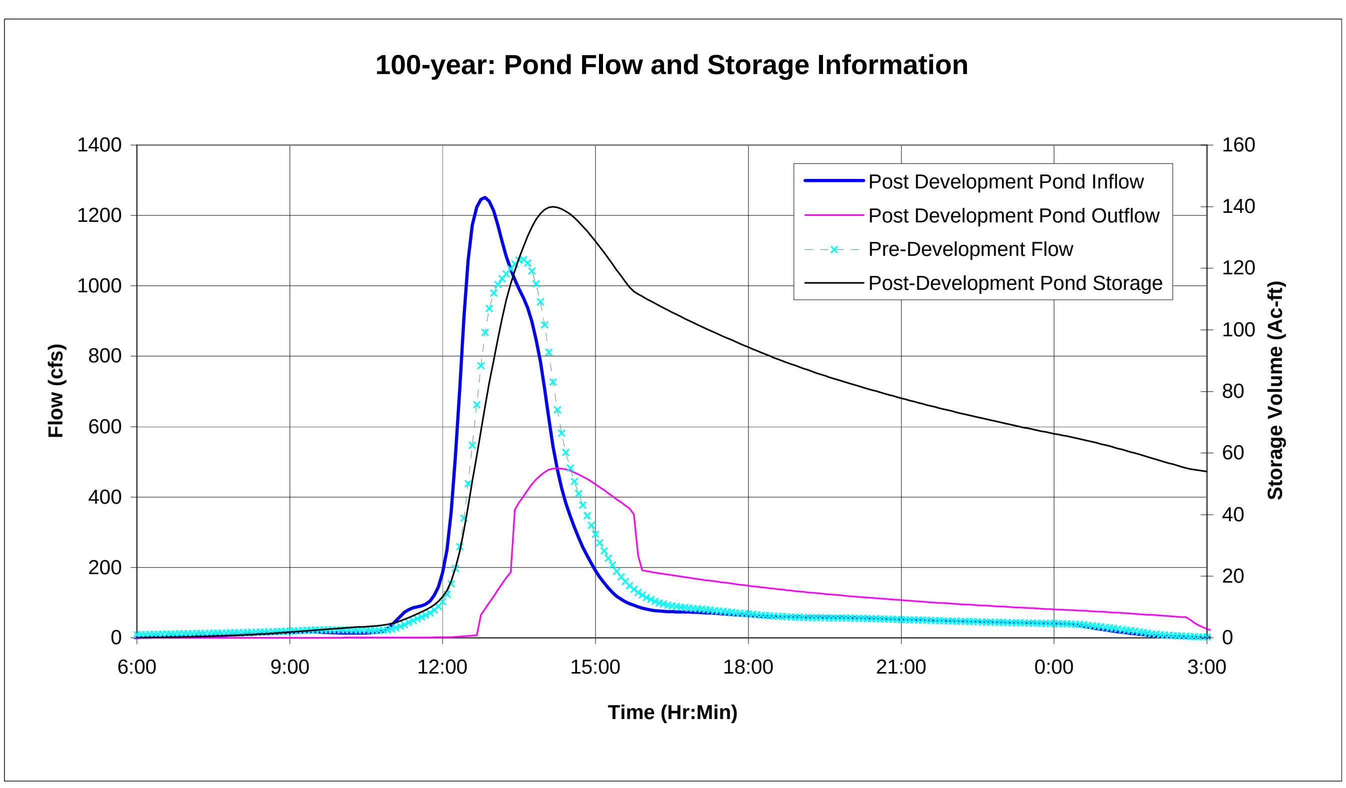
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
2.9	53.54	7.87
3	55.44	58.38
3.5	64.98	77.54
3.9	72.67	94.32
4	74.60	98.70
4.5	84.31	121.59
5	94.11	145.92
5.9	111.96	192.33
6	113.96	360.10
6.5	124.03	406.04
7	134.18	453.78
7.5	144.42	503.25
8	154.75	554.41
8.5	165.17	607.19
9	175.69	661.54

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.34		Pond Bottom Length	1036	ft
Max Pond Depth	9	ft	Pond Bottom Width	756	ft
Side Slope (H:1)	4		Pond Top Length	1100	ft
Pond Volume at Max. Depth	154.75	Ac-ft	Pond Top Width at Max Depth	820	ft
5-yr control opening type	Pipe		100-yr control opening type	Box	
5-yr control opening size	6	ft	100-yr control opening size	8x10	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	6	ft	100-yr water surface elevation	8	ft
WQCV top control height	3	ft			
			Estimated impoundment area for 100-year detention	20.71	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	30.44	Ac







Watershed 25, Pond 25-3 Output Summary

Water Quality Capture Volume: 9.06 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	624	cfs
Post-Development Peak Outflow:	511	cfs
Pre-Development Peak Flow:	1418	cfs
Total Volume:	215.2	Ac-ft
Peak Storage:	17.5	Ac-ft

100-Year Storm Event Summary

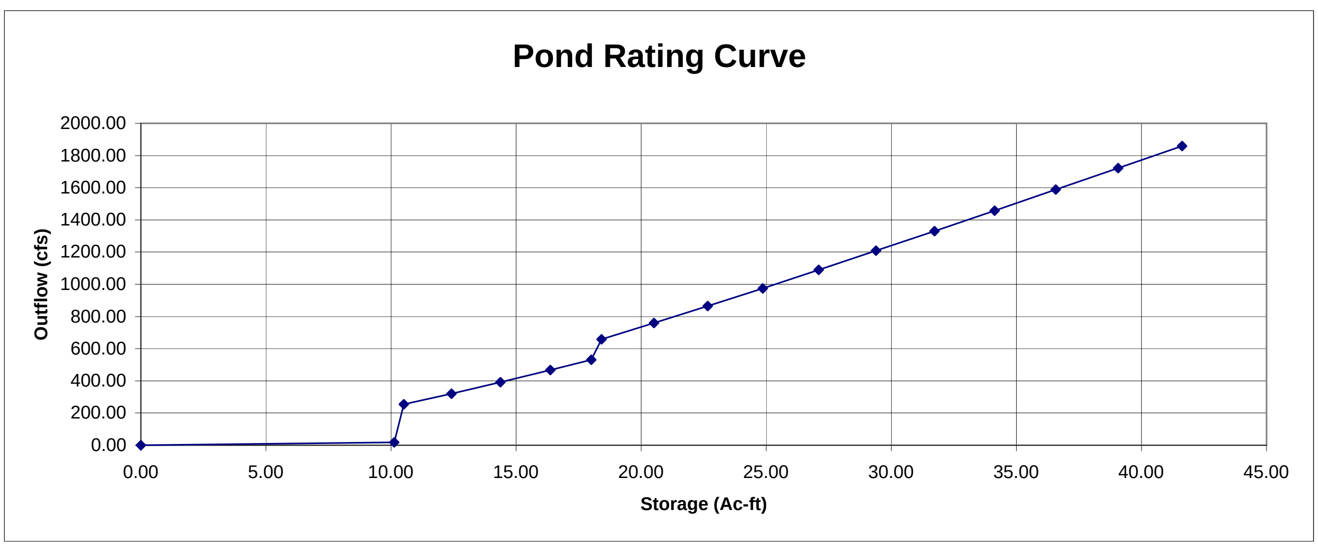
Post-Development Peak Inflow:	1805	cfs
Post-Development Peak Outflow:	1465	cfs
Pre-Development Peak Flow:	3627	cfs
Total Volume:	472.6	Ac-ft
Peak Storage:	34.3	Ac-ft

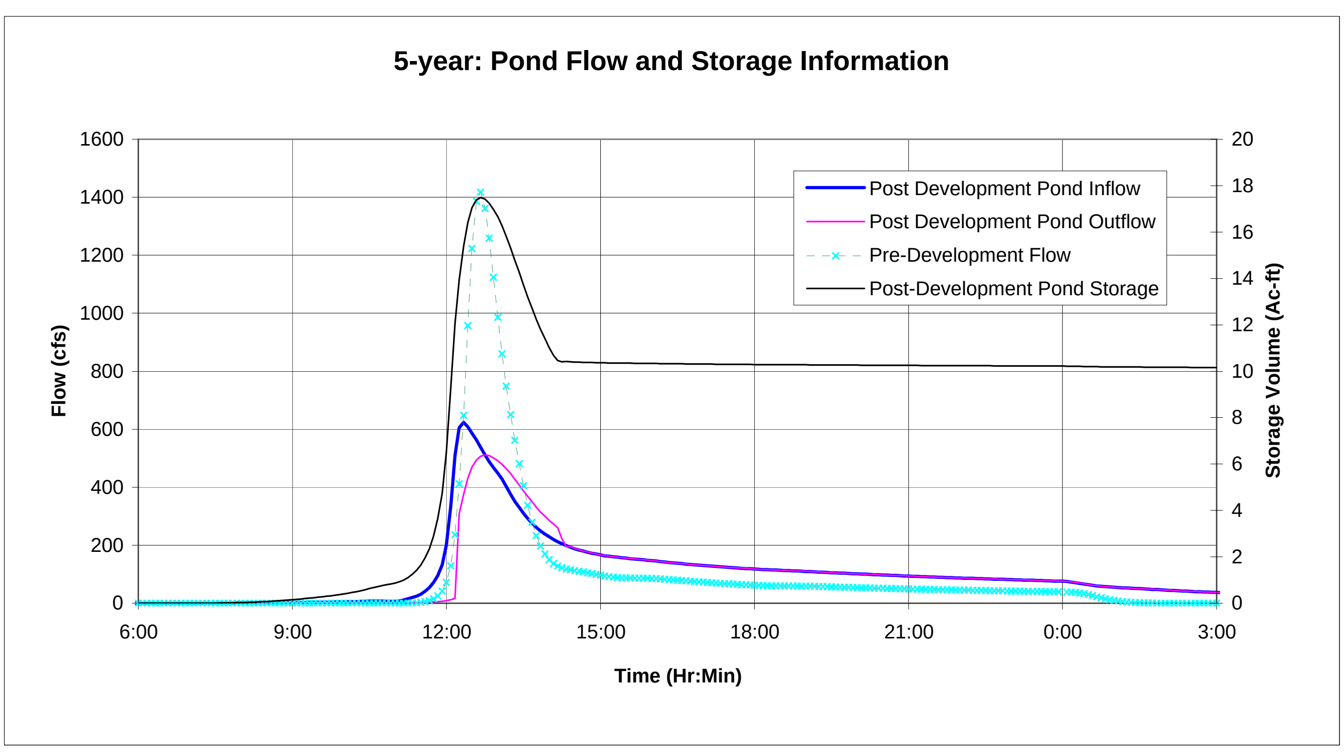
POND GEOMETRY

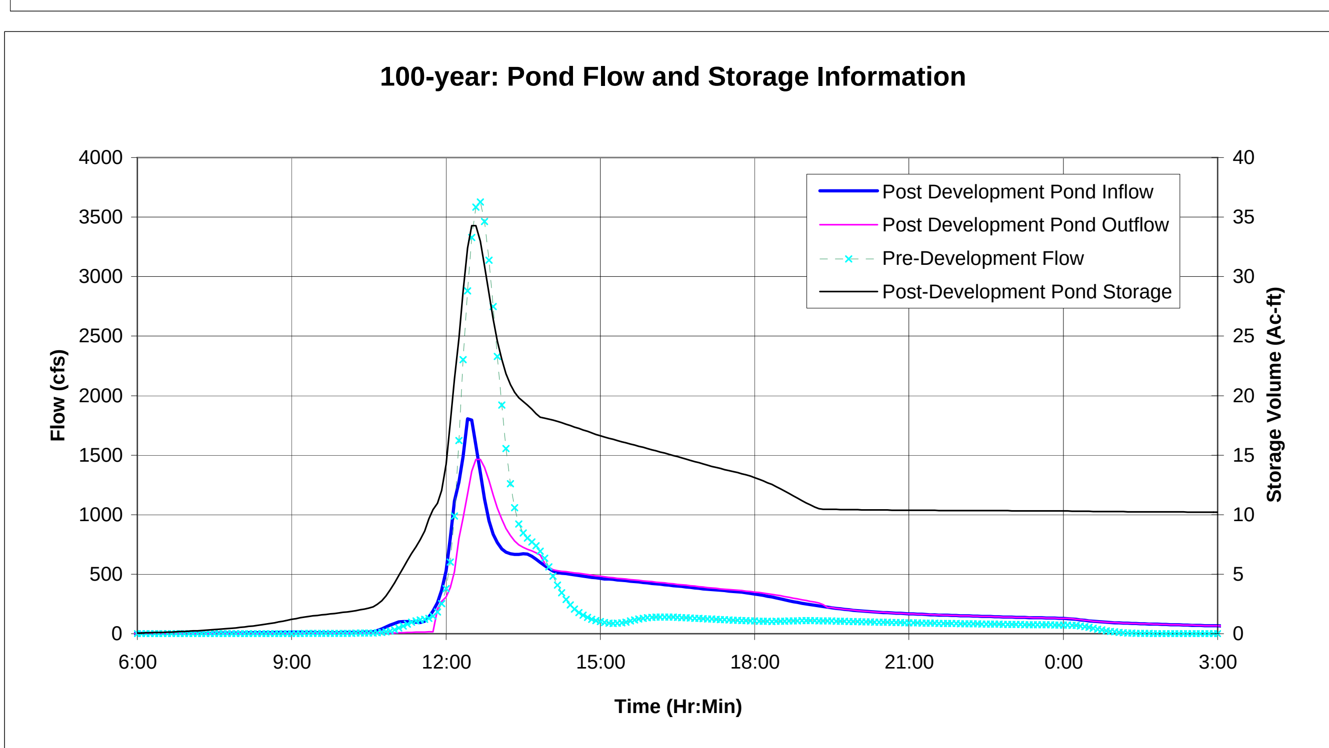
Pond Length to Width Ratio (xL:1W)	3.01		Pond Bottom Length	728	ft
Max Pond Depth	10	ft	Pond Bottom Width	194	ft
Side Slope (H:1)	4		Pond Top Length	800	ft
Pond Volume at Max. Depth	36.57	Ac-ft	Pond Top Width at Max Depth	266	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x20	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	2	
5-yr top control height	5	ft	100-yr water surface elevation	9	ft
WQCV top control height	3	ft			
			Estimated impoundment area for 100-year detention	4.89	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	10.70	Ac

Detention Pond 25-3 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
2.9	10.13	18.27
3	10.51	254.63
3.5	12.42	320.87
4	14.37	392.03
4.5	16.37	467.78
4.9	18.01	531.52
5	18.42	657.44
5.5	20.52	758.50
6	22.66	864.24
6.5	24.85	974.48
7	27.10	1089.06
7.5	29.39	1207.82
8	31.73	1330.58
8.5	34.13	1457.26
9	36.57	1587.70
9.5	39.07	1721.84
10	41.62	1859.54







Watershed 303, Pond 303-2 Output Summary

Water Quality Capture Volume: 10.79 Ac-ft

5-Year Storm Event Summary

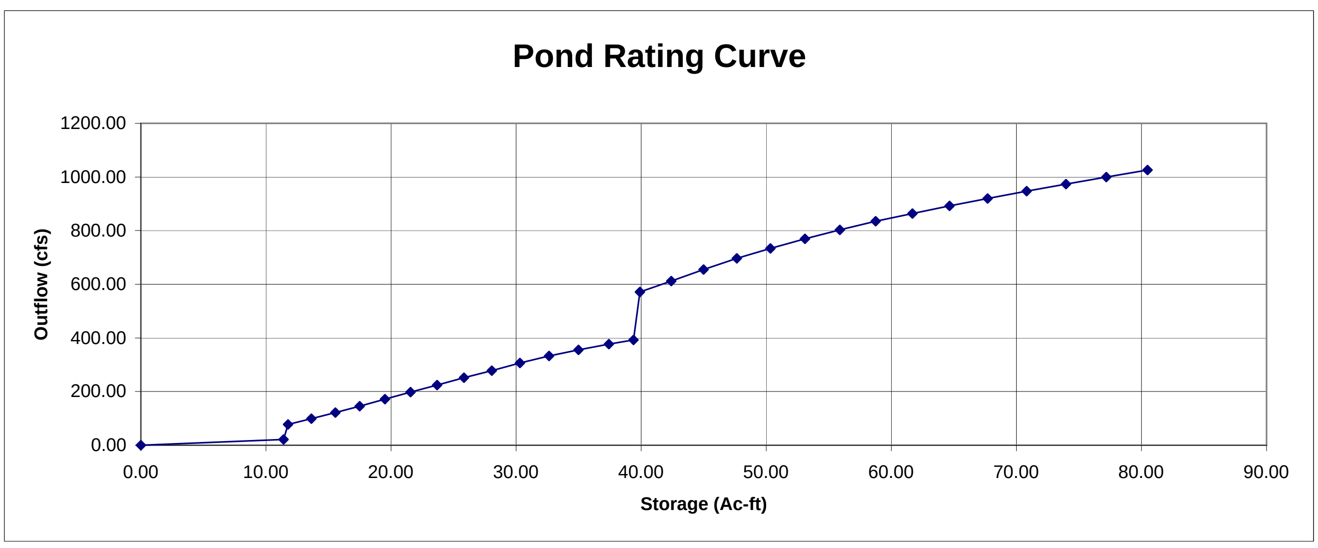
Post-Development Peak Inflow:	810	cfs
Post-Development Peak Outflow:	377	cfs
Pre-Development Peak Flow:	448	cfs
Total Volume:	106.8	Ac-ft
Peak Storage:	37.3	Ac-ft

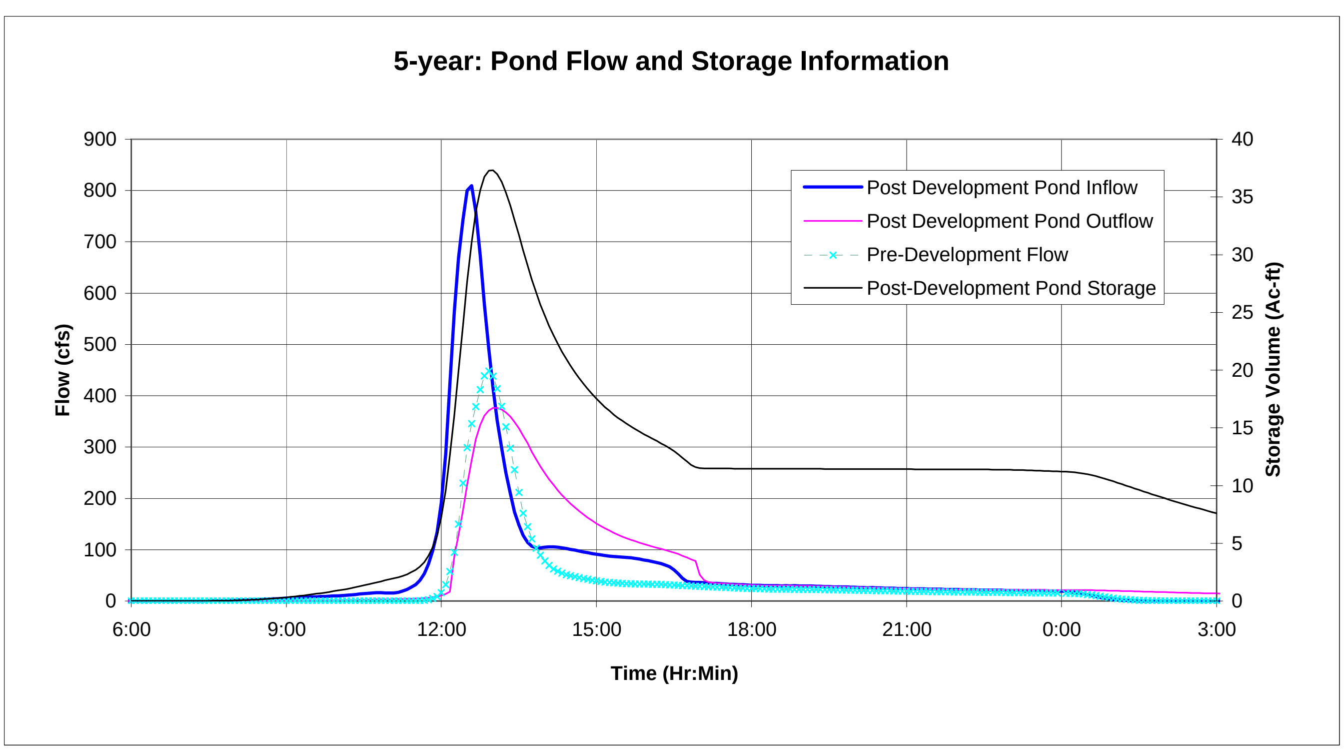
100-Year Storm Event Summary

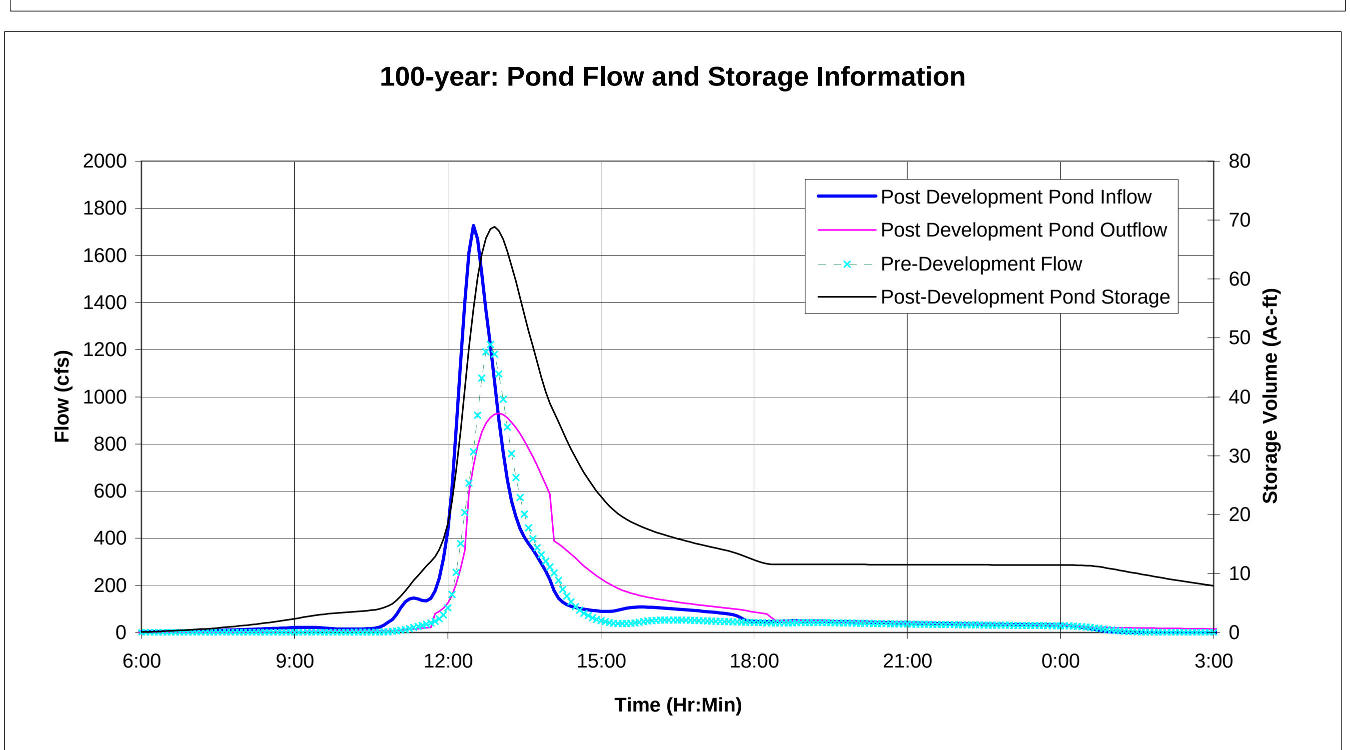
Post-Development Peak Inflow:	1727	cfs
Post-Development Peak Outflow:	930	cfs
Pre-Development Peak Flow:	1221	cfs
Total Volume:	214.9	Ac-ft
Peak Storage:	68.9	Ac-ft

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	3.00		Pond Bottom Length	772	ft
Max Pond Depth	17	ft	Pond Bottom Width	172	ft
Side Slope (H:1)	4		Pond Top Length	900	ft
Pond Volume at Max. Depth	73.97	Ac-ft	Pond Top Width at Max Depth	300	ft
5-yr control opening type	Pipe		100-yr control opening type	Pipe	
5-yr control opening size	6	ft	100-yr control opening size	8	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	10	ft	100-yr water surface elevation	16	ft
WQCV top control height	3.5	ft			
			Estimated impoundment area for 100-year detention	6.20	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	12.63	Ac







Detention Pond 303-2 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
3.4	11.40	21.76
3.5	11.76	77.54
4	13.63	98.70
4.5	15.54	121.59
5	17.50	145.92
5.5	19.51	171.37
6	21.57	197.63
6.5	23.68	224.40
7	25.84	251.36
7.5	28.05	278.37
8	30.31	306.81
8.5	32.62	332.40
9	34.99	355.91
9.5	37.41	377.35
9.9	39.39	392.57
10	39.89	571.16
10.5	42.41	612.09
11	45.00	655.37
11.5	47.64	696.08
12	50.33	733.94
12.5	53.08	769.65
13	55.89	803.32
13.5	58.76	834.95
14	61.68	863.87
14.5	64.67	891.93
15	67.71	919.61
15.5	70.81	946.86
16	73.97	973.62
16.5	77.20	999.90
17	80.48	1025.67

Watershed 25, Pond 25-2 Output Summary

Water Quality Capture Volume: 4.66 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	531	cfs
Post-Development Peak Outflow:	39	cfs
Pre-Development Peak Flow:	239	cfs
Total Volume:	46.9	Ac-ft
Peak Storage:	31.2	Ac-ft

100-Year Storm Event Summary

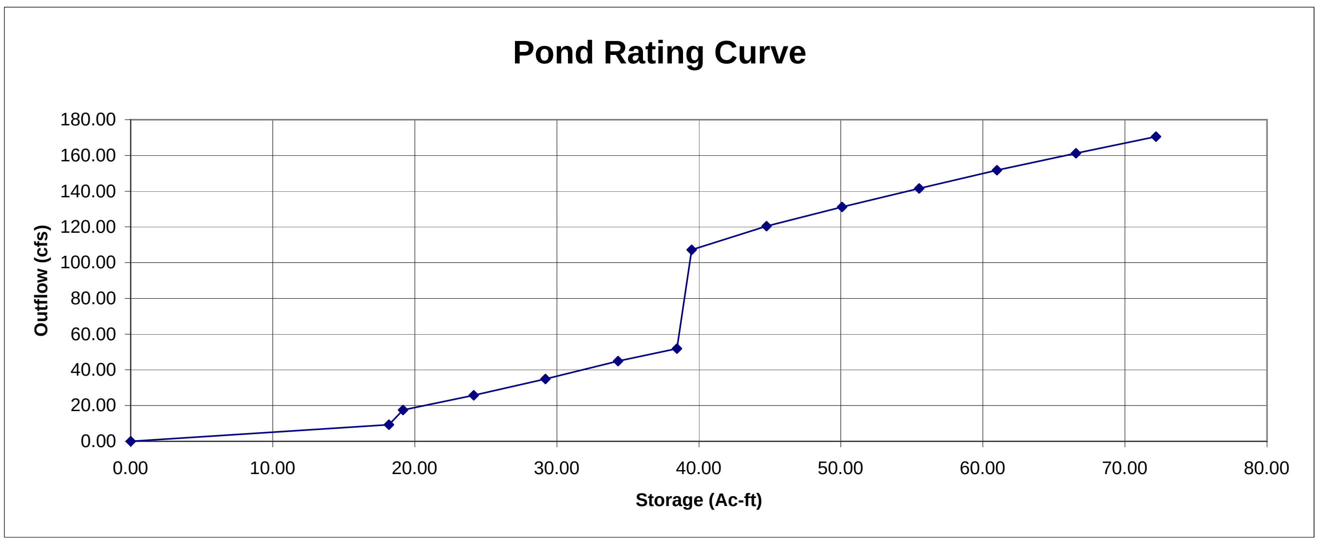
Post-Development Peak Inflow:	1092	cfs
Post-Development Peak Outflow:	150	cfs
Pre-Development Peak Flow:	620	cfs
Total Volume:	95.0	Ac-ft
Peak Storage:	59.9	Ac-ft

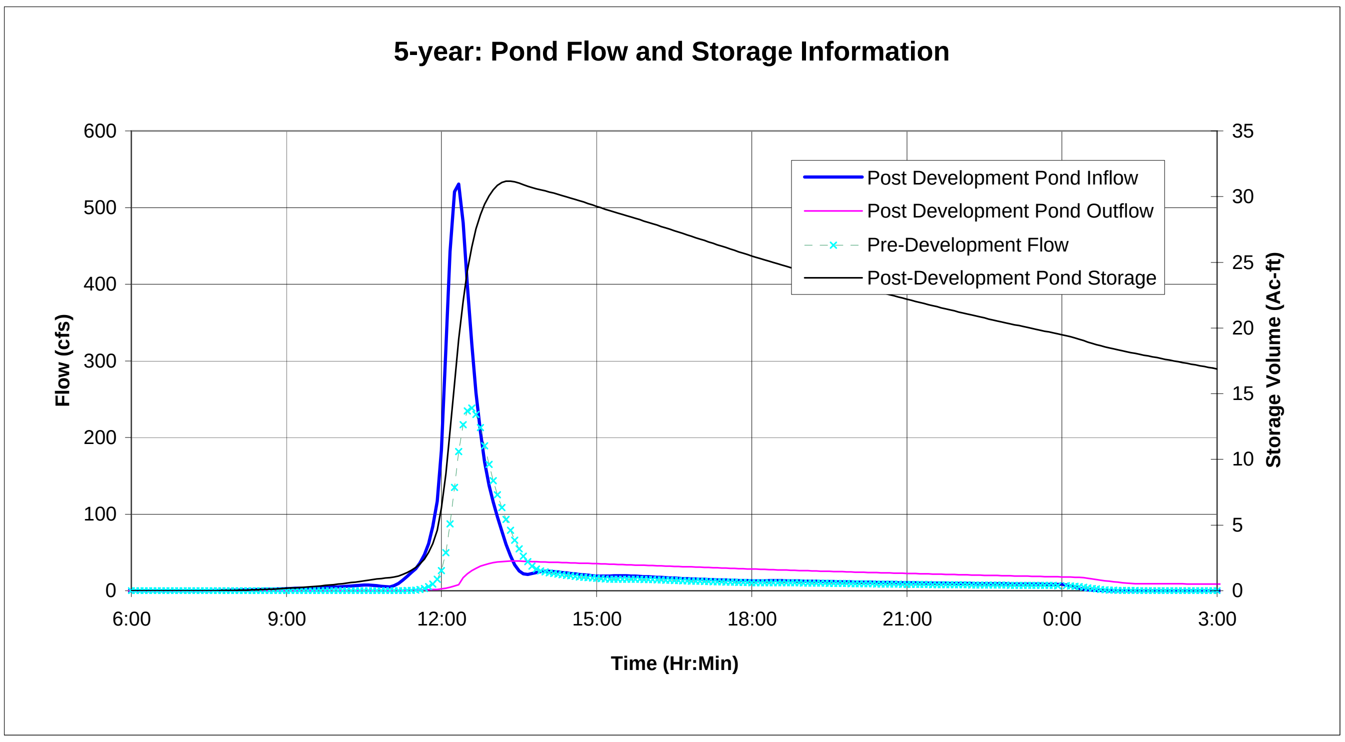
Detention Pond 25-2 Rating Curve

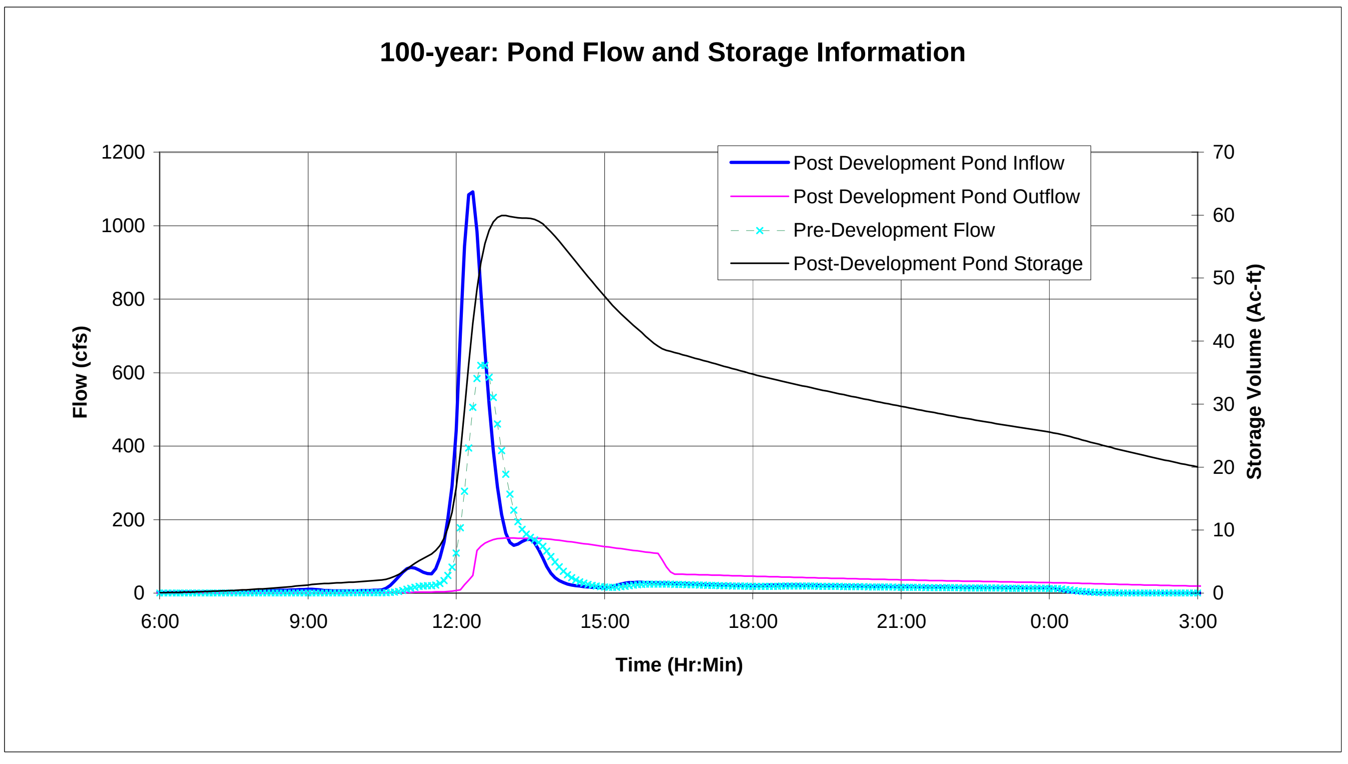
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	18.19	9.39
2	19.18	17.45
2.5	24.15	25.79
3	29.19	34.94
3.5	34.31	44.83
3.9	38.45	51.97
4	39.49	107.18
4.5	44.75	120.36
5	50.09	131.10
5.5	55.50	141.58
6	60.99	151.66
6.5	66.55	161.30
7	72.18	170.54

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	3.00		Pond Bottom Length	1152	ft
Max Pond Depth	7	ft	Pond Bottom Width	352	ft
Side Slope (H:1)	4		Pond Top Length	1200	ft
Pond Volume at Max. Depth	60.99	Ac-ft	Pond Top Width at Max Depth	400	ft
5-yr control opening type	Pipe		100-yr control opening type	Pipe	
5-yr control opening size	3	ft	100-yr control opening size	3	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	2	
5-yr top control height	4	ft	100-yr water surface elevation	6	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	11.02	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	19.28	Ac







Watershed 25, Pond 25-1 Output Summary

Water Quality Capture Volume: 6.47 Ac-ft

Detention Pond 25-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	22.13	13.04
2	23.32	17.45
2.5	29.34	25.79
3	35.43	34.94
3.5	41.60	44.83
4	47.84	53.59
4.5	54.16	60.18
4.9	59.27	64.48
5	60.55	113.69
5.5	67.03	132.05
6	73.58	149.34
6.5	80.21	164.67
7	86.92	177.88
7.5	93.71	188.81
8	100.58	199.68
8.5	107.53	210.29
9	114.56	220.60

5-Year Storm Event Summary

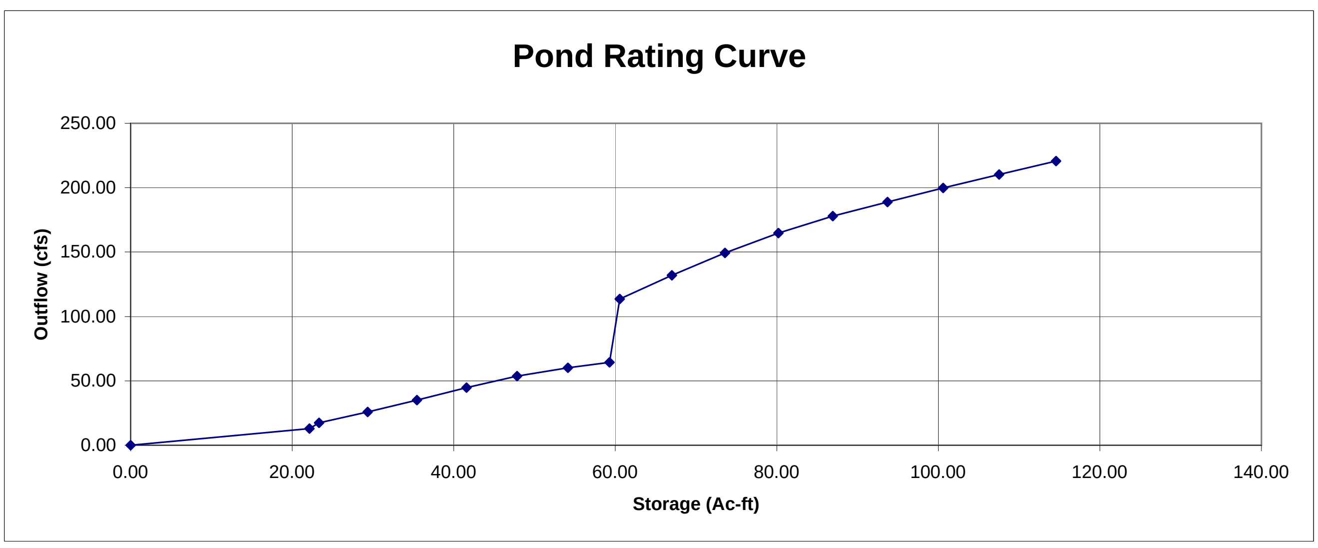
Post-Development Peak Inflow:	925	cfs
Post-Development Peak Outflow:	47	cfs
Pre-Development Peak Flow:	402	cfs
Total Volume:	64.8	Ac-ft
Peak Storage:	43.4	Ac-ft

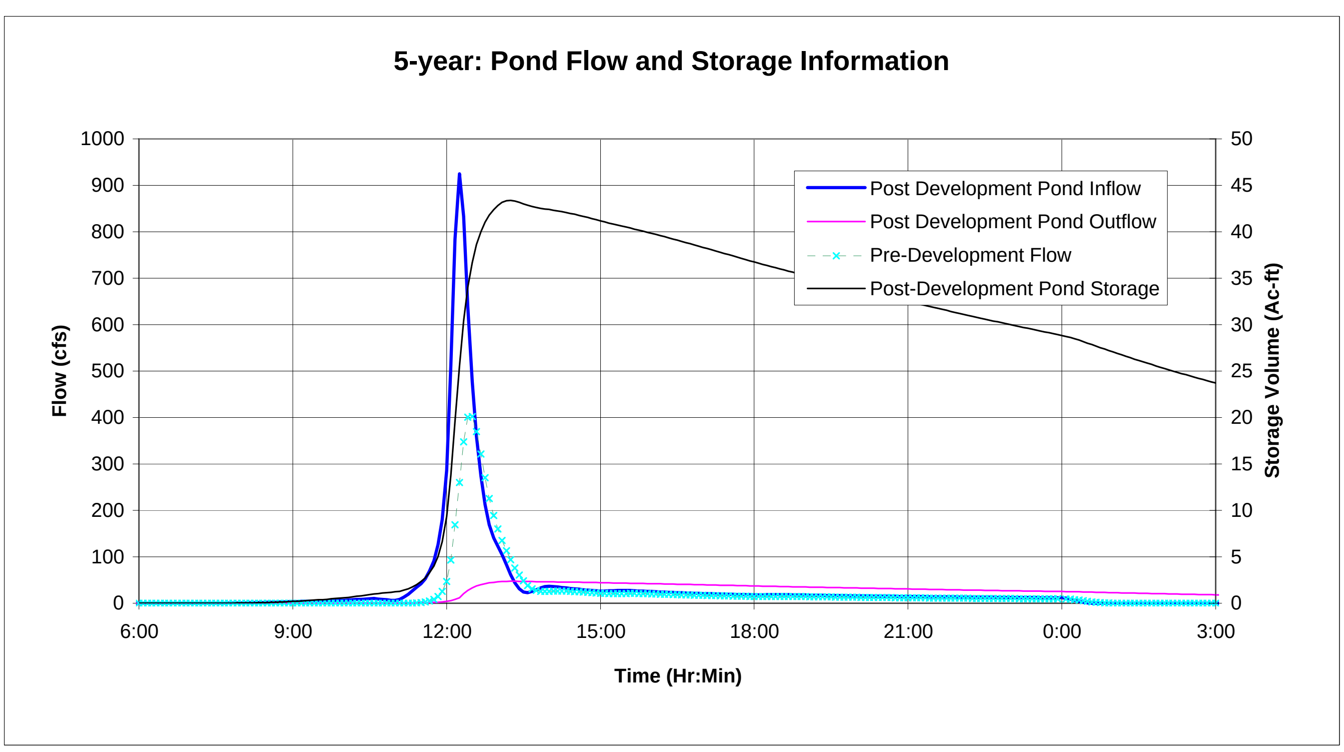
100-Year Storm Event Summary

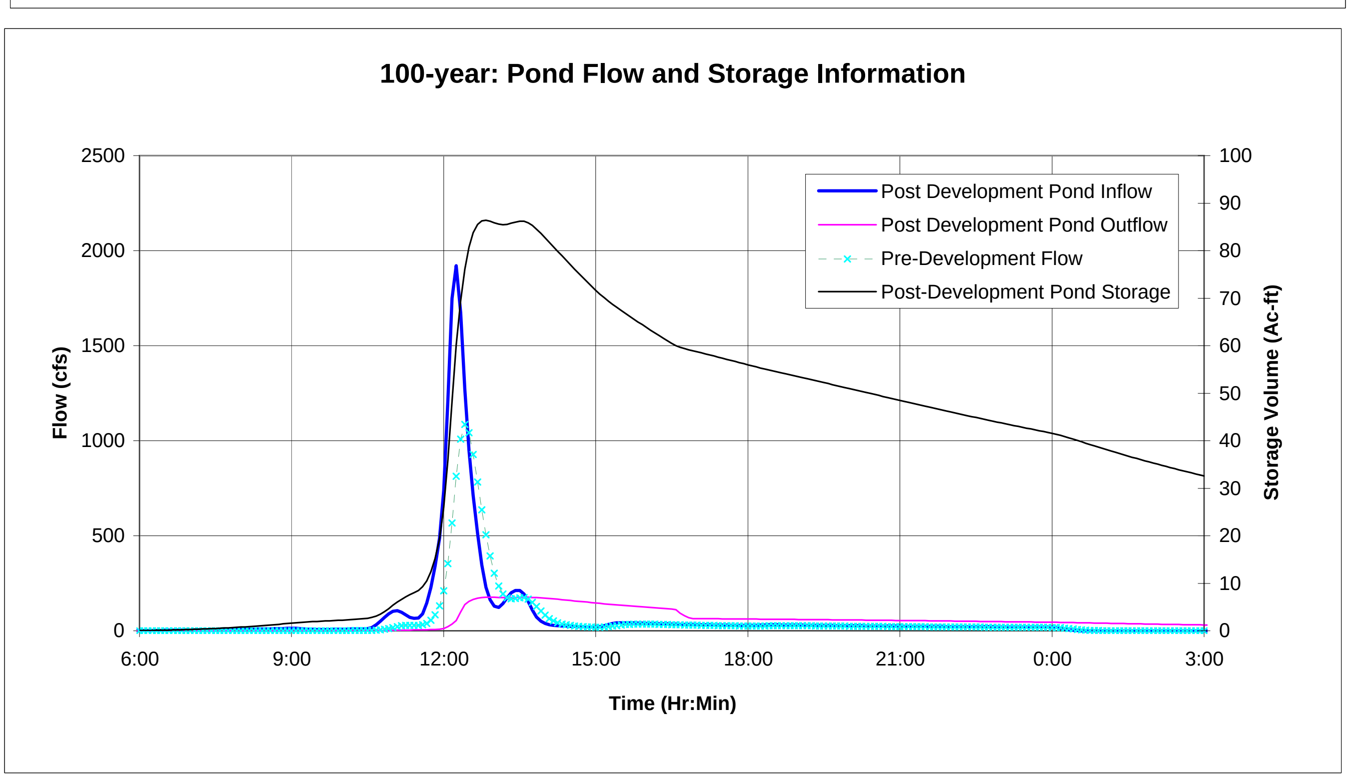
Post-Development Peak Inflow:	1921	cfs
Post-Development Peak Outflow:	177	cfs
Pre-Development Peak Flow:	1087	cfs
Total Volume:	132.3	Ac-ft
Peak Storage:	86.4	Ac-ft

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	2.40		Pond Bottom Length	1136	ft
Max Pond Depth	9	ft	Pond Bottom Width	436	ft
Side Slope (H:1)	4		Pond Top Length	1200	ft
Pond Volume at Max. Depth	100.58	Ac-ft	Pond Top Width at Max Depth	500	ft
5-yr control opening type	Pipe		100-yr control opening type	Pipe	
5-yr control opening size	3	ft	100-yr control opening size	4.5	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	5	ft	100-yr water surface elevation	8	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	13.77	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	22.50	Ac







Watershed 41A, Pond 41A Output Summary

Water Quality Capture Volume: 13.85 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1412	cfs
Post-Development Peak Outflow:	476	cfs
Pre-Development Peak Flow:	552	cfs
Total Volume:	129.6	Ac-ft
Peak Storage:	62.9	Ac-ft

100-Year Storm Event Summary

Post-Development Peak Inflow:	2777	cfs
Post-Development Peak Outflow:	1092	cfs
Pre-Development Peak Flow:	1414	cfs
Total Volume:	250.3	Ac-ft
Peak Storage:	116.2	Ac-ft

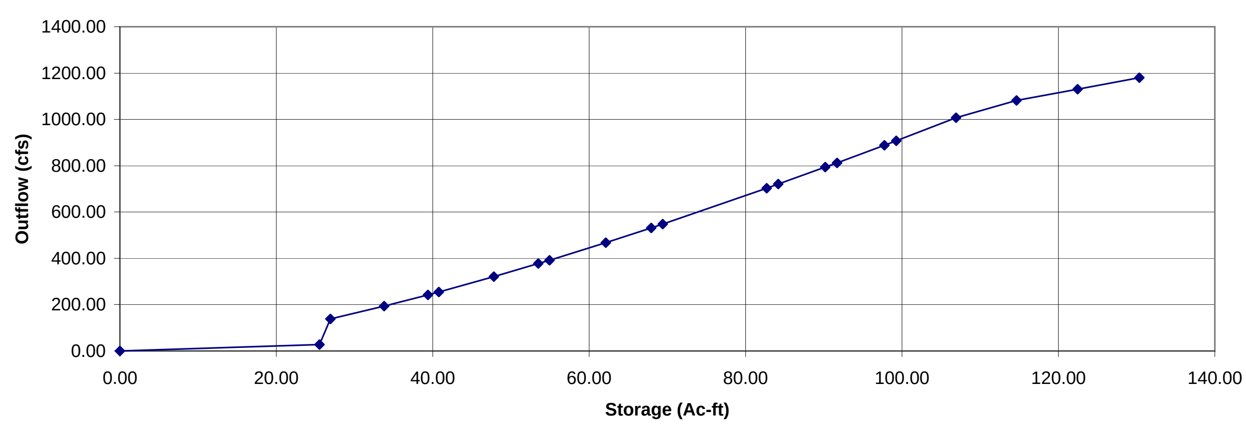
POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.20		Pond Bottom Length	836	ft
Max Pond Depth	9	ft	Pond Bottom Width	686	ft
Side Slope (H:1)	4		Pond Top Length	900	ft
Pond Volume at Max. Depth	114.65	Ac-ft	Pond Top Width at Max Depth	750	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x10	ft	100-yr control opening size	6x10	ft
Number of parallel 5-yr openings	2		Number of parallel 100-yr structures	2	
5-yr top control height	5	ft	100-yr water surface elevation	8	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	15.50	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	23.99	Ac

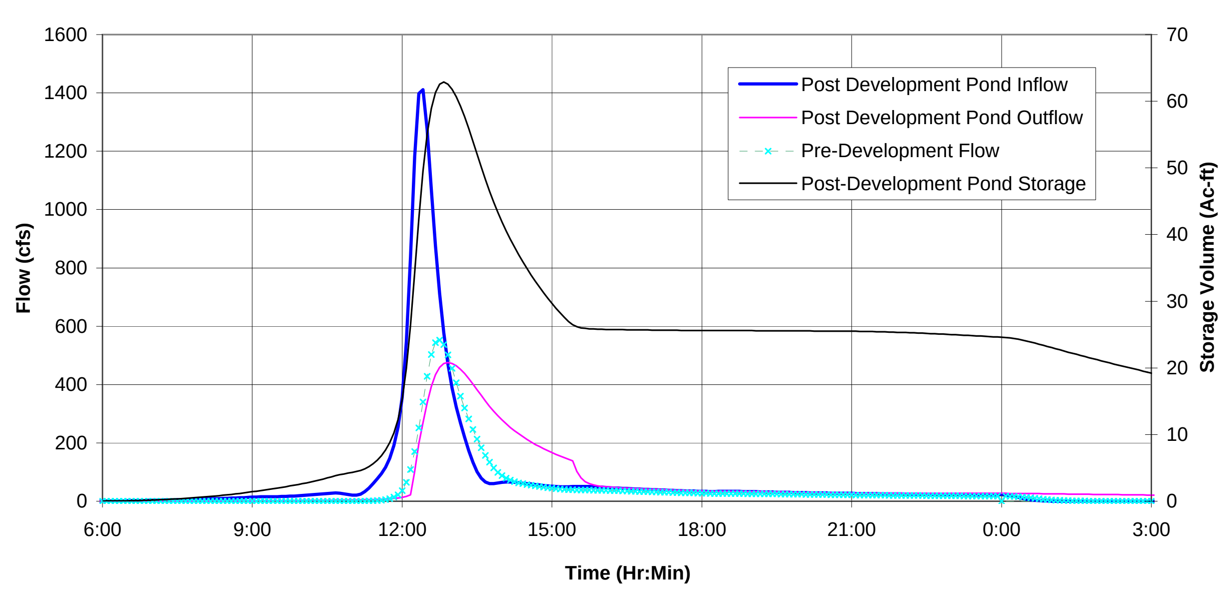
Detention Pond 41A Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	25.52	27.93
2	26.90	138.60
2.5	33.80	193.70
2.9	39.37	242.00
3	40.77	254.62
3.5	47.82	320.86
3.9	53.52	377.42
4	54.95	392.02
4.5	62.14	467.78
4.9	67.95	531.52
5	69.41	547.88
5.9	82.69	702.26
6	84.18	720.20
6.4	90.18	793.40
6.5	91.68	812.08
6.9	97.74	888.18
7	99.26	907.56
7.5	106.91	1006.50
8	114.65	1082.44
8.5	122.46	1130.76
9	130.35	1180.70

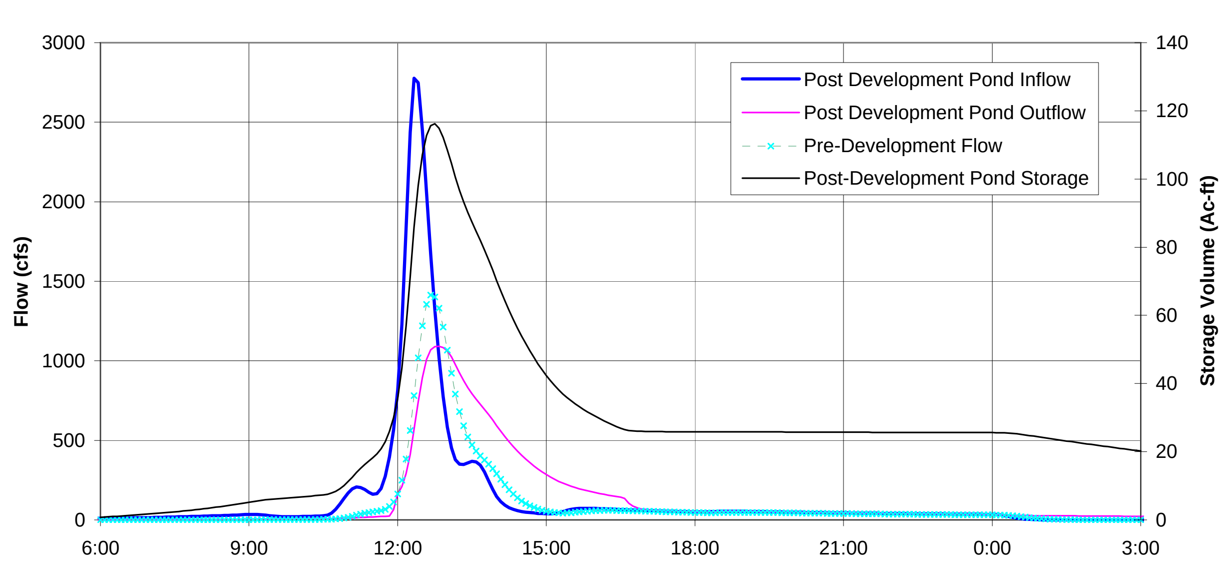
Pond Rating Curve



5-year: Pond Flow and Storage Information



100-year: Pond Flow and Storage Information



Watershed 401, Pond BMP 401-2 Output Summary

Water Quality Capture Volume: 22.47 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	695	cfs
Post-Development Peak Outflow:	383	cfs
Pre-Development Peak Flow:	501	cfs
Total Volume:	147.8	Ac-ft
Peak Storage:	63.1	Ac-ft

100-Year Storm Event Summary

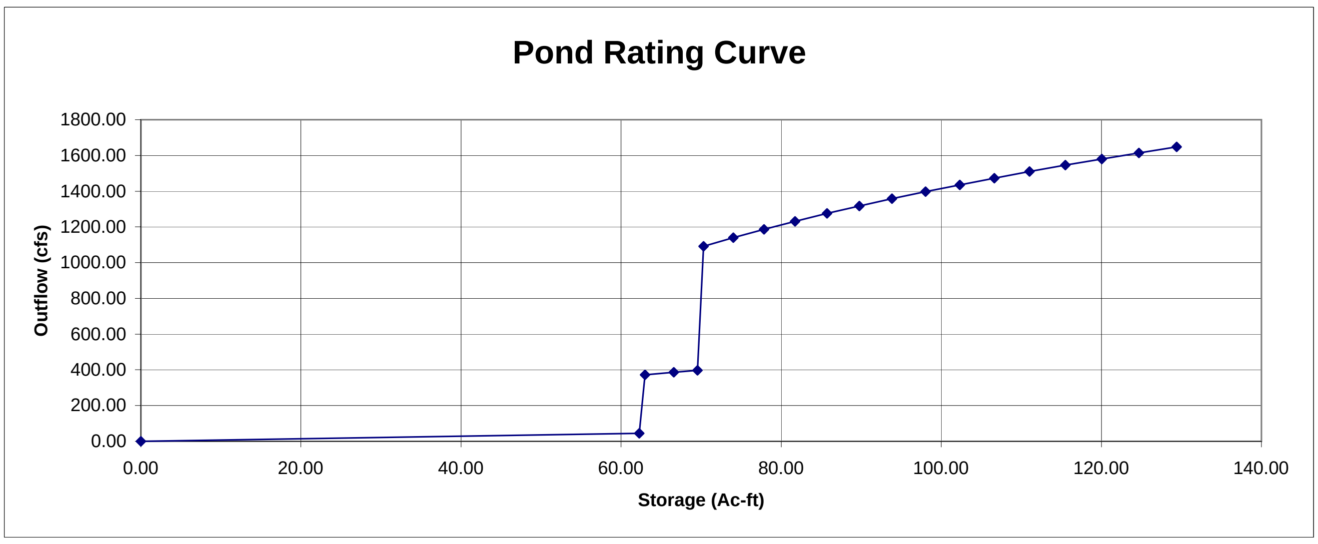
Post-Development Peak Inflow:	2447	cfs
Post-Development Peak Outflow:	1569	cfs
Pre-Development Peak Flow:	1708	cfs
Total Volume:	430.1	Ac-ft
Peak Storage:	114.1	Ac-ft

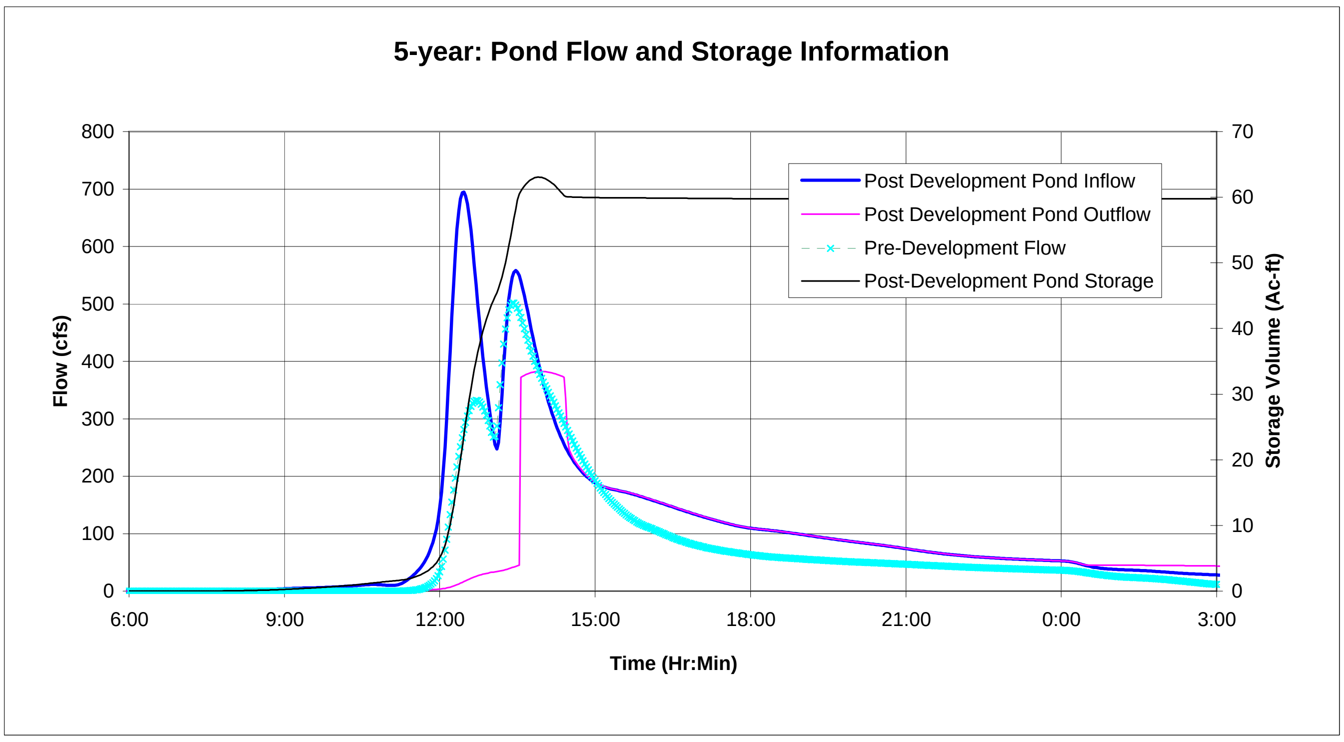
POND GEOMETRY

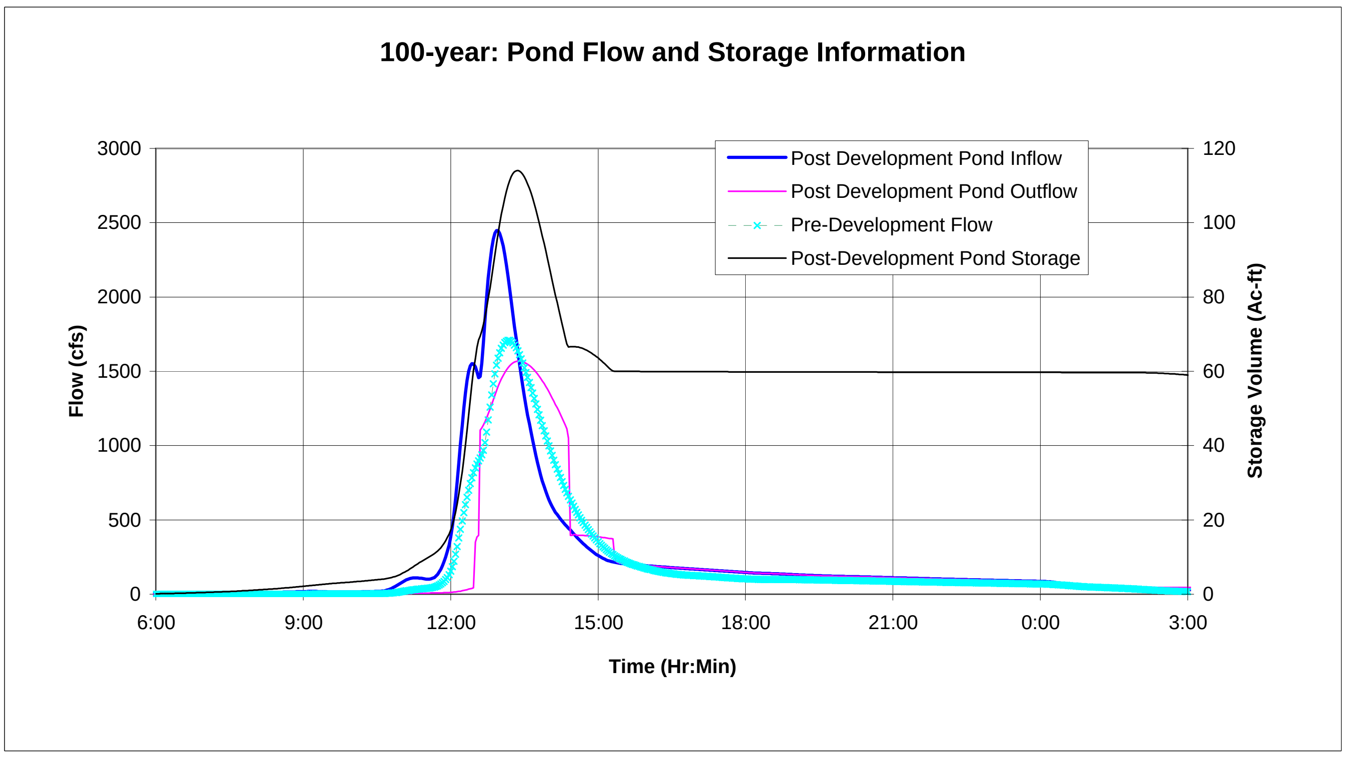
Pond Length to Width Ratio (xL:1W)	3.69		Pond Bottom Length	1056	ft
Max Pond Depth	19	ft	Pond Bottom Width	181	ft
Side Slope (H:1)	4		Pond Top Length	1200	ft
Pond Volume at Max. Depth	120.07	Ac-ft	Pond Top Width at Max Depth	325	ft
5-yr control opening type	Pipe		100-yr control opening type	Box	
5-yr control opening size	5.5	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	12	ft	100-yr water surface elevation	18	ft
WQCV top control height	11	ft			
			Estimated impoundment area for 100-year detention	8.95	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	16.87	Ac

Detention Pond BMP 401-2 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
10.9	62.27	45.32
11	62.99	371.55
11.5	66.60	385.65
11.9	69.54	396.66
12	70.28	1090.68
12.5	74.03	1139.53
13	77.85	1186.36
13.5	81.75	1231.42
14	85.71	1274.88
14.5	89.75	1316.91
15	93.86	1357.65
15.5	98.04	1397.19
16	102.29	1435.64
16.5	106.63	1473.09
17	111.03	1509.62
17.5	115.51	1545.28
18	120.07	1580.13
18.5	124.70	1614.23
19	129.41	1648.63







Watershed 401, Pond BMP 401-1 Output Summary

Water Quality Capture Volume: 14.58 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1139	cfs
Post-Development Peak Outflow:	659	cfs
Pre-Development Peak Flow:	803	cfs
Total Volume:	238.1	Ac-ft
Peak Storage:	51.7	Ac-ft

100-Year Storm Event Summary

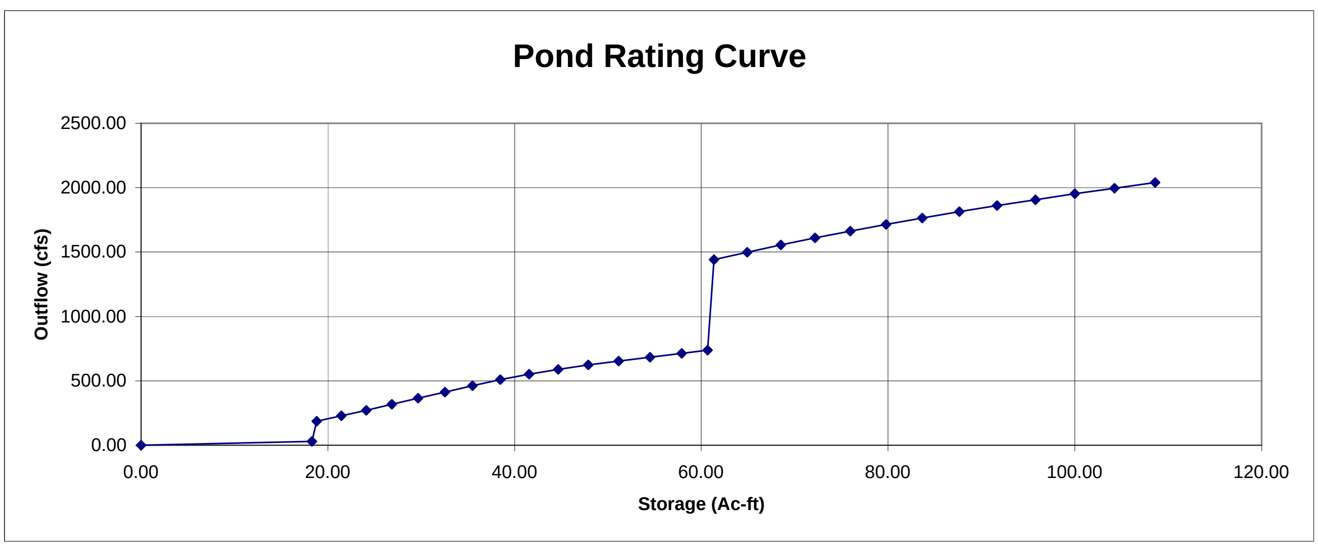
Post-Development Peak Inflow:	2707	cfs
Post-Development Peak Outflow:	1884	cfs
Pre-Development Peak Flow:	2439	cfs
Total Volume:	728.5	Ac-ft
Peak Storage:	93.8	Ac-ft

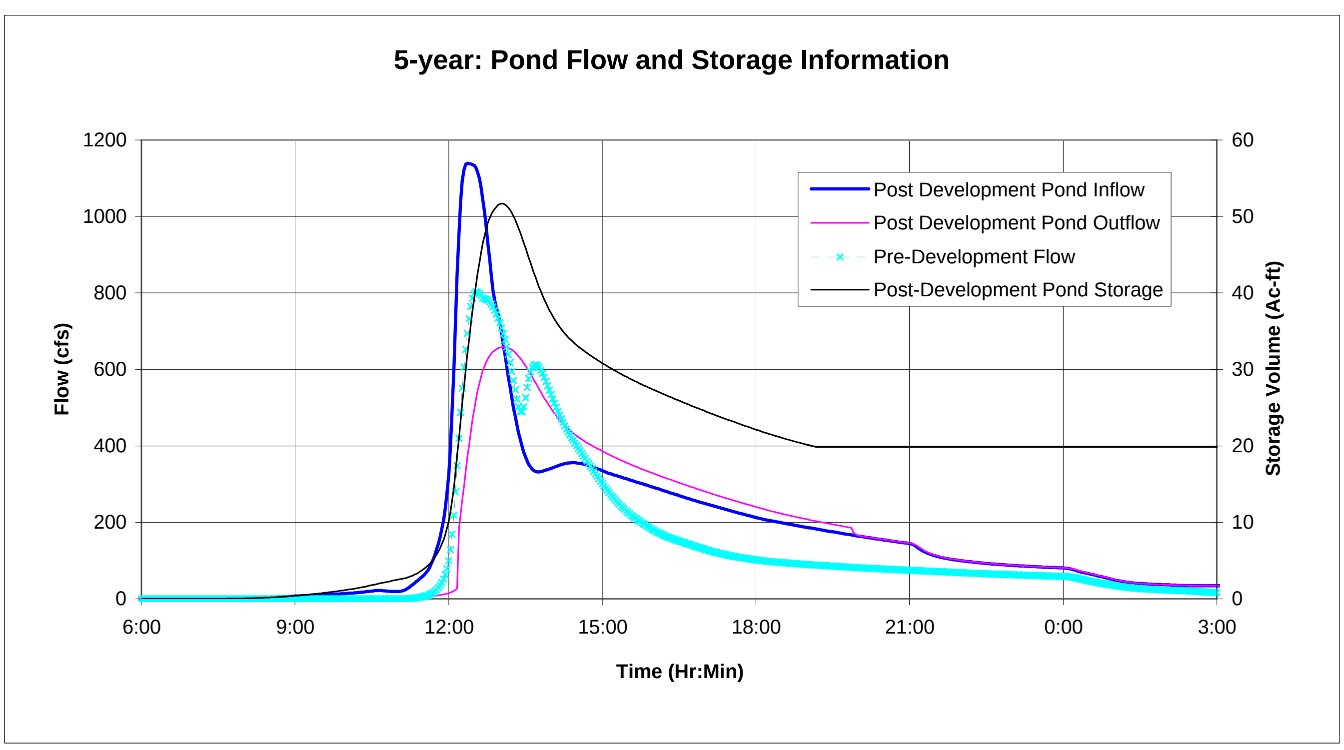
POND GEOMETRY

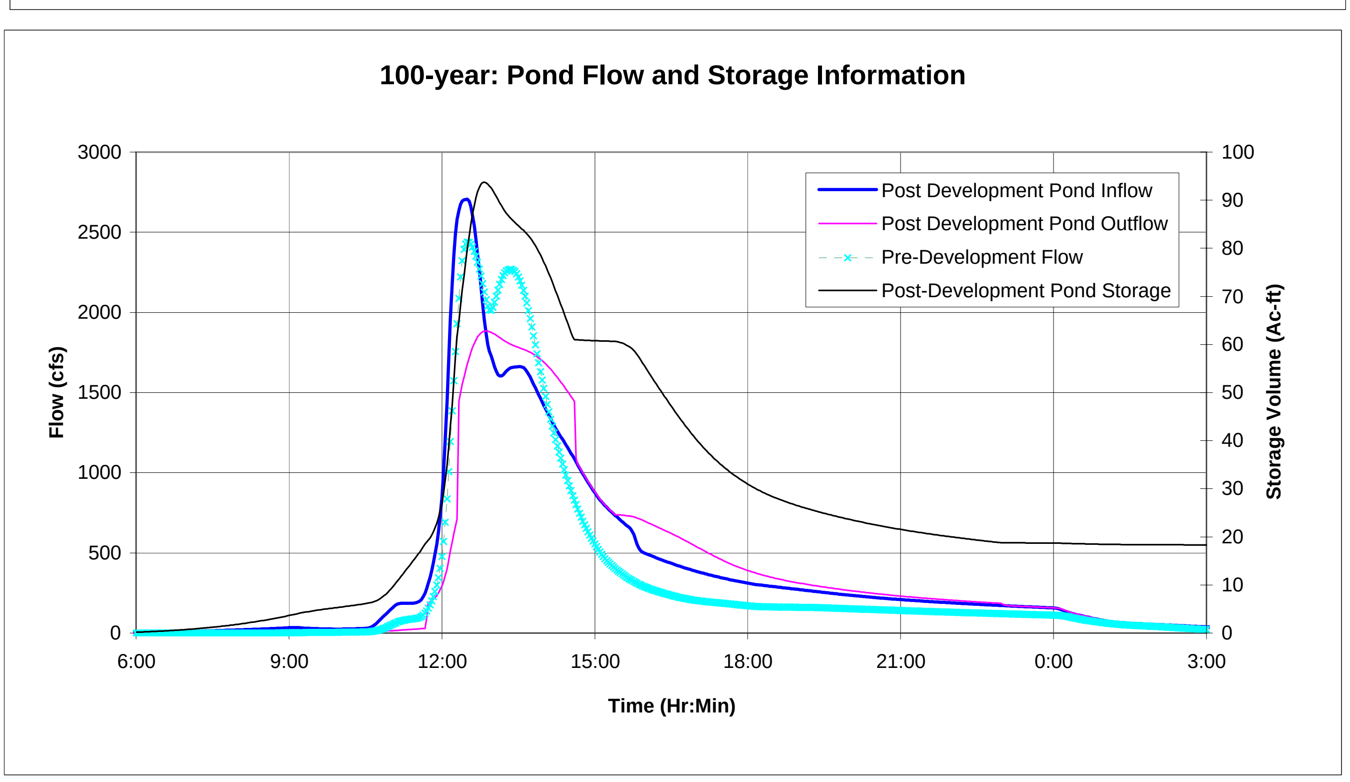
Pond Length to Width Ratio (xL:1W)	4.00		Pond Bottom Length	1072	ft
Max Pond Depth	17	ft	Pond Bottom Width	172	ft
Side Slope (H:1)	4		Pond Top Length	1200	ft
Pond Volume at Max. Depth	99.98	Ac-ft	Pond Top Width at Max Depth	300	ft
5-yr control opening type	Pipe		100-yr control opening type	Box	
5-yr control opening size	5.5	ft	100-yr control opening size	6x20	ft
Number of parallel 5-yr openings	2		Number of parallel 100-yr structures	1	
5-yr top control height	11	ft	100-yr water surface elevation	16	ft
WQCV top control height	4	ft			
			Estimated impoundment area for 100-year detention	8.26	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	16.07	Ac

