Site Suitability Assessment for Stormwater Management

Burlington, Iowa

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Summary

This document is intended to guide planners, engineers, and technical staff through a GIS-based analysis to help identify opportunities to improve stormwater management. This document serves two purposes:

- It **provides a methodology** for using geographic information systems (GIS) to assess the suitability of sites in Burlington, Iowa, for stormwater management practices. Burlington's planners, engineers, and technical staff can use this methodology to find opportunities to improve stormwater management across the city. Other cities may find the methodology useful in their own communities.
- It **demonstrates the use** of this methodology, providing results based on currently available information for Burlington, Iowa.

Installing stormwater management practices can enhance infiltration, reduce localized flooding, reduce the occurrence of combined sewer overflow (CSO) events, improve water quality, recharge groundwater, improve site aesthetics, and increase the resiliency of the city's landscape.[1] These benefits support Burlington's larger community goals, including the important priority of mitigating the occurrence and impacts of CSOs discharging to the Mississippi River.

Burlington's sewer system is divided into three sewer basins: Hawkeye Basin, Cascade Basin, and Market-Angular-South-Locust (MASL) Basin. Originally, one pipe system—called a combined sewer system—carried both sanitary sewage and stormwater runoff from all three basins to the municipal wastewater treatment facility for treatment and discharge into the Mississippi River. In combined sewer systems, the volume of wastewater can sometimes exceed the capacity of the pipes or treatment plant during heavy rainfall events or snowmelt. When this occurs, a mix of untreated stormwater and wastewater (called combined sewer overflows or CSOs) discharges directly to nearby streams or rivers. In recent years, the city undertook projects in the Cascade and Hawkeye Basins to separate the combined sewer system into two separate pipe networks: one that carries only sanitary sewage and a second that carries only stormwater. This has reduced the number of CSOs in those basins. During heavy rainfall and snowmelt, those basins' sanitary sewer systems still experience elevated flows due to groundwater and stormwater infiltrating the sanitary sewer pipes through cracks/defects in the pipe network, manholes, or improperly connected stormwater/groundwater sources (often referred to as infiltration and inflow). The MASL Basin, in and near the downtown, currently has a combined sewer system and four CSO outfalls. Each CSO outfall has its own delineated CSO sub-basin. A project to fully separate the Locust Sub-basin of the MASL Basin started in 2019 and will be completed in 2021.

[1] https://www.epa.gov/green-infrastructure/performance-green-infrastructure and https://www.epa.gov/green-infrastructure/benefits-green-infrastructure

Installing stormwater management practices in all three basins can help improve water quality by reducing the volume of stormwater runoff entering the combined sewer system (where it contributes to CSOs), reducing volumes and pollutants in stormwater discharges, and reducing infiltration and inflow in areas with separate sewer systems.

For the specific sites within the basins where stormwater management practices will be installed, a variety of practices may be appropriate depending on site conditions or a targeted need for water quality treatment or flood mitigation. For a developed urban environment such as Burlington, these practices include a combination of more traditional "gray" approaches (e.g., detention ponds, concrete and other hard structures to collect and store stormwater runoff) and a host of "green" practices (e.g., bioretention, permeable pavements, bioswales). Green practices integrate vegetation, soil, and natural processes such as filtration and biological transformation to manage stormwater. Green practices also offer a variety of additional benefits, such as aesthetics, air quality improvements, habitat benefits, and green spaces. The city recognizes the need for gray and green practices, indicating its commitment to use both in its 2019 *Wastewater and Stormwater Integrated Management Plan*.

This document's GIS-based methodology groups stormwater management practices into four categories, based on function and site requirements:

- Infiltration
- Biofiltration
- Underground detention
- Surface detention

Each category provides a different set of water quality and quantity benefits and requires a unique combination of physical site conditions to work properly. Stormwater management practices can be designed, sized, and adapted to almost any location. Identifying opportunities across all four categories is essential to understand the menu of available stormwater management practices that could be used to tackle Burlington's CSO, flooding, and infiltration and inflow challenges across both combined and separate sewer areas.

By carrying out an assessment using this document's framework, communities can identify sites where beneficial conditions for a category of stormwater management practices align with the city's needs for the areas around those sites. This will give the city screening-level results—key information to inform the city's decision-making and planning. This framework is flexible and adjustable if the city revisits its priorities. It does not identify all potential sites where practices can be implemented across the city. Rather, it can help Burlington prioritize sites with the best potential to investigate further.

To illustrate the use of this document's methodology, a site suitability assessment has been carried out for Burlington, using available data. Burlington's assessment results are shown via heat maps with planning-level information about where different categories of practices may be suitable. The maps demonstrate that biofiltration is the most widely applicable category of stormwater management practices across Burlington. Surface detention practices are also widely suitable across the city. Sites that may be suitable for underground detention are located throughout Burlington but are more concentrated in the western part of the city. Sites suitable for infiltration practices are limited, primarily due to soil permeability. This type of siting information complements the 2019 *Wastewater and Stormwater Integrated Management Plan,* which explicitly includes the use of green infrastructure to protect public health and water quality and to generate other benefits including groundwater recharge, flood reduction, reduction in infiltration and inflow, and reduction in hydromodification within streams and channels in basins where separation has already occurred.

1. Introduction

The city of Burlington, Iowa, is actively working to improve stormwater management, reduce localized flooding, and address the water quality impacts of combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) on the adjacent Mississippi River. This document presents a methodology to help the city screen sites for their potential suitability for different categories of stormwater management practices.

The sewer infrastructure of the city was originally a network of combined sanitary and storm sewer pipes (referred to as a combined sewer system). Over time, the city has undertaken efforts to separate the sewers to manage stormwater in a separate network of pipes than those for sanitary sewage. The system has three main sewer basins: Hawkeye Basin, Cascade Basin, and Market-Angular-South-Locust (MASL) Basin (see Figure 1). In recent years, the city has completed sewer separation efforts in the Cascade and Hawkeye Basins. The system in the MASL Basin is currently combined and includes four CSO outfalls that discharge untreated sewage and stormwater to the river during heavy storm events. The design to fully separate the system in the Locust CSO Sub-basin is complete and will be constructed in 2021.

As part of the effort to reduce the water quality impacts from CSOs, the city is interested in implementing practices to divert and detain stormwater from the combined sewer system in the MASL Basin. The city is also interested in implementing stormwater management practices that improve water quality, improve groundwater recharge, reduce flooding, reduce infiltration and inflow, and reduce hydromodification within streams and channels in basins where separation has already occurred. Stormwater management practices, particularly green infrastructure, are a key part of Burlington's 2019 *Wastewater and Stormwater Integrated Management Plan* – a means to lower costs for the city's sewer separation and wastewater treatment facility nutrient management improvements.

Green Infrastructure

"Green infrastructure" (as defined by the Water Infrastructure Improvement Act) is the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest or reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters. These practices mimic natural conditions of a site to reduce the negative impacts that challenge urbanized areas and contribute to CSOs. Green infrastructure, such as bioretention, tree boxes, and permeable pavements, is included in the assessment categories of infiltration and biofiltration stormwater management practices. These practices can be attractive elements of the landscape. Figure 2 on page 6 shows a variety of installed green infrastructure.

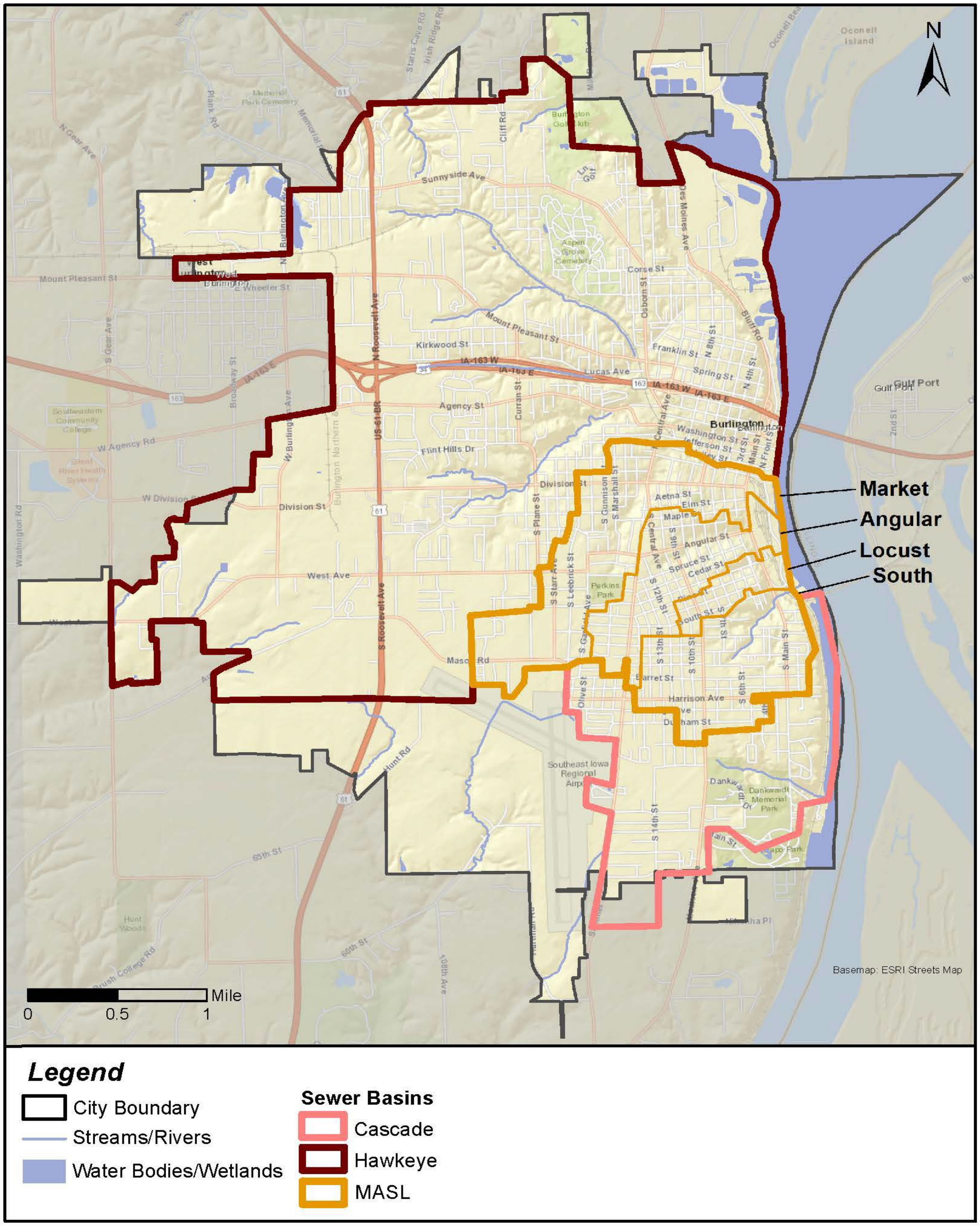

Figure 1. Sewer Basins in Burlington, Iowa

Green Infrastructure Examples

Clockwise from top left:
- Tree box
- Bioswale
- Tree trench
- Constructed wetland
- Permeable pavement
- Infiltration basin
- Bioretention system

Figure 2. Green Infrastructure Examples

This assessment considers the physical conditions of a site, based on available geospatial data such as slope, depth to bedrock, hydrologic soil group (HSG), and other characteristics, and provides screening-level information that can help the city prioritize its efforts.

Different stormwater management practices have different functions and require specific site characteristics for successful implementation. Using this methodology, site suitability assessments are performed separately for each of four categories of stormwater management practices:

- Infiltration practices
- Biofiltration (surface filtration) practices
- Underground detention
- Surface detention

Different practices also have different benefits, depending on designed functionality, specified materials, and physical location. For example, practices that infiltrate water into the ground provide the added benefits of groundwater recharge and, in many cases, flood mitigation. They can also help reduce the occurrence of CSOs. Practices that detain water underground or on the land surface provide flood mitigation and help alleviate CSO occurrence. Biofiltration practices that filter runoff through vegetation and shallow soils provide beneficial water quality treatment and slow the flow of runoff.

Infiltration: These practices store stormwater and allow it to infiltrate into the underlying soil and groundwater. They help reduce the volume and flow rate of stormwater runoff and remove pollutants.

Biofiltration: These practices include underdrains or liners to prevent stormwater infiltration. They use soils and vegetation at the ground surface to slow the flow of stormwater and remove pollutants.

Underground detention: These practices store a significant volume of stormwater runoff in an underground chamber or gravel layer before slowly releasing it to a stormwater pipe or water body. They help to reduce stormwater flooding.

Surface detention: These practices store a significant volume of stormwater runoff in a surface depression before slowly releasing it to a stormwater pipe or water body. They help to reduce stormwater flooding.

Table 1 lists examples of each stormwater management practice category in this assessment and its associated benefits.

Table 1. Benefits of Stormwater Management Practices

Stormwater Management Practice	Category: Infiltration	Category: Biofiltration	Category: Underground Detention	Category: Surface Detention	Potential Benefits: Aquifer Recharge	Flood Mitigation	CSO Occurrence Mitigation	Water Quality Treatment	Habitat Creation and/or Preservation	Cooling/Reduced Heat Island Effect	Reduced Need for Deicers	Reduced Roadway Spray and Noise	Air Quality Improvement
Bioretention/bioswale *(no underdrain/liner)*	✓				✓	✓	✓	✓	✓	✓			✓
Bioretention/bioswale *(with underdrain/liner)*		✓		✓		✓	✓	✓	✓	✓			✓
Tree trench *(no underdrain/liner)*	✓				✓	✓	✓	✓	✓	✓			✓
Tree trench *(with underdrain/liner)*		✓						✓	✓	✓			✓
Tree box *(no underdrain/liner)*	✓				✓	✓	✓	✓	✓	✓			✓
Tree box *(with underdrain/liner)*		✓						✓	✓	✓			✓
Permeable pavement/pavers *(no underdrain)*	✓				✓	✓	✓	✓		✓	✓	✓	
Permeable pavement/pavers *(with underdrain)*		✓		✓		✓	✓	✓		✓	✓	✓	
Sand or media filter *(no underdrain/liner)*	✓				✓	✓	✓	✓		✓			
Sand or media filter *(with underdrain/liner)*		✓		✓		✓	✓	✓		✓			
Infiltration chamber	✓				✓	✓	✓	✓		✓			
Infiltration basin	✓				✓	✓	✓	✓	✓	✓			
Wet pond		✓		✓		✓	✓	✓	✓				
Infiltration trench	✓				✓	✓	✓	✓		✓			
Underground detention chamber			✓			✓	✓						
Dry pond				✓	✓	✓	✓	✓	✓	✓			
Constructed wetland		✓		✓		✓	✓	✓	✓	✓			✓

2. Methodology

This screening-level site suitability assessment is a desktop geographic information system (GIS) analysis that uses a set of physical criteria to assess the potential suitability of sites for stormwater management practices to enhance infiltration, reduce localized flooding, improve water quality, recharge groundwater, improve site aesthetics, and increase the resiliency of the landscape in ways that not only meet stormwater management needs but also support Burlington's broader community vision. This analysis evaluates site suitability for the following four general categories of stormwater management practices, based on the primary physical processes and site conditions that define them:

- Infiltration
- Biofiltration (surface filtration)
- Underground detention
- Surface detention

These stormwater management categories were chosen to reflect the interests of Burlington but could be adjusted for other communities along with the methodology framework.

Five site suitability assessment steps are outlined below.

- **Step 1** identifies the physical site characteristic data that will be used as criteria to assess the most suitable sites for each stormwater management category.
- **Step 2** describes how the criteria established in Step 1 are either excluded or rated for the analysis.
- **Step 3** describes the mechanics of the suitability analysis, which uses a simple equation to compute a suitability score in GIS for each pixel in the data grid across the city.
- **Step 4** describes the development of heat maps to visually display site suitability scores.
- **Step 5** discusses how to use the maps generated in Step 4 to identify potentially suitable stormwater management practices for chosen locations.

Once the assessment results are produced, lenses such as land ownership (public versus private lands), location in relation to the CSO sub-basin, or locations of planned city projects can be added to the output maps to further prioritize future investigation efforts. The developed maps can be used as a screening and decision support tool to distinguish which sites in the city may be better suited for each category of stormwater management practice.

2.1 Step 1: Identify Site Characteristics for Site Suitability Assessment

The first step of the site suitability assessment is to compile physical site characteristic data. The feasibility of implementing a stormwater management practice depends in part on a location's physical site characteristics, such as soil permeability, slope, and depth to bedrock. A community can map these physical site characteristics in GIS using data that are publicly available or generated by the community. Table 2 and Table 3 contain the full set of physical site characteristics data that were sought for use as criteria in the Burlington screening assessments. The names of the GIS data layers in the tables are specific to the Burlington data source and naming conventions will vary in each community.

Table 2 lists the available data for Burlington at the time of this analysis. For each characteristic used in the assessment, it provides the data file name and data source as well as describing how it is relevant to site suitability for stormwater management practice implementation. For several characteristics, it provides additional technical references to support and expand on the information presented. Table 3 includes additional data that were not available at the time of this analysis, but that Burlington could use if they become available. It also provides potential sources for these data.

Table 2. Burlington Site Characteristics Used in Site Suitability Assessment

Physical Site Characteristic	GIS Data Layer	Source	Considerations for Stormwater Management Practice Implementation
Soil permeability	Soil survey for Des Moines County	U.S. Natural Resources Conservation Service https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx	More permeable soils such as sand and gravel, categorized as hydrologic soil group (HSG) A soils, have a higher capacity for infiltration. Sites with less permeable soils (HSG C and D) may also achieve some runoff volume and pollutant load reduction and provide replenishment to groundwater storage reservoirs. Recharge can be particularly important during times of drought in Burlington. In less permeable soils, smaller capacity biofiltration and shallow infiltration practices may be considered.
Water bodies and associated buffers	IA_geodatabase_wetlands.shp	National Wetlands Inventory (2018) https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/	Wetlands, streams, rivers, and their associated buffers are protected by state and local wetland protection regulations. Avoiding these regulated areas and buffer zones will reduce risk of damaging existing water bodies and avoid administrative burden during planning and construction. The Zoning Ordinance of Des Moines County, Iowa, Ordinance No. 34, Division 85, states that it is desirable to leave a 66-foot buffer along streams, lake shores, rivers, and bodies of water. Furthermore, within 300 feet of a stream or wetland or within 1,000 feet of a lake or pond, special erosion control measures may be required for construction. The analysis used these buffer zones, as they are in place to protect downstream drainage channels and water bodies from impairment, and at the same time impose stricter guidelines for the construction site.
	NHD flow	ftp://rockyftp.cr.usgs.gov/vdelivery/Datasets/Staged/Hydrography/NHD/State/HighResolution/	
	“Hydro” in map package	Local source	
Flood hazard zones	“FloodZone” in map package	FEMA National Flood Hazard Layer	Stormwater management infiltration practices should generally be constructed in areas outside mapped Flood Hazard Zones (Zones A, AE or AH) so that floods will not damage them. In addition, wet, poorly drained soils and shallow groundwater depths within those flood zones may render a site unsuitable for infiltration practices. Biofiltration practices are flexible in design and may be considered within flood zones, but areas outside flood zones are more desirable sites for all practices. Preservation of natural lands within flood zones can also be used to protect flood capacity and protect habitat.

