Madison Stormwater Inventory

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Prepared by the

PIEDMONT TRIAD
REGIONAL COUNCIL

TOWN OF
Madison
NORTH CAROLINA

Madison Stormwater Inventory

Prepared by the
Piedmont Triad Regional Council
in partnership with
Blue Stream Environmental Consulting

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Background & Purpose

The Town of Madison is located in Rockingham County at the junction of the Dan and Mayo Rivers and has a population of around 2,200 people. As a riverfront community, water has played an integral role in the Town's development and culture. However, over the past few years, stormwater has become an increasing problem for the Town. Heavy rainfall during a number of recent severe weather events has resulted in substantial property damage to both local businesses and homeowners – the worst of which occurred in Madison's historic downtown in 2017.

In an effort to proactively address this problem, the Town of Madison partnered with the Piedmont Triad Regional Council (PTRC) and Town of Mayodan to conduct a detailed inventory of both towns' stormwater drainage systems. The primary goals of this project were to establish an online database of all stormwater infrastructure throughout the two towns (including all drains, pipes, and outfalls), evaluate any potential maintenance needs, and identify additional opportunities to reduce stormwater flows. This inventory will help the towns of Madison and Mayodan more easily manage and maintain existing stormwater infrastructure, while better informing future stormwater management decisions. The following report outlines the work completed and summarizes the project's findings.

Process

Field Work

In order to determine how stormwater is channeled throughout the Town of Madison, PTRC staff surveyed each inlet, junction box, culvert, manhole, outlet, and outfall over the course of several fieldwork days. A geodatabase was created in ESRI ArcGIS to house all of the town's stormwater infrastructure data. Each type of stormwater feature and its associated attributes (characteristics) was given a set of rules (attribute domains) for field data entry to enforce data integrity and ease data collection in the field (see Table 2 and Table 3). Attachments were enabled on the geodatabase to allow for photographs to be taken in the field and associated with each point.

The completed database structure was then uploaded to an online web map in ArcGIS Online so that it could be populated during field work. PTRC staff used the ArcGIS Collector app on Android tablets to collect stormwater infrastructure point data. For better locational accuracy, a Trimble R1 integrated GNSS Bluetooth device was used in combination with ArcGIS Collector. Hard copy maps were also generated in a tile index format to aid PTRC staff in field collection.

Public works staff from each Town worked closely with PTRC staff to assist with grate access, traffic control, and pipe measurements as needed.

Stormwater attribute data collected in the field consisted of stormwater inlet and outlet type, location (x-y coordinates), pipe material, diameter, direction, depth, condition, description of problems/failures, and a high-resolution hyperlinked photo of each stormwater feature. A laser distance tool and tape measurer aided in pipe diameter and depth measurements. At the end of each fieldwork day, data points from the Android tablets were synced back to the geodatabase. A total of 1,667 points were collected in 22 days of fieldwork. (Note: this number does not reflect total number of infrastructure points resulting after data cleanup.) An additional 334 state maintained inlets were provided by the NCDOT in a GIS shapefile for inclusion in the Towns' stormwater system files.

Analysis

Upon completion of the stormwater point data collection, PTRC reviewed the data in ArcMap. Necessary data edits were made to snap collected points to aerial imagery and existing ditch lines and add any additional points found from orthophotography analysis. A stormwater pipe layer was created using pipe diameter and flow direction information collected in the field. The stormwater pipe layer was symbolized with arrows to indicate flow directions so that stormwater flow can be traced from the point of origin to the surface or stream outfall.

Stormwater Inventory

Summary

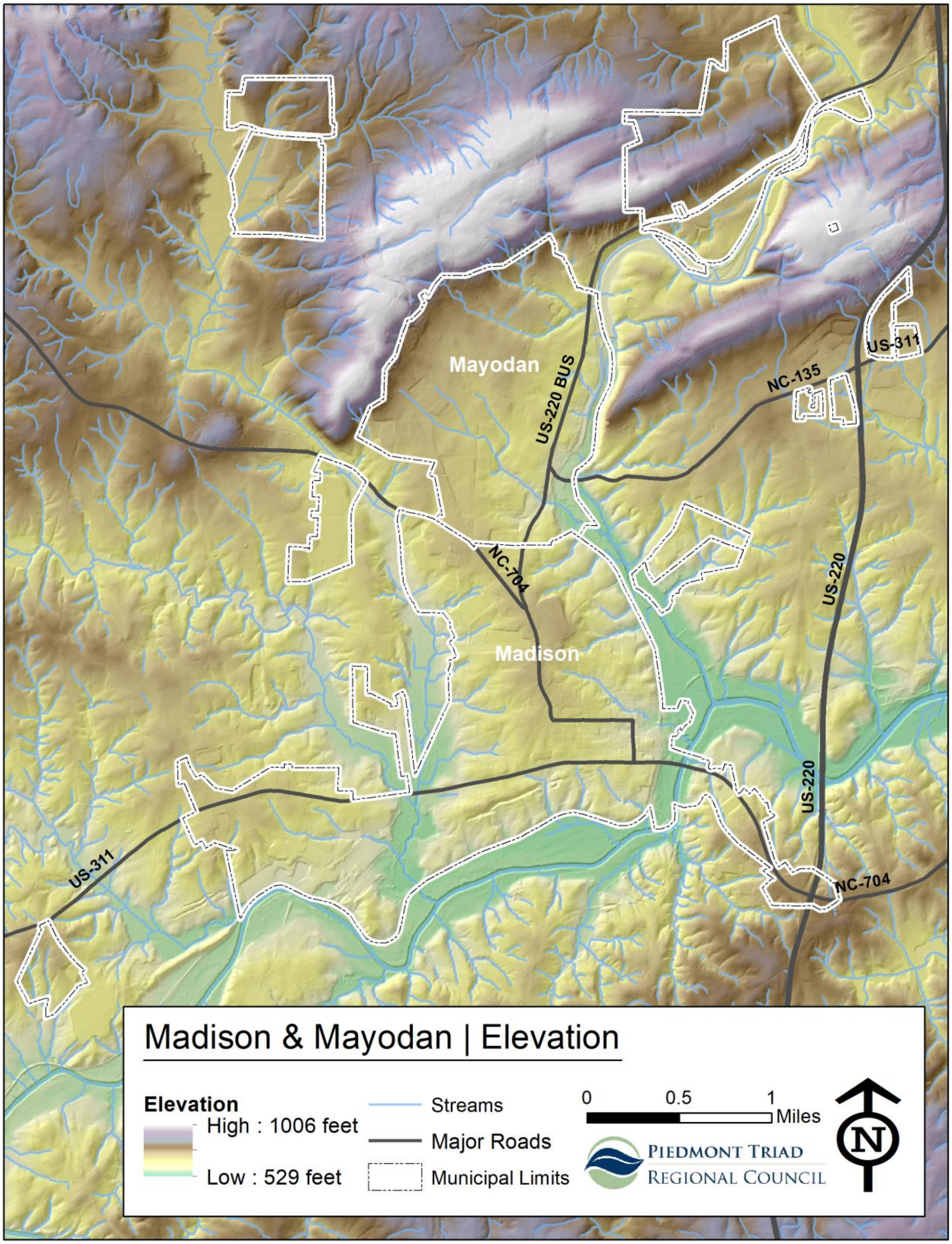
The completed stormwater inventory includes 1,710 stormwater points (876 in the Town of Madison and 834 in the Town of Mayodan) and 997 stormwater pipes (491 in the Town of Madison and 506 in the Town of Mayodan) and is intended to be a resource to help both towns locate, manage, and maintain their existing stormwater systems, as well as make better informed stormwater management decisions. The following sections go into more detail about what influences stormwater runoff, the data collected, and how the database can be accessed and used.