Detention Pond BMP 401-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
3.9	18.29	29.41
4	18.81	185.36
4.5	21.43	227.52
5	24.11	271.94
5.5	26.86	317.98
6	29.67	365.00
6.5	32.54	412.32
7	35.48	461.98
7.5	38.48	508.94
8	41.55	551.50
8.5	44.68	590.02
9	47.88	623.36
9.5	51.15	654.14
10	54.49	684.46
10.5	57.89	714.16
10.9	60.66	737.38
11	61.36	1440.45
11.5	64.90	1498.37
12	68.51	1555.13
12.5	72.19	1609.96
13	75.95	1663.04
13.5	79.77	1714.54
14	83.67	1764.59
14.5	87.63	1813.31
15	91.67	1860.81
15.5	95.79	1907.16
16	99.98	1952.46
16.5	104.24	1996.76
17	108.58	2040.15







Watershed 40, Pond 40-2 Output Summary

Water Quality Capture Volume: 30.12 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1398	cfs
Post-Development Peak Outflow:	1264	cfs
Pre-Development Peak Flow:	1466	cfs
Total Volume:	1511.8	Ac-ft
Peak Storage:	302.1	Ac-ft

100-Year Storm Event Summary

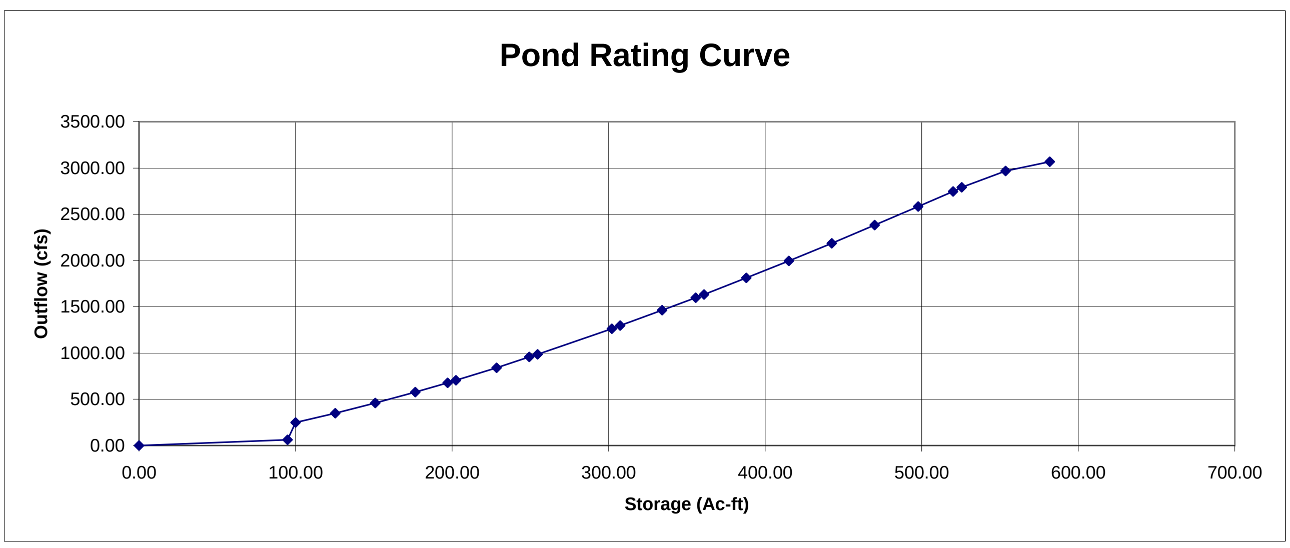
Post-Development Peak Inflow:	2737	cfs
Post-Development Peak Outflow:	2614	cfs
Pre-Development Peak Flow:	3682	cfs
Total Volume:	3204.7	Ac-ft
Peak Storage:	501.9	Ac-ft

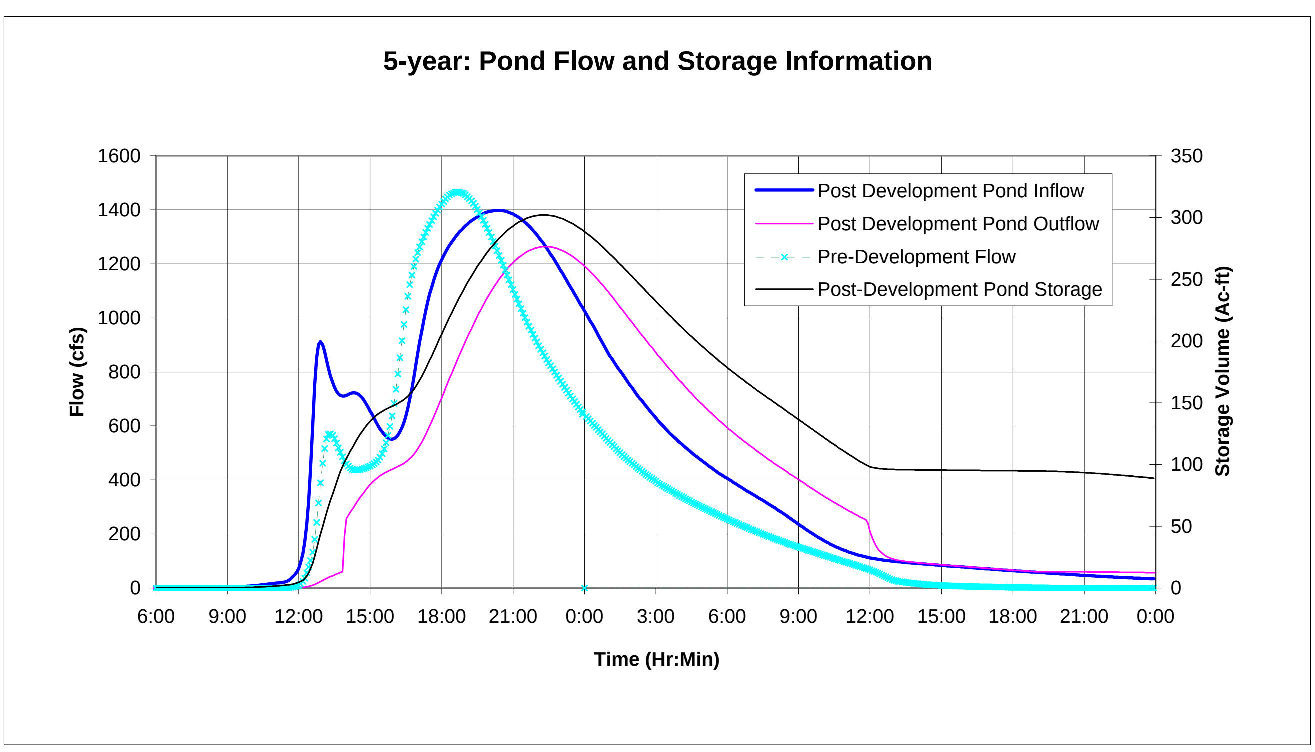
POND GEOMETRY

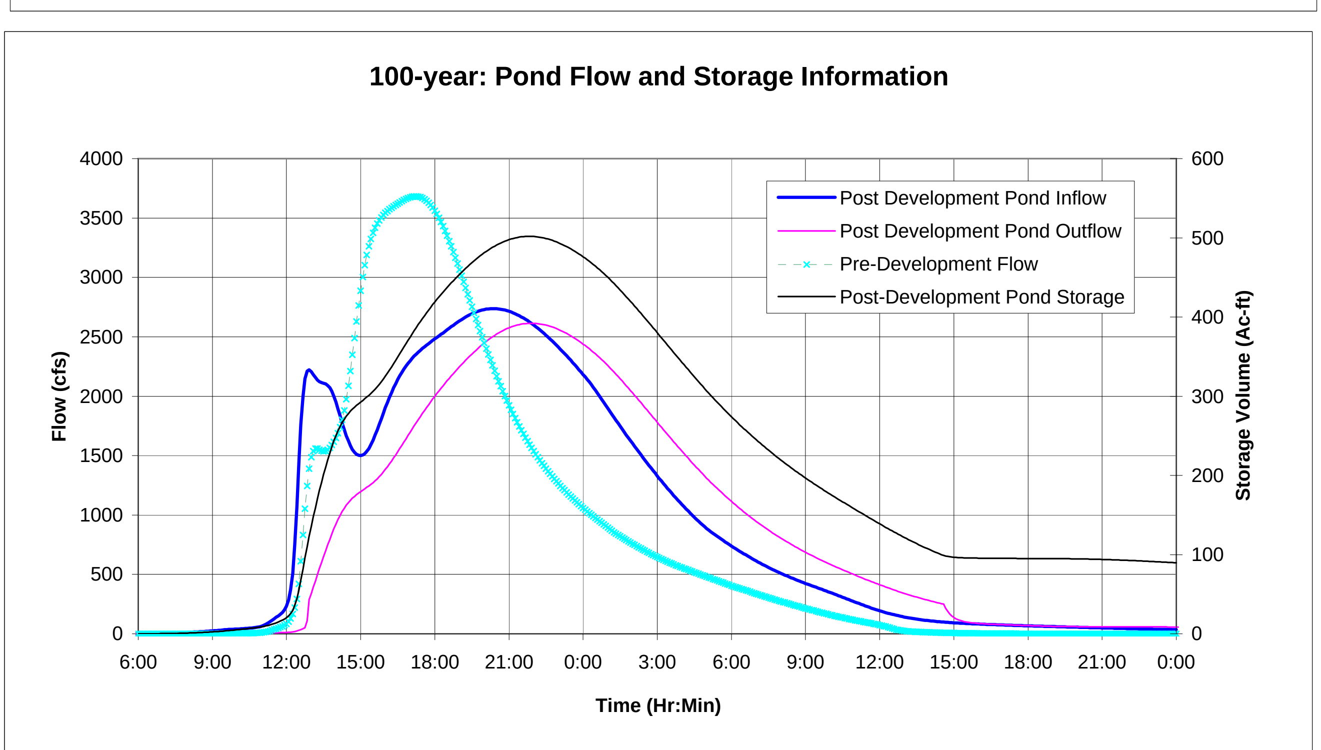
Pond Length to Width Ratio (xL:1W)	3.00		Pond Bottom Length	2620	ft
Max Pond Depth	11	ft	Pond Bottom Width	820	ft
Side Slope (H:1)	4		Pond Top Length	2700	ft
Pond Volume at Max. Depth	525.53	Ac-ft	Pond Top Width at Max Depth	900	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	8x12	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	3		Number of parallel 100-yr structures	3	
5-yr top control height	6	ft	100-yr water surface elevation	10	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	55.79	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	73.23	Ac

Detention Pond 40-2 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	94.85	60.75
2	99.91	249.48
2.5	125.29	348.66
3	150.82	458.34
3.5	176.52	577.56
3.9	197.20	679.35
4	202.38	705.66
4.5	228.41	842.01
4.9	249.34	956.73
5	254.59	986.16
5.9	302.14	1264.08
6	307.45	1296.36
6.5	334.13	1461.72
6.9	355.59	1598.73
7	360.97	1633.59
7.5	387.98	1811.73
8	415.16	1995.87
8.5	442.50	2185.89
9	470.01	2381.55
9.5	497.68	2582.76
9.9	519.95	2747.58
10	525.53	2789.31
10.5	553.54	2966.28
11	581.73	3066.69







Watershed 304, Pond 304 Output Summary

Water Quality Capture Volume: 5.96 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	609	cfs
Post-Development Peak Outflow:	254	cfs
Pre-Development Peak Flow:	323	cfs
Total Volume:	57.7	Ac-ft
Peak Storage:	24.6	Ac-ft

100-Year Storm Event Summary

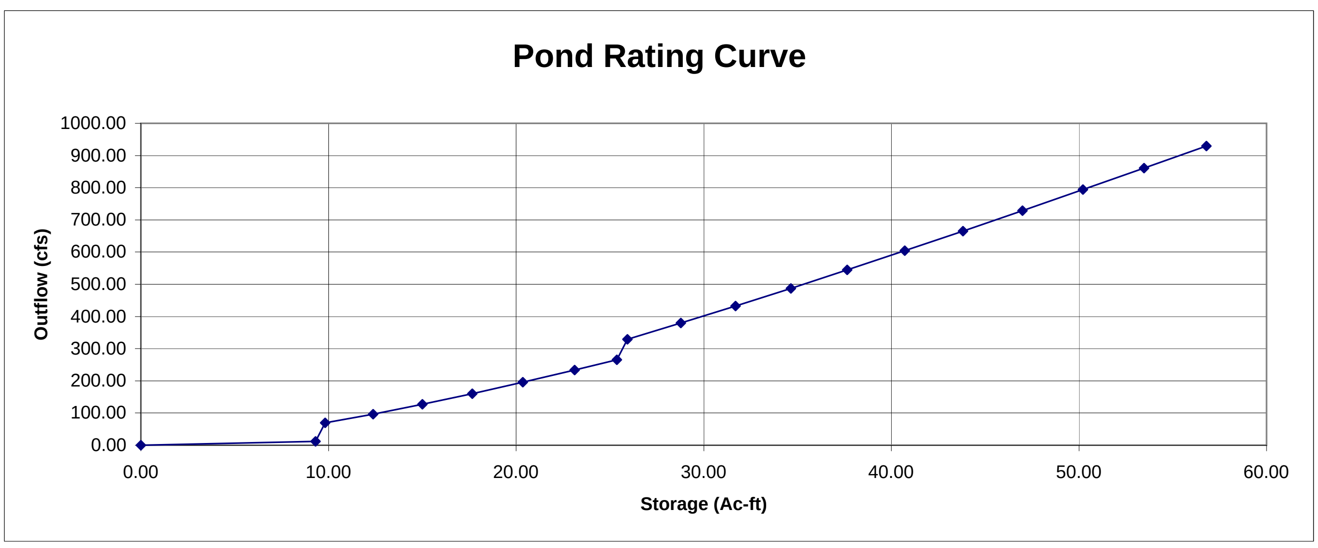
Post-Development Peak Inflow:	1307	cfs
Post-Development Peak Outflow:	703	cfs
Pre-Development Peak Flow:	853	cfs
Total Volume:	119.4	Ac-ft
Peak Storage:	45.7	Ac-ft

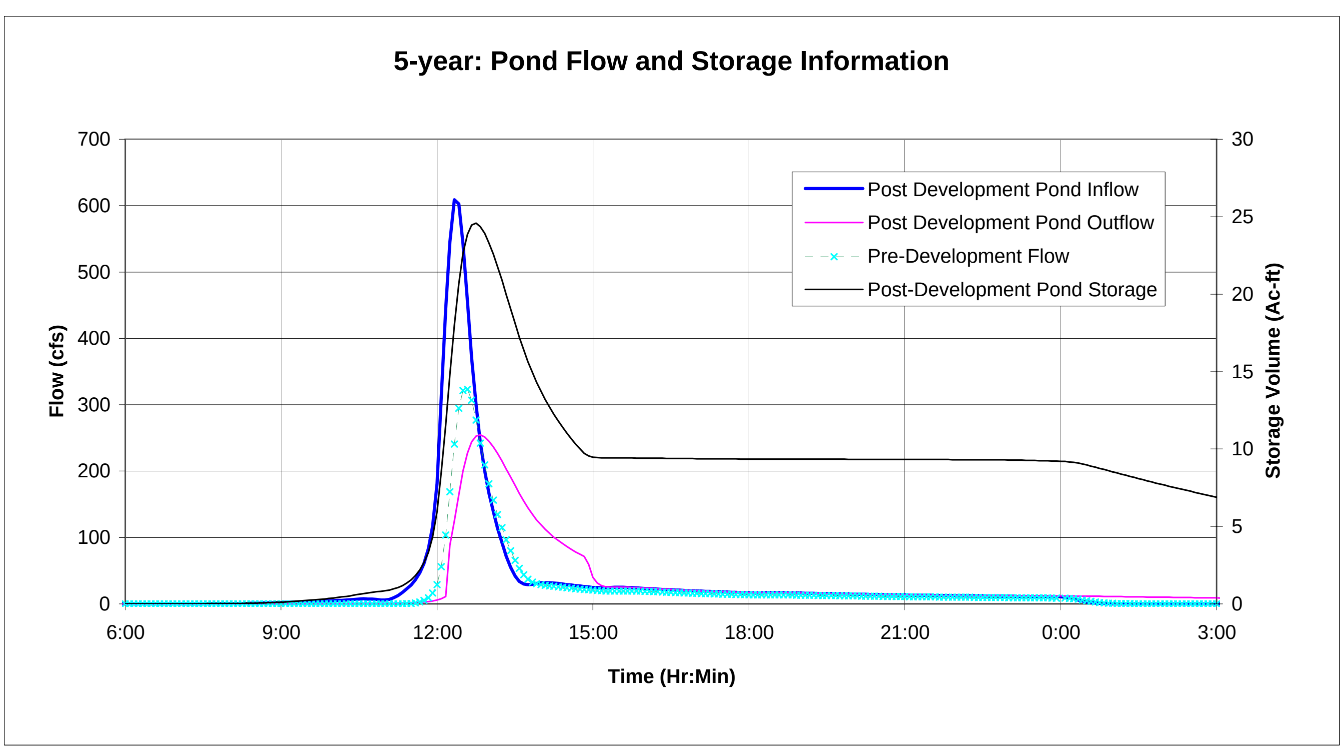
POND GEOMETRY

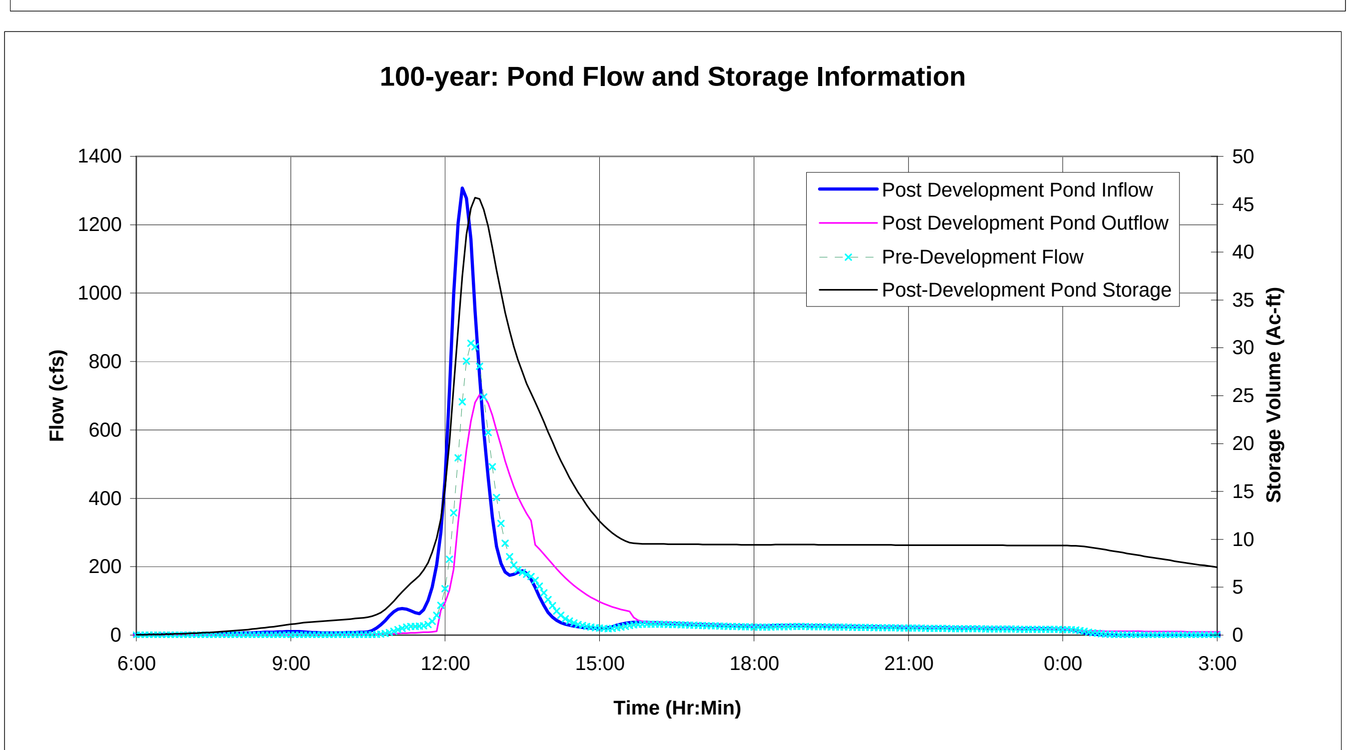
Pond Length to Width Ratio (xL:1W)	1.75		Pond Bottom Length	628	ft
Max Pond Depth	10	ft	Pond Bottom Width	328	ft
Side Slope (H:1)	4		Pond Top Length	700	ft
Pond Volume at Max. Depth	50.20	Ac-ft	Pond Top Width at Max Depth	400	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x10	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	5	ft	100-yr water surface elevation	9	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	6.43	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	12.40	Ac

Detention Pond 304 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	9.31	12.02
2	9.81	69.30
2.5	12.38	96.85
3	15.00	127.31
3.5	17.66	160.43
4	20.37	196.01
4.5	23.12	233.89
4.9	25.37	265.76
5	25.93	328.72
5.5	28.79	379.25
6	31.69	432.12
6.5	34.65	487.24
7	37.65	544.53
7.5	40.71	603.91
8	43.82	665.29
8.5	46.99	728.63
9	50.20	793.85
9.5	53.48	860.92
10	56.80	929.77







Watershed 312, Pond 312 Output Summary

Water Quality Capture Volume: 13.35 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	728	cfs
Post-Development Peak Outflow:	260	cfs
Pre-Development Peak Flow:	402	cfs
Total Volume:	85.7	Ac-ft
Peak Storage:	28.8	Ac-ft

100-Year Storm Event Summary

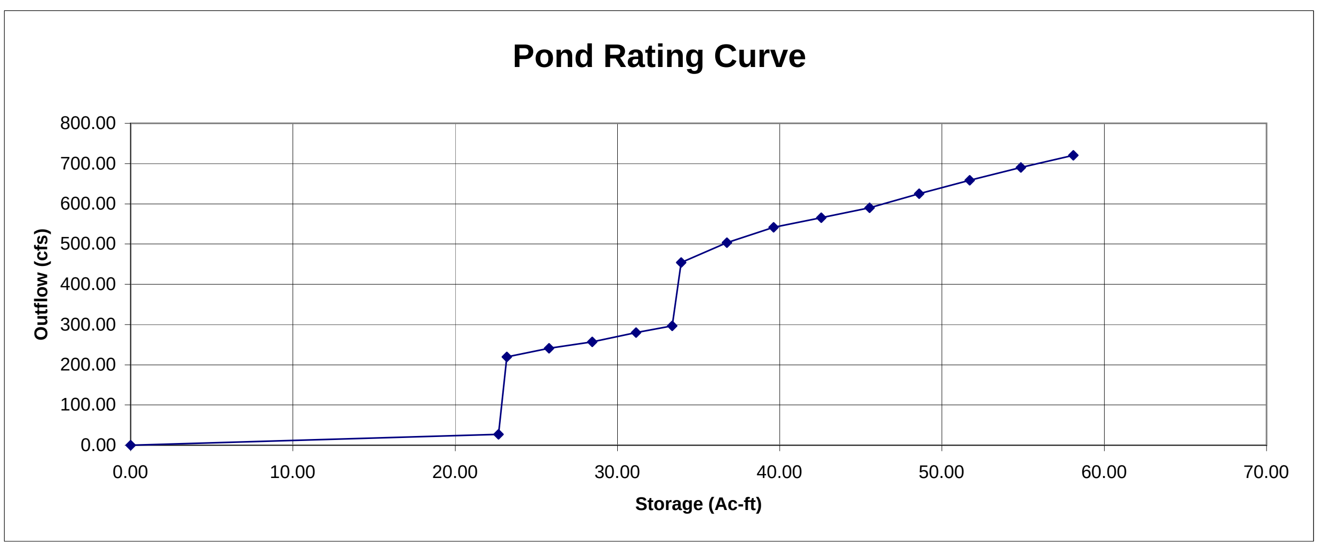
Post-Development Peak Inflow:	1352	cfs
Post-Development Peak Outflow:	618	cfs
Pre-Development Peak Flow:	1040	cfs
Total Volume:	164.2	Ac-ft
Peak Storage:	48.0	Ac-ft

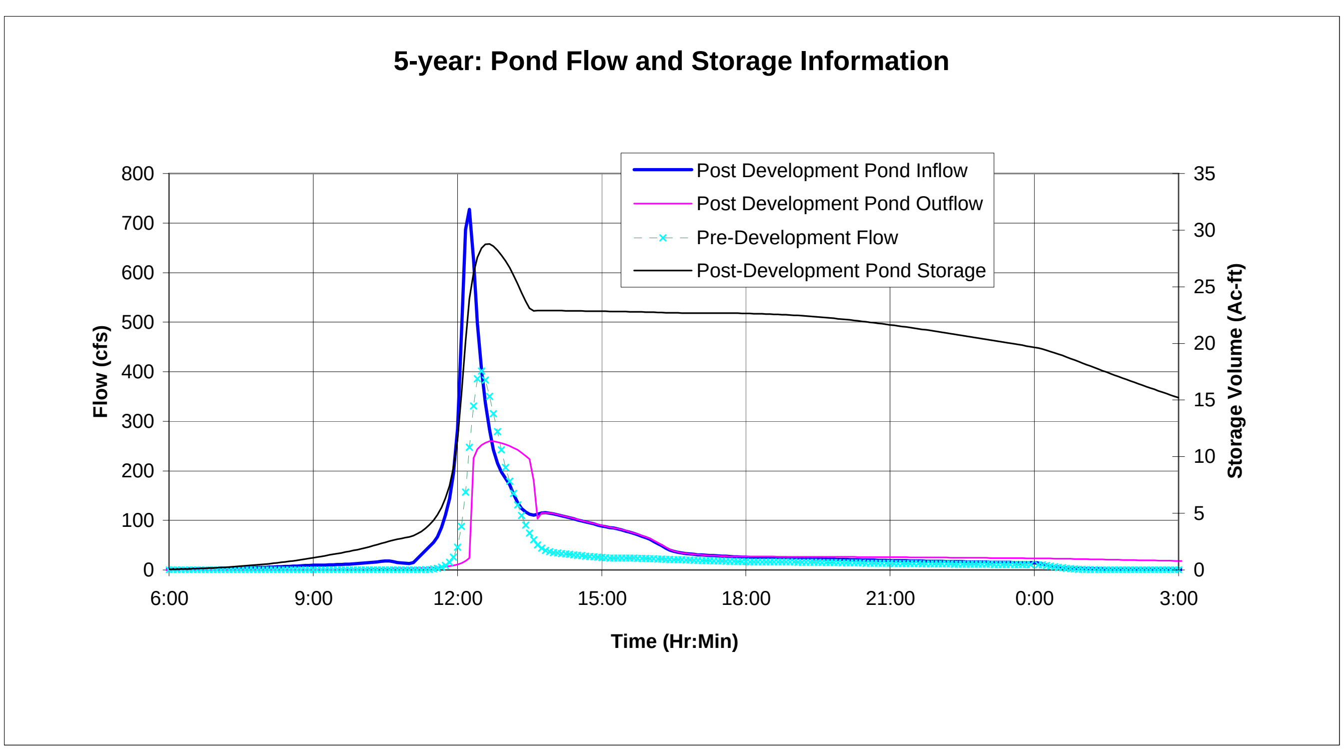
POND GEOMETRY

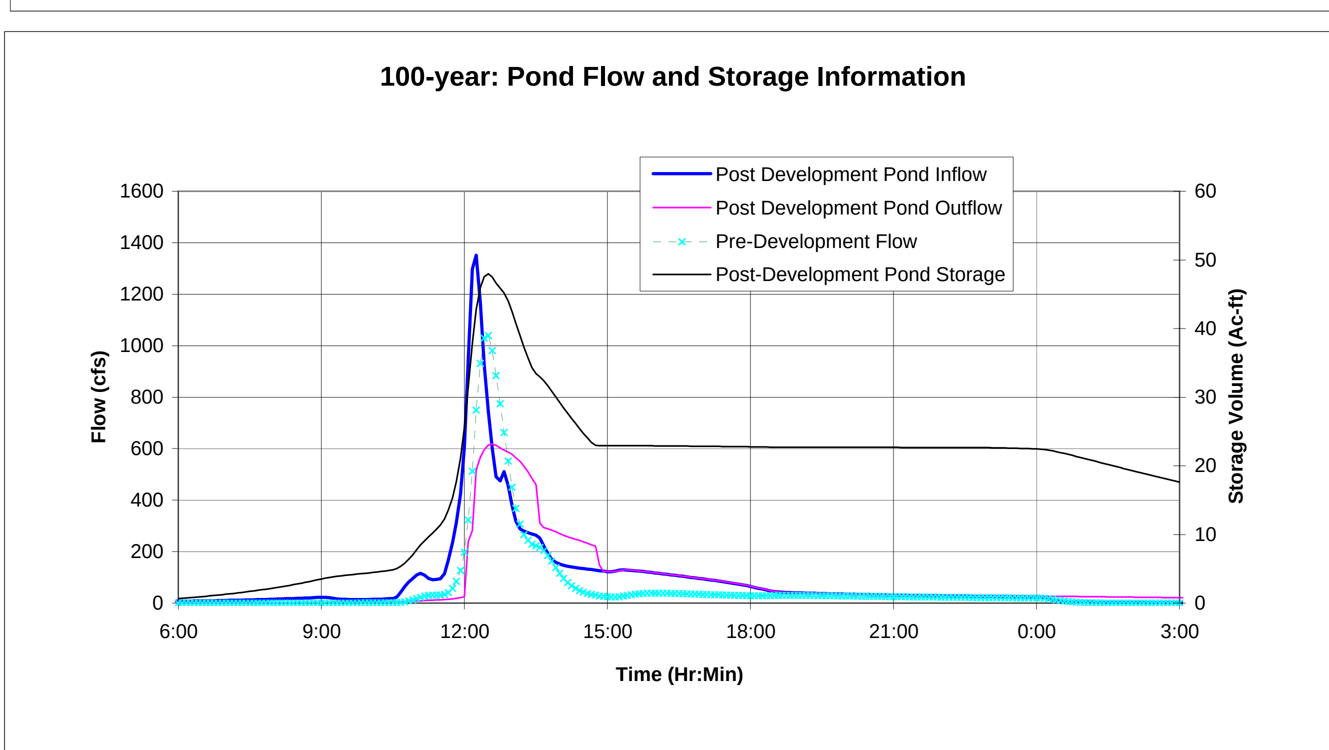
Pond Length to Width Ratio (xL:1W)	3.00		Pond Bottom Length	820	ft
Max Pond Depth	11	ft	Pond Bottom Width	220	ft
Side Slope (H:1)	4		Pond Top Length	900	ft
Pond Volume at Max. Depth	51.70	Ac-ft	Pond Top Width at Max Depth	300	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x8	ft	100-yr control opening size	6x10	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	7	ft	100-yr water surface elevation	10	ft
WQCV top control height	5	ft			
			Estimated impoundment area for 100-year detention	6.20	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	12.63	Ac

Detention Pond 312 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
4.9	22.67	26.92
5	23.19	219.15
5.5	25.79	240.94
6	28.45	257.08
6.5	31.16	279.63
6.9	33.36	296.44
7	33.92	453.78
7.5	36.74	503.25
8	39.62	541.22
8.5	42.55	565.38
9	45.54	590.35
9.5	48.59	625.35
10	51.70	658.50
10.5	54.86	690.05
11	58.09	720.22







Watershed 400, Pond BMP 400 Output Summary

Water Quality Capture Volume: 11.05 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	967	cfs
Post-Development Peak Outflow:	361	cfs
Pre-Development Peak Flow:	484	cfs
Total Volume:	92.9	Ac-ft
Peak Storage:	39.3	Ac-ft

100-Year Storm Event Summary

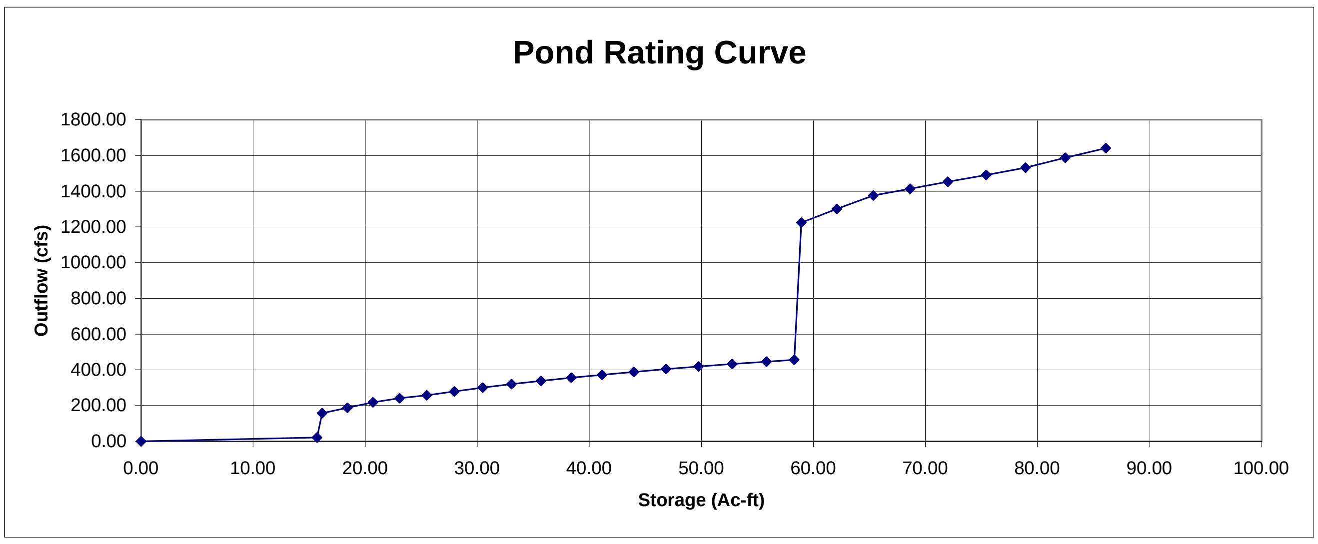
Post-Development Peak Inflow:	2623	cfs
Post-Development Peak Outflow:	1524	cfs
Pre-Development Peak Flow:	1574	cfs
Total Volume:	230.5	Ac-ft
Peak Storage:	78.3	Ac-ft

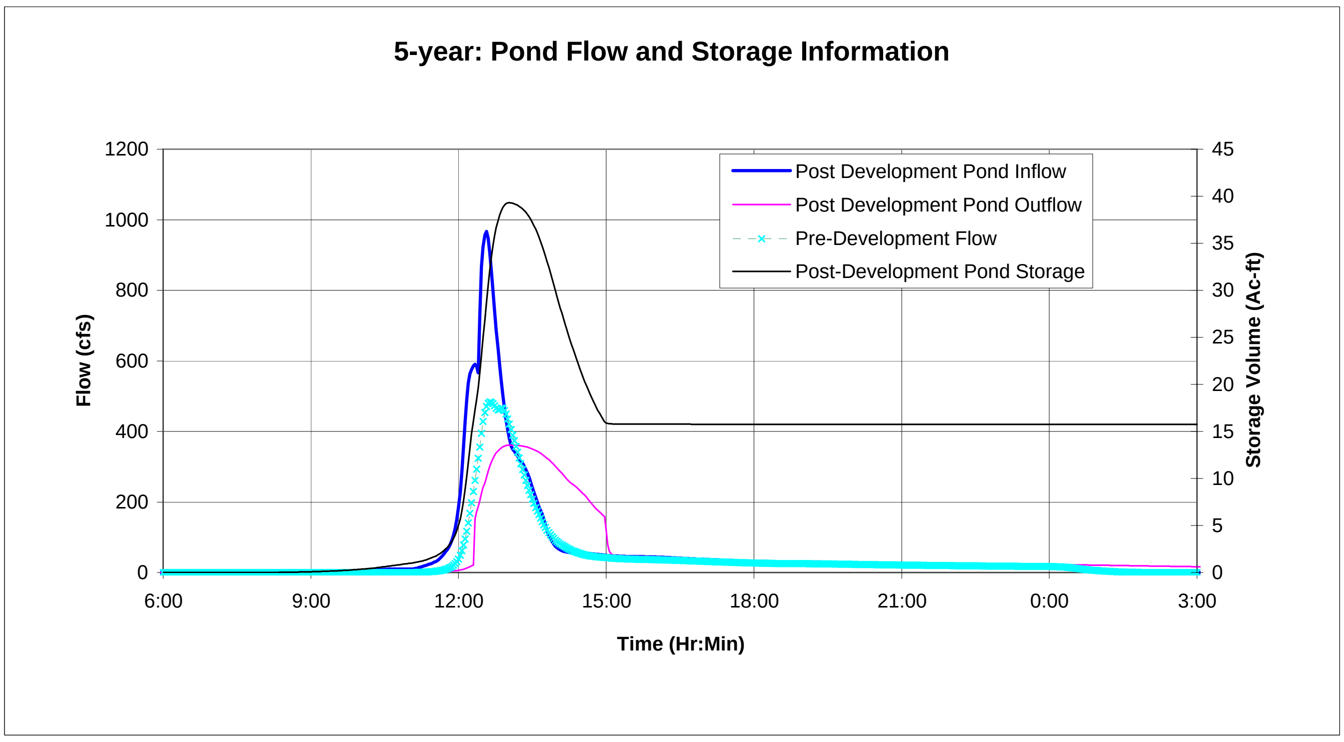
POND GEOMETRY

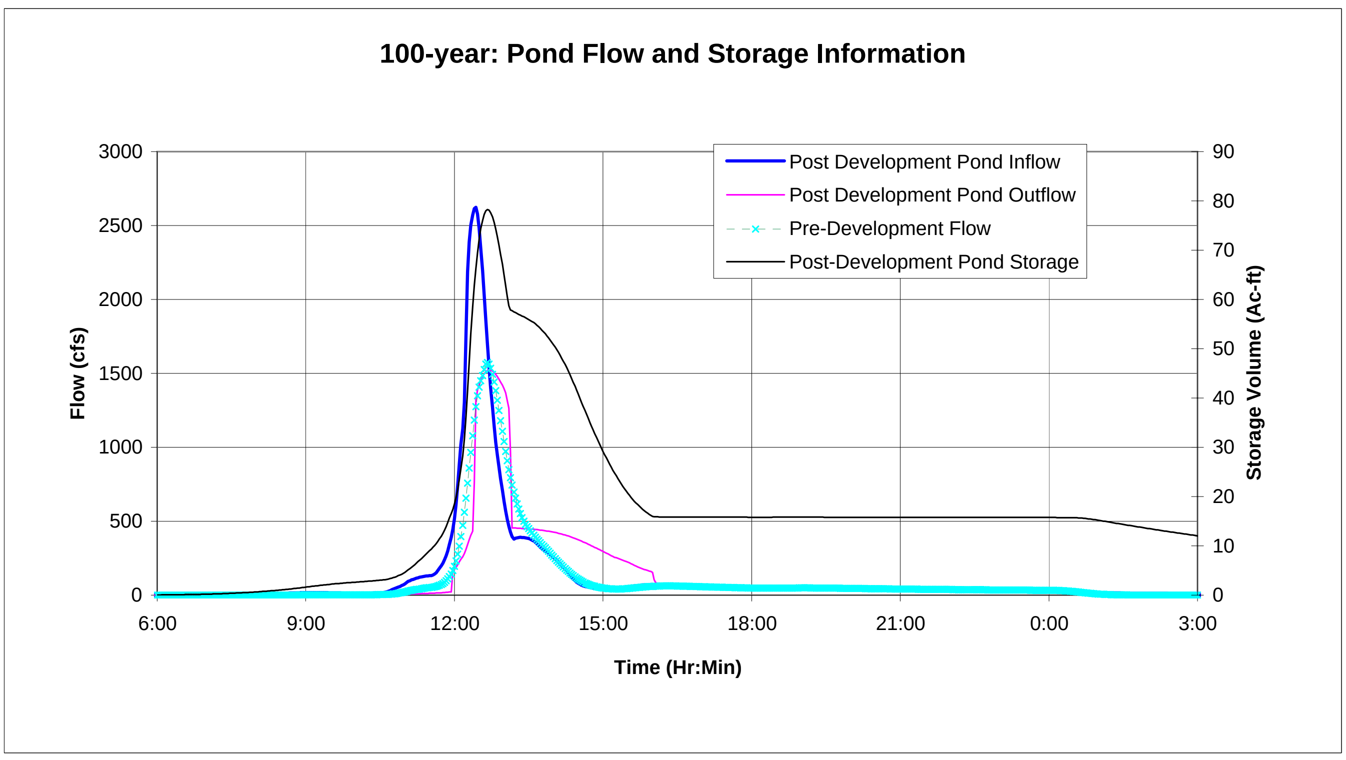
Pond Length to Width Ratio (xL:1W)	3.33		Pond Bottom Length	880	ft
Max Pond Depth	16	ft	Pond Bottom Width	180	ft
Side Slope (H:1)	4		Pond Top Length	1000	ft
Pond Volume at Max. Depth	78.93	Ac-ft	Pond Top Width at Max Depth	300	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x8	ft	100-yr control opening size	10x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	12	ft	100-yr water surface elevation	15	ft
WQCV top control height	4	ft			
			Estimated impoundment area for 100-year detention	6.89	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	13.77	Ac

Detention Pond BMP 400 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
3.9	15.71	22.28
4	16.15	156.81
4.5	18.40	187.11
5	20.71	219.15
5.5	23.07	240.94
6	25.48	257.08
6.5	27.95	279.63
7	30.48	300.49
7.5	33.06	320.00
8	35.70	338.38
8.5	38.39	355.82
9	41.15	372.44
9.5	43.96	388.35
10	46.83	403.63
10.5	49.76	418.36
11	52.76	432.58
11.5	55.81	446.35
11.9	58.29	457.07
12	58.92	1223.22
12.5	62.10	1301.40
13	65.34	1375.48
13.5	68.64	1413.90
14	72.00	1452.32
14.5	75.43	1490.74
15	78.93	1531.27
15.5	82.48	1587.12
16	86.11	1641.12







Watershed 303, Pond 303-4 Output Summary

Water Quality Capture Volume: 11.04 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1110	cfs
Post-Development Peak Outflow:	623	cfs
Pre-Development Peak Flow:	788	cfs
Total Volume:	210.0	Ac-ft
Peak Storage:	24.6	Ac-ft

100-Year Storm Event Summary

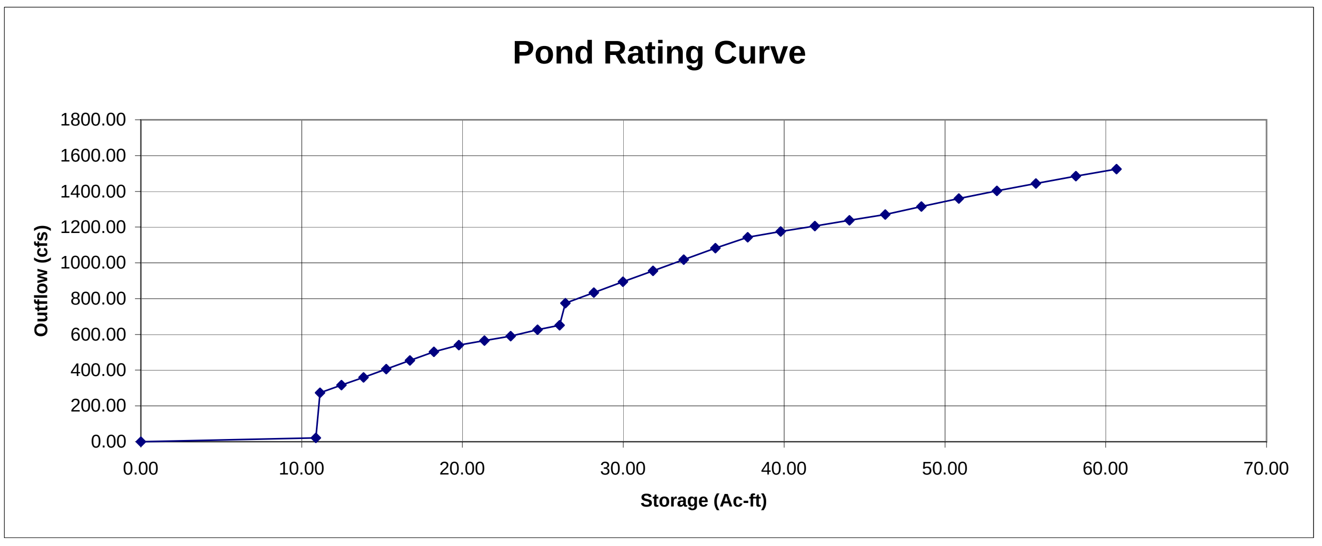
Post-Development Peak Inflow:	2429	cfs
Post-Development Peak Outflow:	1373	cfs
Pre-Development Peak Flow:	2264	cfs
Total Volume:	443.1	Ac-ft
Peak Storage:	51.6	Ac-ft

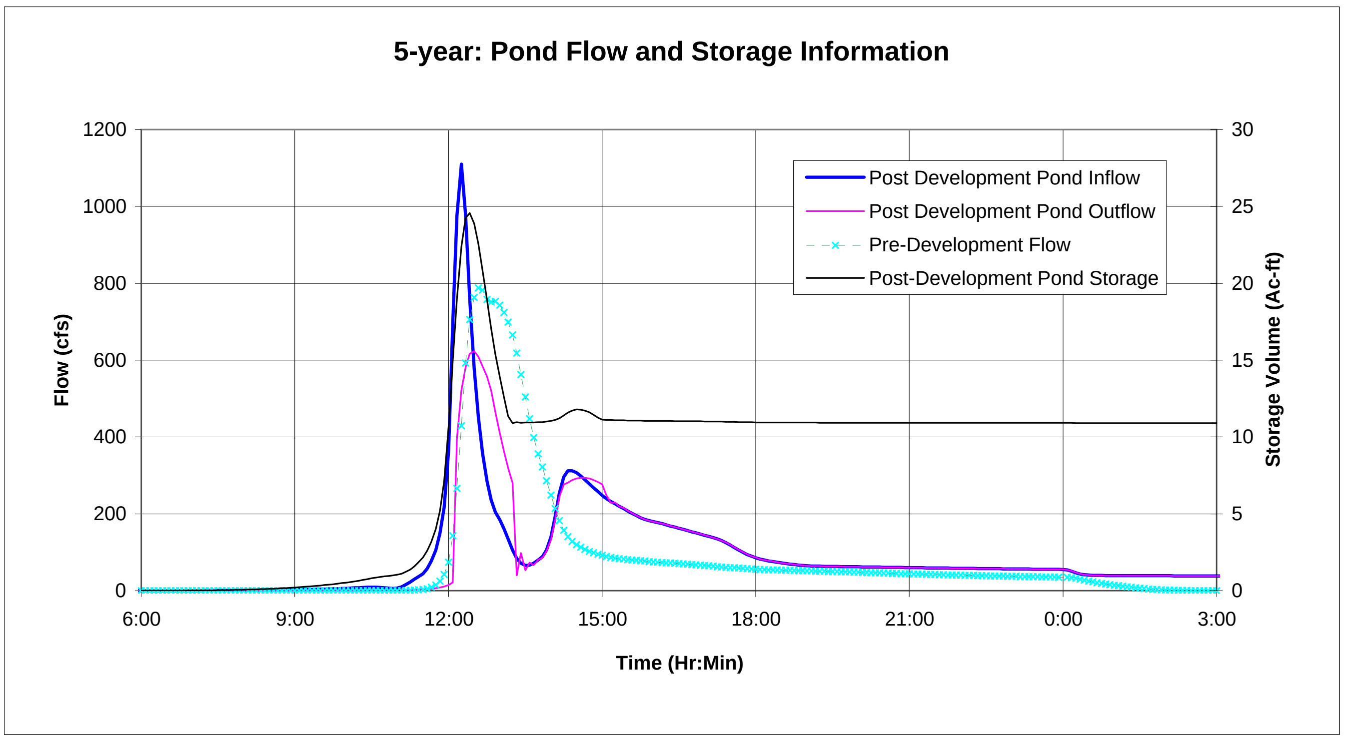
POND GEOMETRY

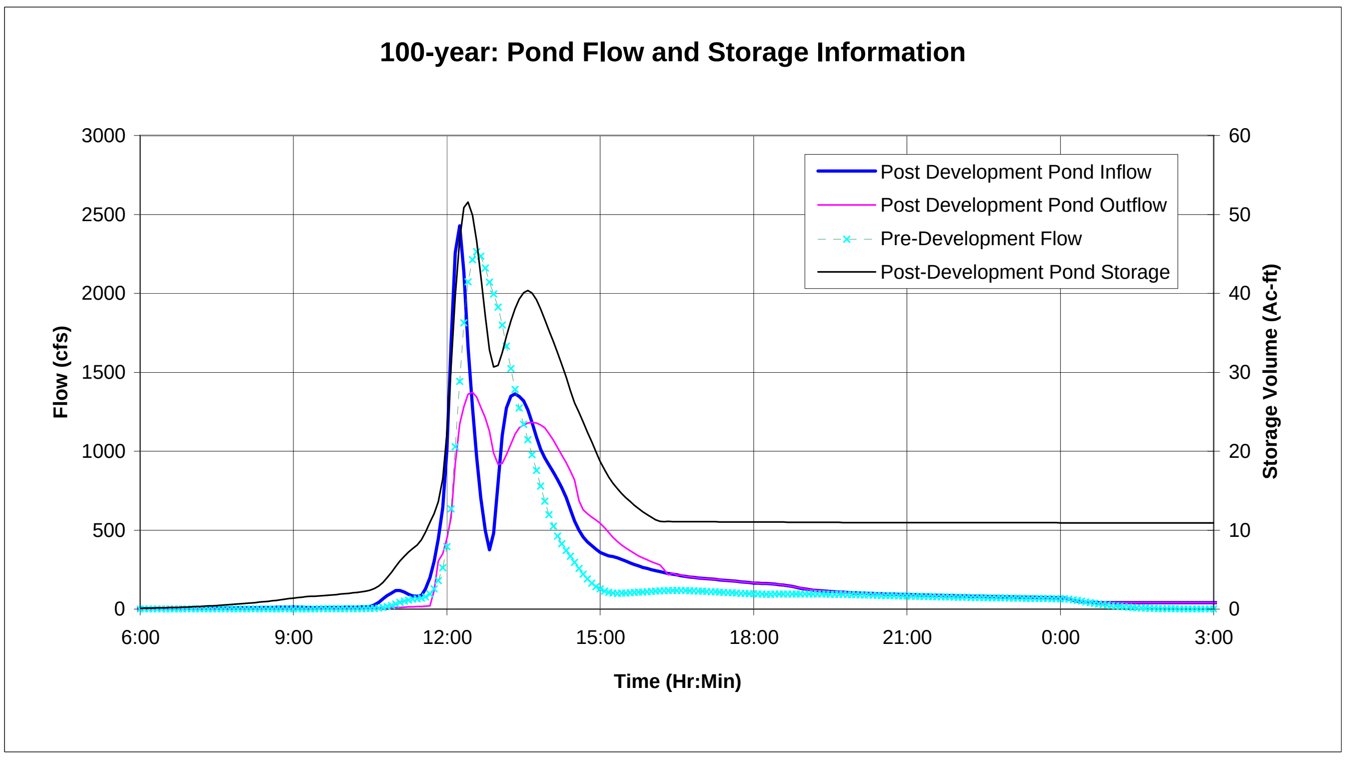
Pond Length to Width Ratio (xL:1W)	3.00		Pond Bottom Length	647	ft
Max Pond Depth	18	ft	Pond Bottom Width	125	ft
Side Slope (H:1)	4		Pond Top Length	783	ft
Pond Volume at Max. Depth	55.66	Ac-ft	Pond Top Width at Max Depth	261	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	6x10	ft	100-yr control opening size	10x10	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	10	ft	100-yr water surface elevation	17	ft
WQCV top control height	5	ft			
			Estimated impoundment area for 100-year detention	4.69	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	10.40	Ac

Detention Pond 303-4 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
4.9	10.89	22.27
5	11.15	273.94
5.5	12.48	316.04
6	13.85	360.10
6.5	15.27	406.04
7	16.72	453.78
7.5	18.22	503.25
8	19.77	541.22
8.5	21.35	565.38
9	22.99	590.35
9.5	24.67	625.35
9.9	26.04	652.00
10	26.39	774.81
10.5	28.16	833.64
11	29.98	893.89
11.5	31.84	955.53
12	33.76	1018.51
12.5	35.72	1082.83
13	37.73	1143.73
13.5	39.79	1174.92
14	41.90	1206.10
14.5	44.07	1237.28
15	46.28	1270.23
15.5	48.54	1315.93
16	50.86	1360.10
16.5	53.23	1402.88
17	55.66	1444.40
17.5	58.14	1484.75
18	60.67	1524.04







Watershed 22, Pond BMP22 Output Summary

Water Quality Capture Volume: 6.96 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1088	cfs
Post-Development Peak Outflow:	333	cfs
Pre-Development Peak Flow:	472	cfs
Total Volume:	64.6	Ac-ft
Peak Storage:	32.7	Ac-ft

100-Year Storm Event Summary

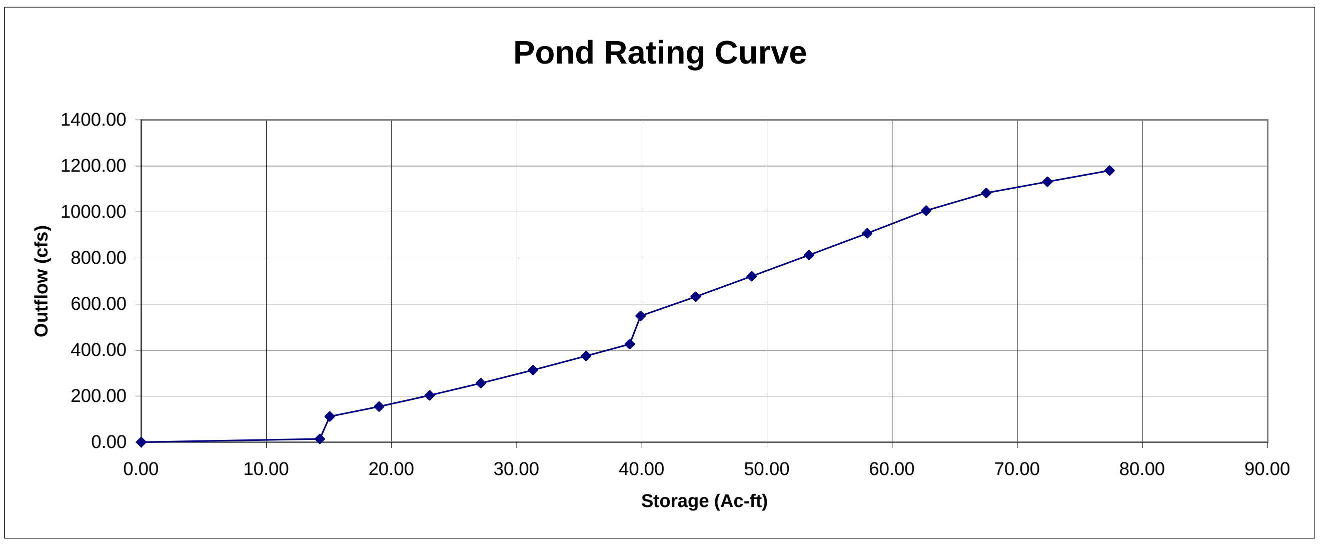
Post-Development Peak Inflow:	2370	cfs
Post-Development Peak Outflow:	1030	cfs
Pre-Development Peak Flow:	1245	cfs
Total Volume:	153.4	Ac-ft
Peak Storage:	64.2	Ac-ft

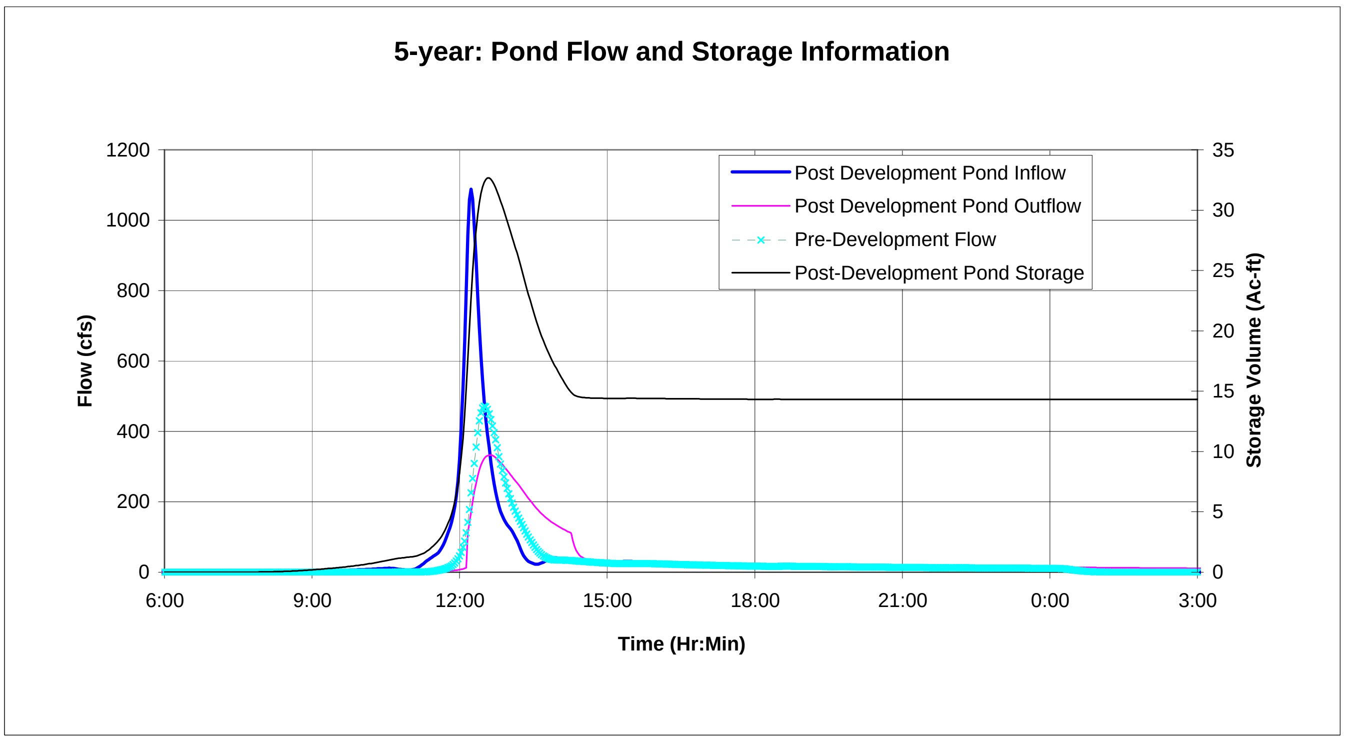
POND GEOMETRY

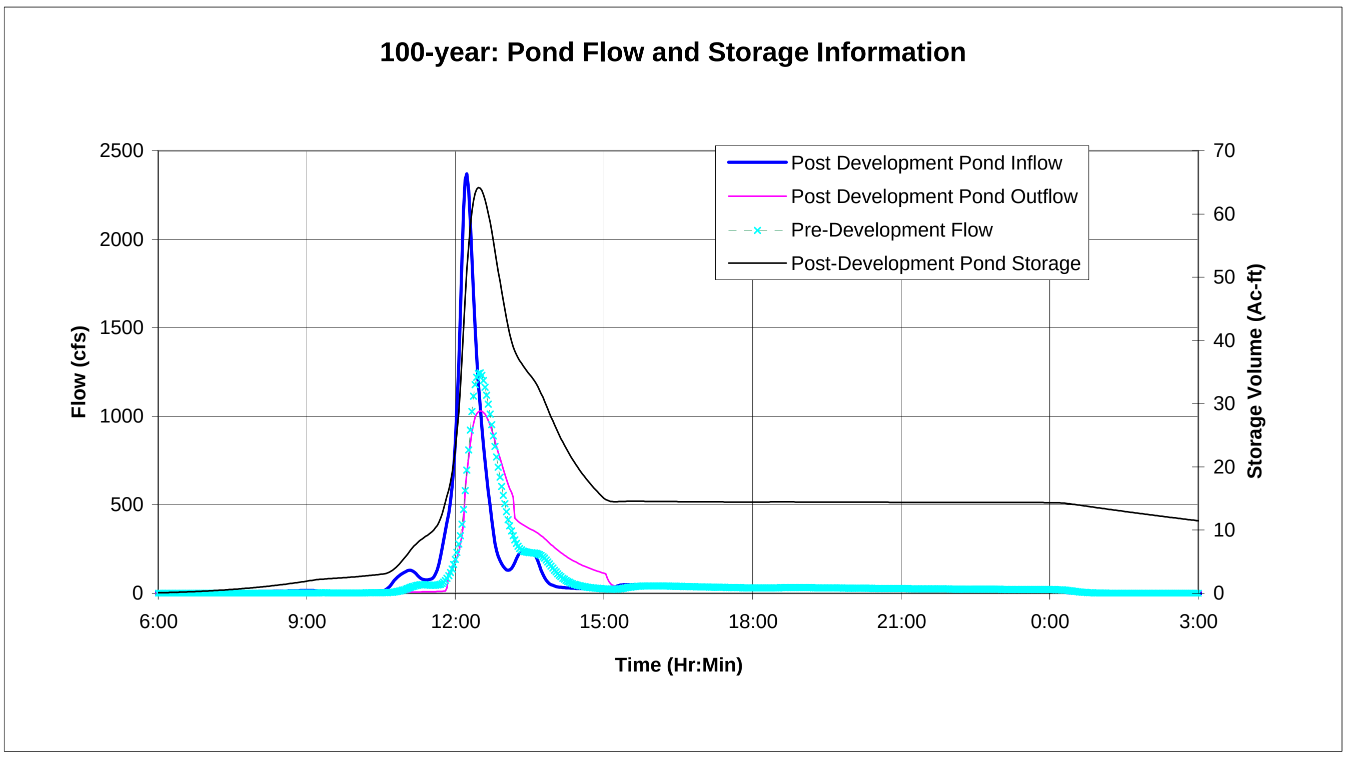
Pond Length to Width Ratio (xL:1W)	4.67		Pond Bottom Length	1336	ft
Max Pond Depth	9	ft	Pond Bottom Width	236	ft
Side Slope (H:1)	4		Pond Top Length	1400	ft
Pond Volume at Max. Depth	67.52	Ac-ft	Pond Top Width at Max Depth	300	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x16	ft	100-yr control opening size	6x20	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	5	ft	100-yr water surface elevation	8	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	9.64	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	18.37	Ac

Detention Pond BMP22 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	14.28	14.03
2	15.06	110.88
2.5	19.01	154.96
3	23.03	203.70
3.5	27.13	256.69
4	31.31	313.62
4.5	35.56	374.23
4.9	39.02	425.22
5	39.89	547.87
5.5	44.30	632.08
6	48.78	720.20
6.5	53.35	812.07
7	57.99	907.55
7.5	62.72	1006.51
8	67.52	1082.44
8.5	72.41	1130.75
9	77.37	1180.70







Watershed 317, Pond 317 Output Summary

Water Quality Capture Volume: 10.67 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1497	cfs
Post-Development Peak Outflow:	473	cfs
Pre-Development Peak Flow:	649	cfs
Total Volume:	108.2	Ac-ft
Peak Storage:	49.6	Ac-ft

100-Year Storm Event Summary

Post-Development Peak Inflow:	2988	cfs
Post-Development Peak Outflow:	1561	cfs
Pre-Development Peak Flow:	1744	cfs
Total Volume:	220.5	Ac-ft
Peak Storage:	86.7	Ac-ft

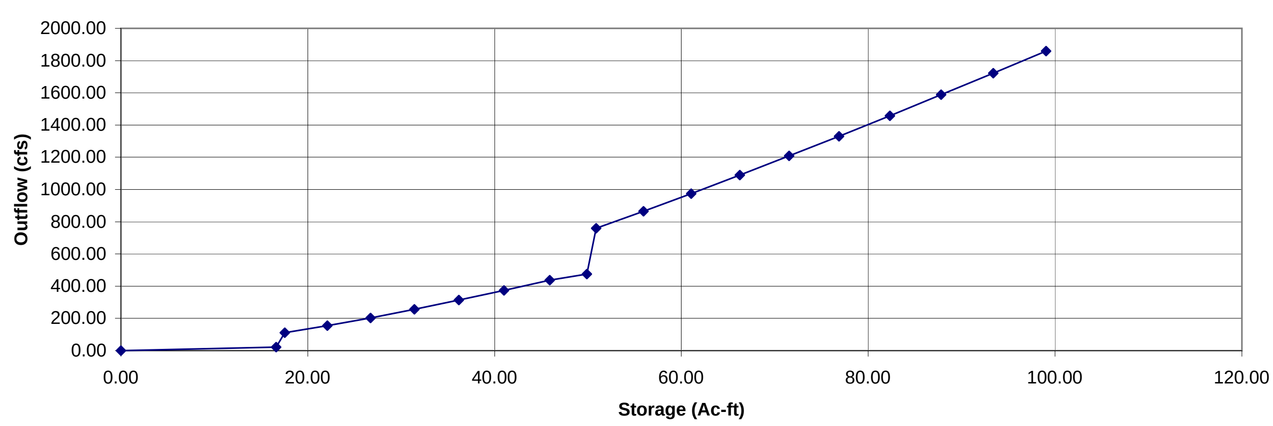
Detention Pond 317 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	16.63	21.51
2	17.53	110.88
2.5	22.08	154.96
3	26.70	203.70
3.5	31.40	256.69
4	36.16	313.62
4.5	41.00	374.23
5	45.90	438.30
5.4	49.88	475.57
5.5	50.88	758.50
6	55.93	864.24
6.5	61.06	974.48
7	66.26	1089.06
7.5	71.53	1207.82
8	76.88	1330.58
8.5	82.31	1457.26
9	87.81	1587.70
9.5	93.39	1721.84
10	99.04	1859.54

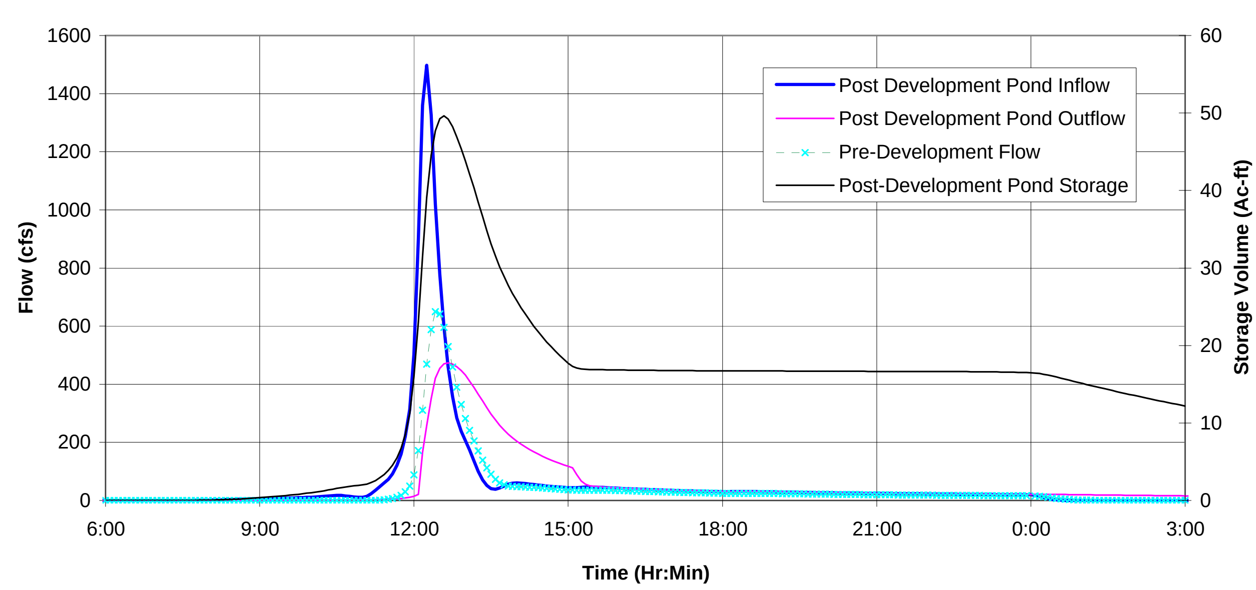
POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	3.00		Pond Bottom Length	1128	ft
Max Pond Depth	10	ft	Pond Bottom Width	328	ft
Side Slope (H:1)	4		Pond Top Length	1200	ft
Pond Volume at Max. Depth	87.81	Ac-ft	Pond Top Width at Max Depth	400	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x16	ft	100-yr control opening size	8x12	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	2	
5-yr top control height	5.5	ft	100-yr water surface elevation	9	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	11.02	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	19.28	Ac

