Final Report

Storm Water Master Plan

Mathews Avenue and Main Quadrangle

University of Illinois

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Foth

Mathews Avenue Corridor Stormwater Master Plan

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1.0 INTRODUCTION

1.1 PURPOSE OF STUDY

The University of Illinois at Urbana-Champaign ("University") is interested in developing a stormwater infrastructure assessment for the central portion of campus, along the Mathews Avenue corridor and including the Main Quad ("study area"). In addition to this assessment, the University would like to develop a Stormwater Master Plan for the study area. This Master Plan includes specific recommendations on flood control and stormwater quality enhancement.

Foth Infrastructure and Environment, LLC assessed the existing stormwater conveyance system within the study area and investigated multiple improvement options. Stormwater management was studied from two different perspectives:

- The first perspective focused on "grey infrastructure", including basic components such as inlets, pipes and manholes. This approach focuses on flood control and providing an adequate level of service for the unique needs of the University.

- The second perspective focused on "green infrastructure", including site retrofits to reduce the impact of impervious surfaces on receiving waters. This focus addresses water quality and pollution prevention.

1.2 STUDY AREA

The study area has been experiencing reoccurring flooding problems, based on interviews with University staff. Compounding this issue, many of the flooded areas are around or even within historical University buildings. The University made the decision to conduct a drainage study of the following flood-prone elements:

- The storm sewer along Mathews Avenue which is the main trunk line draining the University buildings and the street towards the Boneyard Creek. Previous efforts by the City of Urbana and University staff have revealed that the Mathews Avenue storm sewer is in poor structural condition. It has been recently cleaned and de-rooted.

- The Noyes Chemistry Laboratory which experiences occasional flooding within its courtyard and the tunnel from the lower level to the south. On occasion the flooding enters the lower level and floods offices and labs. This flooding became slightly less frequent after the Mathews Avenue storm sewer was cleaned in 2009; however, the problem still exists.

- Harker Hall which has experienced flooding from surcharged storm sewer inlets immediately outside the building. Based on interviews with University staff familiar with Harker Hall, the inlet immediately north of the north door will flood first. Shortly after, the inlets to the south will surcharge. Both of these inlets are only a few inches below the first floor elevation. It is common for the water to rise high enough to enter Harker Hall, allowing water to flow into the main floor of the building.

The study area was divided into two primary subbasins (see Figure 1-1):

- **Mathews Avenue Subbasin.** This 24-acre area consists of all areas upstream and draining to the storm sewer system that runs along Mathews Avenue.

- **Main Quad Subbasin.** This 20-acre area is immediately west of the Mathews Avenue Subbasin and consists of the Main Quad grassed area, including the rear of buildings along Mathews and Wright that drain towards the Quad. This system was studied at the request of the University in order to verify whether it causes flooding identified in and around Harker Hall.

The general drainage pattern in the study area is from the south to the north. The Mathews Avenue subbasin and the Main Quad subbasin independently outlet into the Boneyard Creek north of Engineering Hall. Both subbasins are illustrated in Figure 1-1.

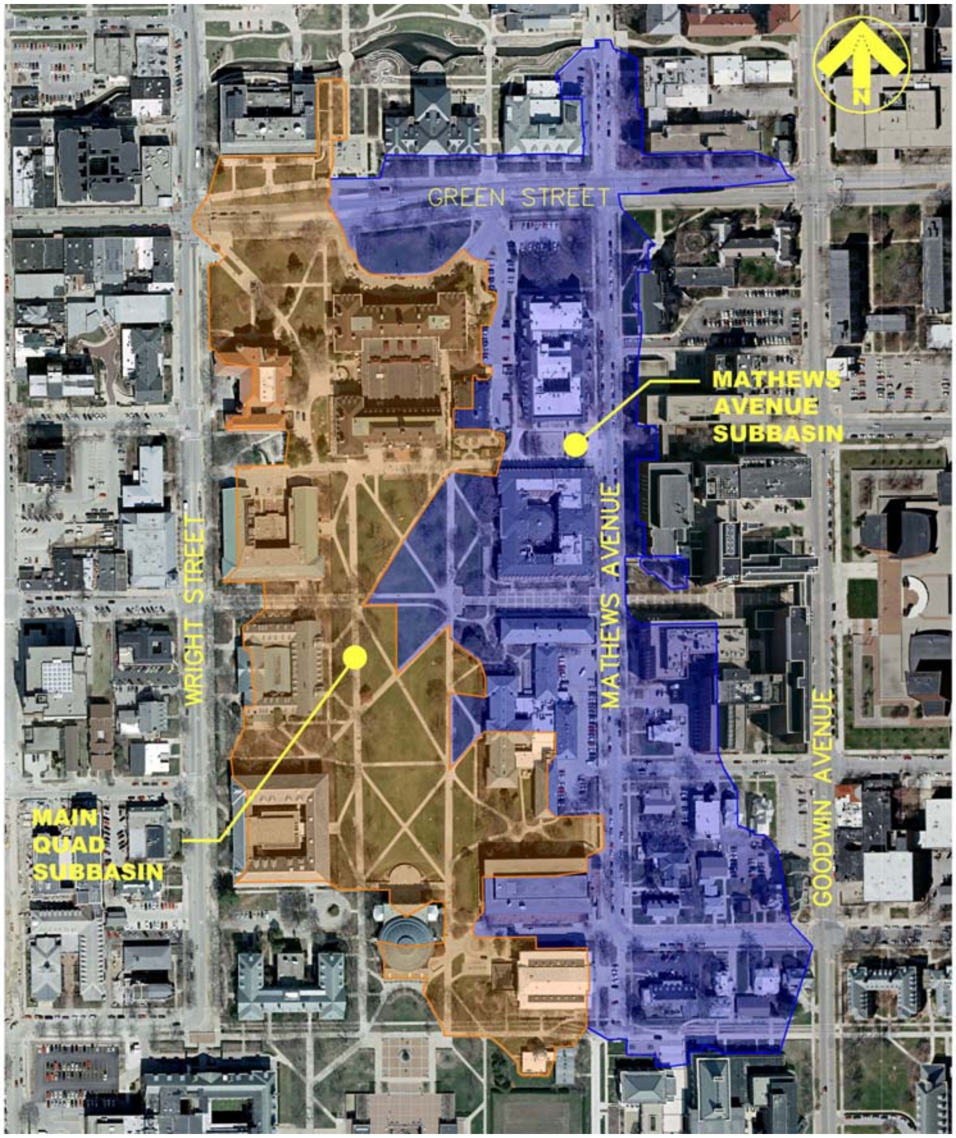


Figure 1-1
Studied Subbasins

1.3 INTRODUCTION TO LOW IMPACT DEVELOPMENT

The addition of impervious surfaces (i.e. rooftops and parking lots) increases runoff potential. Traditional stormwater management consists of a stormwater collection system and immediate transport of stormwater runoff downstream to a receiving water body (such as a lake, river or creek). This describes the current stormwater management system in the study area, which discharges directly to the Boneyard Creek.

Traditional stormwater management provides for flood control, but does not explicitly address stormwater quality. Emerging trends in stormwater management (including regulatory changes) promote stormwater infiltration as an effective method to reduce the impact of development on stormwater runoff quantity and quality. Low Impact Development (LID) is a practice through which decentralized stormwater controls, such as stormwater Best Management Practices (BMPs), are used to intercept stormwater and allow it to infiltrate, as opposed to flowing directly to a receiving stream.

LID design focuses on more frequent storms (i.e. 1 inch of rainfall over a 1 hour period) as opposed to traditional design which focuses on less frequent but more intense rainfalls. The goal of LID design is to minimize (or eliminate) stormwater runoff for frequent storm events (see Figure 1-2). A typical goal for such designs is infiltrating the first 1 inch of rainfall, allowing larger storms to access the conventional stormwater collection system. This design technique tends to mimic pre-development hydrology and improve the overall health and stability of downstream river systems.

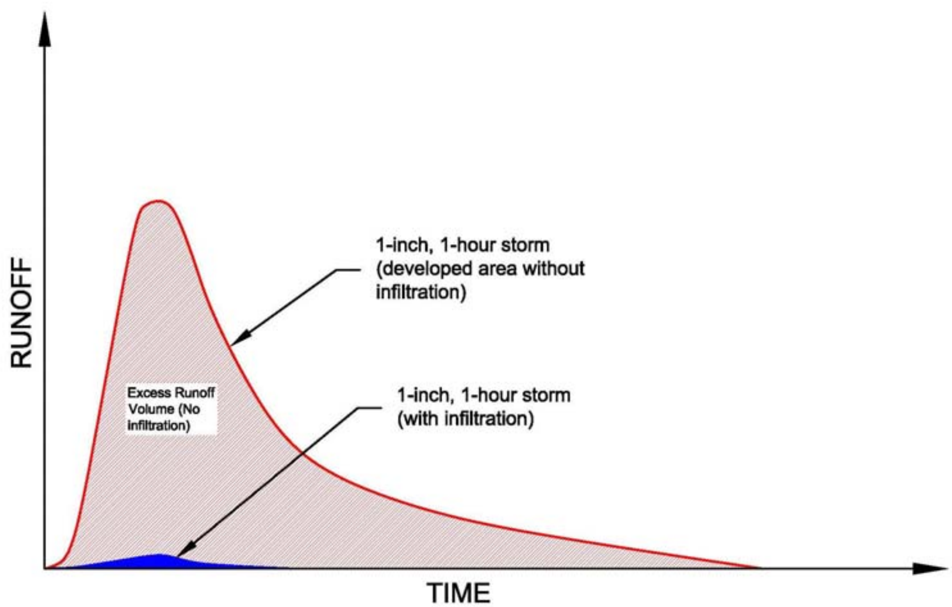


Figure 1-2
Impact of Infiltration of Runoff Potential for Frequent Storms

Approximately 70% of the study area is impervious, and there are currently no means to infiltrate stormwater runoff. The majority of stormwater runoff from these impervious areas discharges directly into the storm sewer and ultimately into the Boneyard Creek. Without infiltration, this runoff transports significant volumes of trash, debris, sediment, and pollutants from the impervious areas and deposits them into the Boneyard Creek.

Key results of LID are:

- Complete or near-complete infiltration for the first-flush storm (approximately 1 inch of rainfall in 1 hour)
- Reduction in concentrations of known stormwater pollutants, including (but not limited to) Nitrogen, Phosphorus, Lead, Zinc, Copper, Fecal Coliform, etc….
- Reduced stress on receiving streams, as runoff volumes are maintained (traditional stormwater management results in prolonged periods of increased flows in receiving streams, which accelerates stream bank erosion).
- Increased land values, as properly-designed BMPs create an attractive landscape, and can often be integrated into green space otherwise relegated to turf grass.

1.4 BENEFITS OF LID FOR THE UNIVERSITY

Installing and maintaining stormwater BMPs to promote infiltration will allow the University to take credit for these practices in its NPDES Phase II (stormwater) permit. These BMPs can also be used to educate students, local residents, developers, and engineers on innovative stormwater management, allowing the University to satisfy the public education requirements for their NPDES permit.

Practicing LID along the Mathews Avenue corridor can set an example to the students and the local community, educating and encouraging students and general public alike on LID. As a leader in the community, the University can continue to set the standard for sustainable site design with respect to stormwater.

Upon our review of the University's Notice of Intent (for the IEPA Stormwater Permit), the following BMPs are closely related to the type of design/construction recommended in the report:

- BMP B.1.2 *(Meet with Environmental Stewardship Committee to review storm water quality and storm water issues around campus)*
- BMP E.2.1 *(Upgrade stormwater management policy)*
- BMP E.3.1 *(Evaluate feasibility of bio-retention areas for new or redeveloped surface parking lots)*

Any significant steps forward the University can make with respect to stormwater design in the Mathews Avenue Corridor can be documented to show that the University is serious about its compliance with the IEPA NPDES stormwater rules and is willing to be a local leader in implementing design methods that will enhance stormwater quality.