Factors Influencing Runoff

When it rains, some of the rainwater is absorbed into the ground, while part of it flows over the ground. All that water that rolls off of your roof, through your yard, and over the street is called stormwater runoff. The flow and volume of stormwater runoff is influenced by a number of environmental and human factors including the season, severity of storm, topography, soil conditions, and amount of vegetation or impervious surfaces (such as roads, driveways, parking lots, and roofs). To better understand the various factors influencing stormwater runoff in the Town of Madison, the PTRC reviewed available elevation, soil, and land cover data.

Generally, rainwater in Madison drains from the highest elevations in the northwest to the Dan River in southeast. Highway NC-704 splits the middle of town and acts as a dividing line for stormwater runoff. Rainwater that falls to the west of NC-704 flows westward into Big Beaver Island Creek, while rainwater that falls to the east of NC-704 flows eastward into the Mayo River before emptying into the Dan River.

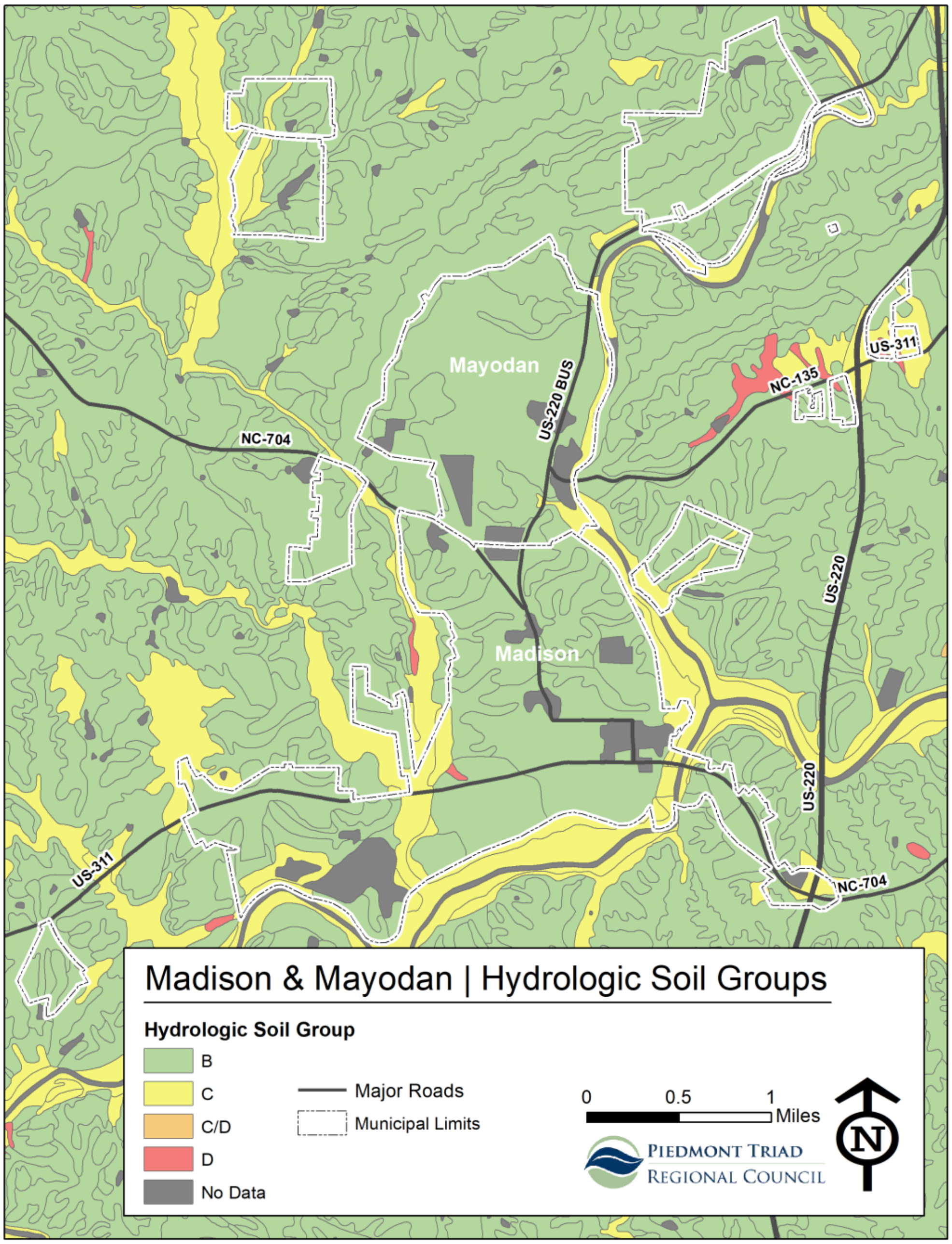
Map 1: Elevation



Source: 2007 LiDAR, 20 Foot Resolution

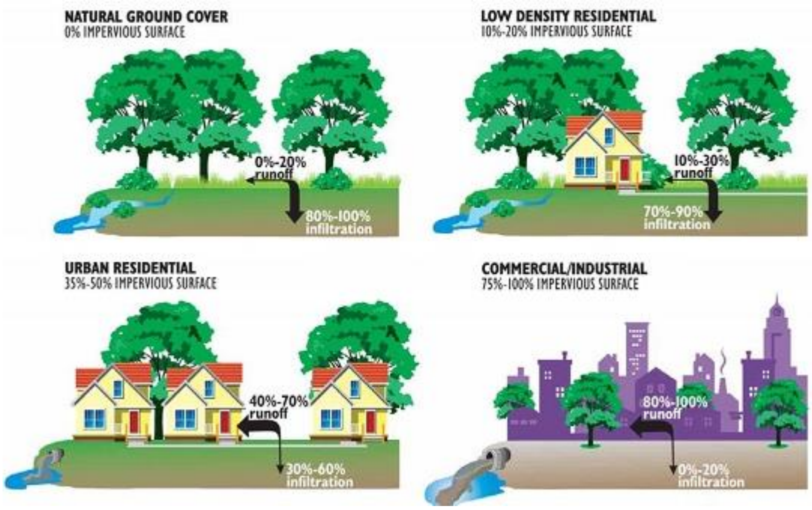
Soil composition also affects how much water can be absorbed into the ground. Sandy soils have low runoff potential and high infiltration rates, while clay soils have high runoff potential and low infiltration rates. Soils are typically classified into four hydrologic soil groups (A, B, C, and D) based on their runoff potential, where A's generally have the smallest runoff potential and D's the greatest. A majority of the underlying soils in Madison are silt loam or loamy soils, which drain fairly well and have moderately low runoff potential. These soils are good at filtering stormwater runoff and well suited for green stormwater control measures, such as raingardens or bioretention cells.