Physical Site Characteristic	GIS Data Layer	Source	Considerations for Stormwater Management Practice Implementation
Source water protection area	Groundwater capture zones https://geodata.iowa.gov/dataset/source-water-protection	State source https://geodata.iowa.gov/dataset/source-water-protection	The term "source water" means drinking water, either surface water (rivers, streams, reservoirs, lakes) or groundwater (aquifers). Source water protection, thus, includes both surface water and groundwater (wellhead) protection. The Iowa Source Water Protection Program has delineated source water capture areas for each community. Most of Iowa's drinking water systems use groundwater. The data source delineates buffers around each wellhead that correspond to a two-year, five-year, and 10-year travel time to the well. For this assessment, sites outside these areas should be prioritized over sites inside them for infiltration practices to protect the quality of the drinking water source from potential contamination. More information can be found at http://www.iowadnr.gov/Portals/idnr/uploads/water/wse/SWPPGuidebook.pdf.
Contaminated sites	Contaminated sites facility	State source https://geodata.iowa.gov/	Infiltration should be avoided at sites with contaminated soils because contaminants can be mobilized by the increased movement of water through the soils. The locations of contaminated sites were obtained from the Contaminated Sites Sections of the Iowa Department of Natural Resources (IDNR), which addresses contamination caused by releases of hazardous materials or hazardous waste products. The IDNR's database includes point data representing the addresses of sites that are contaminated by hazardous materials or wastes. These sites have come to the IDNR's attention primarily through environmental assessments, generally associated with real estate transfers. The list also includes Superfund sites identified through EPA's CERCLA program. Only actively monitored sites are considered in the assessment. Others are understood to be closed cases that no longer pose a contamination risk. In total, there are 12 active contaminated sites listed in Burlington. Point data were converted for each active site into the parcel associated with the location and address of the contamination site, based on information provided in the GIS data. These parcels were then used in this assessment to express the estimated spatial extent of the potential contamination, to be conservative.

Physical Site Characteristic	GIS Data Layer	Source	Considerations for Stormwater Management Practice Implementation
Slope	1-meter lidar	Geographic Information Systems at Iowa State University http://ortho.gis.iastate.edu/client.cgi?zoom=500&x0=469163&y0=4653689&layer=lidar_hs&pwidth=1100&pheight=750	For this analysis, and in accordance with the screening process described in the *Iowa Storm Water Management Manual*, Chapter 4, pp. 15–16 (2009), sites with slopes greater than 10 percent were not considered suitable for stormwater management practices. Sites with shallow slopes (less than 10 percent) are better able to capture rainfall on site and slow stormwater runoff to provide more opportunities for infiltration. Certain stormwater management practices, such as biofiltration and shallow filtration types, can be considered for use at sites with greater slopes with certain adjustments to manage high flows and erosion. For this assessment, any sites above a 10 percent slope were assumed to be sufficiently challenging to exclude from consideration.
Parcel boundaries	"Parcels" in map package	Local source (assessors)	Parcels provide a unit of assessment for the site assessment.
Depth to bedrock	Depth to bedrock	Iowa DNR https://geodata.iowa.gov/	Depth to bedrock is a constraint that defines the constructability and effectiveness of many stormwater management practices. Infiltration practices require minimum depths to bedrock. Depth to bedrock can also restrict the ability to construct practices, since construction in bedrock can be very expensive or cost prohibitive. Areas with certain minimum depths to bedrock have been excluded from consideration for stormwater management practices, other than biofiltration practices, which can be shallow and confined. Depth to bedrock can also be used to prioritize sites: a greater depth means better functioning and easier construction.
Impaired water bodies	Impaired streams (2014) Impaired lakes (2014)	State source https://geodata.iowa.gov/	Stormwater management practices that address water quality treatment can provide particular benefit in watersheds with impairments. However, according to the data layer, no impaired water bodies were included in the city boundaries. Therefore, this criterion was not included in the assessment.

Physical Site Characteristic	GIS Data Layer	Source	Considerations for Stormwater Management Practice Implementation
Impervious cover	National Agriculture Imagery Program	U.S. Geological Survey https://earthexplorer.usgs.gov/	Impervious cover generates runoff and prevents rainwater from infiltrating into the ground. Impervious cover includes paved areas as well as buildings. The amount of impervious area on a parcel can limit the area available for surface stormwater management practices. However, impervious areas can also be retrofitted with facilities for underground infiltration or detention of stormwater. These areas most commonly include parking lots but could also include sidewalks and paths in some cases. In addition, reducing impervious area can help to manage stormwater in urban areas because it reduces the volume of stormwater runoff generated at a site.
Land use	HRLC_2009_29.img	State source https://geodata.iowa.gov/	Land use data are used in the site assessment methodology to identify parking lots. The land use layer available for Burlington subdivided impervious area into buildings and other impervious area. Excluding roads from the latter resulted in the category this analysis used for "parking lots." This category includes primarily parking space, but also other large impervious areas such as airport landing strips. Land use is a useful additional piece of information when further evaluating the feasibility of a potential implementation site and the contributing area. Land use data are important for determining the expected pollutant loading in runoff from a site and will help to further define the individual practices that might be appropriate to manage runoff from a given site.

Table 3. Additional Site Characteristics to Consider in Site Suitability Assessment When Data Are Available

Physical Site Characteristic	Potential Data Source	Considerations for Stormwater Management Practice Implementation Criteria
Depth to groundwater	U.S. Natural Resources Conservation Service	The depth to groundwater is, similarly to depth to bedrock, a constraint that defines the ability of many stormwater management practices to function effectively. Infiltration practices require minimum depths to groundwater. Areas with certain minimum depths to groundwater should be excluded from consideration for certain practices that depend on infiltration. Depth to groundwater could also be used to prioritize sites, as a greater depth ensures a better ability of the practice to function and increases the ease of constructability. The depth to groundwater data set for Burlington significantly lacked data and exhibited considerable uncertainty and inaccuracy and was therefore excluded from the analysis.
Surficial geology	Iowa DNR https://geodata.iowa.gov/	Typically, this provides additional understanding of the potential for infiltration, especially in areas where soils are characterized as urban land. These data were not available for Burlington and were not included in the assessment.
Existing stormwater infrastructure and best management practices	Local sourceData layers provided: "swInlets," "swoutlets," "swmanholes," "swgravitymain"	Existing stormwater management practices, such a detention ponds, can be relatively easy locations for stormwater management retrofits because water is already draining to the site. This data layer was not included in this assessment because the GIS data layers were incomplete, and locations were approximate. However, this data layer was used as an example lens to examine the site suitability results in the Angular CSO Sub-basin of the MASL Basin in Section 3.3 below.
Existing utilities (drinking water, wastewater, power, etc.)	Local source Data layer provided: "Sanitary"	Existing utilities (water, sewer, gas, electric, etc.) can conflict with the installation of stormwater management practices and may render a retrofit impractical. The only utility mapping data available for this assessment is sewer infrastructure mapping, which is referenced separately below. Otherwise, existing utility data were not included in the assessment.
Municipal separate storm sewer system (MS4) regulated areas	Census (2010) https://www2.census.gov/geo/tiger/TIGER2010/UA/2010/2010	A community that is regulated by the NPDES MS4 permit program may be interested in evaluating whether a site is within or outside the regulated MS4 area because stormwater management practices may help the community meet permit requirements within the MS4 area. Currently, Burlington is not a regulated MS4. However, the city anticipates being regulated at some future point, and the likely regulated area can be estimated based on the mapped urbanized areas according to the census. At this time, the anticipated MS4 regulated area is excluded as a lens in this assessment.

2.2 Step 2: Establish Exclusion Criteria, Rated Criteria, and a Rating System

Once physical site characteristic data is gathered, the community should establish which criteria will be excluded versus rated. For rated criteria, a range of ratings specific to each category of stormwater management practice should be set up. The community will use this rating system to calculate a location-specific site suitability score in GIS (Step 3). The sections below describe the exclusion criteria and rated criteria, which are also identified in Table 4 and Table 5. The following sections describe the exclusion and rating processes.

Exclusion Criteria

These criteria are used to exclude sites with certain characteristics from the assessment. Some conditions render a site ineffective or too challenging for a stormwater management practice category. For example, sites within water bodies and sites that are contaminated are excluded (refer to Table 2 for further explanation). Some exclusions remove areas that the city does not want to target. For example, the underground detention category analysis is focused on parking lots and large impervious areas where underground detention practices could be installed. Therefore, areas other than large parking lots and impervious areas are excluded for that category. Exclusion criteria are applied by assigning a rating of 0 to excluded areas. In the equation used to compute the suitability score in Step 3, exclusion criteria are applied as multipliers (i.e., a 0 rating will result in a 0 overall suitability score). General types of exclusion criteria for each category of stormwater management practice are shown with check marks in Table 4 below. Specific exclusion criteria parameters are provided in Table 6 through Table 9.

Table 4. Exclusion Criteria for Each Stormwater Management Category

Exclusion Criteria	Infiltration	Biofiltration	Underground Detention	Surface Detention
Area within water bodies	✓	✓	✓	✓
Contaminated sites	✓	✓	✓	✓
High slope	✓	✓	✓	✓
Non-parking lots			✓	
Small parking lots			✓	
Low depth to bedrock			✓	
Impervious surface				✓
Soils with low permeability	✓			

Rated Criteria

Criteria that are not exclusions receive ratings between 1 and 5. Higher ratings indicate more suitability for the stormwater management category under assessment. In cases where a data set includes "no data" for some areas, the "no data" entries receive ratings of 3 so that they do not unduly influence the overall scoring. Rated criteria are added and contribute cumulatively to the suitability score (see Step 3).

In many cases, a rating of 1 does not prevent the successful installation of a stormwater management practice, but it does indicate that further investigation into site suitability should be pursued. The city may adjust or weight the ratings as needed in the future to reflect a different emphasis on certain criteria, or to ensure that the resulting suitability scores are meaningfully distributed. This process is intended to be iterative and repeatable.

General types of rated criteria for each category of stormwater management practice are shown with check marks in Table 5 below. Rated criteria are given a rating between 1 and 5 depending on criteria parameters outlined in Table 6 through Table 9.

Table 5. Rated Criteria for Each Stormwater Management Category

Rated Criteria	Infiltration	Biofiltration	Underground Detention	Surface Detention
Buffer to waterbodies	✓		✓	✓
FEMA flood zone	✓	✓	✓	✓
GW/SW protection zone	✓			
Depth to bedrock	✓		✓	✓
Slope	✓	✓	✓	✓
Parking lot area per parcel			✓	
Pervious area per parcel				✓

Different Exclusions and Ratings for Stormwater Management Categories

The key exclusion and rated criteria applied to each of the four stormwater management categories are summarized below and presented in Table 6 through Table 9.

Infiltration Practices

Infiltration practices (Table 6) use temporary surface or underground storage to allow captured stormwater to exfiltrate into underlying soils. Areas with the following characteristics are excluded from this assessment for infiltration practices: water bodies, documented contamination, slopes greater than 10 percent, and low-permeability soils (indicated by HSG C and D).

Higher ratings are applied to the remaining areas with the following criteria:

- Greater buffer distance from water bodies and wetlands
- Location outside versus inside flood zones
- Location outside versus inside groundwater capture zones of different sizes
- Greater depth to bedrock
- Lower slope

Biofiltration Practices

Biofiltration practices (Table 7) filter captured stormwater and use physical, chemical, and biological mechanisms to remove pollutants from runoff. Only sites located outside of water bodies, without documented contamination and with slopes less than 10 percent are considered for potential suitability in this assessment. For these areas, higher ratings are applied to areas that meet the following criteria:

- Location outside versus inside flood zones
- Lower slope

Underground Detention Practices

Underground detention practices (Table 8) are underground structures used to temporarily detain and release stormwater. Treatment or aquifer recharge of stormwater does not *typically* occur with this type of practice. Areas with the following characteristics are excluded from this assessment for underground detention practices: water bodies, documented contamination, slopes greater than 10 percent, areas other than parking lots with at least 10 parking spaces, and a depth to bedrock of less than 4 feet. Higher ratings are then applied to the remaining areas with the following criteria:

- Greater buffer distance from water bodies and wetlands
- Location outside versus inside of flood zones
- Greater depth to bedrock
- Lower slope
- Larger size of parking lot

In this assessment, parking lots are targeted because they are ideal for underground detention practices within the developed landscape. Note that soil permeability (indicated by HSG) is not included as a criterion for the site suitability of underground detention because the function of the practice is not dependent upon infiltration.

Surface Detention Practices

Surface detention practices (Table 9) are designed to temporarily hold stormwater, allowing solids to settle and reducing local and downstream flooding. Areas with the following characteristics are excluded from this assessment for surface detention practices: water bodies, documented contamination, slopes greater than 10 percent, and impervious surfaces. For the remaining areas, higher ratings are applied to areas that meet the following criteria:

- Greater buffer distance from water bodies and wetlands
- Location outside versus inside flood zones
- Greater depth to bedrock
- Lower slope
- Larger area of pervious surface within the parcel

Table 6. Criteria Ratings for Infiltration Practice Site Suitability Assessment

Rating[a]	Infiltration Practice Exclusion Criteria				Infiltration Practice Rated Criteria				
	Water Bodies	**Contaminated Sites**	**Slope[b]**	**Soil Permeability (HSG)**	**Water Bodies and Associated Buffers[c]**	**FEMA Flood Zone**	**Groundwater Capture Zone[d]**	**Depth to Bedrock**	**Slope[b]**
0 (exclusion)	Inside wetland, lake or river	Within documented contamination	>10%	HSG C or D (+ A/D, B/D, C/D)					
1	Outside wetland, lake or river	No known contamination	≤10%	HSG A or B or no data	Within 66 feet of wetlands/streams/ lakes/ponds	Inside zones A, AE, AH	Inside two-year capture zone	0 to 2 feet	>8% to 10%
2							Inside five-year capture zone	>2 to 4 feet	>6% to 8%
3					Within 66–300 feet of wetlands/streams or within 66–1,000 feet of lakes/ponds		Inside 10-year capture zone	No data	>4% to 6%
4								>4 to 6 feet	>2% to 4%
5					Beyond 300 feet from wetlands/streams or beyond 1,000 feet from lakes/ponds	Outside zone A, AE, AH	Outside 10-year capture zone	>6 feet	0% to 2%

[a] The ratings apply to each criterion individually, not to all the criteria for a given site. For example, a site can have a rating of 2 for one criterion and 5 for another.

[b] Based on BMP specifications in the *Iowa Storm Water Management Manual,* pp. 15–16.

[c] Based on the Des Moines County Zoning Ordinance, Chapter 85.

[d] The data source delineates buffers around each wellhead, which correspond to two-, five-, and 10-year travel times to the location of the well. These areas should be avoided to protect the quality of the water source from potential contamination.

Table 7. Criteria Ratings for Biofiltration Practice Site Suitability Assessment

Rating[a]	Biofiltration Practice Exclusion Criteria			Biofiltration Practice Rated Criteria	
	Water Bodies	Contaminated Sites	Slope[b]	FEMA Flood Zone	Slope[b]
0 (exclusion)	Inside wetland, lake, or river	Within documented contamination	>10%		
1	Outside wetland, lake, or river	No known contamination	≤10%	Within zones A, AE, AH	>8% to 10%
2					>6% to 8%
3					>4% to 6%
4					>2% to 4%
5				Outside zones A, AE, AH	0% to 2%

[a] The ratings apply to each criterion individually, not to all the criteria for a given site. For example, a site can have a rating of 2 for one criterion and 5 for another.

[b] Based on BMP specifications in the *Iowa Storm Water Management Manual,* pp. 15–16.

Table 8. Criteria Ratings for Underground Detention Practice Site Suitability Assessment

Rating[a]	Underground Detention Exclusion Criteria						Underground Detention Rated Criteria				
	Water Bodies	Contaminated Sites	Slope[b]	Land Use Other Than Parking[c]	Small Parking Lots	Depth to Bedrock	Water Bodies and Associated Buffers[d]	FEMA Flood Zone	Depth to Bedrock	Slope[b]	Parking Lot Area per Parcel[c]
0 (exclusion)	Inside wetland, lake, or river	Within documented contamination	>10%	Yes	<10 parking spaces	<4 feet					
1	Outside wetland, lake, or river	No known contamination	≤10%	No	≥10 parking spaces	≥4 feet	Within 66 feet of wetlands/ streams/lakes/ ponds	Inside zones A, AE, AH		>8% to 10%	1,500 to 2,500 square feet (equivalent to 10 to 15 parking spaces)
2										>6% to 8%	>2,500 to 3,500 square feet (equivalent to 16 to 20 parking spaces)
3							Within 66 to 300 feet of wetlands/ streams or within 66 to 1,000 feet of lakes/ponds		No data	>4% to 6%	>3,500 to 4,500 square feet (equivalent to 21 to 25 parking spaces)
4									4 to 6 feet	>2% to 4%	>4,500 to 5,500 square feet (equivalent to 26 to 30 parking spaces)

Rating[a]	Underground Detention Exclusion Criteria						Underground Detention Rated Criteria				
	Water Bodies	Contaminated Sites	Slope[b]	Land Use Other Than Parking[c]	Small Parking Lots	Depth to Bedrock	Water Bodies and Associated Buffers[d]	FEMA Flood Zone	Depth to Bedrock	Slope[b]	Parking Lot Area per Parcel[c]
5							Beyond 300 feet from wetlands/ streams or beyond 1,000 feet from lakes/ponds	Outside zones A, AE, AH	>6 feet	0% to 2%	>5,500 square feet (equivalent to more than 30 parking spaces)

[a] The ratings apply to each criterion individually, not to all the criteria for a given site. For example, a site can have a rating of 2 for one criterion and 5 for another.