Furthermore, this study area drains into the City of Urbana stormwater management system and will therefore be subject to fees as part of a likely Stormwater User Fee that is currently being planned by the City of Urbana. Any modifications that effectively “disconnect” impervious surfaces through bioretention or other infiltration measure should be eligible for stormwater user fee credits. It is anticipated that the City of Urbana will provide a stormwater credit system for their proposed user fee and the University should be able to participate in this program. At this time, it is unknown what the economic impact of these credits would be, but it should be expected that stormwater infiltration should reduce the overall fee within those areas that are retrofitted.

1.5 STUDY GOALS

The goals of the drainage study are as follows:

- Evaluate the stormwater infrastructure in the study area.
- Confirm areas of chronic flooding problems using hydrologic/hydraulic modeling and identify deficient stormwater infrastructure.
- Meet with University staff and building managers to confirm the locations and severity of flooding.
- Evaluate traditional engineering improvements to reduce the frequency of street and building flooding along Mathews Avenue and the Main Quad.
- Evaluate options to reduce flooding in chronic problem areas.
- Evaluate Sustainable Low Impact Development options to reduce runoff volume for smaller more frequent rain events and enhance water quality for the University’s stormwater discharges to the Boneyard Creek.

2. HYDROLOGIC/HYDRAULIC MODELING

2.1 GENERAL CONVEYANCE

The majority (approximately 70%) of the study area is impervious consisting of rooftops, sidewalks, bike paths, parking lots, patios, and streets. The storm water is conveyed via overland flow directly into inlets (or downspouts) and into lateral storm sewer pipes. The lateral storm sewer pipes join together in either the Mathews Avenue storm sewer system or the Main Quad storm sewer system. See Figure 2-1 for an illustration of the storm sewer systems. Each of these storm sewer trunk lines empty directly into the Boneyard Creek north of Engineering Hall.

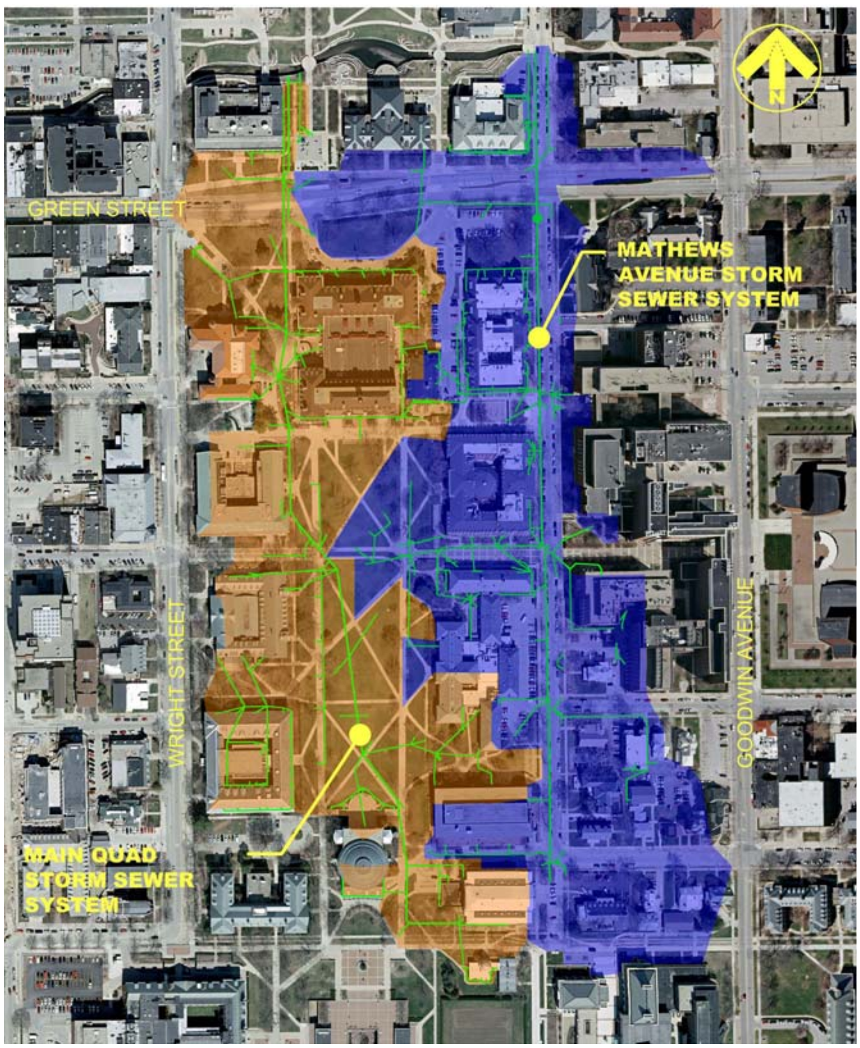


Figure 2-1
Mathews Avenue and Main Quad Sewer Systems

2.2 HYDROLOGY

A hydrologic analysis of the study area was performed using XP-SWMM v.2011, a proprietary version of the Environmental Protection Agency (EPA) Storm Water Management Model (SWMM). The storm sewer system was analyzed under the following conditions:

a. 1-year recurrence interval
b. 10-year recurrence interval
c. 50-year recurrence interval

A critical duration analysis was performed to determine the rainfall duration that will result in the highest peak flow rate for each modeled storm. Rainfall durations of 3 hours, 2 hours, 1 hour and 30 minutes were analyzed for the 3 recurrence interval storms listed above. The 30-minute rainfall duration yielded the highest peak flow rates for each analyzed storm.

The EPA SWMM model of the Boneyard Creek, including all recent upstream flood control improvements, was added to the XP-SWMM model to accurately represent downstream boundary conditions and to verify whether the Boneyard Creek hydraulics impact the studied sewer system. The 2-hour duration storm event was chosen as it represents the storm duration that results in the highest peak flow rates in the Boneyard Creek. This analysis was deemed necessary to show whether the peaking in the Boneyard Creek would adversely impact the hydraulics along the storm sewer components in the study area.

Both the 10-year and the 50-year storms were chosen for the analysis of existing and proposed hydraulic characteristics. Although the 10-year storm is typical for municipal storm sewer design, the 50-year storm was also analyzed to determine the amount of improvements necessary to protect against surcharging within areas (i.e. tunnels and courtyards) that adversely impact the function of University facilities.

Rainfall depths in this study were based on data from the National Oceanic and Atmospheric Administration (NOAA) Atlas of the United States (Atlas 14, Volume 2, Version 3) Precipitation-Frequency tabular. These data are the most recent data published and include 20 years of additional data not included in the commonly used Bulletin 70. The more recent NOAA data generally indicate slightly higher rainfall depths for the same storms previously indexed from the Bulletin 70 data. The following rainfall depths were used for the modeling effort:

	3-hour duration (inches)	2-hour rainfall duration (inches)	1-hour rainfall duration (inches)	30-minute rainfall duration (inches)
1-year storm	1.61	1.50	1.26	1.03
10-year storm	2.76	2.57	2.17	1.71
50-year storm	3.83	3.53	2.87	2.18

The Mathews Avenue and Main Quad subbasins were further divided into multiple drainage areas. This was done to quantify the amount of stormwater runoff entering specific junctions and to assist in the evaluation of site-specific improvements. XP-SWMM was used to generate runoff hydrographs for each drainage area.

Modeling the drainage areas with XP-SWMM takes into consideration the average shape, slope, and pervious percentage of each subbasin. All rainfall on impervious areas becomes runoff. Pervious areas were calculated with a decaying infiltration rate with excess rainfall becoming runoff. Infiltration rates used for the hydrologic analysis in this study are the same values as assigned for the Mathews Avenue subbasin in the EPA SWMM model of the Boneyard Creek watershed.

2.3 HYDRAULICS

The hydraulic analysis for this study, also performed using XP-SWMM, included the two storm sewer systems and the Boneyard Creek. The storm sewer layout and connectivity were obtained from University's GIS data with rim and invert elevations based on field survey data provided by the University.

Recent sewer televising along Mathews Avenue (facilitated by the City of Urbana) was used to determine the current condition of the existing pipes. The existing pipes have deteriorated and are in poor structural condition. There are many segments of the existing pipes that are cracked, deflected, and clogged by roots. Figure 2-2 includes examples of the root penetration and pipe deformation.

Clogged Pipe (Root Intrusion)

Deformed Pipe (Longitudinal Cracking)

Figure 2-2
Mathews Avenue Storm Sewer Conditions

The existing conditions hydraulic model was adjusted to reflect the reduced hydraulic efficiency resulting from structural defects as illustrated in Figure 2-2.

The hydraulic impacts of the Boneyard Creek were added to the XP-SWMM model using data from the EPA SWMM model of the Boneyard Creek. The model version used was most recently updated by Camp, Dresser & McKee (CDM) to account for additional stormwater detention constructed between Springfield and University Avenues (Second Street Detention Project).

The EPA SWMM model components used for this project were Boneyard Creek cross sections between Wright and Goodwin, and flow hydrographs at Wright Street (representing upstream flows entering the studied reach of the Boneyard).

The XP-SWMM model includes outlets for the two studied trunk storm sewers into the Boneyard Creek. The hydraulic conditions within the Boneyard Creek were included in our analysis of all system scenarios.

2.4 HYDROLOGIC/HYDRAULIC MODEL SCENARIOS

The scenarios modeled to analyze the study area are listed below. The scenarios were used to model the impacts of the recommended improvements.

XP-SWMM Model Scenarios

Scenario 1	Existing Conditions
Scenario 2	Lining of Existing Pipes (Mathews Ave Only)
Scenario 3	Hydraulic Improvements

The first scenario models the study area in its current state, with modifications made to represent the deteriorating condition of the sewers. Due to the pipe conditions illustrated in Figure 2-2, the Manning's roughness coefficient was increased to represent rougher pipe wall conditions.

The second scenario includes an analysis of the impacts of lining the existing storm sewers. To simulate the rehabilitated pipes, the sewer diameter was reduced to represent the thickness of the pipe lining material. The Manning's roughness coefficient was also reduced to represent the smooth interior of the lining material.

The third scenario represents the recommended hydraulic improvements to the storm sewer system. The diameter of main trunk of the Mathews Avenue storm sewer was analyzed under several size scenarios, ranging from 36-inch diameter to 48-inch diameter. Section 4 includes specific recommendations for pipe sizes.

2.5 LID SCENARIO

XP-SWMM was also used to model the impacts of the recommended stormwater infiltration areas. An annual rainfall data set, representing the typical rainfall occurring in Champaign County during the growing season, was used to model the long-term impacts of the proposed stormwater infiltration areas on runoff volume to the Boneyard Creek. The recommendations for specific stormwater infiltration areas are included in Section 4.