Map 2: Hydrologic Soil Groups

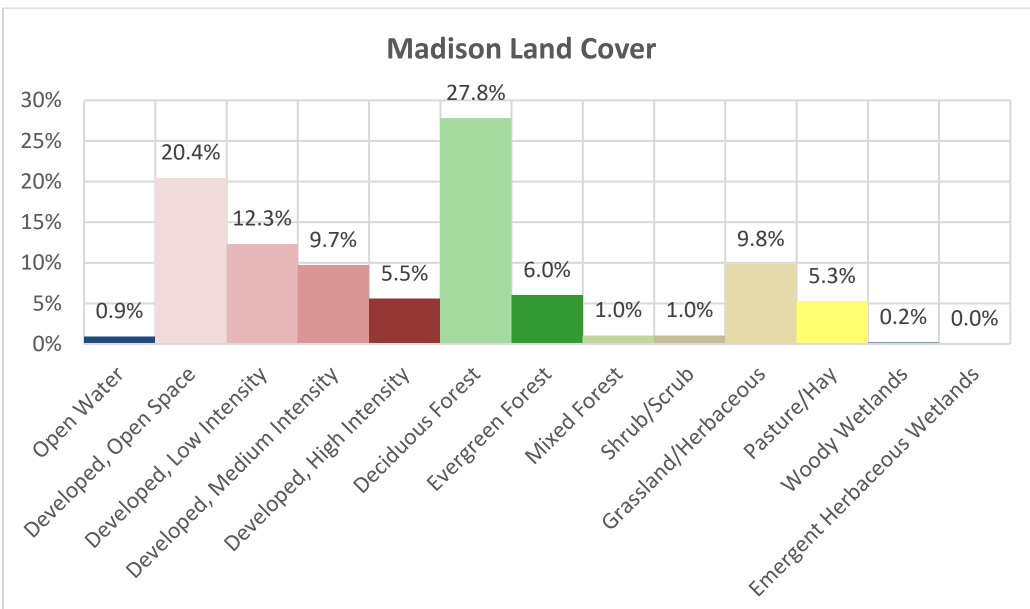


Source: USDA SSURGO Soil Database

Another factor that influences stormwater runoff is the amount of impervious surfaces, such as roads, driveways, parking lots, and roofs, in an area. These hard surfaces prevent rainwater from percolating into the ground, which increases the amount of stormwater runoff and can lead to pooling or flooding if water is not directed into underground stormwater pipes.



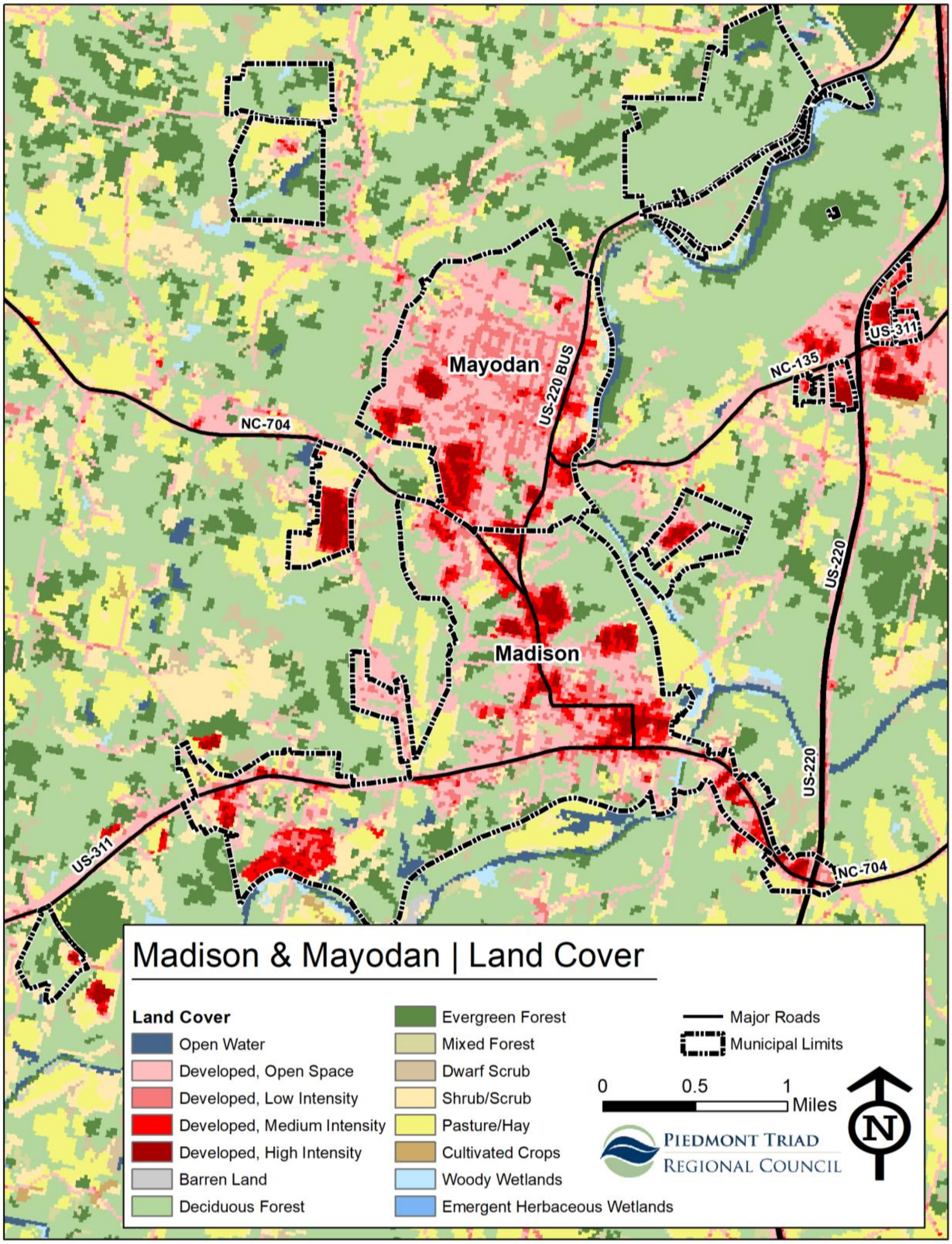
There are 370 acres of impervious surfaces in Madison, which makes up 17.2% of the total land area of the town (NLCD Percent Developed Imperviousness, 2016). Impervious surfaces are primarily concentrated along the town's commercial and industrial centers. A more detailed breakdown of land cover shows that deciduous forests make up the largest percentage of land cover (27.8%), followed by developed open space (20.4%) and developed low intensity (12.3%). This reflects the high percentage of low-medium density residential throughout the town. Map 3 describes how land cover is distributed across the town (NLCD 2016 Land Cover).



Source: NLCD 2016 Land Cover

According to research by the Center for Watershed Protection, streams begin to be negatively impacted when impervious surfaces exceed just 10% of a watershed and streams in watersheds where impervious surfaces cover 25% of the watershed typically cannot support aquatic life. These ecological impacts can be offset by encouraging development in existing commercial and industrial centers and increasing the amount of greenspace and vegetation in open areas, which helps slow and filter stormwater runoff.