[b] Based on BMP specifications in the *Iowa Storm Water Management Manual,* pp. 15–16.

[c] "Parking lot" in this assessment is defined as impervious area that is neither a building nor a road. The land use layer available for Burlington subdivided impervious area into buildings and other impervious area. Excluding roads from the latter resulted in the land use category described as "parking lots" in this assessment. This category includes mostly parking space, but also other large impervious areas such as airport landing strips. The city should review and analyze the results to consider the land use at each location being considered for a stormwater management practice. One parking space was assumed to be roughly 9 by 19 feet. Only the total amount of impervious area estimated as "parking lot" on a parcel is considered. The shape or contiguity of the parking area within a parcel, existence of access driveways, landscaping elements, and ADA compliance of the parking space are not considered.

[d] Based on the Des Moines County Zoning Ordinance, Chapter 85.

Table 9. Criteria Ratings for Surface Detention Practice Site Suitability Assessment

Rating[a]	Surface Detention Exclusion Criteria				Surface Detention Rated Criteria				
	Water Bodies	Contaminated Sites	Slope[b]	Impervious Area	Water Bodies and Associated Buffers[c]	FEMA Flood Zone	Depth to Bedrock	Slope[b]	Pervious Area per Parcel[d]
0 (exclusion)	Inside wetland, lake, or river	Within documented contamination	>10%	Yes					
1	Outside wetland, lake, or river	No known contamination	≤10%	No	Within 66 feet of wetlands/streams/ lakes/ponds	Inside zones A, AE, AH	0 to <2 feet	>8% to 10%	≤0.2 acres
2							2 to 4 feet	>6% to 8%	>0.2 to 0.4 acres
3					Within 66 to 300 feet of wetlands/streams or within 66 to 1,000 feet of lakes/ponds		No data	>4% to 6%	>0.4 to 0.6 acres
4							>4 to 6 feet	>2% to 4%	>0.6 to 0.8 acres
5					Beyond 300 feet from wetlands/streams or beyond 1,000 feet from lakes/ponds	Outside zones A, AE, AH	>6 feet	0% to 2%	≥0.8 acres

[a] The ratings apply to each criterion individually, not to all the criteria for a given site. For example, a site can have a rating of 2 for one criterion and 5 for another.

[b] Based on BMP specifications in the *Iowa Storm Water Management Manual,* pp. 15–16.

[c] Based on the Des Moines County Zoning Ordinance, Chapter 85.

[d] The pervious area per parcel is the total amount of pervious area on a parcel. The contiguity of the pervious area within a parcel or shape is not considered.

2.3 Step 3: Perform Site Suitability Scoring

Site suitability scores are computed in GIS at every assessed location based on the criteria ratings established in Step 2. Suitability scores are computed for each of the four stormwater management categories (infiltration, biofiltration, underground detention, and surface detention). The site suitability scores incorporate the exclusion criteria and the rated criteria according to the scoring equations below. Exclusion criteria scores are multiplied together and then multiplied by the sum of the rating criteria scores.

The User Can Adjust These Scores and Scoring Equations
These scores and equations were developed by the EPA in conjunction with the city of Burlington. The data and scores used in this assessment can be updated as needed in future iterations of the analysis, using the same methodology framework.

The overall format of each of the scoring equations is as follows:

suitability score	=	product of exclusion criteria	×	sum of rating criteria

Scoring Equation: Infiltration Category

infiltration suitability score	=	water bodies × contaminated sites × steep slope × low soil permeability	×	buffer to water bodies + FEMA flood zone + groundwater capture zone + depth to bedrock + slope

total possible infiltration suitability score = 25

Scoring Equation: Biofiltration Category

biofiltration suitability score	=	water bodies × contaminated sites × steep slope	×	FEMA flood zone + slope

total possible biofiltration suitability score = 10

Scoring Equation: Underground Detention Category

underground detention suitability score	=	water bodies × contaminated sites × steep slope × areas other than parking lots × small parking lots × depth to bedrock	×	buffer to water bodies + FEMA flood zone + depth to bedrock + slope + parking lot area per parcel

total possible underground detention score = 25

Scoring Equation: Surface Detention Category

surface detention suitability score = water bodies × contaminated sites × steep slope x impervious area × buffer to water bodies + FEMA flood zone + depth to bedrock + slope + pervious area per parcel

total possible surface detention score = 25

2.4 Step 4: Map Site Suitability

Once calculated, the site suitability scores can be presented on a map. Scores can be grouped into ranges to create a "heat map," with colors showing suitability for a given category of stormwater management practices. The GIS process required to calculate the site suitability scores across the study area is presented in Figure 3 below. (Although the figure shows the assessment process for site suitability for infiltration practices, the process is similar for all categories.) The GIS data are transformed to apply the ratings and then compute the rating scores to develop the final assessment heat maps. The common methods of GIS data transformation used in this process are:

- **Buffer.** Creates a zone around a set of map elements using a set distance.
- **Clip.** Overlay map layers on top of one another, then extract only that area of a map that is within the polygon or polygons defined by one of the data layers.
- **Exclude.** Overlay map layers on top of one another, then exclude only that area of the map that is outside a polygon or polygons defined by one of the data layers.
- **Rate.** Assign a rating score to individual pixels or polygons based on a given characteristic.
- **Union.** Overlay one map layer on top of another and combine two types of map features into one feature to create a new map layer.
- **Dissolve.** Merge different features of a map into one feature to create a new map layer.

The flow chart in Figure 3 serves as a guide for a GIS analyst to recreate this assessment process and revise it in the future as needed, so that the city can employ this methodology as data and priorities evolve.

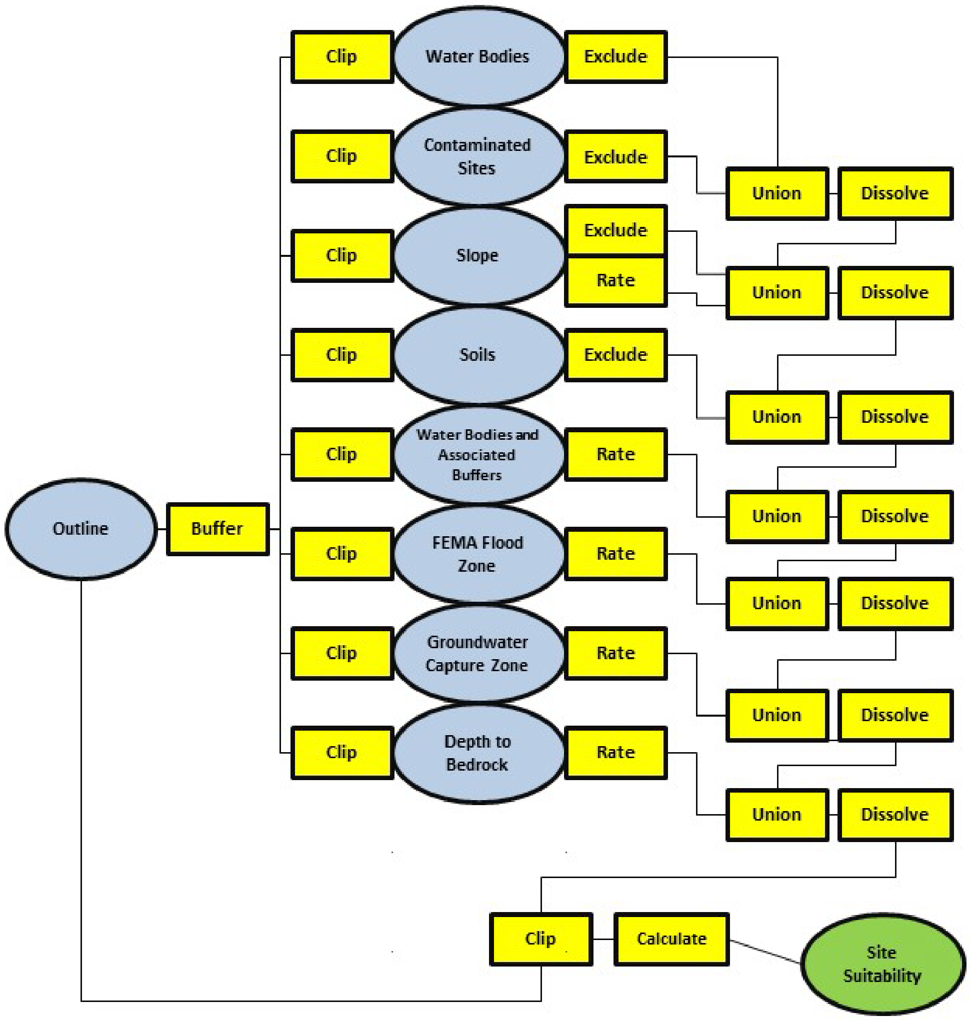

Figure 3. Flow Chart: GIS Suitability Assessment Process for Infiltration Practices

The output from this process is a map in which each pixel in the map grid is assigned a final suitability score and those scores are then grouped into categories and color coded to define differing levels of suitability.

2.5 Step 5: Evaluate Site Suitability Assessment Results

The maps generated in Step 4 can be used to evaluate the suitability of parcels or sites for the implementation of infiltration, biofiltration, underground detention, and surface detention.

Lenses

Several additional data layers representing geographic, physical, or regulatory characteristics can be applied to the assessment maps as “lenses” through which the user can further evaluate the results. Lenses are not rated or included in the computation of the suitability score, but they add context to help the user evaluate the site suitability results. Lenses are typically boundaries for a targeted suitability assessment. For example, the city can examine whether and what type of stormwater management practices may be suitable within public parcels by mapping the public parcel boundary and using it as a lens. Or, if the city wanted to know what categories of practices may be suited to the areas within a CSO sub-basin, city staff could use the CSO sub-basin boundaries as a lens. Table 10 lists the lenses applied to Burlington's assessment.

Table 10. Burlington Lenses for Interpreting Targeted Results

Lens	Source	GIS Data Layer	Considerations for Assessment
Parcel ownership	Local source	"Parcels" in map package	Parcel ownership is used as a lens for further evaluate targeted public parcel opportunities because parcels owned by public entities may be easier or less costly for the city to retrofit or conserve as open space than privately owned parcels. Retrofits on private parcels require a voluntary action by the private landowner, partnership with the private landowner, or a regulation requirement.
Basins and CSO sub-basins	Local source	Sewer basins	Basin and CSO sub-basin boundaries can be used as a lens to further evaluate where to implement targeted stormwater management practices to support CSO separation efforts, CSO event reduction efforts, and stormwater management in basins with separate sewers. Burlington delineated four basins that collect sanitary waste in main trunk lines that travel to the wastewater treatment facility. Within the MASL basin (a combined sanitary and stormwater sewer), there are four locations with CSOs. The city delineated the contributing areas to those CSOs. The strategic implementation of detention and infiltration practices within these areas can help to reduce the stormwater burden contributing to the occurrence of CSOs. In basins where the system is separated, stormwater management can be enhanced by installing stormwater management practices that provide water quality treatment and runoff control. In areas experiencing infiltration and inflow (I/I), stormwater management practices that do not infiltrate may be more suitable to help mitigate or at least avoid exacerbating the I/I.
Existing sewer mapping	Local source	"Sanitary" in map package	Existing utilities can conflict with the installation of stormwater management practices and may render a practice impractical. The only existing utility data available for this assessment were data on the sewer network.

Mapped results can be evaluated within GIS (recommended for parcel-specific investigations) or by printing suitability maps for each category of stormwater management, with or without lenses. Printed maps from Burlington's assessment are included in Section 3 below to provide a visual example of the methodology outputs and how they were used to evaluate site suitability results.

3. Evaluating Site Suitability Assessment Results

Burlington was interested in evaluating the suitability of all land (publicly and privately owned) within each of the basins, as well as the suitability of publicly owned parcels outside of the basins, which were added as lenses and are described in Sections 3.1 and 3.2, respectively.

3.1 Site Suitability Across Burlington and the Three Basins

Citywide maps (Figure 4 through Figure 7) showing site suitability for each of the four stormwater management categories were prepared for Burlington using the methodology described in Section 2. In each figure, the assessment results are presented on a scale from lowest potential suitability (gray) to highest potential suitability (dark green) for the targeted category of stormwater management practices. Each map can be used to initially screen which category of stormwater management practices may be the most suitable for implementation at a given site. Figures showing the individual criteria used in the site suitability assessments, color coded according to the assigned rating scores, are included in Attachment 1 for reference.

The Cascade and Hawkeye Basins have separate stormwater and sanitary sewer systems. Those systems are still affected by wet weather events and during peak flows, may experience SSOs due to infiltration and inflow (I/I). Stormwater discharged from separate storm sewer pipes in Burlington is not treated before it enters the Mississippi River. Stormwater management retrofits within Cascade and Hawkeye Basins can help to reduce the I/I and improve water quality. This screening assessment shows that there are large areas in the upper Hawkeye Basin that may be suitable for underground and surface detention as well as biofiltration practices. A few locations within the basin may also be good for infiltration practices. The Cascade Basin offers many opportunities for biofiltration and surface detention practices and some opportunities for underground detention practices.

Infiltration and Inflow (I/I)

Infiltration: Water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as defective pipes, pipe joints, connections, or manholes. (40 CFR 35.2005(b)(20))

Inflow: Water other than wastewater that enters a sewer system (including sewer service connections) from sources such as, but not limited to, roof leaders, cellar drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, storm waters, surface runoff, street wash waters, or drainage. (40 CFR 35.2005(b)(21))

As Figure 4 through Figure 7 show, there are many suitable sites for more than one category of stormwater management practice, and many opportunities throughout the city overall. The heat maps show that biofiltration is the most widely applicable practice category across Burlington. Surface detention practices also appear to be widely suitable across the city. Sites that may be suitable for underground detention are located throughout Burlington, with a heavier concentration on the western portion of the city. Sites suitable for infiltration practices are limited based on the criteria requirements, primarily due to the soil permeability.

Implementing targeted stormwater management practices throughout the city could help reduce the stormwater volume and peak flows that exacerbate CSOs, SSOs, flooding, and water quality issues. The city has delineated individual basins, which were applied as a lens in this assessment to help focus and prioritize the implementation of certain stormwater management practices to meet management goals within each basin. Figure 4 through Figure 7 also include the boundaries of the basins, so the results can be evaluated through the lens of each basin boundary.

The four figures show that there are minimal infiltration and underground detention practice opportunities, but there are many potential biofiltration and surface detention opportunities within the MASL Basin that if implemented could help reduce CSOs.