3.0 RELEVANT FINDINGS

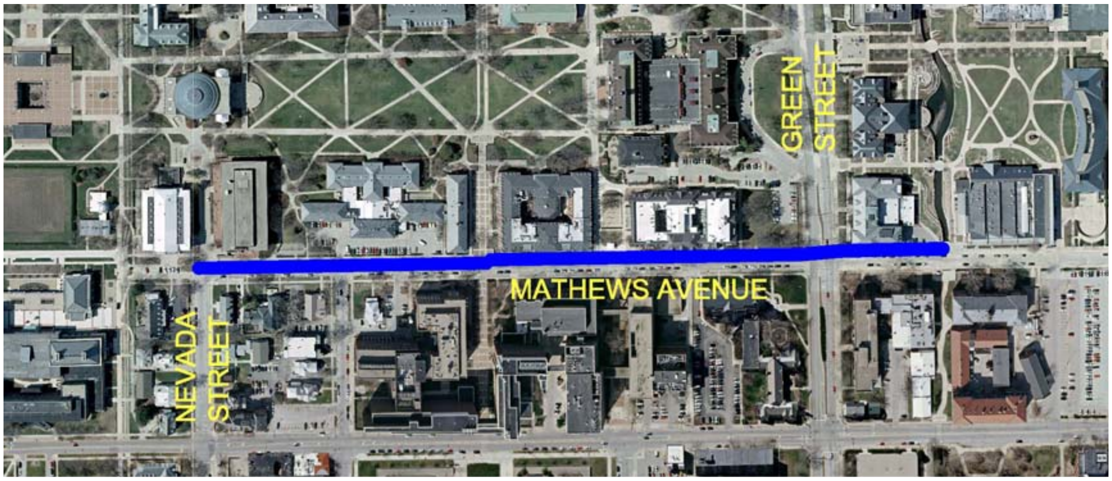
3.1 BONEYARD CREEK

The Boneyard creek water levels do not affect the studied storm sewer systems for the storms analyzed as part of this study. The Boneyard Creek, at its maximum elevation during a 100-years storm, ranges from an elevation of 710.3 at Mathews Avenue to 711.7 at Wright Street. The Mathews Avenue and Main Quad storm sewer systems outlet at 708.75 and 705.20, respectively. While the Boneyard Creek can exceed the elevation of the two storm sewer outfalls, this does not affect the flow capacities of either the Mathews Avenue storm sewer system or the Main Quad storm sewer system. As the time differential between the peak flow in the study area and the Boneyard Creek is significant for most large storms, we do not expect the Boneyard Creek to adversely impact the drainage system in the study area.

Figures 4-5a and 4-5b in Section 4 provide additional detail on the timing impacts of the Boneyard Creek flows relative to the Mathews / Quad storm sewer systems.

3.2 MATHEWS AVENUE STORM SEWER

The Mathews Avenue storm sewer is undersized and will not adequately serve the Mathews Avenue subbasin. This sewer will be subjected to significant hydraulic surcharge for storms as frequent as the 1-year recurrence interval. Figure 3-1 illustrates the level of hydraulic surcharge in this storm sewer.



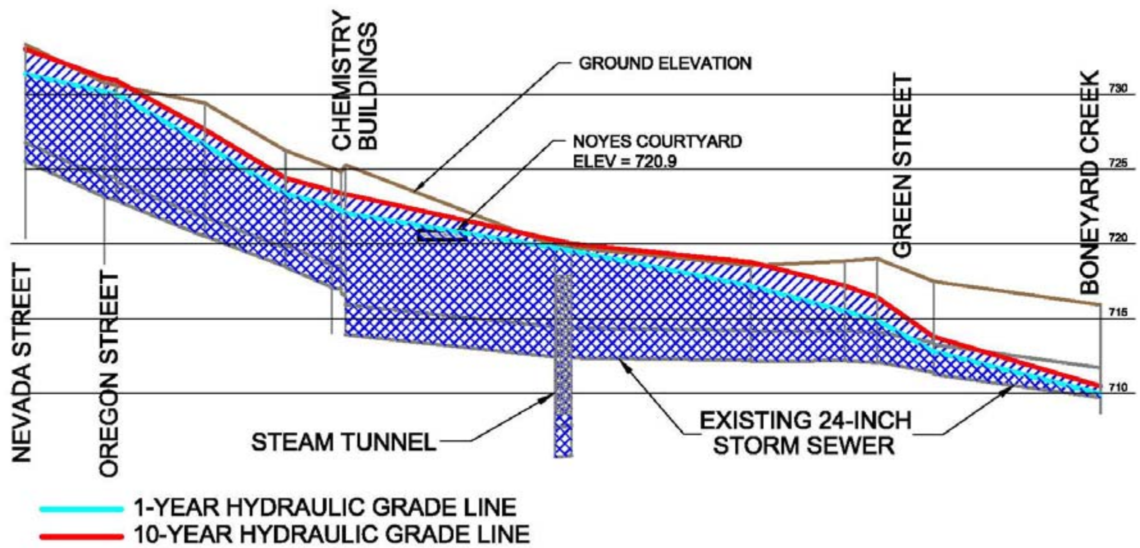


Figure 3-1
Hydraulic Profiles – Existing Mathews Avenue Storm Sewer

Rehabilitating (i.e. relining) the Mathews Avenue storm sewer will have not have a material impact on flow capacity, as the existing pipe size is well below what is needed to convey stormwater in this area. Figure 3-1 illustrates the hydraulic profiles along Mathews Avenue. Figure 3-2 identifies locations of sewer surcharge for the entire study area, color-coded by severity.

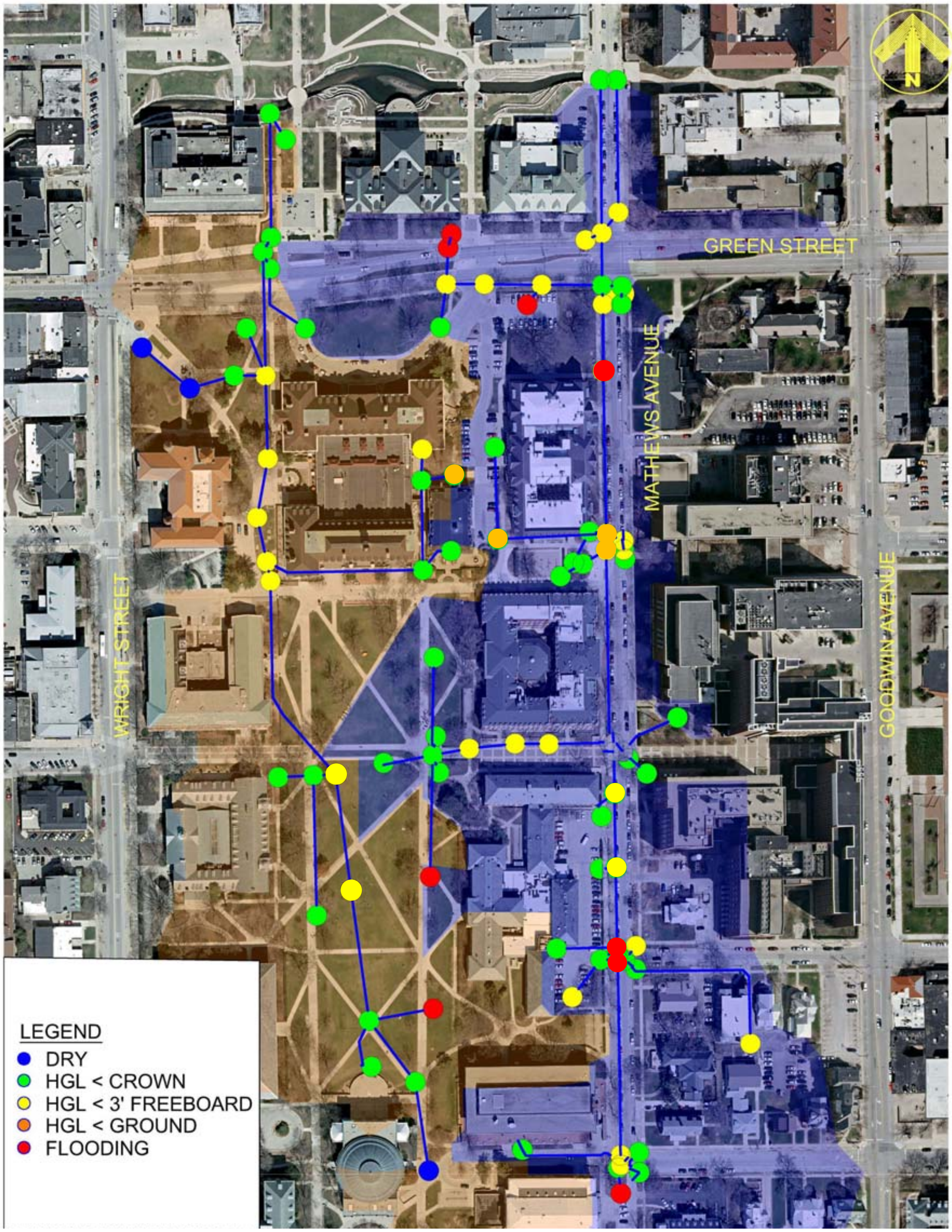


Figure 3-2
Storm Sewer System Surcharges
10-year Storm – Existing Conditions

3.2.1 Noyes Chemistry Laboratory

The Noyes Chemistry Laboratory ("Noyes") courtyard and first floor are approximately four feet below the adjacent ground elevation around the exterior of Noyes. The courtyard has two catch basins that outlet directly to the storm sewer along Mathews Avenue. Based on information from University staff, the courtyard inlets will occasionally flood, sometimes extending into the building.

The observed flooding within the Noyes courtyard appears to be directly related to the hydraulic surcharging of the Mathews Avenue sewer.

3.2.2 Noyes Tunnel

The pedestrian tunnel between Noyes, the Chemistry Annex and Roger Adams Laboratory has experienced reoccurring flooding. Between the start of the tunnel at Noyes and the branch where the tunnel splits to the two other buildings there is an opening in the floor. The purpose and connectivity of this opening is unknown. It does not appear to be a floor drain as it is located towards the high end of the tunnel.

During periods of heavy rain, University officials have observed water surcharging out of the opening (See Figure 3-3). Although we have not been able to confirm to which pipe this opening in the floor is connected, our modeling results suggest that the surcharging within the Mathews Avenue storm sewer forces stormwater to back up into the tunnel as shown in Figure 3-3.

The observations of water surcharging into the tunnel coincide with heavy rain events. This suggests that this opening is hydraulically connected to the Mathews Avenue storm sewer (or one of its laterals) and is subject to the hydraulic surcharging of the system.

Figure 3-3
Opening in Tunnel Immediately South of Noyes Hall

3.3 MAIN QUAD STORM SEWER

The Main Quad storm sewer does not provide adequate hydraulic capacity for the 10-year recurrence interval storm.

Based on our review of storm sewer data and interviews with University staff, there were no direct complaints about flooding within or immediately surrounding the buildings between the Main Quad storm sewer and Wright Street. This is likely due to the fact that this system is directly under the central Quad, and some occasional flooding in grassed areas is observed and expected. However, this type of surcharging can impact adjacent buildings that are hydraulically connected to the storm sewer.

Figure 3-4 illustrates the studied sewer reach and corresponding hydraulic profiles along the Main Quad storm sewer. Figure 3-2 identifies locations of sewer surcharge during the 10-year storm, color-coded by severity.