Map 3: Land Cover

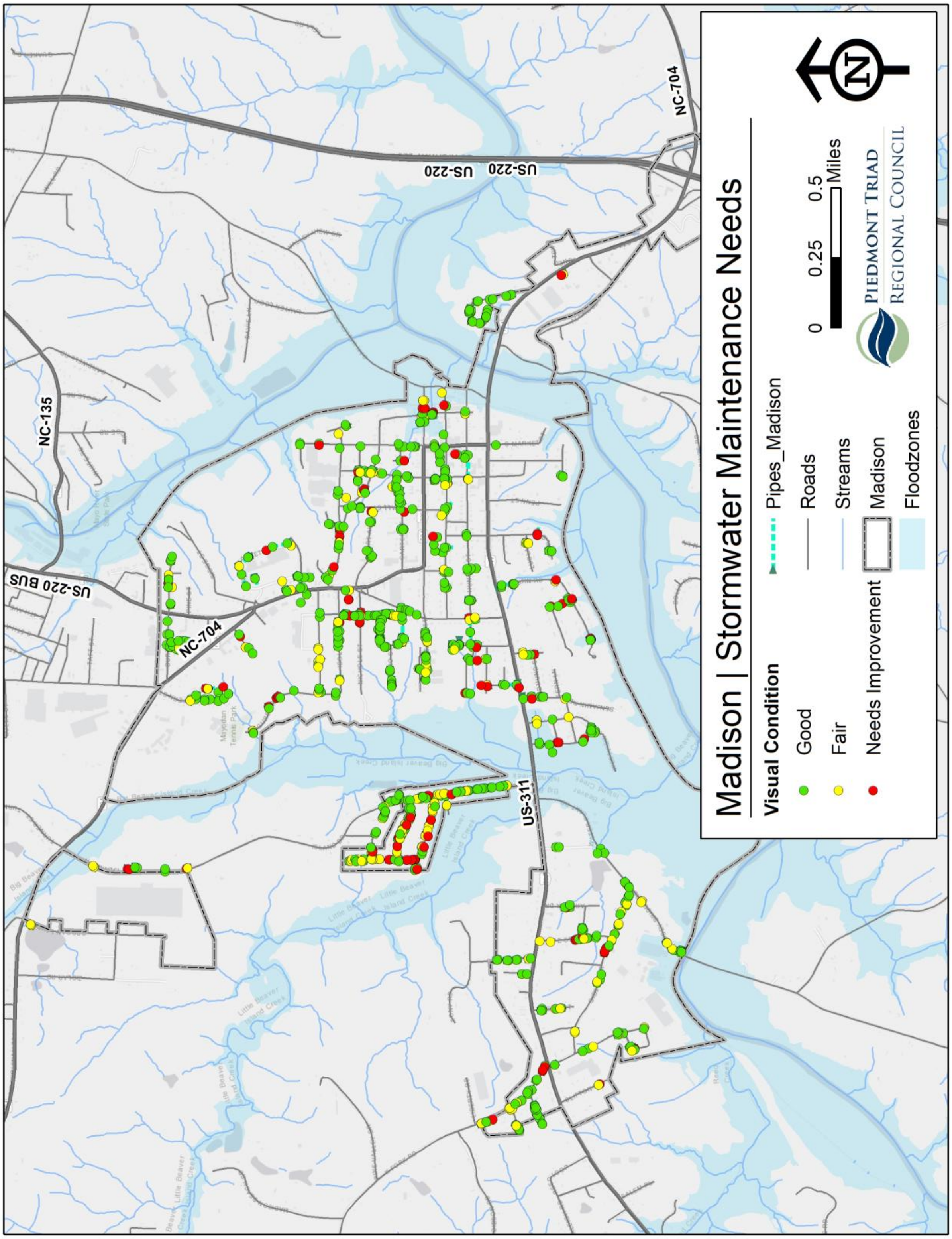


Source: NLCD 2016 Land Cover

Maintenance Needs

Over the course of fieldwork, PTRC staff noted the visual condition of each stormwater feature to assist public works staff with infrastructure maintenance. Each feature was ranked as "Good", "Fair", or "Needs Improvement", based on their condition. Features were classified as "Fair" or "Needs Improvement" if they were not functioning as intended due to clogging or other structural impairments. Common issues included sediment, leafs, or other buildup of debris, as well as cracked or inaccessible lids. Maintenance needs are fairly evenly spread throughout town, suggesting that there are no areas of particular concern. However, some inlets may require more regular maintenance than others to prevent debris buildup. Map 4 showcases the visual condition of stormwater infrastructure throughout town in more detail. Towns should prioritize features ranked as "Needs Improvement" for maintenance and repair.

Map 4: Stormwater Maintenance Needs



Further Investigation

While a thorough effort was made to pinpoint underground pipe connections and outfall locations, there were a number of areas where it was impossible to verify connections or outlets due to conflicting field data, inaccessibility, buried pipes, or overgrown vegetation. In some instances, pipe directions, materials, and sizes, did not align with nearby stormwater points, suggesting that there may be additional underground connections that are not accessible from above ground. These data inconsistencies may require further investigation, beyond the scope of this project, to explain certain segments of the stormwater network and more accurately reflect stormwater connections and routes. A list of areas that require further investigation has been provided below for the Town's convenience.

Table 1: List of Areas with Missing Stormwater Data

Location	Description
1900 S Oak Forest Drive	Unable to locate outlet for drop inlet on corner.
1909 S Oak Forest Circle	Unable to locate inlet and outlet for two manhole pipe connections. Two curb inlets to the south have no outlet.
267 Island Drive	Unable to locate pipe outlet at the end of private road.
311 Westview Road	Curb inlets clogged. Unable to determine where north inlet leads. Likely connection with manhole to the north.
Pineland Avenue	Unable to locate multiple outlets. Pipe may run under street and exit just south of the western end of the road.
207 Hillcrest Drive	Unable to confirm connections with NCDOT maintained inlets.
702 Sunset Avenue	Unable to locate two outfalls near intersection of Lonesome Rd & Hunter St Exd.
705 Sunset Avenue	Unable to locate terracotta pipe inlet to the south.
107-109 Lonesome Road	Unable to locate pipe inlets to north and east, as well as pipe outlet for junction box at the end of the cul-de-sac.
522 W Hunter Street	Unable to confirm pipe connections due to curb inlet clogging.
400 Cassandra Road	Unsure about pipe connections and unable to locate outlets due to debris.
501 US-311	Unable to confirm connections with NCDOT maintained inlets.
403 Dahl Street	Unable to locate outfall to east.
800 Mc Geehee Street	Unable to locate outfall to north.
713 W Decatur Street	Unable to locate outlet to west.
N Wilson Street between W Decatur Street & Collins Street	Potential NCDOT road. Several curb inlets with manhole covers that were not investigated. Unable to locate outfall to west.
512 W Hunter Street	Unable to locate outfall to south.
501 W Hunter Street	Unsure where 24in pipe originates, unable to locate outfall to south.
405 W Murphy Street	Unable to locate outfall to the south.
109 Dahl Street	Unsure where pipes in curb inlets originate or lead.
211 W Murphy Street	Unable to locate outfall to south.
101 N Franklin Street	Unable to determine pipe origins, outlets, and connections based on field data. May be multiple pipes that run underneath the road.
104 W Hunter Street	Unable to locate outfall to the east and connection to south.
122 W Murphy Street	Unable to determine pipe origin west of drop inlet.

30 N Dalton Street	Unable to determine multiple pipe connections based on field data. Curb inlets east likely connect with large east/west pipe to south.
203 E Murphy Street	Unable to locate outlets to the east.
222 N Market Street	Unable to locate outlets to south.
Oak Grove Avenue	Unable to locate outfall to east.
212 W Gene Hairston Street	Unable to locate outlet to south.
401 Pinewood Drive	Unable to locate outfall to east.
Rockingham Square Shopping Center	Unable to locate pipe origins north of Chief Martin Street.
New Market Shopping Center	Unable to locate several outfalls and connections based on field data.

Database Access & Use

Collected stormwater data was organized into a final Stormwater Master Geodatabase for each Town enabling them to view and query infrastructure locations, attributes, and hyperlinked photos using ESRI ArcGIS or any similar GIS software. Each file geodatabase has a feature class containing three feature datasets: Points, Pipes, and Inlets_NCDOT. The stormwater points layer includes all stormwater inlets, junction boxes, manholes, outlets, and outfalls. Users can view additional information about each feature by clicking on each point or pipe, including invert depths, sizes, material, flow directions, and visual conditions. The Mayodan geodatabase also has a BMP feature dataset. In total, the database includes 491 pipes, 876 stormwater points, and 784 pictures attached to the points in Madison and 506 pipes, 3 BMPs, and 834 stormwater points with 828 pictures attached in Mayodan. PTRC will work closely with both towns to ensure that the database is kept up-to-date to meet each town's specific needs.