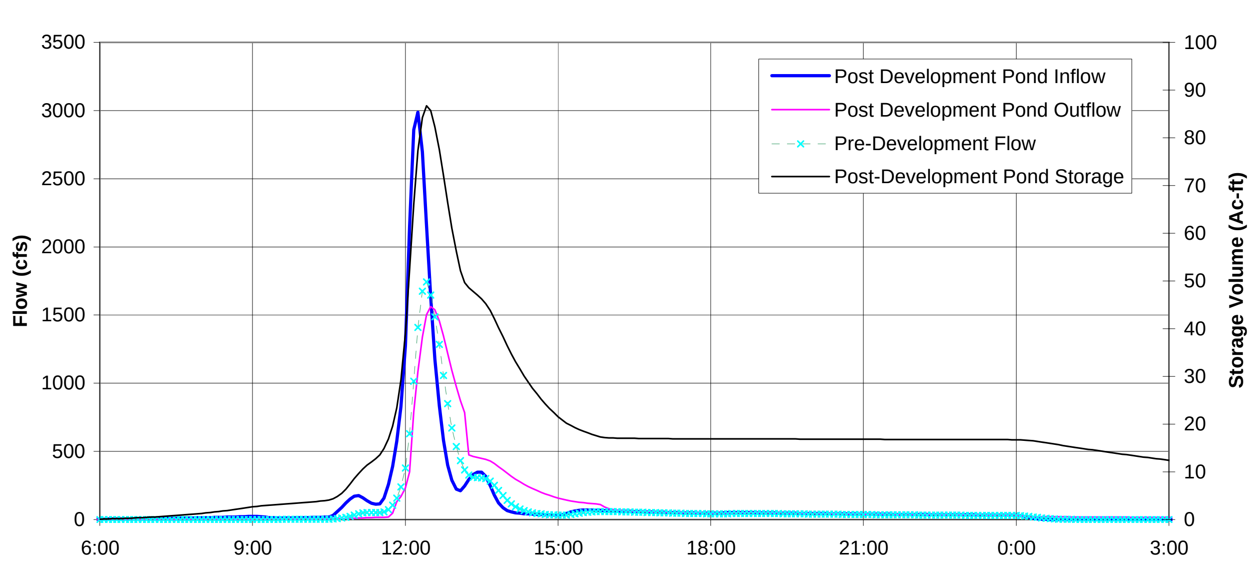
Pond Rating Curve



5-year: Pond Flow and Storage Information



100-year: Pond Flow and Storage Information



Watershed 40, Pond 40-3 Output Summary

Water Quality Capture Volume: 6.20 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	687	cfs
Post-Development Peak Outflow:	199	cfs
Pre-Development Peak Flow:	248	cfs
Total Volume:	67.5	Ac-ft
Peak Storage:	36.5	Ac-ft

100-Year Storm Event Summary

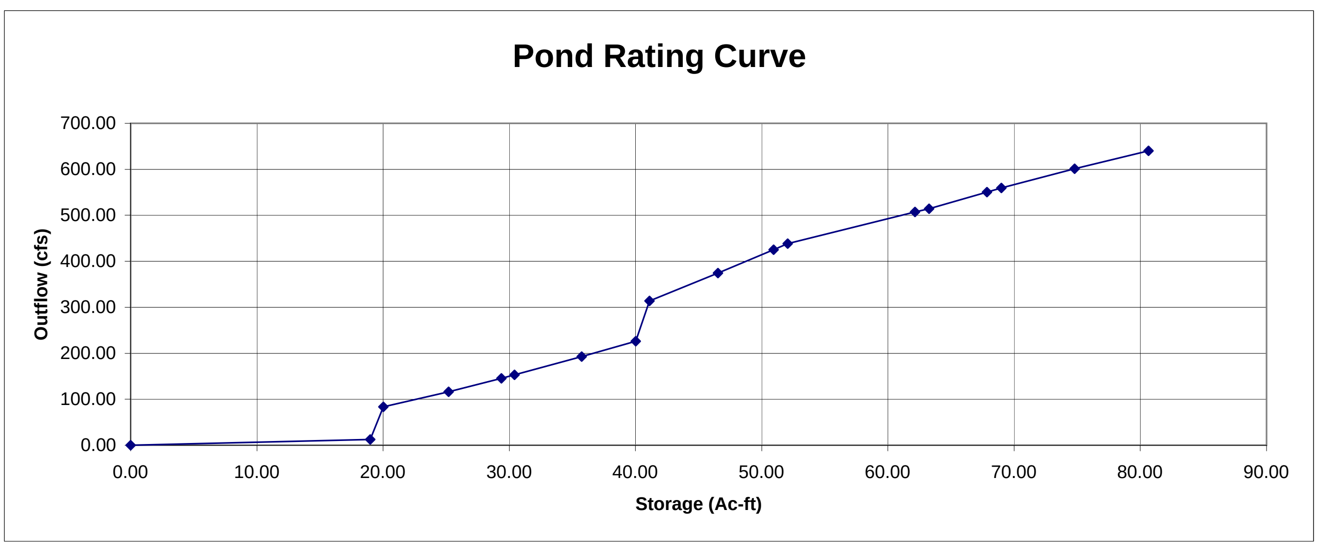
Post-Development Peak Inflow:	1277	cfs
Post-Development Peak Outflow:	500	cfs
Pre-Development Peak Flow:	624	cfs
Total Volume:	124.3	Ac-ft
Peak Storage:	61.1	Ac-ft

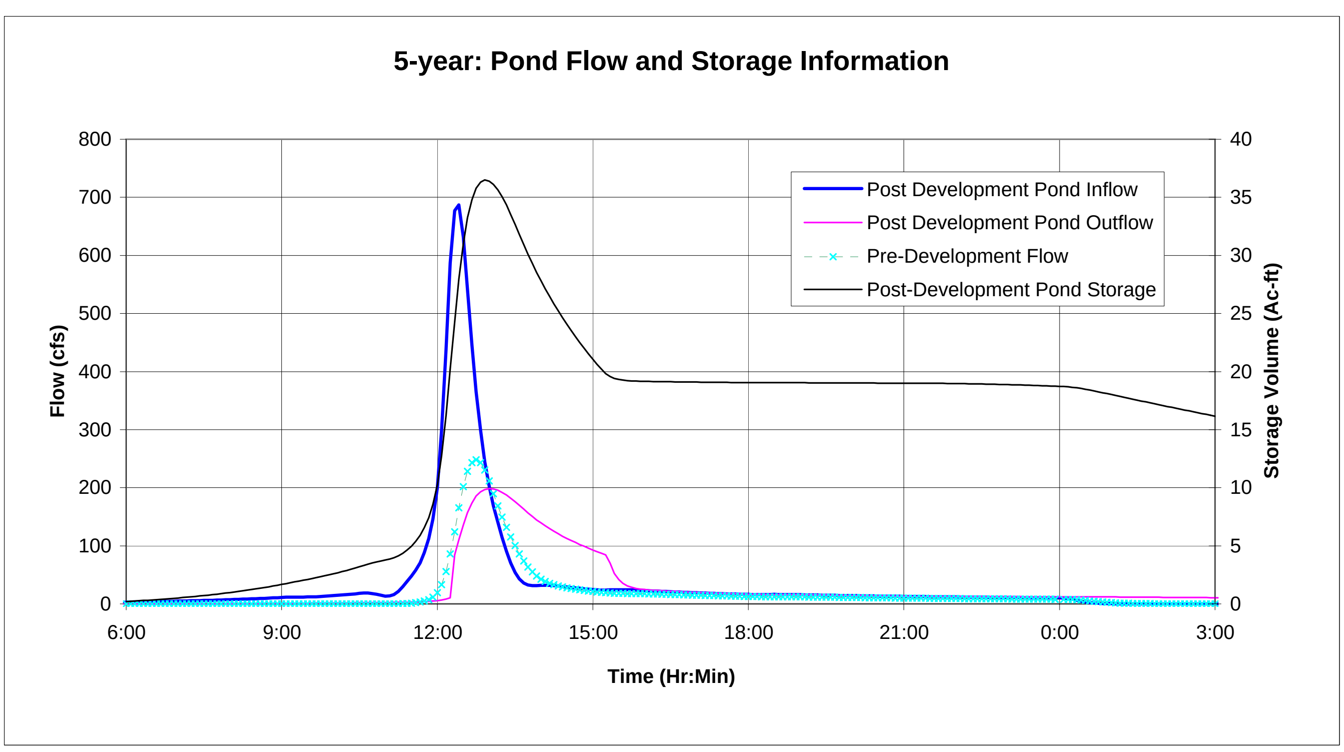
POND GEOMETRY

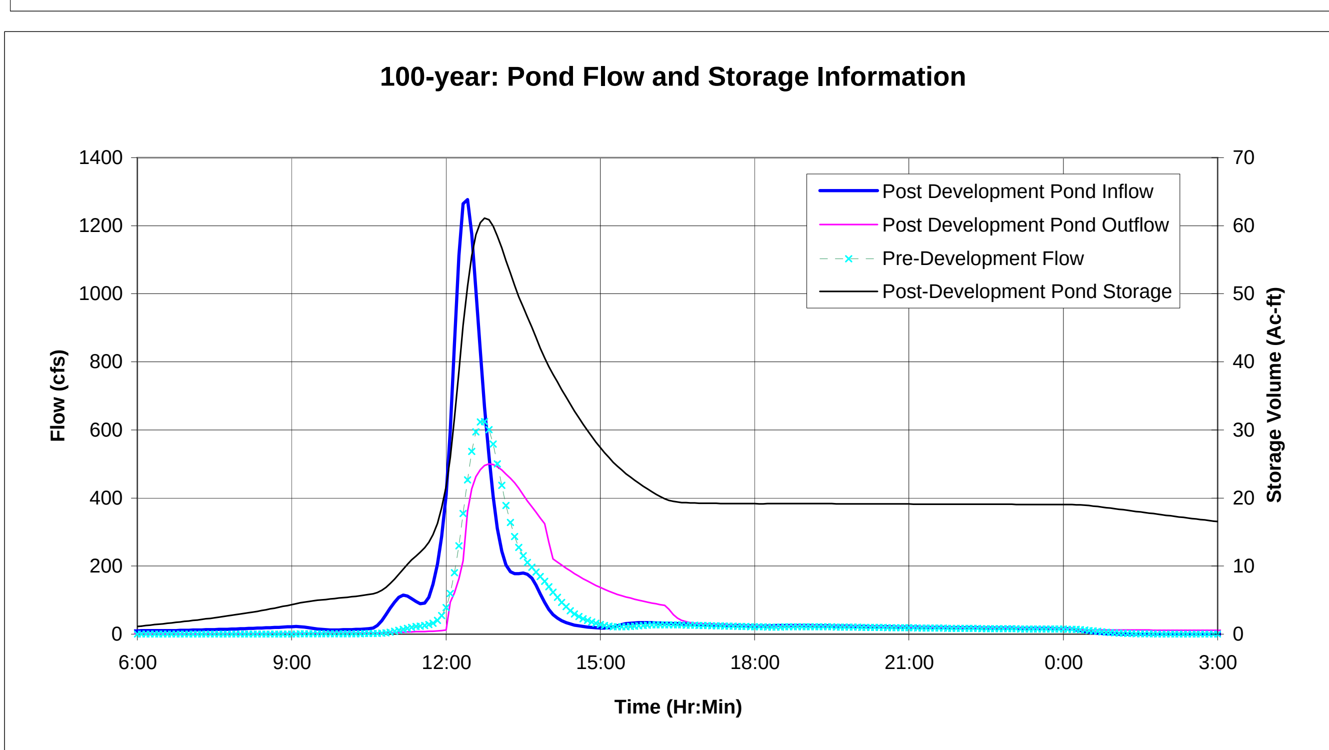
Pond Length to Width Ratio (xL:1W)	2.00		Pond Bottom Length	948	ft
Max Pond Depth	7.5	ft	Pond Bottom Width	448	ft
Side Slope (H:1)	4		Pond Top Length	1000	ft
Pond Volume at Max. Depth	68.99	Ac-ft	Pond Top Width at Max Depth	500	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x6	ft	100-yr control opening size	4x8	ft
Number of parallel 5-yr openings	2		Number of parallel 100-yr structures	2	
5-yr top control height	4	ft	100-yr water surface elevation	6.5	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	11.48	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	19.28	Ac

Detention Pond 40-3 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	18.99	12.50
2	20.02	83.16
2.5	25.19	116.22
2.9	29.37	145.20
3	30.42	152.78
3.5	35.73	192.52
3.9	40.02	226.46
4	41.10	313.62
4.5	46.54	374.22
4.9	50.94	425.22
5	52.05	438.30
5.9	62.14	507.12
6	63.27	514.16
6.4	67.84	550.54
6.5	68.99	559.26
7	74.78	600.98
7.5	80.64	640.00







Watershed 305, Pond 305 Output Summary

Water Quality Capture Volume: 5.31 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	818	cfs
Post-Development Peak Outflow:	134	cfs
Pre-Development Peak Flow:	418	cfs
Total Volume:	57.6	Ac-ft
Peak Storage:	37.4	Ac-ft

100-Year Storm Event Summary

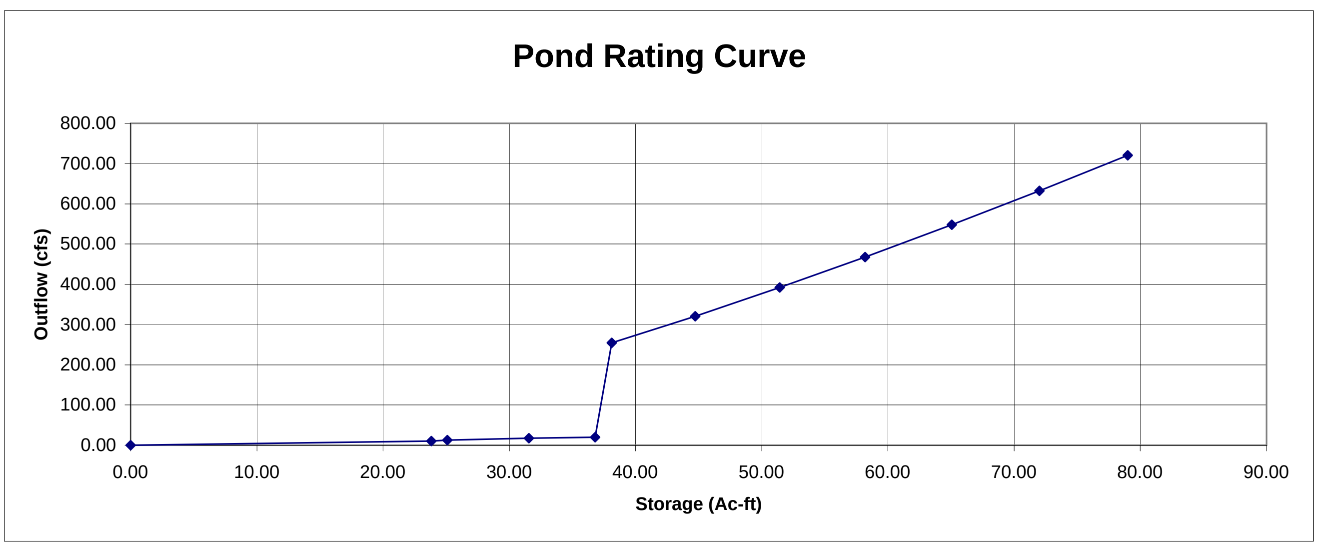
Post-Development Peak Inflow:	1622	cfs
Post-Development Peak Outflow:	505	cfs
Pre-Development Peak Flow:	1003	cfs
Total Volume:	113.5	Ac-ft
Peak Storage:	61.4	Ac-ft

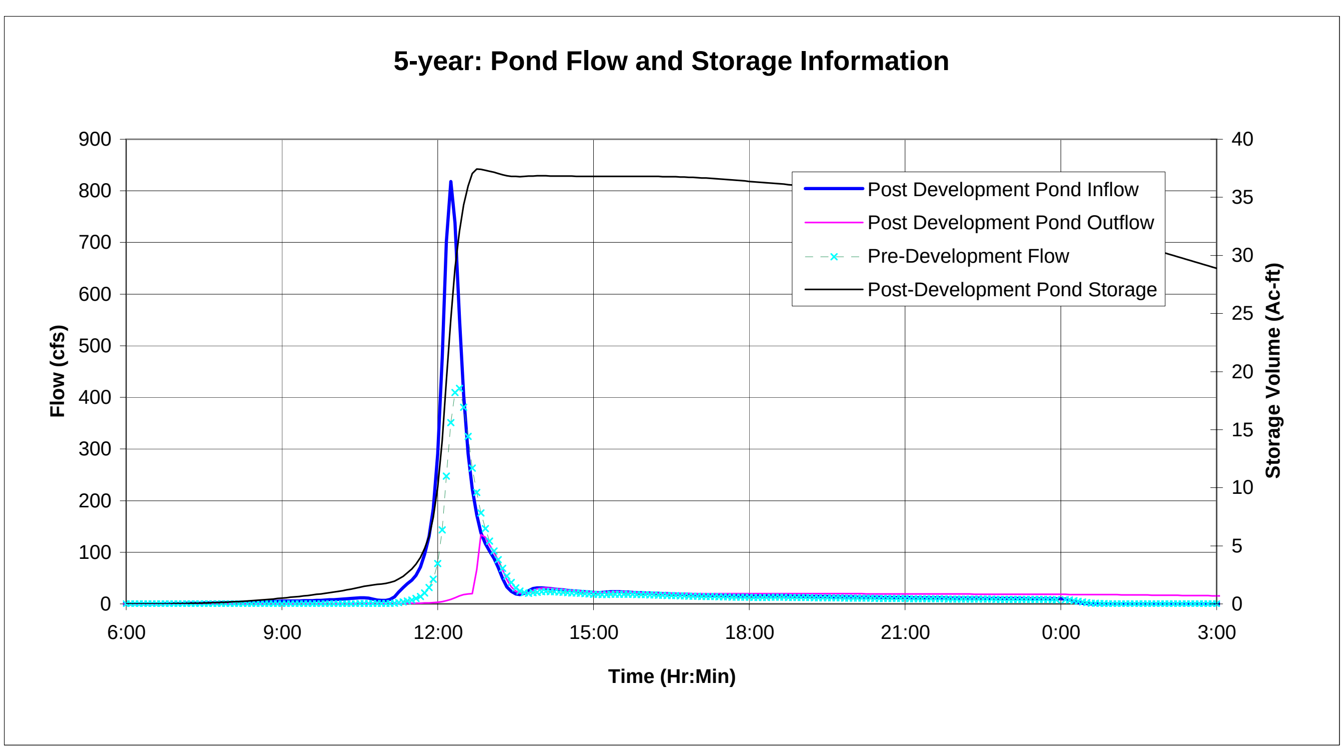
Detention Pond 305 Rating Curve

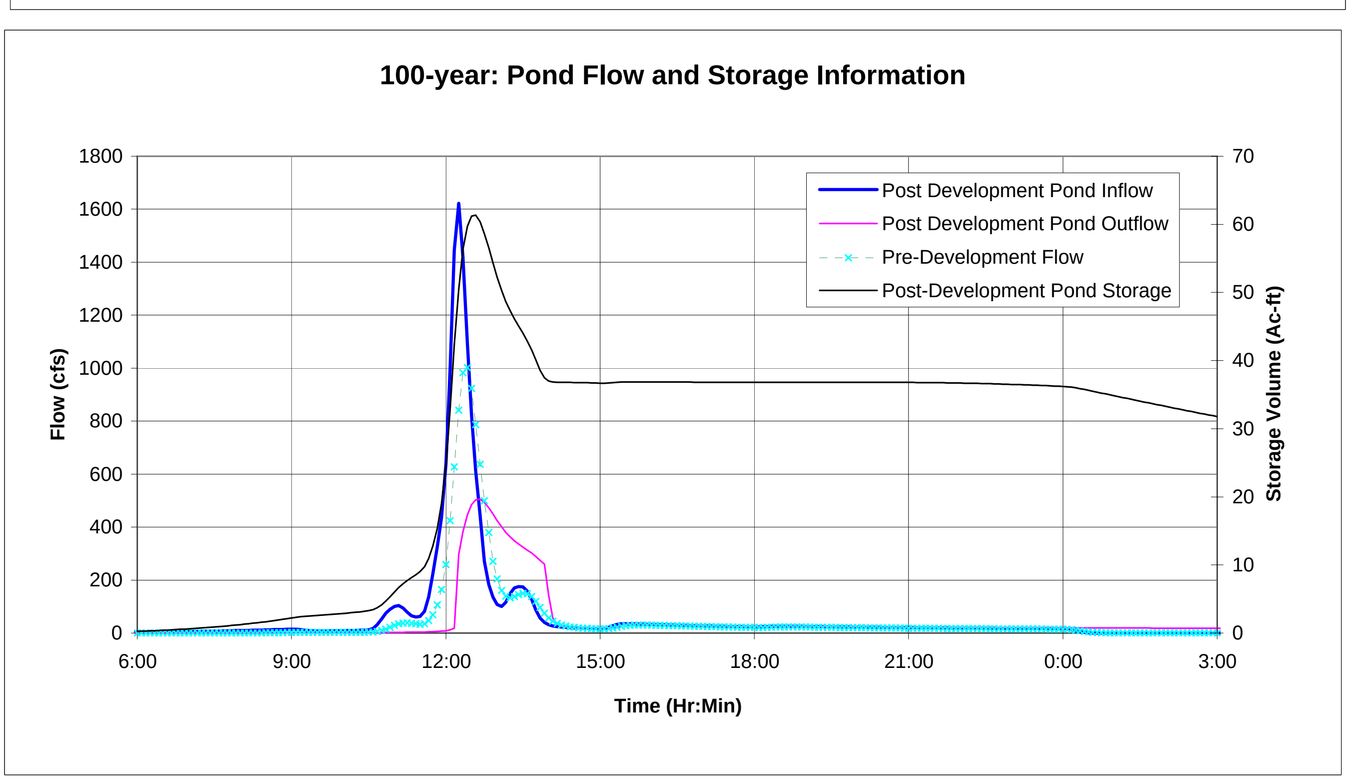
Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	23.82	10.71
2	25.10	12.80
2.5	31.57	17.64
2.9	36.79	20.18
3	38.11	254.63
3.5	44.73	320.87
4	51.43	392.03
4.5	58.20	467.78
5	65.06	547.87
5.5	72.00	632.08
6	79.01	720.20

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	2.40		Pond Bottom Length	1160	ft
Max Pond Depth	6	ft	Pond Bottom Width	460	ft
Side Slope (H:1)	4		Pond Top Length	1200	ft
Pond Volume at Max. Depth	65.06	Ac-ft	Pond Top Width at Max Depth	500	ft
5-yr control opening type	Pipe		100-yr control opening type	Box	
5-yr control opening size	2	ft	100-yr control opening size	5x20	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	3	ft	100-yr water surface elevation	5	ft
WQCV top control height	2	ft			
			Estimated impoundment area for 100-year detention	13.77	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	22.50	Ac







Watershed 306, Pond BMP 306 Output Summary

Water Quality Capture Volume: 8.18 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	916	cfs
Post-Development Peak Outflow:	376	cfs
Pre-Development Peak Flow:	421	cfs
Total Volume:	67.6	Ac-ft
Peak Storage:	28.1	Ac-ft

100-Year Storm Event Summary

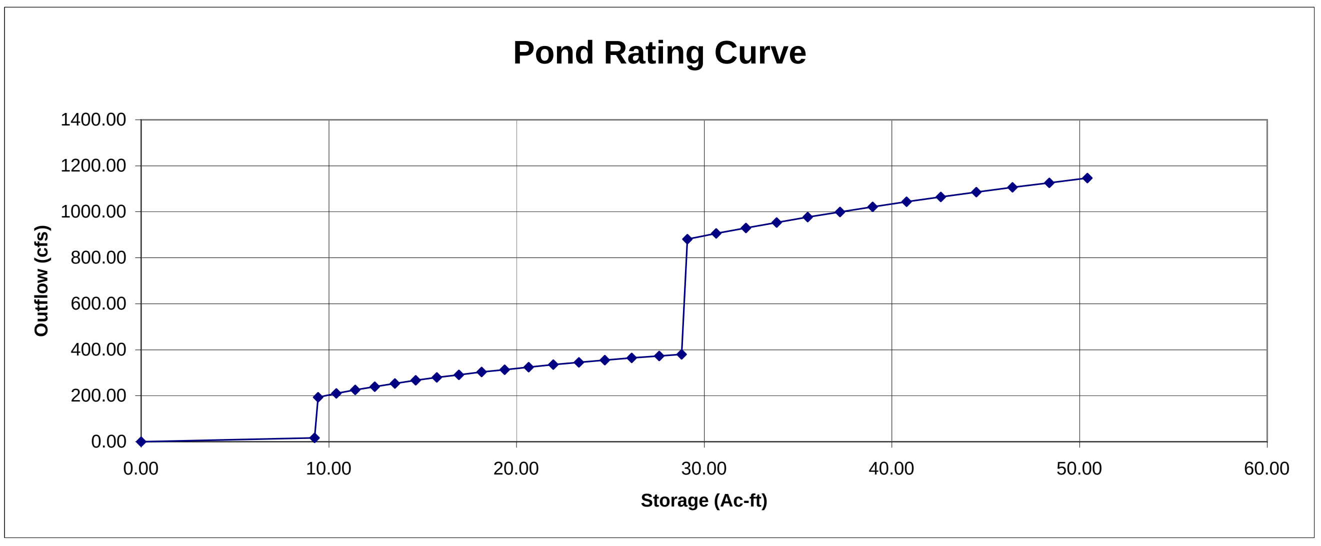
Post-Development Peak Inflow:	1874	cfs
Post-Development Peak Outflow:	1132	cfs
Pre-Development Peak Flow:	1156	cfs
Total Volume:	158.0	Ac-ft
Peak Storage:	48.9	Ac-ft

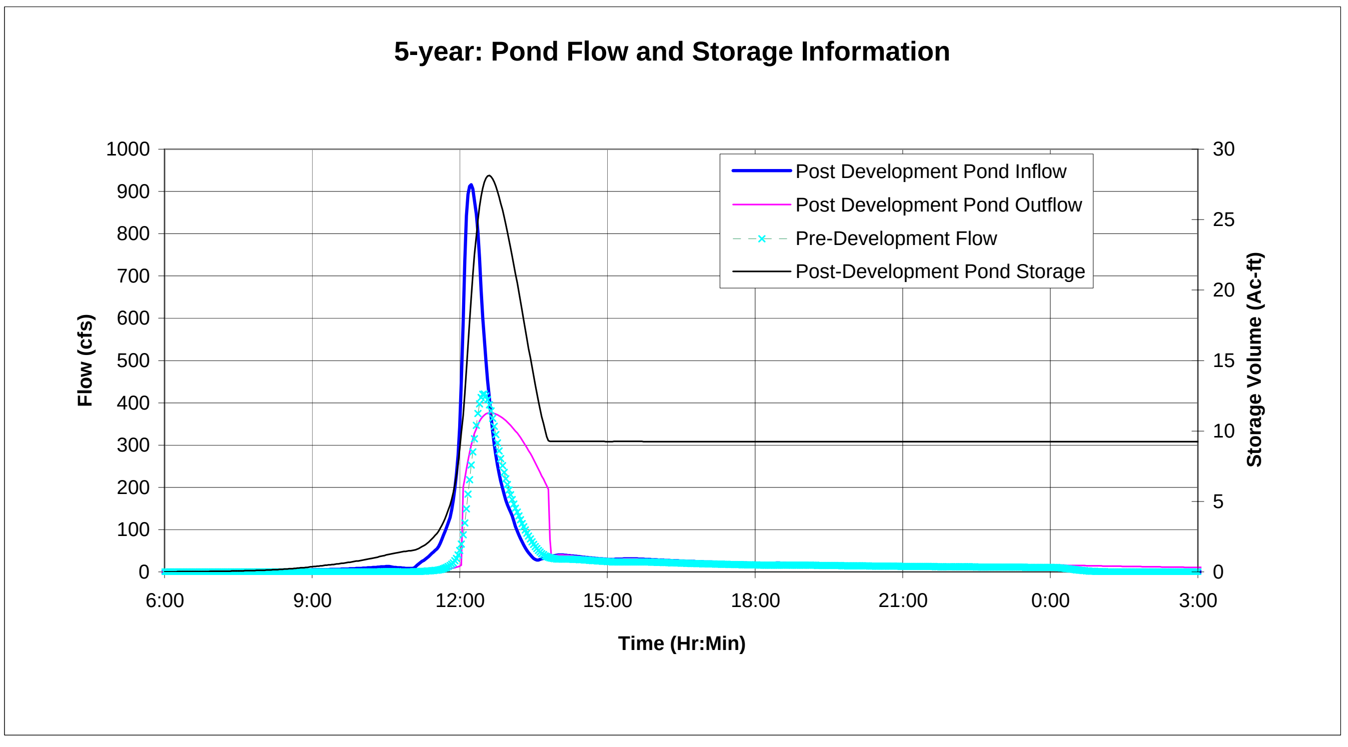
POND GEOMETRY

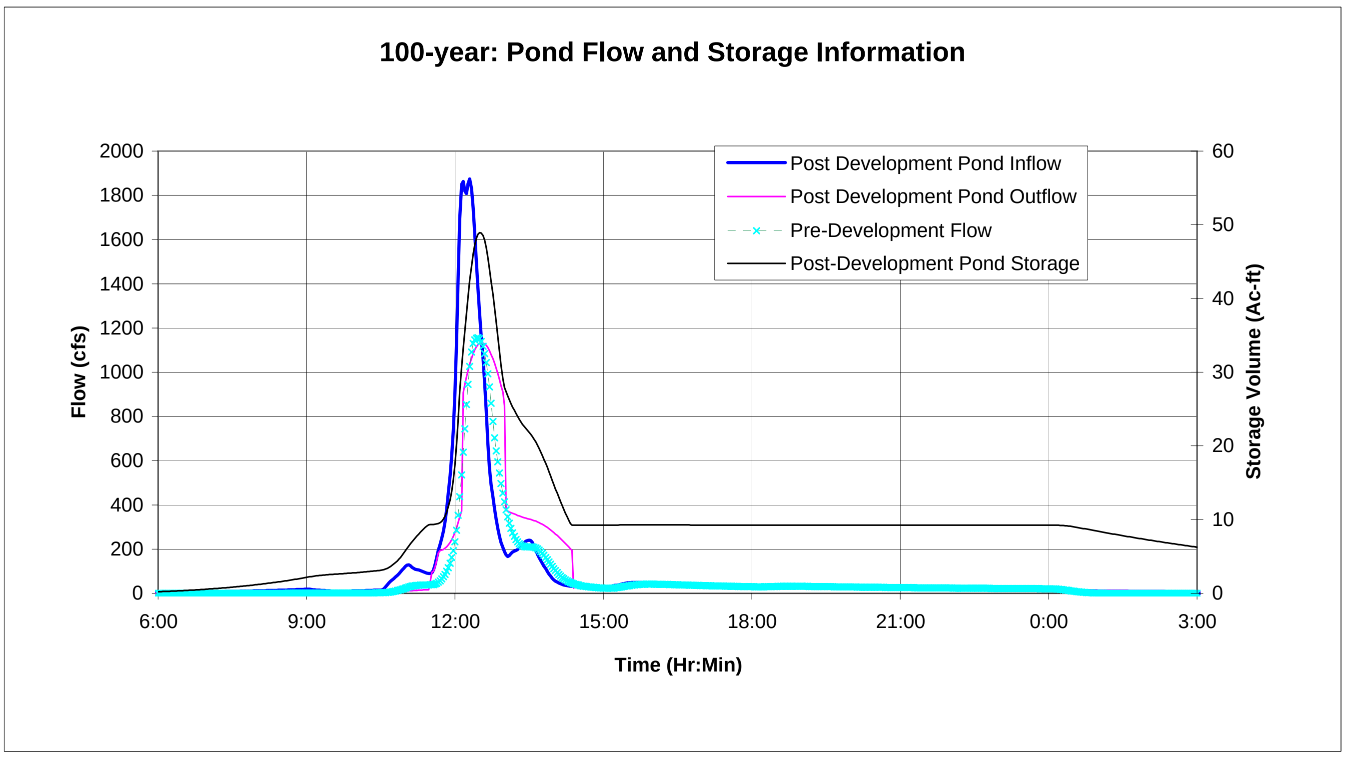
Pond Length to Width Ratio (xL:1W)	1.83		Pond Bottom Length	390	ft
Max Pond Depth	21	ft	Pond Bottom Width	140	ft
Side Slope (H:1)	4		Pond Top Length	550	ft
Pond Volume at Max. Depth	50.41	Ac-ft	Pond Top Width at Max Depth	300	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	4x6	ft	100-yr control opening size	6x10	ft
Number of parallel 5-yr openings	1		Number of parallel 100-yr structures	1	
5-yr top control height	14	ft	100-yr water surface elevation	20	ft
WQCV top control height	6	ft			
			Estimated impoundment area for 100-year detention	3.79	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	8.61	Ac

Detention Pond BMP 306 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
5.9	9.24	16.50
6	9.43	192.81
6.5	10.41	209.72
7	11.41	225.37
7.5	12.45	240.00
8	13.52	253.79
8.5	14.62	266.87
9	15.76	279.33
9.5	16.93	291.26
10	18.14	302.73
10.5	19.38	313.77
11	20.65	324.44
11.5	21.97	334.77
12	23.32	344.78
12.5	24.71	354.52
13	26.13	364.00
13.5	27.60	373.23
13.9	28.80	380.46
14	29.10	880.80
14.5	30.65	905.66
15	32.23	929.90
15.5	33.86	953.58
16	35.52	976.73
16.5	37.23	999.38
17	38.98	1021.57
17.5	40.78	1043.33
18	42.61	1064.68
18.5	44.50	1085.65
19	46.42	1106.25
19.5	48.40	1126.51
20	50.41	1146.44







Watershed 316, Pond 316 Output Summary

Water Quality Capture Volume: 20.71 Ac-ft

Detention Pond 316 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
1.9	18.84	0.00
2	19.86	0.00
2.5	24.98	0.00
3	30.17	254.62
3.5	35.43	320.86
3.9	39.69	377.42
4	40.76	392.02
4.5	46.15	467.78
5	51.61	547.88
5.9	61.61	702.26
6	62.74	720.20
6.5	68.41	812.08
7	74.14	907.56
7.5	79.95	1006.50
8	85.83	1108.82
8.5	91.79	1214.38
9	97.81	1323.08
9.5	103.91	1434.86
10	110.08	1549.62
10.5	116.32	1667.28
11	122.64	1787.78
11.5	129.04	1911.06
12	135.51	2037.02

5-Year Storm Event Summary

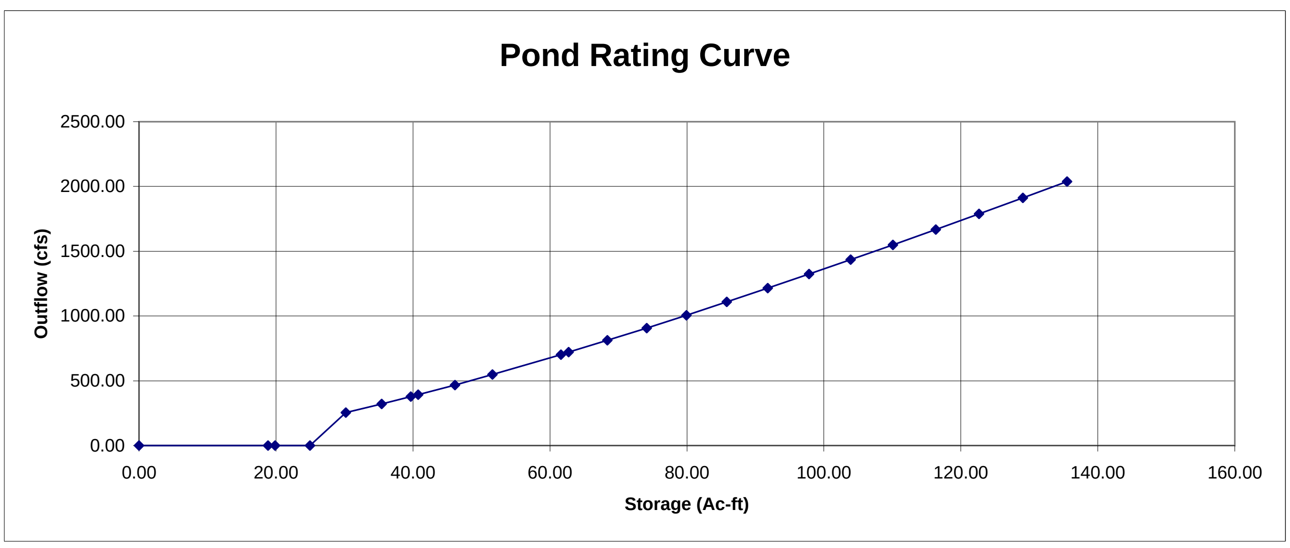
Post-Development Peak Inflow:	1581	cfs
Post-Development Peak Outflow:	676	cfs
Pre-Development Peak Flow:	737	cfs
Total Volume:	144.3	Ac-ft
Peak Storage:	59.9	Ac-ft

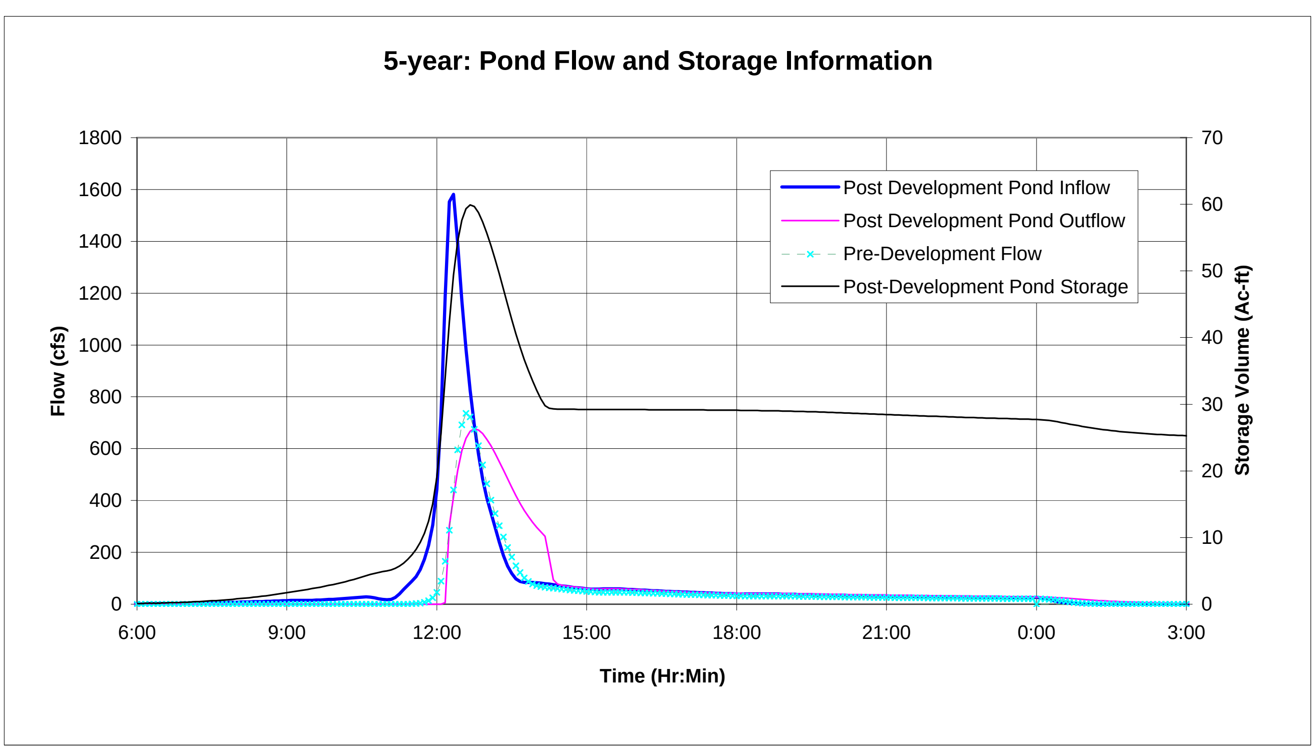
100-Year Storm Event Summary

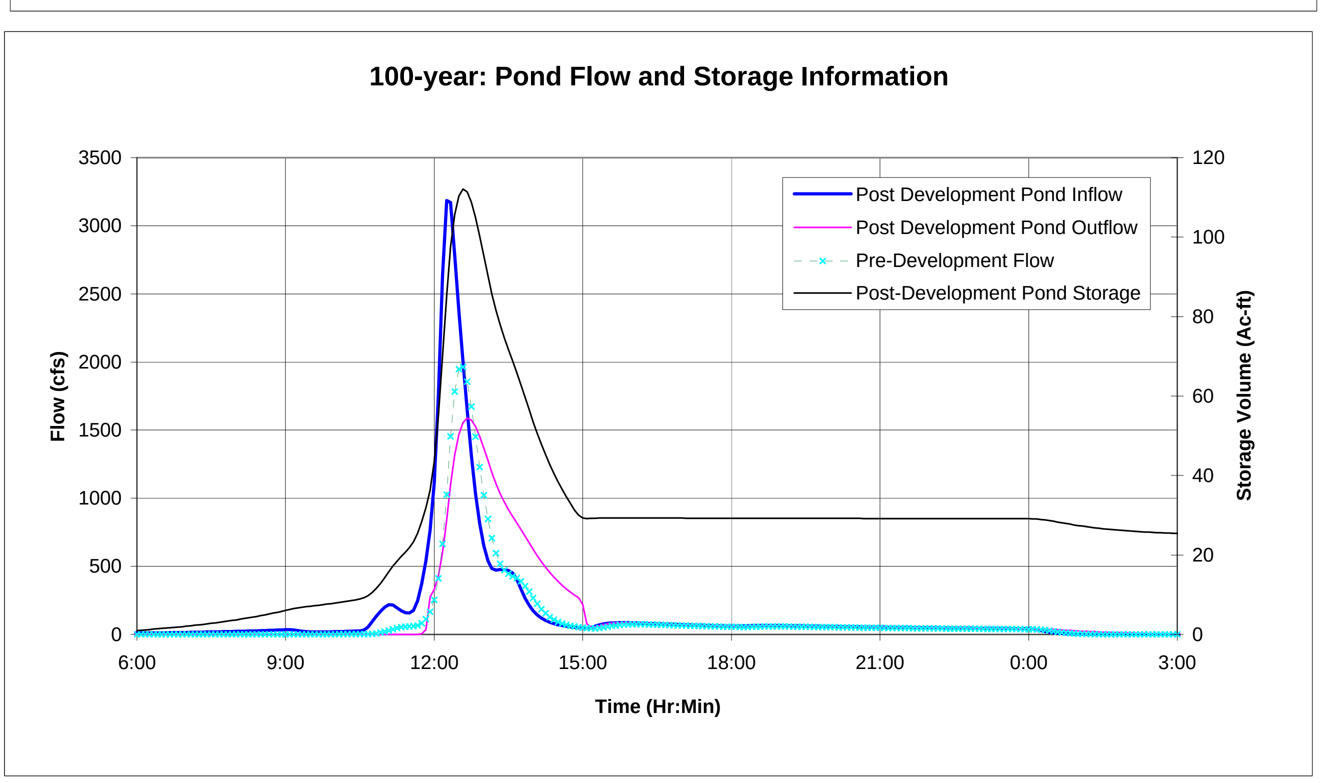
Post-Development Peak Inflow:	3185	cfs
Post-Development Peak Outflow:	1587	cfs
Pre-Development Peak Flow:	1963	cfs
Total Volume:	289.7	Ac-ft
Peak Storage:	112.1	Ac-ft

POND GEOMETRY

Pond Length to Width Ratio (xL:1W)	1.82		Pond Bottom Length	912	ft
Max Pond Depth	12	ft	Pond Bottom Width	462	ft
Side Slope (H:1)	4		Pond Top Length	1000	ft
Pond Volume at Max. Depth	122.64	Ac-ft	Pond Top Width at Max Depth	550	ft
5-yr control opening type	Box		100-yr control opening type	Box	
5-yr control opening size	8x10	ft	100-yr control opening size	10x10	ft
Number of parallel 5-yr openings	2		Number of parallel 100-yr structures	2	
5-yr top control height	6	ft	100-yr water surface elevation	11	ft
WQCV top control height	3	ft			
			Estimated impoundment area for 100-year detention	12.63	Ac
			Estimated footprint area for 100-year detention (includes riparian area)	20.66	Ac







Preliminary Design Pond Modeling Summary

Watershed 11, Pond 11-1 Output Summary

Water Quality Capture Volume: 14.46 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1167	cfs
Post-Development Peak Outflow:	704	cfs
Pre-Development Peak Flow:	712	cfs
Total Volume:	163.0	Ac-ft
Peak Storage:	45.9	Ac-ft

100-Year Storm Event Summary

Post-Development Peak Inflow:	2463	cfs
Post-Development Peak Outflow:	1433	cfs
Pre-Development Peak Flow:	1550	cfs
Total Volume:	333.8	Ac-ft
Peak Storage:	94.8	Ac-ft

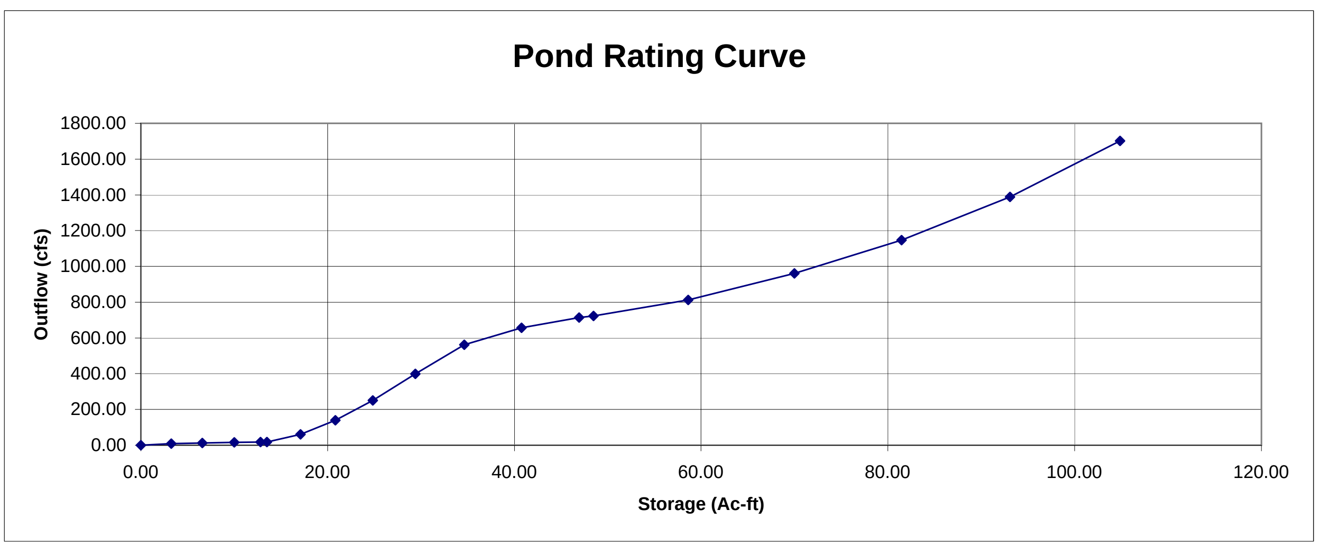
POND GEOMETRY

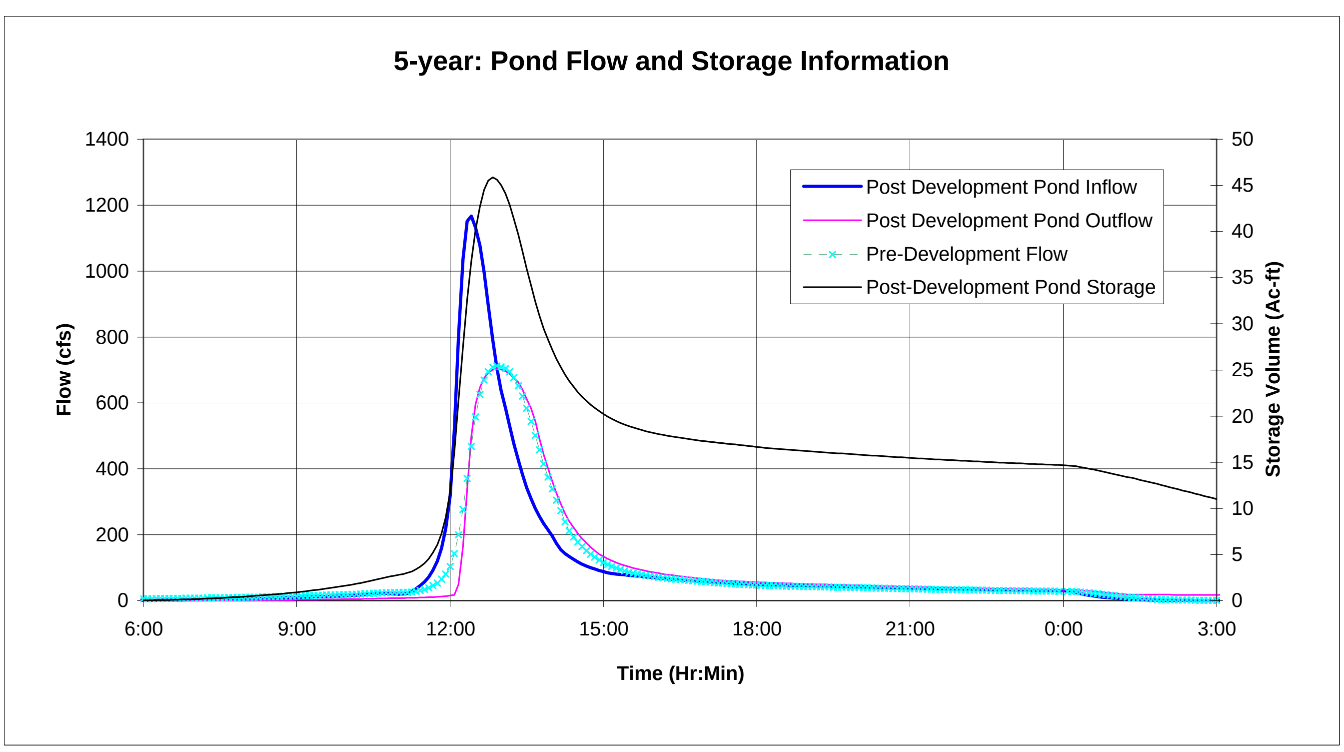
Pond Length to Width Ratio (xL:1W)	1.00	
Max Pond Depth	8	ft
Side Slope (H:1)	4	
Pond Volume at Max. Depth	104.85	Ac-ft
5-yr control opening type	Box	
5-yr control opening size	4x12	ft
Number of parallel 5-yr openings	2	
5-yr top control height	5.5	ft

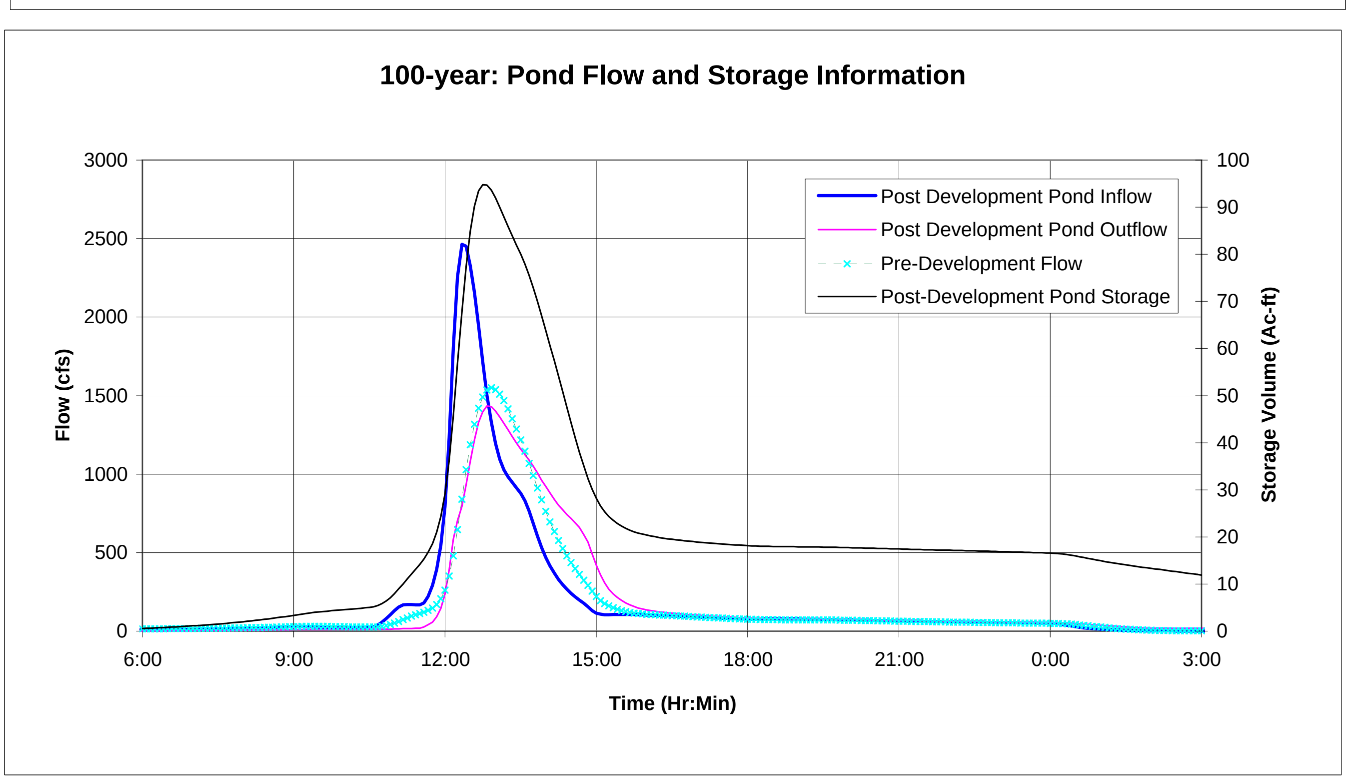
WQCV top control height	2	ft
100-yr control opening type	Box	
100-yr control opening size	6x16	ft
Number of parallel 100-yr structures	2	
100-yr water surface elevation	7.6	ft

Detention Pond 11-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
0.5	3.25	9.39
1	6.58	13.28
1.5	10.00	16.27
1.9	12.80	18.31
2	13.50	18.78
2.5	17.10	60.90
3	20.82	139.57
3.5	24.84	250.37
4	29.40	398.33
4.5	34.64	561.34
5	40.76	657.44
5.4	46.94	713.36
5.5	48.49	722.82
6	58.60	811.55
6.5	69.97	960.40
7	81.47	1147.51
7.5	93.09	1387.88
8	104.85	1701.37







Watershed 11, Pond 11-2 Output Summary

Water Quality Capture Volume: 5.39 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	422	cfs
Post-Development Peak Outflow:	194	cfs
Pre-Development Peak Flow:	254	cfs
Total Volume:	50.6	Ac-ft
Peak Storage:	22.2	Ac-ft

100-Year Storm Event Summary

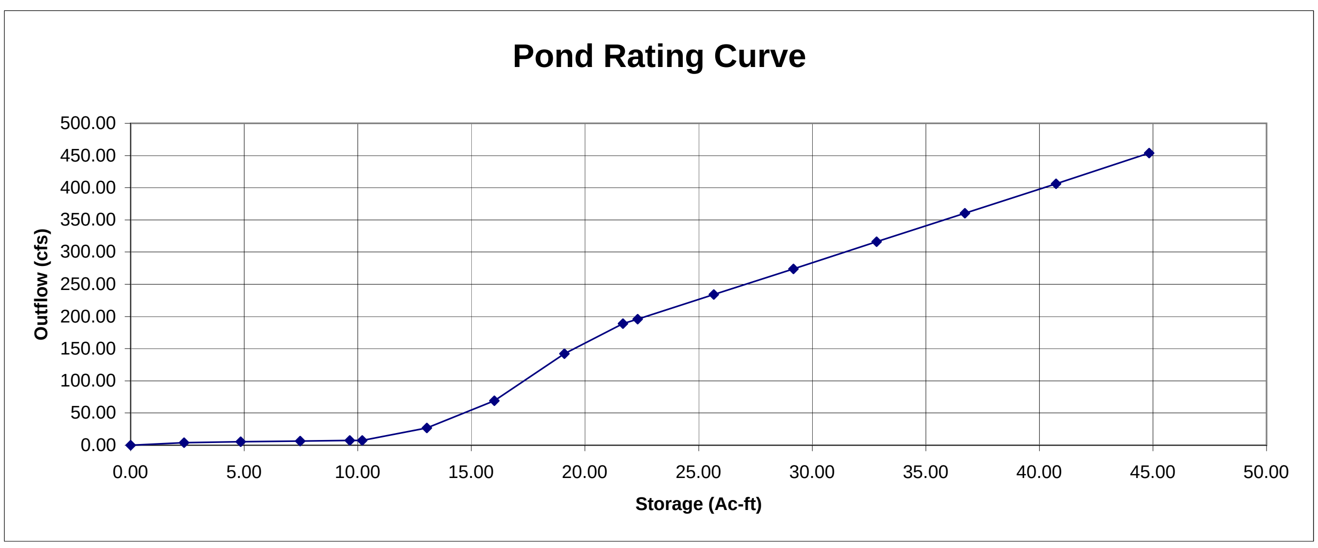
Post-Development Peak Inflow:	919	cfs
Post-Development Peak Outflow:	438	cfs
Pre-Development Peak Flow:	551	cfs
Total Volume:	105.9	Ac-ft
Peak Storage:	43.5	Ac-ft

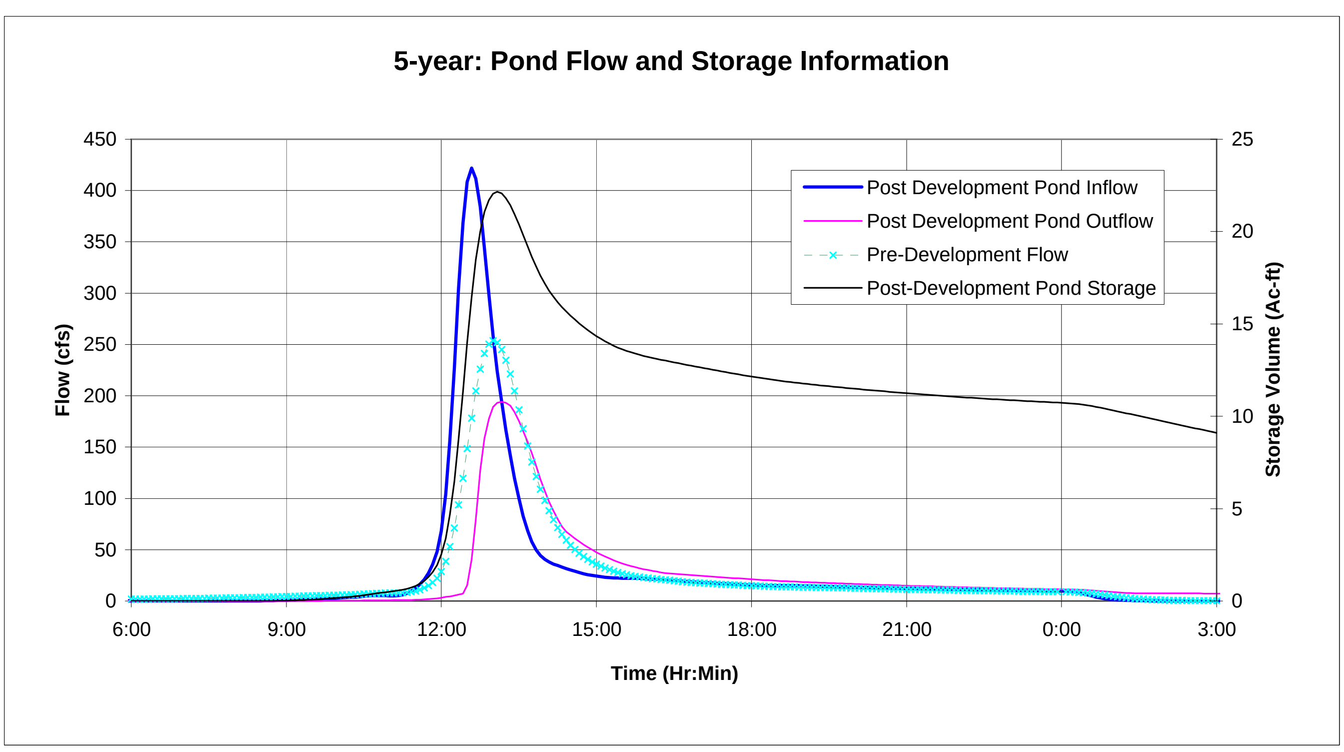
POND GEOMETRY

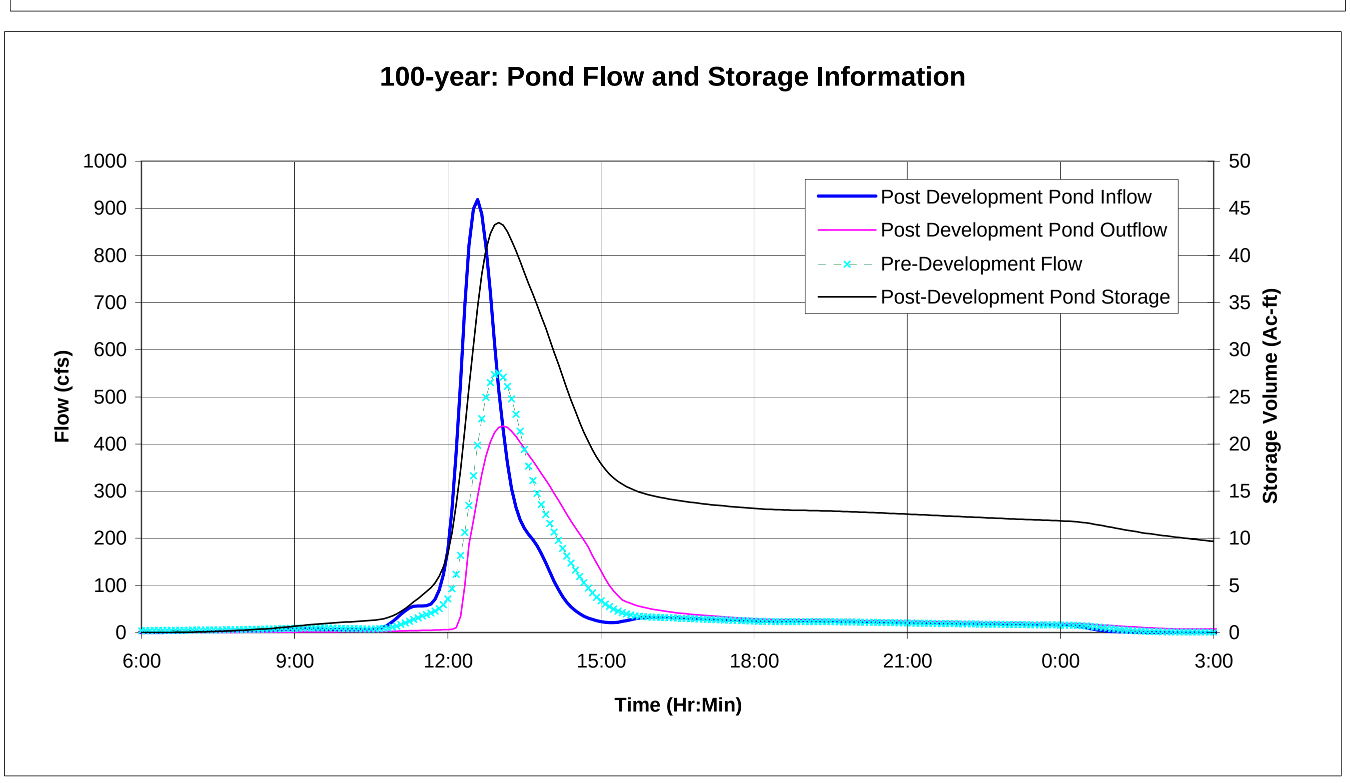
Pond Length to Width Ratio (xL:1W)	1.25		WQCV top control height	2	ft
Max Pond Depth	7	ft	100-yr control opening type	Box	
Side Slope (H:1)	4		100-yr control opening size	6x10	ft
Pond Volume at Max. Depth	44.83	Ac-ft	Number of parallel 100-yr structures	1	
5-yr control opening type	Box		100-yr water surface elevation	6.8	ft
5-yr control opening size	4x10	ft			
Number of parallel 5-yr openings	1				
5-yr top control height	4	ft			

Detention Pond 11-2 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
0.5	2.35	3.83
1	4.84	5.41
1.5	7.47	6.63
1.9	9.65	7.46
2	10.20	7.66
2.5	13.04	26.97
3	16.01	68.90
3.5	19.10	142.25
3.9	21.67	188.71
4	22.32	196.01
4.5	25.67	233.89
5	29.17	273.94
5.5	32.84	316.04
6	36.72	360.10
6.5	40.74	406.04
7	44.83	453.78







Watershed 40, Pond 40-1 Output Summary

Water Quality Capture Volume: 55.08 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	1625	cfs
Post-Development Peak Outflow:	1376	cfs
Pre-Development Peak Flow:	1454	cfs
Total Volume:	1218.8	Ac-ft
Peak Storage:	203.5	Ac-ft

100-Year Storm Event Summary

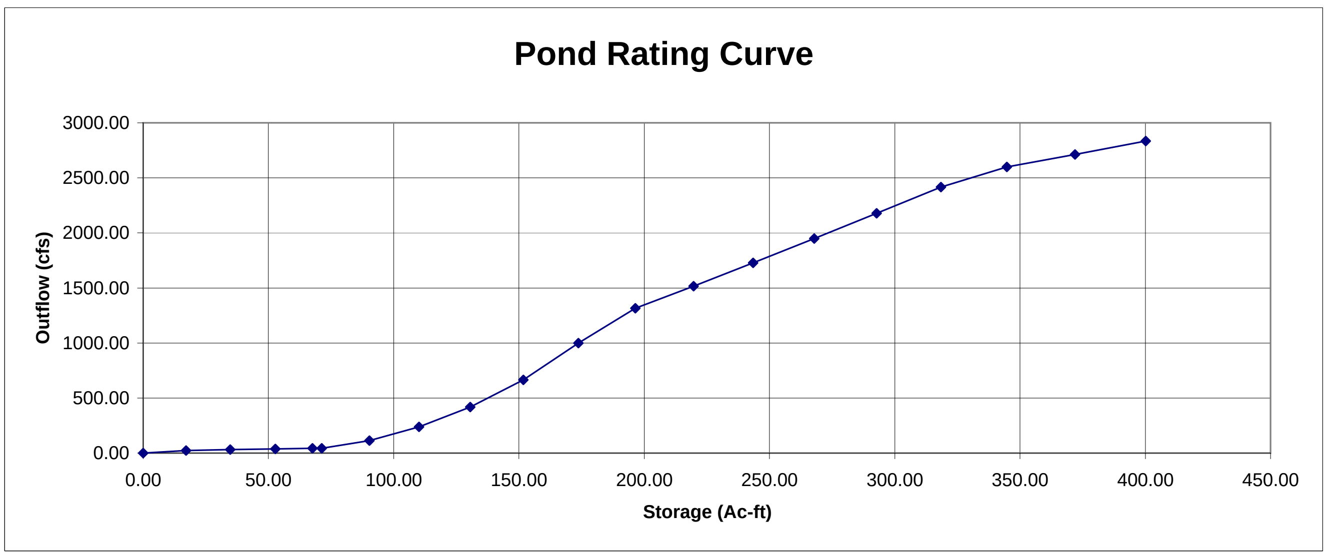
Post-Development Peak Inflow:	3330	cfs
Post-Development Peak Outflow:	2610	cfs
Pre-Development Peak Flow:	3790	cfs
Total Volume:	2581.7	Ac-ft
Peak Storage:	347.7	Ac-ft

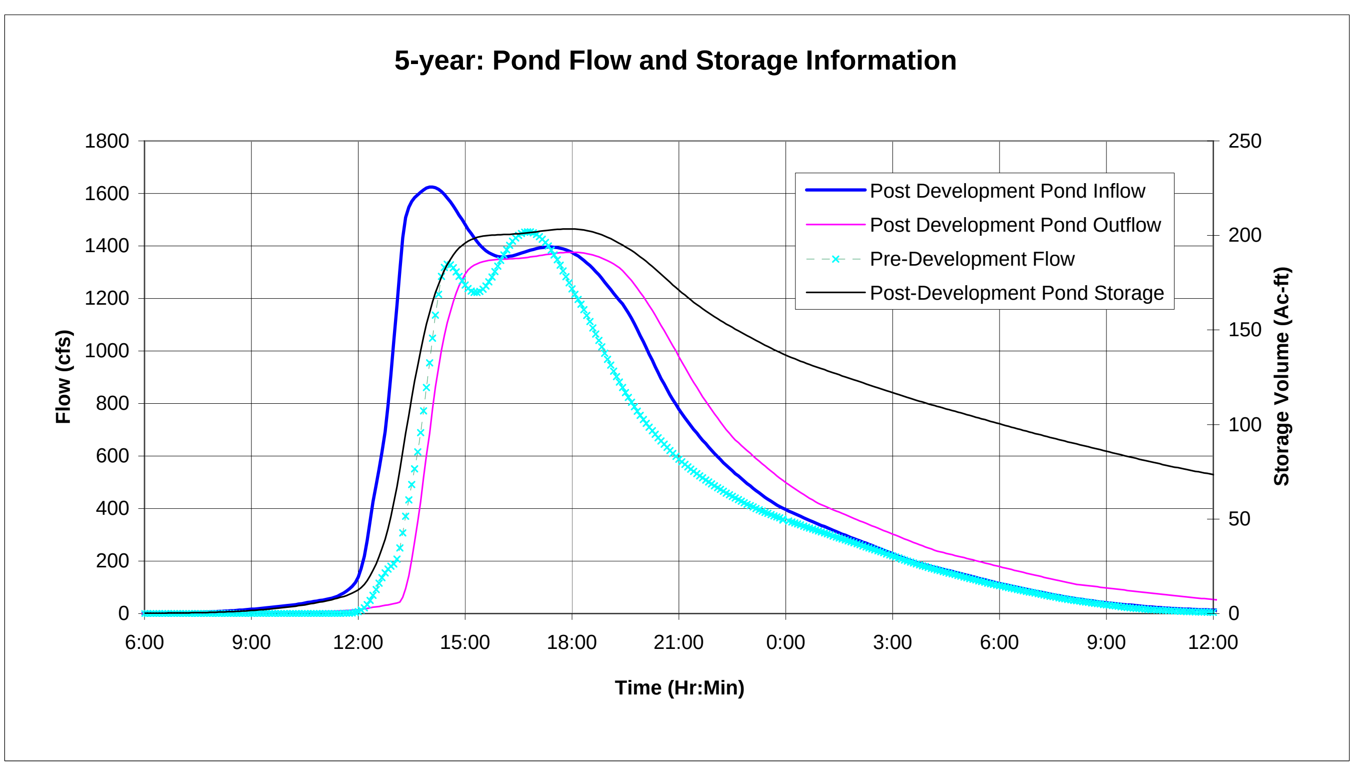
POND GEOMETRY

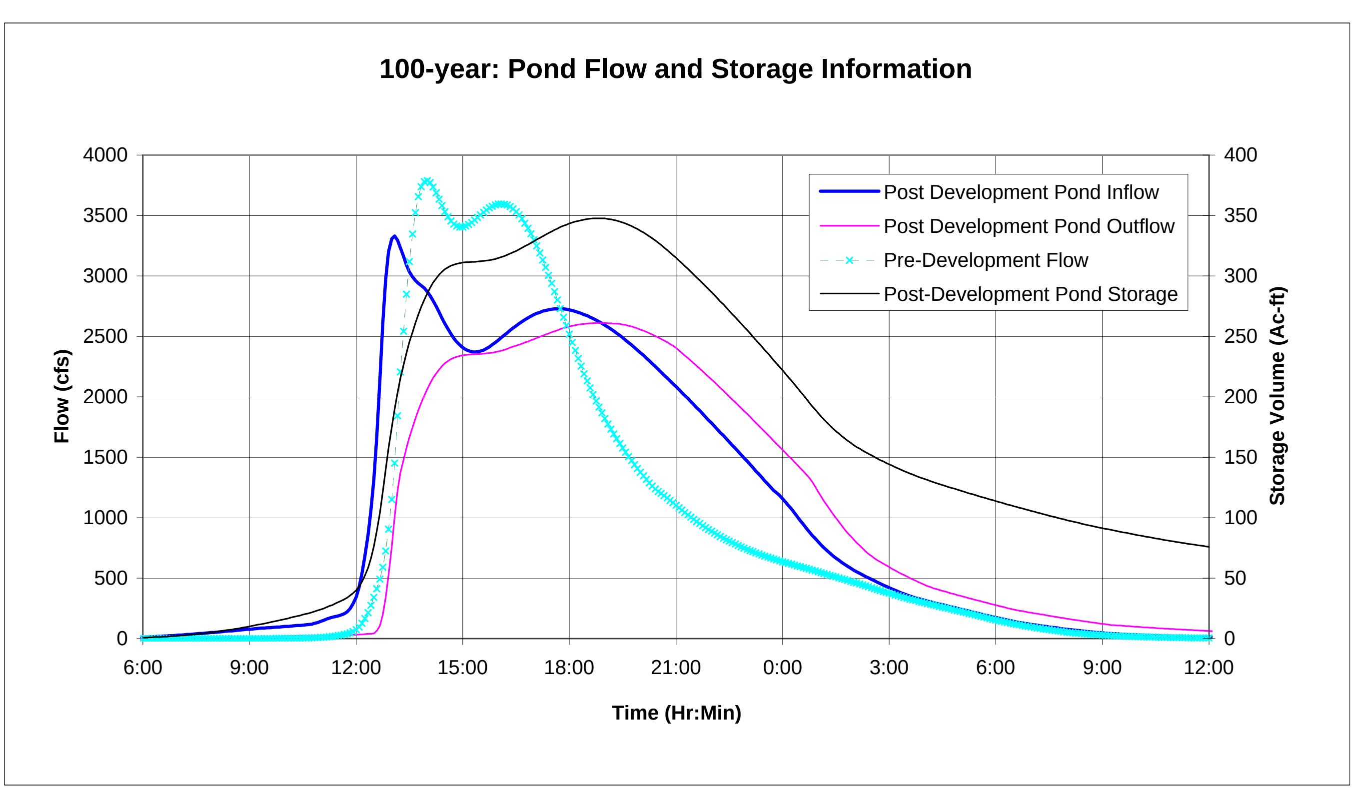
Pond Length to Width Ratio (xL:1W)	2.00		WQCV top control height	2	ft
Max Pond Depth	9	ft	100-yr control opening type	Box	
Side Slope (H:1)	4		100-yr control opening size	6x16	ft
Pond Volume at Max. Depth	400.15	Ac-ft	Number of parallel 100-yr structures	3	
Number of parallel 5-yr openings	0		100-yr water surface elevation	8.1	ft