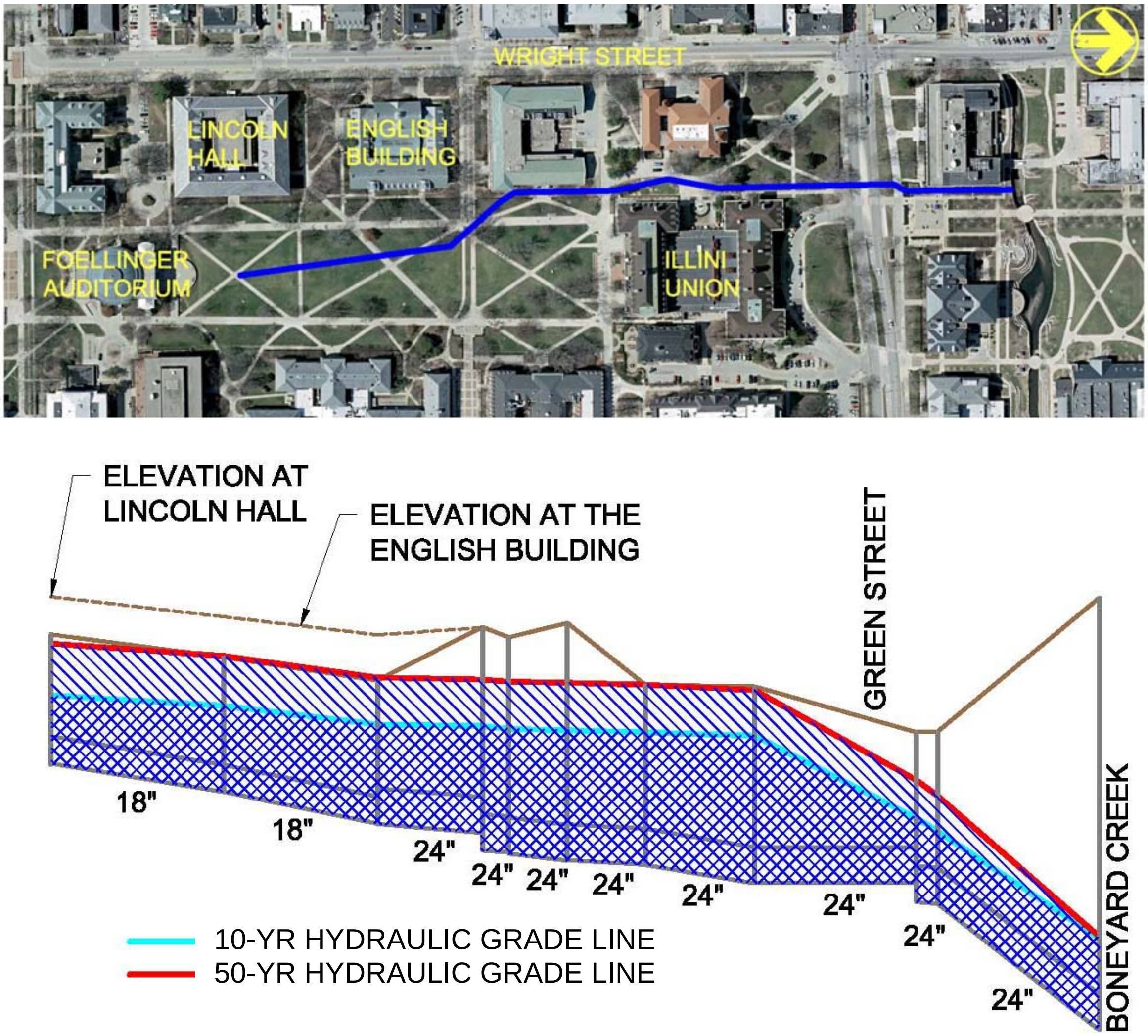


Figure 3-4
Main Quad Storm Sewer: 10-year and 50-year Hydraulic Profiles

The northern (downstream) component of the Quad storm sewer is undersized and is causing a surcharge condition that impacts facilities such as Harker Hall (see Figure 3-5). The 10-year storm will cause significant surcharging and the 50-year storm will surcharge the majority of the Main Quad storm sewer to the surface.

3.3.1 Harker Hall

Harker Hall has a recent history of the storm sewer inlets on both the north and the south sides of the building flooding. This flooding has been observed multiple times per year. The inlet immediately north of Harker Hall (see Figure 3-5) experiences the most frequent flooding and is generally the first to flood. Generally, the inlets immediately south of Harker Hall will begin to surcharge shortly after the inlet to the north. Occasionally, inlets further northeast of Harker Hall (see Figure 3-5) will surcharge and water has been observed to "bubble up" from the manhole.

The sewer from the inlet immediately north of Harker Hall is relatively shallow and the sewer from this inlet to the southwest corner of Harker is relatively flat. However, the hydraulic analysis revealed that the storm sewer in this area should adequately convey runoff without significant surcharge (except for rare storm events, such as the 50-year storm).

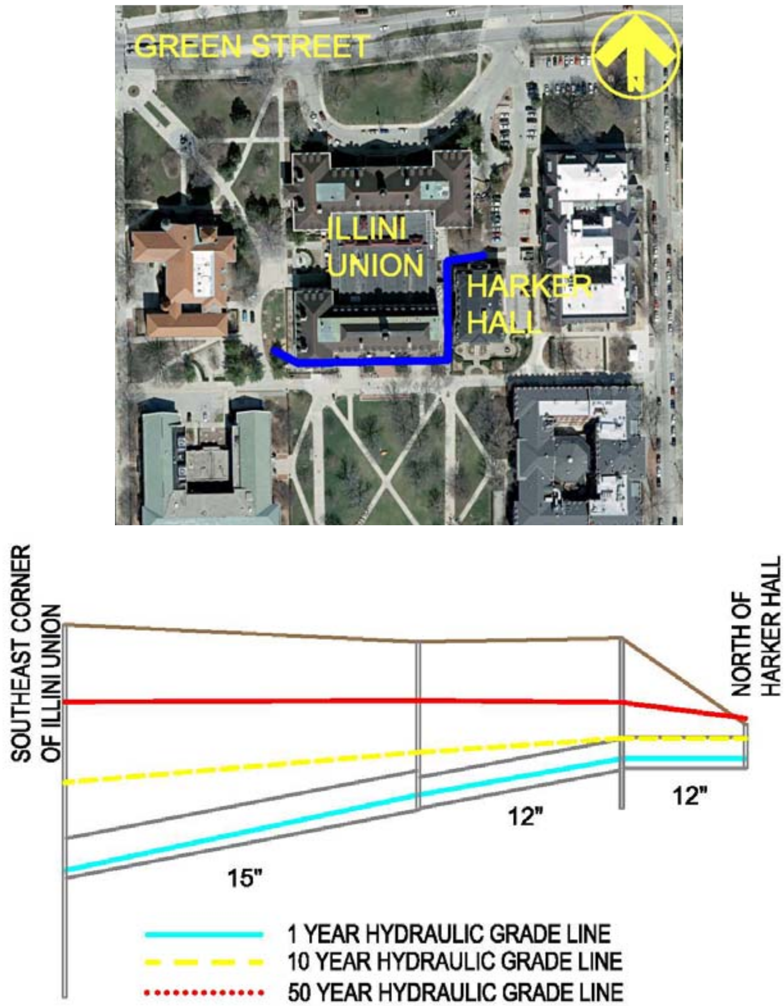


Figure 3-5
Harker Hall Profile

The hydraulic analysis of the storm sewer leading to Harker Hall suggests that the sewer should adequately convey flows from the 1-year and 10-year rain events. Upon discussing this finding with University staff, the sewers around the south side of the Illini Union were cleaned and televised. This effort revealed that the 15-inch sewer had two structural failures and root intrusion. This was the likely source of frequent flooding at Harker Hall.

4.0 RECOMMENDED IMPROVEMENTS

4.1 HYDRAULIC IMPROVEMENTS – MATHEWS AVENUE

The existing conditions hydraulic analysis revealed that the primary deficiencies in the study area are:

- Undersized and structurally-deficient storm sewer on Mathews Avenue
- Low-lying building areas that are directly connected to the storm sewer system and within the influence of the predicted hydraulic surcharge

Based on our hydraulic analysis, the existing flooding problems within the study area are tied to the above deficiencies.

The proposed hydraulic improvements within the Mathews Avenue subbasin are as follows:

Improvement	Description / Notes	Key Benefits
Replace the Mathews Avenue storm sewer from the Boneyard Creek to Nevada Street, ranging in size from 18-inch diameter (near Nevada) to 48-inch diameter (from the south side of Noyes Lab to the Boneyard Creek).	The proposed storm sewer should replace the existing storm sewer and follow the same approximate profile and alignment so as to minimize potential utility conflicts. It will be necessary to construct the proposed sewer under the steam tunnel crossing of Mathews Avenue.	Reduces the hydraulic surcharging along Mathews Avenue and prevents backups into the Noyes courtyard. Reduced hydraulic pressures along Mathews Avenue will reduce the duration and magnitude of saturated soil conditions for buildings along the Mathews Avenue corridor.
Cap / plug the floor opening in the Noyes pedestrian tunnel. If this floor drain is connected to the storm sewer system (as suspected), it is an illicit connection and should be removed.	Do not perform this work until the connection to the storm sewer system is verified by smoke testing and/or dye testing.	Prevents backflow from the storm sewer system into the pedestrian tunnel.
Clean and televise the primary east-west storm sewer laterals draining the buildings and plazas west of Mathews Avenue. This effort may result in additional sewer rehabilitation or replacement.	Due to existence of tree root systems, pipe age, and known structural problems with other nearby storm sewers, confirmation of pipe condition is critical in this area.	Reduces threat of storm sewer backups near or within University facilities along Mathews Avenue.

4.1.1 Alternatives

Three storm sewer sizes were considered for the northern (downstream) component of Mathews Avenue. The benefits of each sewer size are summarized in the following table.

Sewer Diameter	System Impacts
24-inch (Existing)	Mathews Avenue storm sewer system is surcharged during the 1-year event. System overflows and street/courtyard flooding occur for all storms analyzed in this report.
36-inch (Alternate 1)	Mathews Avenue storm sewer system is moderately surcharged during the 10-year event, with additional surcharging and courtyard flooding (Noyes) during the 50-year event.
42-inch (Alternate 2, Proposed)	Mathews Avenue storm sewer system is moderately surcharged during the 10-year event, with additional surcharging during the 50-year event. The 50-year high water level will reach the elevation of the Noyes courtyard.
48-inch (Alternate 3, Proposed)	**Mathews Avenue storm sewer system is only minimally surcharged during the 10-year event, with moderate surcharging during the 50-year event. The 50-year high water level would be at least 1 foot below the elevation of the Noyes courtyard.**

A 48-inch diameter sewer is recommended for the replacement along Mathews Avenue from the south side of Noyes to the Boneyard Creek. Although the 36-inch and 42-inch diameter options will provide adequate protection against severe surcharging during a 10-year recurrence interval storm, the 48-inch storm sewer will provide an additional factor of safety against flooding within the Noyes courtyard and the pedestrian tunnel south of Noyes, which is important due to the direct connection of the Noyes courtyard to the Mathews Avenue storm sewer system and the likely connection of the pedestrian tunnel connection to the same storm sewer.

A new 24-inch storm sewer is recommended to replace the 15-inch and 18-inch storm sewers from the south extent of the proposed 48-inch storm sewer to Nevada Street (see Figure 4-3). Two short segments of 36-inch storm sewer are recommended immediately upstream of the proposed 48-inch sewer. This will help to control hydraulic surcharging in the southern portion of the study area.

The Mathews Avenue storm sewer south of Nevada Street is adequately sized to convey runoff with some surcharging. However, based on University storm sewer maps, surcharging south of Nevada should only impact street inlets and would result only in minor ponding at low points along Mathews Avenue.

Figures 4-1 and 4-2 illustrate the impact of improvements to the Mathews Avenue storm sewer on the hydraulic profiles. Figure 4-3 includes a plan view of system surcharges under proposed conditions.

Figure 4-4 illustrates the impact on sewer enlargement on Mathews Avenue on the east-west storm sewer between Noyes and the Chemistry Annex.