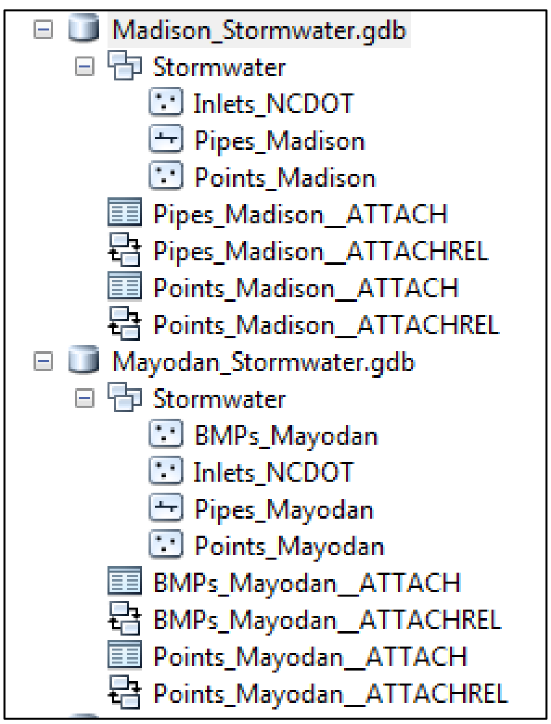


Table 2: Stormwater Point File Structure

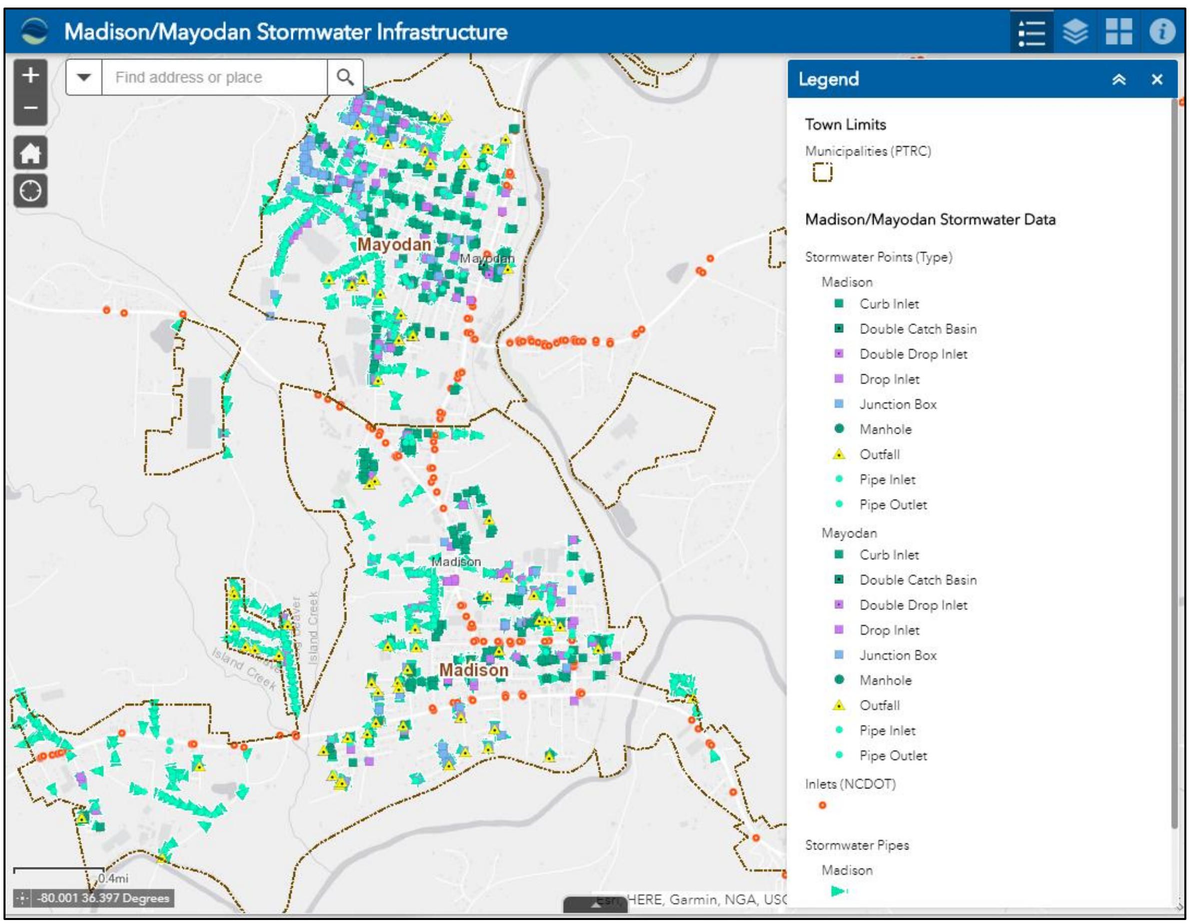
Column:	Type:	Domain:
Type	String 30	SW Point Types
Invert_Material	String 30	SW Material
Invert_Depth	Double	-
Outlet_To	String 5	SW Direction
Outlet_Diam	Double	SW Pipe Diameter
Outetl_Material	String 30	SW Material
P1_From	String 5	SW Direction
P1_Diam	Double	SW Pipe Diameter
P1_Material	String 30	SW Material
P2_From	String 5	SW Direction
P2_Diam	Double	SW Pipe Diameter
P2_Material	String 30	SW Material
P3_From	String 5	SW Direction
P3_Diam	Double	SW Pipe Diameter
P3_Material	String 30	SW Material
P4_From	String 5	SW Direction
P4_Diam	Double	SW Pipe Diameter
P4_Material	String 30	SW Material
Drain_Struct	String 30	SW Drainage Structure
Flow_Presence	String 5	SW Flow
Outfall_Odor	String 5	SW Flow
Surf_Water	String 30	SW Outfall Surface
Rock_Channel	String 5	SW Flow
Visual_Pollut	String 5	SW Flow
Visual_Cond	String 30	SW Condition
Cond_Desc	String 100	-
Comments	String 100	-
created_user	String 50	-
created_date	Date	-
last_edited_user	String 50	-
last_edited_date	Date	-

Table 3: Attribute Table Domains

SW Point Types	SW Material	SW Direction	SW Pipe Diameter		SW Flow	SW Condition
Pipe Inlet	Brick	N	2	20	Yes	Good
Pipe Outlet	Concrete	S	3	24	No	Fair
Culvert	Concrete Block	E	4	30		Needs Improvement
Drop Inlet	CMP	W	6	36		
Double Drop Inlet	CMP Dipped	NE	8	40		
Curb Inlet	Corrugated HDPE	NW	10	48		
Double Catch Basin	Iron	SE	12	50		
Junction Box	Smoothwall HDPE	SW	14	54		
Manhole	Terracotta		15	60		
Outfall	PVC		16	72		
	Other		18			

To increase use and ease of access to the dataset, the final stormwater infrastructure network was exported as a map service and brought into a web map in ArcGIS Online for public viewing. This web map can be accessed from any device with internet access at the following address:

https://ptrc.maps.arcgis.com/apps/webappviewer/index.html?id=3f0652aba62b4fd1a6e8d27767b26647



Other Stormwater Management Opportunities

While upgrading and properly maintaining stormwater infrastructure plays an important role in managing stormwater runoff, there are a number of additional ways to reduce stormwater flows. Several communities throughout North Carolina have begun installing or requiring stormwater control measures (SCMs) or stormwater best management practices (BMPs) to help absorb and treat stormwater onsite. In general, SCM's or stormwater BMPs are engineered devices that use natural processes, such as soil and vegetation, to capture, filter, slow, and reuse rain water, but can range greatly in design and function. Some examples include raingardens, street trees, bioretention cells, vegetated swales, or stormwater ponds. This approach to stormwater management is sometimes also referred to as low impact development (LID). The ability of these practices to deliver multiple ecological, economic, and social benefits or services has made them an increasingly popular strategy in recent years.