Detention Pond 40-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
0.5	17.17	22.36
1	34.73	31.62
1.5	52.73	38.73
1.9	67.54	43.59
2	71.24	44.72
2.5	90.34	112.25
3	110.09	238.29
3.5	130.56	419.09
4	151.79	666.49
4.5	173.76	998.37
5	196.42	1314.90
5.5	219.68	1516.98
6	243.48	1728.48
6.5	267.84	1948.98
7	292.80	2178.12
7.5	318.43	2415.63
8	344.78	2597.85
8.5	371.98	2713.80
9	400.15	2833.68







Watershed 51, Pond 51-1 Output Summary

Water Quality Capture Volume: 8.60 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	452	cfs
Post-Development Peak Outflow:	423	cfs
Pre-Development Peak Flow:	551	cfs
Total Volume:	162.9	Ac-ft
Peak Storage:	25.9	Ac-ft

100-Year Storm Event Summary

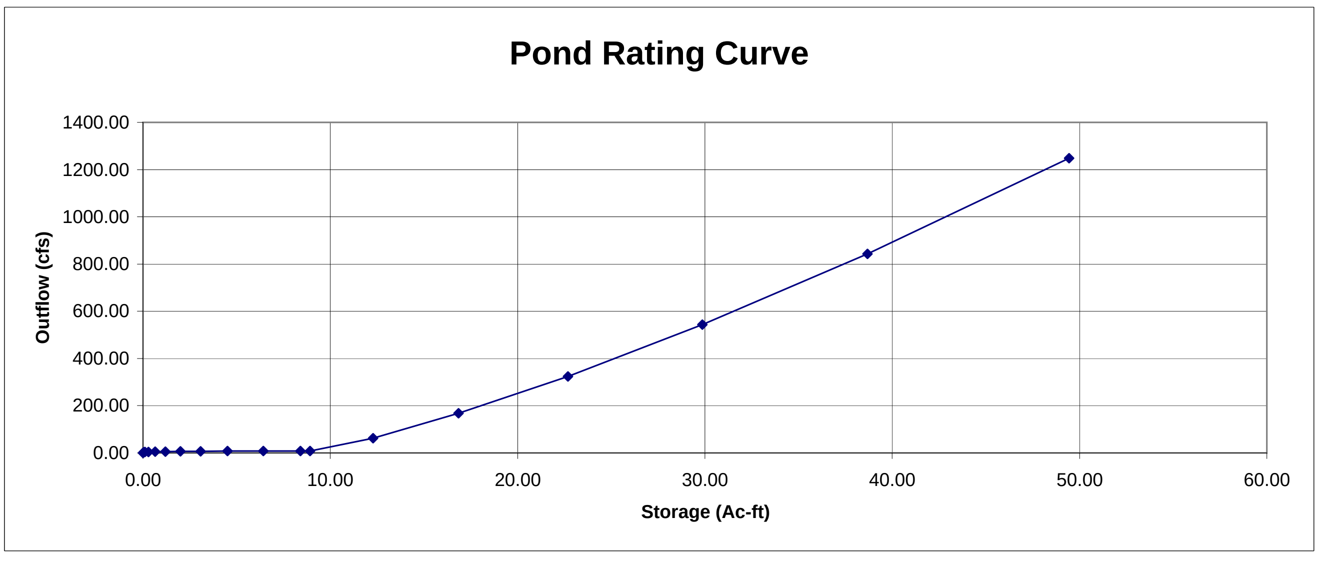
Post-Development Peak Inflow:	1257	cfs
Post-Development Peak Outflow:	1188	cfs
Pre-Development Peak Flow:	1515	cfs
Total Volume:	356.7	Ac-ft
Peak Storage:	47.9	Ac-ft

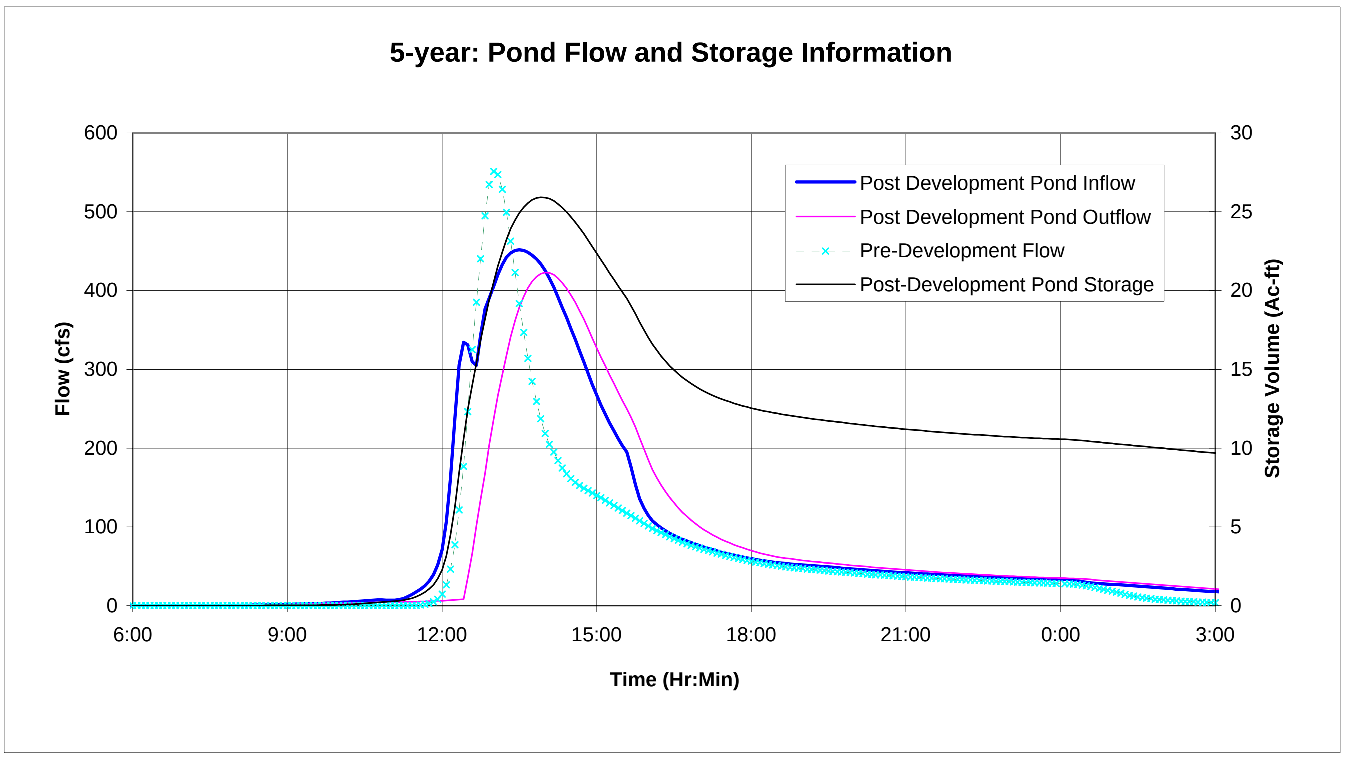
POND GEOMETRY

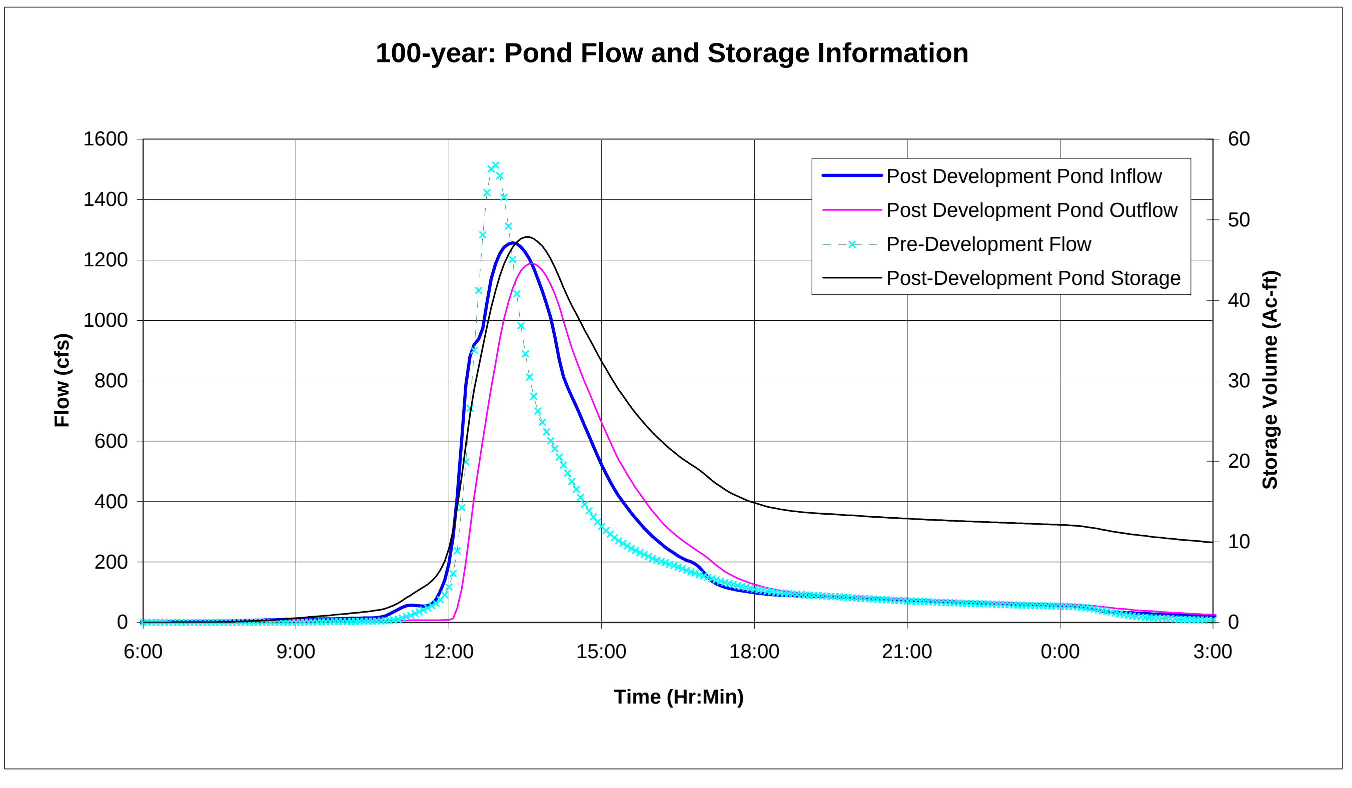
Pond Length to Width Ratio (xL:1W)	2.00		WQCV top control height	5	ft
Max Pond Depth	8	ft	100-yr control opening type	Box	
Side Slope (H:1)	4		100-yr control opening size	6x16	ft
Pond Volume at Max. Depth	8.91	Ac-ft	Number of parallel 100-yr structures	2	
Number of parallel 5-yr openings	0		100-yr water surface elevation	7.9	ft

Detention Pond 51-1 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
0.5	0.03	2.65
1	0.11	3.75
1.5	0.30	4.59
2	0.65	5.30
2.5	1.20	5.93
3	1.99	6.49
3.5	3.08	7.01
4	4.52	7.50
4.5	6.42	7.95
4.9	8.41	8.30
5	8.91	8.38
5.5	12.28	62.27
6	16.85	167.90
6.5	22.68	323.92
7	29.86	543.02
7.5	38.68	843.52
8	49.44	1247.70







Watershed 303, Pond 303-2 Output Summary

Water Quality Capture Volume: 10.79 Ac-ft

5-Year Storm Event Summary

Post-Development Peak Inflow:	809	cfs
Post-Development Peak Outflow:	247	cfs
Pre-Development Peak Flow:	448	cfs
Total Volume:	106.8	Ac-ft
Peak Storage:	49.0	Ac-ft

100-Year Storm Event Summary

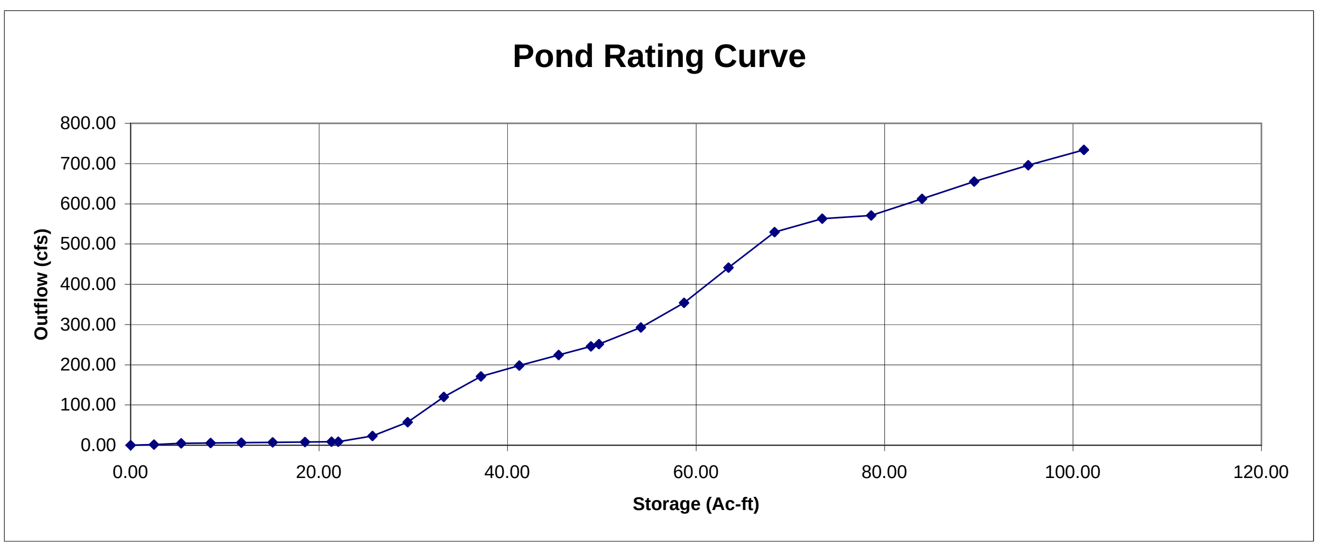
Post-Development Peak Inflow:	1727	cfs
Post-Development Peak Outflow:	681	cfs
Pre-Development Peak Flow:	1221	cfs
Total Volume:	214.9	Ac-ft
Peak Storage:	93.2	Ac-ft

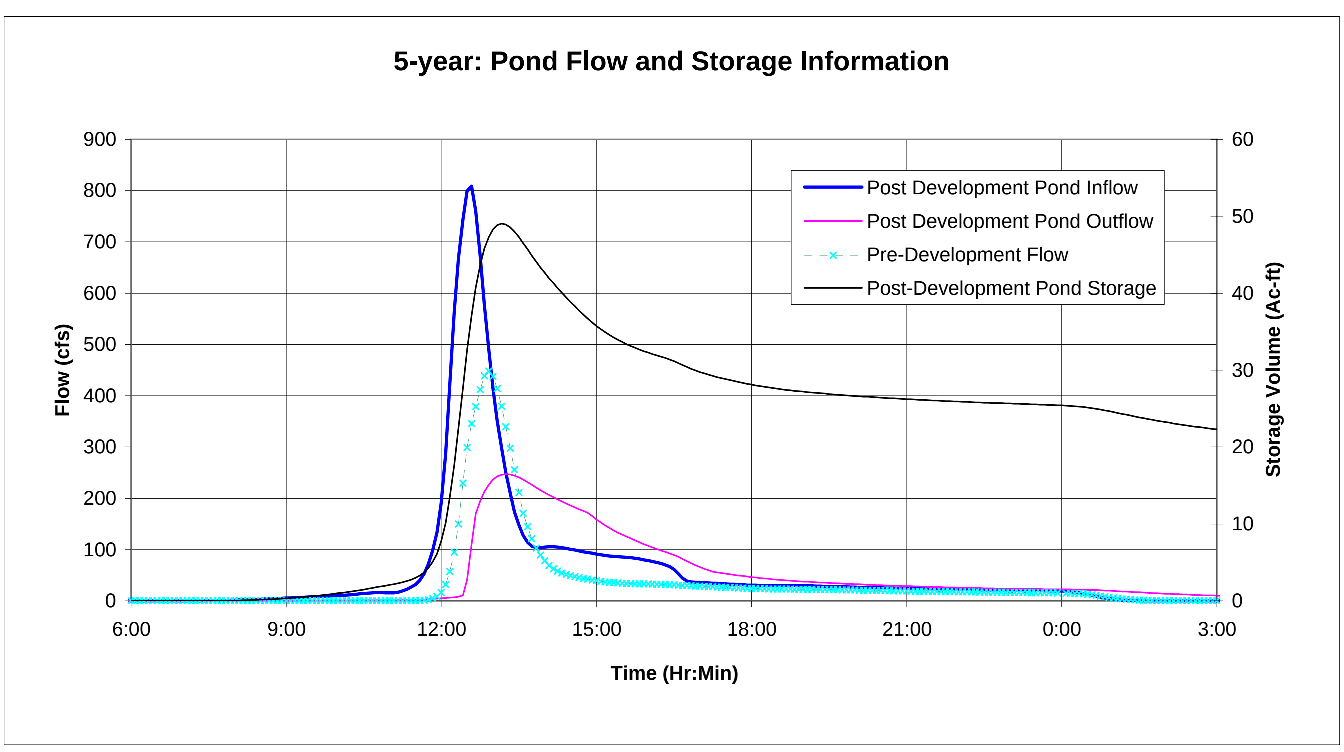
POND GEOMETRY

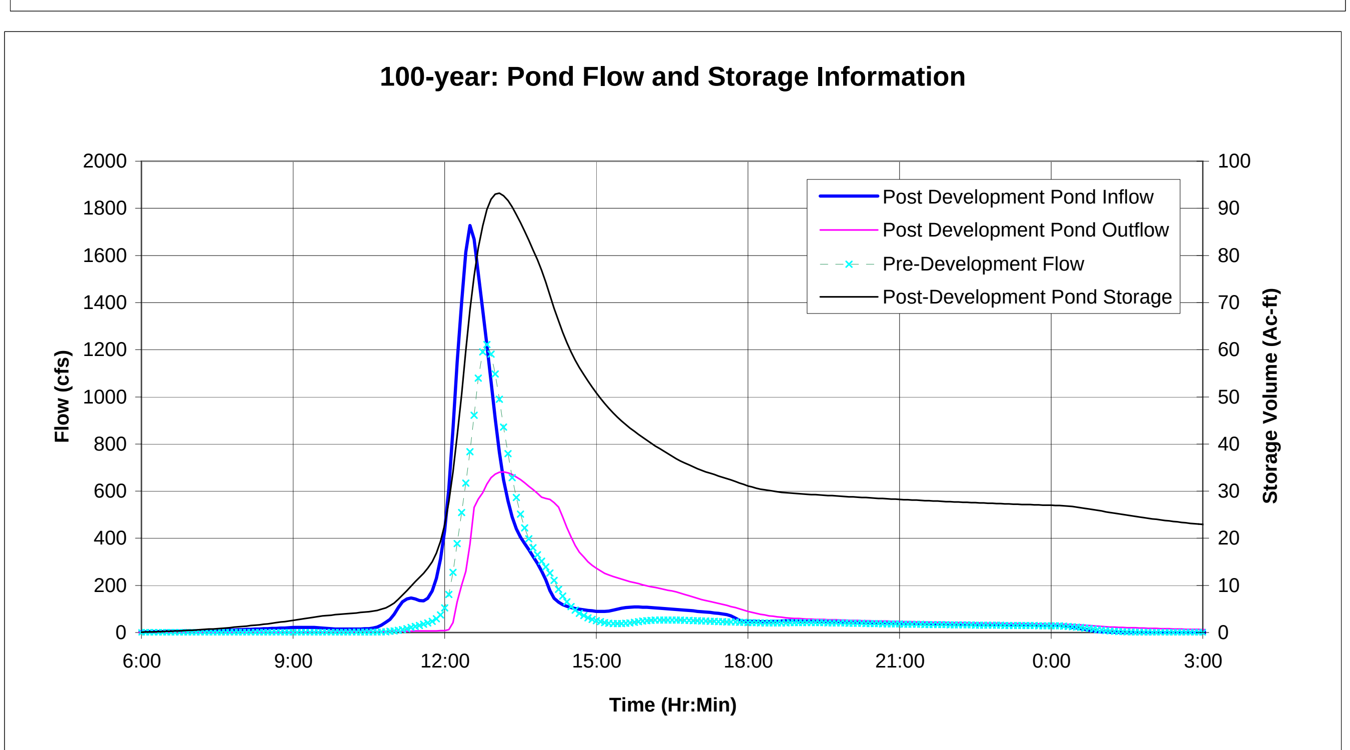
Pond Length to Width Ratio (xL:1W)	3.00		WQCV top control height	3.5	ft
Max Pond Depth	12	ft	100-yr control opening type	Pipe	
Side Slope (H:1)	4		100-yr control opening size	8	ft
Pond Volume at Max. Depth	101.15	Ac-ft	Number of parallel 100-yr structures	1	
5-yr control opening type	Pipe		100-yr water surface elevation	11.3	ft
5-yr control opening size	6	ft			
Number of parallel 5-yr openings	1				
5-yr top control height	7	ft			

Detention Pond 303-2 Rating Curve

Depth (ft)	Storage (Ac-ft)	Outflow (cfs)
0	0.00	0.00
0.5	2.49	1.81
1	5.37	4.68
1.5	8.50	5.73
2	11.74	6.62
2.5	15.07	7.40
3	18.51	8.11
3.4	21.33	8.63
3.5	22.04	8.76
4	25.67	23.39
4.5	29.40	57.05
5	33.23	119.82
5.5	37.17	171.37
6	41.23	197.63
6.5	45.41	224.40
6.9	48.85	245.97
7	49.71	251.36
7.5	54.15	292.40
8	58.73	353.93
8.5	63.46	441.75
9	68.34	529.82
9.5	73.39	562.91
10	78.60	571.16
10.5	83.98	612.09
11	89.53	655.37
11.5	95.25	696.08
12	101.15	733.94







Howard R. Green Company

Master Plan for Stormwater BMPS

CH2MHILL

Informational Meeting

We are pleased to present the first of a series of Informational Meetings for the City of Sioux Falls Best Management Practices (BMPs) for stormwater. You will also have the opportunity to ask questions or offer comments. If you prefer to mail your questions/ comments, a postcard will be available at the meeting.

Date: Wed, February 19, 2003

Time: 1:00 p.m. and 7:00 p.m.

Location: Kuehn Community Center, 2801 S. Valley View Rd.
Sioux Falls, South Dakota

Howard R. Green Company
309 W. 43rd Street, Suite 101
Sioux Falls, SD 57105

SEAL OF THE CITY OF SIOUX FALLS
SOUTH DAKOTA

JUN 25 03
MAILED FROM ZIP CODE 57105

What Are Best Management Practices For Stormwater?

Stakeholder Address

Sioux Falls Best Management Practices (BMPs) For Stormwater

Comment/Question Form

NAME: ______________________________ **TELEPHONE:** ______________________

ADDRESS: ___________________________

______________________________________ **E-MAIL:** __________________________

____

COMMENTS/QUESTIONS:

____

____

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Please place this comment/question form in the designated box on your way out of the meeting, or mail it to Mark Cotter, Howard R. Green Company, 309 West 43rd Street, Suite 101, Sioux Falls, SD 57105-6805

Attn: Mark Cotter
Howard R. Green Company
309 West 43rd Street, Suite 101
Sioux Falls, SD 57105-6805

STORMWATER BMP MASTER PLAN IRAB MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Wednesday, February 19, 2003 at 8:30 a.m.
Location: Kuehn Community Center
Re: Public Informational Meeting for IRAB Group
Attendance: See Attached Attendance Sheet

Mark Mittag from CH2M Hill introduced the team and reviewed the vision of the project. Mark Cotter of the Howard R. Green Company distributed the agenda, hard copy of the PowerPoint presentation, comment cards and Master Plan 2015 Growth Area. (See attachments to these minutes.)

The following is a summary of the items discussed:

1. Jeff Dunn: Please expanded on the difference between structural and non-structural BMP. Each will have WQCV.
   - Structural – Detention Pond – including a WQCV.
   - Non-Structural – Grass swale and buffer. Does offer benefits but do not capture and release to treat the water quality.

2. Jeff Dunn: What is opinion of products like Stormceptor?
   - Key is maintenance.
   - WQ catch basins that are out of sight and out of mind are typically not maintained.

3. Jim Soukup: Who polices the water quality?
   - No effluent limit similar to sanitary sewer effluent.
   - No specific measurement/testing – if you construct with BMP design criteria's, it will function accordingly based on past results and on-going studies around country.

4. Jeff Dunn: Have to clean twice a year to operate according to plan. Have to coordinate with street department.
   - Some ponds will need to be cleaned once a year some may only need to be cleaned every 5 to 10 years, based on the activities upstream.

5. Jon Schmidt: What type of maintenance and how often?
   - It depends. If have heavy contaminants in stormwater, will be needed more often.
   - Location may only require once a year based on the land use upstream. Typically, an inspection is done once a year to determine the level of maintenance needed for that year.

6. Cindy Friessen: What is priority since City is looking at entire City growth area?
   - The priority is when do they have to be constructed.
   - Cindy's comment – therefore it is based on sequence of developments? Yes

7. Chuck Point: What about existing developed areas – areas outside the colored area?
    - Lyle Johnson: Retrofit plan in place for existing ponds.
    - Bob Kappel: Regulation is written. New development or significant redevelopment occurs. BMPs have to be implemented. Site specific – 2005; residential – 2005.
    - Lyle Johnson: If you know of an area we have left out, please bring it to our attention.
    - Steve Quincey: There are drainage studies completed and ponds have not been constructed, and these areas need to be included.

8. Cindy Friessen: Economic impact of a program like this?
    - Cost varies depending on the amount of land and design criteria.
    - Denver area: ½% to 2% of land is BMP.

9. Steve Brockmueller: What pollutants are included in BMP design criteria?
    - Sediment, nutrients, oils (highly commercial area) can be removed with BMPs.

10. Chuck Point: Sample Big Sioux River above Sioux Falls and below Sioux Falls. What will be the difference in 5 years if these BMPs are implemented?
    - Can't guarantee what will happen in the Big Sioux River, but do know the water quality downstream of the BMP is better than upstream of the BMP.

11. Jim Soukup: Is regional better than site specific?
    - Communities select regional or site specific.
    - Sioux Falls has taken a regional approach. Maintenance is a key savings with regional BMP.

12. Steve Quincey: Site specific – property owner maintains?
    - Yes, but not necessary – City is the permit holder and is responsible for the ultimate water quality discharging from their storm sewer system.

13. Steve Brockmueller: Will there be site specific plus regional?
    - There may be areas which require site specific BMPs and other areas served by a regional BMP based on the location in the basin.

14. Steve Quincey: What will design parameters will the Study recommended?
    - WQCV.
    - 5 year and 100 year volumes.

15. Jeff Dunn: IRAB Subcommittee for this project?
    - Lyle Johnson said contact Jeff Dunn directly.

16. Next meeting of IRAB is March 5th at the Water Purification Plant.

17. Next meeting: April 10, 2003.

Copies sent to Jeff Dunn and Mark Mittag.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

MEETING ATTENDANCE SIGN-UP SHEET
BEST MANAGEMENT PRACTICES FOR STORM WATER, 2003 – SIOUX FALLS, SD
FEBRUARY 19, 2003 - 8:30 a.m.

No.	Name (Please Print)	Representing	Office Phone (Area Code/No.)	Cell Phone (Area Code/No.)	E-Mail Address
1.	Shannon Ausen	City of Sioux Falls	367-8607	–	sausen@siouxfalls.org
2.	DUNN, JEFF	C.O.S.F.	367-8665		jdunn@siouxfalls.org
3.	CHUCK SERBUS	C.O.S.F.	367-8650		CSERBUS@SiouxFalls.org
4.	Kerry Ellis	C.O.S.F.	367-8670		kellis@sioux falls.org
5.	Bob Kappel	SF	367-7088		
6.	Lyle Johnson	City of Sioux Falls	367-8600		ljohnson@siouxfalls.org
7.	Jane Andersen	City SF	8606		janderson@siouxfalls.org
8.	Jeff Schmitt	City of Sioux Falls	367-8888		
9.	Joy Cordier Jensen	Stockwell Engineers	338-6668		sbrockmueller.stockwell@all.net
10.	Steve Brockmueller	" "	" "		
11.	Cynthia Mannin	Friessen Construction	332-6355	321-0870	Friessenco@aol.com
12.	Jim Soukup	Soukup Constr.	332-5282	360-5394	jsoukup@digner.com
13.	Jan Meulenburg	Viereck Comm	332-7500	728-5678	jan@viereckcommercial.com
14.	Mark Perry	City of SF	367-8641	941-1151	mperry@siouxfalls.org
15.	Chuck Point	Ronning Homes	3366000	360-1680	Chuck.Point@ronninghomes.com
16.	Thad Roberts	Sayre Assoc.	332-7211		robertsta@rfsayre.com

No.	Name (Please Print)	Representing	Office Phone (Area Code/No.)	Cell Phone (Area Code/No.)	E-Mail Address
17.	Steve Quincey	Sayre Assoc.	332-7211		quinceysm@r.l.sayre.com
18.	Mark Mittag	CH2M Hill	(414) 847-0536		mmittag@ch2m.com
19.	Joe Tranke	HR Green	319-841-4380		jtranke@hrgreen.com
20.	Jon D. Schmidt	IMAA & Schmidt Eng.	336-3062		schmidt Engineer @ AOL.COM
21.	MARK D. COTTER	Howard R. Green	331-4499		MCOTTER@hrgreen.com
22.	Kim Buhl	Schmitz Kalda			
23.	Russ Sorensen	City of SF	367-8886		rsorensen@siouxfalls.org
24.					
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IRAB Presentation Agenda

TO: Jeff Dunn/Sioux Falls

COPIES: Laurens van der Tak/CH2M HILL
Kyle Hamilton/CH2M HILL
Mark Cotter/H.R. Green

FROM: Mark D. Mittag

DATE: February 18, 2003

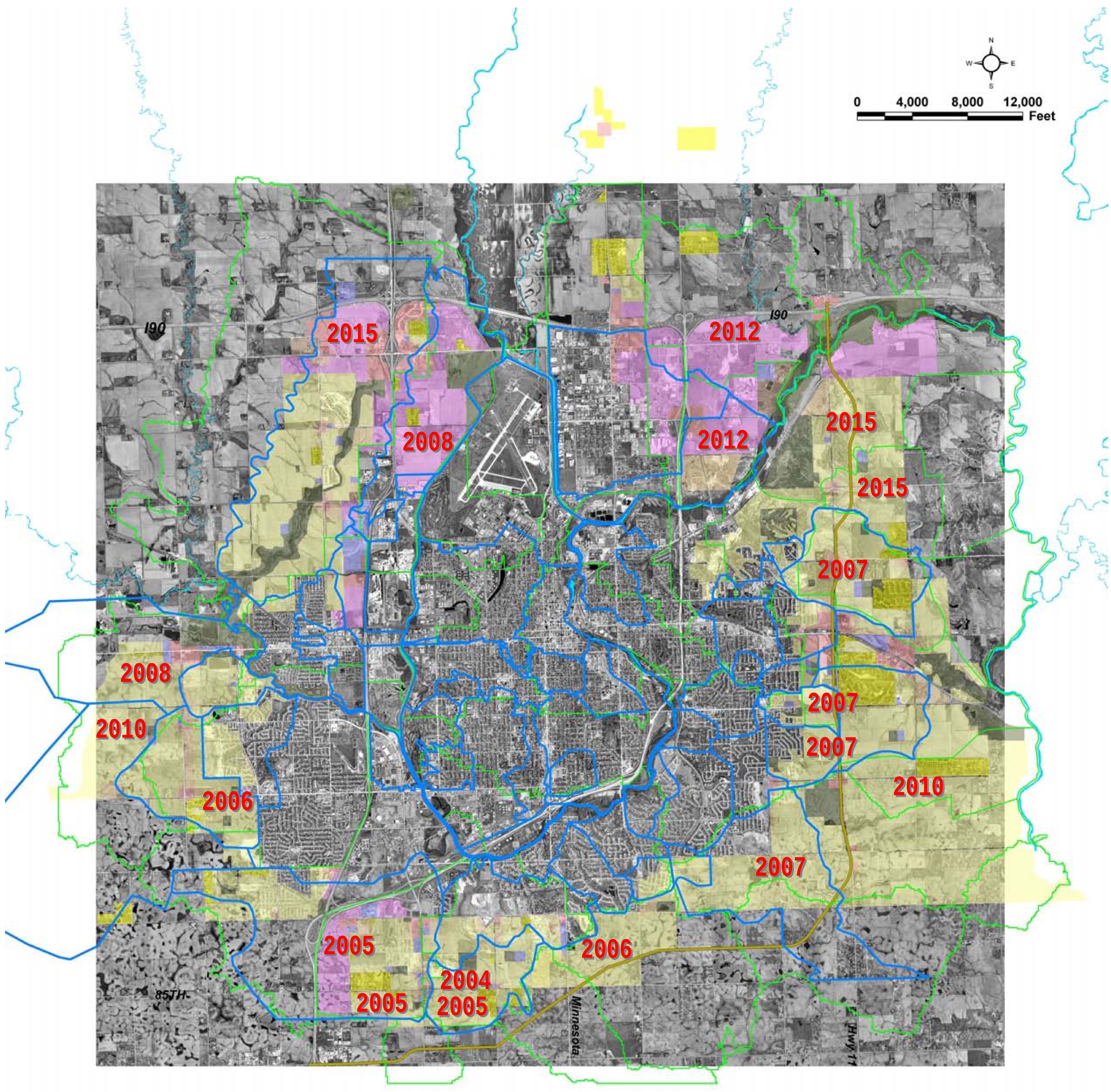
The items we plan to cover at the February 19th IRAB meeting are included below. We will discuss draft concepts for each of these areas at the meeting and will be interested in receiving feedback.

Stormwater BMP Master Plan IRAB Meeting Agenda

A brief overview of the following items is planned during the IRAB meeting.

- Overview of Stormwater BMP Master Plan Project
- Draft Design Criteria
- Draft Non-Structural BMP (buffers and greenways) Application
- Example Siting Criteria
- Priority Areas in the City
- Preliminary BMP Design Locations
- Percent Impervious Findings
- Stormwater BMP Master Plan Sub-Committee
- Regularly Scheduled Outreach Meetings:
  February 19, 1PM City Departments and SDDOT; 7PM General Public
  Future tentative dates: April 10-11, June 4, 5

Master Plan 2015 Growth Area



Sioux Falls 2015 Land Use and Stormdrain Boundaries

2015landuse.shp

- Residential Single Family
- Existing Rural Residential
- Residential Multiple Family
- Manufacturing
- Transportation, Communication, Utilities, Parking Facilities
- General Commercial
- Heavy Commercial
- Offices, Churches, Institutions, Schools
- Cultural Activity; Libraries, Museums, Parks
- Cemetery, Landfills, Mining, Quarrying, Under Construction
- Cropland, Grasslands, Vacant
- 2001approvedresidentialdevelopments.shp
- Prior Drainage Study Areas
- Sanitary Sewer Basin
- 2010 Priority Schedule

CH2MHILL
in association with
Howard R. Green Company

STORMWATER BMP MASTER PLAN MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Wednesday, February 19, 2003 at 1:00 p.m.
Location: Kuehn Community Center
Re: Public Informational Meeting for City, DOT and Other Agencies in the Immediate Area of the Study
Attendance: See Attached Attendance Sheet

Mark Mittag from CH2M Hill introduced the team, reviewed the vision of the project and presented the PowerPoint presentation. Mark Cotter of the Howard R. Green Company distributed the agenda, hard copy of the PowerPoint presentation and comment cards. (See attachments to these minutes.)

Mark Mittag opened it up to questions and asked how this project might affect each individual responsibility:

1. Jeff Dunn: How is WQCV computed/calculated?
   - It is based on the impervious area draining to the pond.

2. Russ Sorenson: As the City develops and the land use matures, this is a new thought process for developers.

3. Scott Buss, Minnehaha Water: As the City grows; it will impact the locations of their lines. Location of BMP may also impact their distribution lines.

4. Mike Bassing: Monitoring person for erosion control compliance for the City of Sioux Falls. Mark Mittag commented, if Mike does his job enforcing erosion control, less maintenance will be required in the regional BMPs.

5. John Osman: John may be involved with the construction of these facilities.

6. Debra Moeller, SECOG: She works with securing SRF funding. Discussions have occurred with the DENR and SRF funding should be available to build these facilities. SRF funding cannot be used to purchase land.

7. Russ Sorenson: How much land is set aside in other communities across the country?
   - ½% to 2%.
   - Comment: This land is often not developable because of where it is located. Very little impact on economic development (RS).

8. Bob Kappel: Developers with green design. How will you deal with giving the developer a hard number of green area required?
   - Site specific BMP would have flexibility if they are bringing a larger green space percent than required.
   - It may affect the regional BMP if the green proposal is greatly different impervious area is proposed.

- The percent impervious numbers developed from a review of Sioux Falls data will be used in preparing the regional BMP Master Plan. For on-site BMP situations, the actual percent impervious could be used instead of these planning numbers.

9. Russ Sorenson: Will there be standards or guidelines for sampling and maintenance of these BMPs?
   - A sampling program is not part of the BMP Master Plan,
   - The City does however obtain samples both at existing BMP sites and in-stream as separate part of City's stormwater permit requirements.

Copies sent to Jeff Dunn and Mark Mittag.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

MEETING ATTENDANCE SIGN-UP SHEET
BEST MANAGEMENT PRACTICES FOR STORM WATER, 2003 – SIOUX FALLS, SD
FEBRUARY 19, 2003 - 1:00 p.m.

No.	Name (Please Print)	Representing	Office Phone (Area Code/No.)	Cell Phone (Area Code/No.)	E-Mail Address
1.	Jim Evans	Minnehaha Comm. Water	605 428-3374		
2.	Scott Buss	Minnehaha Co. Water	605-428-3374		mcwc@siouxvalley.net
3.	DEBRA MOELLER	SECOG	367-5390		debra@secog.org
4.	Mark Mittag	CH2M Hill	414 847-0536		mmittag@ch2m.com
5.	Bob Kappel	City of Sioux Falls	(605) 367-7088		Same.
6.	Mike Bassing	City of SF	941-1133		
7.	John Osmun	" " "	367-8640		josmun@siouxfalls.org
8.	DUNN, JEFF	CITY OF S.F.	367-8665		jdunn@siouxfalls.org
9.	Laurens van der Tak	CH2M HILL	703-471-1441		Lvandert@ch2m.com
10.	Brooke White	SDDOT	605-367-5680		brooke.white@state.sd.us
11.	MARK COTTER	HRG	605-334-4499		mcotter@hrgreen.com
12.	Russ Sorenson	City of Sioux Falls	605-367-____		Same
13.	Joe Trnka	HRG	605-334-4499		jtrnka@hrgreen.com
14.	Ron Nelson	Bender Commercial	336-7600		rnelson@benderco.com
15.					
16.					

City Department Presentation Agenda

TO: Jeff Dunn/Sioux Falls

COPIES: Laurens van der Tak/CH2M HILL
Kyle Hamilton/CH2M HILL
Mark Cotter/H.R. Green

FROM: Mark D. Mittag

DATE: February 18, 2003

The items we plan to cover at the February 19th City Department and inter-agency meeting are included below. We will discuss draft concepts for each of these areas at the meeting and will be interested in receiving feedback.

The goals of the meeting include:

1. Present an overview of the Stormwater BMP Master Plan Project
2. Discuss standards and goals for open space, river greenways, buffers, utility and street corridors, and development needs.
3. Discuss viewpoints and important issues for the departments and agencies.

Stormwater BMP Master Plan City Department and Inter-Agency Meeting Agenda

A brief overview of the following items is planned during the meeting.

- Overview of Stormwater BMP Master Plan Project
- Draft Design Criteria
- Draft Non-Structural BMP (buffers and greenways) Application
- Example Siting Criteria
- Priority Areas in the City
- Preliminary BMP Design Locations
- Standards for open space
- Street corridors
- Utility corridors
- Regularly Scheduled Outreach Meetings:
  February 19, 7PM General Public
  Future tentative dates: April 10-11, June 4, 5

STORMWATER BMP MASTER PLAN MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Wednesday, February 19, 2003 at 7:00 p.m.
Location: Kuehn Community Center
Re: Public Informational Meeting for General Public
Attendance: See Attached Attendance Sheet

Mark Mittag from CH2M Hill introduced the team, reviewed the vision of the project and presented the PowerPoint presentation. He then opened it up to questions:

1. Paul Clinton: Thinks terracing the 5-year and 100-year in a detention pond can better utilize and create a multiuse facility – 57th & Cliff.

2. Mark Vellinga: What is the schedule of the project?
   - July 1st is the date the Master Plan will be completed.
   - Next meeting is expected April 10, 2003.

3. Mike Cooper: Is there a specific number of BMPs planned?
   - No number in place until the modeling is complete.
   - Typically a BMP will accommodate 100-300 acre sites.

4. What do BMPs mean to developers? What are the positive elements?
   - Benefits are provided by the BMPs.
   - Provide aesthetic amenities – water front properties.
   - Buffers.
   - Green space for multi uses.
   - They are typically located in areas known as "marginally developable."
   - If they have a piece of land that has a regional BMP downstream, they won't have a change the way they currently operate.

5. Paul Clinton: Please remove Reed Canary Grass from list?
   - Chapter 12 – Seed.

6. Paul Clinton: Will a site specific BMP receive credit?
   - Jeff Dunn: Yes, if planned well, it will relieve some of the capacity of a downstream BMP. The City is developing a funding approach, which includes credit for on-site BMPs.

See attached for comments written on comment cards.

Copies sent to Jeff Dunn and Mark Mittag.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

MEETING ATTENDANCE SIGN-UP SHEET
BEST MANAGEMENT PRACTICES FOR STORM WATER, 2003 – SIOUX FALLS, SD
FEBRUARY 19, 2003 - 7:00 p.m.

No.	Name (Please Print)	Representing	Office Phone (Area Code/No.)	Cell Phone (Area Code/No.)	E-Mail Address
1.	Mark Cotter	HRG	605 334-4499		mcotter@hrgreen.
2.	Shannon Ausen	City of Sioux Falls	605-367-8667		sausen@siouxfalls.org
3.	DUNN, JEFF	CITY OF SIOUX FALLS	367-8665		jdunn@siouxfalls.or
4.	Laurens van der Tak	CH2M HILL	703-471-1441		Lvandert@ch2m.com
5.	Mark Mittag	CH2M HILL			
6.	Joe Tranka	HRG	319-841-4380		jtranka@hrgreen.com
7.	Mike Cooper	Parks and Rec.	605 367-7060		mcooper@siouxfalls.org
8.	Mark Vellinga	Hegg Companies	336-2111		mvellinga@heggcompanies.com
9.	Russ Sorenson	City of SF	367-8896		rsorenson@siouxfalls.org
10.	Paul Clinton	DAKOTA LAND SITE	334 4882		
11.	Jerrod Schum	KDLT - TV	361 - 1357		
12.					
13.					
14.					
15.					
16.					

SIOUX FALLS BEST MANAGEMENT PRACTICES (BMPs) FOR STORMWATER
PUBLIC INFORMATION MEETINGS
February 19, 2003

Comments

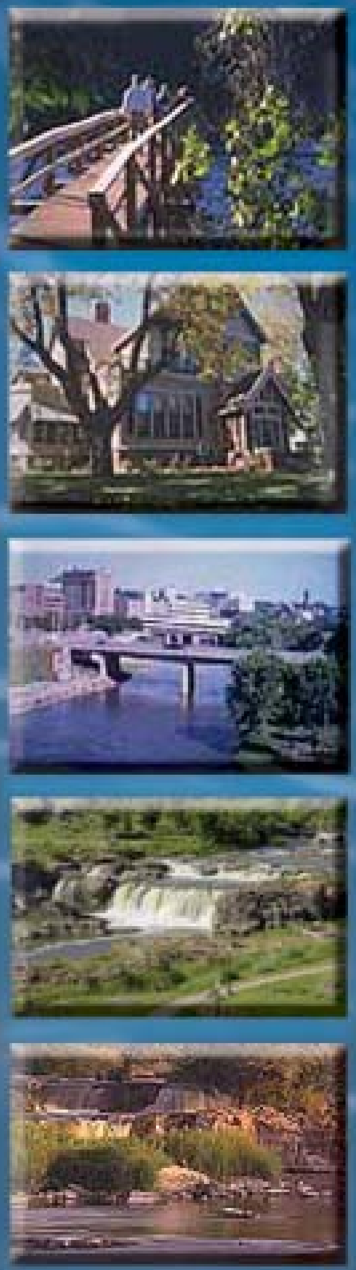
Property Owners	Comments
Paul C. Clinton 2000 W. 42nd, Suite B-6 Sioux Falls, SD 57105 334-4882	• Place terrace in dry ponds. • Route channel away from street for access to multiuse areas. • Embankment slops should be 3:1 or 4:1 for maintenance. • Dry pond should be multiuse for recreation • No Reed Canary Grass – please.
Bob Kappel 4500 N. Sycamore Avenue Sioux Falls, SD 57104 367-7088	• Assist the City by implementing a Master Plan that will encourage green development and hinder green development. Good luck! • Provide additional outreach to develop more public interest!
Russ Sorenson City of Sioux Falls E-mail: rsorenson@SiouxFalls.org	• What are the positive aspects of BMPs to SF developers? • What costs or range of costs can a SF developer expect for implementing simple BMP techniques vs. a regional basin pond? • What study recommendation(s) to the City can be expected regarding consistent and regular water quality monitoring in SF growth areas to 2015?
Cynthia Monnin (Friessen) 615 S. Marion Road Sioux Falls, SD 57106 332-6355 E-mail: Friessenco@aol.com	• What is the project development time frame of the NW area of Sioux Falls? Is the residential the same as the commercial at 2015? I would not think so due to the fact that the sanitary sewer is already there unlike other areas where it will be installed as development progresses. This will be an interesting area for BMPs!

Presentation for

Public Meeting
What is a BMP?

for

The City of Sioux Falls, South Dakota



CH2MHILL

in association with

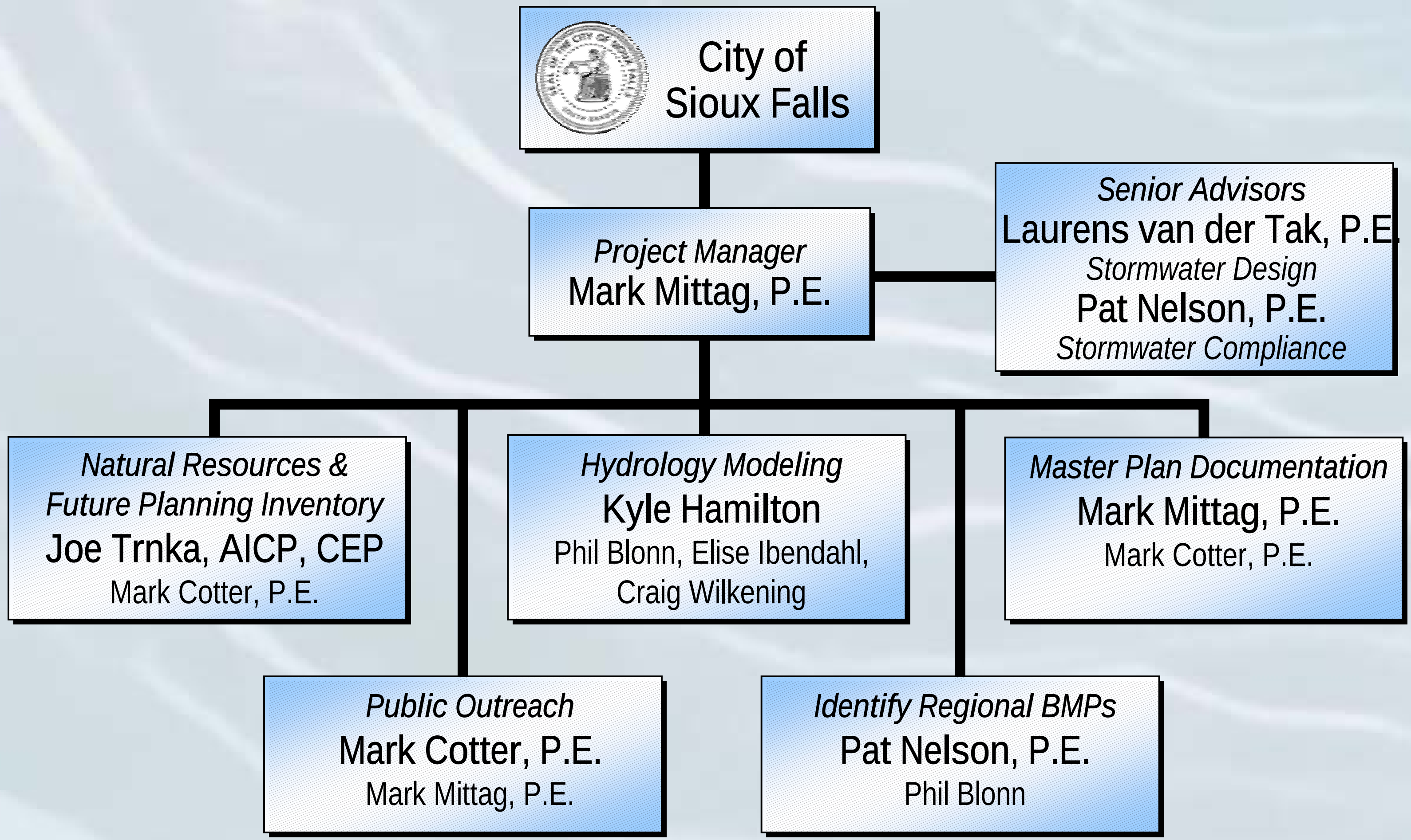
Howard R. Green Company

February 19, 2003

Stormwater BMP Master Plan Vision Statement

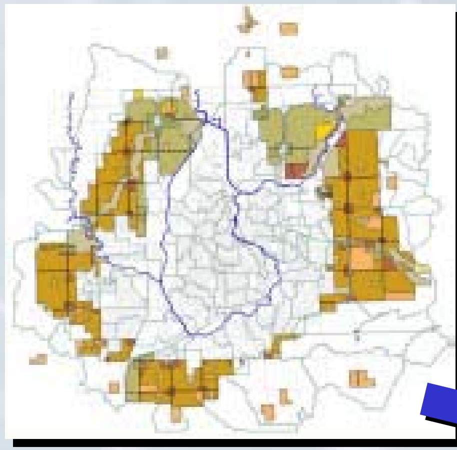
- To develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. The stormwater plan will:
  - establish Sioux Falls as a leader in South Dakota
  - provide a template of how to manage stormwater discharges
  - be endorsed by the development community
  - be understood by the general public
  - facilitate planned growth
  - support water quality
  - enhance natural resources
  - be affordable

Project Team Organizational Chart

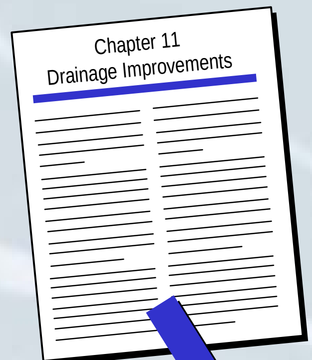


Master Plan Process

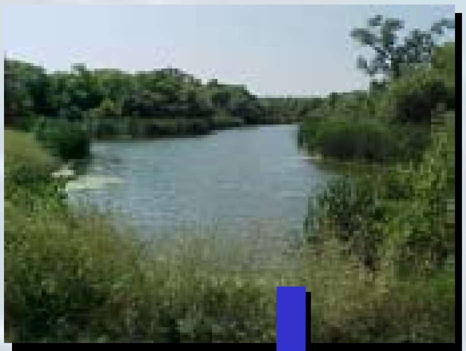
2015 Growth Plan



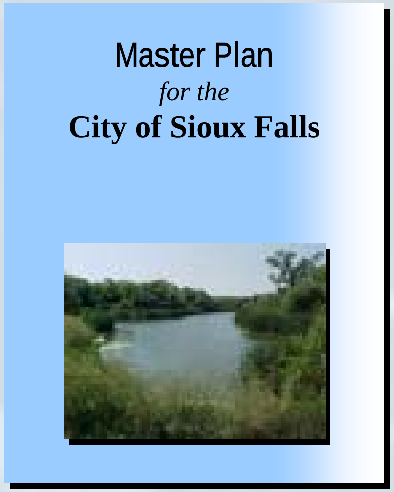
BMPs



Natural Resource Inventory



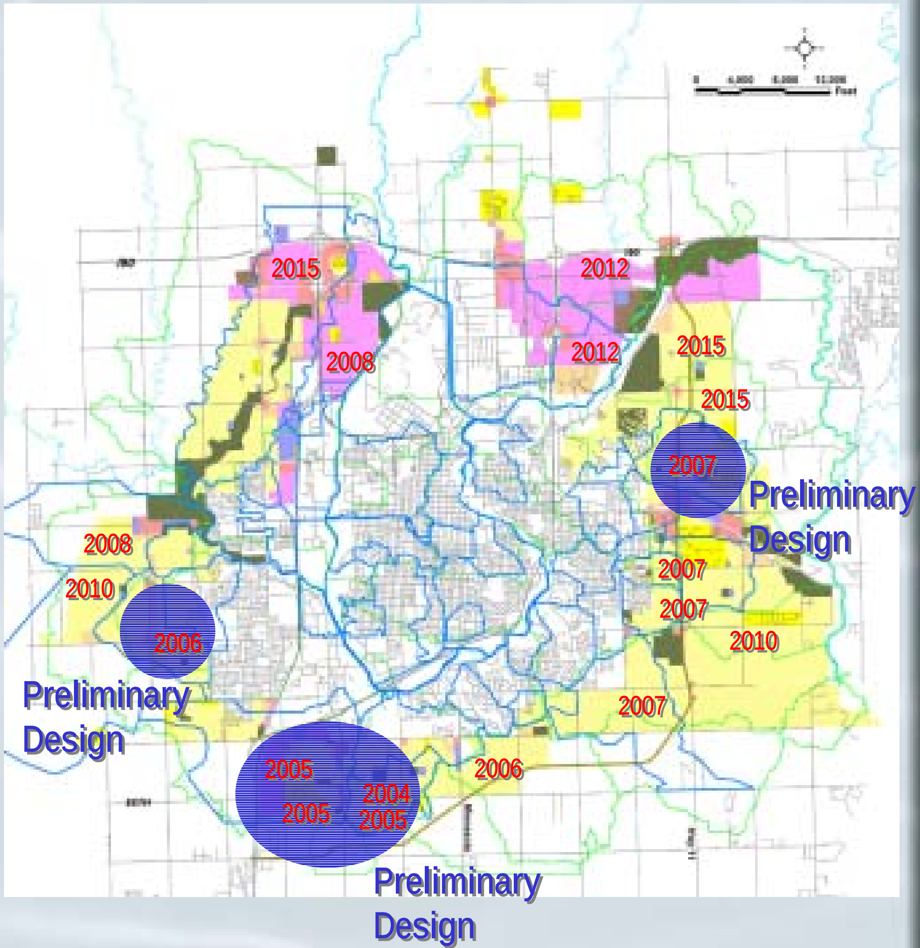
Public Involvement



- Prioritized list of BMPs
- Schedule and Cost
- Conceptual design
- Natural Resources Inventory, supporting permit application
- GIS maps of facility locations

2015 Landuse Analysis

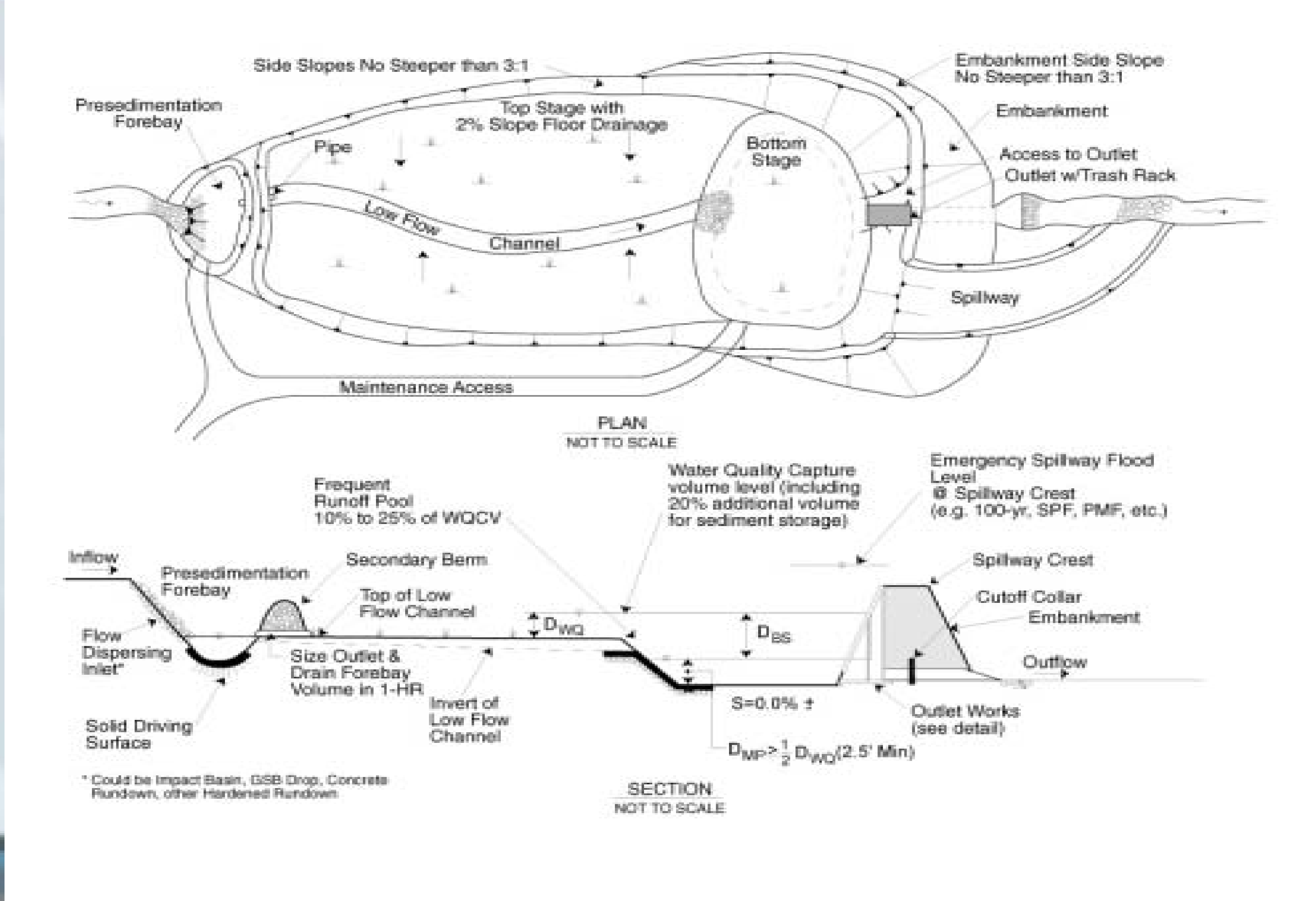
- Existing Rural Residential
- Future Landuses
  - Residential
  - Commercial
  - Industrial
  - Open Space
- Prioritized Development Areas
- Preliminary Designs



Engineering Design Standards Water Quality BMPs

- Grass Buffer
- Grass Swale
- Porous Landscape Detention
- Extended Detention Basin
- Sand Filter Basin
- Constructed Wetlands Basin
- Retention Pond
- Constructed Wetland Channel
- Water Quality Catch Basins
- Bioretention

Example Stormwater Best Management Practice (BMP)
Extended Detention Basin (Dry Pond)

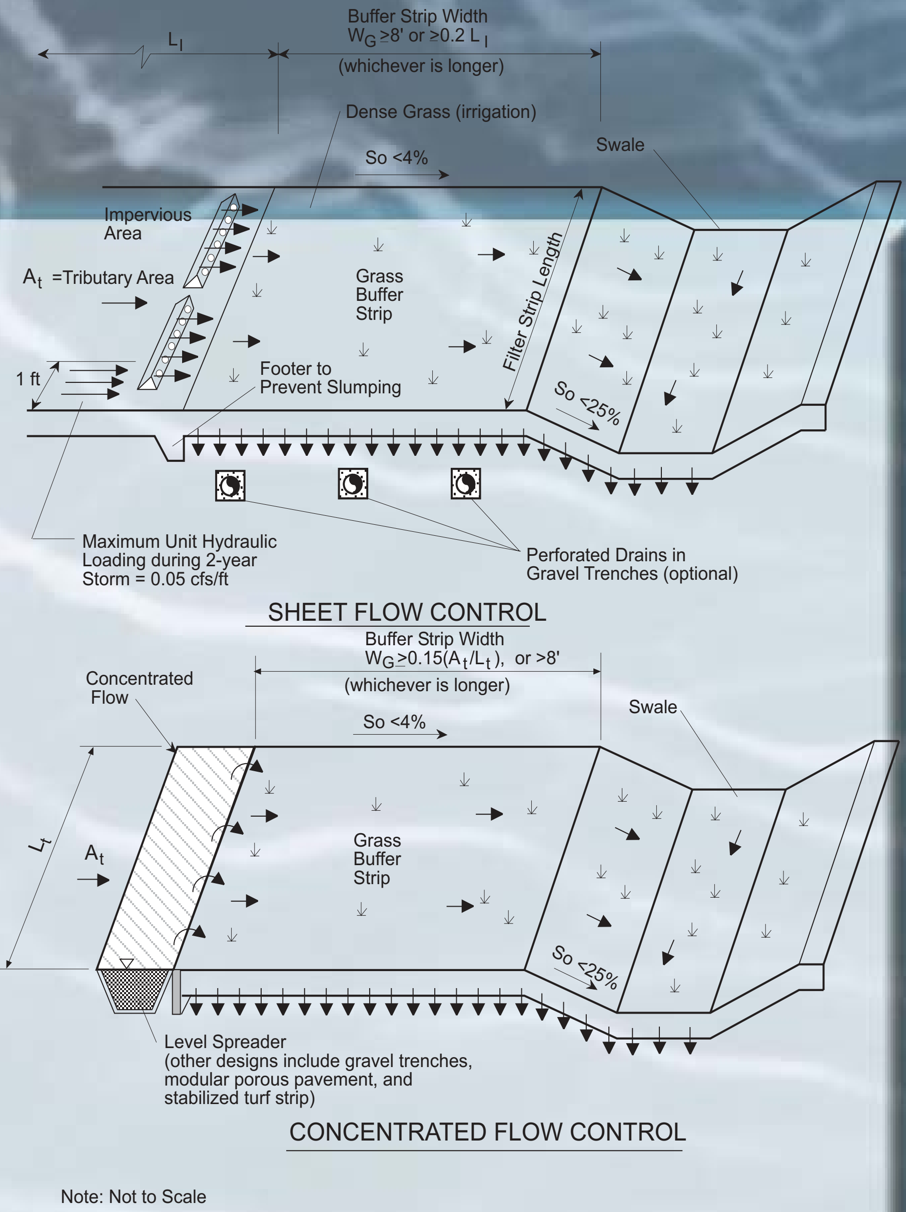


Buffers

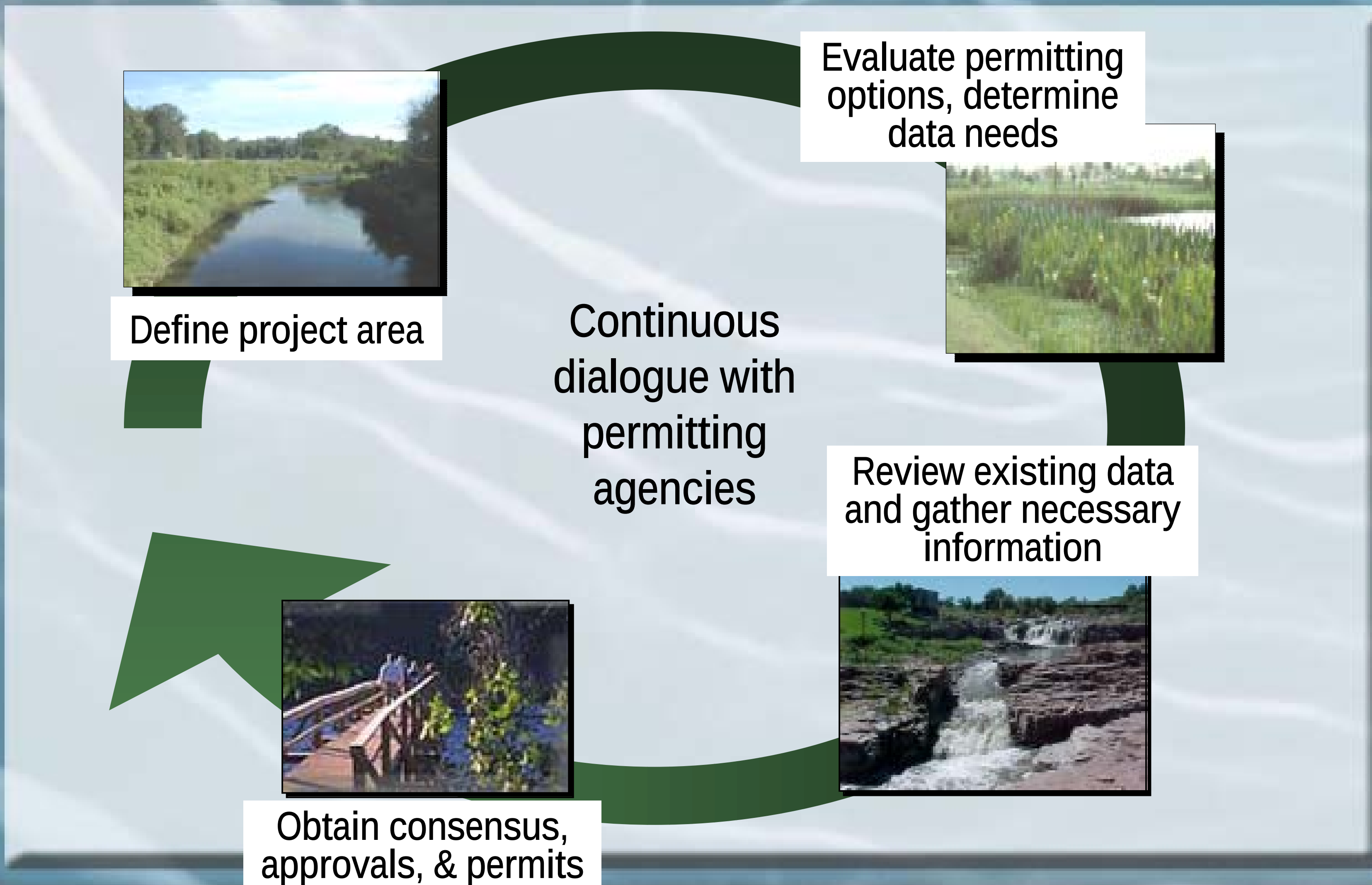
Ease Corps Permitting

Water Quality Benefits

Integrated with Greenways and Floodplains



Natural Resource Agency Involvement and Permitting



Natural Resource Permitting Agencies

Natural Resource Agency Involvement

Stakeholder	Issues	Level of Interest	What do they want?
COE	• Protect wetlands (404 Permit)	Very high	Minimize wetlands impacts
DENR	• SWD Permit • Protect state waters	High	Minimize wetlands impacts
USFWS	• Protect endangered and threatened species	High	Compliance
SHPO	• Protect historic resources	High	Compliance

Public involvement:

- IRAB
- City Departments
- SD DOT
- General Public
- Developers

Effective BMP siting criteria

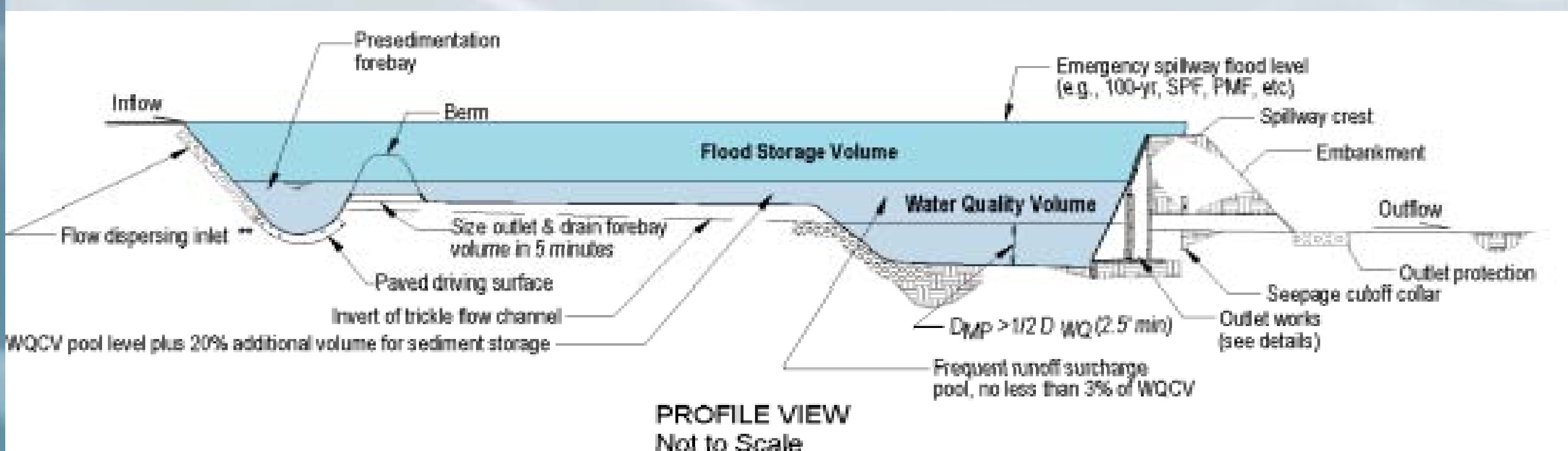
Sample Siting Criteria

- Topography & natural vegetation
- Soils & wetlands
- Maximize BMP coverage
- Minimize embankment height and length
- Target BMP location based on known critical habitat
- Known cultural resources