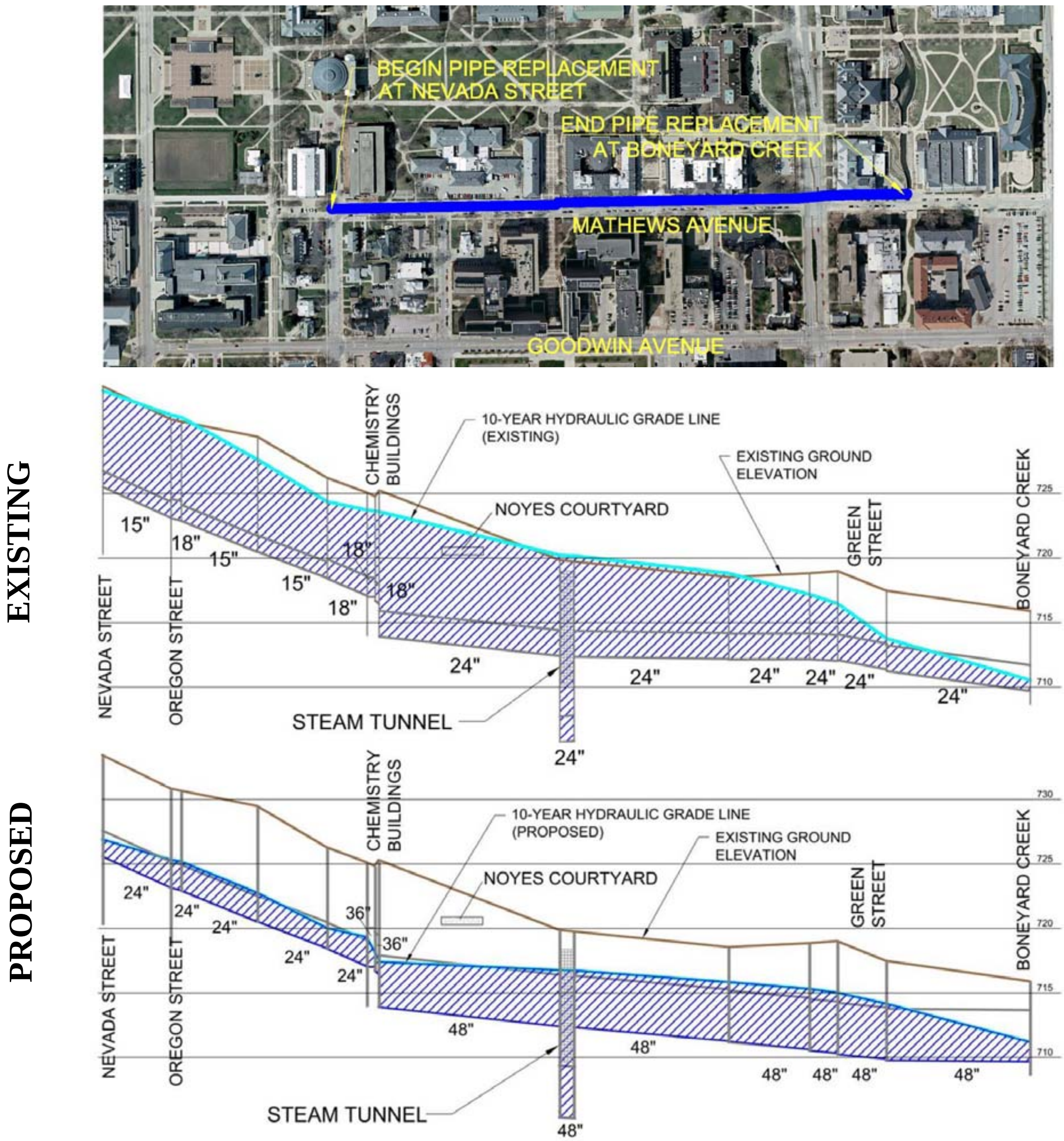


Figure 4-1
Mathews Avenue Storm Sewer Improvements – 10-year Storm

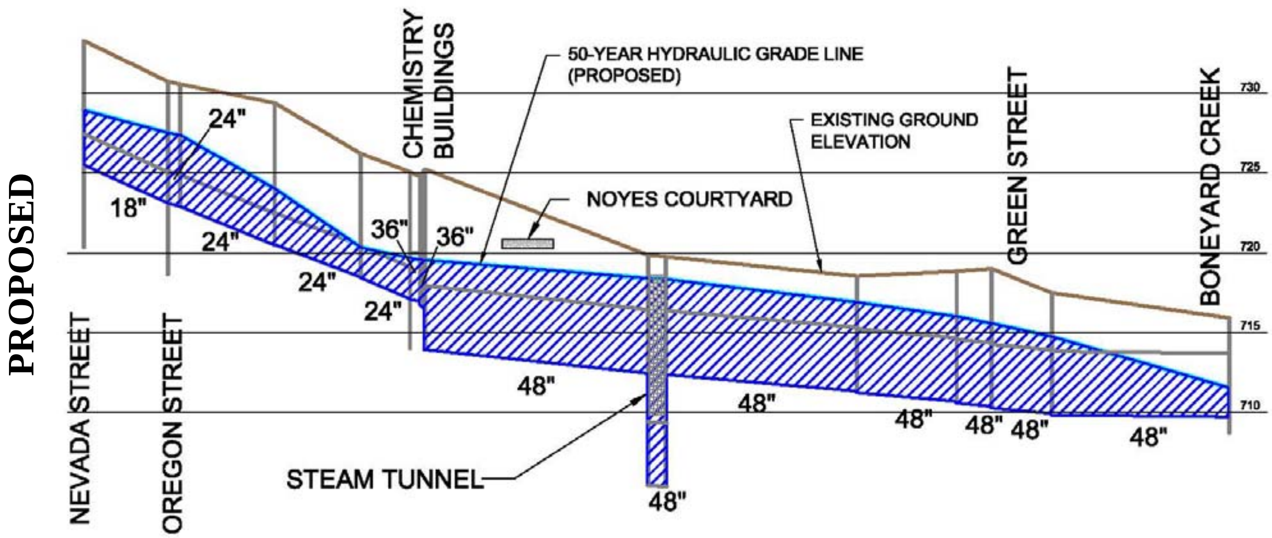


Figure 4-2
Mathews Avenue Storm Sewer Improvements – 50-year Storm

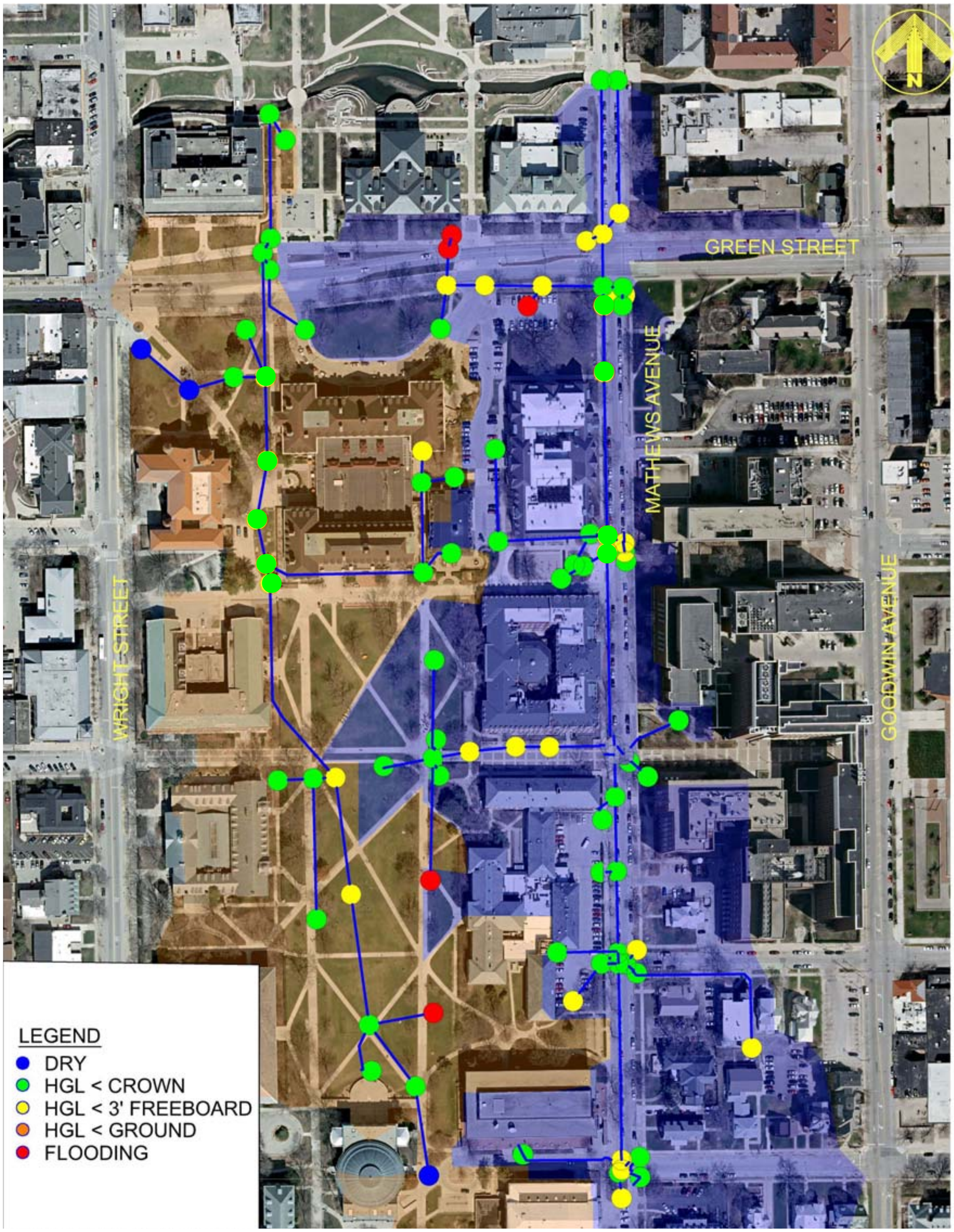
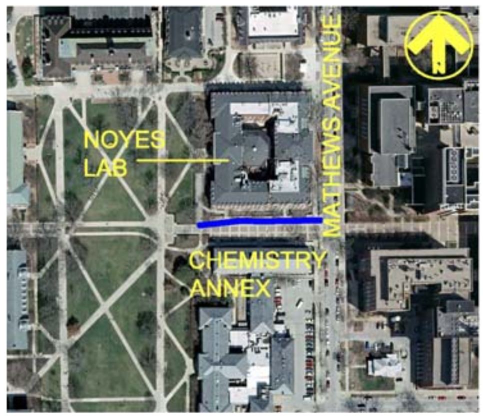


Figure 4-3
Mathews Avenue Storm Sewer System Surcharges
Proposed 10-Year Event Conditions

Figure 4-3 shows that the storm sewer system, under proposed conditions, will still surcharge above the ground surface at several locations. Two of these locations are on the Main Quad and should not adversely impact University facilities. The surcharged locations along Green Street (and the parking area northeast of the Illini Union) would experience brief and minor ponding during a 10-year event.

Eliminating the flood potential at the remaining "red dot" locations on Figure 4-3 would require significant additional investment and would not likely result in any meaningful flood reduction, as minor street and parking lot flooding is common (and manageable) during heavy storms .