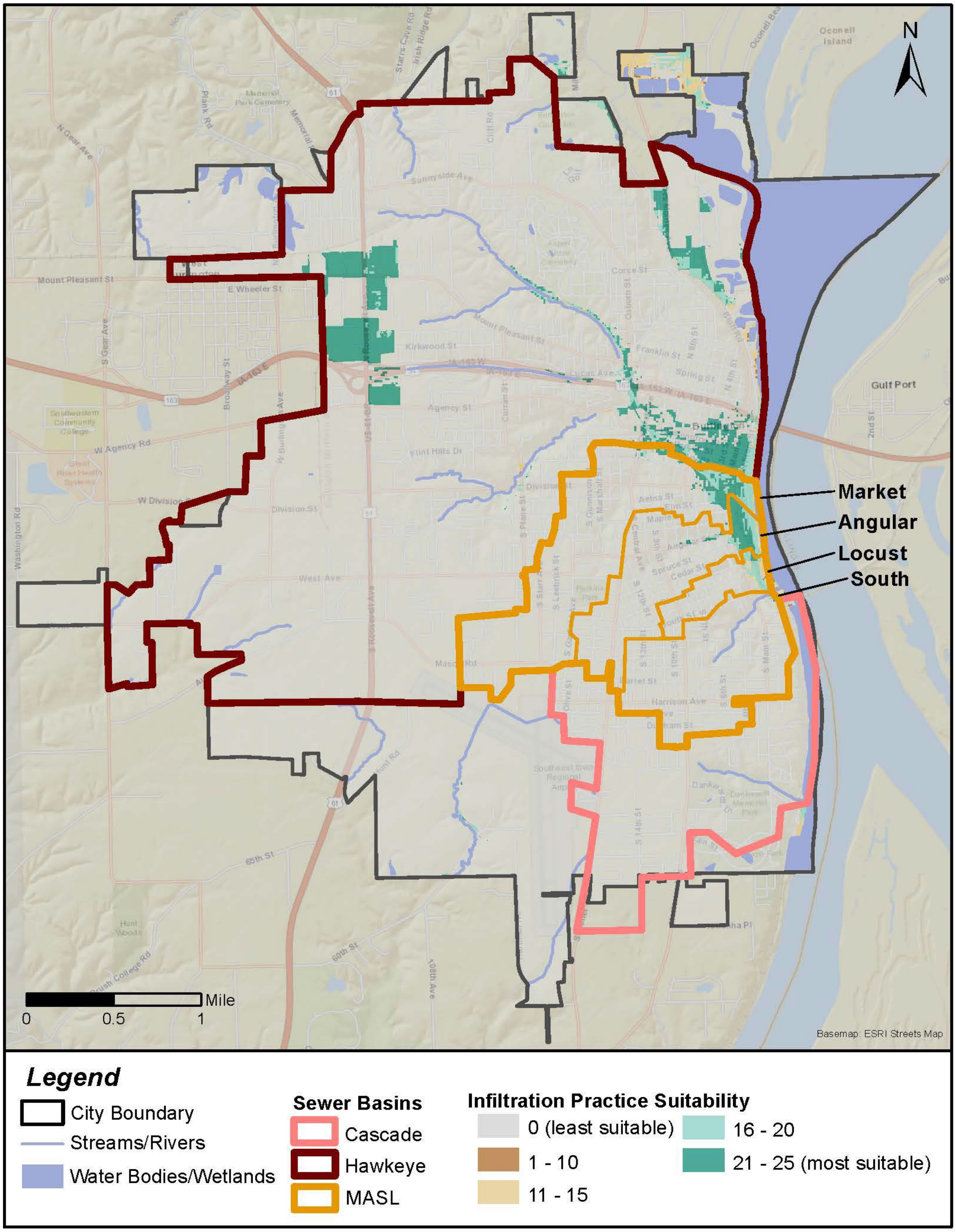

Figure 4. Infiltration Practice Suitability

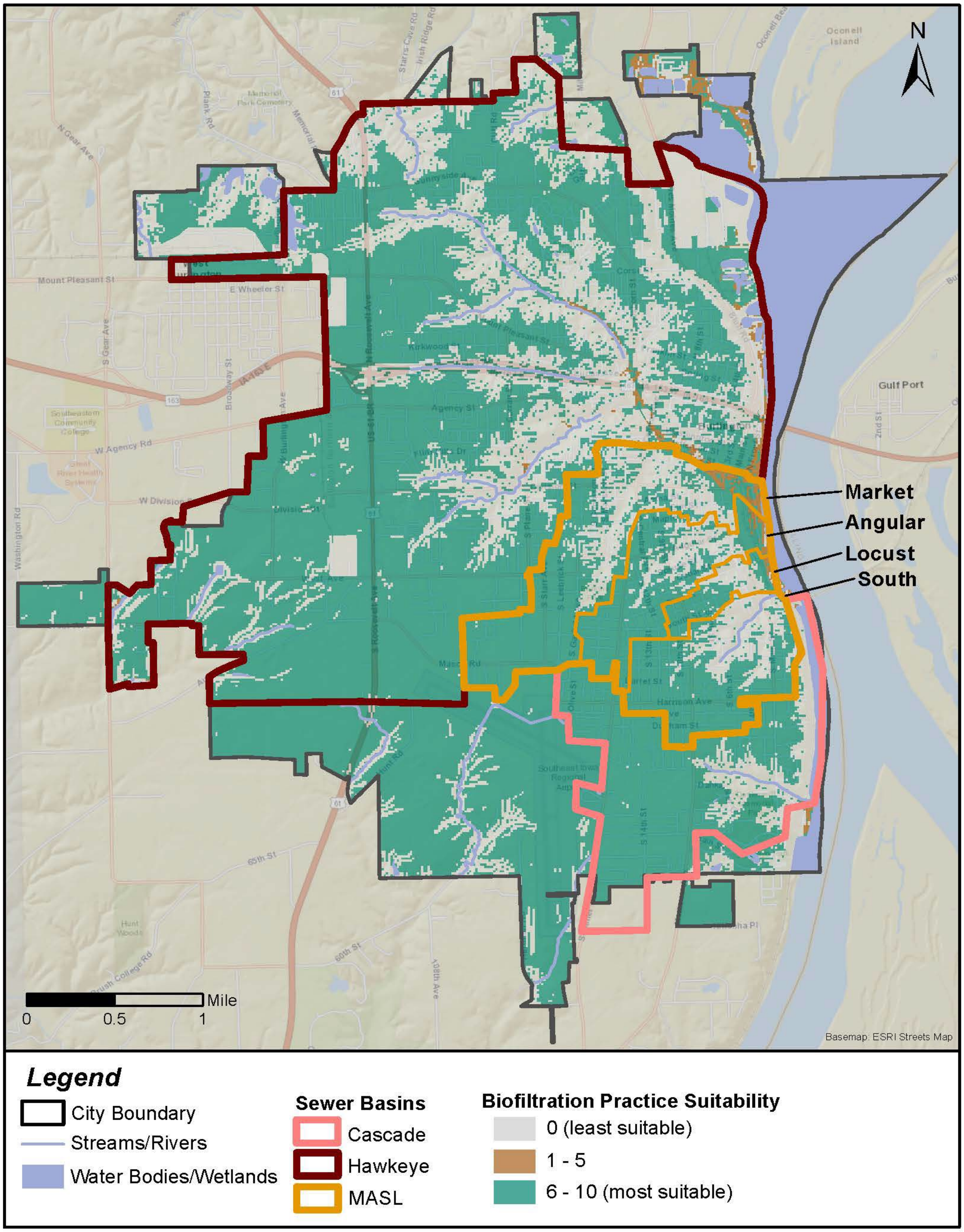

Figure 5. Biofiltration Practice Suitability

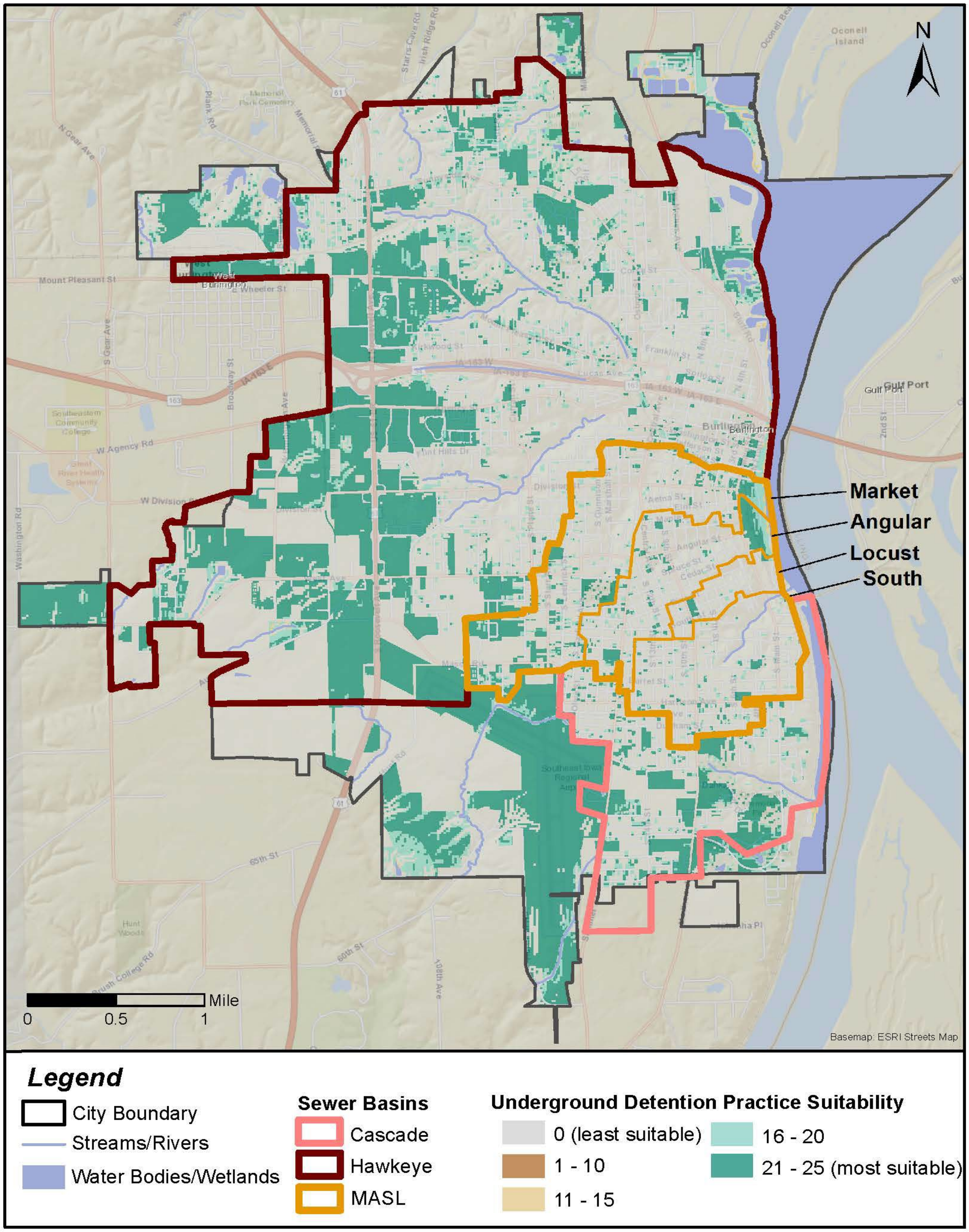

Figure 6. Underground Detention Practice Suitability

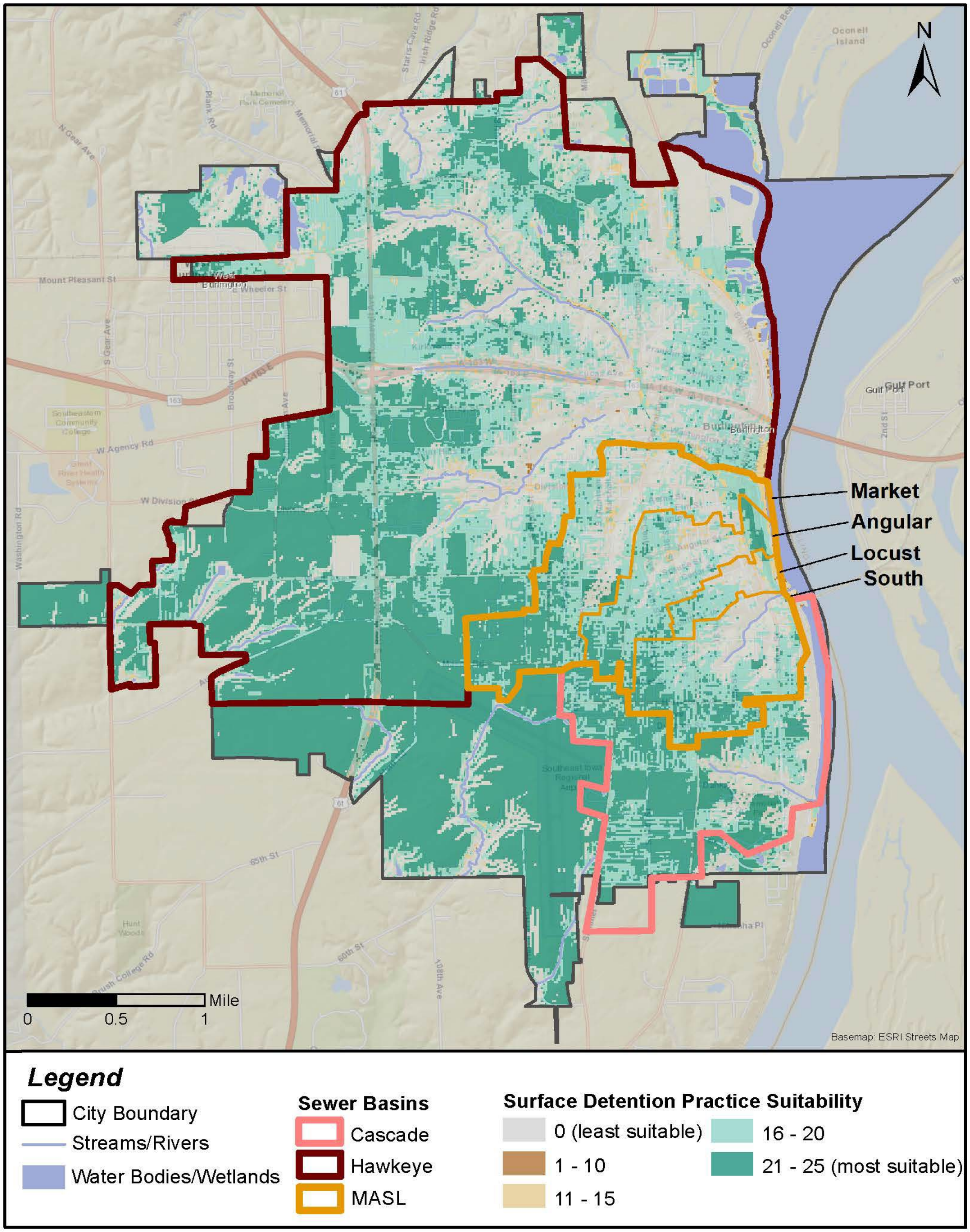

Figure 7. Surface Detention Practice Suitability

3.2 Site Suitability Within the Angular CSO Sub-Basin

To further demonstrate how this assessment can be used to target project locations to reduce CSO discharges, Figure 8 through Figure 11 present the results of the stormwater management practice suitability assessments within the Angular CSO Sub-basin, which is a part of the MASL Basin. The Angular CSO Sub-basin reaches overflow capacity at very small flow frequency, according to the city's *Wastewater and Stormwater Integrated Management Plan*. Any practices that divert or detain stormwater in the Angular CSO Sub-basin would help reduce the occurrence and impacts of CSOs from the Angular CSO outfall. In each figure, the assessment results are presented on a scale from lowest potential suitability (gray) to highest potential suitability (dark green) for the targeted category of stormwater management practices.

Figure 8 shows that infiltration practices are most suitable in just a few parts of this basin.

Figure 9 shows widespread potential opportunities for biofiltration in the upper portion of the basin (shown in the southwest quadrant of the figure). As Table 1 suggests, biofiltration practices such as bioretention, bioswales, or permeable pavement with an underdrain might be suitable choices in the upper portion of the basin to treat stormwater water quality as the system is separated or detain and slow down stormwater as it enters the combined system, potentially alleviating some peak flows that challenge the capacity of the pipes.

Figure 10 suggests potential opportunities for underground detention throughout the Angular CSO Sub-basin. This can be useful in detaining stormwater and reducing the peak flows in the combined system that contribute to the occurrence of CSOs.

Figure 11 suggests that there are widespread opportunities for surface detention, specifically in the upper portion of the Angular CSO Sub-basin.

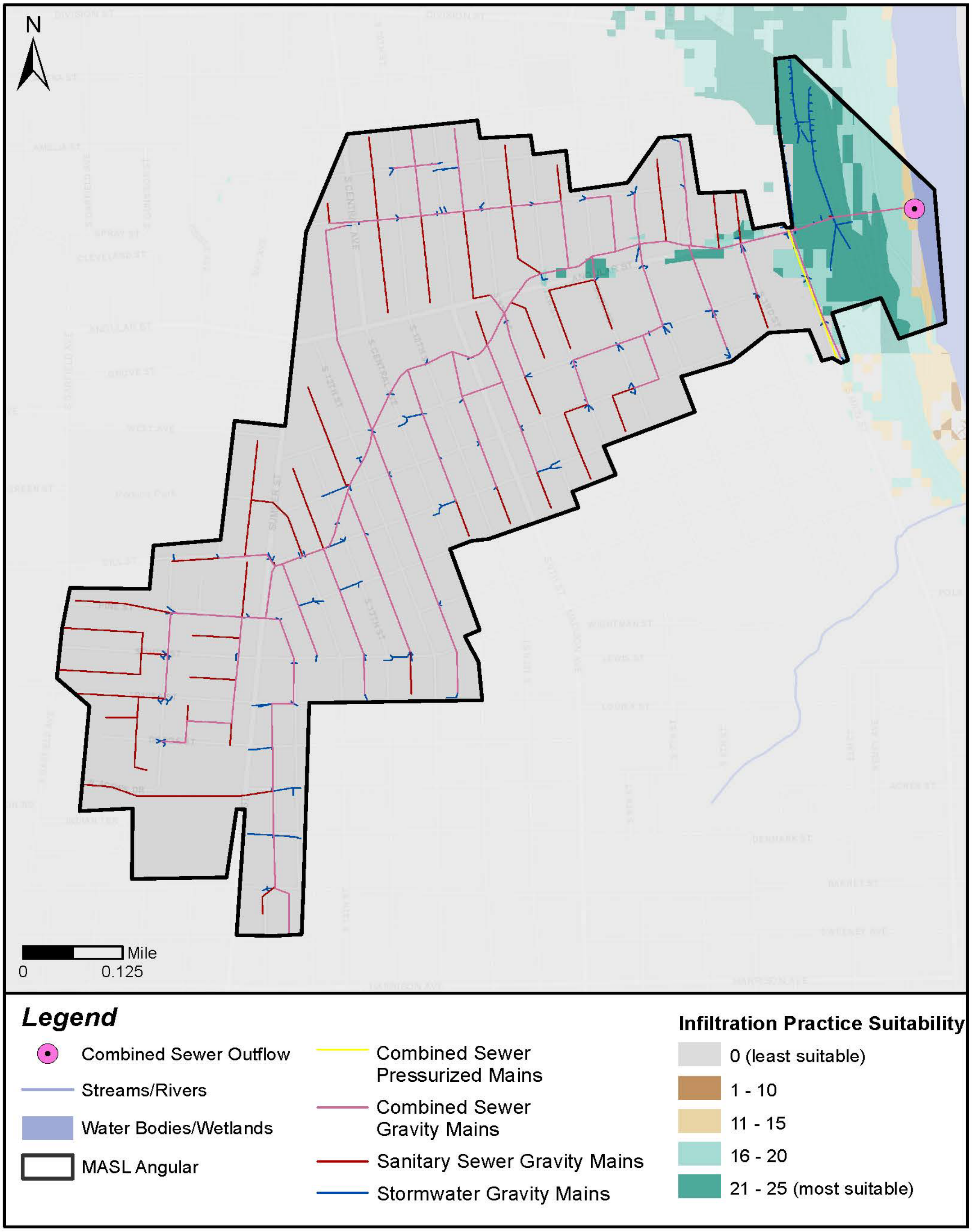

Figure 8. Infiltration Practice Suitability and Sewer Infrastructure Within the Angular CSO Sub-basin of MASL Basin