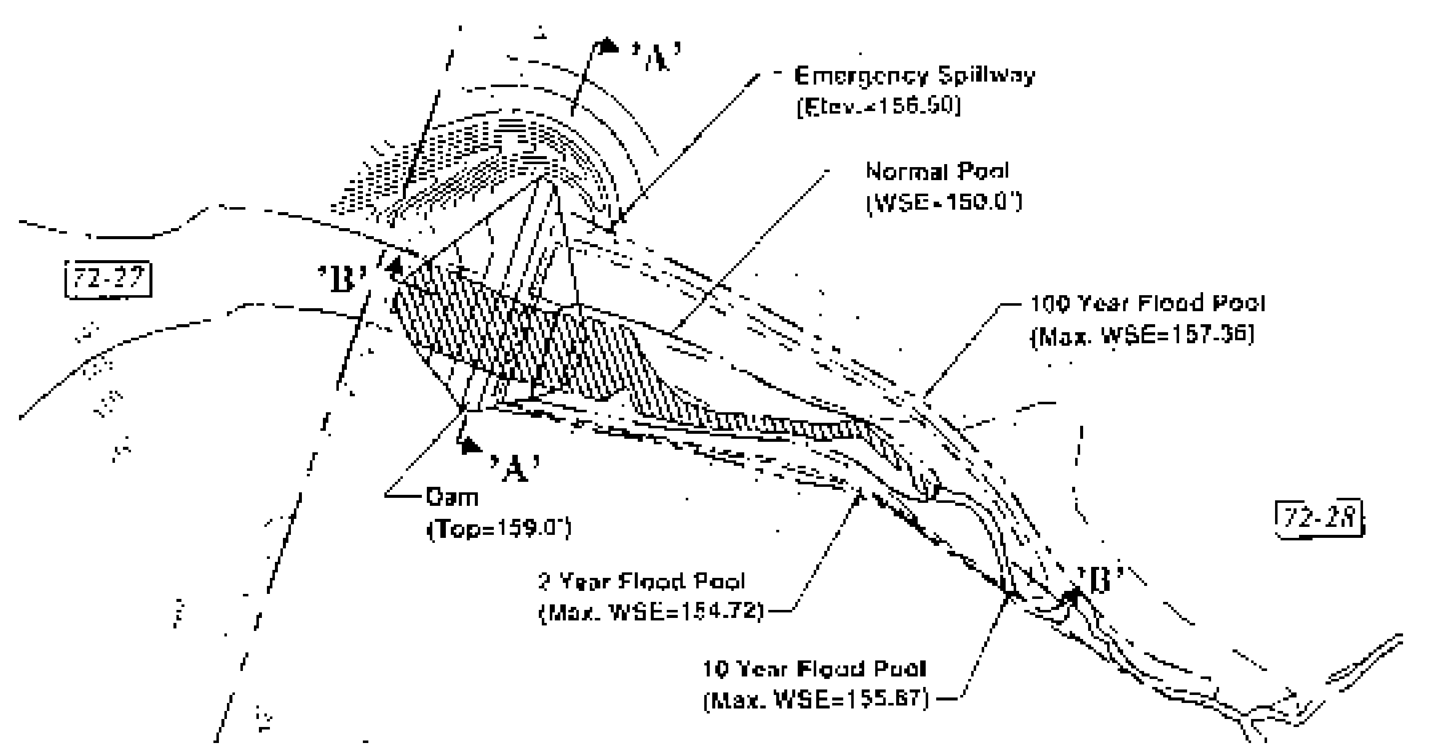
Example Design Criteria

Sample Design Criteria

- Water Quality Volume from Engineering Design Standards
- 5-year and 100-year peak flow control (match existing landuse)
- Maintenance Access
- Wet or Dry Ponds



Example regional BMP plan view



Design Considerations

- Water quality enhancement features
- Install hydraulic energy dissipaters
- Reduction in maintenance costs

Questions

MAILING LIST FOR STORMWATER BMP MASTER PLAN ON FEBRUARY 19, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 a.m. Mtg	1:00 pm Mtg	7:00 pm Mtg
Howard R. Green Company	Attn: Mark Cotter	309 W 43rd St Ste 101	Sioux Falls SD	57105-6805		X	X
Howard R. Green Company	Attn: Joe Trnka	PO Box 9009	Cedar Rapids IA	52409-9009		X	X
CH2M HILL	Attn: Mark Mittag	135 S. 84th Street, Ste 325	Milwaukee WI	53214		X	X
CH2M HILL	Attn: Craig Wilkening	9193 S. Jamaica Street	Englewood CO	80112		X	X
CH2M HILL	Attn: Kyle Hamilton	9193 S. Jamaica Street	Englewood CO	80112-5946		X	X
CH2M HILL	Attn: Laurens van der Tak	13921 Park Center Rd, Ste 600	Herndon VA	20171		X	X
CH2M HILL	Attn: Elise Ibendahl	727 N. 1st Street, Ste 400	St. Louis MO	63102		X	X
CH2M HILL	Attn: Phillip Blonn	135 S. 84th Street, Ste 325	Milwaukee WI	53214		X	X
CH2M HILL	Attn: Patricia Nelson	9193 S. Jamaica Street	Englewood CO	80112-5946			
US Corps of Engineers	Attn: M. James Oehlerking	28563 Powerhouse Rd, Rm 118	Pierre SD	57501	Preliminary meeting was held in Pierre on February 17, 2003. No formal invitation issued for this meeting.		
US Corps of Engineers	Attn: Steven E. Naylor	28563 Powerhouse Rd, Rm 118	Pierre SD	57501			
US Corps of Engineers	Attn: Andy Mitzel	28563 Powerhouse Rd, Rm 118	Pierre SD	57501			
US Corps of Engineers	Attn: Tom Lowin	28563 Powerhouse Rd, Rm 118	Pierre SD	57501			
SD DENR	Attn: John Miller	523 E. Capitol Avenue	Pierre SD	57501-3182			
SD Game, Fish, and Parks	Attn: Leslie Petersen	523 E. Capitol Avenue	Pierre SD	57501-3182			
SD Game, Fish, and Parks	Attn: John Kirk	523 E. Capitol Avenue	Pierre SD	57501-3182			
US Fish & Wildlife Service	Attn: Natalie Gates	420 S. Garfield Avenue, Ste 400	Pierre SD	57501			
State Historic Preservation Office	Attn: Paige Hoskinson	900 Governors Drive	Pierre SD	57501-2217			
Sioux Falls Bd of Preservation	Attn: Don Seten, Planning Dept	224 W. 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Shannon Ausen	224 W 9th Street	Sioux Falls SD	57104-6407		X	X
City of Sioux Falls	Attn: Jeff Dunn	224 W 9th Street	Sioux Falls SD	57104-6407		X	X
City of Sioux Falls	Attn: Bob Kappel	4500 N. Sycamore Avenue	Sioux Falls SD	57104		X	X
City of Sioux Falls	Attn: Kevin Smith	224 W 9th Street	Sioux Falls SD	57104-6407		X	X
City of Sioux Falls	Attn: Sam Trebilcock	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Mark Perry	224 W 9th Street	Sioux Falls SD	57104-6407		X	X
City of Sioux Falls	Attn: Russ Sorenson	224 W 9th Street	Sioux Falls SD	57104-6407		X	X
City of Sioux Falls	Attn: Tony Everson	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Gary Halstead	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Nancy Stanga	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Lyle Johnson	224 W 9th Street	Sioux Falls SD	57104-6407		X	X
City of Sioux Falls	Attn: Mayor Dave Munson	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Jeff Schmitt	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Steve Metli	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Chuck Serbus	224 W 9th Street	Sioux Falls SD	57104-6407		X	

MAILING LIST FOR STORMWATER BMP MASTER PLAN ON FEBRUARY 19, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 a.m. Mtg	1:00 pm Mtg	7:00 pm Mtg
City of Sioux Falls	Attn: John Osman	224 W 9th Street	Sioux Falls SD	57104-6407		X	
City of Sioux Falls	Attn: Wally Doolittle	224 W 9th Street	Sioux Falls SD	57104-6407			
City of Sioux Falls	Attn: Dorothy Franklin, Health Dept	132 N. Dakota Avenue	Sioux Falls SD	57104		X	
Parks Department	Attn: Mike Cooper	600 E 7th Street	Sioux Falls SD	57103-1338		X	X
Sioux Falls City Council (8)	Attn: Barb Johnson	235 W. 10th Street	Sioux Falls SD	57104		X	
SD Dept of Transportation	Attn: Craig Smith	5316 W. 60th Street North	Sioux Falls SD	57107		X	
SD Dept of Transportation	Attn: Cary Cleland	5316 W. 60th Street North	Sioux Falls SD	57107		X	
SECOG	Attn: Austin Eich	1000 N. West Ave, Ste 210	Sioux Falls, SD	57104-1332		X	
Minnehaha Co Highway Dept	Attn: Bob Meister	P.O. Box 1364	Sioux Falls SD	57104		X	
Minnehaha Co Highway Dept	Attn: Tom Wilsey	P.O .Box 1364	Sioux Falls SD	57104		X	
Minnehaha Co Planning Office	Attn: David K. Queal, Dir	415 N Dakota Ave	Sioux Falls SD	57104		X	
Minnehaha Co Commission Office	Attn: Ken McFarland	415 N Dakota Ave	Sioux Falls SD	57104		X	
Minnehaha Co Community Water Corp	Attn: Scott Buss, Exec Dir	47381 248th Street	Dell Rapids SD	57022		X	
Wayne Township	Attn: Sid Walters	46774 266th Street	Sioux Falls SD	57106		X	
Benton Township	Attn: Dale V. Benson	47056 258th Avenue	Sioux Falls SD	57107		X	
Mapleton Township	Attn: Paul Evenson	47482 258th Street	Sioux Falls SD	57005		X	
Splitrock Township	Attn. John Monahan	7901 E 38th Street	Sioux Falls SD	57110		X	
City of Tea	Attn: Mayor John Lawler	115 W 2nd Street	Tea, SD	57064		X	
City of Brandon	Attn: Mayor Mike Schultz	P.O. Box 95	Brandon, SD	57005-0095		X	
City of Brandon	Attn: Dennis Olson, City Adm	P.O. Box 95	Brandon, SD	57005-0095		X	
City of Harrisburg	Attn: Mayor Jim Aalbers	P.O. Box 26	Harrisburg SD	57032-0026		X	
City of Hartford	Attn: Mayor Patty Siemonsma	P.O. Box 727	Hartford SD	57033-0727		X	
Lincoln Co Planning	Attn: Paul Aslesen, Director	100 E. 5th Street	Canton SD	57013		X	
Lincoln Co Planning	Attn: Jon Peters, GIS Tech	100 E. 5th Street	Canton SD	57013		X	
Lincoln Co Auditor	Attn: Helen Nelson	100 E. 5th Street	Canton SD	57013		X	
Lincoln Co Commissioners		100 E. 5th Street	Canton SD	57013		X	
Lincoln Co Rural Water	Attn: Dennis Larsen, Mgr	P.O. Box 36	Harrisburg SD	57032		X	
Springdale Township	Attn: Tim Burns	27063 Sycamore Ave	Sioux Falls SD	57108		X	
Delepre Township	Attn: Jim Poppens	46594 271st Street	Tea SD	57064		X	
Northern Natural Gas Co.	Attn: Mike Garry, Mgr	P.O. Box 336	Harrisburg SD	57032		X	
Williams Pipeline Company	Attn: Tom Barr, Mgr	5300 W. 12th Street	Sioux Falls SD	57107		X	

MAILING LIST FOR STORMWATER BMP MASTER PLAN ON FEBRUARY 19, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 a.m. Mtg	1:00 pm Mtg	7:00 pm Mtg
Developers							
Ronning Enterprises Inc	Attn: Charles A. Point	4401 E 6th Street	Sioux Falls SD	57103-1172			X
Van Buskirk Companies	Attn: Steve Van Buskirk	5101 S Nevada Avenue	Sioux Falls SD	57108			X
Stencil Construction & Development	Attn: Clint Stencil	4804 S Minnesota	Sioux Falls SD	57108			X
Dunham Company	Attn: Darla Jorgensen	230 S Phillips Avenue	Sioux Falls SD	57104			X
C-Lemme Custom Homes, L.L.C.	Attn: Dan Lemme	3408 S Sycamore	Sioux Falls SD	57110			X
Candle Development, L.L.C.	Attn: Josh Bartels	5601 S Sundowner Avenue	Sioux Falls SD	57106			X
Daniels Construction, Inc.	Attn: James Daniels	27160 470 Avenue	Tea, SD	57064			X
Paul Fick Homes, Inc.	Attn: Paul Fick	3909 S Southeastern Ave	Sioux Falls SD	57103			X
Friessen Construction Co, Inc.	Attn: Patricia Vognild	601 S Marion Rd	Sioux Falls SD	57106			X
Scott Gilbert Construction Co.	Attn: Scott Gilbert	5200 S Cliff Avenue	Sioux Falls SD	57108			X
The Grasslands, L.L.C.	Attn: Mark Vellinga	1300 W 57th St. Ste 100	Sioux Falls SD	57108			X
Haight Construction	Attn: Rob Haight	27124 Grummand Ave	Tea, SD	57064			X
Craig Harr Construction	Attn: Craig Harr	7008 E Stoakes Cir.	Sioux Falls SD	57110			X
G & D Harr Construction, L.L.C.	Attn: Gary Harr	3408 S Sycamore	Sioux Falls SD	57110			X
Lloyd Construction	Attn: Craig Lloyd	3130 W 57th Street	Sioux Falls SD	57108			X
Masonry Homes, Inc.	Attn: Randy Martens	3012 S Coral Cir.	Sioux Falls SD	57103			X
Paul Nelson Construction	Attn: Paul Nelson	725 S 9th Avenue	Sioux Falls SD	57104			X
Otten Construction Inc.	Attn: Herman Otten	601 S Mary	Tea, SD	57064			X
Ramstad Development	Attn: Cliff Ramstad	702 E 3rd Street	Colton, SD	57018			X
Mike Schultz Construction, Inc.	Attn: Tim Miller	206 S Main Ave	Sioux Falls SD	57104			X
Sunset Ridge Development, L.L.C.	Attn: LuAnn Wright	5513 W 61st Street	Sioux Falls SD	57106			X
Thurman Construction	Attn: Mike Thurman	528 W 29th Street	Sioux Falls SD	57105-0858			X

MAILING LIST FOR STORMWATER BMP MASTER PLAN ON FEBRUARY 19, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 a.m. Mtg	1:00 pm Mtg	7:00 pm Mtg
Infrastructure Review and Advisor Board (IRAB)							
Asphalt Surfacing Company	Attn: Dick Johnson	P.O. Box 84010	Sioux Falls SD	57118-4010			
Concrete Materials	Attn: Pat Sweetman	P.O. Box 84140	Sioux Falls SD	57104			
Daniels Construction	Attn: Jim Daniels	27160 470th Avenue	Tea SD	57064			
Dunham Company	Attn: Bonnie Mogen	230 S Phillips Avenue	Sioux Falls SD	57104			
Friessen Construction Co, Inc.	Attn: Cindy Friessen	601 S Marion Rd	Sioux Falls SD	57106			
Hagen Commercial Real Estate	Attn: Craig Hagen	201 N Minn Ave, Ste 103	Sioux Falls SD	57104			
HDR Engineering	Attn: Mark Wiederrich	600 S Cliff Ave, Ste 106	Sioux Falls SD	57104			
Home Builders Assoc.	Attn: Cindy	4320 Arway Drive	Sioux Falls SD	57106			
JSA Engineers	Attn: Rich Schwanke	3700 S. West Avenue	Sioux Falls SD	57105-6352			
Runge Enterprises	Attn: Michael Runge	3500 N. Hovland Drive	Sioux Falls SD	57107			
R.F. Sayre & Associates	Attn: Steve Quincey	P.O. Box 734	Sioux Falls SD	57101-0734			
Schmidt Engineering Inc.	Attn: Jon Schmidt	401 E 8th St. Ste 200G	Sioux Falls SD	57103			
Schmitz Kalda & Associates	Attn: Kim Buell	320 N Main Ave, Ste A	Sioux Falls SD	57104			
Sioux Empire Housing	Attn: Jim Schmidt	200 N. Phillips Avenue	Sioux Falls SD	57104			
Soukup Construction	Attn: James Soukup	221 N Marion Rd	Sioux Falls SD	57107-0501			
Stockwell Engineers	Attn: Jon Brown	211 E. 14th St, Ste 200	Sioux Falls SD	57104-6913			
Stockwell Engineers	Attn: Steve Brockmueller	211 E. 14th St, Ste 200	Sioux Falls SD	57104-6913			
Qwest Communications	Attn: Dan Kaiser	125 S Dakota Ave	Sioux Falls SD	57104			
Viereck Commercial	Attn: Jan Muilenburg	812 S. Minnesota Avenue	Sioux Falls SD	57104	No Formal invitation issued. We are on their agenda.		
Xcel Energy	Attn: Pam Osthus	500 W Russell Street	Sioux Falls SD	57104			
General Public							
Notice of Meeting to Argus Leader							
www.bigsioux.com							
TV: Channel 16							
Neighborhood Link: http://www.siouxfalls.org/neighborhoods/							
Pine Lake Hills Homeowners Assoc.	Attn. Steve Pederson	601 N. Appaloosa Trail	Sioux Falls SD	57110			X
Pine Lake Hills	Attn. Doug Derheim, Water Supt.	700 Meadowbrooke Lane	Sioux Falls SD	57110			X
Pine Hills Homeowners Assoc.	Attn. Warren Oakland, Pres	3205 Keith Lane	Sioux Falls SD	57110			X
Izaac Walton League		5000 E. Oakview Place	Sioux Falls SD	57110			X
Sierra Club	Attn: Tracie Weber	231 S. Phillips Avenue	Sioux Falls SD	57104			X
Northern Prairies Land Trust	Attn: Rachel Brewster, Exec Dir	1905 W. 57th St. #3	Sioux Falls SD	57108			X
Augustana College	Attn: L Adrien Hannus	2001 S. Summit Avenue	Sioux Falls SD	57197			X
HDR	Attn: Dan Graber	600 S. Cliff Ave, Ste 106	Sioux Falls SD	57104			X

Howard R. Green Company

Master Plan for Stormwater BMPS

CH2MHILL

Informational Meeting

We are pleased to present the second of a series of Informational Meetings for the City of Sioux Falls Best Management Practices (BMPs) for stormwater. You will also have the opportunity to ask questions or offer comments. If you prefer to mail your questions/comments, a postcard will be available at the meeting.

Date: Thursday, April 10, 2003

Time: 8:30 a.m. and 7:00 p.m.

Location: Kuehn Community Center, 2801 S. Valley View Rd.
Sioux Falls, South Dakota

Howard R. Green Company
309 W. 43rd Street, Suite 101
Sioux Falls, SD 57105

SEAL OF THE CITY OF SIOUX FALLS SOUTH DAKOTA

$00.00 JUN 26 03
MAILED FROM ZIP CODE 57105

What Are Best Management Practices For Stormwater?

Stakeholder Address

Sioux Falls Best Management Practices (BMPs) For Stormwater

Comment/Question Form

NAME: ______________________________ **TELEPHONE:** ________________________

ADDRESS: ___________________________

______________________________________ **E-MAIL:** ___________________________

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COMMENTS/QUESTIONS:

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Please place this comment/question form in the designated box on your way out of the meeting, or mail it to Mark Cotter, Howard R. Green Company, 309 West 43rd Street, Suite 101, Sioux Falls, SD 57105-6805

Attn: Mark Cotter
Howard R. Green Company
309 West 43rd Street, Suite 101
Sioux Falls, SD 57105-6805

STORMWATER BMP MASTER PLAN IRAB MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Thursday, April 10, 2003 at 8:30 a.m.
Location: Kuehn Community Center
Re: Public Informational Meeting for IRAB Group
Attendance: See Attached Attendance Sheet

Mark Mittag from CH2M Hill introduced the team and gave a brief recap of the nature of the project for individuals not able to attend the last meeting. This is a progress meeting for the project. Mark Mittag explained the approach for the project and talked specifically about:

- Design criteria.
- Quad maps on display.

The following materials were handed out:

- Agenda.
- PowerPoint Presentation.
- Spreadsheet of Basin number and areas per basin.
- All four quad maps.
- Updated 2015 Development Map listing years anticipated for development.
- Example BMP - #51 preliminary design location.

The following is a summary of the items discussed:

1. Chuck Point: Why is there nothing planned in the 22nd to 12th Street area by Memorial Middle School?
   - Specific areas will be discussed afterwards at the maps.

2. Steve Quincey: What is the difference between Pink D and Green D?
   - Green D is included in the Study to be preliminary design. Pink will be in the Master Plan for design in the future.

3. Steve Quincey: Schedule on Master Plan by year.
   - Schedule is tied to sanitary sewer schedule.

4. Chuck Point: What is impression of 10 small or 1 large facility?
   - 10 small may impact more wetlands. It depends on goal. Some jurisdictions are to maintain streams. Some jurisdictions are interested in reducing maintenance from 10 down to 1, for example. Laurens van der Tak says regional facilities may impact more wetlands. It is a basin specific issue.
   - ACOE (Army Corps of Engineers) does not recognize storm water control ponds as wetlands.

5. Russ Sorenson: Does ACOE place higher value with tree and cattails as opposed to just plant materials?
   - Yes. If you have to mitigate wooded wetland, the mitigation ratio is higher (maybe 2.5 to 1) since they are harder to create.

6. Jim Soukup: What other cities does the firm work with?
   - Page County and other communities around Great Lakes area.
   - Milwaukee - developments implement by themselves. Regional are used for flood control. Chesapeake Bay area south of Richmond are doing regional approach. Other suburbs around large cities (i.e. Chicago).

7. Chuck Point: What funding source does CH2M Hill see around country?
   - Tax, bill (through County).
   - Developer fee.
   - Laurens van der Tak – one time fee for developer, based on permeability. Storm water utility – continual billing along with water and sewer bill.
   - Some do it separate because agricultural area may not have City sewer and water. Need to keep it simple to communicate with fee to the community. (i.e. 5,000 acres of impervious area and $35/year for storm water utility).

8. Chuck Point: How shall we communicate this funding mechanism. What is the reaction?
   - Make sure they know the benefits.

9. Jeff Dunn: What are issues when we develop the top of a watershed and have a regional BMP?
   - Laurens van der Tak – have to have stream maintenance mechanism in place to control erosion of the stream in between. Need to get permission to stabilize stream instead of having restoration.

10. Steve Quincey: We develop many flat areas and a site specific pond does not work due to topography.
    - Regionals will backup a large area in these flat areas.

Mark had the group get up and attach numbered stickers on where they want BMPs located. Below is the list with name and corresponding number:

1. Jan Muilenburg of Viereck Com.
2. Jim Soukup
3. Chuck Point
4. Jim Daniels
5. Kim Buell
6. Rich Schwanke of JSA
7. Steve Brockmueller
8. Tony Everson
9. Steve Quincey
10. Mark Mittag

Next meeting: June 18, 2003.

One Comment Card turned in:

Paul Clinton
Dakota Land Survey & Engineering
2000 W. 42nd Street, B-6
Sioux Falls, SD 57105
Ph: 334-4882

Items of concern:

- Mix use of pond – passive recreation in dry areas.
- Consider bike/waking trails with scale to pond.
- Real native plants.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

STORMWATER BMP MASTER PLAN MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Thursday, April 10, 2003 at 7:00 p.m.
Location: Kuehn Community Center
Re: Public Informational Meeting
Attendance: See Attached Attendance Sheet

Mark Mittag from CH2M Hill introduced the team, reviewed the vision and the reason for the project and went through the PowerPoint presentation. He then opened it up to questions:

1. What do the colors mean on Cultural Resources Map?
   - Colors signify different levels of concerns (culturally).

2. Explain curve numbers: 75% Pre-development and 85% Post-development.
   - Hydraulic number developed by NRCS.

3. How much will the City of Sioux Falls save with regional BMPs?
   - Maintenance and upkeep are expensive; therefore, regional should provide reduced expense over the long term. They also provide quality of life amenities/dual purpose facilities. Buffers will also be included in the design.

4. What ponds will be wet and which dry?
   - If area will have a base flow, it will be wet pond.

5. What are concerns with these ponds for West Nile Virus?
   - If the pond is designed to sustain fish, fish eat mosquito larva thus reducing West Nile threat.

6. Does the City plan to stock these?
   - It is not evaluated at this point.

7. How big would the 81 acre ft. pond be?
   - That particular pond is preliminary designed at 25-30 acres for the 100-year event.

   Comment: Need to plant the right plant material to withstand wet and dry cycles.

   Comment: People will see these BMPs as they plan to move near these facilities and that they are a storm water control mechanism.

8. Will these be constructed in planned park areas?
   - Some will. Parks Department currently maintains the existing ponds.

9. Who will pay for these facilities:
   - There are two programs in place for existing and proposed storm water controls.
   - Cost recovery for drainage systems - 50% by developers and 50% City.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

April 10, 2003 Presentation Agenda

TO: Jeff Dunn/Sioux Falls

COPIES: Laurens van der Tak/CH2M HILL
Kyle Hamilton/CH2M HILL
Mark Cotter/H.R. Green

FROM: Mark D. Mittag

DATE: April 9, 2003

The items we plan to cover at the April 10th meeting are included below. We will discuss BMP sites and will be interested in receiving feedback.

Stormwater BMP Master Plan Meeting Agenda

A brief overview of the following items is planned during the meeting.

- BMP siting criteria
- Summary of hydrology parameters
- BMP sites
- Preliminary modeling results
- Preliminary design locations
- Permitting issues update
- Regularly Scheduled Outreach Meetings:
  April 10, 7PM General Public
  Future tentative date: June 4, 5

Presentation for

BMP Master Plan Progress Update

for

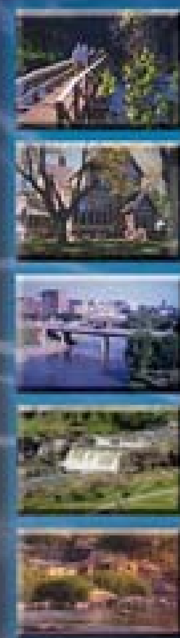
The City of Sioux Falls, South Dakota

CH2MHILL

in association with

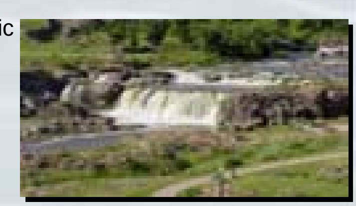
Howard R. Green Company

April 10, 2003

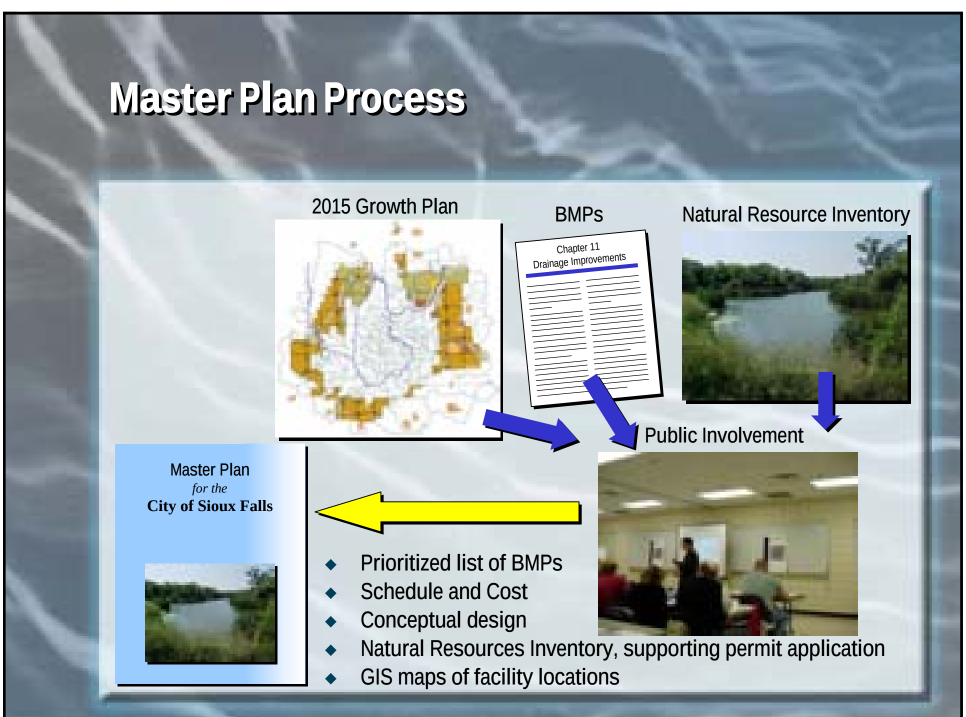


Stormwater BMP Master Plan Vision Statement

- To develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. The stormwater plan will:
  - establish Sioux Falls as a leader in South Dakota
  - provide a template of how to manage stormwater discharges
  - be endorsed by the development community
  - be understood by the general public
  - facilitate planned growth
  - support water quality
  - enhance natural resources
  - be affordable




Project Team Organizational Chart
City of Sioux Falls
Project Manager
Mark Mittag, P.E.
Senior Advisors
Laurens van der Tak, P.E.
Stormwater Design
Pat Nelson, P.E.
Stormwater Compliance
Natural Resources & Future Planning Inventory
Joe Trnka, AICP, CEP
Mark Cotter, P.E.
Hydrology Modeling
Kyle Hamilton
Phil Blonn, Elise Ibendahl, Craig Wilkening
Master Plan Documentation
Mark Mittag, P.E.
Mark Cotter, P.E.
Public Outreach
Mark Cotter, P.E.
Mark Mittag, P.E.
Identify Regional BMPs
Pat Nelson, P.E.
Phil Blonn

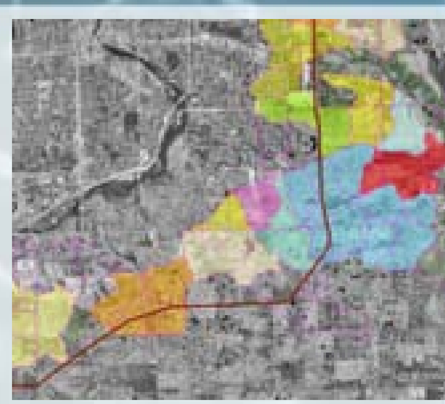

Master Plan Process
2015 Growth Plan
BMPs
Chapter 11
Drainage Improvements
Natural Resource Inventory
Public Involvement
Master Plan
for the
City of Sioux Falls
Prioritized list of BMPs
Schedule and Cost
Conceptual design
Natural Resources Inventory, supporting permit application
GIS maps of facility locations

BMP Siting Criteria

- Strategic Locations
  - Road Crossings
  - Tributary Confluences
- Consider Permitting
  - Wetlands
  - Cultural Resources
  - Habitat
- Minimize Number of BMPs
- Basin Size

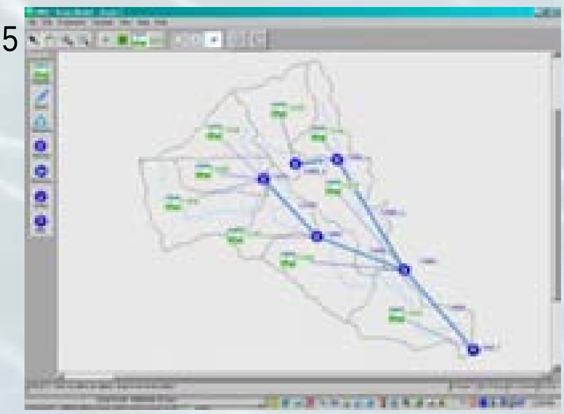
BMP Coverage

- Regional BMP Locations
- Site-Specific Locations (no regional BMP)
- Existing Development



BMP Modeling Summary

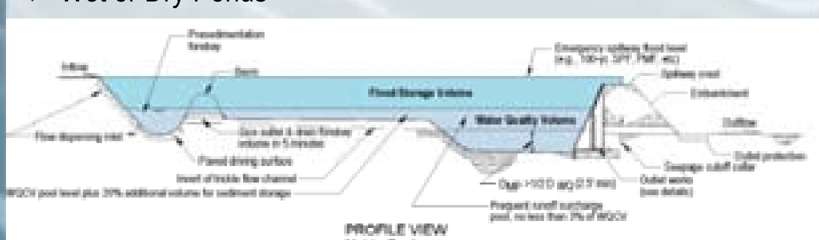
- Area Considered: 64,000 acres
- New BMP Sites: 26
- Sites In-design: 5
- Site Specific Areas: 87



Review Design Criteria

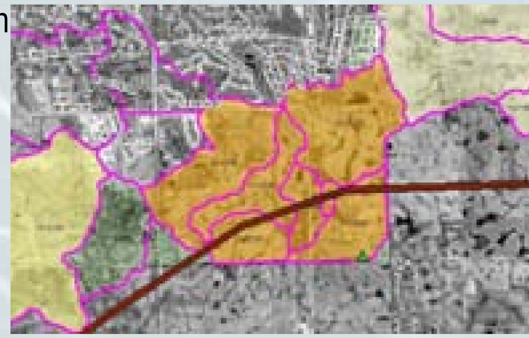
Design Criteria

- Water Quality Volume from Engineering Design Standards
- 5-year and 100-year peak flow control (match pre-development landuse)
- Maintenance Access
- Wet or Dry Ponds



Preliminary Example Modeling Findings

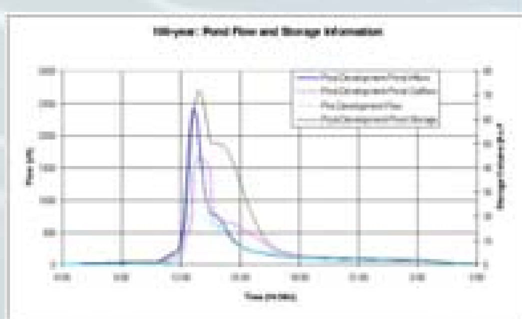
- 69th & Cliff Region
- Proposed One Regional BMP
- Area: 997 acres
- CN: existing 75
  developed 85



- Percent Impervious: 50%

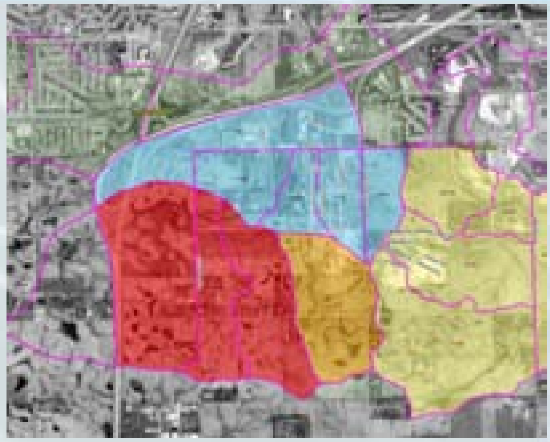
Draft Modeling Results

- 69th & Cliff Region
- WQCV: 26 acre-feet
- 100-Year Storm Volume: 81 acre-feet
- Modeling on-going



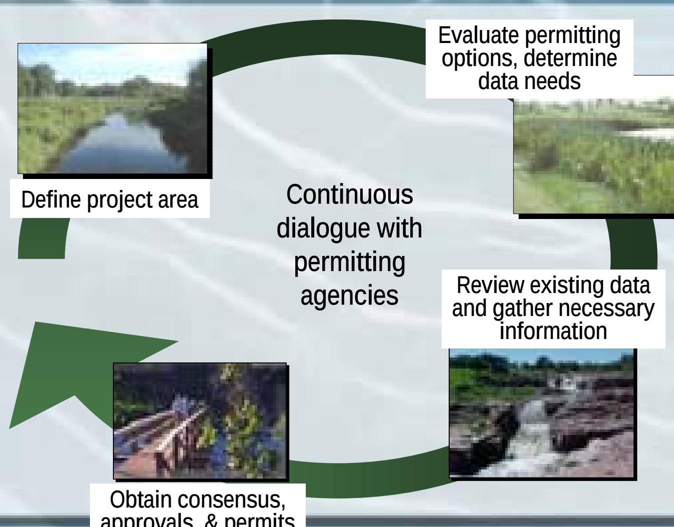
Preliminary Design Locations

- Five Total Sites
  - *Model example results is one site*
  - *Two locations in SW*
  - *Two others on east-side*



- View sites on display boards

Natural Resource Agency Involvement and Permitting



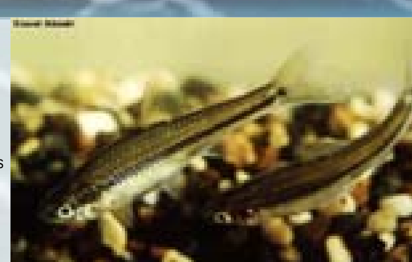
Natural Resource Permitting Agencies

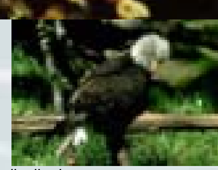
Natural Resource Agency Involvement

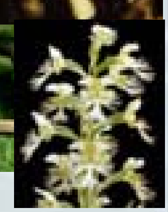
Stakeholder	Issues	Level of Interest	What do they want?
COE	• Protect wetlands (404 Permit)	Very high	Minimize wetlands impacts
DENR	• SWD Permit • Protect state waters	High	Minimize wetlands impacts
USFWS	• Protect endangered and threatened species	High	Compliance
SHPO	• Protect historic resources	High	Compliance

Threatened & Endangered (T&E) Species Update

- Federal Listed Species:
  - *Topeka Shiner*
    - Historically known to occur in Sioux Falls (1939 Willow Creek Drainage, not found in '97 & '99 surveys)
    - Known to occur north and east of Sioux Falls ('99 vicinity of Dell Rapids, Brandon)
  - *Western Prairie Fringed Orchid*
    - Occurs in wet prairie habitat
    - Could potentially occur based upon historic records and habitat distribution
    - Survey where wet prairie remnant habitat exists
  - *Bald Eagle*
    - Known to occur in Sioux Falls



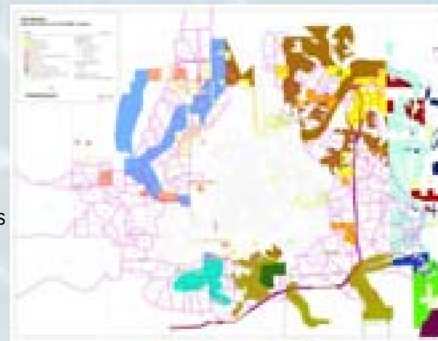




- T&E influence on BMP permitting:
  - *Additional future surveys may be required to clarify distribution in urbanizing area*
  - *Corps ultimate decision maker for wetland permitting*
  - *If present, additional coordination & planning may be required*

Cultural Resources Update

- Analysis:
  - *East-side corridor information*
  - *Blood Run located*
  - *High sensitivity areas*
    - higher probability
    - along perennial waterways
    - along perennial waterway bluffs
  - *Mound groups*
  - *Previous survey locations*
- Example cultural resource influence on projects:
  - *High sensitive areas reconnaissance survey*
  - *Early-on Corps coordination to address their concerns*



Public involvement:

- Today, we are interested in your:
  - Feedback on BMP locations
  - Information you think is important to the process
  - General questions

Next Steps:

- Continue & complete modeling
- BMP site field verification
- Complete preliminary designs
- Develop cost estimates
- Prepare draft report
- Public meeting in early June

Questions

City of Sioux Falls
Best Management Practice (BMP) Master Plan

CH2M Hill
April 10, 2003

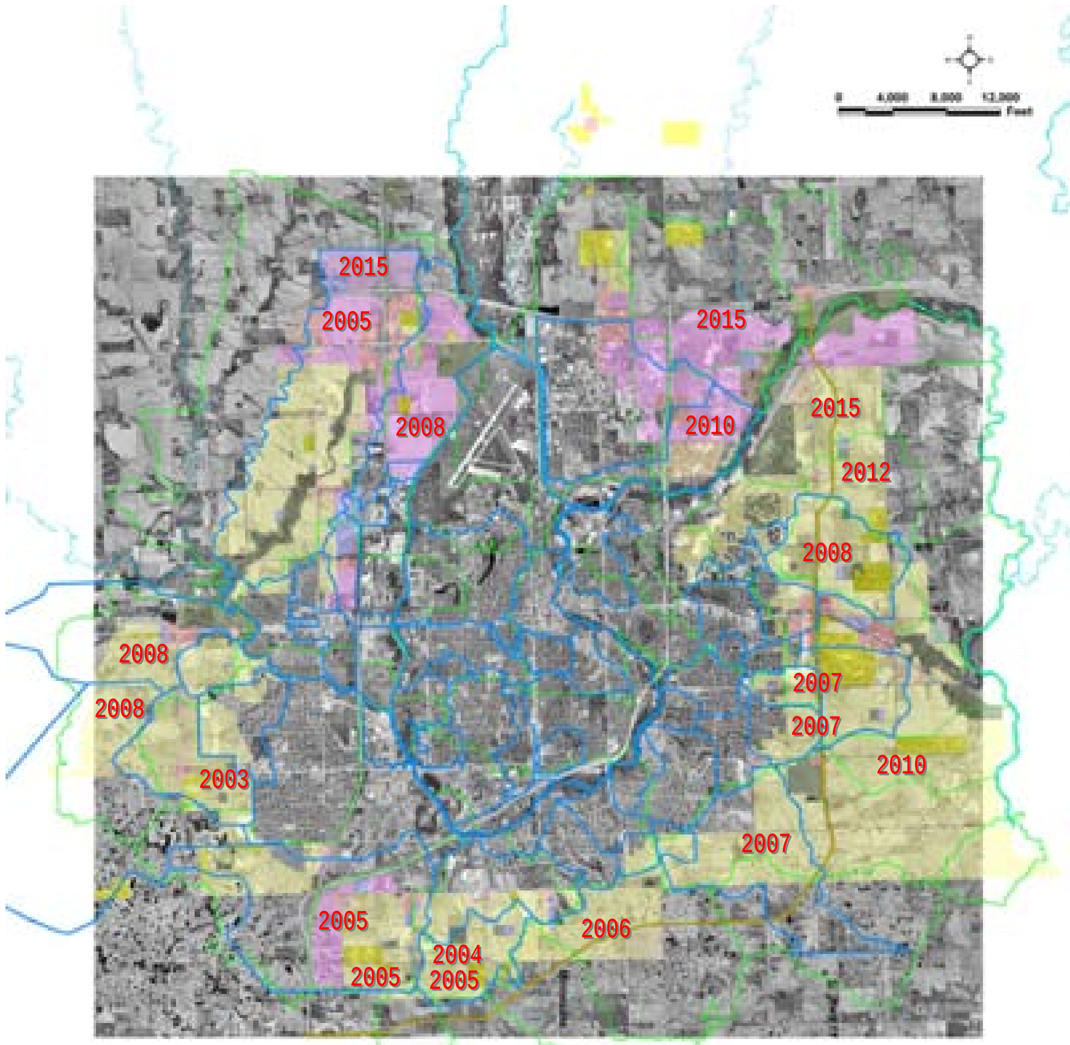
Basin ID	Drainage Area (acres)	Drains to Regional BMP # or Site Specific BMP
1-N	92	Site Specific BMP
1-C	112	Site Specific BMP
1-S	76	Site Specific BMP
2-005	52	2
2-010	266	2
2-020	49	2
22-005	160	22
22-008	263	22
25-005	209	25
25-010	140	25
25-015	222	25
25-019	145	25
25-020	90	25
25-021	69	303-3
25-022	128	303-3
25-023	139	303-3
25-024	67	303-3
25-025	123	303-3
26-005	129	303-2
26-010	193	303-2
57S-010	172	Site Specific BMP
57S-040	97	Site Specific BMP
57S-005	57	Site Specific BMP
57S-020	55	Site Specific BMP
57N-005	140	Site Specific BMP
57N-010	77	Site Specific BMP
57N-020	250	Site Specific BMP
302-005	166	Site Specific BMP
302-010	25	Site Specific BMP
303-005	259	303-2
303-010	56	Site Specific BMP
303-015	154	Site Specific BMP
303-020	127	Site Specific BMP
303-025	50	303-4
303-030	195	303-4
303-031	32	303-4
303-035	23	303-4
303-040	184	303-4
303-044	139	303-1
303-045	207	Site Specific BMP
303-050	149	303-3
303-055	47	303-4
303-060	300	303-5
303-065	39	303-5
303-070	89	Site Specific BMP
303-075	17	Site Specific BMP
303-080	398	Site Specific BMP
305-005	248	305
305-010	50	305
306-005	226	306
306-010	123	306
306-020	49	306
306-030	29	306
307-005	33	Site Specific BMP
307-010	212	Site Specific BMP

Basin ID	Drainage Area (acres)	Drains to Regional BMP # or Site Specific BMP
307-020	64	Site Specific BMP
308-005	47	Site Specific BMP
308-010	178	Site Specific BMP
308-020	108	Site Specific BMP
309-005	81	Site Specific BMP
309-030	43	Site Specific BMP
310-010	55	Site Specific BMP
310-015	28	Site Specific BMP
310-020	38	Site Specific BMP
311-005	74	Site Specific BMP
311-010	38	Site Specific BMP
312-005	49	312
312-010	132	312
312-025	229	312
312-040	140	Site Specific BMP
313-005	122	Site Specific BMP
313-020	37	Site Specific BMP
314-005	203	Site Specific BMP
314-020	149	Site Specific BMP
314-030	240	Site Specific BMP
316-005	78	316
316-010	88	316
316-020	200	316
316-030	193	316
316-050	239	316
317-005	54	317
317-006	113	317
317-008	214	317
317-010	230	317
4	210	303-1
4A-005	109	303-1
4A-010	320	303-1
10-010B	379	Diamond Creek
10-020B	395	Diamond Creek
10-030B	222	Diamond Creek
10-040B	64	Diamond Creek
10A-010B	144	Diamond Creek
10A-020B	76	City Pond 47
10A-030B	186	City Pond 47
10A-040B	325	City Pond 47
10A-050B	182	City Pond 47
10A-060B	156	City Pond 47
400-010B	168	400
400-015B	77	400
400-020B	297	400
400-030B	126	400
401-005B	272	401
401-010B	210	401
401-015B	101	401
401-020B	213	401
401-025B	35	401
401-030B	195	401
401-040B	249	401
401-045B	204	401
401-050B	216	401
401-060B	138	401
401-070B	331	401
401-080B	122	Site Specific BMP
402-010B	67	Site Specific BMP
403-010B	10	Site Specific BMP
404-010B	22	Site Specific BMP
405-010B	38	Site Specific BMP
406-010B	92	Site Specific BMP
407-010B	178	Site Specific BMP

Basin ID	Drainage Area (acres)	Drains to Regional BMP # or Site Specific BMP
408-010B	21	Site Specific BMP
409-010B	97	Site Specific BMP
410-010B	24	Site Specific BMP
411-010B	26	Site Specific BMP
412-010B	12	Site Specific BMP
413-010B	236	Site Specific BMP
413-020B	164	Site Specific BMP
413-030B	25	Site Specific BMP
51-010B	262	51
51-020B	134	51
51-030B	277	51
51-050B	98	51
51-060B	67	51
51-070B	13	51
51-080B	146	51
6B-010B	239	City Pond 28
6B-020B	148	City Pond 28
6B-030B	103	City Pond 28
11-010-B	356	11-1
11-020-B	162	11-1
11-030-B	224	11-1
11-040-B	255	11-2
11-050-B	118	City Pond 52?
11-060-B	76	City Pond 52?
11-070-B	97	City Pond 52?
11-080-B	271	City Pond 52?
11-090-B	79	City Pond 52?
11-100-B	109	Site Specific BMP
11A-010-B	391	Site Specific BMP
11A-020-B	348	Site Specific BMP
11A-030-B	376	City Pond 52
11A-040-B	250	City Pond 52
11B-010-B	314	Site Specific BMP
56-010-B	196	Site Specific BMP
56-020-B	70	Site Specific BMP
7-010B	157	7-5
7-020B	288	Brooks
7-030B	196	Bahnson
7-040B	172	7-4
7-050B	340	7-4
7-060B	332	Beyond 2015 Area
7-070B	207	7-4
7-080B	356	Beyond 2015 Area
7-090B	367	7-5
7-100B		Beyond 2015 Area
13-040-B	117	Site Specific BMP
13-010-B	195	13-3
13-020-B	401	13-3
13-022-B	65	13-2
13-025-B	47	13-1 or 13-2
13-030-B	210	13-1
14A-020-B	92	Inside 2015 Area
14A-010-B	221	Inside 2015 Area
15-010-B	49	Site Specific BMP
16-010-B	51	Site Specific BMP
D1-010-B	307	Site Specific BMP
D1-020-B	198	Site Specific BMP
D1-030-B	128	Skunk Creek
D1-040-B	30	Skunk Creek
32A-010-B	3664	Beyond 2015 Area
32B-010-B	10868	Beyond 2015 Area
32B-020-B	246	Site Specific BMP
32B-040-B	371	Site Specific BMP
32B-030-B	386	Site Specific BMP

Basin ID	Drainage Area (acres)	Drains to Regional BMP # or Site Specific BMP
32C-010-B	7053	Beyond 2015 Area
32D-080-B	139	Site Specific BMP
32D-120-B	160	Site Specific BMP
32D-010-B	237	Beyond 2015 Area
32D-020-B	342	Beyond 2015 Area
32D-030-B	98	Beyond 2015 Area
32D-100-B	79	Beyond 2015 Area
32D-060-B	103	Beyond 2015 Area
32D-110-B	225	Site Specific BMP
32D-090-B	195	Site Specific BMP
32D-070-B	155	Site Specific BMP
32D-050-B	55	Beyond 2015 Area
32D-040-B	349	Site Specific BMP
37-010-B	749	Inside 2015 Area
38-030-B	178	Site Specific BMP
38-040-B	324	Site Specific BMP
38-050-B	284	Site Specific BMP
38-060-B	295	Site Specific BMP
38-070-B	153	Site Specific BMP
38-020-B	28	Site Specific BMP
38-015-B	70	Site Specific BMP
38-010-B	200	Site Specific BMP
40-040-B	386	40-1
40-050-B	291	40-1
40-070-B	16	40-1
40-060-B	41	40-1
40-030-B	65	40-1
40-020-B	307	40-1
40-110-B	22	40-1
40-080-B	27	40-1
40-090-B	282	40-1
40-130-B	226	40-1
40-120-B	303	40-1
40-140-B	346	40-1
40-150-B	173	40-1
40-170-B	93	40-2
40-180-B	222	40-2
40-160-B	283	40-2
40-210-B	188	40-2
40-200-B	145	40-2
40-250-B	193	40-2
40-230-B	86	40-2
40-220-B	234	40-2
40-240-B	242	40-2
40-100-B	237	40-1
40-260-B	288	Site Specific BMP
40-190-B	384	40-2
40-010-B	4874	40-1
41A-040-B	147	Inside 2015 Area
41A-010-B	178	41-A
41A-020-B	168	41-A
41A-030-B	290	Site Specific BMP

Master Plan 2015
Growth Area

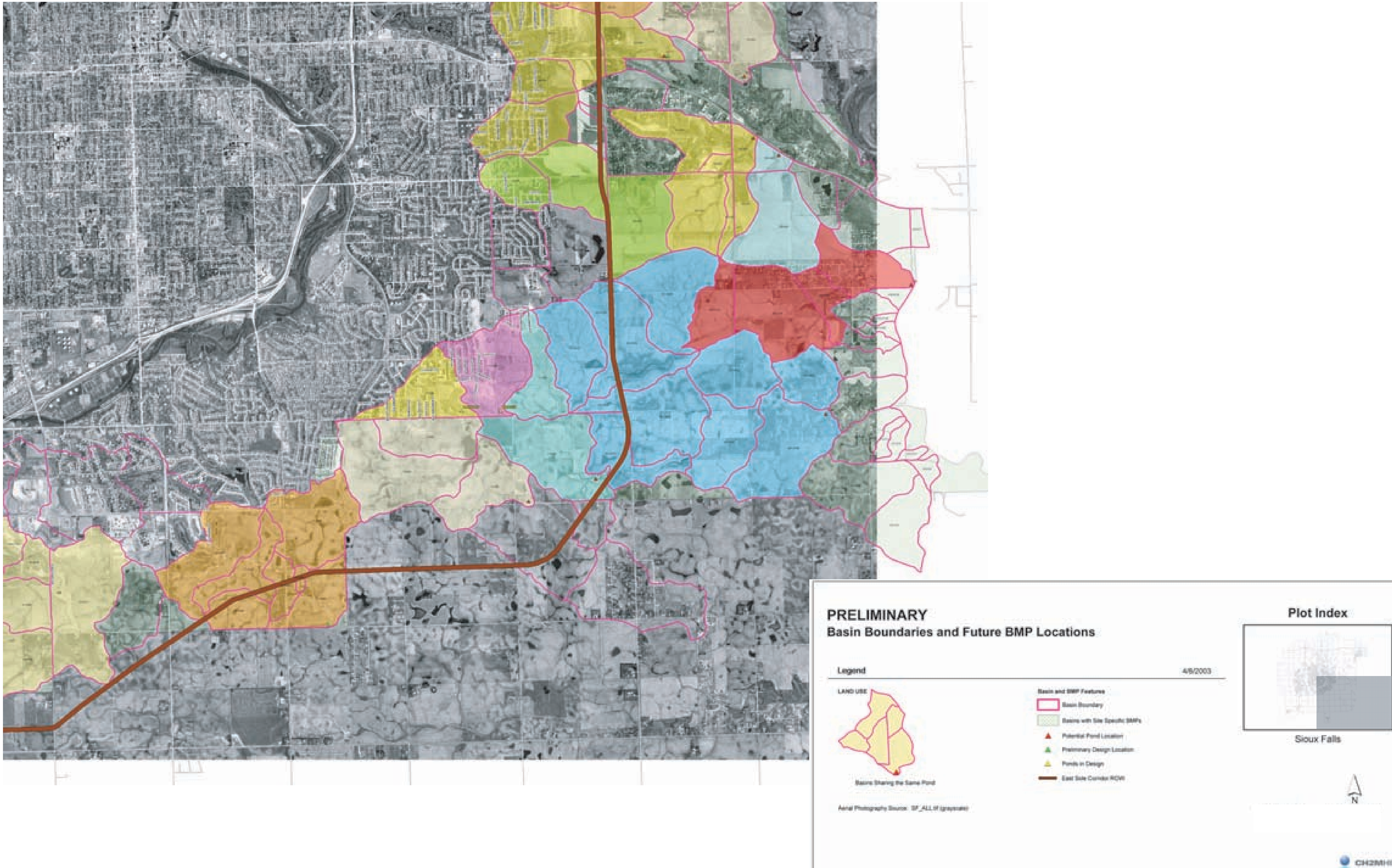


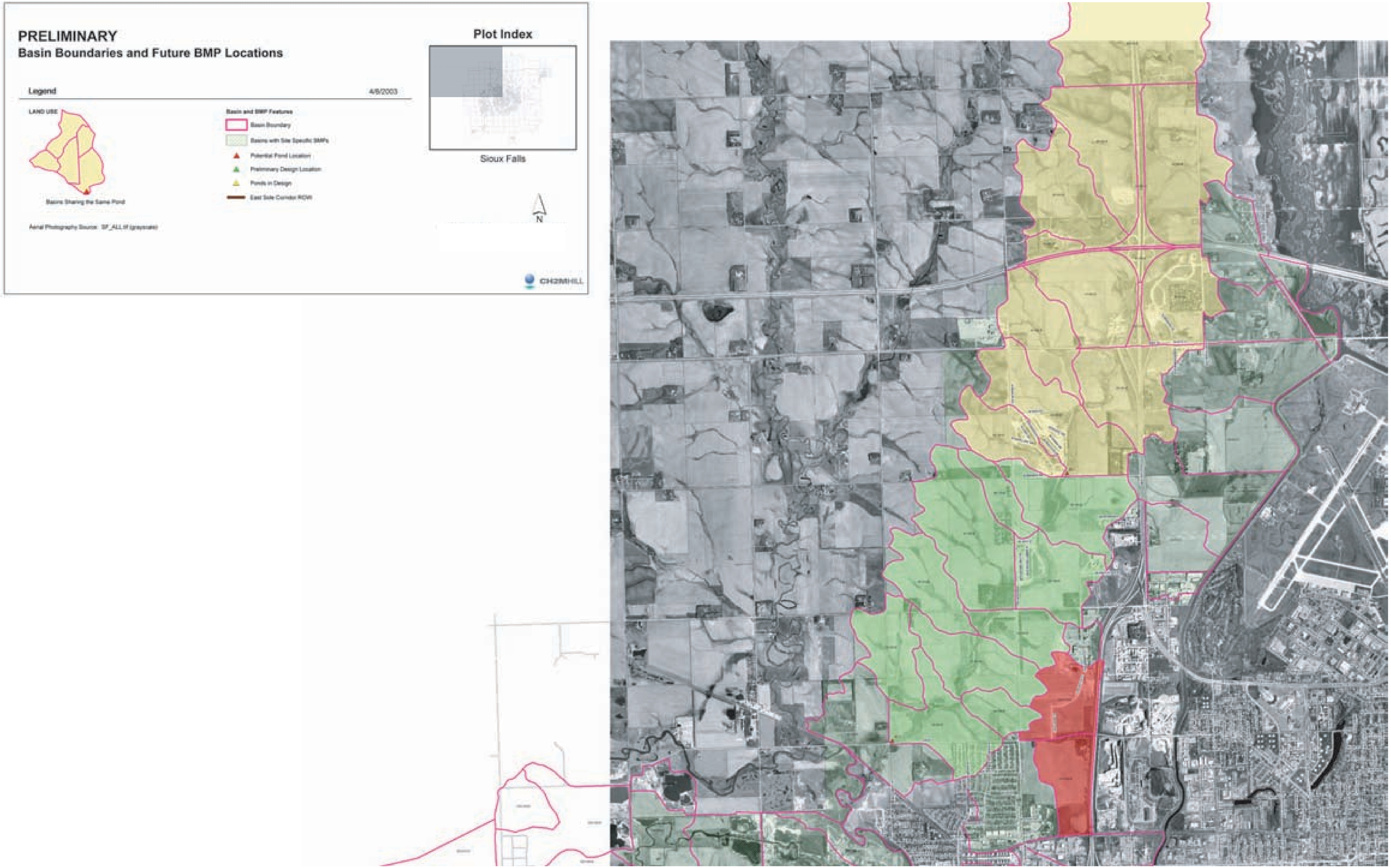
Sioux Falls 2015 Land Use and Stormdrain Boundaries

2015landuse.shp

- Residential Single Family
- Existing Rural Residential
- Residential Multiple Family
- Manufacturing
- Transportation, Communication, Utilities, Parking Facilities
- General Commercial
- Heavy Commercial
- Offices, Churches, Institutions, Schools
- Cultural Activity; Libraries, Museums, Parks
- Cemetery, Landfills, Mining, Quarrying, Under Construction
- Cropland, Grasslands, Vacant
- 2001approvedresidentialdevelopments.shp
- Prior Drainage Study Areas
- Sanitary Sewer Basin
- 2010 Priority Schedule

CH2MHILL
in association with
Howard R. Green Company


PRELIMINARY
Basin Boundaries and Future BMP Locations
Legend
4/8/2003
LAND USE
Basins Sharing the Same Pond
Basin and BMP Features
Basin Boundary
Basins with Site Specific BMPs
Potential Pond Location
Preliminary Design Location
Ponds in Design
East Side Corridor ROW
Aerial Photography Source: SF_ALL.tif (grayscale)
Plot Index
Sioux Falls
N
CH2MHILL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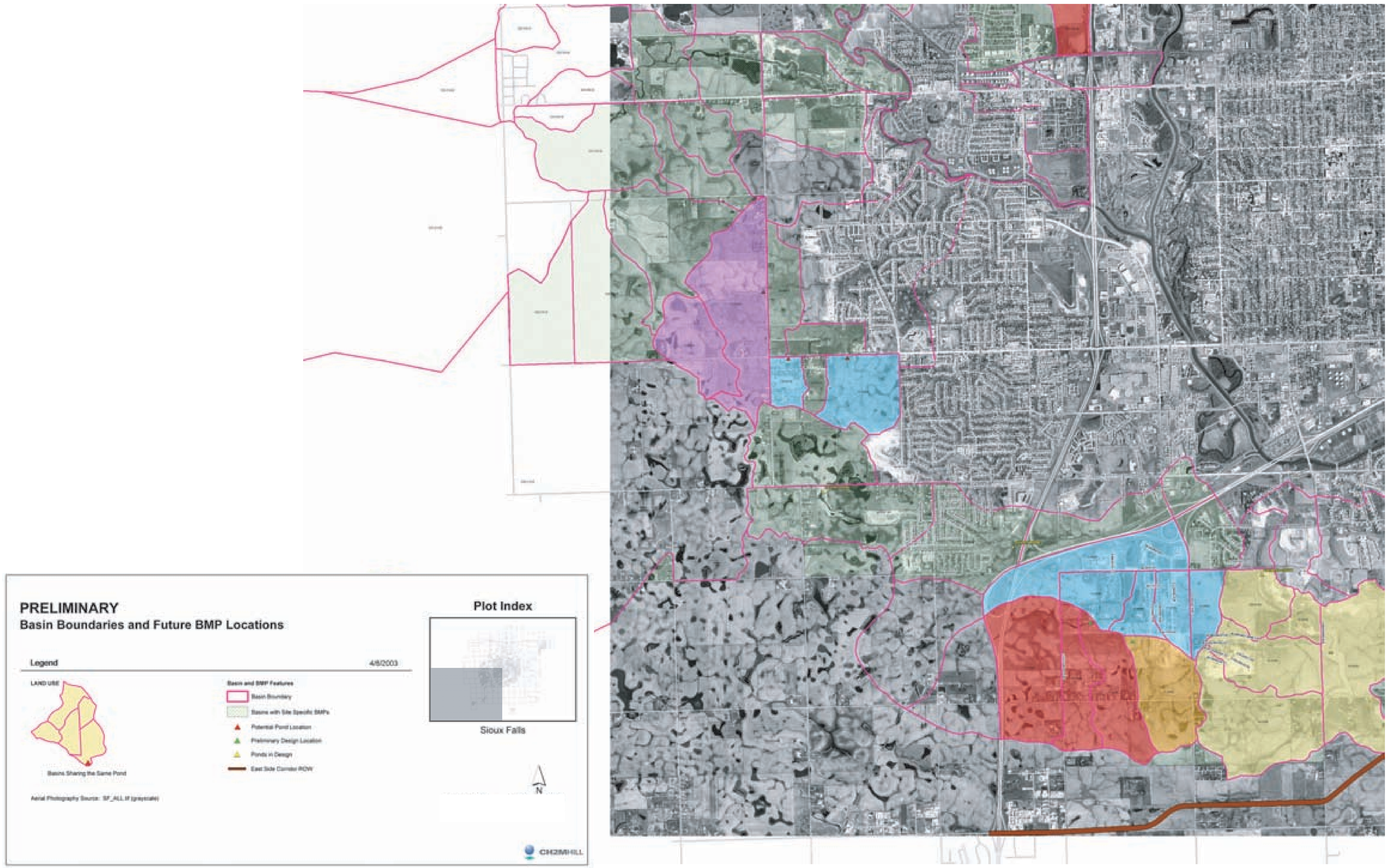

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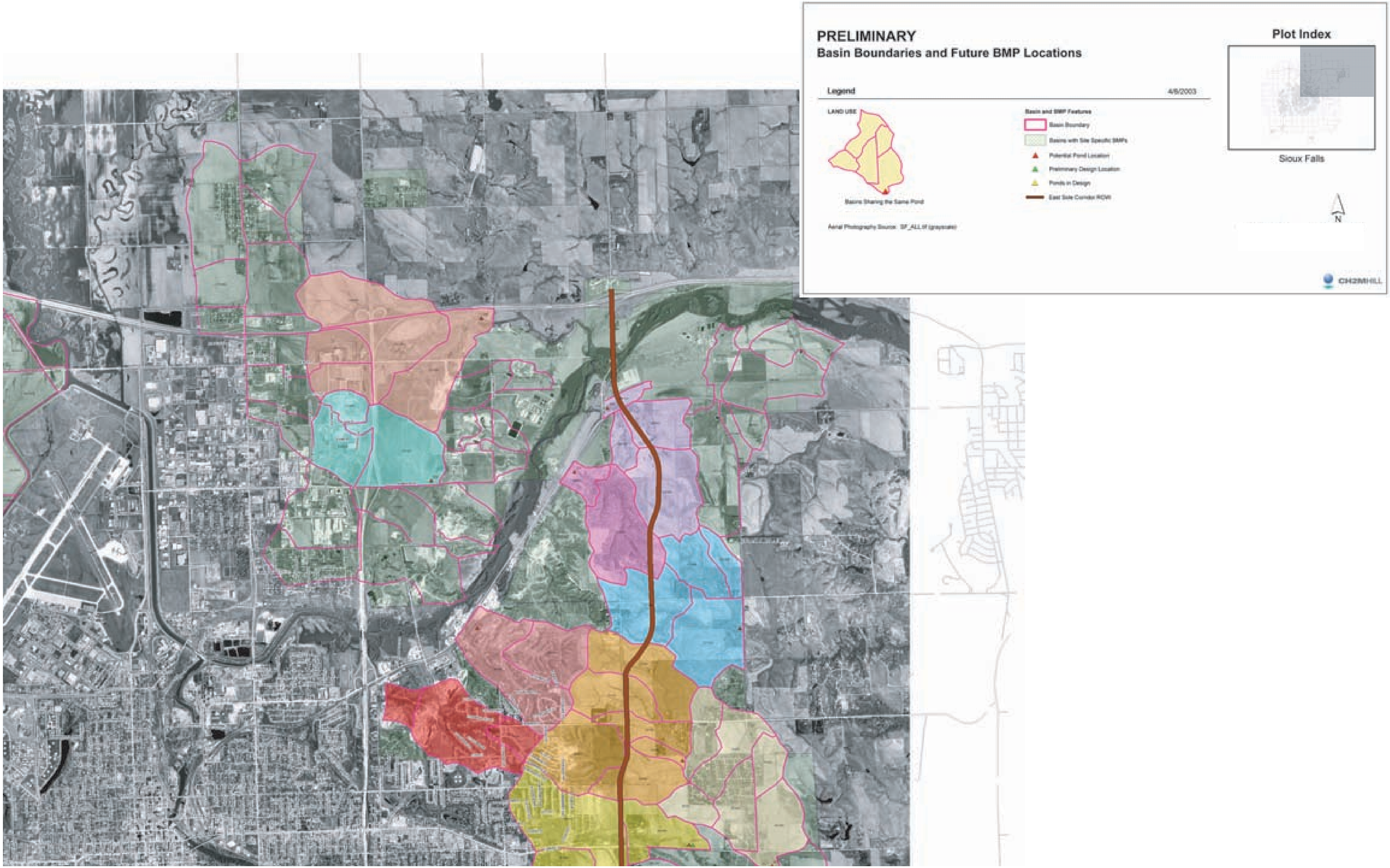
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East Side Corridor ROW
Plot Index
Sioux Falls
N

MAILING LIST AND ATTENDANCE SHEET FOR STORMWATER BMP MASTER PLAN ON APRIL 10, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Mtg Inv	7:00 pm Mtg Inv	8:30 Attend	7:00 Attend
Howard R. Green Company	Attn: Mark Cotter	309 W 43rd St Ste 101	Sioux Falls SD	57105-6805	X &	X	X	X
Howard R. Green Company	Attn: Joe Trnka	PO Box 9009	Cedar Rapids IA	52409-9009	X &	X	X	X
						X		
CH2M HILL	Attn: Mark Mittag	135 S. 84th Street, Ste 325	Milwaukee WI	53214	X &	X	X	X
CH2M HILL	Attn: Craig Wilkening	9193 S. Jamaica Street	Englewood CO	80112	X &	X		
CH2M HILL	Attn: Kyle Hamilton	9193 S. Jamaica Street	Englewood CO	80112-5946	X &	X		
CH2M HILL	Attn: Laurens van der Tak	13921 Park Center Rd, Ste 600	Herndon VA	20171	X &	X	X	X
CH2M HILL	Attn: Elise Ibendahl	727 N. 1st Street, Ste 400	St. Louis MO	63102	X &	X		
CH2M HILL	Attn: Phillip Blonn	135 S. 84th Street, Ste 325	Milwaukee WI	53214	X &	X		
CH2M HILL	Attn: Patricia Nelson	9193 S. Jamaica Street	Englewood CO	80112-5946	X &			
US Corps of Engineers	Attn: M. James Oehlerking	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
US Corps of Engineers	Attn: Steven E. Naylor	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
US Corps of Engineers	Attn: Andy Mitzel	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
US Corps of Engineers	Attn: Tom Lowin	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
SD DENR	Attn: John Miller	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
SD DENR	Attn: Stacy J. Reed	523 E. Capitol Avenue	Pierre SD	57501-3182		X		X
Rain For Rent/IECA	Attn: Michael Chase	3000 Joshua Ct	Bakersfield CA	93301				X
SD Game, Fish, and Parks	Attn: Leslie Petersen	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
SD Game, Fish, and Parks	Attn: John Kirk	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
US Fish & Wildlife Service	Attn: Natalie Gates	420 S. Garfield Avenue, Ste 400	Pierre SD	57501		X		
State Historic Preservation Office	Attn: Paige Hoskinson	900 Governors Drive	Pierre SD	57501-2217		X		
Sioux Falls Bd of Preservation	Attn: Don Seten, Planning Dept	224 W. 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Shannon Ausen*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X		
City of Sioux Falls	Attn: Jeff Dunn*	224 W 9th Street	Sioux Falls SD	57104-6407	X &	X	X	X
City of Sioux Falls	Attn: Bob Kappel	4500 N. Sycamore Avenue	Sioux Falls SD	57104		X		X
City of Sioux Falls	Attn: Kevin Smith	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Sam Trebilcock	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Mark Perry	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Russ Sorenson	224 W 9th Street	Sioux Falls SD	57104-6407		X	X	
City of Sioux Falls	Attn: Tony Everson*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X	X	X
City of Sioux Falls	Attn: Gary Halstead	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Nancy Stanga	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Lyle Johnson*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X		
City of Sioux Falls	Attn: Mayor Dave Munson	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Jeff Schmitt*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X		
City of Sioux Falls	Attn: Steve Metli*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X		
City of Sioux Falls	Attn: Chuck Serbus	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: John Osman	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Kerry Ellis	224 W 9th Street	Sioux Falls SD	57104-6407		X	X	
City of Sioux Falls	Attn: Wally Doolittle*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X		
City of Sioux Falls	Attn: Dorothy Franklin, Health Dept	132 N. Dakota Avenue	Sioux Falls SD	57104		X		X

MAILING LIST AND ATTENDANCE SHEET FOR STORMWATER BMP MASTER PLAN ON APRIL 10, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Mtg Inv	7:00 pm Mtg Inv	8:30 Attend	7:00 Attend
Parks Department	Attn: Mike Cooper	600 E 7th Street	Sioux Falls SD	57103-1338		X		
Sioux Falls City Council (8)	Attn: Barb Johnson*	235 W. 10th Street	Sioux Falls SD	57104	X Or	X		
						X		
SD Dept of Transportation	Attn: Craig Smith	5316 W. 60th Street North	Sioux Falls SD	57107		X		
SD Dept of Transportation	Attn: Cary Cleland	5316 W. 60th Street North	Sioux Falls SD	57107		X		
						X		
SECOG	Attn: Austin Eich	1000 N. West Ave, Ste 210	Sioux Falls, SD	57104-1332		X		
Minnehaha Co Highway Dept	Attn: Bob Meister	P.O. Box 1364	Sioux Falls SD	57104		X		
Minnehaha Co Highway Dept	Attn: Tom Wilsey	P.O .Box 1364	Sioux Falls SD	57104		X		
Minnehaha Co Planning Office	Attn: David K. Queal, Dir	415 N Dakota Ave	Sioux Falls SD	57104		X		
Minnehaha Co Commission Office	Attn: Ken McFarland	415 N Dakota Ave	Sioux Falls SD	57104		X		
Minnehaha Co Community Water Corp	Attn: Scott Buss, Exec Dir	47381 248th Street	Dell Rapids SD	57022		X		
Wayne Township	Attn: Sid Walters	46774 266th Street	Sioux Falls SD	57106		X		
Benton Township	Attn: Dale V. Benson	47056 258th Avenue	Sioux Falls SD	57107		X		
Splitrock Township	Attn. John Monahan	7901 E 38th Street	Sioux Falls SD	57110		X		
City of Tea	Attn: Mayor John Lawler	115 W 2nd Street	Tea, SD	57064		X		
City of Brandon	Attn: Mayor Mike Schultz	P.O. Box 95	Brandon, SD	57005-0095		X		
City of Brandon	Attn: Dennis Olson, City Adm	P.O. Box 95	Brandon, SD	57005-0095		X		
City of Harrisburg	Attn: Mayor Jim Aalbers	P.O. Box 26	Harrisburg SD	57032-0026		X		
City of Hartford	Attn: Mayor Patty Siemonsma	P.O. Box 727	Hartford SD	57033-0727		X		
Lincoln Co Planning	Attn: Paul Aslesen, Director	100 E. 5th Street	Canton SD	57013		X		
Lincoln Co Planning	Attn: Jon Peters, GIS Tech	100 E. 5th Street	Canton SD	57013		X		X
Lincoln Co Auditor	Attn: Helen Nelson	100 E. 5th Street	Canton SD	57013		X		
Lincoln Co Commissioners		100 E. 5th Street	Canton SD	57013		X		
Lincoln Co Rural Water	Attn: Dennis Larsen, Mgr	P.O. Box 36	Harrisburg SD	57032		X		
Springdale Township	Attn: Tim Burns	27063 Sycamore Ave	Sioux Falls SD	57108		X		X
Springdale Township	Attn: Rich Minder	27049 Revillo Place	Sioux Falls SD	57108				X
Springdale Township	Attn: Jerry Lingen	26989 Southeastern	Sioux Falls SD	57108				X
Springdale Township	Attn: Norman Enger	27260 476th Avenue	Harrisburg SD	57032				X
Delepre Township	Attn: Jim Poppens	46594 271st Street	Tea SD	57064		X		
Northern Natural Gas Co.	Attn: Mike Garry, Mgr	P.O. Box 336	Harrisburg SD	57032		X		
Williams Pipeline Company	Attn: Tom Barr, Mgr	5300 W. 12th Street	Sioux Falls SD	57107		X		
Developers								
Ronning Enterprises Inc	Attn: Charles A. Point*	4401 E 6th Street	Sioux Falls SD	57103-1172	X Or	X	X	
Van Buskirk Companies	Attn: Steve Van Buskirk*	5101 S Nevada Avenue	Sioux Falls SD	57108	X Or	X		
Stencil Construction & Development	Attn: Clint Stencil	4804 S Minnesota	Sioux Falls SD	57108		X		
Dunham Company	Attn: Darla Jorgensen	230 S Phillips Avenue	Sioux Falls SD	57104		X		
C-Lemme Custom Homes, L.L.C.	Attn: Dan Lemme	3408 S Sycamore	Sioux Falls SD	57110		X		
Candle Development, L.L.C.	Attn: Josh Bartels	5601 S Sundowner Avenue	Sioux Falls SD	57106		X		
Daniels Construction, Inc.	Attn: James Daniels*	27160 470th Avenue	Tea, SD	57064	X Or	X	X	

MAILING LIST AND ATTENDANCE SHEET FOR STORMWATER BMP MASTER PLAN ON APRIL 10, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Mtg Inv	7:00 pm Mtg Inv	8:30 Attend	7:00 Attend
Paul Fick Homes, Inc.	Attn: Paul Fick*	3909 S Southeastern Ave	Sioux Falls SD	57103	X Or	X		
Friessen Construction Co, Inc.	Attn: Patricia Vognild	601 S Marion Rd	Sioux Falls SD	57106		X		
Scott Gilbert Construction Co.	Attn: Scott Gilbert	5200 S Cliff Avenue	Sioux Falls SD	57108		X		
The Grasslands, L.L.C.	Attn: Mark Vellinga	1300 W 57th St. Ste 100	Sioux Falls SD	57108		X		
Haight Construction	Attn: Rob Haight	27124 Grummand Ave	Tea SD	57064		X		
Craig Harr Construction	Attn: Craig Harr	7008 E Stoakes Cir.	Sioux Falls SD	57110		X		
G & D Harr Construction, L.L.C.	Attn: Gary Harr	3408 S Sycamore	Sioux Falls SD	57110		X		X
Lloyd Construction	Attn: Craig Lloyd	3130 W 57th Street	Sioux Falls SD	57108		X		
Masonry Homes, Inc.	Attn: Randy Martens	3012 S Coral Cir.	Sioux Falls SD	57103		X		
Paul Nelson Construction	Attn: Paul Nelson	725 S 9th Avenue	Sioux Falls SD	57104		X		
Otten Construction Inc.	Attn: Herman Otten	601 S Mary	Tea SD	57064		X		
Ramstad Development	Attn: Cliff Ramstad	702 E 3rd Street	Colton, SD	57018		X		
Mike Schultz Construction, Inc.	Attn: Tim Miller	206 S Main Ave	Sioux Falls SD	57104		X		
Sunset Ridge Development, L.L.C.	Attn: LuAnn Wright	5513 W 61st Street	Sioux Falls SD	57106		X		
Thurman Construction	Attn: Mike Thurman*	528 W 29th Street	Sioux Falls SD	57105-0858	X Or	X		
Infrastructure Review and Advisor Board (IRAB)								
Asphalt Surfacing Company	Attn: Dick Johnson	P.O. Box 84010	Sioux Falls SD	57118-4010	X			
Concrete Materials	Attn: Pat Sweetman	P.O. Box 84140	Sioux Falls SD	57118-4140	X			
Dunham Company	Attn: Bonnie Mogen	230 S Phillips Avenue	Sioux Falls SD	57104	X			
Friessen Construction Co, Inc.	Attn: Cindy Monnin	601 S Marion Rd	Sioux Falls SD	57106	X			
Hagen Commercial Real Estate	Attn: Craig Hagen	201 N Minn Ave, Ste 103	Sioux Falls SD	57104	X			
HDR Engineering	Attn: Mark Wiederrich	600 S Cliff Ave, Ste 106	Sioux Falls SD	57104	X			
Home Builders Assoc.	Attn: Cindy	4320 Arway Drive	Sioux Falls SD	57106	X			
JSA Engineers	Attn: Rich Schwanke	3700 S. West Avenue	Sioux Falls SD	57105-6352	X		X	
Runge Enterprises	Attn: Michael Runge	3500 N. Hovland Drive	Sioux Falls SD	57107	X			
R.F. Sayre & Associates	Attn: Steve Quincey	P.O. Box 734	Sioux Falls SD	57101-0734	X			
Schmidt Engineering Inc.	Attn: Jon Schmidt	401 E 8th St. Ste 200G	Sioux Falls SD	57103	X			
Schmitz Kalda & Associates	Attn: Kim Buell	320 N Main Ave, Ste A	Sioux Falls SD	57104	X		X	
Sioux Empire Housing	Attn: Jim Schmidt	200 N. Phillips Avenue	Sioux Falls SD	57104	X			
Soukup Construction	Attn: James Soukup	221 N Marion Rd	Sioux Falls SD	57107-0501	X		X	
Stockwell Engineers	Attn: Jon Brown	211 E. 14th St, Ste 200	Sioux Falls SD	57104-6913	X			
Stockwell Engineers	Attn: Steve Brockmueller	211 E. 14th St, Ste 200	Sioux Falls SD	57104-6913	X		X	
Qwest Communications	Attn: Dan Kaiser	125 S Dakota Ave	Sioux Falls SD	57104	X			
Viereck Commercial	Attn: Jan Muilenburg	812 S. Minnesota Avenue	Sioux Falls SD	57104	X		X	
Xcel Energy	Attn: Pam Osthus	500 W Russell Street	Sioux Falls SD	57104	X			

MAILING LIST AND ATTENDANCE SHEET FOR STORMWATER BMP MASTER PLAN ON APRIL 10, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Mtg Inv	7:00 pm Mtg Inv	8:30 Attend	7:00 Attend
General Public								
Notice of Meeting to Argus Leader								
www.bigsioux.com								
TV: Channel 16								
Neighborhood Link: http://www.siouxfalls.org/neighborhoods/								
Pine Lake Hills Homeowners Assoc.	Attn. Steve Pederson	601 N. Appaloosa Trail	Sioux Falls SD	57110		X		
Pine Lake Hills	Attn. Doug Derheim, Water Supt.	700 Meadowbrooke Lane	Sioux Falls SD	57110		X		
Pine Hills Homeowners Assoc.	Attn. Warren Oakland, Pres	3205 Keith Lane	Sioux Falls SD	57110		X		
Izaac Walton League		5000 E. Oakview Place	Sioux Falls SD	57110		X		
Sierra Club	Attn: Tracie Weber	231 S. Phillips Avenue	Sioux Falls SD	57104		X		
Northern Prairies Land Trust	Attn: Rachel Brewster, Exec Dir	1905 W. 57th St. #3	Sioux Falls SD	57108		X		
Augustana College	Attn: L Adrien Hannus	2001 S. Summit Avenue	Sioux Falls SD	57197		X		
HDR	Attn: Dan Graber	600 S. Cliff Ave, Ste 106	Sioux Falls SD	57104		X		
Dakota Land Survey & Eng.	Attn: Paul Clinton	2000 W. 42nd St, B-6	Sioux Falls SD	57105				X

* Also on IRAB

Howard R. Green Company

Master Plan for Stormwater BMPS

CH2MHILL

Informational Meeting

We are pleased to present the Master Plan findings for the City of Sioux Falls Best Management Practices (BMPs) for stormwater. You will also have the opportunity to ask questions or offer comments. If you prefer to mail your questions/comments, a postcard will be available at the meeting.