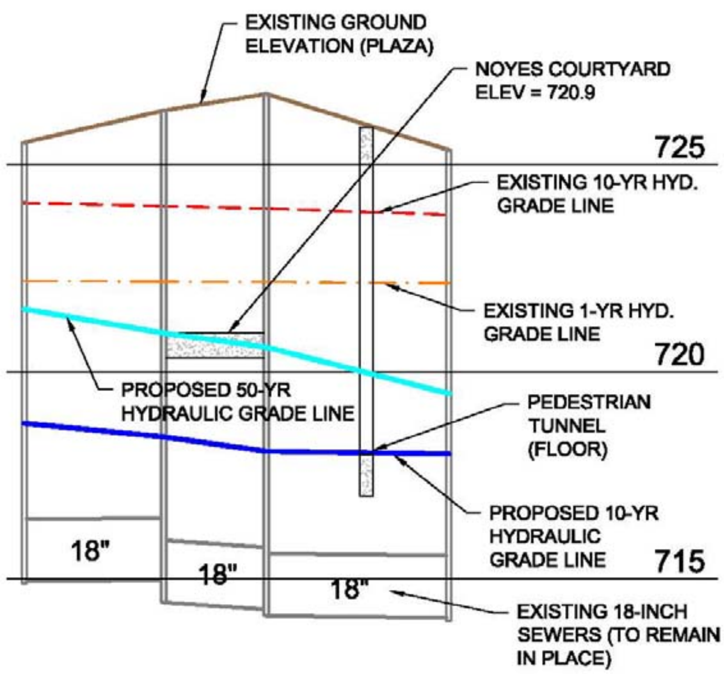


Figure 4-4
Storm Sewer Lateral South of Noyes Laboratory
Hydraulic Impacts of Mathews Avenue Sewer Replacement

The proposed replacement of the Mathews Avenue storm sewer will have a profound impact on the hydraulic grade line along critical lateral sewers. The existing storm sewer between Noyes and the Chemistry Annex will not need to be replaced, as the larger Mathews Avenue storm sewer will lower the hydraulic grade line enough to avoid the need for additional sewer replacement.

Furthermore, the hydraulic grade line should be low enough to minimize the potential for surcharging into the pedestrian tunnel south of Noyes (see Figure 4-4). This should facilitate the eventual removal of the floor drain discussed earlier in this report.

Figures 4-5a and 4-5b illustrate the impact of the Mathews Avenue storm sewer improvements on peak flows. Although the improvements will increase peak flows *to* the Boneyard Creek, they will not increase peak flows *within* the Boneyard Creek. This is due to the timing of peak flows in the study area versus the Boneyard Creek watershed. Figures 4-5a and 4-5b show that the improved system will allow the stormwater runoff to drain efficiently to the Boneyard Creek in the early stages of a heavy rainfall, with flow rates dropping off quickly before the Boneyard Creek reaches its crest. *This has the overall impact of reducing peak flows in the Boneyard Creek.*

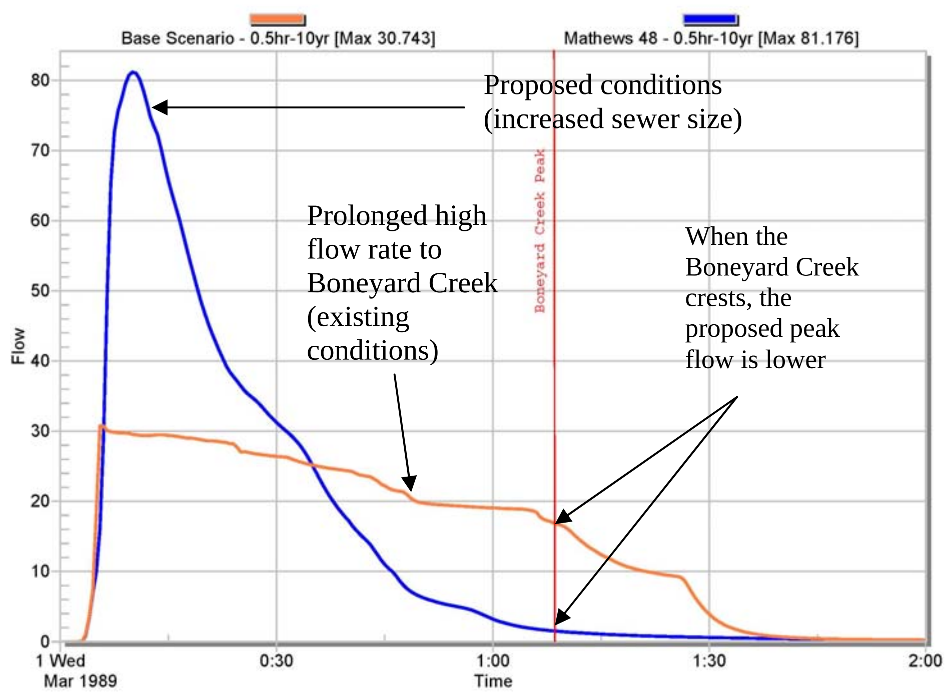


Figure 4-5a
Proposed Improvements: Impact on Peak Flows (10-year Storm)

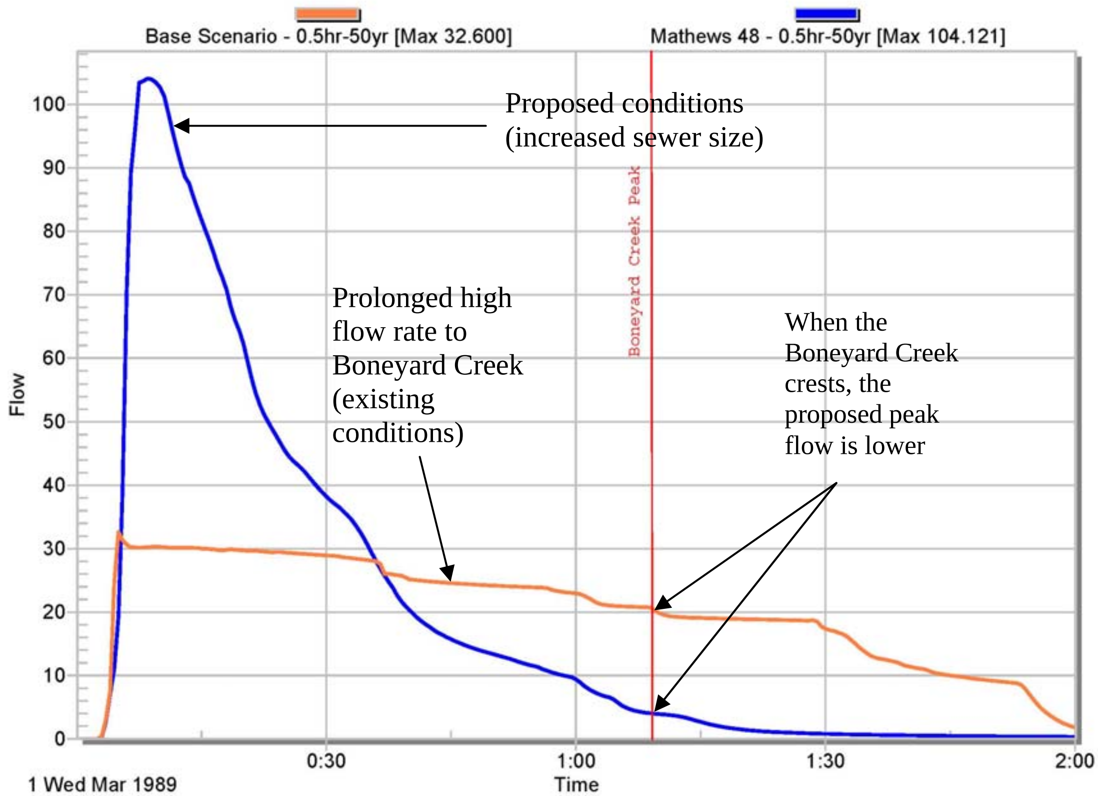


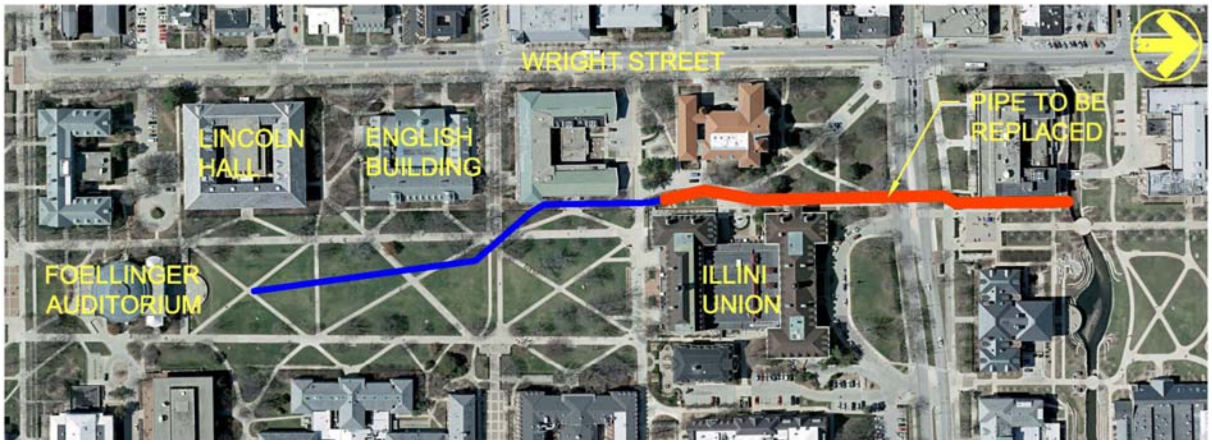
Figure 4-5b
Proposed Improvements: Impact on Peak Flows (50-year Storm)

4.2 HYDRAULIC IMPROVEMENTS – MAIN QUAD

Based on our findings summarized in Chapter 3, there is a need to replace the existing 24-inch storm sewer from the southwest corner of the Illini Union to the Boneyard Creek with a 36-inch storm sewer (see Figure 4-6). Additionally, given the occurrence of structural failures south of the Illini Union and their impact on flooding at Harker Hall, the University should rehabilitate the existing 15-inch storm sewer along the south side of the Illini Union. Figure 4-7 illustrates the positive impact the improvements will have on the storm sewer system connected to Harker Hall.

The proposed hydraulic improvements within the Main Quad subbasin are as follows:

Improvement	Description / Notes	Key Benefits
Replace the 24-inch storm sewer from the southwest corner of the Illini Union to the Boneyard Creek with a 36-inch diameter sewer.	Proposed sewer should be constructed along the same alignment and slope as the existing storm sewer to minimize utility conflicts.	Reduces hydraulic surcharging in the system, directly benefiting the sewer draining portions of Harker Hall, which are currently subjected to frequent flooding.
Rehabilitate the 15-inch storm sewer along the south side of the Illini Union.	Clean the existing sewer and reline with a cured in place pipe (CIPP) lining system. This will extend the useful service life of the existing sewer.	Provides effective drainage away from Harker Hall and reduces the potential sewer surcharges and corresponding flooding at Harker Hall.
Clean and televise remaining storm sewers in the Main Quad subbasin. This effort may result in additional sewer rehabilitation or replacement.	Due to existence of tree root systems, pipe age, and known structural problems with other nearby storm sewers, confirmation of pipe condition is critical in this area.	Reduces threat of storm sewer backups near or within University facilities along Wright Street.