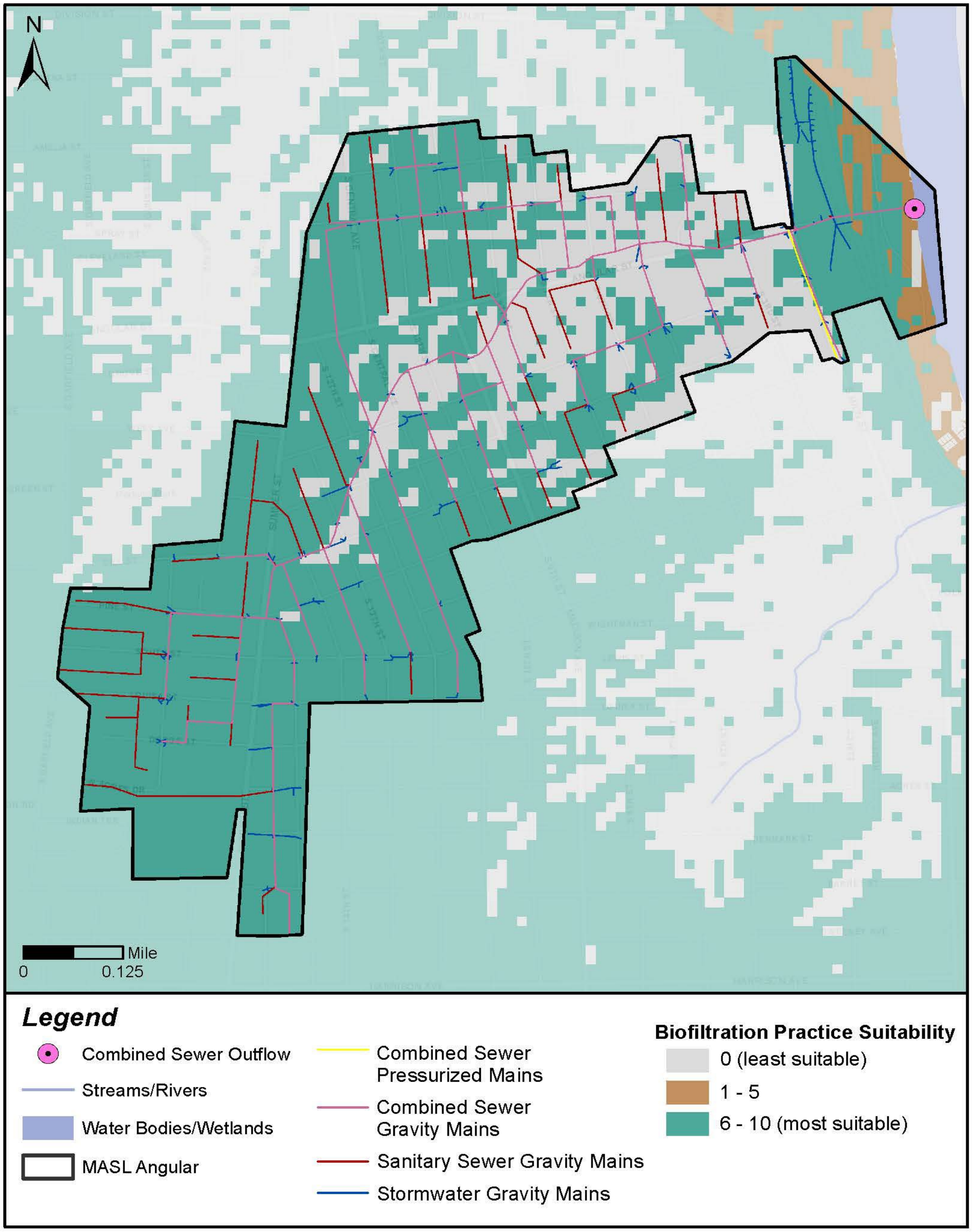

Figure 9. Biofiltration Practice Suitability and Sewer Infrastructure Within the Angular CSO Sub-basin of MASL Basin

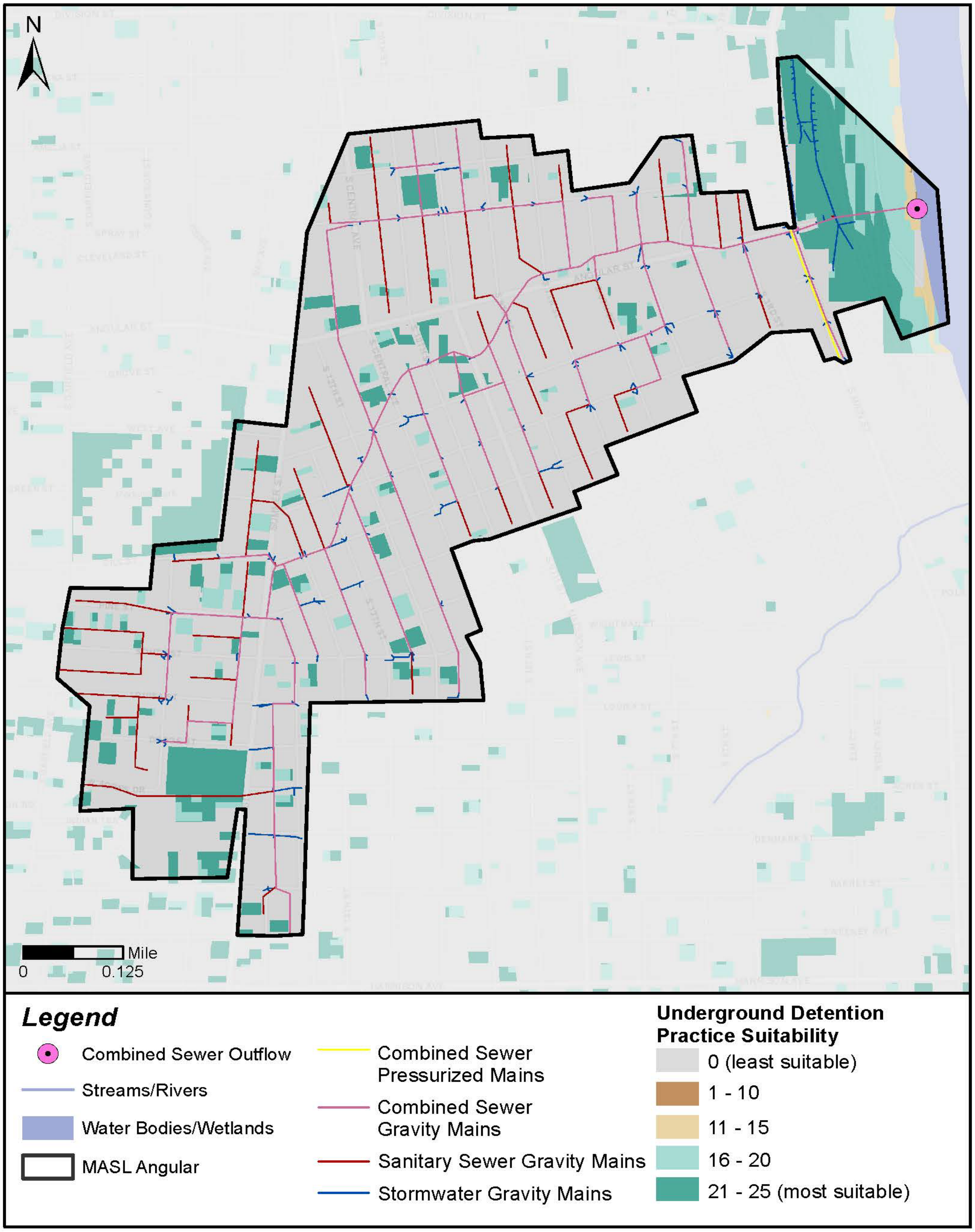

Figure 10. Underground Detention Practice Suitability and Sewer Infrastructure Within the Angular CSO Sub-basin of MASL Basin

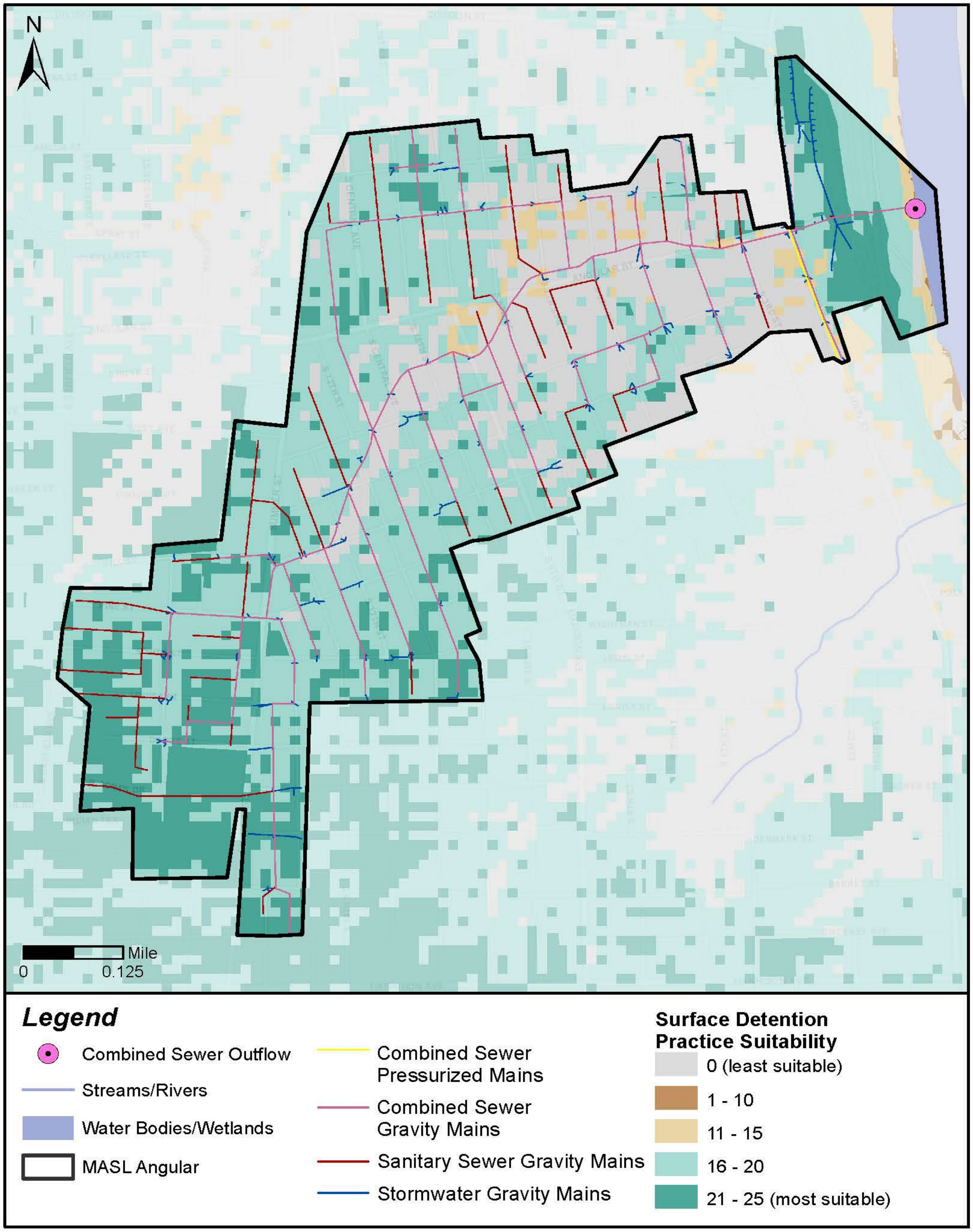

Figure 11. Surface Detention Practice Suitability and Sewer Infrastructure Within the Angular CSO Sub-basin of MASL Basin

3.3 Site Suitability Within Publicly Owned Parcels

The public parcels lens can be combined with the basins lens to further identify possible locations for targeted stormwater management practices on public property, where access and implementation may be easier and quicker than on private property. The city can examine in more detail whether a parcel or portion of a parcel is well suited for specific category of stormwater management practices. This screening-level suitability information can help the city quickly identify potential opportunities for stormwater projects when a new construction project is proposed on a specific publicly owned site. The city could also review the heat maps to identify targeted public parcels to assess further. This assessment data and city criteria can be continually updated, and outputs can be an ongoing point of reference for city staff to use when pursuing projects on city property or when looking to implement additional stormwater management for the targeted purposes of detention, infiltration, and/or biofiltration.

Figure 12 indicates that biofiltration may be suitable at four of the public properties within the Angular CSO Sub-basin. Biofiltration practices include bioretention, bioswales, tree trenches, tree boxes, permeable pavement, and sand or media filters (all designed with underdrains), as well as wet ponds or constructed wetlands. All of the four public properties drain to gravity stormwater mains that discharge to the combined sewer system. The biofiltration practices identified above could help to slow the flow of stormwater and reduce peak storm discharges before the enter the combined sewer system.

The assessment results in Figure 12 indicate that there are not many public properties in the Angular CSO Sub-basin; therefore, the city may also want to explore pursuing assistance from and partnerships with private landowners to install stormwater management practices on private properties (see Section 3.2 for additional project opportunities on private properties in the Angular CSO Sub-basin).

The city could repeat this type of public parcel assessment within a CSO Sub-basin in other areas to identify similar opportunities and targeted approaches to meet water quality goals.

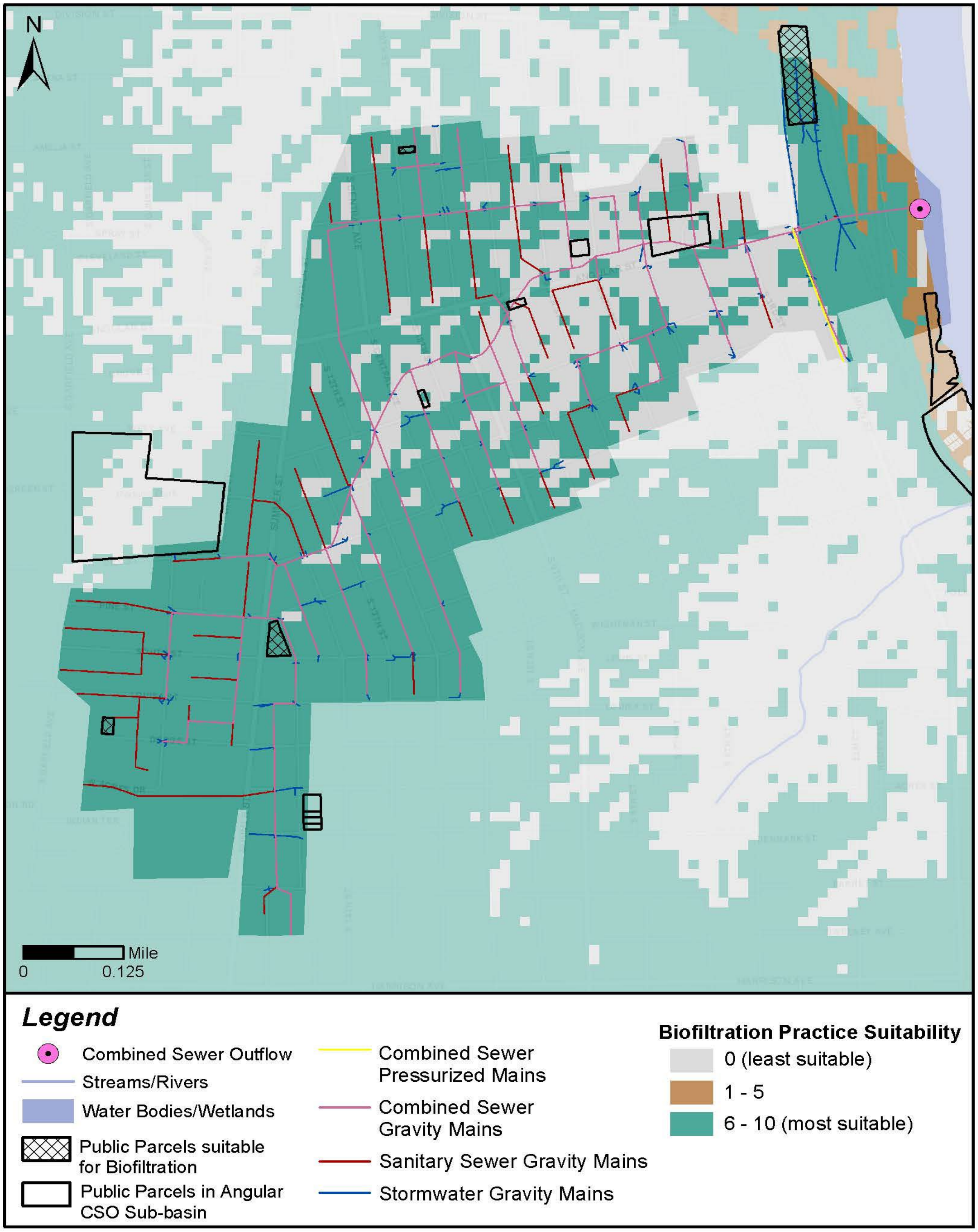

Figure 12. Biofiltration Practice Suitability for Public Parcels Within the Angular CSO Sub-basin of MASL Basin

4. Next Steps: Building on the Site Suitability Assessment

The site suitability assessment methodology described in this document can be used to guide the city toward targeted and informed stormwater management practice implementation. This methodology helps the city narrow in on where to further investigate potential stormwater management opportunities. The results of this assessment are screening-level only and should not be interpreted as prohibiting certain types of stormwater management practices in areas that score low in the suitability assessment. Rather, the results help to focus limited city funds and efforts on areas that appear to have more suitability based on the chosen criteria, scoring, and city priorities. Using this methodology to perform assessments provides a logical path forward when the city is looking to make stormwater management improvements.

4.1 Targeted Desktop Analysis

The site suitability assessment and evaluation lenses can identify a variety of potential sites where stormwater management practices might be suitable. There may also be locations that surprisingly did not appear on the heat maps as good spots for stormwater management. A more detailed review of each data layer that went into the assessment can provide important insight into the assessment results for a given parcel. An aerial photo can also provide context and help to clarify what land use and site conditions exist at the site. Other available GIS data layers can also be incorporated. In the case of Burlington, the city has GIS mapping of the sanitary and storm sewer mains to augment the site suitability assessment data.

Figure 13 and Figure 14 focus in on one publicly owned parcel in the Angular CSO Sub-basin, identified as suitable for biofiltration. Figure 13 shows that the northern portion of the parcel is vegetated, a large area of the parcel contains a building, and the remainder contains a large parking lot that drains to a stormwater main that ultimately feeds into a combined sewer system. The individual data layers presented in Figure 14 indicate that the northern grassy area of the parcel is relatively flat and located in the flood plain, while the southern portion is slightly more sloped and is outside the flood plain. No other characteristics, aside from impervious cover, differentiate areas of the site. A rating of '1' for contamination indicates that there is no known contamination (a '0' would indicate the presence of contamination and would result in that area being excluded). A rating of '1' for hydrologic soil group indicates that the soils are either HSG A or B (or no data), meaning that they are suitable for infiltration practices and are not excluded from consideration. Based on these characteristics, the parking area could be renovated to incorporate bioswales or bioretention to treat stormwater runoff, or permeable pavement or a wetland system to also detain stormwater.