Bioretention Cell

Bioswale

Stormwater Pond

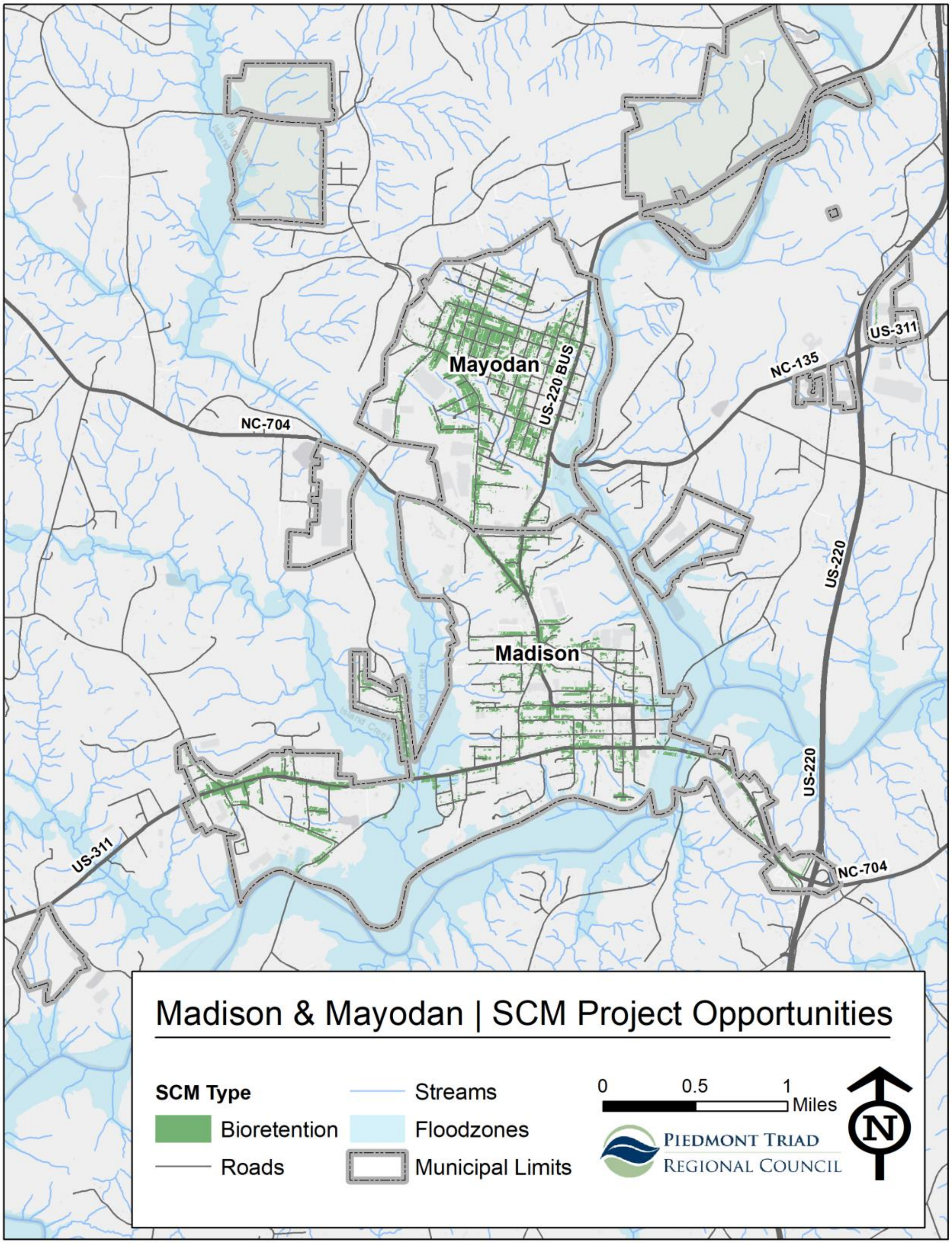
There are also a number of creative actions that individuals can take at their own homes to conserve natural resources. Simple acts, such as disconnecting downspouts that are directly connected to the storm drain system, installing rain barrels, or planting small raingardens can dramatically reduce stormwater loads. Some communities have established creative programs to incentivize homeowners to reduce stormwater, including awards programs that recognize homeowners that implement green practices or financial assistance or rebate programs. Other communities have held events such as rain barrel workshops/giveaways and storm drain markings to remind residents that anything entering the storm drains flows directly into our streams. Homeowners can also help protect water quality and prevent localized flooding by picking up after their pets, bagging their leaves and grass clippings, and limiting fertilizers and pesticide use.

In order to supplement the stormwater infrastructure database, PTRC developed a GIS model to identify additional opportunities for stormwater management projects. Using criteria from the US EPA's *System for Urban Stormwater Treatment and Analysis IntegratioN (SUSTAIN) BMP Siting Tool*, this model overlays environmental and land use data to identify suitable locations for SCM projects. Only bioretention, grassed swale, dry pond, and constructed wetland/wet pond projects were modeled for the purposes of this project. Maps 5-8 highlight areas where bioretention, grassed swale, dry pond, and constructed wetland projects may be suitable. These maps can be used by each town to help prioritize future stormwater management projects. Property ownership and costs should also be considered when weighing various projects, as certain stormwater BMPs are much cheaper than others and typically easier to implement on publically-owned land unless there is significant local buy-in.