Date: Wednesday, June 18, 2003

Time: 8:30 a.m. and 7:00 p.m.

Location: Kuehn Community Center, 2801 S. Valley View Rd.
Sioux Falls, South Dakota

Howard R. Green Company
309 W. 43rd Street, Suite 101
Sioux Falls, SD 57105

SEAL OF THE CITY OF SIOUX FALLS SOUTH DAKOTA

PB9314811
$00.00^0 JUN 25 03
MAILED FROM ZIP CODE 57105

What Are Best Management Practices For Stormwater?

Stakeholder Address

Sioux Falls Best Management Practices (BMPs) For Stormwater

Comment/Question Form

NAME: ______________________________ **TELEPHONE:** ______________________________

ADDRESS: ______________________________

______________________________ **E-MAIL:** ______________________________

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COMMENTS/QUESTIONS:

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Please place this comment/question form in the designated box on your way out of the meeting, or mail it to Mark Cotter, Howard R. Green Company, 309 West 43rd Street, Suite 101, Sioux Falls, SD 57105-6805

Attn: Mark Cotter
Howard R. Green Company
309 West 43rd Street, Suite 101
Sioux Falls, SD 57105-6805

STORMWATER BMP MASTER PLAN IRAB MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Wednesday, June 18, 2003 at 8:30 a.m.
Location: Kuehn Community Center
Re: Public Informational Meeting for IRAB Group
Attendance: See Attached Attendance Sheet

Lyle Johnson from the City of Sioux Falls opened the IRAB Meeting and went through IRAB business.

Mark Mittag from CH2M Hill made the introductions and went though the handout materials and started the PowerPoint Presentation.

The following materials were handed out:

- Agenda.
- Executive Summary.
- Figure 8-1.
- Powerpoint Slides.
- Location Map for BMP's (all 28 with names) and Basin Boundaries.

The following is a summary of the items discussed:

1. Jeff Dunn: Is the WQCV a typical percentage of the pond?
   - Mark Mittag said roughly 10% but has not reviewed and calculated the average WQCV area for the 28 BMPs in the Master Plan.

2. Jeff Schmitt: 28 sites have been selected. How is the determination made to get the best use of the land?
   - Mark Mittag responded that location is normally located next to roads because:
     1. Access to BMP and hydraulic structure.
     2. Tributary Confluences – locate 1 instead of 2 or 3 upstream.
     3. Permitting:
        a. Minimize wetlands impacts.
        b. Cultural resources – reviewed high/low probability areas for sensitivity.

3. Jeff Schmitt: Master Plan states they are typically located at the end of basins, what does this mean?
   - Mark Mittag – Locating them at the end allows for collecting and discharging the volume, before it goes into another basin.

4. Shannon Ausen: If the BMP is relocated or moved, does the Corps have to approve?
   - Mark Mittag – Not necessary. The Corps will review the Master Plan, but does not get involved if there are no impacts to waters of United States or impacts to a wetland.

5. Steve Quincey: Counts and get more than 28. How many are there?
   - Mark Mittag – 5 are being designed by others and 28 in Study. Should be 33 total red and yellow triangles.

6. Chuck Point: Site specific BMP. Contour of land. How and why are they site BMP?
   - Mark Mittag – Typically they are largely developed or are very small and may drain directly to Big Sioux River.

7. Chuck Point: Why is the extreme west (middle) left as site specific?
   - Mark Mittag – Date of construction and sewerability is primarily why these are set up for site specific. (Chuck thinks the westside will develop sooner than 7-4 and 7-5.)

8. Cindy Monnin: Will some areas be covered under retrofit. Lyle have you factored that into cost analysis?
   - Mark Mittag - New development or redevelopment has to have storm water quality, some areas will be covered under a retrofit.

9. Kim Buehl: How many acreage are on-site specific areas?
   - Mark Mittag – Did not calculate that acreage.

10. Chuck Point: Can non-IRAB member pay for a copy?
    - Lyle Johnson – Yes. Want your comments on draft.

11. Lyle Johnson: Let's discuss cost of Regional BMP costs?
    - Five sites determine the cost by regression analysis of the other 23.
    - Land cost - $25,000/acre.
    - Approximately $1,100/acre – ½ City and ½ developer.
    - Estimate cost of construction is $2,500/acre.

    Regional BMP and Regional Detention Charge (RDL):
    - Provides an indication ($585) of what this cost will be to build these facilities.

    How are we going to pay for the:
    - Regional BMP fee.
    - Drainage fee.
    - Payback over 25 years – 1.33 million/year.
    - Can't use SRF loans to pay for land.
    - Dean N. – Proposed loan on sales tax.

    Option #2:
    - Increase drainage fee more aggressive to get up to the level sooner.

    Need to put a funding package together and are currently working on this.

12. Chuck Point: $585/Acre is proposed. Currently paying $750/acre. What will the developer pay? This cost is currently being figured and will know more next meeting.

13. Cindy Monnin: Will a loan on sales tax impact other projects?
    - Lyle Johnson – No, based on the timing of some bonds to be paid off (interdepartmental loans).

14. Lyle Johnson: We are not asking for a vote today. We will have the numbers and ordinance ready at the next meeting. Like to take the ordinance to Council by next meeting.

15. What is the political support?
    - Lyle Johnson – Mayor is in favor of project and several Council members. If we put together a funding package, feels they will support it. There has not been a drainage fee rate increase since 1996.

16. Jim Soukup: Will parts of the multi-use amenities (bike trail) be supported by Parks funding?
    - Lyle Johnson – Yes, that will be a Parks cost.

17. Steve Quincey: Increase for inflation in the cost estimates?
    - Lyle Johnson – No, but there is a 3.5% increase for growth which should cover inflation.

18. Lyle Johnson: BMPs need to be placed prior to development, possibly need temporary BMPs. It would be nice if the land for the 28 sites were owned by developers, acquiring the land would be easier.

19. Lyle Johnson: Plan to use SRF program for construction costs. 20-year payback to fund program.

20. Steve Van Buskirk: How will the land be purchased in the short-term?
    - Purchase land and payment to landowner. 2005, 2006, the balloon payment.

21. Lyle Johnson: Will start negotiating land on 28 sites later this year. RDC payment will help make payment to sales tax.

Next meeting: July 2, 2003 (holiday week) – Water Plant at 8:30 a.m.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

STORMWATER BMP MASTER PLAN MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Meeting Minutes

Date: Wednesday, June 18, 2003 at 7:00 p.m.
Location: Kuehn Community Center
Re: Public Informational Meeting
Attendance: See Attached Attendance Sheet

Mark Mittag from CH2M Hill made introductions and went through an outline of the meeting and went through the PowerPoint presentation.

1. Jeff Dunn: What is the purpose of a BMP?
   - Mark Mittag responded:
     - ➢ Water quality to separate out the pollutants and sediment in stormwater.
     - ➢ Flood control – Attenuate 5 year and 100 year flows

2. Buzz Nelson: What is the maintenance of these facilities?
   - Mark Mittag responded:
     - ➢ Primarily remove the sediments in the forbay.
     - ➢ More frequent maintenance is cleaning the trash off the outlet structure.

3. Dan Graber: $60 million project cost for how many acres?
   - Mark Mittag: 22,000 acres.

4. Rich Minder: Please clarify the 7 to 1 acre reduction of wetland impacts?
   - For example – if 7 acres of wetlands were affected based on the location of a BMP, then we would look at moving the BMP upstream to hopefully reduce this wetland impact to zero or 1 acre.

5. Mark Vellinga: Can wetlands be avoided altogether?
   - No, not completely.

6. Dan Graber: What is a perennial stream?
   - Joe Trnka – This stream will typically have flow all year long.

7. Mark Vellinga: What ponds are wet?
   - Mark Mittag – These BMPs will be retention (wet) ponds that have a continuous base flow.

8. Rich Minder: Is excavation needed to create BMP #40-1?
   - Yes.

9. Jon Peters: Who will build these ponds?
   - Jeff Dunn responded:
     - ➢ If City is ahead of development, the City will build.
     - ➢ If the development is going in before the city has the chance to construct, the developer will grade the pond out and cost sharing will be engaged.

10. Jon Peters: Concerned with wetland at 57th and Sycamore to south of the intersection. Is not sure what to tell the developers.
    - Jeff Dunn is working on this.

11. Mark Vellinga: Referred to 40-1 Figure. Can this be downsized?
    - Jeff Dunn – This site was discussed today and we plan to split this one up – up and down the 100 year flood plain. These figures are not set in stone.

    Comment: They have a windmill they wanted to pump into a retention area.

12. Jon Peters: Will you need a permit from the County?
    - Jeff Dunn – The City is okay with Minnehaha, but will need a permit from Lincoln County.

13. Buzz Nelson: Blood Run is outside 2015 plan. He owns the land the State is trying to buy. He also owns land slated for site specific near Hwy 42 and east of Powderhouse Road.

14. Rich Minder: Will these coincide with the sanitary sewer?
    - Jeff Dunn: Yes. He intends to meet with HRG and HDR to have the sewers go around these facilities.

Howard R. Green Company

Mark Cotter, P.E.
Project Manager

FIGURE 8-1
Proposed BMP Construction Schedule
Regional Stormwater BMP Master Plan
City of Sioux Falls, South Dakota

BMP Name	Preliminary Design	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
7-5														
7-4														
11-1	X													
11-2	X													
13-1														
13-2														
13-3														
22														
25-1														
25-2														
51-1	X													
51-2														
303-2	X													
25-3														
303-4														
304														
305														
306														
312														
316														
317														
400														
401-1														
401-2														
40-1	X													
40-2														
40-3														
41-A														
Total		3	0	4	2	3	3	0	7	0	2	0	0	4

Executive Summary

Project Vision and Goals

The City of Sioux Falls chose to develop a Stormwater Best Management Practices (BMP) Master Plan to address growth areas in the city. The priority of the Master Plan focused on new development areas based on the 2015 Growth Plan and 2002 Sanitary Sewer Collection Systems Facility Plan. The extent of the study area was developed based upon land use as anticipated in the 2015 Growth Plan.

The vision statement for the master plan is to develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. The goals for the stormwater BMP master plan are to:

- Establish Sioux Falls as a leader in South Dakota
- Provide a template of how to manage stormwater discharges
- Be endorsed by the development community
- Be understood by the general public
- Facilitate planned growth
- Support water quality
- Enhance natural resources
- Be affordable

To deal with growth and to ensure that stormwater BMPs are in place before development occurs, a Master Plan is needed to pinpoint the regional stormwater needs. The regional stormwater basins need to include both flood control and water quality elements as based on the *Sioux Falls Engineering Design Standards,* Chapter 11, "Drainage Improvements." The water quality requirements were developed to be in compliance with the Surface Water Discharge System Permit (SDS-000001) for stormwater that the city received in 1999 from the South Dakota Department of Environment and Natural Resources (DENR).

Master Planning Process

This report documents the master planning process and results so that Sioux Falls can implement a regional stormwater BMP approach based upon anticipated new development and future planning.

As Sioux Falls continues to grow, natural resources in new development areas must be considered in the development process. Identifying such resources in new development areas provides the twofold benefit of having both the city and development community aware of impacts on regulated natural resources. Consequently, the Master Plan has identified the regulated resources and the permitting process required by regulatory agencies. The U.S. Army Corps of Engineers and the South Dakota DENR regulate construction in wetlands and streams. The regional stormwater BMPs have the potential to affect both natural resources.

The CH2M HILL team's approach to the Stormwater BMP Master Plan was developed to identify regional BMP locations based upon environmental constraints, public input, anticipated development, and siting constraints. That approach provides guidelines for implementing the regional BMP approach to address both water quality and flood control. Hydrologic modeling was conducted to determine the required pond volumes and outlet structure dimensions to detain the water quality capture volume, and the 5- and 100-year detention volumes needed to meet Chapter 11 requirements. Preliminary designs and an implementation plan provide examples and concepts to bring the information contained within the Master Plan to implementation.

To implement the findings of the Master Plan, a prioritization schedule and cost opinion for the improvements have been developed. The prioritization schedule will allow the city to incorporate stormwater BMP construction into capital improvement budgets. Identifying funding needs will allow the city to schedule BMP construction with available funding.

This report documents the major activities and findings of the BMP Master Plan with supporting documentation found in the appendixes. The major sections of this report are:

- Natural Resource Inventory
- BMP Siting Considerations
- BMP Locations
- Public Outreach
- Hydrologic Modeling
- Preliminary Design
- Implementation Plan

Master Plan Summary

Figure 1 shows the locations of proposed regional stormwater BMPs, including those being designed by others and those for which preliminary designs were prepared on this project. It also shows areas assumed to be served by site-specific BMPs, using criteria presented in Section 3.

Table 1 summarizes the locations, 100-year storage volumes and estimated capital costs for the proposed regional BMPs. The total capital costs for the program are estimated to be $59.1 million, with the cost of individual BMPs ranging from $650,000 to $5.4 million. This cost estimate is an order-of-magnitude cost estimate appropriate for a master planning analysis. The expected range of accuracy is +50 to – 30 percent. This cost estimate has been prepared for guidance in project evaluation and implementation from the information available at the time that the estimate was developed. The final costs for the project will depend on final project scope, implementation schedule, actual labor and material costs, competitive market conditions, and other variable conditions. As a result, the final project cost will vary from the estimate presented herein.

TABLE 1
Proposed Detention Pond Volumes and Capital Costs

BMP Site	Location Description	WQCV (ac-ft)	5-yr Vol. (ac-ft)	100-yr Vol. (ac-ft)	Construction Cost	Capital Costs*
7-4	3,200 feet east of intersection of Sycamore and 69th	16	101	151	$1,873,000	$3,213,000
7-5	1,000 feet east of intersection of Sycamore and 69th	13	75	140	$1,803,000	$3,077,000
11-1	East of Tallgrass, south of 69th, Pond 17C of Prairieview Study	14	46	95	$2,229,000	$3,493,000
11-2	West of 77th Street, Pond 17B of Prairieview Study	5	22	44	$642,000	$1,082,000
13-1	41st and Tea Ellis (E)	4	18	31	$602,000	$942,000
13-2	41st and Tea Ellis (W)	1	3	6	$454,000	$654,000
13-3	Tea Ellis, midway between 41st and 22nd	11	54	86	$1,351,000	$2,201,000
22	Between Rice Street and the railroad tracks.	7	33	64	$1,077,000	$1,669,000
25-1	Madison, east of Powderhouse	7	43	86	$1,351,000	$2,201,000
25-2	Powderhouse, midway between 6th and Madison	5	31	60	$1,017,000	$1,552,000
25-3	SE Quad of Intersection of Linden and 6 Mile	9	18	34	$619,000	$975,000
40-1	W 34th at Creek Crossing	55	204	354	$2,461,000	$4,815,000
401-1	8,000 feet directly east and south of intersection of 57th and Sycamore	15	52	94	$1,433,000	$2,360,000
401-2	NE corner of intersection of 6 mile and 69th, east of industrial development	23	63	114	$1,612,000	$2,708,000
40-2	W. Madison and La Mesa	28	305	505	$2,986,000	$5,374,000
40-3	NW Corner intersection of I-90 and I-229	6	35	56	$953,000	$1,460,000
41-A	NW intersection of EERR and I-29	14	63	116	$1,628,000	$2,739,000
51-1	NW Corner intersection of 85th and EERR	8	15	48	$528,000	$1,022,000
51-2	1,500 feet north of Cliff Ave./85th Street intersection	9	44	86	$1,351,000	$2,201,000
304	2,600 feet SE of intersection of 6 mile and 42 along 42	6	25	46	$771,000	$1,205,000
305	Rice Street, near Great Bear	5	37	61	$1,033,000	$1,583,000
306	Intersection of Rice and Timberline	8	28	49	$830,000	$1,287,000
312	Benson Rd, north and east of I-29	13	29	48	$811,000	$1,260,000
316	South of I-90, end of future Sycamore extension to interstate	21	60	112	$1,596,000	$2,676,000
317	4,000 feet north of 6 mile and E Madison along 6 mile	11	50	87	$1,362,000	$2,222,000
400	Farm Pond south of 41 an existing rural residential subdivision	11	39	78	$1,261,000	$2,026,000
303-2	1,150 feet east of intersection of Powderhouse and 26th	11	37	93	$1,209,000	$1,775,000
303-4	1,500 feet SE of intersection of 6 Mile and 42 along 42	11	25	52	$885,000	$1,363,000

*This is an order-of-magnitude cost estimate, with an expected accuracy range of +50 to -30 percent.

Table 2 lists a breakdown of cost for each BMP between items related to both water quality control and water quantity control. Also listed in Table 2 are WQCV tributary acres and the projected area of each BMP.

TABLE 2
Water Quality versus Water Quantity Cost Breakdown and Tributary and Pond Areas

BMP Site	Cost for Water Quality	Cost for Water Quantity	WQCV Tributary Area (acres)	Pond Area (acres)
7-4	$105,000	$3,108,000	917	44
7-5	$100,000	$2,977,000	741	42
11-1	$148,000	$3,345,000	698	38
11-2	$36,000	$1,046,000	309	13
13-1	$31,000	$911,000	210	10
13-2	$21,000	$633,000	65	6
13-3	$72,000	$2,129,000	596	27
22	$54,000	$1,615,000	424	18
25-1	$72,000	$2,129,000	369	27
25-2	$51,000	$1,501,000	252	16
25-3	$32,000	$943,000	547	11
40-1	$141,000	$4,674,000	2,691	72
401-1	$77,000	$2,283,000	834	30
401-2	$88,000	$2,620,000	1,351	35
40-2	$175,000	$5,199,000	1,793	80
40-3	$48,000	$1,412,000	291	15
41-A	$89,000	$2,650,000	636	36
51-1	$17,000	$1,005,000	457	8
51-2	$72,000	$2,129,000	540	27
304	$39,000	$1,166,000	339	13
305	$52,000	$1,531,000	298	17
306	$42,000	$1,245,000	427	14
312	$41,000	$1,219,000	410	14
316	$87,000	$2,589,000	699	35
317	$73,000	$2,149,000	612	27
400	$66,000	$1,960,000	669	24
303-2	$74,000	$1,701,000	582	16
303-4	$45,000	$1,318,000	531	15

Table 3 presents cost estimates for the inspection and maintenance of the 28 regional BMPs included in the master plan. These estimates are based on the number and types of BMP facilities, the identified maintenance actions (e.g., debris removal, sediment removal, etc.) for each type of BMP facility, the identified staff costs and expenses, frequency of maintenance, and desired level of service. As such, it is not the intent of the maintenance cost analysis to provide a single number for overall maintenance. Instead, the analysis separates costs into routine (preventive) maintenance and nonroutine (long-term) maintenance.

TABLE 3
Inspection and Maintenance Cost Estimate for 28 Wet Ponds

Number of Facilities	28
Total Routine Maintenance	$55,000
Total Nonroutine Maintenance	$191,000
Inspection	$3,000
Total (without inflation)	$249,000
Total (with inflation)	$286,000

Preliminary estimates of potential wetland and stream impacts were developed for the recommended BMP sites. Initially, 51 proposed BMP locations were compared to resulting wetland locations from both the NWI and available data on locations of hydric soils to determine potential wetland impacts as a result of BMP construction. Estimated pond footprints for these 51 sites were developed based upon rule-of-thumb BMP footprint areas. After the initial screening and a fatal flaw analysis, 28 final BMP locations were selected. The wetland and stream length impact analysis for the final BMP locations is summarized in Table 4, which shows the significant reduction in wetland and stream length impacts from the initial locations to the final locations.

TABLE 4
Analysis of Potential Impacts to Wetlands and Streams

	Initial 51 Sites	Final 28 Sites
NWI Wetland Potential Impact	26.3 acres	15.4 acres
Hydric Soils Potential Impact	97.5 acres	68.1 acres
Stream Potential Impact	88,588 LF	57,161 LF

Note: Wetland areas are based on available NWI and hydric soils data and have not been field verified. Stream potential impact is based upon flow-line information developed during basin delineation and is not an indication of stream type (intermittent, perennial, etc.).

Implementation Schedule and Steps

The planning period for the master plan regional BMP construction costs is 2004 through 2015. A detailed construction implementation schedule is provided for the 28 regional BMPs in Section 8. Inevitably, the phasing of construction will change to reflect actual economic conditions and priorities in the City. The key to successful implementation of the Stormwater BMP Master Plan is to adopt the plan and set in place an overall implementation strategy. The phasing and implementation strategy for the Stormwater BMP Master Plan includes the following key components:

- **Stakeholder Involvement**: To ensure successful implementation, City staff and the CH2M HILL team conducted a proactive stakeholder involvement campaign during the preparation of the Stormwater BMP Master Plan. The stakeholders included the public, community associations, the Infrastructure Review and Advisory Board, resource and regulatory agencies, City staff, elected officials, developers, and engineers. Coordination with these and other stakeholders should continue during the implementation of the Stormwater BMP Master Plan.

- **Phasing and Implementation Steps:** The overall implementation of the Stormwater BMP Master Plan should be conducted in accordance with the following concurrent steps:

  - Step 1—Procedural Approvals
  - Step 2—Funding Mechanisms
  - Step 3—BMP Design, Construction, and Maintenance
  - Step 4—Program Enhancements

Figure 2 shows the proposed 18-month Implementation Schedule. The procedural approvals in Step 1 result in formal adoption of the Master Plan by the City Council. In Step 2, the funding mechanisms for the BMPs are evaluated and finalized. Step 3 consists of refining the BMP designs and proceeding with permitting, construction, and establishing a maintenance program. Step 4 addresses related stormwater program administration and outreach. Details of these steps are provided in Section 8.

It is recommended that the construction of regional (watershed-level) BMPs be funded with developer-based support through the adoption of a pro-rata share ordinance, or extension of the existing Drainage System Cost Recovery program. It is further recommended that other implementation activities (see phasing and implementation steps below), including operations and management of existing and proposed regional BMPs, be supported through the existing stormwater utility.

Presentation for

Stormwater BMP Master Plan

for

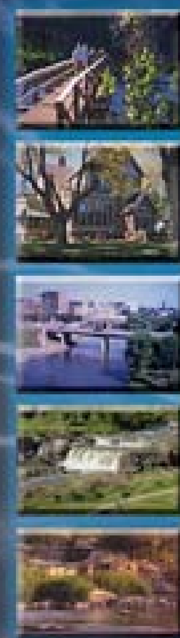
The City of Sioux Falls, South Dakota

CH2MHILL

in association with

Howard R. Green Company

June 18, 2003



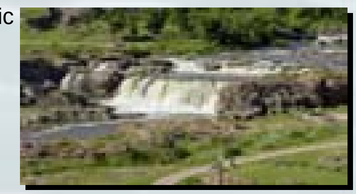
Presentation Outline

Purpose: Present the Draft Master Plan and obtain your feedback

- Review vision and process
- BMP Siting Criteria and Recommended Sites
- BMP Modeling and Facility Sizes
- Permitting and Impact Summary
- Preliminary Designs
- Costs
- Implementation Plan - Discussion by City

Stormwater BMP Master Plan Vision Statement

- To develop a stormwater plan that meets regulatory requirements, enhances quality of life, and is implemented through a regional BMP approach. The stormwater plan will:
  - establish Sioux Falls as a leader in South Dakota
  - provide a template of how to manage stormwater discharges
  - be endorsed by the development community
  - be understood by the general public
  - facilitate planned growth
  - support water quality
  - enhance natural resources
  - be affordable



Project Team Organizational Chart

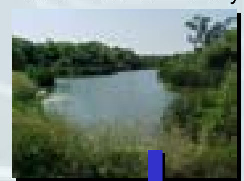
- City of Sioux Falls
  - *Project Manager* — Mark Mittag, P.E.
    - *Senior Advisors*: Laurens van der Tak, P.E. (*Stormwater Design*); Pat Nelson, P.E. (*Stormwater Compliance*)
    - *Natural Resources & Future Planning Inventory* — Joe Trnka, AICP, CEP; Mark Cotter, P.E.
    - *Hydrology Modeling* — Kyle Hamilton; Phil Blonn, Elise Ibendahl, Craig Wilkening
    - *Master Plan Documentation* — Mark Mittag, P.E.; Mark Cotter, P.E.
    - *Public Outreach* — Mark Cotter, P.E.; Mark Mittag, P.E.
    - *Identify Regional BMPs* — Pat Nelson, P.E.; Phil Blonn

Master Plan Process

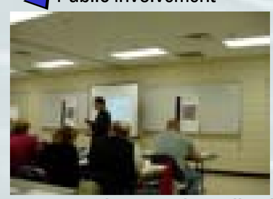
2015 Growth Plan

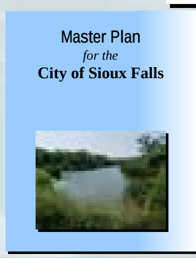
BMPs

Natural Resource Inventory



Public Involvement

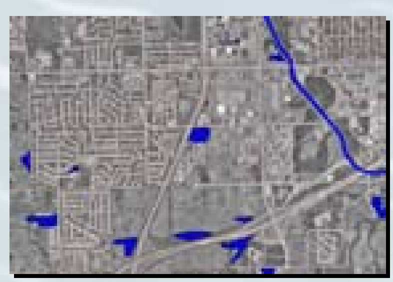




- Prioritized list of BMPs
- Schedule and Cost
- Conceptual design
- Natural Resources Inventory, supporting permit application
- GIS maps of facility locations

BMP Siting Criteria

- Strategic Locations
  - Road Crossings
  - Tributary Confluences
- Consider Permitting
  - Wetlands
  - Cultural Resources
  - Habitat
- Minimize Number of BMPs
- Basin Size



BMP Coverage

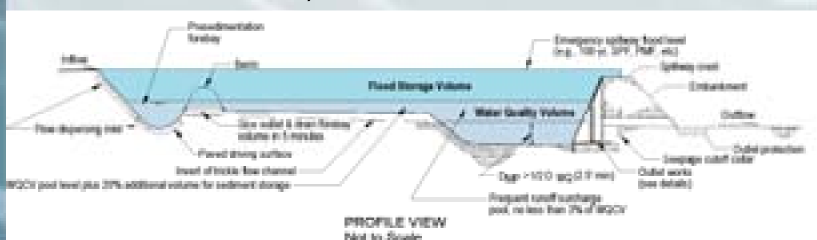
- 33 Regional BMP Locations:
  - *5 preliminary design*
  - *23 additional sites*
  - *5 in-design by others*
- Site-Specific Locations (no regional BMP)

BMP Modeling Summary

- Area Considered: 64,000 acres
- New BMP Sites: 28
- Sites In-design: 5
- 232 subbasins:
  - *10-10,868 ac*
  - *Site Specific Areas: 86.*
- BMP area served:
  - *22,470 ac.*
  - *65 to 7,690 ac. each of 28 BMPs*

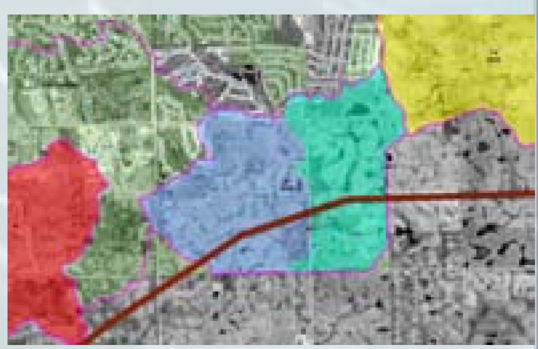
Review BMP Design Criteria

- Water Quality Volume from Engineering Design Standards
- 5-year and 100-year peak flow control (match pre-development landuse)
- Maintenance Access
- Wet or Dry Ponds (All 28 BMPs are wet ponds or constructed wetlands)



Example Modeling Findings

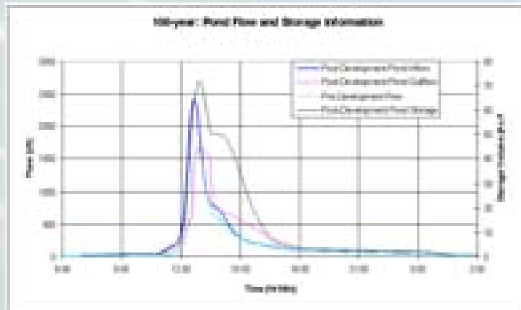
- 69th & Cliff Region
- Proposed Two Regional BMPs
- Area: 456 and 540 acres
- CN: existing 75
  developed 85



- Percent Impervious: 50%

Modeling Results

- 69th & Cliff Region (BMP Site 51-1)
- WQCV: 7 acre-feet
- 100-Year Storm Volume: 25 acre-feet

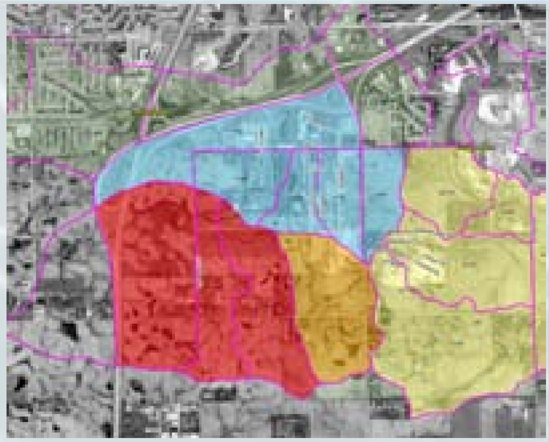


- Modeling summarized in data sheets for each site

BMP Site	Location Description	WQCV (acre-feet)	1-yr Volume (acre-feet)	100-yr Volume (acre-feet)
7-4	3,200 feet east of intersection of Sycamore and 69th	16	101	151
7-5	1,000 feet east of intersection of Sycamore and 69th	13	75	143
11-1	East of Tallgrass, south of 69th, Pond 17C of Prairieview Study	14	46	85
11-2	West of 77th Street, Pond 17B of Prairieview Study	5	22	44
13-1	41st and Tea Ellis (E)	4	16	31
13-2	41st and Tea Ellis (W)	1	3	6
13-3	Tea Ellis, midway between 41st and 22nd	11	54	88
22	Between Rice Street and the railroad tracks	7	33	64
25-1	Madison, east of Powderhouse	7	43	88
25-2	Powderhouse, midway between 8th and Madison	5	31	60
25-3	SE Quad of intersection of Linden and 6 Mile	5	16	34
40-1	W 34th at Creek Crossing	61	257	411
401-1	8,000 feet directly east and south of intersection of 57th and Sycamore	15	52	94
401-2	NE corner of intersection of 6 mile and 85th, east of industrial development	23	63	114
40-2	W. Madison and La Mesa	28	505	505
40-3	NW Corner intersection of I-90 and I-229	6	35	56
41-4	NW intersection of EERR and I-29	14	63	116
51-1	NW Corner intersection of 69th and EERR	6	15	25
51-2	1,500 feet north of Cliff Ave./69th Street intersection	8	44	86
304	2,800 feet SE of intersection of 6 mile and 42 along 42	6	25	48
305	Rice Street, near Great Bear	5	37	61
309	intersection of Rice and Timberline	8	28	49
312	Benson Rd, north and east of I-29	13	29	48
316	South of I-90, end of future Sycamore extension to interstate	60	112	180
317	4,000 feet north of 6 mile and E Madison along 6 mile	11	50	87
400	Farm Pond south of 41 on existing rural residential subdivision	11	39	78
303-2	1,150 feet east of intersection of Powderhouse and 26th	11	37	69
303-4	1,500 feet SE of intersection of 6 Mile and 42 along 42	11	25	52

Preliminary Design Locations

- Five Total Sites
  - *Model example results is one site*
  - *Two locations in SW*
  - *Two others on east-side*
- View sites on display boards



Example Site 40-1

Planning Level Cost Estimates for Preliminary Design Sites

- Construction Cost Estimates include:
  - Mobilization/Construction Access
  - Clearing and Grubbing
  - Earthwork (Cut and Fill)
  - Erosion and Sediment Control
  - Stream Stabilization and Channel Protection
  - Outlet Structure & Box Culverts
  - Plantings/Aquatic Bench
  - Plantings/Grass Seeding
  - Contingency
- Capital Cost Estimates include:
  - Wetland Impacts
  - Survey/Engineering/Permitting
  - Land Acquisition

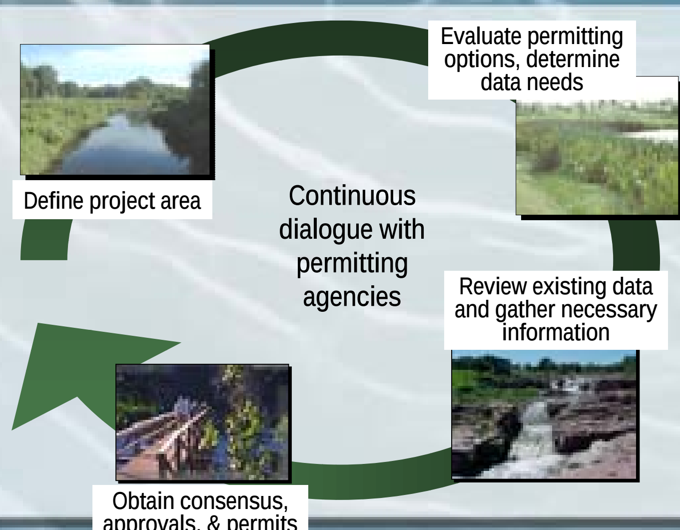
Total Construction and Capital Cost for Preliminary Design Sites

BMP	Total Construction Cost (millions)	Total Capital Cost (millions)
11-1	$2.229	$3.493
11-2	$0.642	$1.082
40-1	$2.461	$4.815
51-1	$0.528	$1.022
303-2	$1.209	$1.775
	$7.069	$12.187

Capital and O&M Costs for Master Plan

- 28 facilities
- $60 million through 2015
- Range per BMP $0.7 to $5.6 million
- Operation and Maintenance Cost: $250,000 per year for all 28 BMPs

Natural Resource Agency Involvement and Permitting

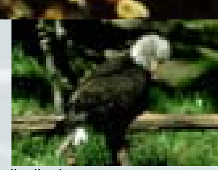


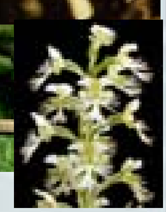
Natural Resource Permitting Agencies

Natural Resource Agency Involvement

Stakeholder	Issues	Level of Interest	What do they want?
COE	♦ Protect wetlands (404 Permit)	Very high	Minimize wetlands impacts
DENR	♦ SWD Permit ♦ Protect state waters	High	Minimize wetlands impacts
USFWS	♦ Protect endangered and threatened species	High	Compliance
SHPO	♦ Protect historic resources	High	Compliance

Threatened & Endangered (T&E) Species Update

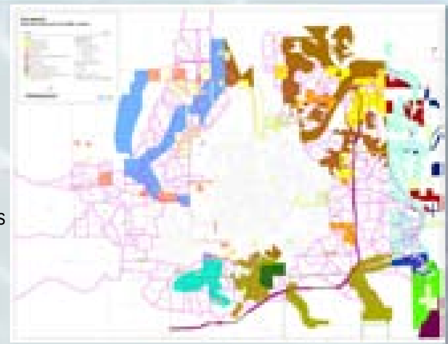




- Federal Listed Species:
  - *Topeka Shiner*
    - Historically known to occur in Sioux Falls (1939 Willow Creek Drainage, not found in '97 & '99 surveys)
    - Known to occur north and east of Sioux Falls ('99 vicinity of Dell Rapids, Brandon)
  - *Western Prairie Fringed Orchid*
    - Occurs in wet prairie habitat
    - Could potentially occur based upon historic records and habitat distribution
    - Survey where wet prairie remnant habitat exists
  - *Bald Eagle*
    - Known to occur in Sioux Falls
- T&E influence on BMP permitting:
  - *Additional future surveys may be required to clarify distribution in urbanizing area*
  - *Corps ultimate decision maker for wetland permitting*
  - *If present, additional coordination & planning may be required*

Cultural Resources Update

- Analysis:
  - *East-side corridor information*
  - *Blood Run located*
  - *High sensitivity areas*
    - higher probability
    - along perennial waterways
    - along perennial waterway bluffs
  - *Mound groups*
  - *Previous survey locations*
- Example cultural resource influence on projects:
  - *High sensitive areas reconnaissance survey*
  - *Early-on Corps coordination to address their concerns*



Wetland and Stream Impacts and Avoidance

	Initial 51 Sites	Final 28 Sites
NWI Wetland Potential Impact	26.3 acres	15.4 acres
Hydric Soils Potential Impact	97.5 acres	68.1 acres
Stream Potential Impact	88,588 LF	57,161 LF

Relocation of BMP 401-2 resulted in reduction in wetland impacts from 7.0 acres to 1.1 acres.

Public involvement:

- Today, we are interested in your:
  - Feedback on BMP locations
  - Information you think is important to the process
  - General questions

- Previous outreach through IRAB and Public Meetings on Feb.19 and April 10, 2003.

Implementation Plan

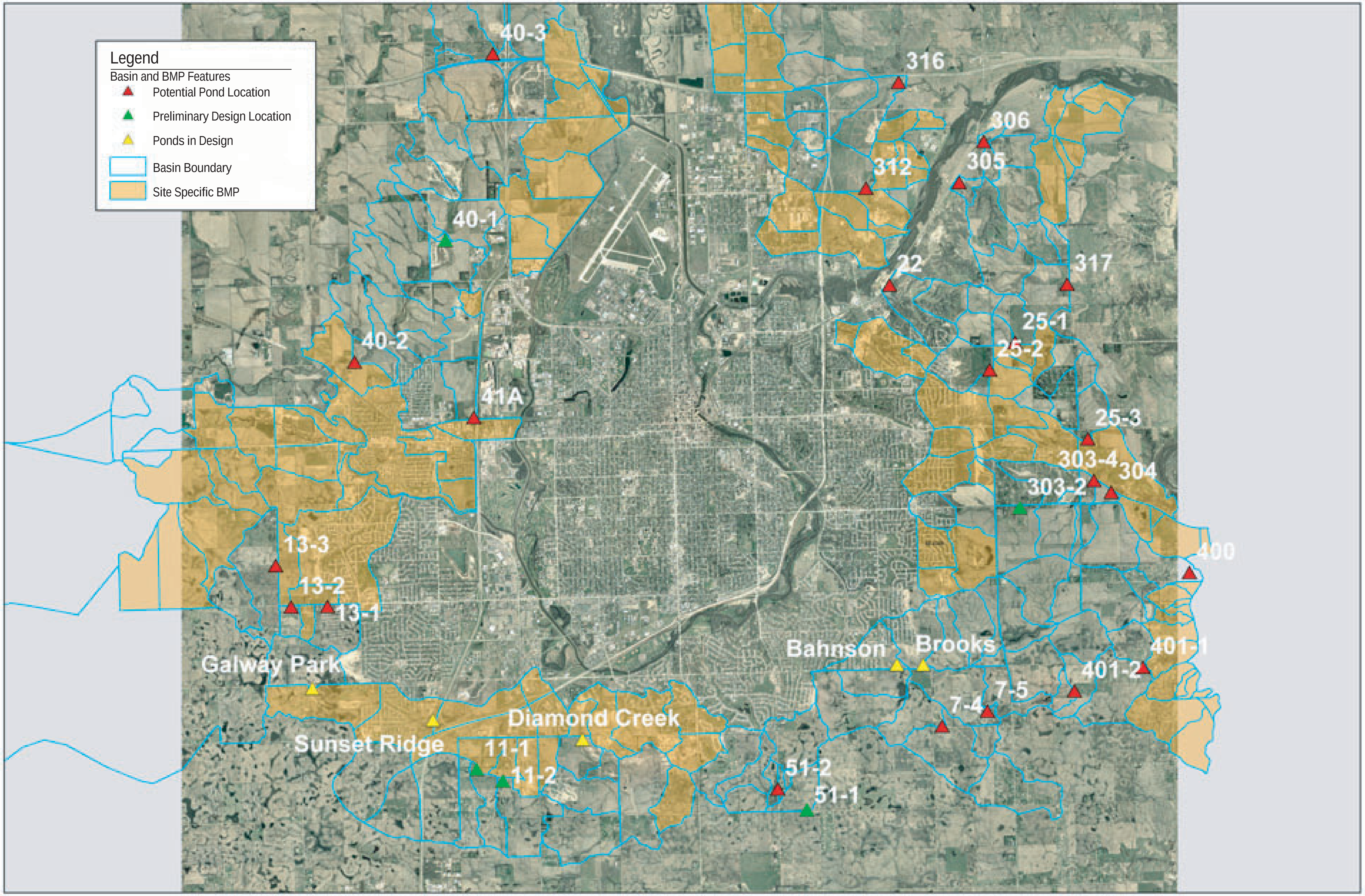
- City developing action plan for implementation steps:
  - *Funding Mechanisms*
  - *BMP Design, Construction and Maintenance*

- Strategies for Managing Risk and Change

Managing Risk and Change

- Potential Risk that can Change the Plan:
  - *Property Acquisition Limitations*
  - *Permit Approval Requirements*
  - *Funding Constraints*
- Management Options
  - *Change BMP location*
  - *Change BMP type*
  - *Convert from regional BMP to site specific BMPs*
  - *Adjust design criteria*

Questions



NOTE: Areas within developed portions of the City are also site specific as shown in Figures 3-1 through 3-4.

FIGURE 1
Location of BMPs (all 28 with names) and Basin Boundaries

Stormwater BMP Master Plan
Sioux Falls, South Dakota

178378.MP.RP Fig1_11x17 6-3-03

CH2MHILL

MAILING LIST AND ATTENDANCE SHEET FOR STORM WATER BMP MASTER PLAN ON JUNE 18, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Inv	7:00 pm Inv	8:30 a.m. Attend	7:00 p.m. Attend
Howard R. Green Company	Attn: Mark Cotter	309 W 43rd St Ste 101	Sioux Falls SD	57105-6805	X &	X	X	X
Howard R. Green Company	Attn: Joe Trnka	PO Box 9009	Cedar Rapids IA	52409-9009	X &	X	X	X
						X		
CH2M HILL	Attn: Mark Mittag	135 S. 84th Street, Ste 325	Milwaukee WI	53214	X &	X	X	X
CH2M HILL	Attn: Craig Wilkening	9193 S. Jamaica Street	Englewood CO	80112	X &	X		
CH2M HILL	Attn: Kyle Hamilton	9193 S. Jamaica Street	Englewood CO	80112-5946	X &	X		
CH2M HILL	Attn: Laurens van der Tak	13921 Park Center Rd, Ste 600	Herndon VA	20171	X &	X	X	X
CH2M HILL	Attn: Elise Ibendahl	727 N. 1st Street, Ste 400	St. Louis MO	63102	X &	X		
CH2M HILL	Attn: Phillip Blonn	135 S. 84th Street, Ste 325	Milwaukee WI	53214	X &	X		
CH2M HILL	Attn: Patricia Nelson	9193 S. Jamaica Street	Englewood CO	80112-5946	X &			
US Corps of Engineers	Attn: M. James Oehlerking	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
US Corps of Engineers	Attn: Steven E. Naylor	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
US Corps of Engineers	Attn: Andy Mitzel	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
US Corps of Engineers	Attn: Tom Lowin	28563 Powerhouse Rd, Rm 118	Pierre SD	57501		X		
SD DENR	Attn: John Miller	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
SD DENR	Attn: Stacy J. Reed	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
SD Game, Fish, and Parks	Attn: Leslie Petersen	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
SD Game, Fish, and Parks	Attn: John Kirk	523 E. Capitol Avenue	Pierre SD	57501-3182		X		
US Fish & Wildlife Service	Attn: Natalie Gates	420 S. Garfield Avenue, Ste 400	Pierre SD	57501		X		
State Historic Preservation Office	Attn: Paige Hoskinson	900 Governors Drive	Pierre SD	57501-2217		X		
Sioux Falls Bd of Preservation	Attn: Don Seten, Planning Dept	224 W. 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Shannon Ausen*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X	X	
City of Sioux Falls	Attn: Jeff Dunn*	224 W 9th Street	Sioux Falls SD	57104-6407	X &	X	X	X
City of Sioux Falls	Attn: Bob Kappel	4500 N. Sycamore Avenue	Sioux Falls SD	57104		X	X	
City of Sioux Falls	Attn: Doug Johnson, Env Div	4500 N. Sycamore Avenue	Sioux Falls SD	57104				X
City of Sioux Falls	Attn: Kevin Smith	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Sam Trebilcock	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Mark Perry	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Russ Sorenson	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X	X	X
City of Sioux Falls	Attn: Tony Everson*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X	X	
City of Sioux Falls	Attn: Gary Halstead	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Nancy Stanga	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Lyle Johnson*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X	X	
City of Sioux Falls	Attn: Mayor Dave Munson	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Jeff Schmitt*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X	X	
City of Sioux Falls	Attn: Steve Metli*	224 W 9th Street	Sioux Falls SD	57104-6407	X Or	X		
City of Sioux Falls	Attn: Chuck Serbus	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: John Osman	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Kerry Ellis	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Wally Doolittle	224 W 9th Street	Sioux Falls SD	57104-6407		X		
City of Sioux Falls	Attn: Dorothy Franklin, Health	132 N. Dakota Avenue	Sioux Falls SD	57104		X		

MAILING LIST AND ATTENDANCE SHEET FOR STORM WATER BMP MASTER PLAN ON JUNE 18, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Inv	7:00 pm Inv	8:30 a.m. Attend	7:00 p.m. Attend
	Dept							
Parks Department	Attn: Mike Cooper	600 E 7th Street	Sioux Falls SD	57103-1338		X		X
Sioux Falls City Council (8)	Attn: Barb Johnson	235 W. 10th Street	Sioux Falls SD	57104		X		
SD Dept of Transportation	Attn: Craig Smith	5316 W. 60th Street North	Sioux Falls SD	57107		X		
SD Dept of Transportation	Attn: Cary Cleland	5316 W. 60th Street North	Sioux Falls SD	57107		X		
						X		
SECOG	Attn: Austin Eich	1000 N. West Ave, Ste 210	Sioux Falls, SD	57104-1332		X		
SECOG	Attn: Debra Moeller	1000 N. West Ave, Ste 210	Sioux Falls, SD	57104-1332		X		
Minnehaha Co Highway Dept	Attn: Bob Meister	P.O. Box 1364	Sioux Falls SD	57104		X		
Minnehaha Co Highway Dept	Attn: Tom Wilsey	P.O .Box 1364	Sioux Falls SD	57104		X		
Minnehaha Co Planning Office	Attn: David K. Queal, Dir	415 N Dakota Ave	Sioux Falls SD	57104		X		
Minnehaha Co Commission Office	Attn: Ken McFarland	415 N Dakota Ave	Sioux Falls SD	57104		X		
Minnehaha Co Comm Water Corp	Attn: Scott Buss, Exec Dir	47381 248th Street	Dell Rapids SD	57022		X		
Wayne Township	Attn: Sid Walters	46774 266th Street	Sioux Falls SD	57106		X		
Benton Township	Attn: Dale V. Benson	47056 258th Avenue	Sioux Falls SD	57107		X		
Splitrock Township	Attn. John Monahan	7901 E 38th Street	Sioux Falls SD	57110		X		
City of Tea	Attn: Mayor John Lawler	115 W 2nd Street	Tea, SD	57064		X		
City of Brandon	Attn: Mayor Mike Schultz	P.O. Box 95	Brandon, SD	57005-0095		X		
City of Brandon	Attn: Dennis Olson, City Adm	P.O. Box 95	Brandon, SD	57005-0095		X		
City of Harrisburg	Attn: Mayor Jim Aalbers	P.O. Box 26	Harrisburg SD	57032-0026		X		
City of Hartford	Attn: Mayor Patty Siemonsma	P.O. Box 727	Hartford SD	57033-0727		X		
Lincoln Co Planning	Attn: Paul Aslesen, Director	100 E. 5th Street	Canton SD	57013		X		
Lincoln Co Planning	Attn: Jon Peters, GIS Tech	100 E. 5th Street	Canton SD	57013		X		X
Lincoln Co Auditor	Attn: Helen Nelson	100 E. 5th Street	Canton SD	57013		X		
Lincoln Co Commissioners		100 E. 5th Street	Canton SD	57013		X		
Lincoln Co Rural Water	Attn: Dennis Larsen, Mgr	P.O. Box 36	Harrisburg SD	57032		X		
Springdale Township	Attn: Tim Burns	27063 Sycamore Ave	Sioux Falls SD	57108		X		
Springdale Township	Attn: Rich Minder	27049 Revillo Place	Sioux Falls SD	57108		X		X
Springdale Township	Attn: Jerry Lingen	26989 Southeastern	Sioux Falls SD	57108		X		
Springdale Township	Attn: Norman Enger	27260 476th Avenue	Harrisburg SD	57032		X		
Delepre Township	Attn: Jim Poppens	46594 271st Street	Tea SD	57064		X		
Northern Natural Gas Co.	Attn: Mike Garry, Mgr	P.O. Box 336	Harrisburg SD	57032		X		
Williams Pipeline Company	Attn: Tom Barr, Mgr	5300 W. 12th Street	Sioux Falls SD	57107		X		
Developers								
Ronning Enterprises Inc	Attn: Charles A. Point	4401 E 6th Street	Sioux Falls SD	57103-1172		X	X	
Van Buskirk Companies	Attn: Steve Van Buskirk	5101 S Nevada Avenue	Sioux Falls SD	57108		X	X	
Stencil Construction & Develop	Attn: Clint Stencil	4804 S Minnesota	Sioux Falls SD	57108		X		
Dunham Company	Attn: Darla Jorgensen	230 S Phillips Avenue	Sioux Falls SD	57104		X		
Bender Commercial R.E. Svcs	Attn: Ron Nelson	122 S Phillips Avenue	Sioux Falls SD	57104		X		
C-Lemme Custom Homes, L.L.C.	Attn: Dan Lemme	3408 S Sycamore	Sioux Falls SD	57110		X		

MAILING LIST AND ATTENDANCE SHEET FOR STORM WATER BMP MASTER PLAN ON JUNE 18, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Inv	7:00 pm Inv	8:30 a.m. Attend	7:00 p.m. Attend
Candle Development, L.L.C.	Attn: Josh Bartels	5601 S Sundowner Avenue	Sioux Falls SD	57106		X		
Daniels Construction, Inc.	Attn: James Daniels	27160 470th Avenue	Tea SD	57064		X	X	
Paul Fick Homes, Inc.	Attn: Paul Fick*	3909 S Southeastern Ave	Sioux Falls SD	57103	X Or	X	X	
Friessen Construction Co, Inc.	Attn: Patricia Vognild	601 S Marion Rd	Sioux Falls SD	57106		X		
Scott Gilbert Construction Co.	Attn: Scott Gilbert	5200 S Cliff Avenue	Sioux Falls SD	57108		X		
The Grasslands, L.L.C.	Attn: Mark Vellinga	1300 W 57th St. Ste 100	Sioux Falls SD	57108		X		X
Haight Construction	Attn: Rob Haight	27124 Grummand Ave	Tea, SD	57064		X		
Craig Harr Construction	Attn: Craig Harr	7008 E Stoakes Cir.	Sioux Falls SD	57110		X		
G & D Harr Construction, L.L.C.	Attn: Gary Harr	3408 S Sycamore	Sioux Falls SD	57110		X	X	
Lloyd Construction	Attn: Craig Lloyd	3130 W 57th Street	Sioux Falls SD	57108		X		
Masonry Homes, Inc.	Attn: Randy Martens	3012 S Coral Cir.	Sioux Falls SD	57103		X		
Paul Nelson Construction	Attn: Paul Nelson	725 S 9th Avenue	Sioux Falls SD	57104		X		
Otten Construction Inc.	Attn: Herman Otten	601 S Mary	Tea, SD	57064		X		
Ramstad Development	Attn: Cliff Ramstad	702 E 3rd Street	Colton, SD	57018		X		
Mike Schultz Construction, Inc.	Attn: Tim Miller	206 S Main Ave	Sioux Falls SD	57104		X		
Sunset Ridge Development, L.L.C.	Attn: LuAnn Wright	5513 W 61st Street	Sioux Falls SD	57106		X		
Thurman Construction	Attn: Mike Thurman	528 W 29th Street	Sioux Falls SD	57105-0858		X		
Viereck Commercial	Attn: Jan Muilenburg	812 S. Minnesota Avenue	Sioux Falls SD	57104			X	
Infrastructure Review and Advisor Board (IRAB)								
Concrete Materials	Attn: Pat Sweetman	P.O. Box 84140	Sioux Falls SD	57118-4140	X			
Friessen Construction Co, Inc.	Attn: Cindy Monnin	615 S Marion Rd	Sioux Falls SD	57106	X		X	
Goldsmith and Heck	Attn: Mark Wiederrich	400 S. Sycamore, #105-2	Sioux Falls SD	57110	X		X	
JSA Engineers	Attn: Rich Schwanke	3700 S. West Avenue	Sioux Falls SD	57105-6352	X		X	
Runge Enterprises	Attn: Michael Runge	3500 N. Hovland Drive	Sioux Falls SD	57107	X			
Soukup Construction	Attn: James Soukup	221 N Marion Rd	Sioux Falls SD	57107-0501	X		X	
Nybergs Ace Hardware	Attn: Kevin Nyberg	330 W. 41st Street	Sioux Falls SD	57105	X			
Qwest Communications	Attn: Dan Kaiser	125 S Dakota Ave	Sioux Falls SD	57104	X			
Xcel Energy	Attn: Pam Osthus	500 W Russell Street	Sioux Falls SD	57104	X			
General Public								
Notice of Meeting to Argus Leader								
www.bigsioux.com								
TV: Channel 16								
Neighborhood Link: http://www.siouxfalls.org/neighborhoods/								
Pine Lake Hills H.O. Assoc.	Attn. Steve Pederson	601 N. Appaloosa Trail	Sioux Falls SD	57110		X		
Pine Lake Hills	Attn. Doug Derheim, Water Supt.	700 Meadowbrooke Lane	Sioux Falls SD	57110		X		
Pine Hills Homeowners Assoc.	Attn. Warren Oakland, Pres	3205 Keith Lane	Sioux Falls SD	57110		X		
Izaac Walton League		5000 E. Oakview Place	Sioux Falls SD	57110		X		
Sierra Club	Attn: Tracie Weber	231 S. Phillips Avenue	Sioux Falls SD	57104		X		
Northern Prairies Land Trust	Attn: Rachel Brewster, Exec Dir	1905 W. 57th St. #3	Sioux Falls SD	57108		X		
Augustana College	Attn: L Adrien Hannus	2001 S. Summit Avenue	Sioux Falls SD	57197		X		

MAILING LIST AND ATTENDANCE SHEET FOR STORM WATER BMP MASTER PLAN ON JUNE 18, 2003

Owner	Attn, etc.	Owner Address	Owner City	Owner Zip	8:30 am Inv	7:00 pm Inv	8:30 a.m. Attend	7:00 p.m. Attend
HDR	Attn: Dan Graber	600 S. Cliff Ave, Ste 106	Sioux Falls SD	57104		X		X
Dakota Land Survey & Eng.	Attn: Paul Clinton	2000 W. 42nd St, B-6	Sioux Falls SD	57105		X		
Willow Run Golf Course	Attn: Dave Hanten	8000 E. Hwy 42	Sioux Falls SD	57110		X		
Sayre Associates, Inc.	Attn: Steve Quincey	P.O. Box 734	Sioux Falls SD	57101-0734		X	X	
Buzz & Lois Nelson		1504 N. Oak Ridge Place	Sioux Falls SD	57110				X
Tom Hein		6100 E. Hein Place	Sioux Falls SD	57110				X
Schmitz Kalda & Associates	Attn: Kim Buell	320 N Main Ave, Ste A	Sioux Falls SD	57104			X	
Schmidt Engineering Inc.	Attn: Jon Schmidt	401 E 8th St. Ste 200G	Sioux Falls SD	57103			X	

* Also on IRAB

CITY OF SIOUX FALLS
PUBLIC WORKS
AN EQUAL OPPORTUNITY EMPLOYER
224 West Ninth Street, Sioux Falls, SD 57104-6407
Hearing Impaired (605) 367-7039
Web Site: www.siouxfalls.org

Revised Training Date and Time
See Below

June 6, 2003

To: Consultants and Architects

Subject: Chapter 11 Best Management Practices (BMPs) Training

CH2M HILL will present a Best Management Practices (BMPs) design training session on the Engineering Design Standards Chapter 11, Section 8, Best Management Practices. The training session will be geared towards informing City staff as well as the Engineering and Architectural Community about design procedures contained in Chapter 11, Section 8.

During the training session, an overview of the types of BMPs contained within Chapter 11, Section 8 will be provided. Example BMP design procedures will be reviewed with a focus upon commonly implemented BMPs. The training session will also include a summary of the regulatory drivers behind the City's stormwater program and an overview of the City's stormwater regional BMP Master Plan currently under development. I am recommending that you send a representative from your staff to this seminar so that you can have any questions answered pertaining to this type of design.

The training is scheduled as follows:

Date:	**Thursday, June 19, 2003**
Time:	**8:30 a.m. to 12:00 p.m.**
Location:	Kuehn Community Center 2801 S. Valley View Road

If you have any questions, please call me at 367-8665 or e-mail me at jdunn@siouxfalls.org.

Sincerely,

Jeff Dunn, P.E.
Principal Engineer

STORMWATER BMP MASTER PLAN MEETING
Sioux Falls, South Dakota
HRG PROJECT #603250-J

Training List – 6/19/03

Invitation List:

Engineers:

Banner & Associates	Brookings, SD
Clark Engineering Corp.	Sioux Falls, SD
Dakota Land Surveying & Eng Inc.	Sioux Falls, SD
DGR	Rock Rapids, IA
DGR	Sioux Falls, SD
Earth Tech	Minneapolis, MN
Ehrhart Griffin & Associates	Sioux Falls, SD
Goldsmith & Heck Engineers	Sioux Falls, SD
HDR Engineering, Inc.	Omaha, NE
HDR Engineering, Inc.	Sioux Falls, SD
JSA Consulting Engineers	Sioux Falls, SD
KMS Engineering	Sioux Falls, SD
Marshall Engineering, Inc.	Sioux Falls, SD
Sayre Associates, Inc.	Sioux Falls, SD
Schmidt Engineering	Sioux Falls, SD
Schmitz Kalda & Associates	Sioux Falls, SD
Short Elliott Hendrickson, Inc.	St. Paul, MN (on both lists)
Short Elliott Hendrickson, Inc.	Sioux Falls, SD (on both lists)
SRF Consulting Group, Inc.	Minneapolis, MN
Stockwell Engineers, Inc.	Sioux Falls, SD
TSP, Inc.	Sioux Falls, SD
Ulteig Engineers, Inc.	Sioux Falls, SD
Willadsen Lund Engineering Corp	Sioux Falls, SD
Wilsey & Associates	Sioux Falls, SD

Architects:

Architectural Concepts	Sioux Falls, SD
Architecture Automated, Inc.	Sioux Falls, SD
Architecture Incorporated	Sioux Falls, SD
Baldridge Architects & Eng, Inc.	Sioux Falls, SD
Big Muddy Workshop, Inc.	Omaha, NE
Burns & McDonnell	Kansas city, MO
Convention Center Design Group	Minneapolis, MN
Durrant Group, Inc.	Dubuque, IA
Greenberg Farrow Architects	Arlington Heights, IL
Hartman Architecture, Inc.	Sioux Falls, SD
Holman & Associates, Inc.	Sioux Falls, SD
Koch Hazard Baltzer, Ltd	Sioux Falls, SD
Miller Sellers Heroux Arch, Inc.	Sioux Falls, SD
RS Architects	Sioux Falls, SD
Scott Norberg	Sioux Falls, SD
Short Elliott Hendrickson, Inc.	St. Paul, MN (on both lists)
Short Elliott Hendrickson, Inc.	Sioux Falls, SD (on both lists)

Spencer Ruff Associates	Sioux Falls, SD
TSP, Inc.	Sioux Falls, SD (on both lists)
Vande Walle & Associates	Sioux Falls, SD
Visser Architects	Sioux Falls, SD
Winkles Group	Sioux Falls, SD

Attendees:

Engineers:

Clark Engineering Corp.	Sioux Falls, SD	Kevin Goff
		Buster Little
Dakota Land Surveying & Eng Inc.	Sioux Falls, SD	Paul Clinton
		Steve Kor
DGR	Sioux Falls, SD	Leonard Neugebauer
Ehrhart Griffin & Associates	Sioux Falls, SD	Heidi Kiekul
Goldsmith & Heck Engineers	Sioux Falls, SD	Jon Heck
		Mark Wiederrich
HDR Engineering, Inc.	Sioux Falls, SD	T.J.
JSA Consulting Engineers	Sioux Falls, SD	Rich Schwanke
		Orlin Jibben
KMS Engineering	Sioux Falls, SD	Keith Stroh
Sayre Associates, Inc.	Sioux Falls, SD	Suzi Retzlaff
		Thad Roberts
		Paul Korn
Schmitz Kalda & Associates	Sioux Falls, SD	Kim Buell
		Gary Andersh
Short Elliott Hendrickson, Inc.	Sioux Falls, SD	Brian Jensen
		Tanya Tordsen
Stockwell Engineers, Inc.	Sioux Falls, SD	Steve Brockmueller
		Jon Brown
TSP, Inc.	Sioux Falls, SD	Chad Kucker
		Lyle Pudwill
		John Jacobson
Ulteig Engineers, Inc.	Sioux Falls, SD	Shannon Schutz
		Craig Hanisch
Willadsen Lund Engineering	Sioux Falls, SD	Robert Roth
		Eric Willadsen
		John Carr
Wilsey & Associates	Sioux Falls, SD	Bruce Wilsey
		Perry Kolb
City of Sioux Falls	Sioux Falls, SD	Kerry Ellis

Architects:

Winkles Group	Sioux Falls, SD	Bob Winkels

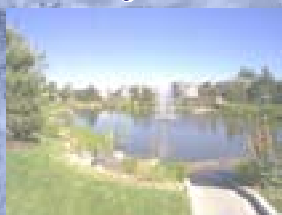
Training Staff:

Jeff Dunn, City of Sioux Falls
Mark Mittag, CH2M Hill
Laurens van der Tak, CH2M Hill
Kyle Hamilton, CH2M Hill

Agenda: BMP Chapter 11 Training

Time	Topic
8:30	Introduction and Regulatory Requirement
8:40	Overview of Chapter 11
8:50	BMP Overview
	Grass Buffer
	Grass Swale
	Water Quality Capture Volume (WQCV)
	Extended Detention Basin
	Constructed Wetlands Channel
	Retention Pond
	Sand Filter Extended Detention Basin
	Porous Landscape Detention
	More Water Quality BMPs
	Constructed Wetlands Basin
	Water Quality Catch Basin
	Bioretention
10:00	Questions
10:15	Break
10:30	Design Example
10:45	Questions
11:00	Case Study Detention
11:20	Case Study Bioretention
11:30	Sioux Falls BMP Master Plan Overview
12:00	End

Best Management Practice Training Seminar



Sioux Falls Chapter 11 Engineering Design Standards

CH2MHILL

Today's Agenda

- Regulatory Background
- Overview of Chapter 11
- Implementation Approach of Best Management Practices (BMPs)
- Discussion of Individual BMPs
- Case Studies
- Master Plan Summary

Stormwater Regulations

- EPA issued Phase I Stormwater Regulations in 1990
  - *Stormwater associated with Industrial Activity including construction sites of 5 acres or more*
  - *Municipal Separate Storm Sewer Systems serving more than 100,000 people*
    - City of Sioux Falls

Municipal Stormwater Permit

- Regulated by the SD DENR
- Sioux Falls' Phase I Municipal Stormwater Permit Issued November 1999
- Goal: Stormwater Pollution Prevention
- "The city of Sioux Falls shall update and implement more comprehensive and detailed planning procedures and enforcement controls to reduce the discharge of pollutants after construction is complete, from areas of new development and significant redevelopment."