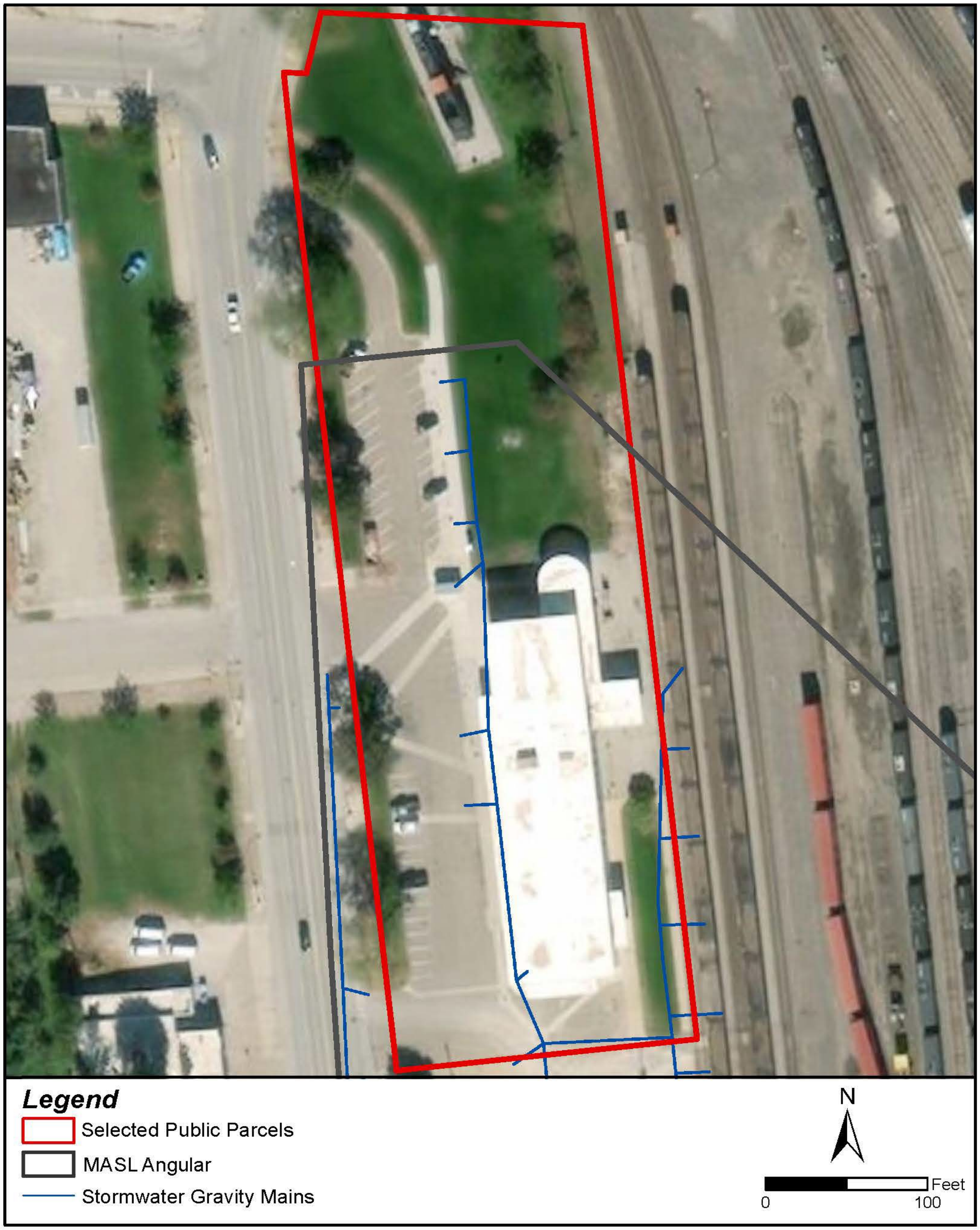

Figure 13. Aerial Overview of a Selected Public Parcel in the Angular CSO Sub-basin

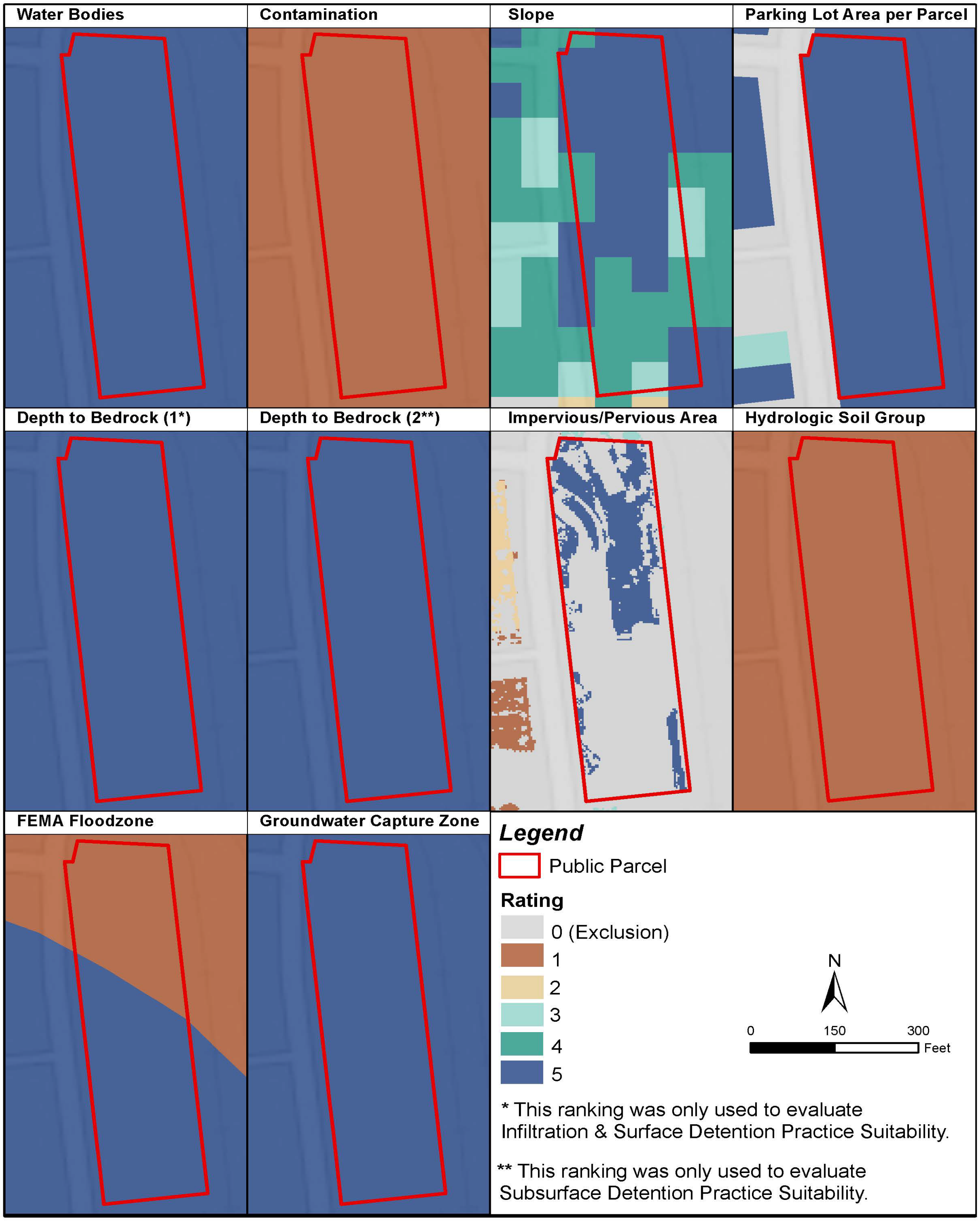

Figure 14. Criteria Overview for a Selected Public Parcel in the Angular CSO Sub-basin

4.2 Field Investigation and Concept Design

Once potentially suitable stormwater management sites are identified through the GIS-based site suitability assessment and targeted desktop analysis, the next step is to investigate these sites in person to identify additional constraints and opportunities that may not be visible using GIS data alone. For example, a site visit may reveal:

- Information on utilities for which the GIS has no data.
- A change in land use that is not reflected in the latest GIS data.
- An impact, such as sediment buildup, erosion, or prevalence of an invasive species, that may influence the design or selection of a particular stormwater management practice.

Site investigations are also an opportunity to begin sketching out conceptual designs for potential stormwater management practices at the site, particularly if the project is a retrofit or renovation of an existing site. A conceptual design of a stormwater management practice can be a sketch using a marker on an aerial photo, or a sketch on a tablet computer that may have mobile GIS capabilities. The idea is to identify:

- A location that is the appropriate size for the proposed stormwater management practice.
- A feasible mechanism for draining water into the stormwater management practice.
- A feasible mechanism for discharging water from the stormwater management practice via infiltration, underdrain connection to existing infrastructure, or overflow.

The concept design should take into consideration an estimate of the size of the site's contributing drainage area and the basic treatment and/or detention volume. All the assumptions made in the concept sketch are estimates but should be made by a designer or engineer with stormwater management experience. An organized site visit effort following the site assessment phase can result in a well-documented plan of stormwater management practice implementation opportunities throughout a neighborhood, basin, or city boundary.

Stormwater Management Opportunities Come in Many Functions, Shapes, and Sizes

Innovative approaches are used in locations throughout the country to integrate green infrastructure into developed landscapes. The restoration work in the Berry Brook watershed in Dover, New Hampshire, and the Mystic River and Buzzards Bay Watersheds in Massachusetts are examples of the effectiveness of smaller-capacity stormwater control systems that provide water quality and other benefits. These case studies also demonstrate the process of evaluating pollutant load reduction and cost effectiveness of green infrastructure on the ground.

(For more information on the restoration projects mentioned above, visit https://www.unh.edu/unhsc/berry-brook-project and https://www3.epa.gov/region1/npdes/stormwater/ma/opti-tool-case-study-demo-buzzards-bay-watershed.pdf.)

4.3 Estimating Benefits

This type of site suitability assessment lays the groundwork for a community to consider the combined water quality benefits of implementing stormwater management practices at scale across a neighborhood, a basin, or the community. Once the suitability assessment identifies potential sites and basic concepts are developed, the community can begin to estimate the potential stormwater water quality treatment, flood mitigation, infiltration, and detention improvements at each site. These estimates can be combined and evaluated against CSO mitigation, combined sewer separation, and receiving water quality goals to see which combinations of practices in which locations might be most effective. A host of modeling tools can be employed for this purpose, ranging in complexity and data intensity. An overview of green infrastructure modeling tools for planning and design can be found at https://www.epa.gov/green-infrastructure/green-infrastructure-modeling-tools. Links to more detailed information about specific tools and models are summarized in the call-out box below.

Green Infrastructure Screening and Selection

The **EPA Green Infrastructure Modeling Toolkit** includes many tools and models to help communities identify and evaluate which green infrastructure and combinations could be effective.

The **Green Infrastructure Wizard** is a web application that provides communities with information about EPA green infrastructure tools and resources.

The **Watershed Management Optimization Support Tool** is a software application that allows users to screen a wide range of management practices for cost-effectiveness and economic sustainability.

Performance Simulation and Modeling

Visualizing Ecosystem Land Management Assessments is a computer software model to help regional planners and land managers determine which green infrastructure practice would be most effective for improving water quality in streams, estuaries, and groundwater.

The **Storm Water Management Model** is a simulation model that communities can use for stormwater runoff reduction planning, analysis, and the design of combined sewers and other drainage systems.

The **National Stormwater Calculator** is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States (including Puerto Rico). SWC allows users to learn about the ways that green infrastructure, like rain gardens, can prevent water pollution in their neighborhoods.

The **Green Infrastructure Flexible Model** is a computer program that evaluates the performance of urban stormwater and agricultural green infrastructure practices. Users can build conceptual models of green infrastructure to predict hydraulic and water quality performance under given weather scenarios.

EPA Region 1's **Stormwater Optimization Tool** is a desktop application combining GIS and spreadsheet analysis that allows users to evaluate options and determine the best mix of structural stormwater management practices, including green infrastructure, to achieve quantitative water resource goals.

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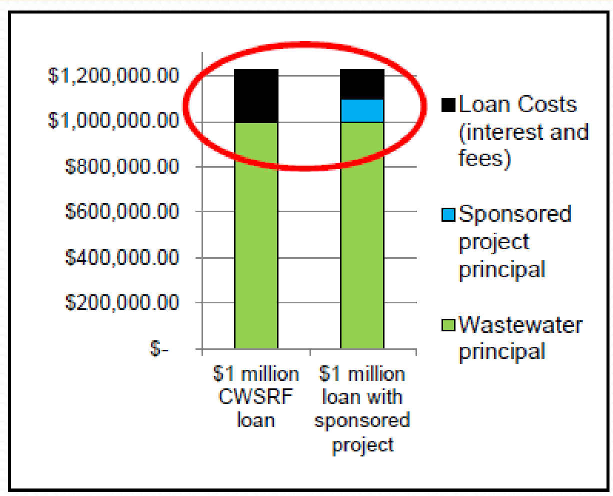
4.4 Leveraging Analysis Results

This type of preliminary stormwater management opportunity assessment also positions the city to pursue and take advantage of available grants and other funding mechanisms to design and install stormwater management practices. Communities are encouraged to think broadly about where they search for implementation funding sources, including sources geared toward water quality improvements, stormwater management, parks improvement, public-private partnerships, climate change resilience, urban revitalization, transportation projects (including green streets and "road diets"), and even historic restoration. Projects and associated funding can be considered at different scales (e.g., individual stormwater management practices, neighborhood or roadway, drainage basin, entire community).

This type of analysis identifies multiple stormwater management and green infrastructure opportunities that could be 'bundled' together to pursue funding for more than one project at a time. For example, communities could apply for funding from the Clean Water State Revolving Fund (CWSRF) to implement multiple opportunities within a given neighborhood or watershed, or multiple opportunities that include a uniform set of stormwater management practices or a uniform set of property types (public parks, residential sites, schools, municipal facilities, historic properties, etc.). For more information about stormwater funding resources and opportunities, visit: https://www.epa.gov/waterdata/water-finance-clearinghouse.

Sponsored Projects

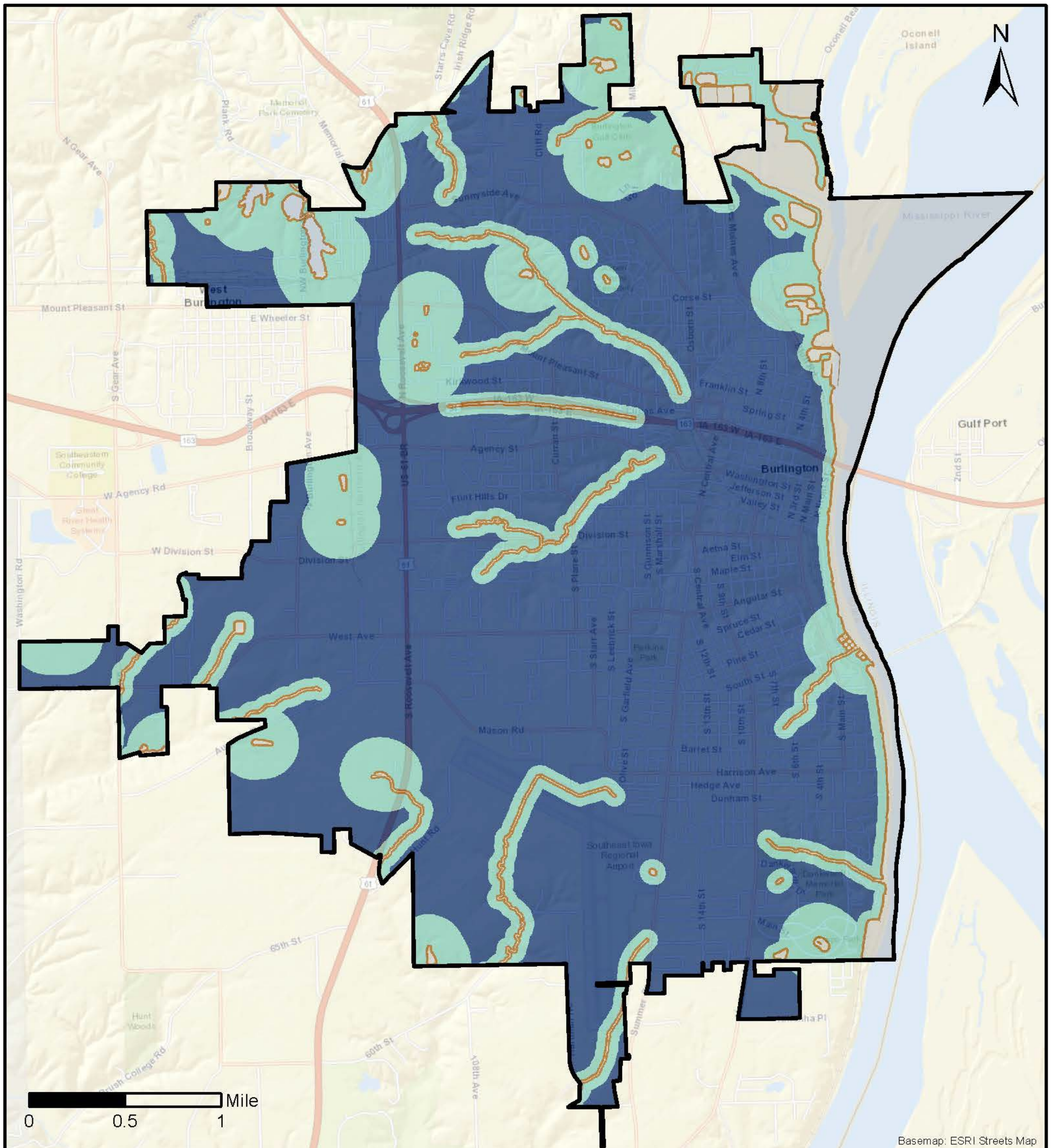
In Iowa, wastewater utility revenues can be used to finance projects called "water resource restoration sponsored projects" that improve water quality in the utility's watershed. Utilities often use a CWSRF loan to finance a wastewater improvement project. If a nonpoint source project is combined with a sponsored project the CWSRF loan's interest rate is reduced. This allows a utility receiving a loan to act as a "sponsor," financing both projects at no additional cost, as shown in the example graphic on the right. Water quality projects, such as green infrastructure, can be installed with no resulting rate increases for customers. Iowa sets aside $10 million per year for sponsored projects. For more information, visit http://www.iowasrf.com/about_srf/sponsored_projects_home_page.cfm.



http://www.iowasrf.com/media/cms/Sponsored_Projects_Handout_E1BF13A15D660.pdf

Thanks to their multiple benefits, stormwater management practices can be integrated into projects to support goals such as revitalization, historic preservation and restoration, habitat creation, localized flooding reduction, or park improvement. The benefits are often experienced by adjacent landowners as well as residents throughout the community, making the value of these projects even greater. In some cases, stakeholders may be interested in supporting a project through a public-private partnership in which the private entity helps fund, finance, or provide space for a project.