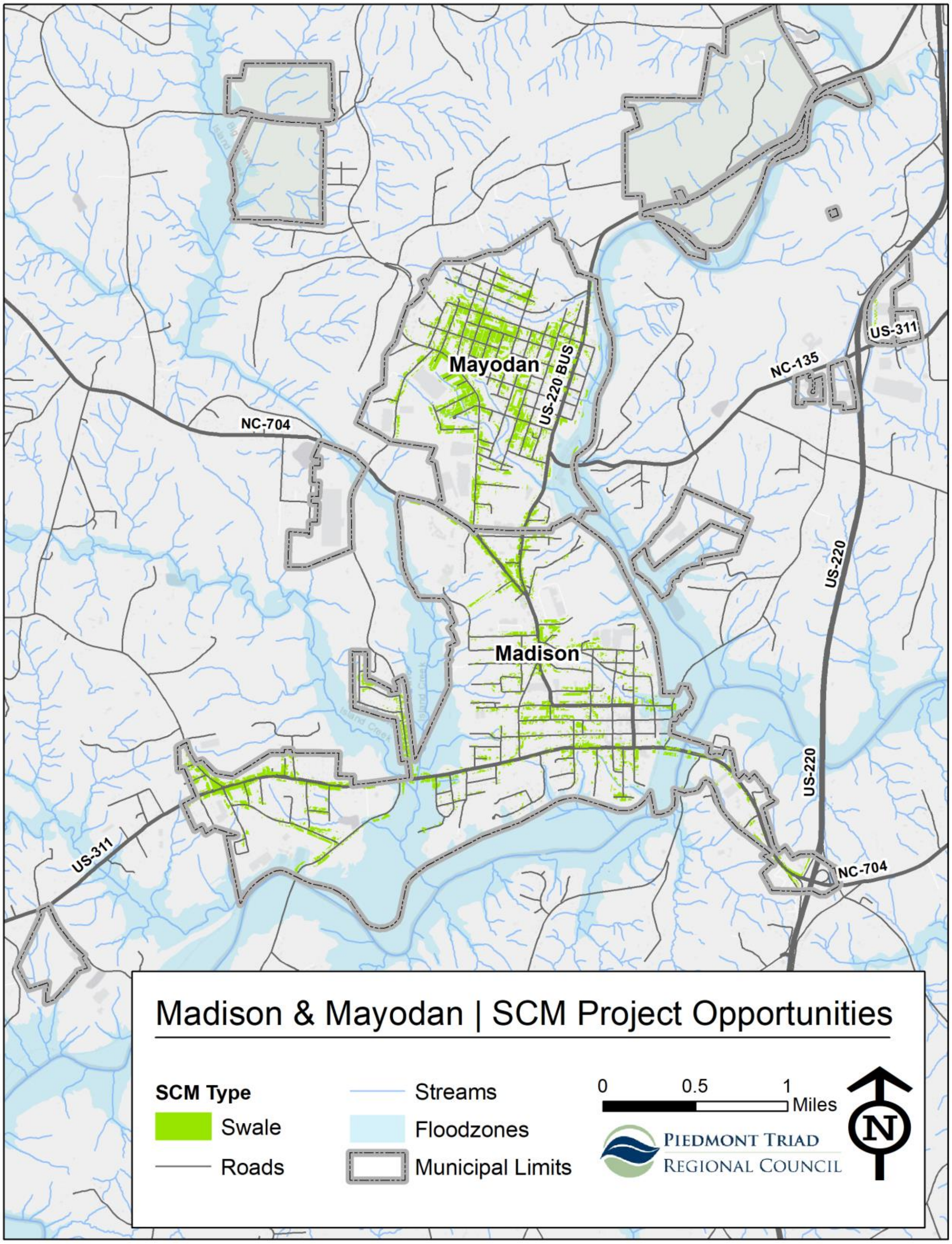
Table 4: Stormwater BMP Suitability Model Criteria

BMP type	Drainage area (acre)	Drainage slope (%)	Impervious (%)	Hydrologic soil group	Water table depth (ft)	Road buffer (ft)	Stream buffer (ft)	Building buffer (ft)
Bioretention	< 2	< 5%	> 0%	A–D	> 2	< 100	> 100	--
Cistern	--	--	--	--	--	--	--	< 30
Constructed Wetland	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--
Dry Pond	> 10	< 15%	> 0%	A–D	> 4	--	> 100	--
Grassed Swale	< 5	< 4%	> 0%	A–D	> 2	< 100	--	--
Green Roof	--	--	--	--	--	--	--	--
Infiltration Basin	< 10	< 15%	> 0%	A–B	> 4	--	> 100	--
Infiltration Trench	< 5	< 15%	> 0%	A–B	> 4	--	> 100	--
Porous Pavement	< 3	< 1%	> 0%	A–B	> 2	--	--	--
Rain Barrel	--	--	--	--	--	--	--	< 30
Sand Filter (non-surface)	< 2	< 10%	> 0%	A–D	> 2	--	> 100	--
Sand Filter (surface)	< 10	< 10%	> 0%	A–D	> 2	--	> 100	--
Vegetated Filterstrip	--	< 10%	> 0%	A–D	> 2	< 100	--	--
Wet Pond	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--

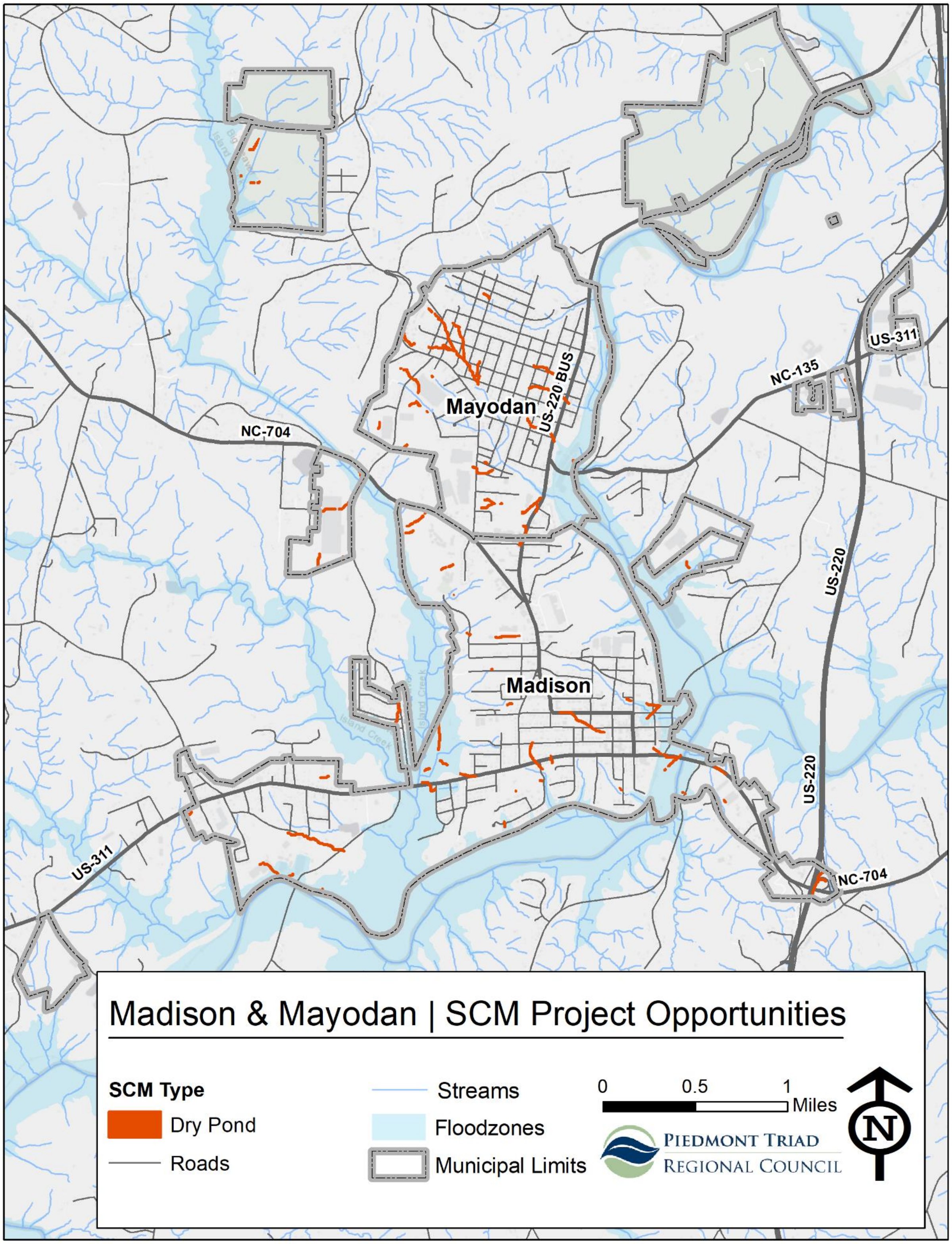
Map 5: Bioretention Project Opportunities