Municipal Stormwater Permit Components

- *Maintenance of Structural Controls*
- *New Development and Redevelopment Planning (Commercial Residential Program)*
- *Public Street Maintenance*
- *Herbicide, Pesticide and Fertilizer Program*
- *Illicit Discharge Program*
- *Industrial Facilities Program*
- *Construction Site Program*
- *Facility Runoff Control Program*

Stormwater Management Program

- Commercial Residential Program
  - *Maintenance of Structural and source controls*
  - *Program for Post construction*
  - *Public Street Maintenance*
  - *Inclusion of water quality elements in flood management projects*
  - *Pesticide, Herbicide and Fertilizer Control Program*

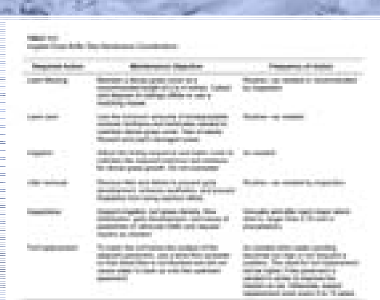
Chapter 11 Overview

- 11.8 Section of Sioux Falls revised Chapter 11 Design Standards Best Management Practices
  - *Text description of each BMP*
  - *All Tables and Figures for Chapter 11 located in the back of the document*
  - *New version to be issued*

Information on Each BMP in Chapter 11

- Design Considerations
- Design Procedure and Criteria
- Design Example
- Maintenance Recommendations (in Tables located in back of document)
- BMP Figure (Figures are located in back)
- Design Forms (Forms are located in back)

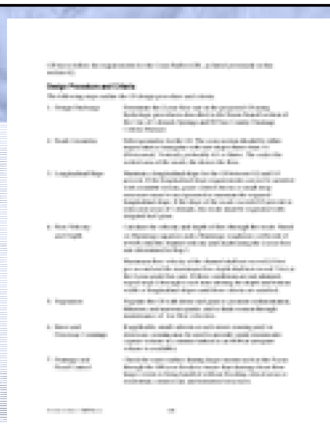
Example of Maintenance Recommendations



Design Examples and Spreadsheet Tool

- Each WQCV BMP has a design example
- Example Design Forms are located among the Figures, and consist of screen captures of the spreadsheet tool
- Blank Design Forms are located after the Figures in Chapter 11
- These are taken from the spreadsheet tool, which aids in the design of BMPs

Design Procedure



Design Form

Sioux Falls Stormwater Management Process

Two Step Process

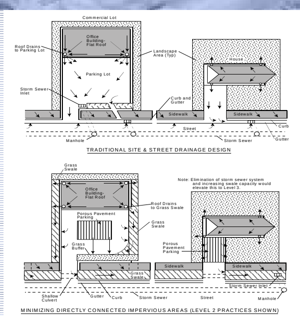
- Step 1 - Employ runoff reduction practices
- Step 2 - Provide Water Quality Capture Volume (WQCV)

Step 1 - Employ Runoff Reduction Practices

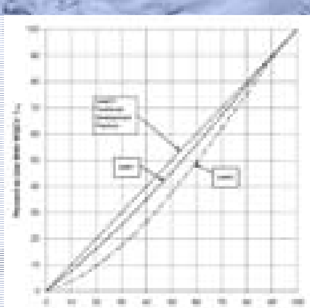
- Minimizing Directly Connected Impervious Areas (MDCIA)
  - *Level 1. Impervious surfaces drain over grass buffers*
  - *Level 2. Grass swales replace curb and gutter and reduce storm sewers*

Benefits of Reducing Imperviousness

- Increased infiltration and decreased runoff
- Decreased WQCV
- Decreased 2- and 5-year runoff
- Reduced storm sewers
- Decreased pavement



Imperviousness to Use With WQCV



Step 1 - Employ Runoff Reduction Practices: Suggested BMPs

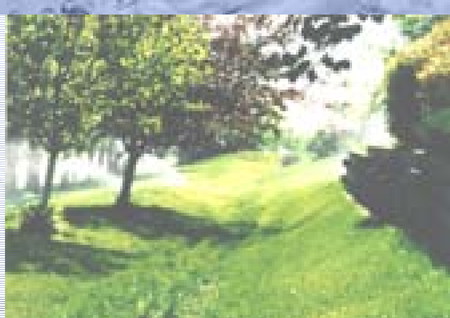
- *Reduced Pavement Area*
- *Grass Buffers*
- *Grass Swales*

Grass Buffer

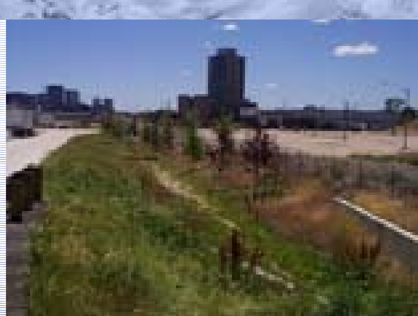
Grass Buffer

Grass Buffer

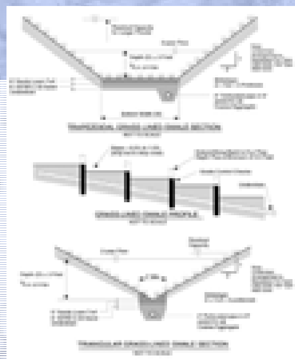
Grass Swale



Grass Swale



Grass Swale



Implementing Step 2 - Provide Water Quality Capture Volume

- Intent of the Storm Capture
- Types of Facilities
- Guidance for selection of WQCV facilities
- Incorporating WQCV into Detention Basins.

Intent of the Water Quality Capture Volume

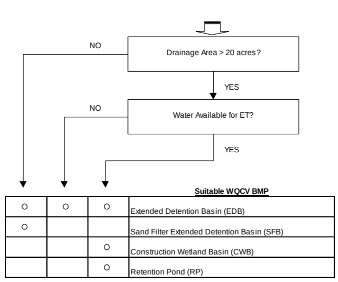
- Provide for physical settling of pollutants and those absorbed to sediments
- Provide for infiltration, biological uptake or absorption of pollutants

Factors Involved in BMP Evaluation

- What Pollutants Are to Be Controlled
- Effectiveness of BMPs
- Reliability/sustainability
- Implementation Cost
- Maintenance Costs
- Public Acceptability
- Risk Liability

Selecting a WQCV BMP

- *Drainage Area*
- *Permanent Pool*
- *Filtration / Infiltration*
- *Vegetation*

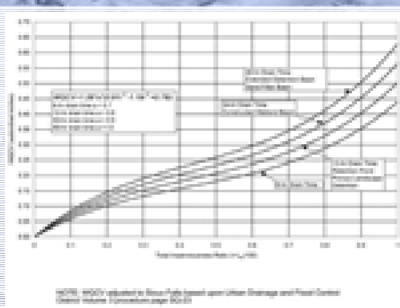


Note: Large drainage areas may be subdivided into areas < 20 acres for use of SFB.

WQCV Facilities

- Provide treatment for a specific volume (80th percentile storm)
- Detention periods 12 to 40 hours

WQCV



Locating WQCV Facilities

- Locations determined as part of a Master Plan
  - *Drainage Basin Planning Study*
  - *Master Development Drainage Plan*
- Site Specific
  - *Onstream or Offstream*
  - *Located downstream of development but prior to state waters*

Onstream vs. Offstream

Onstream

- Single BMP can treat both onsite and offsite
- Designed for entire upstream watershed

Onstream vs. Offstream

Offstream

- Multiple BMPs may be required
- No treatment of offsite areas

Water Quality Capture Volume BMPs

- Extended Detention Basin
- Constructed Wetland Basin
- Retention Pond
- Sand Filter Extended Detention Basin
- Porous Landscape Detention

Removal Efficiencies

Type of BMP	(1)	TSS	TP	TN	TZ	TPb	BOD	Bacteria
Grass Buffer	LRR:	10-50	0-30	0-10	0-10	N/A	N/A	N/A
	EPR	**10-20**	**0-10**	**0-10**	**0-10**	N/A	N/A	N/A
Grass Swale	LRR:	20-60	0-40	0-30	0-40	N/A	N/A	N/A
	EPR	**20-40**	**0-15**	**0-15**	**0-20**	N/A	N/A	N/A
Porous Landscape Detention	LRR:	8-96	5-92	-100-85	10-98	60-90	60-80	N/A
	EPR	**70-90**	**40-55**	**20-55**	**50-80**	**60-80**	N/A	N/A
Extended Detention Basin	LRR:	50-70	10-20	10-20	30-60	75-90	N/A	50-90
	EPR	**55-75**	**45-55**	**10-20**	**30-60**	**55-80**	N/A	N/A
Constructed Wetland Basin	LRR:	40-94	-4-90	21	-29-82	27-94	18	N/A
	EPR	**50-60**	**40-80**	**20-50**	**30-60**	**40-80**	N/A	N/A
Retention Pond	LRR:	70-91	0-79	0-80	0-71	9-95	0-69	N/A
	EPR	**80-90**	**45-70**	**20-60**	**20-60**	**60-80**	N/A	N/A
Sand Filter Extended Detention	LRR:	8-96	5-92	-129-84	10-98	60-80	60-80	N/A
	EPR	**80-90**	**45-55**	**35-55**	**50-80**	**60-80**	**60-80**	N/A
Constructed Wetland Channel*	LRR:	20-60	0-40	0-30	0-40	N/A	N/A	N/A
	EPR	**30-50**	**20-40**	**10-30**	**20-40**	**20-40**	N/A	N/A

Extended Detention Basin

- Sedimentation basin designed to drain dry
- Most common BMP
- Approximately 0.5 to 2 % of total tributary area
- Pollutant removal is moderate to high, depending on drainage time
- Nutrient removal can be obtained by the inclusion of shallow pool or wetlands
- Can be used as a construction BMP

Extended Detention Basin

- Multi stages may be necessary to avoid a pond with a muddy bottom.
- Design volume is based on a storage volume equal to 120 % of WQCV based on a 40 hour drain time.
- May need to include flood control volume
- Repairs may be necessary on inlets, forebays, etc.
- Cleaning of drainage structures and removal of sediment necessary to ensure capacity.

Extended Detention Basin

Constructed Wetland Basin

Constructed Wetlands Basin

- Shallow basin with a base flow and vegetated by rushes, willows, cattails, etc.
- Treatment provided through sedimentation, filtering, and biological uptake
- Can be used by itself or added to another BMP
- Must ensure a permanent base flow exists
- Removals are highly dependent on maintenance.
  - *Metals, sediment, organic matter - moderate to high*
  - *Phosphorus - Low to high*
  - *Nitrogen - 0 to moderate*

Constructed Wetlands Basin

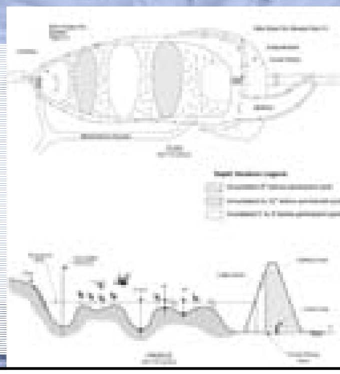
- Surcharge Volume based on WQCV with a 24 hour drain time
- Wetland pool is at least 75% of WQCV
- Maximum depth is 2 feet
- Periodic removal of sediments and plant growth is suggested

Wetland Design

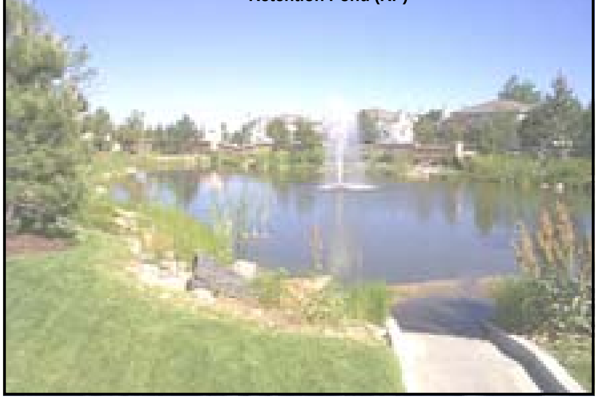
Components	Percent of Permanent Pool Surface Area	Water Design Depth
Forebay, outlet and free water surface areas	30% to 50%	2 to 4 feet deep
Wetland zones with emergent vegetation	50% to 70%	6 to 12 inches deep*

*One-third to one-half of this zone should be 6 inches deep.

Constructed Wetlands Basin



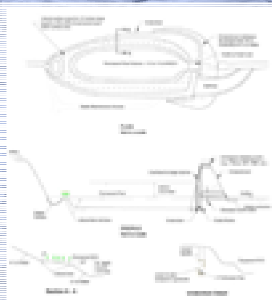
Retention Pond (RP)



Retention Pond

- Sedimentation pond with a permanent pool.
- Provides recreation, aesthetics and open space opportunities.
- Pollutant removal is moderate to high for particulate. Some nutrient removal and biological uptake.
- Basin volume is equal to the WQCV plus the permanent pool. Assumes a 12 hour drain time
- Land requirements are typically 0.5 to 2 % of the tributary watershed area.
- Maintenance requires periodic removal of sediments, structural repairs.

Retention Pond



Sand Filter Extended Detention Basin (SFB)

Sand Filter Extended Detention Basin

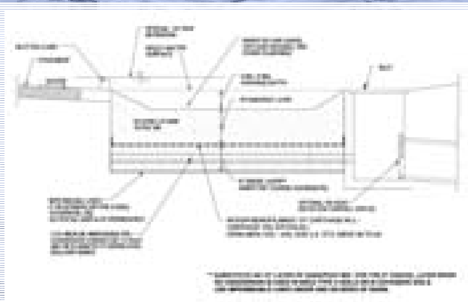
- Filter that consists of a storage zone under lain by sand bed and underdrain system
- Should not be used during construction
- Removal rates should be significant
- Design volume is based on a storage volume equal to WQCV based on a 40 hour drain time
- Filter surface is equal to the storage volume divided by three
- Requires periodic removal of top 3 inches of sand filter (2-5 years)

Sand Filter Extended Detention Basin

Porous Landscape Detention

- Low lying vegetated area over a sand bed with an underdrain
- Ideal for small areas.
- Pollutant removal rates should be significant, similar to sand filter
- Design based on the WQCV with a 12 hour drain time.
- Will require periodic removal of upper layers including vegetation to ensure infiltration rates.

Porous Landscape Detention



More Water Quality BMPs

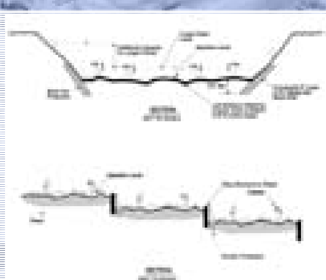
- Constructed Wetlands Channel
- Bioretention
- Water Quality Catch Basins

Constructed Wetlands Channel

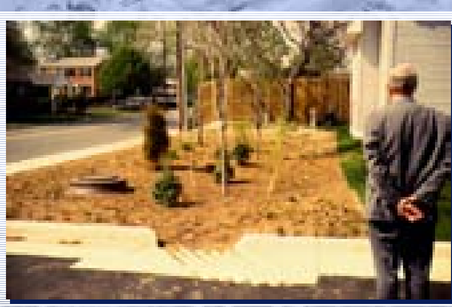
Constructed Wetlands Channel

- Channel with a wetland bottom
- Slows down runoff to allow settling and biological uptake
- Can be used by itself or added to another BMP
- Pollutant Removals similar to Wetland Basins
- Design is based on a 2 year flow rate at 2 fps with a channel depth of 2 to 4 inches

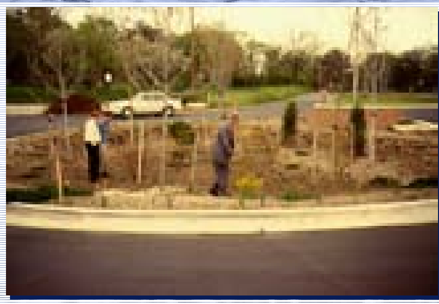
Constructed Wetlands Channel



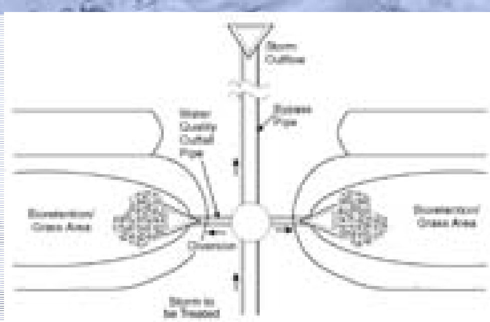
Bioretention



Bioretention

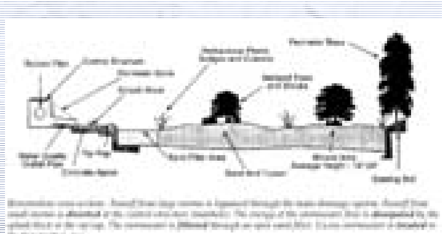


Bioretention

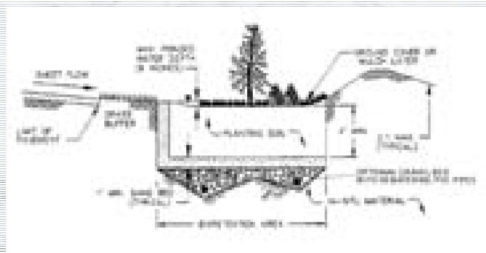


Bioretention Cross Section:

Runoff from large storms is bypassed through the main drainage system. Runoff from small storms is diverted at the control structure (manhole). The energy of the stormwater flow is dissipated by the splash block or the rip rap. The stormwater is filtered through an open sand filter. Excess stormwater is treated in the bioretention area.



Bioretention



Bioretention Applications

- Where can the BMP be used?
- Residential and nonresidential development
  - *Median strips* - *Parking lot islands*
  - *Ramps* - *Common areas*
  - *Loops* - *Swales*
- Sources of runoff
  - *Overland flow*
  - *Flow diversions*
- Facilities located as close as possible to the source

Bioretention Guidelines

- BMP area 5-10% of impervious area
- Water table should be >6’ below BMP
- Permeable soils—use collector pipes

Bioretention Design Considerations

- Discuss design considerations
  - *Soils*
  - *Area required*
  - *Drainage area*
  - *Water availability*
  - *Flow velocity*
  - *Vegetation*
  - *Aesthetics*

Water Quality Catch Basin

Water Quality Catch Basin

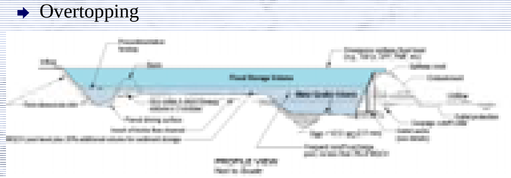
- Act as pretreatment for other treatment practices by capturing large sediments
- Catch Basin inserts for new development and retrofits at existing sites may be preferred in urbanized areas where land is limited
- Optimal sizing of catch basin:
  - *Diameter of catch basin equal to 4 times outlet pipe diameter*
  - *Sump depth at least 4 times outlet pipe diameter*
  - *Top of outlet pipe at least 1.5 times outlet pipe diameter from the bottom of the inlet grate*

Incorporating WQCV into Stormwater Quantity Detention

- Water Quality - Full WQCV
- 5-year Storm- Full WQCV plus match 5-year storm peak flow
- 100-Year Storm - Full WQCV plus match 100-year storm peak flow

Design Criteria and Things to Consider

- Water Quality Volume from Engineering Design Standards
- 5-year and 100-year peak flow control (match pre-development flow rate)
- Maintenance Access
- Overtopping

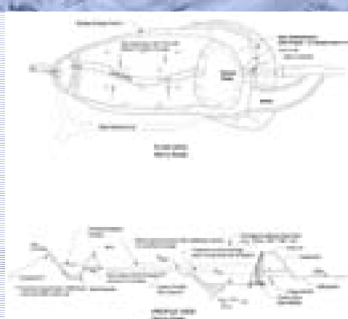


Questions?

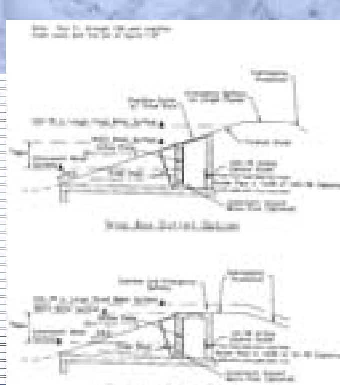
Design Example

- Conditions
  - *10 acre site*
  - *Commercial property*
    - Percent Impervious = 95% (Table 11.1)
  - *Small site, no baseflow or groundwater*
  - *WQ, 5-yr, and 100-yr control required*
  - *Extended Detention Basin chosen*

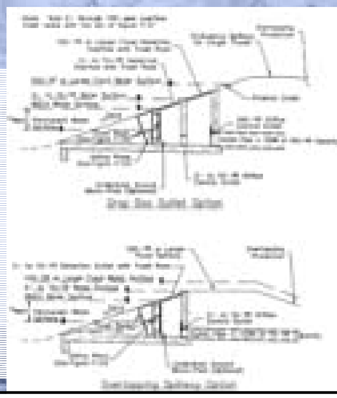
Extended Detention Basin



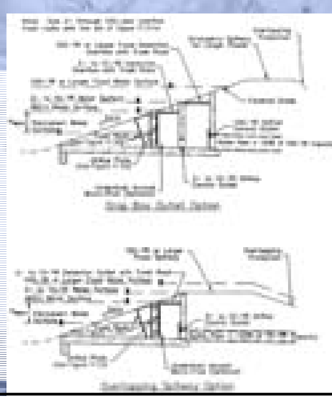
Outlet Structure Configuration: 2-stage



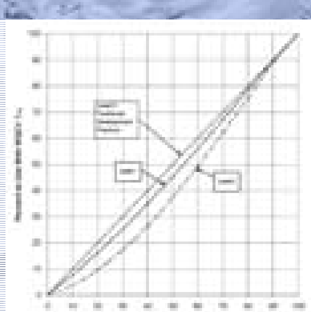
Outlet Structure Configuration: Sloped 3-stage



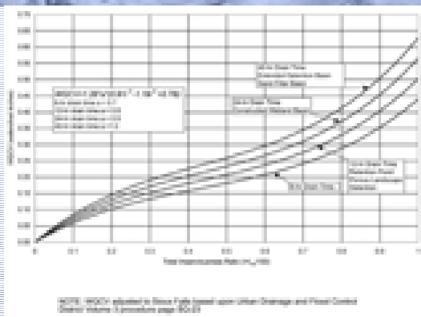
Outlet Structure Configuration: Flat top 3-stage



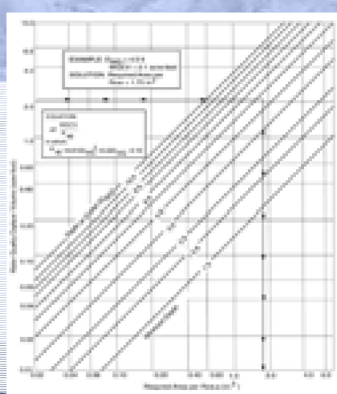
WQCV Imperviousness



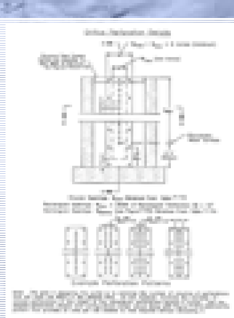
WQCV (Watershed Inches)



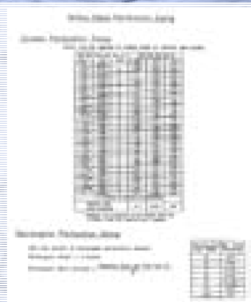
Orifice Plate Area per Row



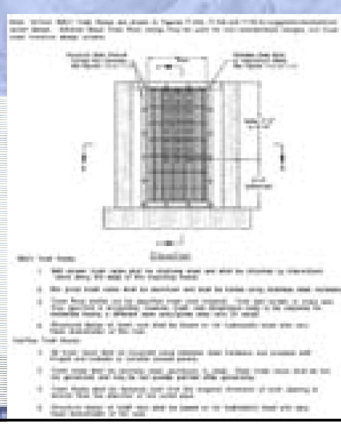
Orifice Hole Options



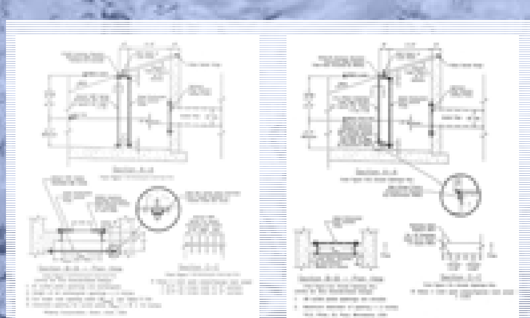
Orifice Hole Sizing



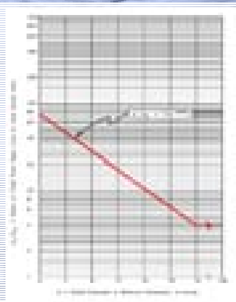
Trash Rack



Trash Rack Configurations



Trash Rack Sizing



Trash Rack Width

TABLE 11.13A

Standardized WQCV Outlet Design Using Circular Openings (2" diameter maximum). Minimum Width ($W_{conc.}$) of Concrete Opening for a Well-Screen-Type Trash Rack. Requires minimum water depth below lowest perforation of 2' 4". See Figure 11.50b for Explanation of Terms.

Maximum Dia. of Circular Opening (in.)	Width of Trash Rack Opening ($W_{conc.}$) Per Column of Holes as a Function of Water Depth H					
	H=2.0'	H=3.0'	H=4.0'	H=5.0'	H=6.0'	Maximum Number of Columns
= 0.25	3 in.	3 in.	3 in.	3 in.	3 in.	14
= 0.50	3 in.	3 in.	3 in.	3 in.	3 in.	14
= 0.75	3 in.	6 in.	6 in.	6 in.	6 in.	7
= 1.00	6 in.	9 in.	9 in.	9 in.	9 in.	4
= 1.25	9 in.	12 in.	12 in.	12 in.	15 in.	2
= 1.50	12 in.	15 in.	18 in.	18 in.	18 in.	2
= 1.75	18 in.	21 in.	21 in.	24 in.	24 in.	1
= 2.00	21 in.	24 in.	27 in.	30 in.	30 in.	1

Trash Rack Sizing

TABLE 11.13B

Standardized WQCV Outlet Design Using 2" Diameter Circular Openings. US Filter™ Stainless Steel Well-Screen* (or equal) Trash Rack Design Specification.

Max. Width of Opening	Screen #93 VEE Wire Slot Opening	Support Rod Type	Support Rod, On-Center Spacing	Total Screen Thickness	Carbon Steel Frame Type
9"	0.139	#156 VEE	3/4"	0.31"	3/8" × 1.0" flat bar
18"	0.139	TE .074" × .50"	1"	0.655"	3/4" × 1.0 angle
24"	0.139	TE .074" ×.75"	1"	1.03"	1.0" × 1½" angle
27"	0.139	TE .074" × .75"	1"	1.03"	1.0" x 1½" angle
30"	0.139	TE .074" × 1.0"	1"	1.155"	1¼" x ½" angle
36"	0.139	TE .074" × 1.0"	1"	1.155"	1¼" x 1½" angle
42"	0.139	TE .105" × 1.0"	1"	1.155"	1¼" x 1½" angle

*US Filter, St. Paul, Minnesota, USA

Design Forms

Additional Design Considerations

- Regulatory Requirements
  - *Water Quality*
  - *Detention (5-yr, 100-yr)*
  - *Peak Discharge Matching*
  - *Dam size, impoundment*
  - *Water rights*
  - *Wetlands*
  - *T&E Species*
  - *Floodplain*
  - *Permitting*

Additional Design Considerations

- Site
  - *Minimize disturbance, excavation*
  - *Access*
  - *Safety*
- Utilities
  - *Relocation vs. constraint*
  - *Crossings*
  - *Modification*

Additional Design Considerations

- Stormwater/Groundwater
  - *Pond bottom condition*
  - *Side slope stability*
  - *Vegetation*
  - *Access*
- Outlet Structures
  - *Hydraulic controls: Inlet, outlet, weir, trash rack*
  - *Combined or separate structures*
  - *Feasible construction*

Additional Design Considerations

- Maintenance
  - *Debris removal*
  - *Water control, bypass*
  - *Equipment access*
  - *Waste area*
  - *Valves, gates, mechanical devices*
  - *Vegetation damage*

Questions?

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Designer: ______________________

Company: ______________________

Date: ______________________

Project: ______________________

Location: ______________________

1. Basin Storage Volume	
A) Tributary Area's Imperviousness Ratio ($i = I_a / 100$)	I_a = ______ % i = ______
B) Contributing Watershed Area (Area)	Area = ______ acres
C) Water Quality Capture Volume (WQCV) ($WQCV = 1.26 * 1.0 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I)$)	WQCV = ______ watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area * 1.2	Vol = ______ acre-feet
2. Outlet Works	
A) Outlet Type (Check One)	______ Orifice Plate ______ Perforated Riser Pipe ______ Other: ______
B) Depth at Outlet Above Lowest Perforation (H)	H = ______ feet
C) Required Maximum Outlet Area per Row, (A_o)	A_o = ______ square inches
D) Perforation Dimensions **(enter one only)**: i) Circular Perforation Diameter **OR** ii) 2" Height Rectangular Perforation Width	D = ______ inches, **OR** W = ______ inches
E) Number of Columns (nc, See Table 11.13a For Maximum)	nc = ______ number
F) Actual Design Outlet Area per Row (A_o)	A_o = ______ square inches
G) Number of Rows (nr)	nr = ______ number
H) Total Outlet Area (A_{ot})	A_{ot} = ______ square inches
3. Trash Rack	
A) Needed Open Area: $A_t = 0.5 * (\text{Figure 11.57 Value}) * A_{ot}$	A_t = ______ square inches
B) Type of Outlet Opening (Check One)	______ ≤ 2" Diameter **Round** ______ 2" High **Rectangular** ______ Other: ______
C) For 2", or Smaller, **Round Opening** (Ref.: Figure 11.50b):	
i) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 11.13a	W_{conc} = ______ inches
ii) Height of Trash Rack Screen (H_{TR})	H_{TR} = ______ inches

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Designer: ______
Company: ______
Date: ______
Project: ______
Location: ______

iii) Type of Screen (Based on Depth H), Describe if "Other"	______ S.S. #93 VEE Wire (US Filter) ______ Other: ______
iv) Screen Opening Slot Dimension, Describe if "Other"	______ 0.139" (US Filter) ______ Other: ______
v) Spacing of Support Rod (O.C.) Type and Size of Support Rod (Ref.: Table 11.13b)	______ inches ______
vi) Type and Size of Holding Frame (Ref.: Table 11.13b)	______
D) For 2" High **Rectangular Opening** (Refer to Figure 11.50a):	
I) Width of Rectangular Opening (W)	W = ______ inches
ii) Width of Perforated Plate Opening (W_{conc} = W + 12")	W_{conc} = ______ inches
iii) Width of Trashrack Opening ($W_{opening}$) from Table 11.14a	$W_{opening}$ = ______ inches
iv) Height of Trash Rack Screen (H_{TR})	H_{TR} = ______ inches
v) Type of Screen (based on depth H) (Describe if "Other")	______ Klemp^IM KPP Series Aluminum ______ Other: ______
vi) Cross-bar Spacing (Based on Table 11.14a, Klemp^IM KPP Grating). Describe if "Other"	______ inches ______ Other: ______
vii) Minimum Bearing Bar Size (Klemp^IM Series, Table 11.14b) (Based on depth of WQCV surcharge)	______
4. Detention Basin length to width ratio	______ (L/W)
5 Pre-sedimentation Forebay Basin - Enter design values	
A) Volume (no less than 5% of Design Volume from 1D)	______ acre-feet
B) Surface Area	______ acres
C) Connector Pipe Diameter (Size to drain this volume in 5-minutes under inlet control)	______ inches
D) Paved/Hard Bottom and Sides	______ yes/no

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Designer: ______________________________

Company: ______________________________

Date: ______________________________

Project: ______________________________

Location: ______________________________

6. Two-Stage Design - See Figure 11.51	
A) Top Stage (Depth D_{WQ} = 2' Minimum)	D_{WQ} = ________ feet Storage= ________ acre-feet
B) Bottom Stage Depth (D_{BS} = 1.0' Minimum, 2.0' Maximum) Bottom Stage Storage (no less than 3% of Design Volume from 1D)	D_{BS} = ________ feet Storage= ________ acre-feet Surf. Area= ________ acres
C) Micro Pool (Minimum Depth = the Larger of 0.5 * Top Stage Depth or 2.5 Feet)	Depth= ________ feet Storage= ________ acre-feet Surf. Area= ________ acres
D) Total Volume: Vol_{tot} = Storage from 5A + 6A + 6B (Must be greater than the Design Volume in 1D.)	Vol_{tot} = ________ acre-feet
7. Basin Side Slopes (Z, horizontal distance per unit vertical) Minimum Z = 4, Flatter Preferred	Z = ________ (horizontal/vertical)
8. Dam Embankment Side Slopes (Z, horizontal distance) per unit vertical) Minimum Z = 3, Flatter Preferred	Z = ________ (horizontal/vertical)
9. Vegetation (Check the method or describe "Other")	________ Native Grass ________ Irrigated Turf Grass ________ Other: ________________

Notes: ______________________________

BMP Master Plan Stormwater Document Review

PREPARED FOR: City of Sioux Falls

PREPARED BY: Kyle Hamilton/CH2M HILL

COPIES: CH2M HILL File
Laurens van der Tak/CH2M HILL
Mark Mittag/CH2M HILL

DATE: February 10, 2003

This technical memorandum summarizes the stormwater document review performed by CH2M HILL. CH2M HILL reviewed the stormwater documents contained in the City Engineering room on January 29, 2002. The document review was performed in order for the project team to become familiar with the work previously performed for the City and to determine which information could be used and built upon in the BMP Master Plan study. The City provided a plan view map to CH2M HILL showing aerial photography, stormwater basin boundaries, and stormwater basin identification numbers that was used to focus the storm drainage study document review effort on 2015 growth areas.

Drainage Reports

A detailed review of the City's drainage reports was determined to not be necessary during the scoping phase of this project. The review focused on stormwater basins that are entirely or partially contained within the 2015 growth area. General information regarding basin boundaries, basin characteristics, hydrologic modeling approaches and parameters, proposed improvements and other relevant data were reviewed. Information obtained for each report is summarized in the Table 1. Table 1 is not meant to be a comprehensive summary of relevant data, but provides guidance to our modeling teams on where to find useful data.

Information from the previous reports will be used wherever applicable and feasible. This information may include subbasin boundary delineation, site characteristics, conveyance component characteristics, outlet structure characteristics, and other relevant information. Each of the significant reports pertaining to this study were copied and will be provided to the appropriate modeling team member for use during this study.

Detention Pond Drawings

Construction drawings were obtained for existing detention ponds. It is assumed that the drawing information is representative of the constructed conditions. Construction drawing information was not available for all previously constructed ponds. Where data for existing detention ponds were not available, the modeling team will generate stage-storage-discharge curves based on information available in the City's drainage reports or included in the City's storm drainage GIS layer. When no data are available, the modeling team will approximate the stage-storage-discharge curves. Each of the drawings provided by the City were copied and will be provided to the appropriate modeling team member for use during this study.

Data Not Taken from Previous Reports

Data that has recently been obtained by CH2M HILL from the City will be used in this study, as it is assumed this information is more accurate than information in previous reports or other documentation. This information includes existing land use information based on the GIS zoning layer, the 2015 future land use GIS layer (latest submittal to CH2M HILL from the City), hydrologic soils group information from the USDA SSURGO website, and the future major road crossings GIS layer.

TABLE 1

Drainage Study and BMP Design Document Review Summary

DOC NO.	TITLE	AUTHOR	DATE	TYPE OF DOC	WATERSHEDS MODELED (stream, basins, area)	MODEL METHODS (loss rate, hydrograph, routing)	MODEL DATA (Tc, CN, routing, ponds, etc.)	Proposed Improvements (Type, Size, Location)	Misc
1	Preliminary Design and Updated Study for Drainage Improvements within Subbasins M1-M4 - Drainage basin No. 6, a Supplement to the Industrial Park Area Drainage Study	Sayre & Associates	Apr-01			None referenced	5-yr & 100-yr Q's Capacity analysis No model output	Detention	Basins in A1 drain west and are addressed.
1	East 54th Street North Drainage Study, Cliff Avenue to Lewis Avenue	Sayre & Associates	Jun-98		1A area that flows west shown 6 subbasins	None referenced	5-yr, 100-yr Q's Existing & full development	Street improvements. Detention options, flow alignment options, and cost shown.	
1	North 4th Avenue Drainage Study. Sioux Empire Development Park Three Addition	Sayre & Associates	May-01		Area west of 4th Avenue. Flows west to Big Sioux. Diversion channels.	None referenced	Q's, WSELs, Volumes	Three alternatives - storm sewer changes to address street flooding - ponding considered, cost est.	Wetlands upstream of 69th
1 & 1A	Northeast Area Drainage Study Includes:	DGR and Assoc.	May-90		I-90 to 34th, Cliff Avenue to I229, Southeast of I229 upstream of Benson Road - west area - Basin 1 & 1A - east area - Basin 1A & 1		5-yr, 100-yr Q's Existing & full development	5 ponds: Q's, WSELs, volumes, grading plans	
1 & 1A	Supplement to Northeast Drainage Study East Watershed Subareas 4 & 5	Sayre & Associates	Apr-95		Southern portion of 1A	Pennsylvania state urban hydrology. Model incorporates TR-55	5, 25, 100-yr using 24-hr storm Areas, Q's, etc.	Storm sewers and ponds, worked with developers - cost estimates	
1 & 1A	Industrial Park Area Drainage Study	Sayre & Associates	Feb-94		1,648 acres		Soils, rainfall, etc. Some Qs	Detention	
4A	Sycamore East/Capitol Hills/Wildflower Drainage Study	Sayre Assoc., Inc.	Mar-02	Update to 3 previous studies	This area is developed except for NE corner of 4A. 4 subbasins - 37 to 305 acres	Used Haestad methods	Tc,CN not stated. Pond volumes, Q's, WSELs, and culvert info. Detention per basin: 8 to 46 af	Future ponds B&D: need WQ, which is addressed. Pond A: construction plan is included. Has inventory of existing components.	
7	Preliminary Engineering Study Stormwater Drainage Tributary Spring Creek Watershed	Stockwell Engineers, Inc.	Jan-90		2,280 acres, 17 subbasins - 45 acres to 301 acres	SCS, Type II Dist with 24-hr, TR-55 for CN, tc, & routing but storage not acct. for. Pond-2, Version 4.10 to get hydrograph composite.	USGS USDA soils info for Minnehaha County and Lincoln County. 5, 10, 25, 100-yr, existing and future, pond-2 output, rating curves for outlets, TR-55 hydrograph summary table with CN, tc, raw, peak Q for 24-hour duration.	Inventory of components. Capacity of culverts discussed. Improvements needed.	Mostly undev. Some minor storms systems. Future only assumes development north of 57th. Cost estimates.
7	Attachment to 7	57th and Bahnson Area Drainage Study	1989	Updated			C's, I's, Q's, areas, some soil info, IDF used.	Ponds info shown.	Majority not part of 2015.
8	Preliminary Design Report 57th/Cliff Detention Pond	DeWild Grant Reckert and Assoc. Co. (DGR)	24-Mar-87		184 acres.	24 hour SCS Type II distribution.	Existing and future: 2, 5, 10, 25, 50, 100 Rating curve, max vol = 40 af, 14 acres, Basin map, no model Data: CN, tc, etc.	Maintain 5 & 100-yr Qs, existing and future, Outlet structure schematic is included - 2-stage Incl. Q's, WSEL, cost.	
10A	Drainage Study 1990 Phase of Prairie Tree Addition	Sayre & Associates	Jun-90		1,100 acres - 5 subbasins	TR55	5-yr, 100-yr Qp Cn	Modified design of ponds D&E	
10A?	Prairie Tree Drainage Study	Howard R. Green Com	Nov-92		9 basins	TR-20 TR-55 for CN, Tc, n values for channel flow given.	Detailed CN, Tc output from TR55 TR20 input & output See Exhibit 1	4 extended detention ponds plus road improvements	Sheet flow 300' to 200' n=.017 to 0.15, n=.06 Whole section on WQBMPs
11	Drainage Study Prairie View Watershed	DGR	1987	Master Plan	3,320 acres 12 subbasins	TR55	CN = 70 Tc = 4.5 hours	12 ponds - 60 to 690 ac drainage area: 6 to 64 af	

TABLE 1

Drainage Study and BMP Design Document Review Summary

DOC NO.	TITLE	AUTHOR	DATE	TYPE OF DOC	WATERSHEDS MODELED (stream, basins, area)	MODEL METHODS (loss rate, hydrograph, routing)	MODEL DATA (Tc, CN, routing, ponds, etc.)	Proposed Improvements (Type, Size, Location)	Misc
11A	Preliminary Engineering Report Sundown Estates Drainage Improvements	DGR	1997	Preliminary Engineering Report	360 acres (basin 12A)	TR55	Not available	42.5 af	Existing inventory
11B	Master Plan for Drainage 57th/Sertoma Drainage Basin	DGR	Oct-02	Master Plan	318 acres	SCS		1 detention pond	Lots of high air potential pocket wetlands - mentions possible BMP retrofit
13	Stormwater Drainage Silver Creek Watershed	Storkwell Engineers	Aug-89		2,000 acres - 13 subbasins	TR55	5-, 10-, 25-, 100-year Qp No data	Two detention ponds on school property - 10.5 af / 47 af (see Figures 7 and 8)	Largely agricultural zoning
13	Drainage Analysis of Silver Creek Watershed Upstream of Proposed 26th Street		Jul-97	Update	3 subbasins 96 acres		Tc in EDSC Model Printouts		
13A	Stormwater Management for Prairie Highlands Addition		Jun-90	Update		TR55 and Pond-2			
32d	Master Plan for Drainage Cherry Creek Drainage Basin (South Tributary of Skunk Creek)	DGR	Jun-01		4 basins ranging from 2,300 to 11,500 acres Estimate 20 tributary subbasins, but not modeled	SCS	5-, 10-, and 100-year Qp	No detention - use "floodplain management" approach	Structure inventory in electronic format and AutoCad
14	Master plan for Drainage Northwest Drainage Basin Sioux Falls, SD	DeWild Grant Reckert and Assoc. Co. (DGR)	Mar-98	Master plan	9933 ac watershed including 3898 ac growth - 7 analysis points - ~60 tributaries not modeled or delineated	SCS compared to SDDOT and regional equations for SD (USGS, 1974, 1980, Draft 1997) and Iowa - HEC-RAS	100-year dev. & undev. - 5 yr Precip = 25"/year, soil inf. 3.33", precip int index = 1.15", slope 4%, RCN = 73, 3.50" - 5 yr, 5.95" - 100 yr (24 hr Type II) - SCS unit hydrograph - no model data given.	3 road crossings to pass 100-yr without overtopping - no delineation on mainline drainageway.	Field inv. of drainage (AutoCad) Wetlands ownership cross-section @ 2000'. Greenway proposed along drainageway based on floodway. Main output is floodplain and floodway and proposed bridges and culverts.
14	Addendum No. 1 (included in 14 above)		Jan-98	Master plan update					
15	Drainage System in Hovland Watershed	DGR	Jul-85	Master plan update			Pond elevation - area - volume data	8.5 af detention was proposed	
15	Drainage Study of the Proposed Louise/I229 Interchange	DGR	Sep-90	Master plan update	About 12 (sec corr in Appendix 60 - 3,200 acres)			Five detention ponds proposed	
16	Sencore Drive Area Drainage Basin	Wright Water Engrs & Sayre & Assoc	Sep-90		66 acres - north portion in 2015 and flows to east	Penn St Urban hydrology, model with TR-55, Muskingum channel routing, modified puls routing - rainfall - tech paper 40, NWS	5, 10, 100-yr for 24-hr event	Detention, outlet structure, storm sewer, Detention improvements.	
22	Aspen Hills/Richmond Estates Drainage Study	DeWild Grant Reckert and Assoc. Co. (DGR)	Sep-92		4 basins, 5 & 100-year, existing & future 6 to 47 acres, analyze capacity of culverts to pass 5- & 100-year flow - basin A-1 is the undev area.	TR-55	Not stated Pond volume and Q's stated.	Inventory of existing components - survey sheets included. 1 pond - det and sed control for basin A-1, just upstream of Dubuque Area.	Find exhibit.

TABLE 1
Drainage Study and BMP Design Document Review Summary

DOC NO.	TITLE	AUTHOR	DATE	TYPE OF DOC	WATERSHEDS MODELED (stream, basins, area)	MODEL METHODS (loss rate, hydrograph, routing)	MODEL DATA (Tc, CN, routing, ponds, etc.)	Proposed Improvements (Type, Size, Location)	Misc
25	Mystic Meadows Drainage Basin Engineering Report	ISA Consulting Engineers/Land Surveyors, Inc.	Feb-93	No previous studies this is a master plan for dev.	1,307 acres, existing and future - 5,10, 100 Culverts modeled. 4 basins A, B, C upstream of Pine Lake - "D" d/s of Pine Lake, all flow to SE corner - field inspected.	Maintain 100-year Q Urban hydrology for small watersheds, U.S. Dept of Ag & TR-55 engineering area systems hydro program (EDS) Civil tools. Ponds - 100' x 300' with 10:1 side slopes.	Broke into 29 subbasins with average area of 30 to 90 acres. Map shows basins, ac, Q in & out for 5-year & 100-year (existing and dev) & 100-yr level storage - TR-55 to CN & TC to EDS to Q. Show ponds (29) and sed tanks (4)	Low density residential design drainageways, parks, commercial, no storm sewer, all drainage through channels & culverts. Cost est provided, row & easements, water quality @ Pine Lake and wetlands at watershed outlet (SE corner), (NW2)	Disk on culvert info missing. Inventory of all storm sewer items. Good info, should get. Area not built yet. Exhibit B.2 (map) is needed.
26	26th Street and Sycamore Avenue Engineering Report	ISA (above)	Jul-93	Previous study R. W. Verviece Storm Sewer System (existing & extension to east)	330 acres, existing and future, 5 & 100 yr - field inspected, surveyed existing storm sewer system. Flow to open channel (26th & Sycamore). Culvert analysis.	TR-55 and EDS (above) Have P&P on storm extension.	13 subbasins (1 to 80 ac) - TR55 to CN, tc to EDS to Q	Inventory of exist components - Basin flows east to 60" culvert at St Highway 11. 5 ponds, 4 sediment traps, maintain 100-yr Q. Ponds - 2 AF to 20 AF (low density resid) Pond shape assumed but not stated in cost estimate - wetlands along 2/3 of main channel.	
38	I-29 and South Dakota Highway 38 Drainage Study	Sayre Associates	6/23/2001	Master plan update	234 ac drainage basin divided into 5 subbasins 28.77 ac DB2 20.36 ac DB3 - 2 subbasins 495 ac DB4 - 7 subbasins 782 ac DB5 - 12 subbasins	TR-55	Figure 1 & 2 in App B have Cn & TC tabulated by subbasin - 2, 5, 100-year exist and dev.	Natural Valley storage detention + 16.5 ac-ft in 4E ~ 7.9 acres, 86 af in 4G = 30 acres, 49 af @ 5 GN = 23 acres, 69.6 af @ 5 GS = 69.6 acres, 36 af @ 5J = 17 acres - onsite	Inventory in AutoCad culverts + five bridges.
41a	Master Plan for Drainage I-29 & Madison Street Drainage Basin	DGR	Apr-01	Master plan update	192 acres split into 6 subbasins north of Madison, 464 acres south of Madison, 65 without basins, 152 acres split in two	SCS	5-year, 100-year, Qp No data	Pond retrofit @ 5th and Marian. Detention west of Lyon -- @ Lackey Avenue - see page 32	Structure inventory in electronic format and AutoCad.
51	Preliminary Engr Report 69th St & Cliff Avenue Drainage Basins	JSA Consulting Engrs/Land Surveyors	Apr-00		107 acres, NE of 69th/Cliff - 7 subbasins, 7 to 30 acres	TR-55 for tc, CN hydrograph	5, 10, 100 existing & dev. Output reports for models included.	Detention	Wetlands exist but no NWI, area is developed.
52	Norton Acres Drainageway	DGR	Apr-99		225 acres	SCS TR-55 - CN, tc, QPC - regressions "water resources report 98-4055, USGS HECRAS - floodplain delin.	10, 100 Q's existing / future		
56	Preliminary Engineering Analysis of Drainage Needs for Pebble Creek Watershed West of Halbrooke Avenue	DGR	Feb-95		5 subbasins, 55 to 200 acres.	No data	2-, 5-, 100-yr QP	Detention - 5.5 af - 6 af	Wetlands map
57	Engineering Report for Cliff Avenue and I-90 Drainage Basin	JSA	Dec-01		553 acres, 4 subbasins, used 2025 plan	TR-55	Existing and future 5, 10, & 100 Q's soils - commercial future land use, rental housing, input and output included - TR-55, culvert rating, tables & calcs, basin delin. Included.	Detention - maintain 100 yr Q Storm sewer Q's	Within 3 miles of city Wetlands exist, NWI Some storm sewer info.
?	Diamond Creek Detention Pond	Shockwell Engineering	May-02			Haestad Methods Pond Pak v-6-1		56.5 af 18.7 acres	

Major Street Drainage Structure Analysis

TO: Jeff Dunn / City of Sioux Falls

COPIES: Mark Cotter / HR Green
Kyle Hamilton / CH2M HILL
Laurens van der Tak / CH2M HILL

FROM: Mark D. Mittag / CH2M HILL
Michael Ryan / HR Green

DATE: April 29, 2003
Updated May 30, 2003

The major street drainage structure analysis for the Sioux Falls BMP Master Plan was conducted at 20 road crossings. This memorandum summarizes the design standards and procedure used to obtain the analytical results. An accompanying table and map show the culvert analysis results and culvert locations.

Design Criteria

The Sioux Falls Engineering Design Standards Chapter 11 contains the culvert analysis standards. Section 11.4 details standards for culverts. The requirements are summarized in Table 1. For the purposes of the major street drainage structure analysis, all culvert analysis locations were assumed to be arterial roads.

TABLE 1
Chapter 11 Culvert Design Standards

Road Classification	10-Year Return Period	100-Year Return Period
Arterial on major drainageways	See 100-year standard	Sufficient capacity to pass all of the runoff considering 20 percent of the inlet plugged, for pipes under 48 inches in diameter.
All other streets	No street overtopping	Flow over the top of the road does not exceed 18 inches

Modeling Approach

The evaluation and sizing of proposed culvert crossing for designated roadway crossings was completed using cross section and topographical information near the roadway crossing locations. Using the discharge estimates provided from the HEC-HMS modeling, the cross section information was used to develop the approximate normal depth at each site. The normal depth rating for the 100-year discharge provided a starting point in evaluating possible culvert heights for the structure sizing. The FlowMaster computer model was used to obtain the normal depth rating for each site. The model uses the Manning's formula relationship for irregular channel and overbank areas to approximate runoff velocities and subsequent normal depth elevations. With the normal depth approximated, possible culvert sizes were reviewed.

In general, the culvert sizing initially was approximated to limit created head or the backwater effect to 1.5 foot or less. A general assumption for limiting created head in this 1.0-foot range is to approximate an inlet velocity into the opening at 5.0 to 6.0 feet per second for the structure. A commercial version of the Federal Highway Administration's culvert analysis program HY-8 was used. The program was CulvertMaster, developed by Haestad Methods, Inc. The program provides for culvert size and shape options and evaluates both inlet and outlet control in the culvert calculations.

Criteria for roadway conditions provided that the road profile be above the design discharge for the culvert, and that the roadway designation of arterial street be a design capacity equal to the 100-year frequency discharge. Culvert lengths were set at 100 feet, equal to the estimated width of roadway right-of-way. Culvert slopes were set at 1.0 percent slope across the length of the culvert. The runoff potential estimated from the hydrology models used future land use patterns consistent with the City of Sioux Falls long-range development patterns.

The topography of the waterways and creek channels under review is relatively flat in the flood plain areas with broad channel sections. This type of cross section provides relatively shallow depths in the channel ratings completed with Flow Master. The shallow depths and the intention to limit created head to the 1.5 foot or less limit provides for wide culvert sizes with limited vertical rise. Consequently, most sites were evaluated with reinforced concrete box culvert sections. A box culvert alternative was selected if multiples of round pipe equaling three singular pipes or fewer did not provide the required hydraulic capacity. Only one instance of round pipe was selected (Culvert site 2), as other sites required more than three parallel pipes to provide the required capacity when compared to the box size equivalent.

Results

Figure G-1 shows the location of each of the 20 culverts analyzed. The following information is summarized in the attached table for each location.

- Location description
- 10-year flow rate (cfs)
- 100-year flow rate (cfs)
- Pipe size
- Pipe material
- Estimated culvert invert elevations
- Estimated road overtopping elevation
- 10-year water surface elevation
- 100-year water surface elevation
- Overtopping depth, if applicable

Culvert location 7 is parallel to Interstate 29 at the bridge crossing of Madison Street over Interstate 29. In reviewing the normal depth of the typical cross section and cross section area available for conveyance adjacent to the Interstate 29 south bound lanes, it appears there is very limited horizontal and vertical allowance to accommodate the estimated conveyance in an open ditch section along the highway or in the proposed box culvert (twin 10-foot horizontal by 6-foot vertical). Drainage conditions along Interstate 29 should be evaluated in greater detail before final structure sizing for the crossing.

The culvert selections for sites 12, 16, and 19 provide for multiple box culvert barrel sections exceeding general structure economics when compared to simple span bridge designs. However, the long-range roadway profiles for these sites and the limited site specific elevation information prevent a detailed estimate of bridge length for estimating site project costs. However, it is viewed that standard bridge construction may be more economical when the number of culvert barrel exceed four barrel sections.

SUMMARY OF CULVERT ANALYSIS

Culvert ID Number	Location Description	Sub-basin	Subbasin Area Upstream of Culvert (acres)	10-Year Flow at Culvert (cfs)	100-Year Flow at Culvert (cfs)	Pipe Diameter or Box Span x Rise (inch)	Pipe Material	Pipe Length (ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Pipe Slope (ft/ft)	Assumed Entrance Losses	Assumed Tailwater Depth (ft)	Assumed Road Elevation from Contours	Estimated Road Elevation Increase (ft)	100-Year Water Surface Elevation (ft)	Overtopping Depth (if Applicable) (ft)	100-Year Velocity at Outlet (fps)	Type of Outlet Protection Required
1	Crosses Maple St., 570 feet west of Six Mile Road, was culvert #16, no pipe there currently	317-006B	113.46	352.6	599	3 - 8' x 4'	RCBC	100	1434.00	1433.00	0.01	0.40	1435.71	1435.00	3.60	1438.56	0	9.21	Riprap
2	Crosses Highway 11, 600 feet south of 26th Street	303-002B	322	565	912	3 - 8' x 6'	RCBC	100	1467.00	1466.00	0.01	0.40	1470.42	1481.00	0.00	1473.05	0	8.61	Riprap
3[a]	Crosses Six Mile Road, 590 feet north of 10th Street	25-025B	1469	540	1465	3 - 10' x 6'	RCBC	100	1357.41	1356.41	0.01	0.40	1362.53	1373.00	0.00	1364.47	0	8.14	Riprap
4	Crosses Six Mile Road, 1400 feet south of 41st Street	400-030B	126	409.5	681	2 - 12' x 4'	RCBC	100	1425.11	1424.11	0.01	0.40	1427.9	1433.50	0.00	1430.08	0	7.49	Riprap
5[b]	Crosses Cliff Ave, 1550 feet north of 85th Street (same location as proposed BMP 51-2)	51-060B	540	195	325	1 - 20' x 6'	RCBC	100	1453.00	1452.00	0.01	0.40	1452.73	1459.00	0.00	1457.82	0	12.93	Riprap
6	Crosses Maple St., 910 feet west of Marion	40-190B	8570	1710	2670	5 - 12' x 6'	RCBC	100	1441.00	1440.00	0.01	0.40	1447.29	1447.00	2.00	1448.65	0	7.63	Riprap
7	Crosses Madison, immediately west of I-29	41A-010B	167.8	530	855	2 - 12' x 6'	RCBC	100	1427.29	1426.29	0.01	0.40	1430.75	1430.00	3.50	1433.08	0	7.99	Riprap
8[a]	Crosses 60th Street North, 500 feet west of southbound I-29 ramp-60th Street North intersection	40-090B	6541	1680	2620	3 - 12' x 8'	RCBC	100	1462.49	1461.49	0.01	0.40	1469.28	1499.00	0.00	1471.69	0	9.34	Riprap
9	Crosses Southeastern Ave., 110 feet north of 69th Street	7-050B	188	485	803	3 - 10' x 4'	RCBC	100	1463.00	1462.00	0.01	0.40	1466.03	1472.00	0.00	1467.78	0	6.69	Riprap
10	Under 26th Street, 75' W of Six Mile Road	303-031B	277	868	1487	3 - 12' x 6'	RCBC	100	1394.00	1393.00	0.01	0.40	1399.38	1399.00	2.00	1400.62	0	6.88	Riprap
11	Crosses 26th Street, 500 feet southwest of Minnehaha Road (just west of "Old 26th Street")	304-060B	300	715.3	1221	3 - 10' x 6'	RCBC	100	1391.00	1390.00	0.01	0.40	1394.71	1404.00	0.00	1397.32	0	8.64	Riprap
12	Crosses Sycamore Ave., 575 feet north of 69th Street	7-070B	860	1502	2488	8 - 12' x 4'	RCBC	100	1433.00	1432.00	0.01	0.40	1435.74	1437.00	1.00	1437.68	0	6.93	Riprap
13	Crosses proposed new Beltline Highway, 2500 feet north of Madison Street	25-001B	77.6	283.8	472.52	1 - 12' x 6'	RCBC	100	1471.00	1470.00	0.01	0.40	1474.47	1485.50	0.00	1477.19	0	8.82	Riprap
14	Crosses proposed new Beltline Highway, 950 feet north of Madison Street	25-009B	108	367	614	2 - 12' x 4'	RCBC	100	1456.81	1455.81	0.01	0.40	1458.16	1469.50	0.00	1461.45	0	12.73	Riprap
15[b] Note: It is assumed that subbasin 25-017 will be redirected to flow through this culvert	Crosses proposed new Beltline Highway, 1700 feet south of Madison Street (same location as proposed BMP 25-2)	25-015B	230	105.93	293	1 - 12' x 4'	RCP	100	1444.49	1443.49	0.01	0.40	1446.03	1448.00	1.00	1448.99	0	12.57	Riprap
16[a]	Under HWY 11, 1/4 mi N of 57th St, flared end section	401-015B	482	1079	2256	8 - 12' x 4'	RCBC	100	1432.94	1431.94	0.01	0.40	1433.73	1436.00	1.50	1437.33	0	12.44	Riprap
17[b]	Crosses proposed new beltline, 750' north and 1250' west of current 69th Street-Highway 11 intersection, this location is currently in a farm field (same location as proposed BMP 7-5)	7-090B	718	546	923	1 - 10' x 8'	RCBC	100	1417.00	1416.00	0.01	0.40	1420.79	1420.00	3.10	1423.09	0	8.03	Riprap
18	Crosses 57th Street, 3300 feet west of Highway 11	7-010B	157	408	679	2 - 12' x 4'	RCBC	100	1427.00	1426.00	0.01	0.40	1430.64	1434.50	0.00	1431.99	0	7.07	Riprap
19	Crosses Benson Road, 2020 feet, east of Marion Road (close to location proposed BMP 40-1)	40-140B	7584	1900	3170	6 - 12' x 6'	RCBC	100	1451.77	1450.77	0.01	0.40	1454.85	1457.00	1.50	1458.43	0	10.79	Riprap
20	Crosses Tallgrass (Marion), 2060 feet south of 69th Street	11-010B	517	895	1388	4 - 12' x 4'	RCBC	100	1480.00	1479.00	0.01	0.40	1482.82	1485.50	0.00	1485.04	0	7.57	Riprap

[a]Indicates culvert under existing storage conditions was used in master plan model. If this culvert is enlarged, master plan modeling must be revised.

[b]Indicates culvert sizing analysis superseded by Master Plan regional BMP outlet structure sizing.

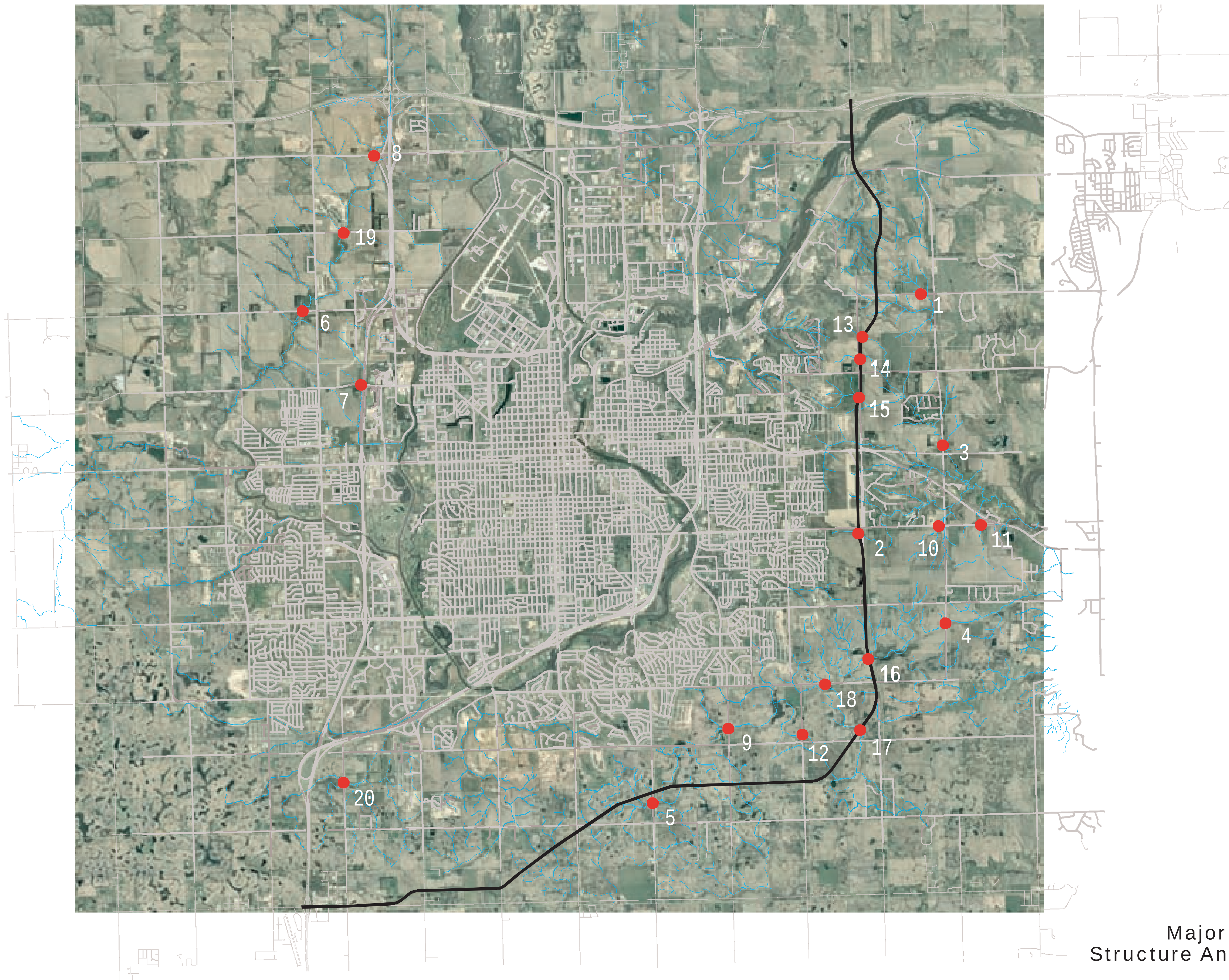


FIGURE G-1
Major Street Drainage Structure Analysis Locations

Stormwater BMP Master Plan
Sioux Falls, South Dakota

CH2MHILL

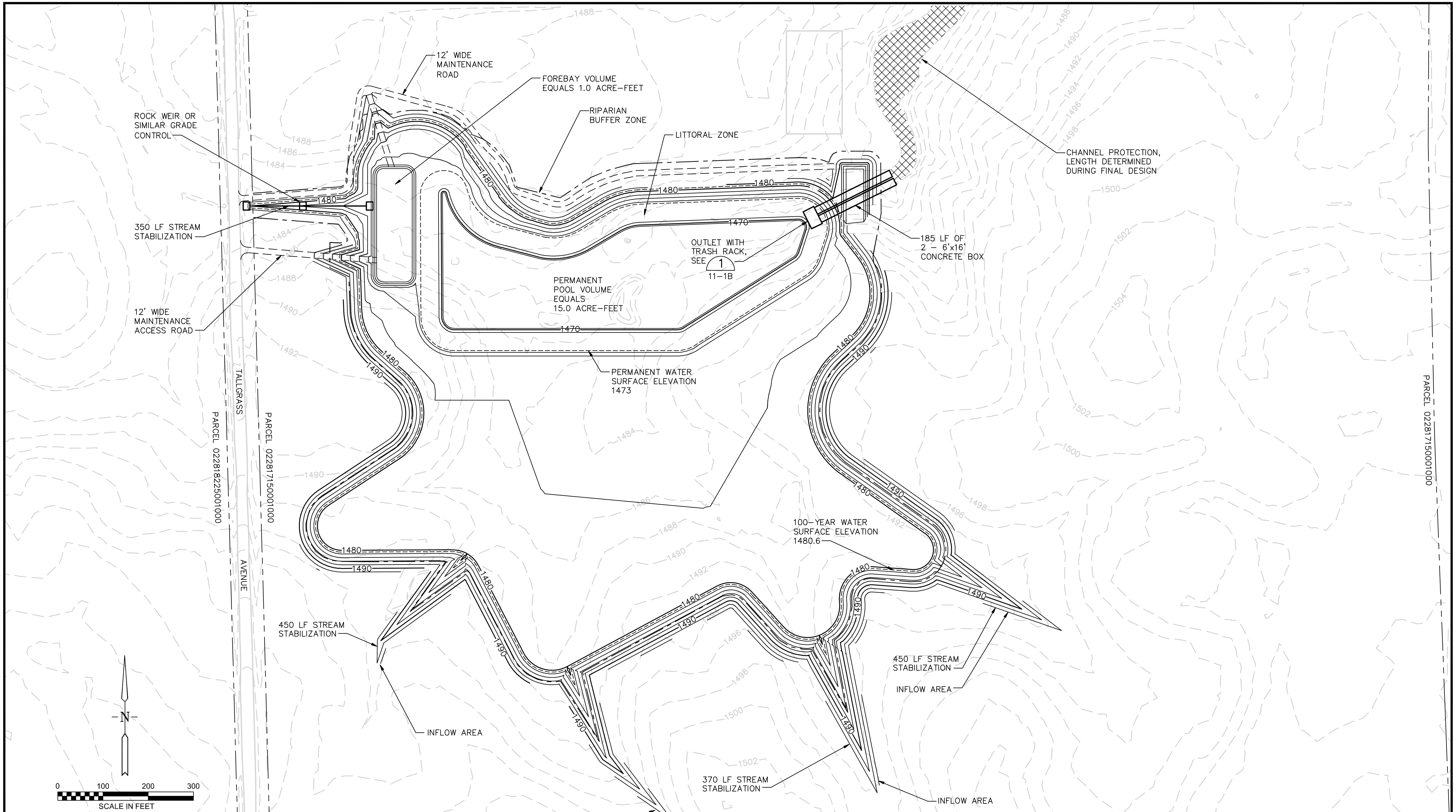
BMP 11-1

Preliminary Design Order-of-Magnitude Cost Opinion

Item Number	Item	Quantities	Unit	Unit Cost	Cost Opinion
1	Mobilization/Construction Access	1	L.S.	$97,100.00	$97,100
2	Clearing and Grubbing	30	AC.	$3,500.00	$105,000
3	Fill for Impoundment	2924	C.Y.	$5.00	$14,620.00
4	Required Cut (Earthwork - Material stockpiled on site)	420,323	C.Y.	$2.10	$882,700
5	Erosion and Sediment Control	30	AC.	$5,500.00	$165,000
6	Class I Riprap (Stream Stabilization - Inlet Grade Control)	1593	C.Y.	$40.00	$63,700
7	Channel Protection (Bioengineered lining)	1000	L.F.	$50.00	$50,000
8	Outlet Structure & box culverts	1	L.S.	$496,000.00	$496,000
9	Topsoil	12684	C.Y.	$1.96	$24,900
10	Plantings/Aquatic Bench	0.4	AC.	$5,000.00	$2,000
11	Plantings/Grass Seeding	6,164.3	lbs.	$5.96	$36,700
			SUBTOTAL=		**$1,938,000**
			15% CONTINGENCY=		$290,700
		TOTAL CONSTRUCTION COST=			**$2,229,000**
12	Wetland Impacts	0.59	AC.	$60,000.00	$35,000
13	Survey/Engineering/Permitting	1	L.S.	$310,000.00	$310,000
14	Land Acquisition	37.5	ACRE	$25,000.00	$937,500
			TOTAL CAPITAL COST=		**$3,512,000**

Assumptions:

1. Mobilization/Construction Access cost is approximately 5% of the cost of items 1 through 11.
2. Earthwork calculations are based on the City of Sioux Falls 2' contour interval GIS topography.
3. Land acquisition costs were estimated through discussions with city real estate personnel.
4. Land acquisition costs do not include spoil pile area, it is assumed that land will not need to be acquired and will be developed.
5. The surveying/engineering/permitting/construction administration costs are based on approximately 16% of the construction cost of the BMP (before contingency).
6. The wetland mitigation cost assumes a mitigation ratio of 1.5:1, and a cost of $40,000 per acre of mitigation.
7. The area of wetland impacts is based on NWI wetlands and/or hydric soils shown on the preliminary design plan.
8. The wetland mitigation cost does not include mitigation for stream impacts.
9. Clearing and grubbing area estimated as BMP footprint size. Land acquisition estimated at 1.25 the BMP footprint size.