Attachment 1: Rating and Exclusion Maps for Each Assessment Criterion

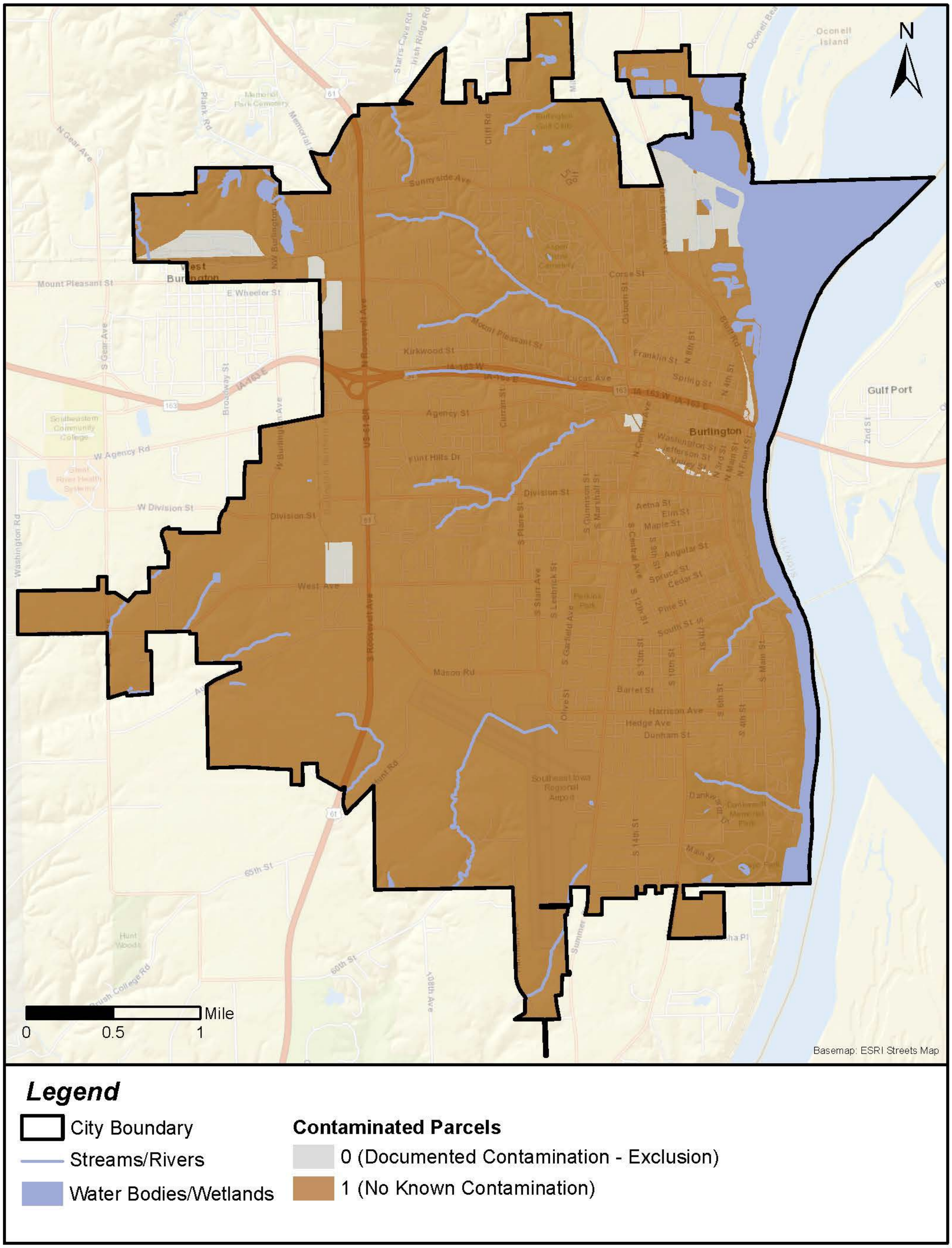


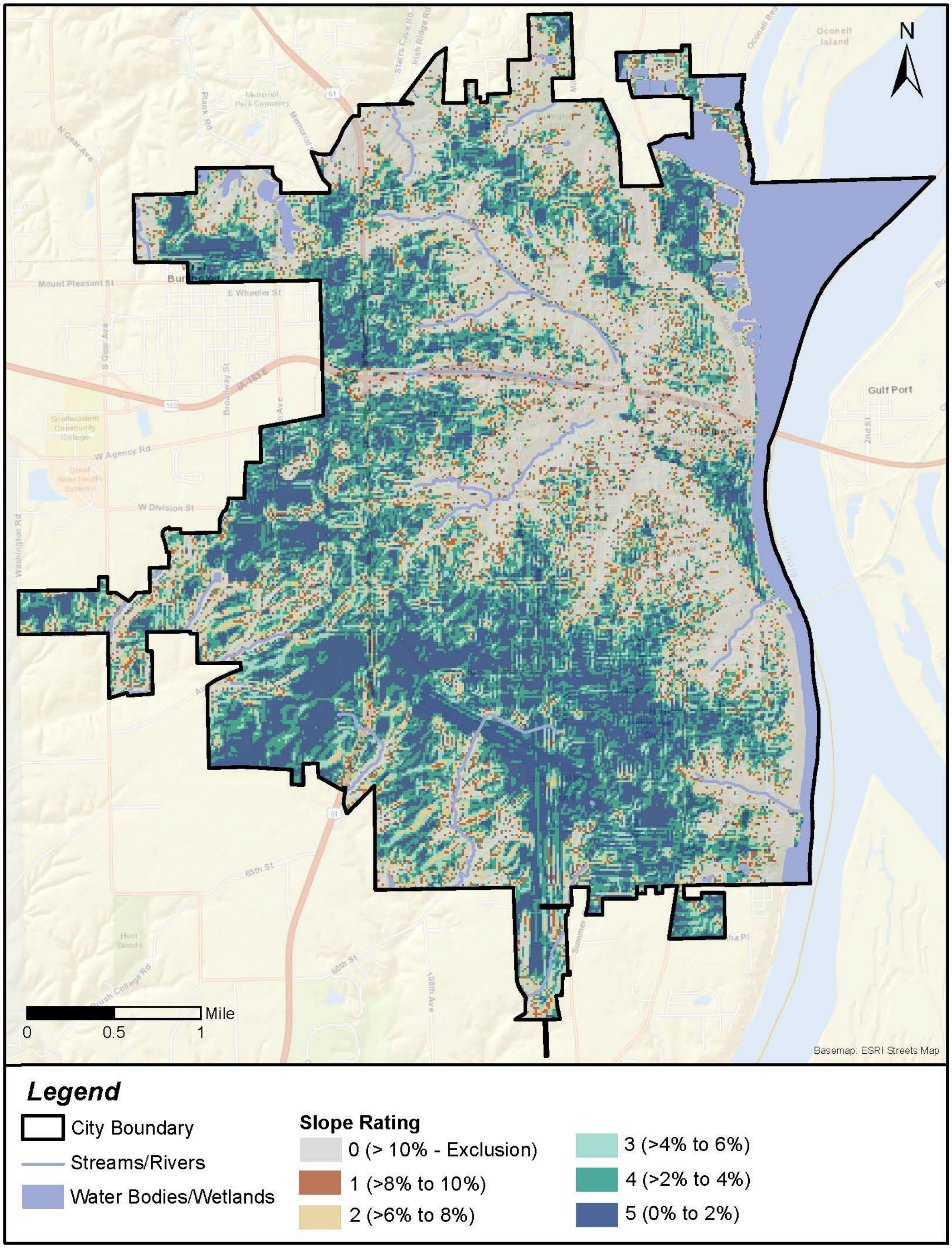
Legend

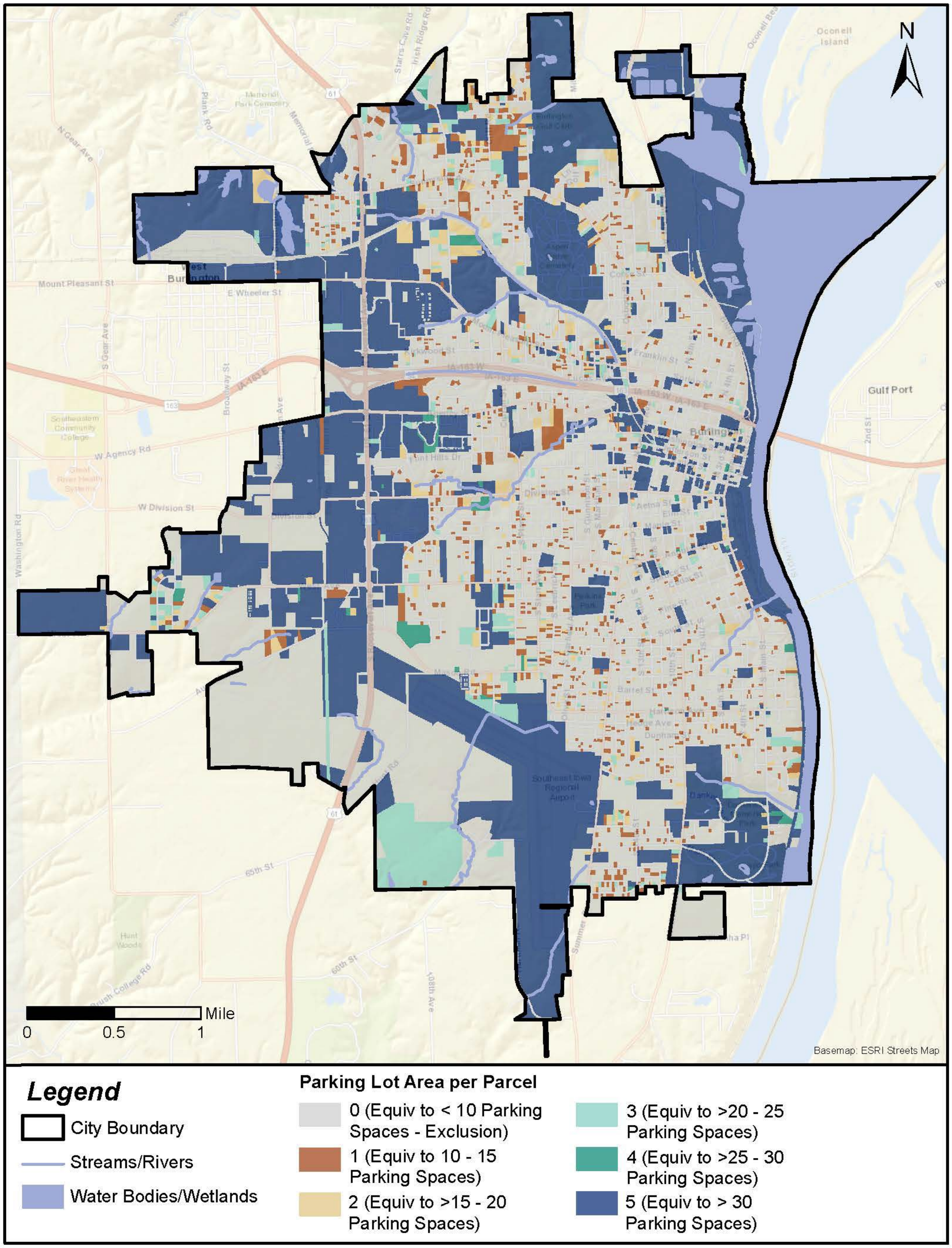
City Boundary

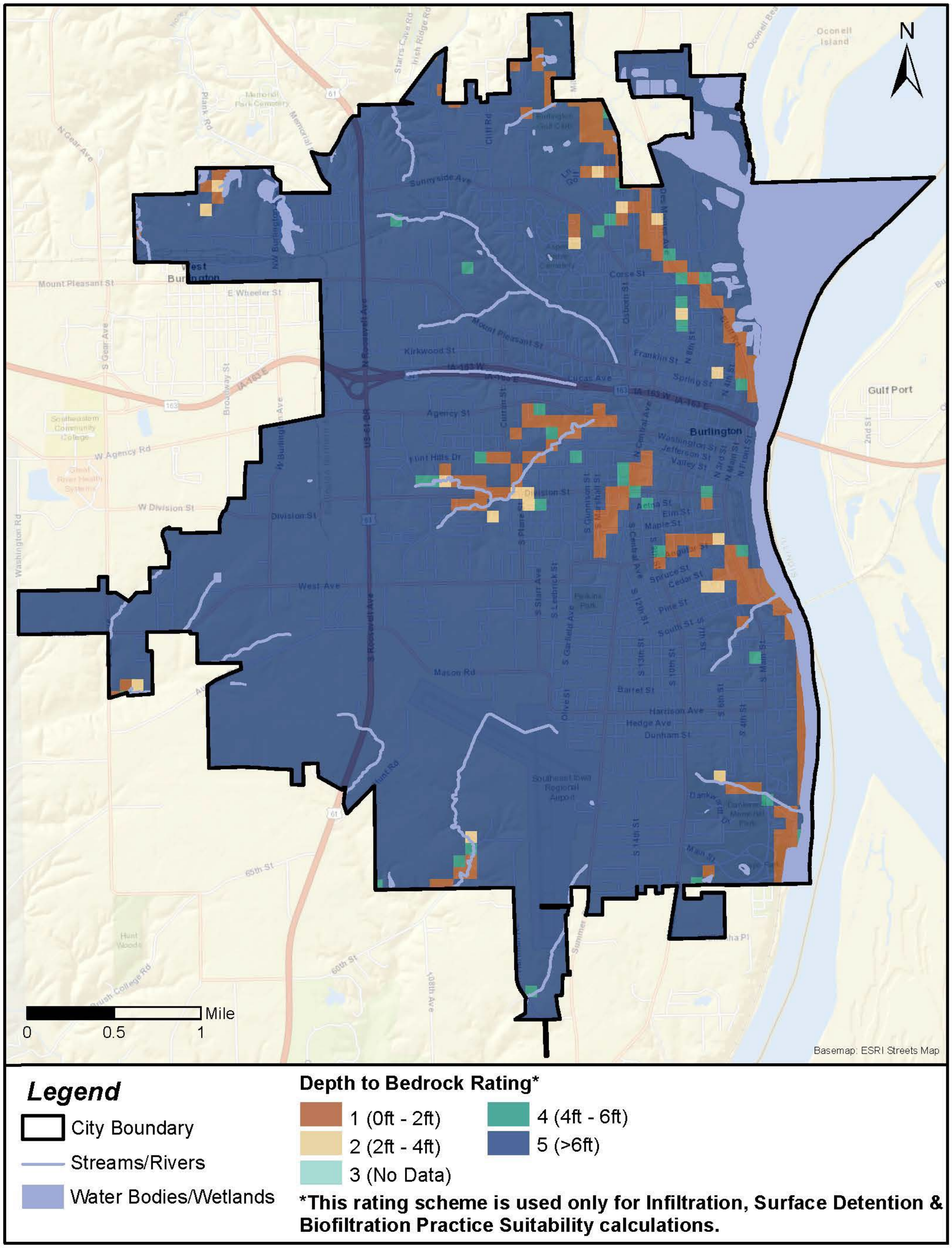
Water Bodies and Associated Buffers Rating

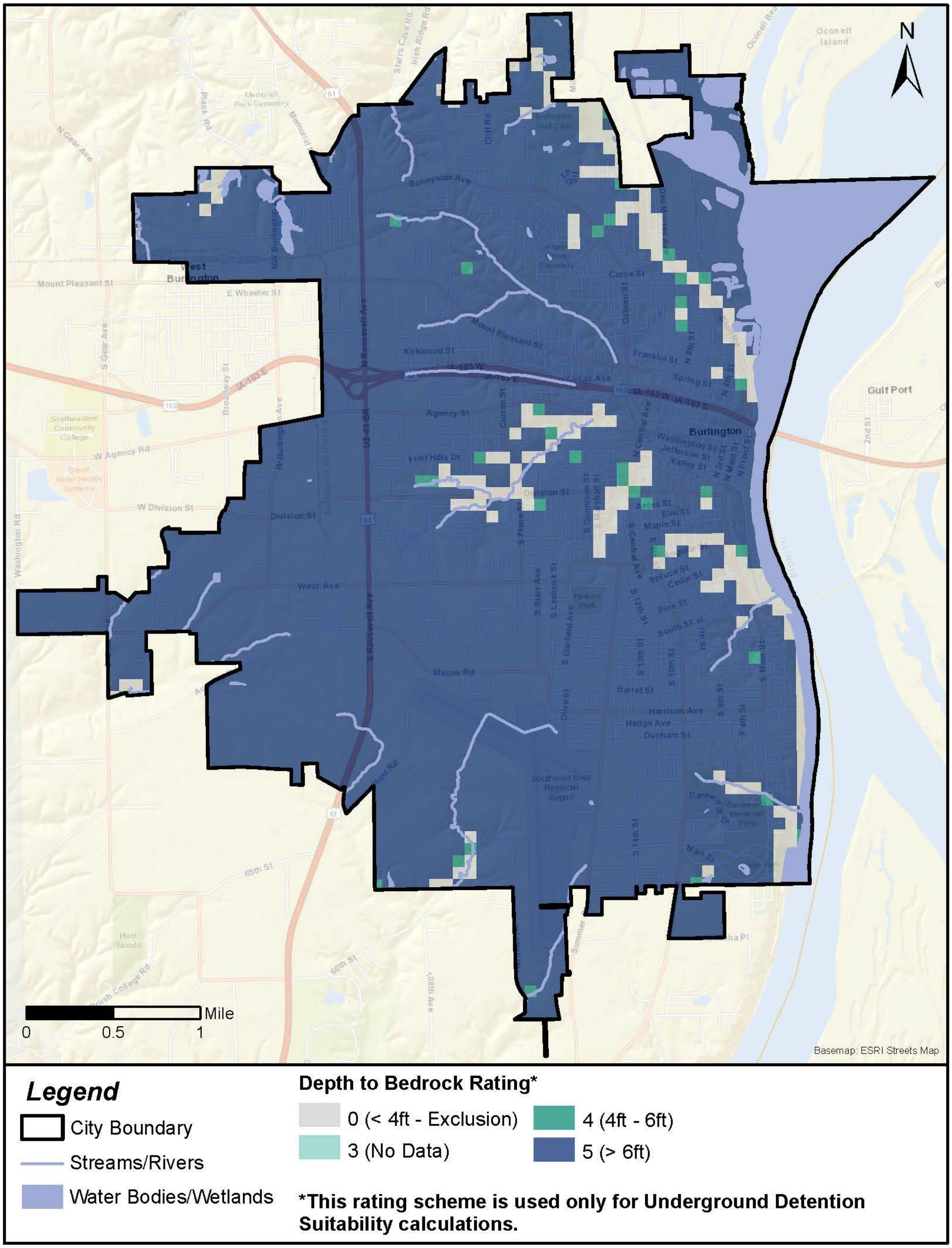
- 0 (Inside Water Bodies - Exclusion)
- 1 (Within 66ft of Water Bodies)
- 3 (Within 300ft of Rivers/Wetlands and 1000ft of Lakes)
- 5 (Outside of Water Bodies and Associated Buffers)