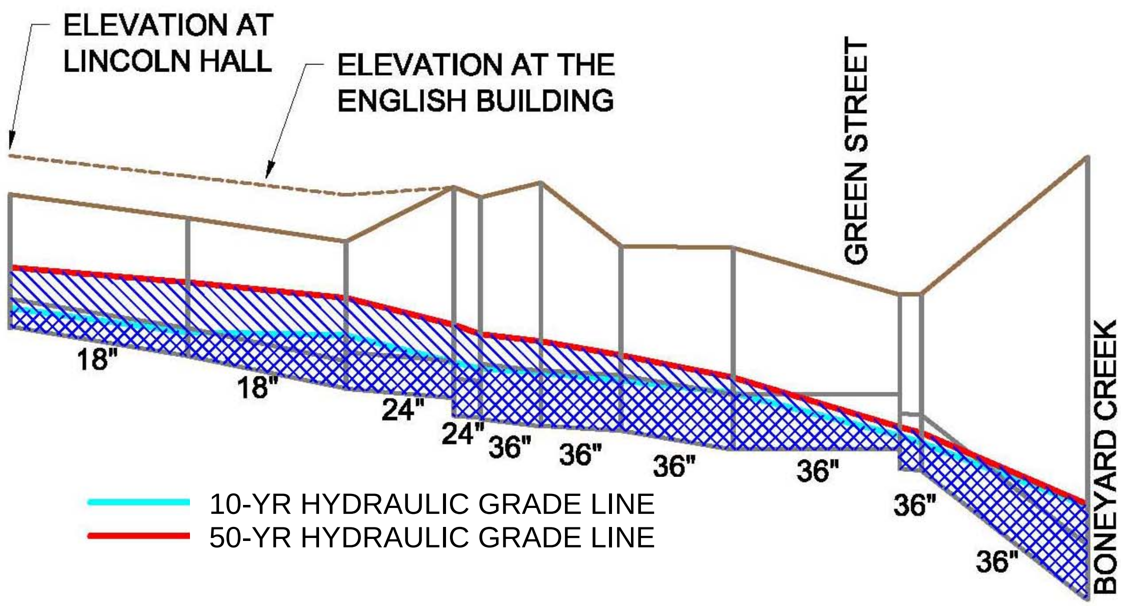


Figure 4-6
Quad Storm Sewer Improvements – Hydraulic Impacts

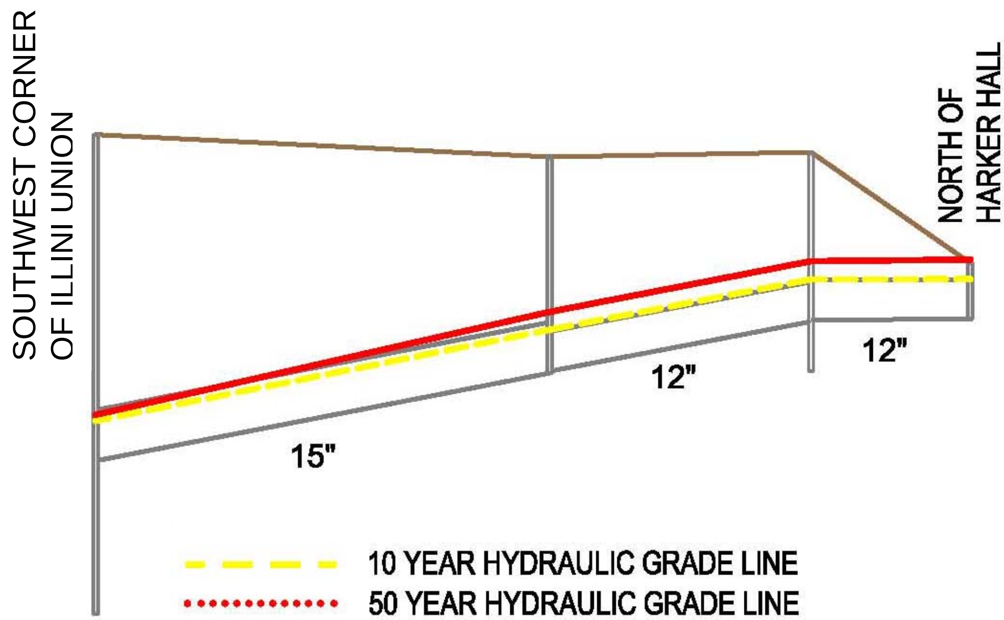


Figure 4-7
Quad Storm Sewer Improvements – Hydraulic Impacts at Harker Hall

4.3 RETROFITS TO ENHANCE STORMWATER QUALITY

A site visit was conducted with University staff to discuss potential locations for implementing stormwater Best Management Practices (BMPs) in the study area. The area along the Mathews Avenue corridor was targeted based on the availability of open areas that could be converted to provide stormwater infiltration.

After reviewing the individual BMP areas, several locations were chosen based on ideal topography (i.e. low-lying areas) and the ability to drain impervious surfaces to them. Figures 4-6 through 4-9 include illustrations of the proposed areas.

The XP-SWMM stormwater model was used to quantify the impacts of implementing the proposed infiltration areas illustrated in Figures 4-6 through 4-9, although the proposed pervious pavement along Mathews Avenue was not modeled, as this area is within City right-of-way and is outside the direct influence of the University.

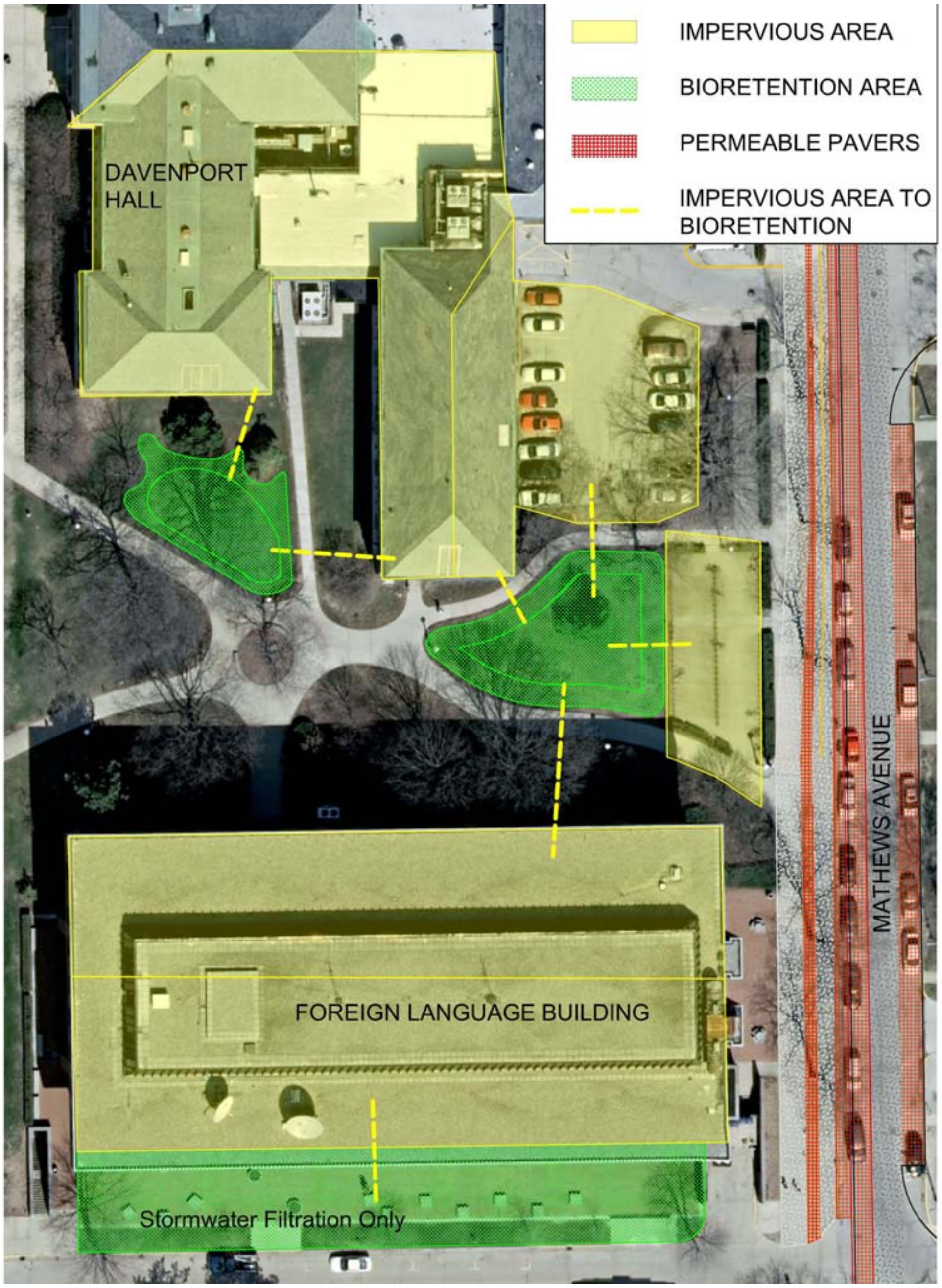


Figure 4-8
Proposed Stormwater BMPs
Foreign Language Building and Davenport Hall

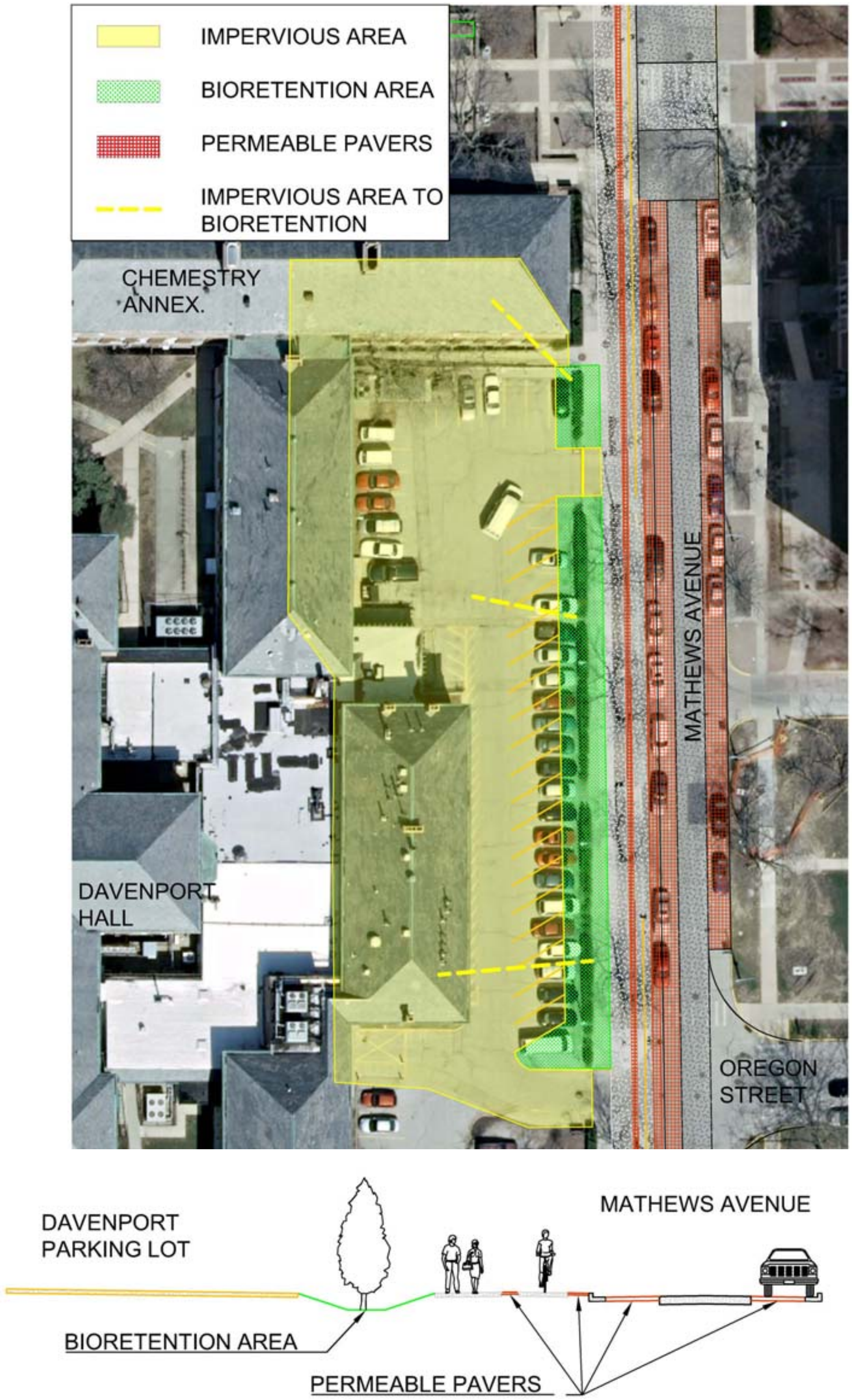


Figure 4-9
Proposed Stormwater BMPs
Davenport Hall and Mathews Avenue Cross Section Modification