BMP 11–1
WQCV DRAINAGE AREA: 698.0 ACRES
100–YEAR STORAGE VOLUME: 95 ACRE–FEET
5–YEAR INFLOW: 1167 CFS
5–YEAR OUTFLOW: 704 CFS
100–YEAR INFLOW: 2463 CFS
100–YEAR OUTFLOW: 1433 CFS

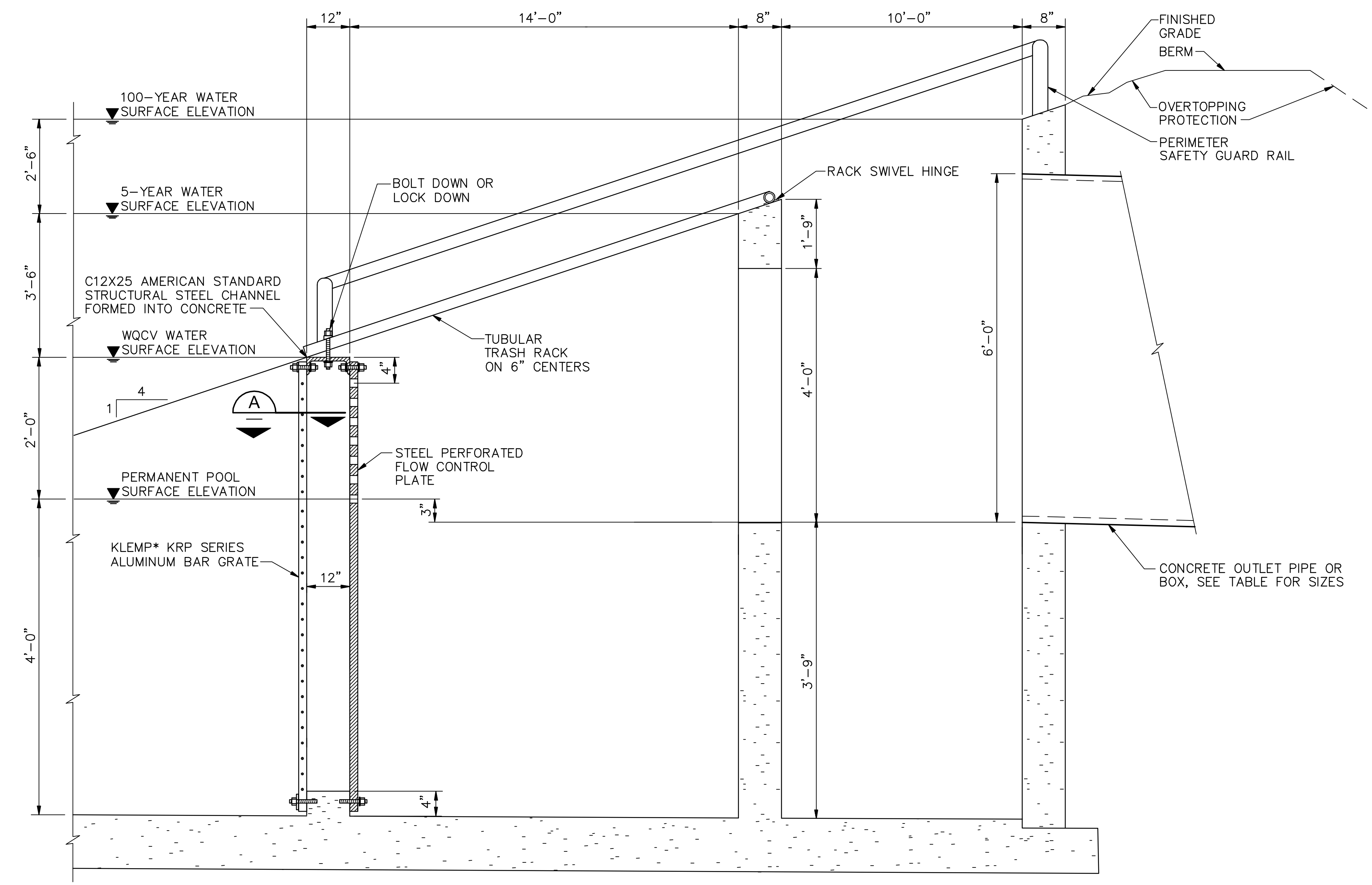
POND 11-1 GRADING PLAN
(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
(605) 367–8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: 11–1pln.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

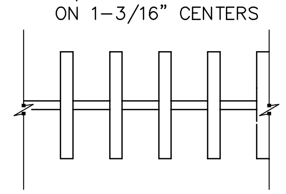
SHEET NO.
11-1A



DROP BOX OUTLET

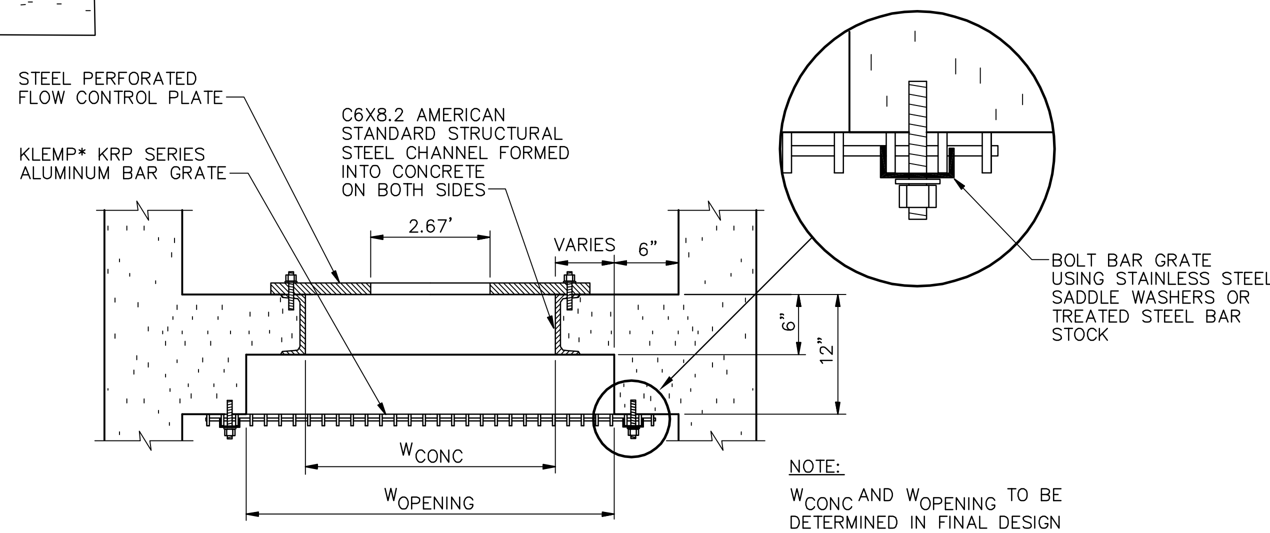
ORIFICE SIZE TABLE	
WQCV ORIFICE	2'x2.67'
5-YEAR ORIFICE	2-4'x12'
100-YEAR OUTLET	2-6'x16'
TOTAL WIDTH OF STRUCTURE	42'

KLEMP* KRP SERIES (OR EQUAL) ALUMINUM BAR GRATE. 3/16" WIDTH BARS ON 1-3/16" CENTERS



R VALUE = (NET OPEN AREA)/(GROSS RACK AREA)
= 0.71 FOR CROSS RODS ON 2" CENTERS
= 0.77 FOR CROSS RODS ON 4" CENTERS

SECTION A
NTS



NOTE:
W_{CONC} AND $W_{OPENING}$ TO BE DETERMINED IN FINAL DESIGN

PARTIAL PLAN

TRASH RACK AND OUTLET STRUCTURE DETAILS (1)
NTS 11-1A

(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

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Howard R Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
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SIOUX FALLS, SD 57104
(605) 367-8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: SFponddtls.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
11-1B

BMP 11-2

Preliminary Design Order-of-Magnitude Cost Estimate

Item Number	Item	Quantities	Unit	Unit Cost	Cost Opinion
1	Mobilization/Construction Access	1	L.S.	$27,900.00	$27,900
2	Clearing and Grubbing	10	AC.	$3,500.00	$35,000
3	Fill for Impoundment	200	C.Y.	$5.00	$1,000.00
4	Required Cut (Earthwork - Material stockpiled on site)	99,000	C.Y.	$2.10	$207,900
5	Erosion and Sediment Control	10	AC.	$5,500.00	$55,000
6	Class I Riprap (Stream Stabilization - Inlet Grade Control)	133	C.Y.	$40.00	$5,300
7	Channel Protection (Bioengineered lining)	1000	L.F.	$50.00	$50,000
8	Outlet Structure & Box Culverts	1	L.S.	$160,400.00	$160,400
9	Topsoil	2935	C.Y.	$1.96	$5,800
10	Plantings/Aquatic Bench	0.3	AC.	$5,000.00	$1,500
11	Plantings/Grass Seeding	1,426.4	lbs.	$5.96	$8,500
			SUBTOTAL=		**$558,000**
			15% CONTINGENCY=		$83,700
		TOTAL CONSTRUCTION COST=			**$642,000**
12	Wetland Impacts	0.72	AC.	$60,000.00	$43,000
13	Survey/Engineering/Permitting	1	L.S.	$89,000.00	$89,000
14	Land Acquisition	12.5	ACRE	$25,000.00	$312,500
			TOTAL CAPITAL COST=		**$1,087,000**

Assumptions:

1. Mobilization/Construction Access cost is approximately 5% of the cost of items 1 through 11.
2. Earthwork calculations are based on the City of Sioux Falls 2' contour interval GIS topography.
3. Land acquisition costs were estimated through discussions with city real estate personnel.
4. Land acquisition costs do not include spoil pile area, it is assumed that land will not need to be acquired and will be developed.
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6. The wetland mitigation cost assumes a mitigation ratio of 1.5:1, and a cost of $40,000 per acre of mitigation.
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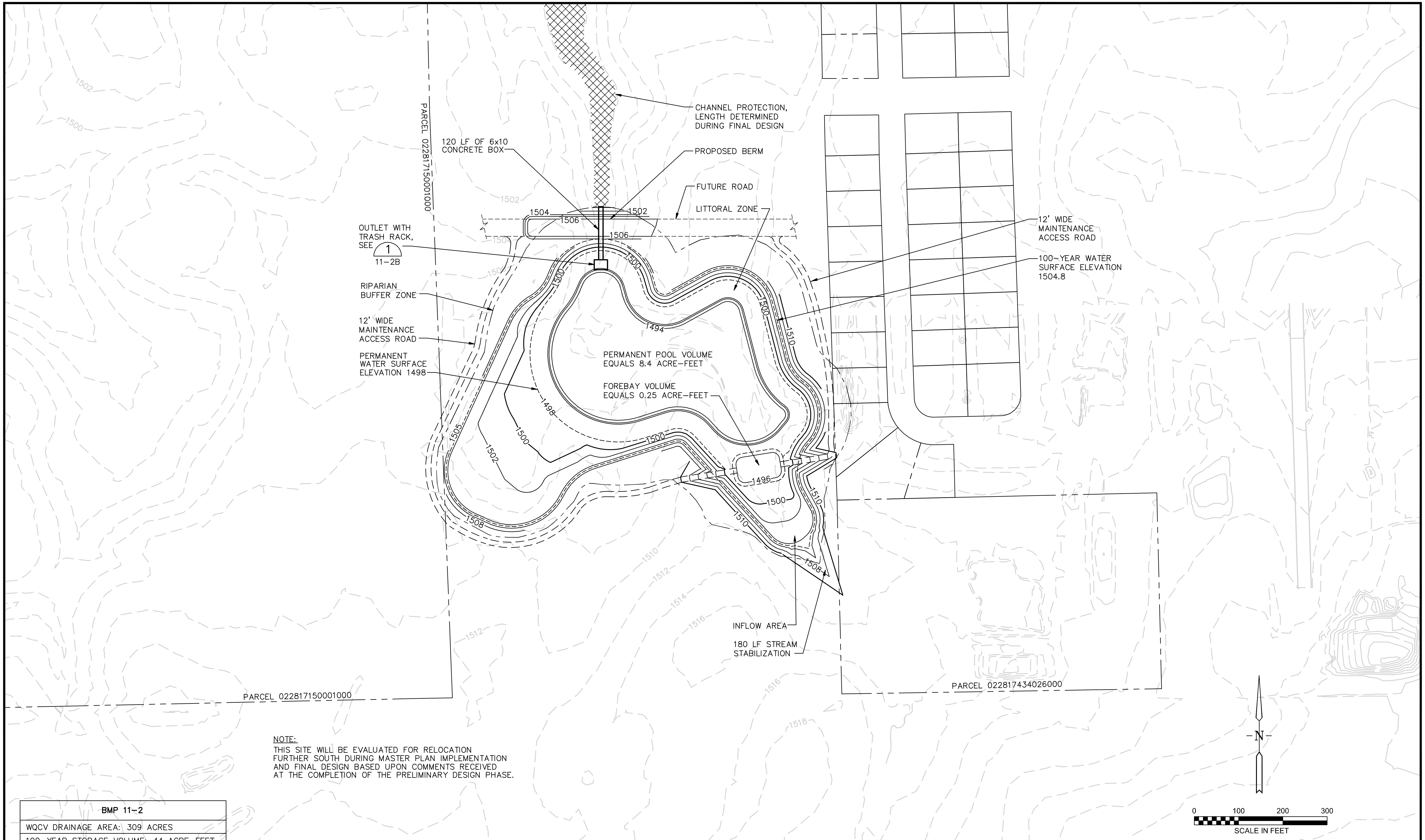
8. The wetland mitigation cost does not include mitigation for stream impacts.
9. Clearing and grubbing area estimated as BMP footprint size. Land acquisition estimated at 1.25 the BMP footprint size.



NOTE:
THIS SITE WILL BE EVALUATED FOR RELOCATION FURTHER SOUTH DURING MASTER PLAN IMPLEMENTATION AND FINAL DESIGN BASED UPON COMMENTS RECEIVED AT THE COMPLETION OF THE PRELIMINARY DESIGN PHASE.

BMP 11-2
WQCV DRAINAGE AREA: 309 ACRES
100-YEAR STORAGE VOLUME: 44 ACRE-FEET
5-YEAR INFLOW: 422 CFS
5-YEAR OUTFLOW: 194 CFS
100-YEAR INFLOW: 919 CFS
100-YEAR OUTFLOW: 438 CFS

POND 11-2 GRADING PLAN
(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R Green Company

CITY OF SIOUX FALLS
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DIVISION OF ENGINEERING
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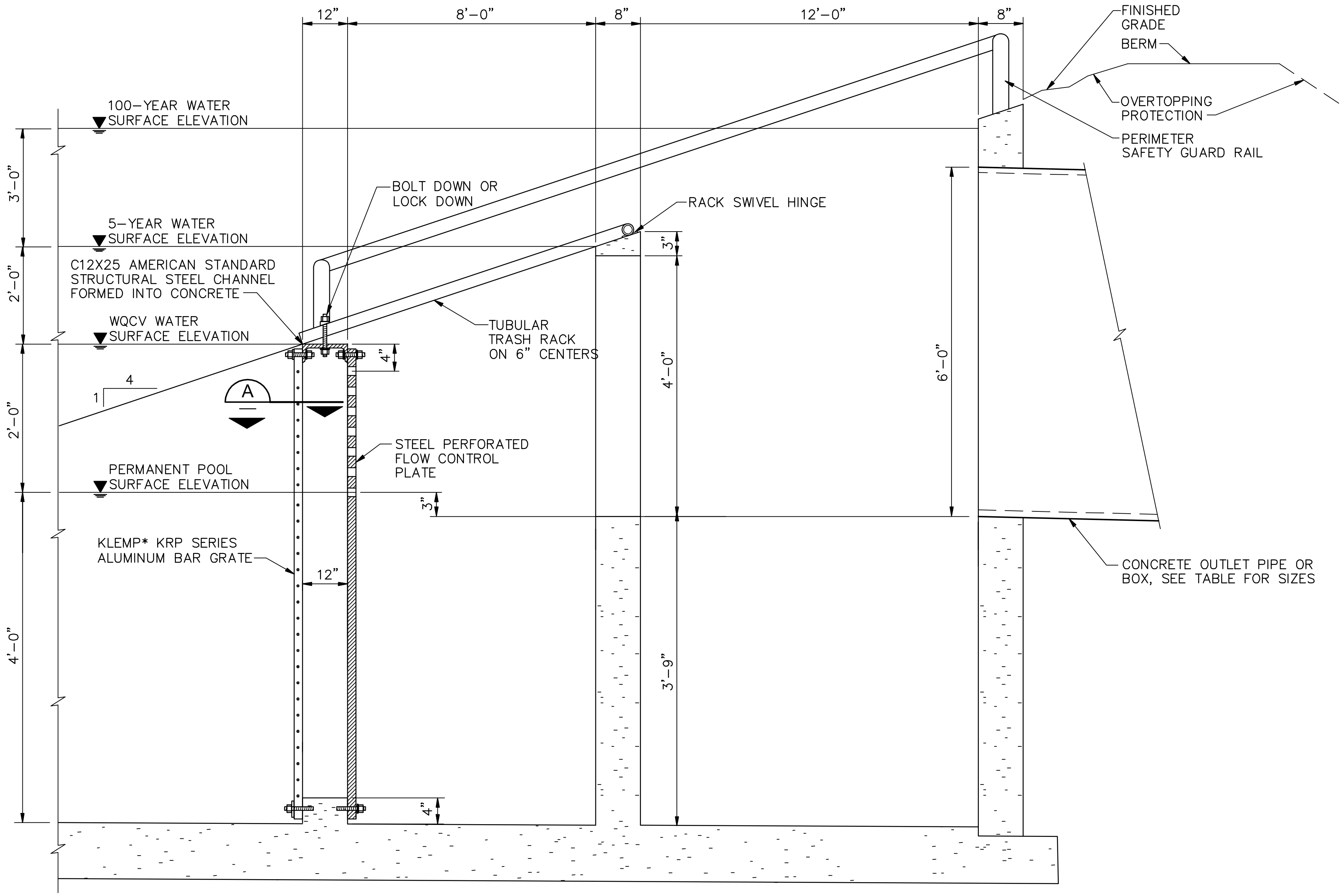
SIOUX FALLS, SD 57104
(605) 367-8601

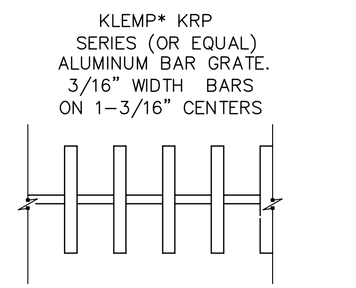
DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: 11-2pln.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
11-2A



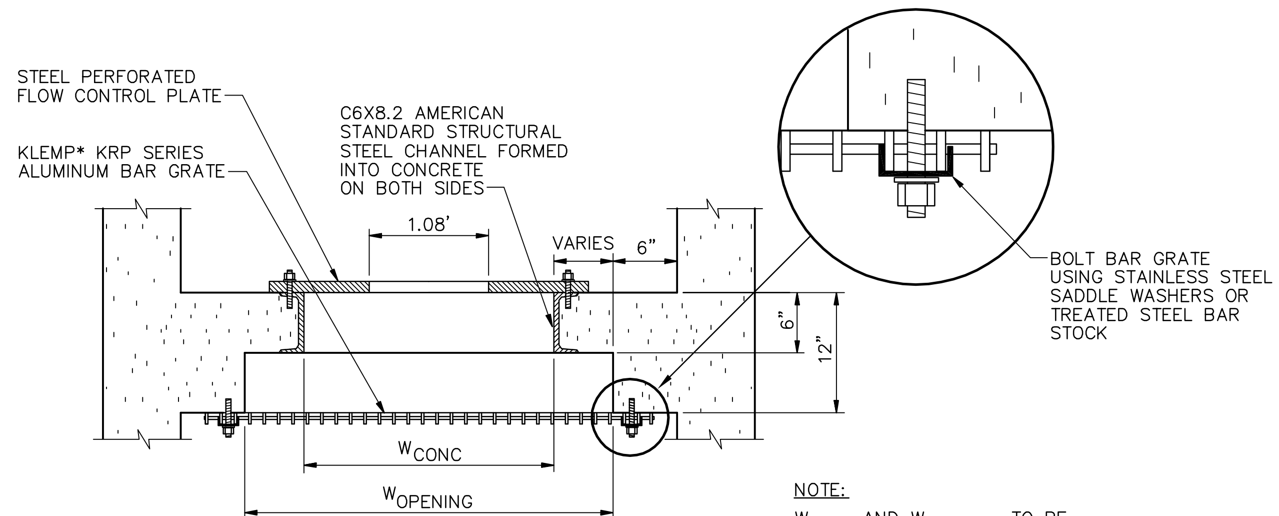
DROP BOX OUTLET

ORIFICE SIZE TABLE	
WQCV ORIFICE	2'x1.08'
5–YEAR ORIFICE	4'x10'
100–YEAR OUTLET	6'x10'
TOTAL WIDTH OF STRUCTURE	30'



R VALUE = (NET OPEN AREA)/(GROSS RACK AREA)
= 0.71 FOR CROSS RODS ON 2" CENTERS
= 0.77 FOR CROSS RODS ON 4" CENTERS

SECTION (A)
NTS



NOTE:
W_{CONC} AND $W_{OPENING}$ TO BE DETERMINED IN FINAL DESIGN

PARTIAL PLAN

TRASH RACK AND OUTLET STRUCTURE DETAILS (1)
NTS 11-2A

(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R. Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
(605) 367–8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: SFponddtls.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
11-2B

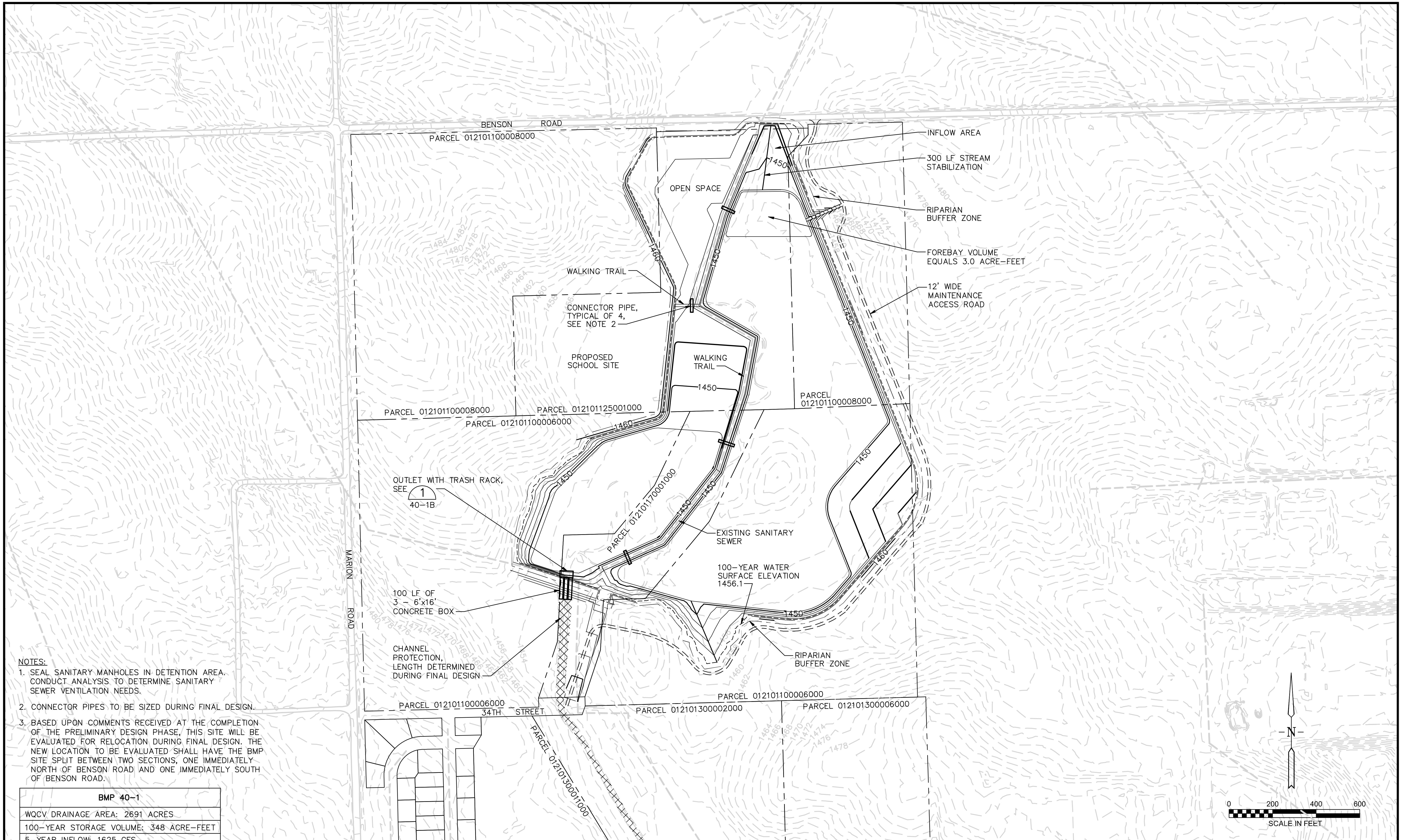
BMP 40-1

Preliminary Design Order-of-Magnitude Cost Estimate

Item Number	Item	Quantities	Unit	Unit Cost	Cost Opinion
1	Mobilization/Construction Access	1	L.S.	$106,400.00	$106,400
2	Clearing and Grubbing	57.3	AC.	$3,500.00	$200,600
3	Fill for Impoundment	3,300	C.Y.	$5.00	$16,500
4	Required Cut (Earthwork - Material stockpiled on site)	374,776	C.Y.	$2.10	$787,000
5	Erosion and Sediment Control	57.3	AC.	$5,500.00	$315,200
6	Class I Riprap (Stream Stabilization - Inlet Grade Control)	222	C.Y.	$40.00	$8,900
7	Channel Protection (Bioengineered lining)	1000	L.F.	$50.00	$50,000
8	Outlet Structure & Box Culverts	1	L.S.	$503,515.00	$503,500
9	Topsoil	30815	C.Y.	$1.96	$60,400
10	Plantings/Aquatic Bench	-	AC.	$5,000.00	$0
11	Plantings/Grass Seeding	14,975.9	lbs.	$5.96	$89,300
12	Seal Sanitary Sewer Manhole	10.0	EACH	$250.00	$2,500
			SUBTOTAL=		**$2,140,000**
			15% CONTINGENCY=		$321,000
		TOTAL CONSTRUCTION COST=			**$2,461,000**
13	Wetland Impacts	4.036	AC.	$60,000.00	$242,000
14	Survey/Engineering/Permitting	1	L.S.	$342,000.00	$342,000
15	Land Acquisition	71.625	ACRE	$25,000.00	$1,790,600
			TOTAL CAPITAL COST=		**$4,836,000**

Assumptions:

1. Mobilization/Construction Access cost is approximately 5% of the cost of items 1 through 12.
2. Earthwork calculations are based on the City of Sioux Falls 2' contour interval GIS topography.
3. Land acquisition costs were estimated through discussions with city real estate personnel.
4. Land acquisition costs do not include spoil pile area, it is assumed that land will not need to be acquired and will be developed.
5. The surveying/engineering/permitting/construction administration costs are based on approximately 16% of the construction cost of the BMP (before contingency).
6. The wetland mitigation cost assumes a mitigation ratio of 1.5:1, and a cost of $40,000 per acre of mitigation.
7. The area of wetland impacts is based on NWI wetlands and/or hydric soils shown on the preliminary design plan.
8. The wetland mitigation cost does not include mitigation for stream impacts.
9. Clearing and grubbing area estimated as BMP footprint size. Land acquisition estimated at 1.25 the BMP footprint size.



NOTES:

1. SEAL SANITARY MANHOLES IN DETENTION AREA. CONDUCT ANALYSIS TO DETERMINE SANITARY SEWER VENTILATION NEEDS.
2. CONNECTOR PIPES TO BE SIZED DURING FINAL DESIGN.
3. BASED UPON COMMENTS RECEIVED AT THE COMPLETION OF THE PRELIMINARY DESIGN PHASE, THIS SITE WILL BE EVALUATED FOR RELOCATION DURING FINAL DESIGN. THE NEW LOCATION TO BE EVALUATED SHALL HAVE THE BMP SITE SPLIT BETWEEN TWO SECTIONS, ONE IMMEDIATELY NORTH OF BENSON ROAD AND ONE IMMEDIATELY SOUTH OF BENSON ROAD.

BMP 40-1
WQCV DRAINAGE AREA: 2691 ACRES
100-YEAR STORAGE VOLUME: 348 ACRE-FEET
5-YEAR INFLOW: 1625 CFS
5-YEAR OUTFLOW: 1376 CFS
100-YEAR INFLOW: 3330 CFS
100-YEAR OUTFLOW: 2610 CFS

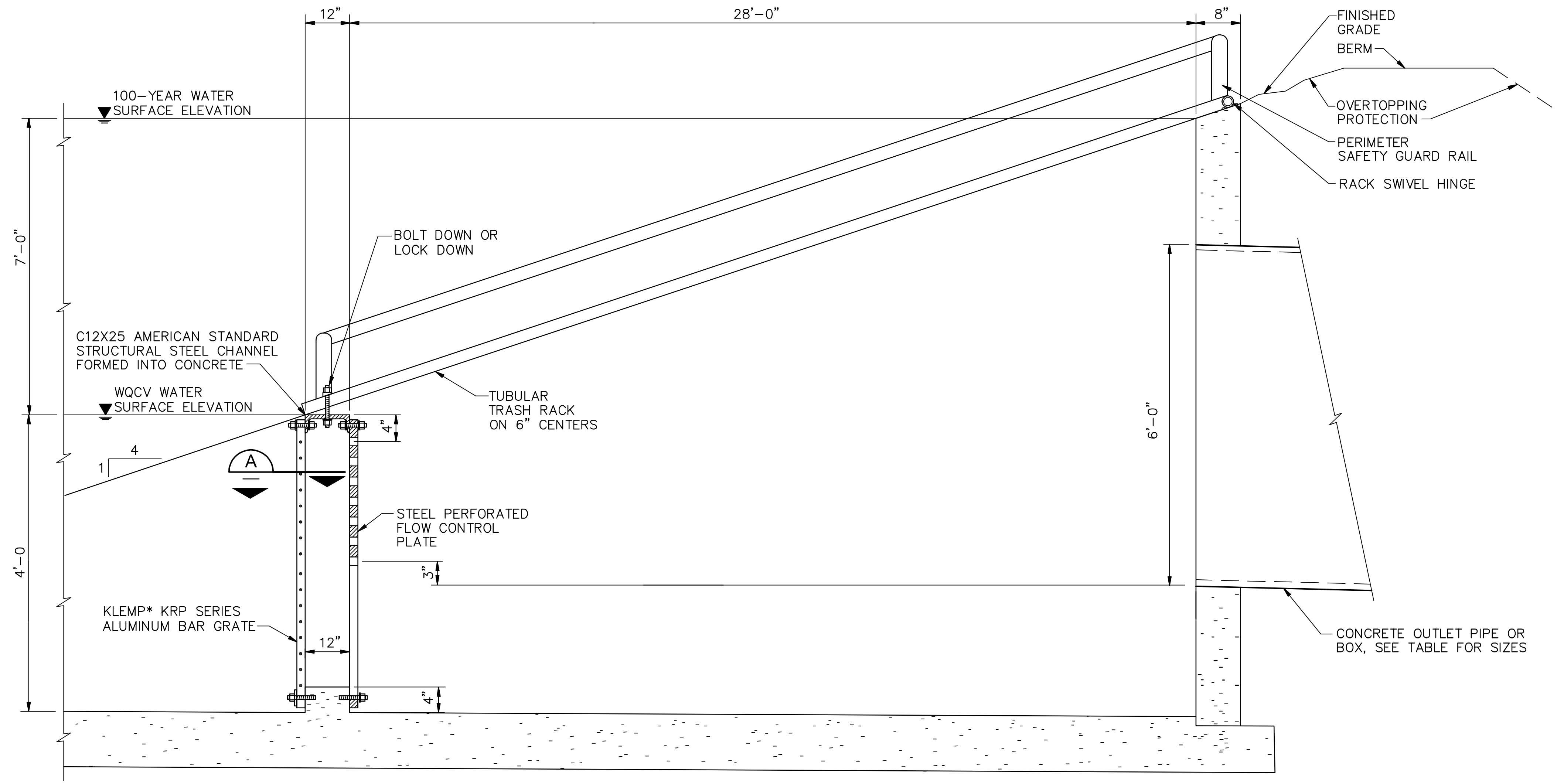
POND 40-1 GRADING PLAN
(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
(605) 367-8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: 40-1pln.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

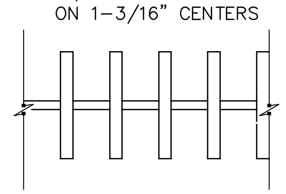
SHEET NO.
40-1A



DROP BOX OUTLET

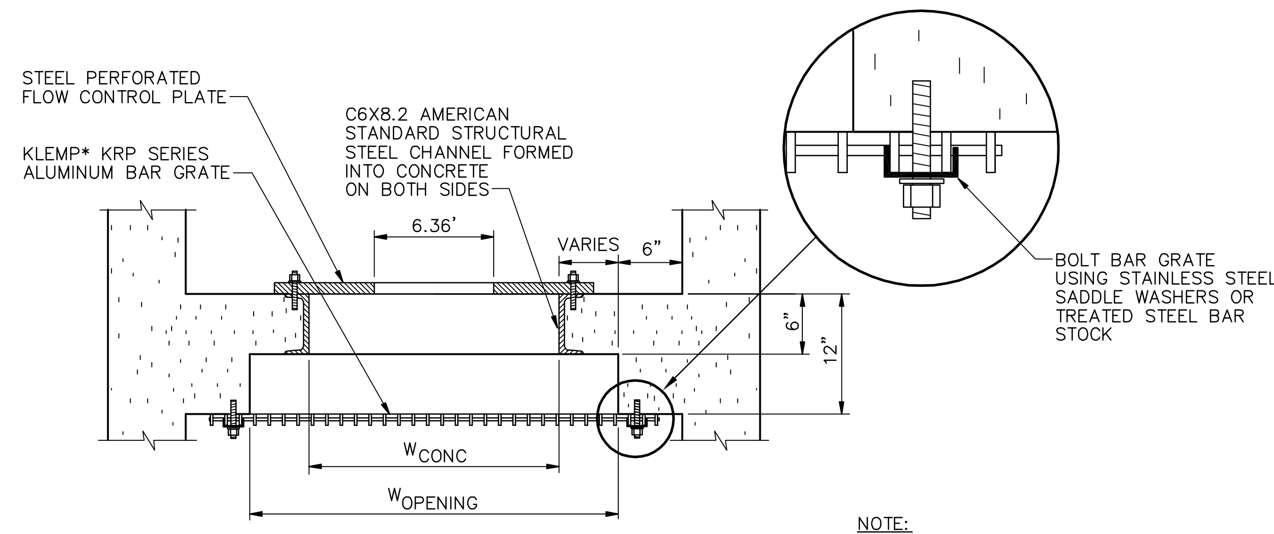
ORIFICE SIZE TABLE	
WQCV ORIFICE	2'x5.77'
100-YEAR OUTLET	3-6'X16'
TOTAL WIDTH OF STRUCTURE	60'

KLEMP* KRP SERIES (OR EQUAL) ALUMINUM BAR GRATE. 3/16" WIDTH BARS ON 1-3/16" CENTERS



R VALUE = (NET OPEN AREA)/(GROSS RACK AREA)
= 0.71 FOR CROSS RODS ON 2" CENTERS
= 0.77 FOR CROSS RODS ON 4" CENTERS

SECTION A
NTS



PARTIAL PLAN

NOTE:
W_{CONC} AND $W_{OPENING}$ TO BE DETERMINED IN FINAL DESIGN

TRASH RACK AND OUTLET STRUCTURE DETAILS (1)
NTS
40-1A

(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R. Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
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DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: SFponddtls.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
40-1B

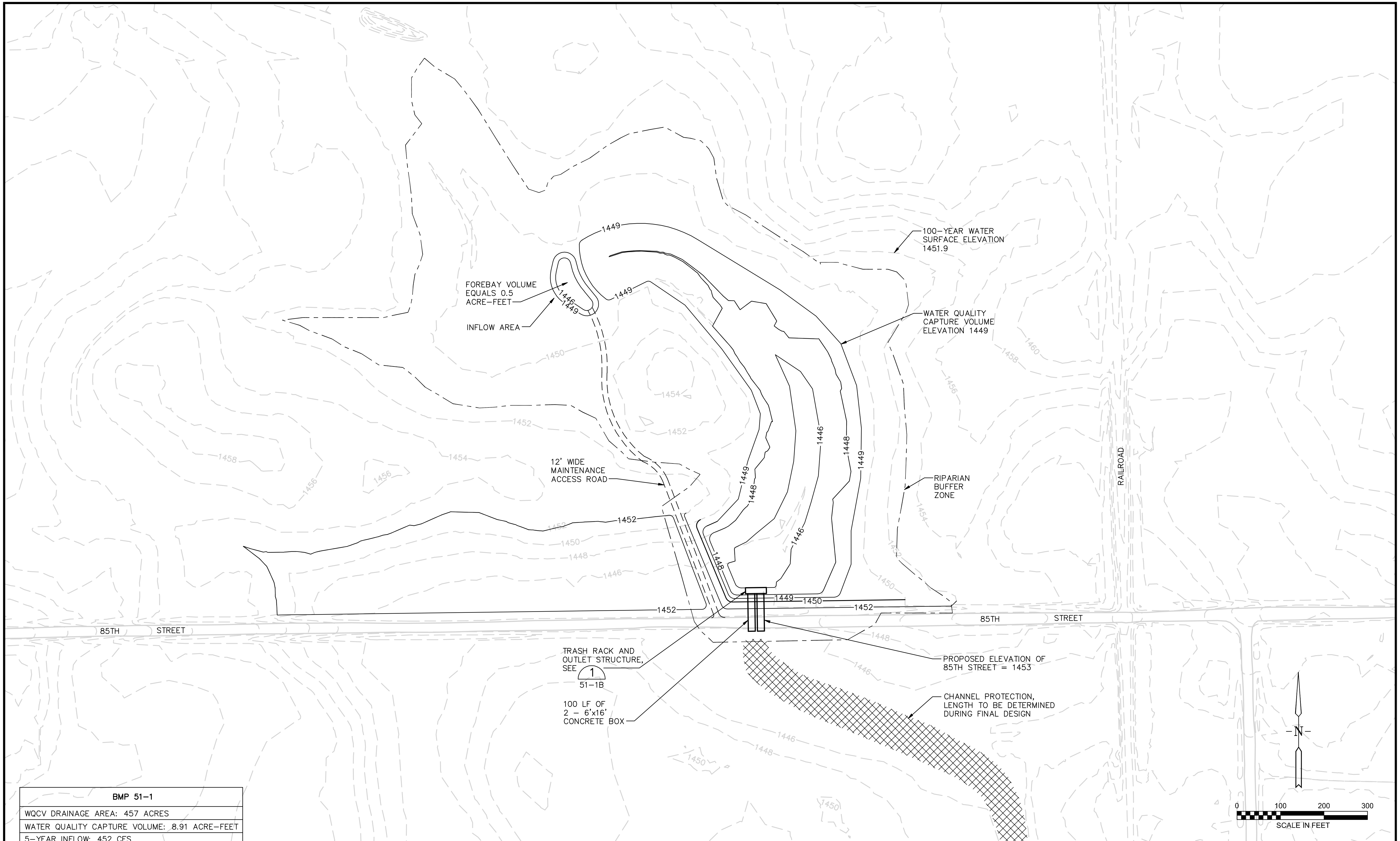
BMP 51-1

Preliminary Design Order-of-Magnitude Cost Opinion

Item Number	Item	Quantities	Unit	Unit Cost	Cost Opinion
1	Mobilization/Construction Access	1	L.S.	$22,400.00	$22,400
2	Clearing and Grubbing	6	AC.	$3,500.00	$21,000
3	Fill for Impoundment	3000	C.Y.	$5.00	$15,000.00
4	Required Cut (Earthwork - Material stockpiled on site)	1,000	C.Y.	$2.10	$2,100
5	Erosion and Sediment Control	6	AC.	$5,500.00	$33,000
6	Class I Riprap (Stream Stabilization - Inlet Grade Control)	0	C.Y.	$40.00	$0
7	Channel Protection (Bioengineered lining)	1000	L.F.	$50.00	$50,000
8	Outlet Structure & Box Culverts	1	L.S.	$299,800.00	$299,800
9	Topsoil	3227	C.Y.	$1.96	$6,300
10	Plantings/Aquatic Bench	-	AC.	$5,000.00	$0
11	Plantings/Grass Seeding	1,568.2	lbs.	$5.96	$9,300
			SUBTOTAL=		**$459,000**
			15% CONTINGENCY=		$68,850
		TOTAL CONSTRUCTION COST=			**$528,000**
12	Wetland Impacts	3.95	AC.	$60,000.00	$237,000
13	Survey/Engineering/Permitting	1	L.S.	$73,000.00	$73,000
14	Land Acquisition	7.5	ACRE	$25,000.00	$187,500
			TOTAL CAPITAL COST=		**$1,026,000**

Assumptions:

1. Mobilization/Construction Access cost is approximately 5% of the cost of items 1 through 11.
2. Earthwork calculations are based on the City of Sioux Falls 2' contour interval GIS topography.
3. Land acquisition costs were estimated through discussions with city real estate personnel.
4. Land acquisition costs do not include spoil pile area, it is assumed that land will not need to be acquired and will be developed.
5. The surveying/engineering/permitting/construction administration costs are based on approximately 16% of the construction cost of the BMP (before contingency).
6. The wetland mitigation cost assumes a mitigation ratio of 1.5:1, and a cost of $40,000 per acre of mitigation.
7. The area of wetland impacts is based on NWI wetlands and/or hydric soils shown on the preliminary design plan.
8. The wetland mitigation cost does not include mitigation for stream impacts.
9. Costs associated with raising the road are not included.
10. Clearing and grubbing area estimated as BMP footprint size. Land acquisition estimated at 1.25 the BMP footprint size.



BMP 51-1
WQCV DRAINAGE AREA: 457 ACRES
WATER QUALITY CAPTURE VOLUME: 8.91 ACRE-FEET
5-YEAR INFLOW: 452 CFS
5-YEAR OUTFLOW: 423 CFS
100-YEAR INFLOW: 1254 CFS
100-YEAR OUTFLOW: 1188 CFS

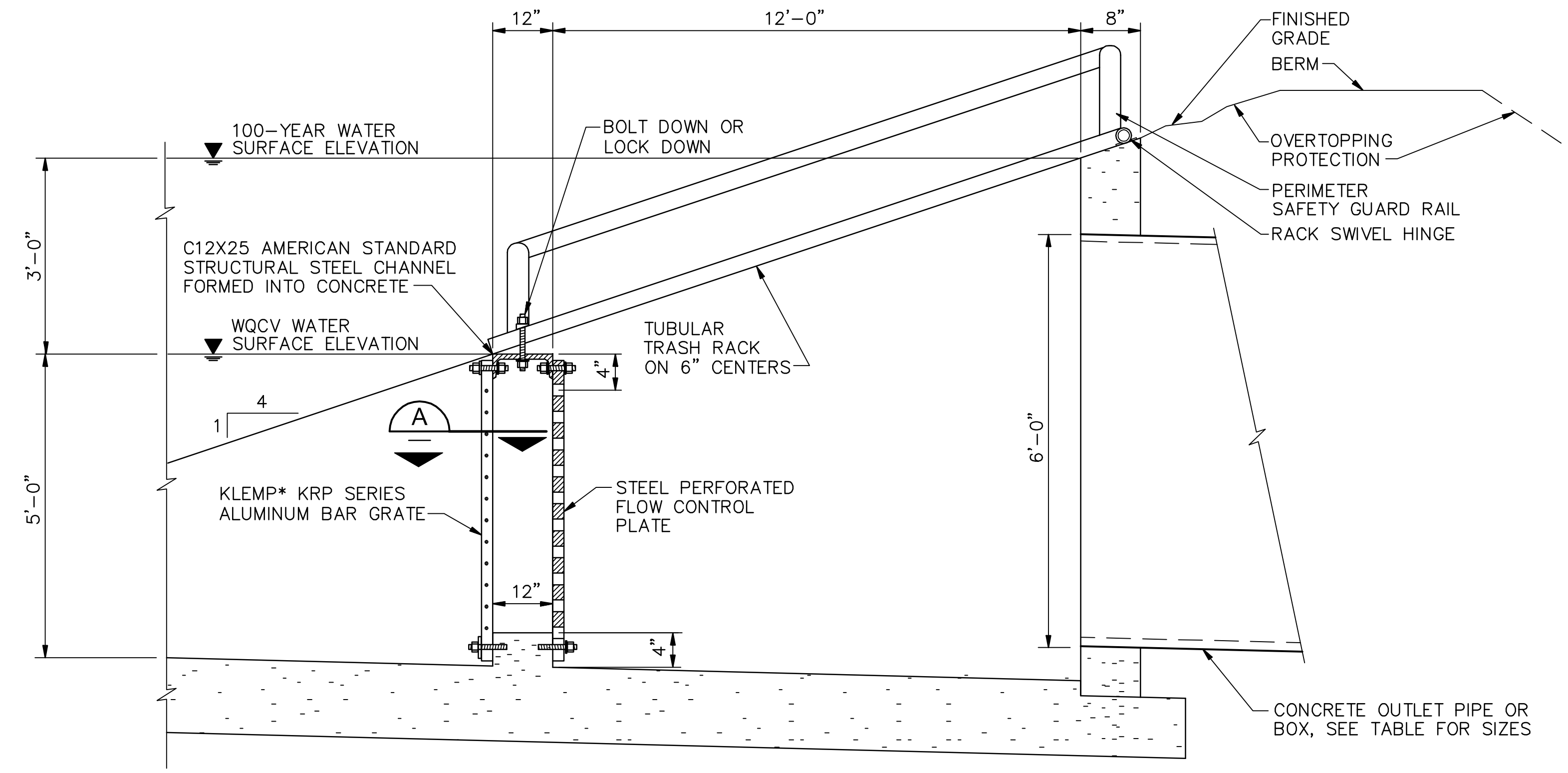
POND 51-1 GRADING PLAN
(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R. Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
(605) 367-8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: 51-1pln.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
51-1A



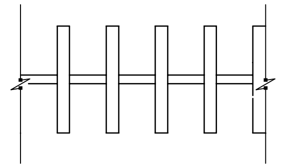
DROP BOX OUTLET

NOTE:

TRASH RACK SIZED ON HYDRAULIC CRITERIA AND DOES NOT MEET DESIGN STANDARD GUIDELINES. TOTAL TRASH RACK AREA EQUALS THREE TIMES THE CONCRETE OUTLET AREA.

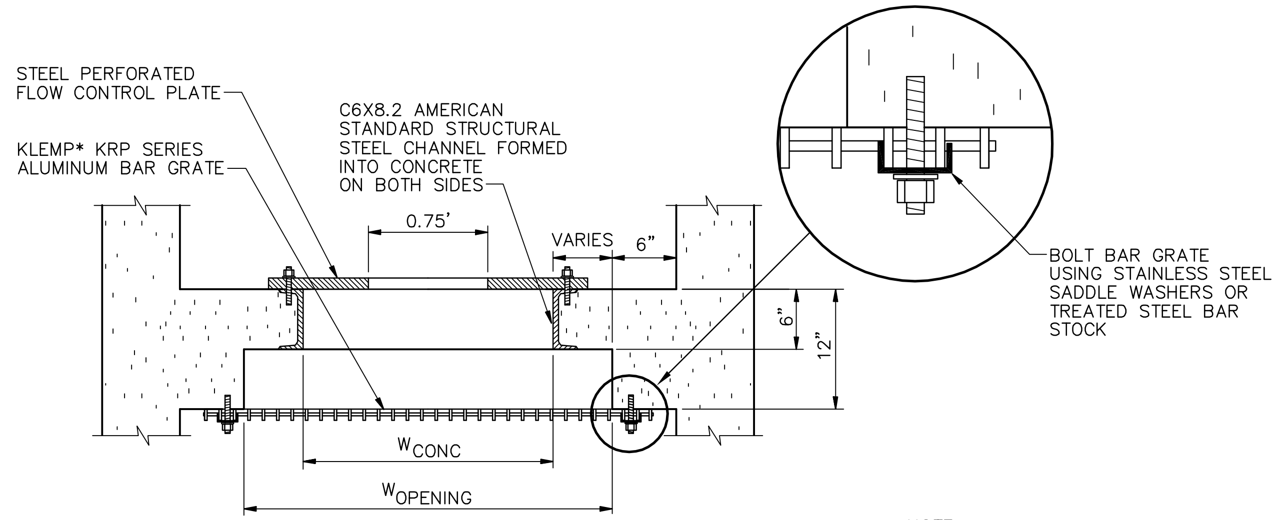
ORIFICE SIZE TABLE	
WQCV ORIFICE	5'x0.75'
100-YEAR ORIFICE	2-6'x16'
TOTAL WIDTH OF STRUCTURE	48'

KLEMP* KRP SERIES (OR EQUAL) ALUMINUM BAR GRATE. 3/16" WIDTH BARS ON 1-3/16" CENTERS



R VALUE = (NET OPEN AREA)/(GROSS RACK AREA)
= 0.71 FOR CROSS RODS ON 2" CENTERS
= 0.77 FOR CROSS RODS ON 4" CENTERS

SECTION A
NTS



PARTIAL PLAN

NOTE:

W_{CONC} AND $W_{OPENING}$ TO BE DETERMINED IN FINAL DESIGN

TRASH RACK AND OUTLET STRUCTURE DETAILS (1)
NTS 51-1A

(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R. Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
(605) 367-8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: SFponddtls.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
51-1B

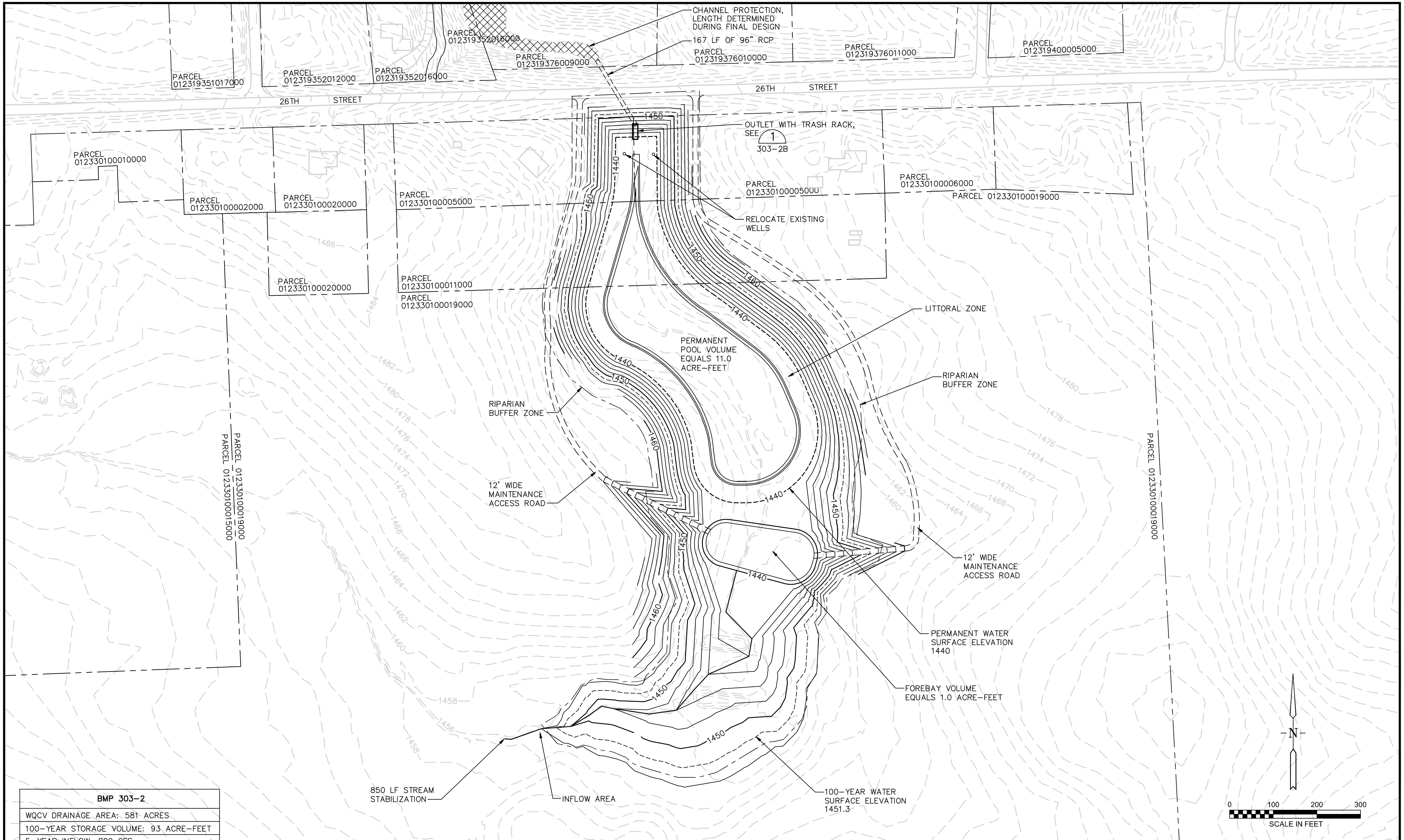
BMP 303-2

Preliminary Design Order-of-Magnitude Cost Opinion

Item Number	Item	Quantities	Unit	Unit Cost	Cost Opinion
1	Mobilization/Construction Access	1	L.S.	$52,500.00	$52,500
2	Clearing and Grubbing	12.7	AC.	$3,500.00	$44,500
3	Fill for Impoundment	0	C.Y.	$5.00	$0.00
4	Required Cut (Earthwork - Material stockpiled on site)	273,065	C.Y.	$2.10	$573,400
5	Erosion and Sediment Control	12.7	AC.	$5,500.00	$69,900
6	Class I Riprap (Stream Stabilization - Inlet Grade Control)	630	C.Y.	$40.00	$25,200
7	Channel Protection (Bioengineered lining)	1000	L.F.	$50.00	$50,000
8	Outlet Structure & Box Culverts	1	L.S.	$208,200.00	$208,200
9	Topsoil	4361	C.Y.	$1.96	$8,500
10	Plantings/Aquatic Bench	0.4	AC.	$5,000.00	$2,000
11	Plantings/Grass Seeding	2,119.3	lbs.	$5.96	$12,600
12	Relocate Residential Well	2.0	EACH	$2,000.00	$4,000
			SUBTOTAL=		**$1,051,000**
			15% CONTINGENCY=		$157,650
		TOTAL CONSTRUCTION COST=			**$1,209,000**
12	Wetland Impacts	0.184	AC.	$60,000.00	$11,000
13	Survey/Engineering/Permitting	1	L.S.	$168,000.00	$168,000
14	Land Acquisition	15.875	ACRE	$25,000.00	$396,900
			TOTAL CAPITAL COST=		**$1,785,000**

Assumptions:

1. Mobilization/Construction Access cost is approximately 5% of the cost of items 1 through 12.
2. Earthwork calculations are based on the City of Sioux Falls 2' contour interval GIS topography.
3. Land acquisition costs were estimated through discussions with city real estate personnel.
4. Land acquisition costs do not include spoil pile area, it is assumed that land will not need to be acquired and will be developed.
5. The surveying/engineering/permitting/construction administration costs are based on approximately 16% of the construction cost of the BMP (before contingency).
6. The wetland mitigation cost assumes a mitigation ratio of 1.5:1, and a cost of $40,000 per acre of mitigation.
7. The area of wetland impacts is based on NWI wetlands and/or hydric soils shown on the preliminary design plan.
8. The wetland mitigation cost does not include mitigation for stream impacts.
9. Clearing and grubbing area estimated as BMP footprint size. Land acquisition estimated at 1.25 the BMP footprint size.



BMP 303-2
WQCV DRAINAGE AREA: 581 ACRES
100-YEAR STORAGE VOLUME: 93 ACRE-FEET
5-YEAR INFLOW: 809 CFS
5-YEAR OUTFLOW: 247 CFS
100-YEAR INFLOW: 1727 CFS
100-YEAR OUTFLOW: 681 CFS

POND 303-2 GRADING PLAN
(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
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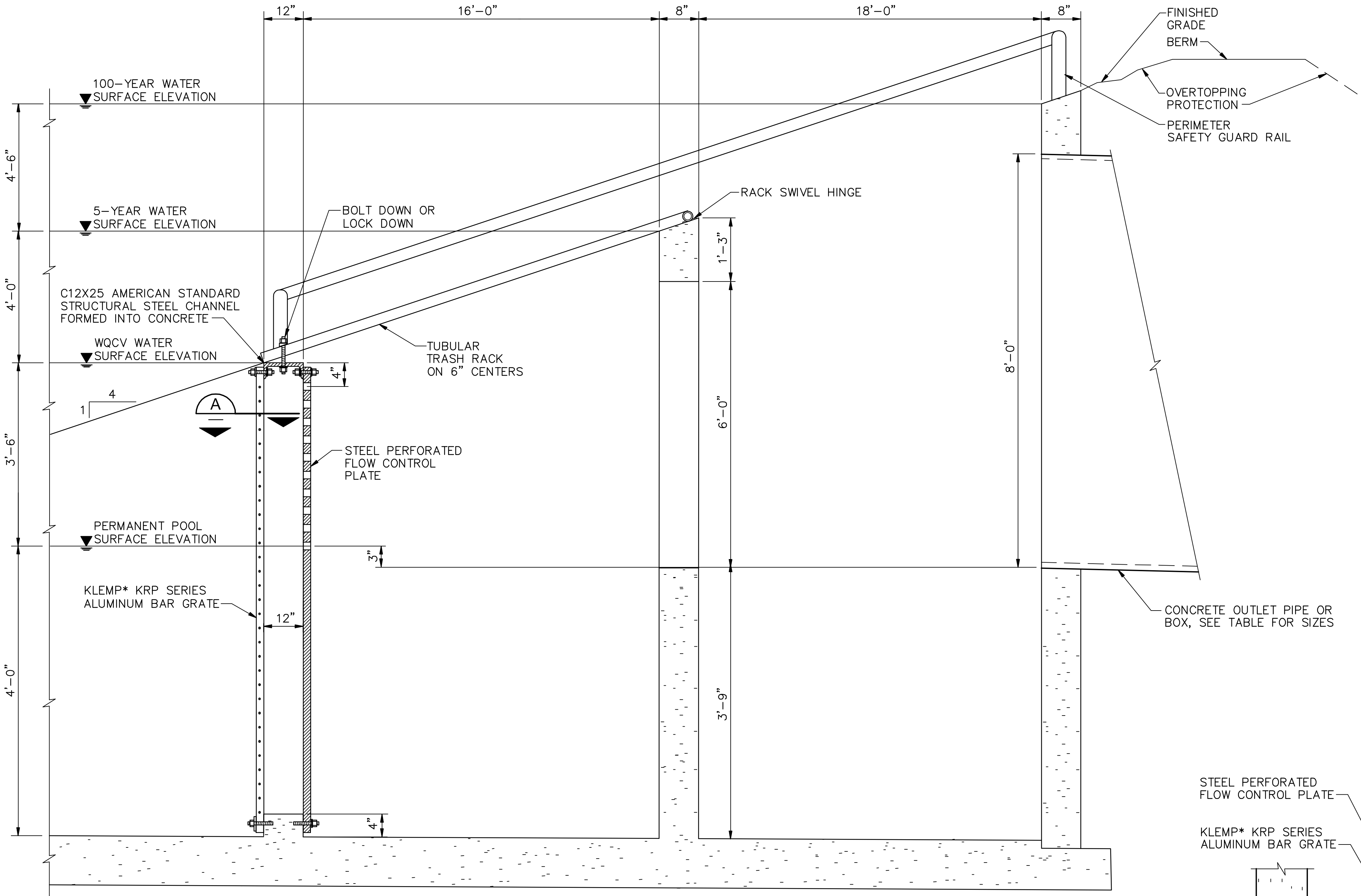
DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: 303-2pln.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

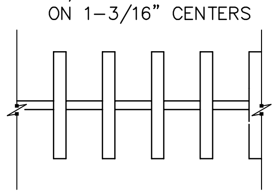
SHEET NO.
303-2A



DROP BOX OUTLET

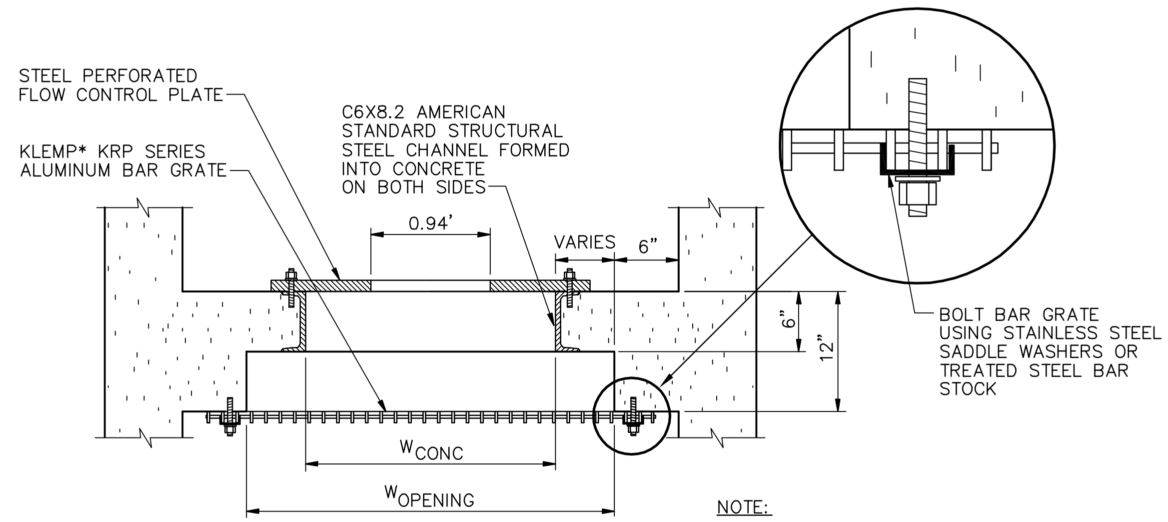
ORIFICE SIZE TABLE	
WQCV ORIFICE	3.5'x0.94'
5-YEAR ORIFICE	6' PIPE
100-YEAR OUTLET	8' PIPE
TOTAL WIDTH OF STRUCTURE	12'

KLEMP* KRP SERIES (OR EQUAL) ALUMINUM BAR GRATE. 3/16" WIDTH BARS ON 1-3/16" CENTERS



R VALUE = (NET OPEN AREA)/(GROSS RACK AREA)
= 0.71 FOR CROSS RODS ON 2" CENTERS
= 0.77 FOR CROSS RODS ON 4" CENTERS

SECTION A
NTS



PARTIAL PLAN

NOTE:
W_{CONC} AND $W_{OPENING}$ TO BE DETERMINED IN FINAL DESIGN

TRASH RACK AND OUTLET STRUCTURE DETAILS 1
NTS 303-2A

(PRELIMINARY DESIGN - NOT FOR CONSTRUCTION)

CH2MHILL
Howard R. Green Company

CITY OF SIOUX FALLS
PUBLIC WORKS
DIVISION OF ENGINEERING
224 WEST 9TH STREET
SIOUX FALLS, SD 57104
(605) 367-8601

DESIGNED BY: P.BLONN
DRAWN BY: M.R. ACAD FILE: SFpondtls.dwg
CHECKED BY: M.MITTAG DATE:
REVISIONS: BY: DATE:
BY: DATE:

SHEET NO.
303-2B

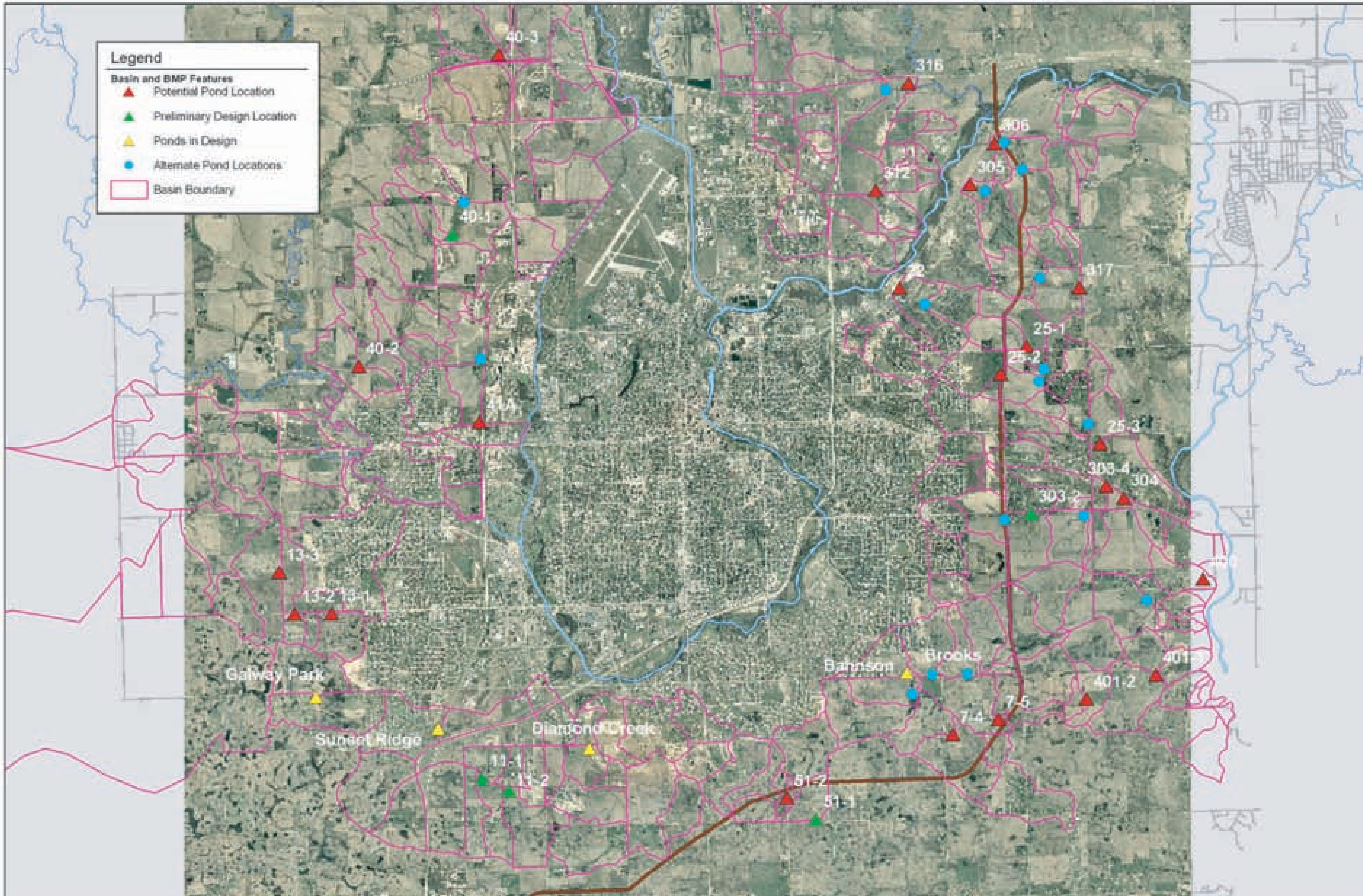


FIGURE I-1
Alternate BMP Locations
Stormwater BMP Master Plan
Sioux Falls, South Dakota

178378.MP.RP Figl-1_11x17_rev1 7-2-03

CH2MHILL

MOU
Attorney's Office
Human Resources
Chief of Staff

CITY OF SIOUX FALLS
OFFICE OF THE MAYOR
EXECUTIVE ORDER NO. 03-07

Subject: Storm Water Management Program
Water Quality Best Management Practices Exemption

In accordance with the City's Surface Water Discharge Permit #SDS-000001 and its corresponding approved Storm Water Management Program, this executive order establishes exemptions for complying with post-construction water quality Best Management Practices (BMPs) in Sioux Falls.

Any development that was initiated prior to December 28, 2002, that meets the following requirements, is exempt from complying with the structural BMP requirements in the Sioux Falls Engineering Design Standards:

Subdivisions: Subdivisions must have had preliminary plans approved prior to December 28, 2002, and must complete the platting of the development by December 28, 2005.

Site Development or Significant Redevelopment: Development must have received an approved City Conditional Use Permit or PD Final Development Plan prior to December 28, 2002, with site construction and development completed by December 28, 2005.

Date adopted: MAR 10 2003

Dave Munson, Mayor

S:\AS\Clark\EO\FIRST\EO021.DOC

Summary of Detention Basin Retrofit Summer 2002 Evaluation

PREPARED FOR: Jeff Dunn/Sioux Falls

PREPARED BY: Mark Mittag/CH2M HILL
Pat Nelson/CH2M HILL
Phil Blonn/CH2M HILL

DATE: July 30, 2003

As part of stormwater Phase I permit compliance measures, Sioux Falls completed a retrofit evaluation of existing detention basins in the summer of 2002. The evaluation was required under the City's Commercial/Residential Management Program for stormwater. The screening level analysis involved developing a priority ranking of detention basins based on retrofit feasibility taking into account various factors such as public acceptance, land use, downstream impact, operation and maintenance concerns, and flood control impacts. The purpose of the program was to determine if it would be feasible to modify the existing basins to improve water quality within areas of existing development.

With that purpose in mind, the retrofit evaluation provides information on potential detention pond retrofit candidates based upon the evaluation criteria. A detention pond with the potential to be retrofit to provide water quality benefits need not be retrofit to the same design standards as those contained in the City's Chapter 11 *Drainage Improvements* standards. Additional water quality benefits may still be able to be provided if a retrofit only partially meets the Chapter 11 standards. The analysis did not include an evaluation of the extent to which a retrofit could meet the Chapter 11 standards for existing development in the watershed. Thus, the intent of the program was not to retrofit existing ponds to supply the WQCV specified in the City's Chapter 11 standards but to supply whatever amount of WQCV is feasible.

The retrofit evaluation also did not include an analysis for the capability of a pond to be retrofit to meet water quality standards for new upstream development. It may be possible to provide additional benefits for upstream development, but that would require further analysis.

Example Evaluation Process

The following description of the analysis of pond #12 at 5th Avenue and Marion Road in the west area of the city serves as a good example of the type of retrofit analysis that was performed. The pond was rated high because of ease of maintenance access due to the long stretch of Marion Road adjacent to the site, regulations due to the low potential for wetland and stream permit issues, public acceptance and land use due to the commercial and light industrial land use prevalent in the area (the only residential areas present are manufactured homes across Marion Road), and flood control function due to available adjacent land. All these factors contribute to the listing of pond #12 as a good candidate for retrofit in order to achieve water quality benefits.

When the pond #12 retrofit is designed, the process should include a determination of the amount of water quality capture volume (WQCV) that could be feasibly provided given financial, space, and other design constraints. The amount of WQCV provided may not be sufficient to provide Chapter 11 WQCV standard for existing or future upstream development in the watershed. Any future development in the watershed upstream of the pond would need its own site-specific BMPs as required by Chapter 11 standards if the full WQCV cannot be provided at pond #12.

Additional information on the retrofit analysis is found in the City's Commercial and Residential Program documentation.

Contents