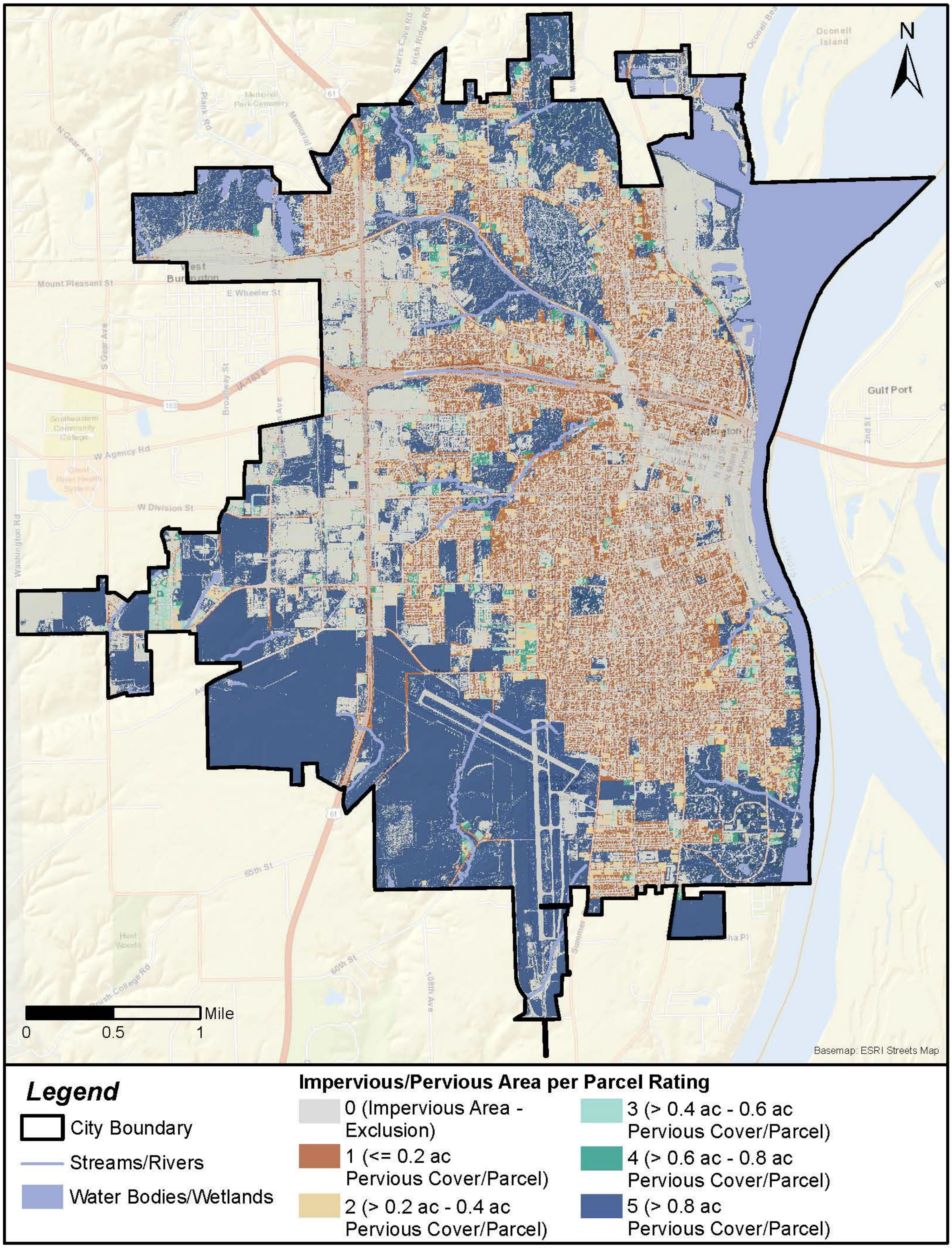

N
Burlington
West Burlington
Gulf Port
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Contaminated Parcels
0 (Documented Contamination - Exclusion)
1 (No Known Contamination)

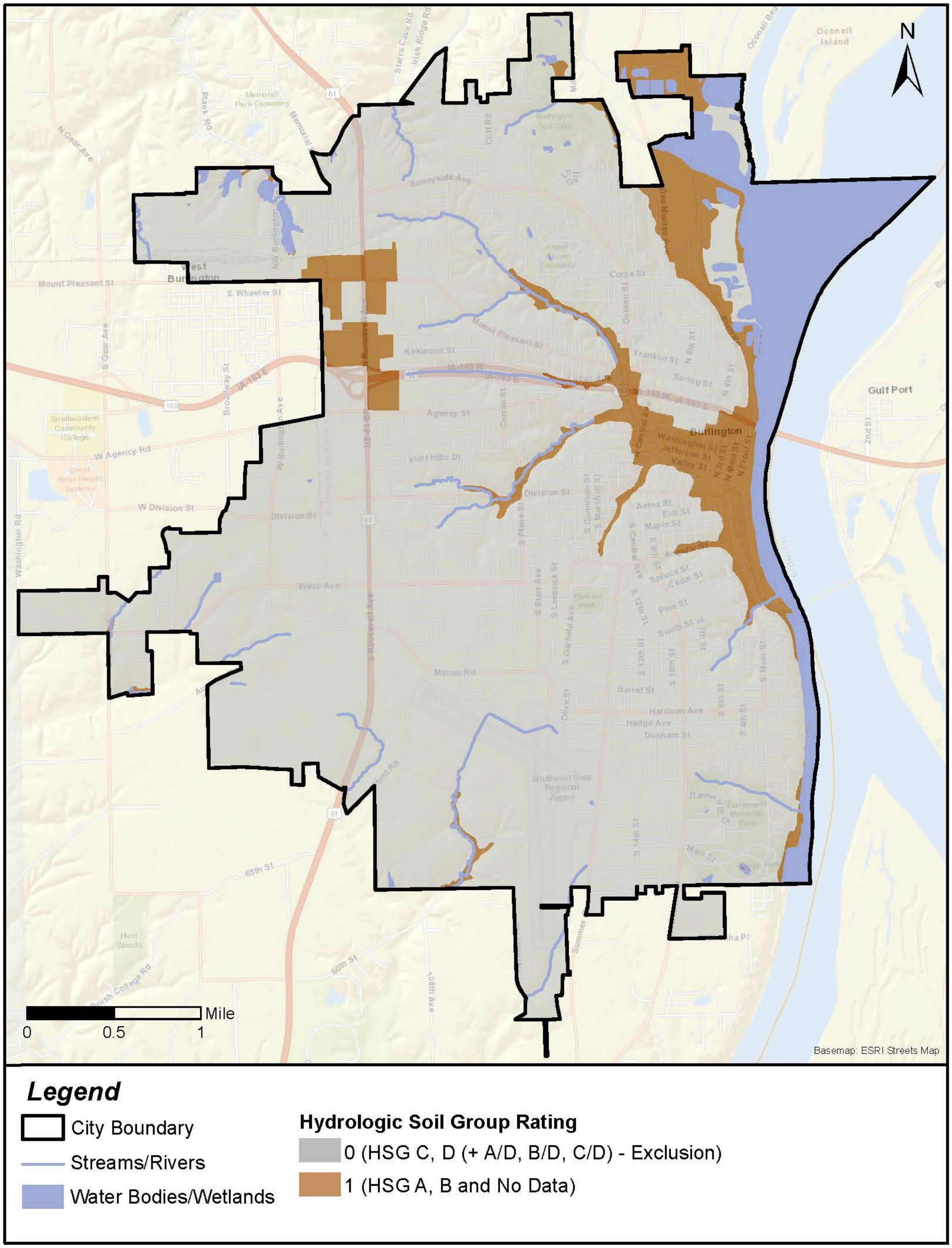

N
Mount Pleasant St
E Wheeler St
W Agency Rd
W Division St
Gulf Port
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Slope Rating
0 (> 10% - Exclusion)
1 (>8% to 10%)
2 (>6% to 8%)
3 (>4% to 6%)
4 (>2% to 4%)
5 (0% to 2%)

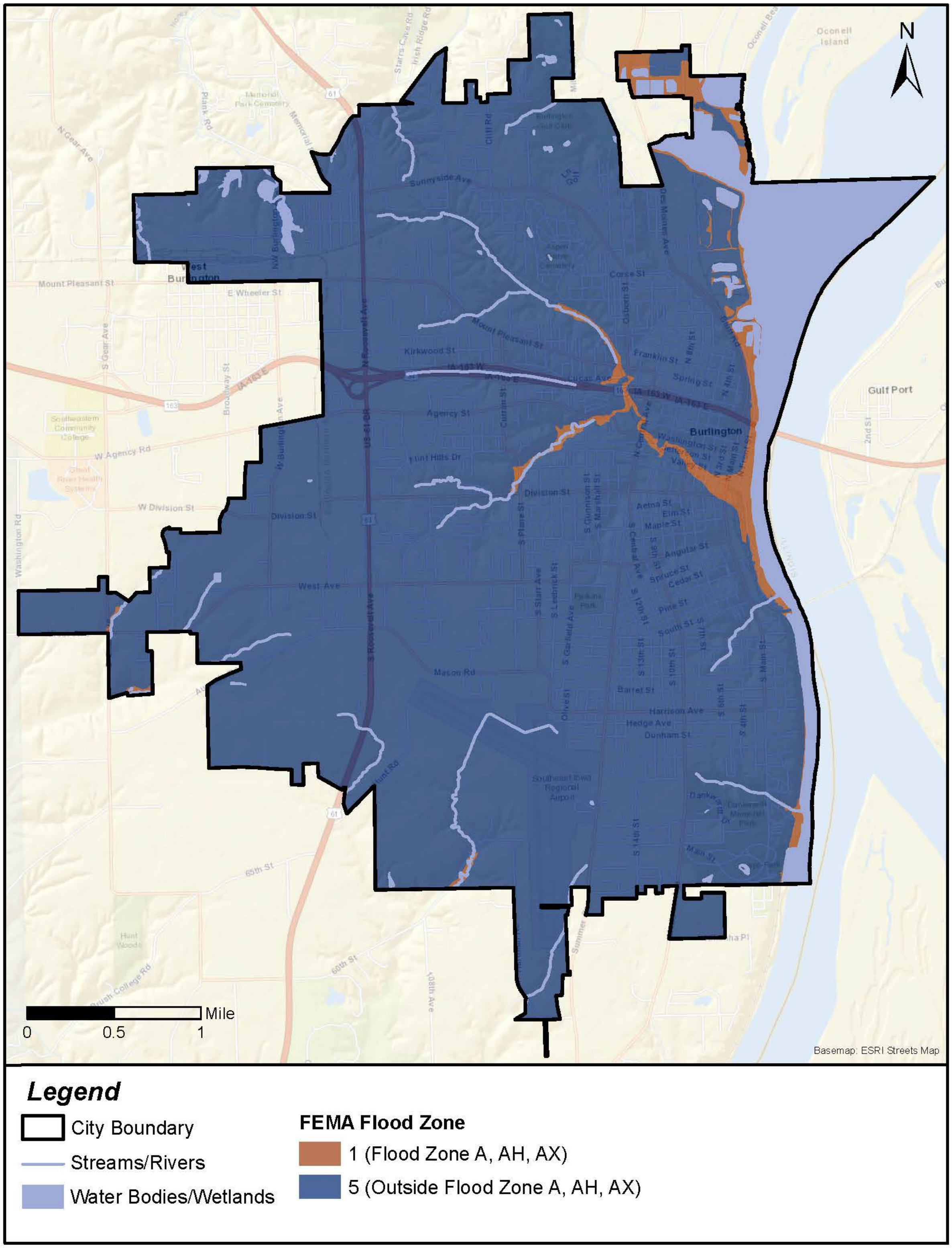

N
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Parking Lot Area per Parcel
0 (Equiv to < 10 Parking Spaces - Exclusion)
1 (Equiv to 10 - 15 Parking Spaces)
2 (Equiv to >15 - 20 Parking Spaces)
3 (Equiv to >20 - 25 Parking Spaces)
4 (Equiv to >25 - 30 Parking Spaces)
5 (Equiv to > 30 Parking Spaces)

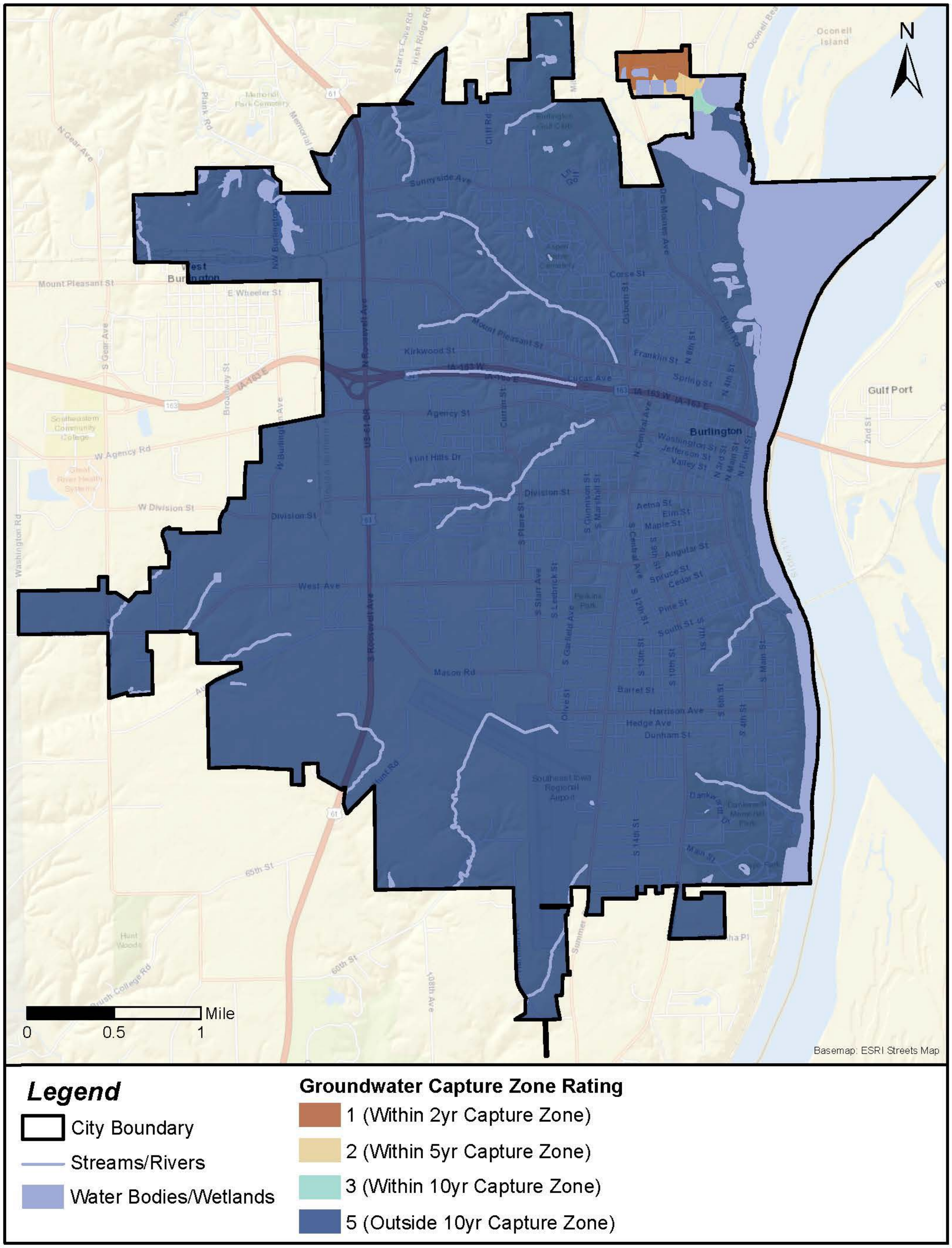

N
Burlington
Gulf Port
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Depth to Bedrock Rating*
1 (0ft - 2ft)
2 (2ft - 4ft)
3 (No Data)
4 (4ft - 6ft)
5 (>6ft)
*This rating scheme is used only for Infiltration, Surface Detention & Biofiltration Practice Suitability calculations.


N
Mile
0
0.5
1
Basemap: ESRI Streets Map
Gulf Port
Burlington
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Depth to Bedrock Rating*
0 (< 4ft - Exclusion)
3 (No Data)
4 (4ft - 6ft)
5 (> 6ft)
*This rating scheme is used only for Underground Detention Suitability calculations.


N
Mount Pleasant St
E Wheeler St
W Agency Rd
W Division St
Gulf Port
Washington Rd
S Gear Ave
Broadway St
Plank Rd
65th St
60th St
108th Ave
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Impervious/Pervious Area per Parcel Rating
0 (Impervious Area - Exclusion)
1 (<= 0.2 ac Pervious Cover/Parcel)
2 (> 0.2 ac - 0.4 ac Pervious Cover/Parcel)
3 (> 0.4 ac - 0.6 ac Pervious Cover/Parcel)
4 (> 0.6 ac - 0.8 ac Pervious Cover/Parcel)
5 (> 0.8 ac Pervious Cover/Parcel)


N
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Hydrologic Soil Group Rating
0 (HSG C, D (+ A/D, B/D, C/D) - Exclusion)
1 (HSG A, B and No Data)


N
Gulf Port
Burlington
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
FEMA Flood Zone
1 (Flood Zone A, AH, AX)
5 (Outside Flood Zone A, AH, AX)


N
Mile
0
0.5
1
Basemap: ESRI Streets Map
Legend
City Boundary
Streams/Rivers
Water Bodies/Wetlands
Groundwater Capture Zone Rating
1 (Within 2yr Capture Zone)
2 (Within 5yr Capture Zone)
3 (Within 10yr Capture Zone)
5 (Outside 10yr Capture Zone)