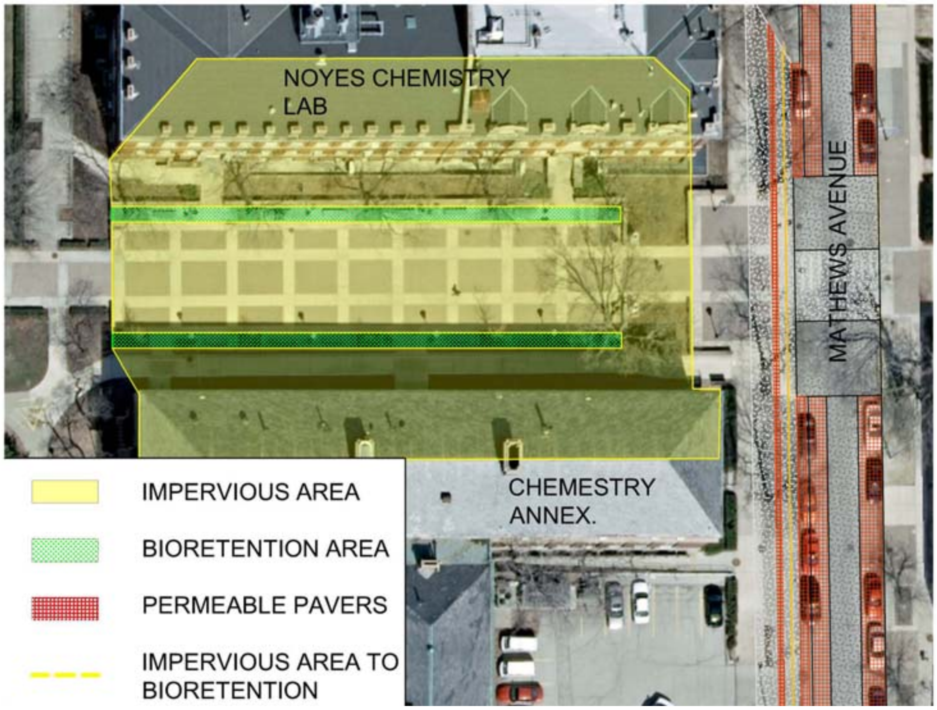


Figure 4-10
Proposed Stormwater BMPs
Noyes / Chemistry Annex Plaza

Figure 4-11
Proposed Stormwater BMPs
Natural History Building

Approximately 3 acres of impervious area within the 24-acre Mathews Avenue subbasin was identified for potential “disconnection” and treatment in an infiltration BMP. Although the aggregate impact of the recommended infiltration on peak flows in the study area is relatively small (see Figure 4-10), the total runoff volume to the Boneyard Creek is reduced by nearly 15% (or about 75,000 gallons for a 1-inch rainfall)

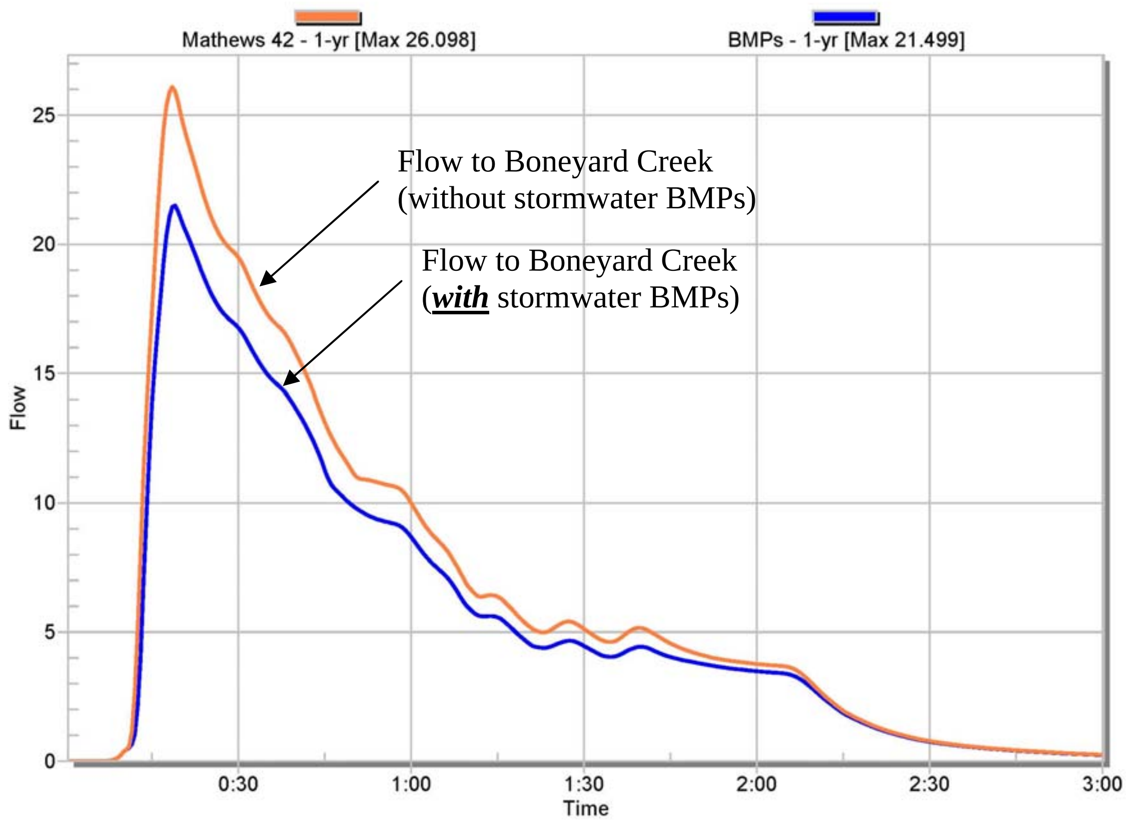


Figure 4-12
Impact of Proposed Infiltration on 1-year Flow Hydrograph
Total Runoff Volume Without BMPs: 72,400 cubic feet
Total Runoff Volume With BMPs: 62,400 cubic feet

Bioretention and Runoff Volumes

The proposed bioretention areas, if properly designed, should have the following aggregate impacts when measured on an *annual* basis:

Impacts of Bioretention on Runoff Volumes
Mathews Avenue Subbasin

	Existing Conditions	After Installation of Bioretention Cells
Total annual runoff volume from identified rooftops and parking lots* (based on 38-inch average rainfall depth in central Illinois)	415,000 cubic feet (3.1 million gallons)	42,000 to 84,000 cubic feet (310,000 to 620,000 gallons)

* *Includes only the bioretention areas proposed on University property. Does not include proposed pervious pavers along the parking lanes on Mathews Avenue or the area on the south side of the Foreign Language Building. The Foreign Language Building can be filtered, not infiltrated, due to the BMP located on a structure classified as a roof (the water must be discharged back to the storm sewer system after filtration). Permeable pavement on Mathews Avenue is outside the University's direct control, as it is a City-owned and maintained street.*

Properly designed bioretention cells typically reduce annual runoff volumes by 80% - 90% from the impervious areas draining to them. The figures above demonstrate that the impact of bioretention is not trivial, and, expanded to a larger scale, can provide significant reductions in flow volumes to the Boneyard Creek.

With the proposed stormwater bioretention, the University can reduce stormwater runoff volumes to the Boneyard Creek by over 2.5 million gallons per year. As much of that runoff is polluted with heavy metals, bacteria and excessive levels of nutrients, the reduction in total runoff volume also translates to a significant reduction in pollutant loading to the Boneyard Creek.

Bioretention and Peak Flows

Although bioretention cells will provide significant reductions in peak flows for frequent storm events (i.e. 1 inch or less of rainfall), they do not typically have an impact on higher magnitude storms (i.e. 10-year, 50-year recurrence interval rain events). As such, the installation of bioretention cells as recommended in this report will not have an impact on the recommended storm sewer pipe sizes on Mathews Avenue.

Basics of Implementing Bioretention

The areas identified in this report as candidates for bioretention were selected based on field reconnaissance with University staff, evaluation of area contours, and review of available building plans to determine locations of roof drain leads. These are areas that should accommodate stormwater infiltration, provided that the following key design issues are resolved for each bioretention cell prior to moving forward with implementation:

1. Hire a geotechnical firm to measure the saturated soil conductivity of the native soils at a depth of approximately 4-6 feet below the existing ground surface. Generally, in-situ soil conductivity should be at least 0.4 inches per hour in order to provide effective infiltration. When soil conductivity is less than 0.4 inches per hour, it may be necessary to install a perforated underdrain to ensure that the areas drain effectively after storm events.
2. Confirm the locations of roof drain leads and verify they can be intercepted and discharged to the nearest bioretention cell.
3. Confirm utility conflicts. The excavation of each bioretention cell will require removal of up to 4-5 feet of native soils within the bioretention cell footprint. Any existing utilities in these areas may need to be relocated or, at a minimum, protected during construction.

Bioretention and Standing Water

In general, bioretention cells are approximately 9-12 inches deep in order to facilitate water drawdown in the first 24 hours following a storm event. Properly-designed bioretention cells should completely drain in a 24-hour period. Given the proximity of these proposed features to pedestrians, it is important that the design addresses the drawdown time.

Foreign Language Building (FLB) – Proposed Infiltration

The proposed stormwater BMP on the south side of the FLB can serve as stormwater filtration. As this area is congruent with a roof structure, it will be necessary to effectively drain the soil media in an effective manner. The filtration can be accomplished using a gravel media or a combination of gravel base and a vegetated surface (similar to a green roof design). Either option will provide a stormwater quality benefit by removing pollutants typically found in stormwater runoff.

Both options will also require regular maintenance. Gravel filters will eventually become clogged with fine particles washed in during runoff events, and the top layer of gravel will need to be removed, cleaned and replaced approximately every 5 years. Green roofs require careful vegetation maintenance, especially during the first 3 years after installation.

Under both options, proper roofing membranes will be necessary to waterproof the structural support below the filtration media.

5.0 PROJECT COSTS

Planning-level cost estimates in this report focus on the following components:

- Mathews Avenue and Main Quad storm sewer replacement and related roadway/utility replacement
- Stormwater BMP installation

The following activities were not included in the cost estimating process:

- Improvements to Mathews Avenue, including streetscape modifications to encourage stormwater infiltration (only areas within direct control of the University were considered for cost estimating).
- Storm sewer rehabilitation in the Main Quad subbasin (the University is currently coordinating this work).
- Future sewer cleaning and televising (the University has separate agreements with contractors/vendors to perform this work).
- Waterproof membranes, discharge piping and porous backfill for the proposed BMP south of the Foreign Language Building (this work has already been completed as part of the current building improvements)

The following summarizes our planning-level cost estimates for the storm sewer replacement projects:

- Mathews Avenue improvements:
  - Construction Cost Estimate: $ 1.61 million
  - Construction Contingency: $ 322,000
  - **Total Construction Cost Estimate: $ 1.93 million**
- Main Quad improvements:
  - Construction Cost Estimate: $ 616,000
  - Construction Contingency: $ 123,000
  - **Total Construction Cost Estimate: $ 739,000**

The above estimates include construction components only. These estimates do not include design, administrative or construction-phase engineering costs.

The proposed stormwater infiltration/filtration BMPs as proposed in Section 4 are estimated to cost approximately $452,000, based on a total footprint of 18,850 square feet and the following average unit costs:

- $20 per square foot for bioretention facilities
- $20 per square foot for the Foreign Language Building to amend/retrofit the existing filtration system to include a "green roof" vegetated surface

The $452,000 includes the base cost estimate with a 20% construction contingency.