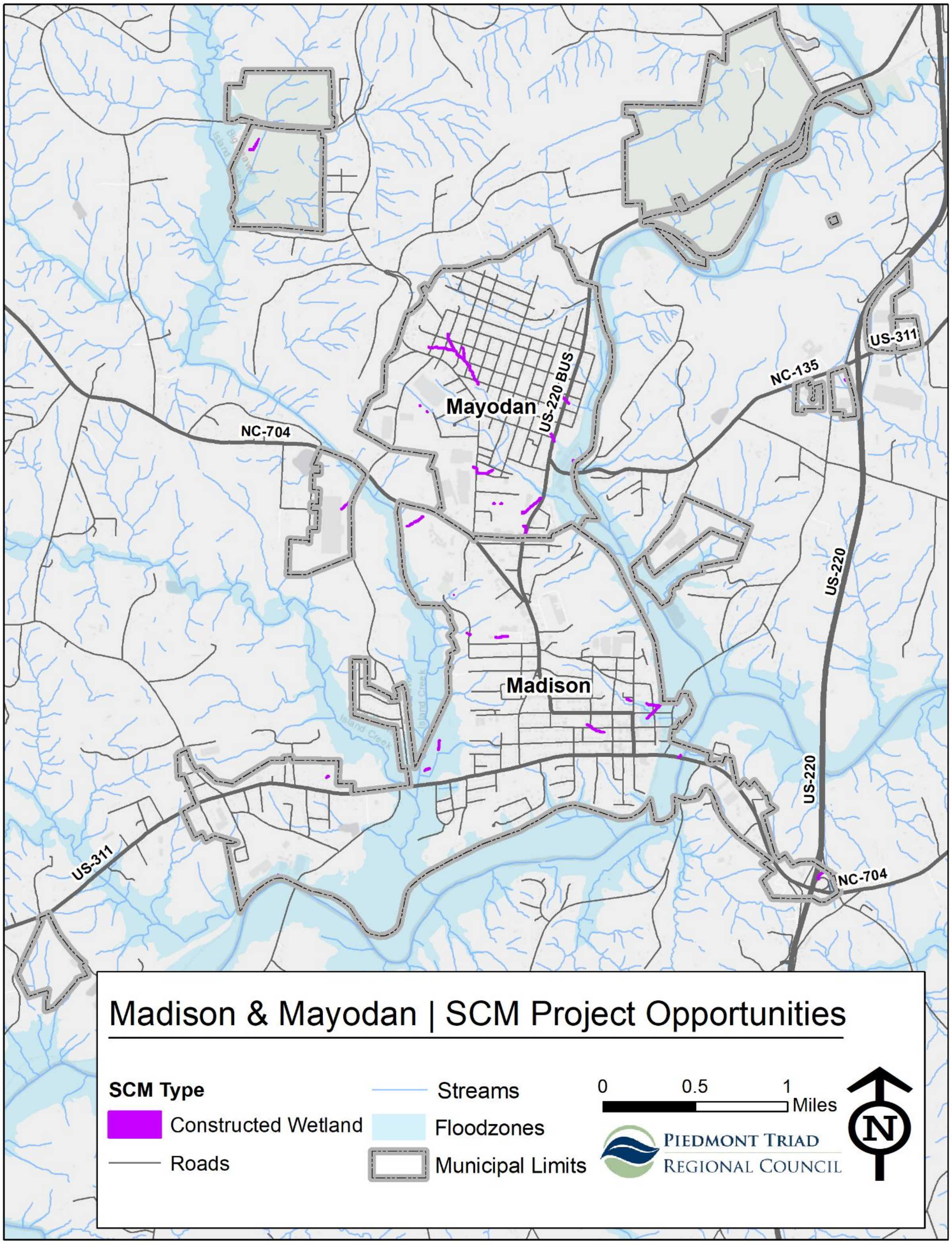
Map 6: Bioswale Project Opportunities



Map 7: Dry Pond Project Opportunities



Map 8: Constructed Wetland Project Opportunities



Next Steps

Managing stormwater runoff can be a difficult task and often requires a multi-pronged approach that involves maintaining and upgrading existing pipes, updating development ordinances to address stormwater, and increasing public awareness about stormwater issues. By completing this project, the Town of Madison has taken a significant step forward in addressing this growing problem and can now begin resolving drainage issues and continue to build upon its stormwater management program. Using the information generated over the course of this project, town public works staff can begin addressing identified maintenance needs as they are able. This will help reduce clogs and improve stormwater flow during major storms. Known problem areas may require some additional investigation to determine upstream sources of erosion, debris, or stormwater.

It is recommended that the Town then explore ways in which they can increase public awareness about stormwater issues, as there are many actions that local residents can take on their own properties to reduce stormwater runoff. Several organizations in Rockingham County are already doing this work and could partner with the Town to help meet stormwater education needs. These groups include PTRC's Stormwater SMART program, the Dan River Basin Association (DRBA), Piedmont Land Conservancy, Rockingham Soil & Water, and Cooperative Extension. These partners may also be able to assist the Town in identifying site-specific SCM projects that could be implemented to further reduce stormwater runoff and pursue state and federal funding to support such efforts. A comprehensive list of potential partners and funding sources has been provided below for the Town's convenience.

Partners & Technical Assistance

Organization	Potential Role
Piedmont Triad Regional Council Stormwater SMART Program	• Locate and secure grant funding for follow-up studies and implementation • Planning assistance and expertise • Assist with stormwater outreach and education
Dan River Basin Association Protects & promotes the Dan River Basin through recreation, education, & stewardship.	• Assist with stormwater outreach and education through various events, workshops, or trainings.
Rockingham County Soil & Water Conservation District	• Assist with stormwater outreach and education, particularly regarding agriculture
Rockingham County Cooperative Extension	• Assist with stormwater outreach and education, particularly regarding agriculture
Piedmont Land Conservancy	• Work with willing property owners to conserve land and protect water quality
NC Wildlife Resources Commission	• Provide free trainings for local officials on Green Growth strategies that reduce runoff and protect wildlife
NCDEQ-DWR	• Provide funding for water quality planning & stormwater management projects

Funding Sources

Funding can be one of the largest barriers to smaller municipalities when seeking to improve their stormwater management programs. Luckily, there are a number of state and federal grants that are specifically designated for projects that reduce stormwater runoff and improve water quality. Some of the most common grants for water quality projects include:

§205(j) Water Quality Management Planning Grants

Through the Section 205(j) Grant program, the U.S. Environmental Protection Agency provides states with funding for water quality planning. These projects can involve identifying the nature, extent and cause of water quality problems or doing planning work to address those problems. Projects can include, but are not limited to the development of EPA 9-Element Watershed Restoration Plans for a 12-digit or smaller USGS HUC, mapping stormwater infrastructure, conducting engineering designs for stormwater best management practices, and GIS-based watershed assessments of pollutant sources. 205(j) grants are eligible to regional Councils of Government, who can partner with any public sector organization to implement projects. Match is preferred, but not required.

Clean Water Management Trust Fund (CWMTF) Grants

The Clean Water Management Trust Fund provides grant assistance to conservation non-profits, local governments and state agencies for the protection of surface waters in North Carolina. The CWMTF funds projects that (1) enhance or restore degraded waters, (2) protect unpolluted waters, and/or (3) contribute toward a network of riparian buffers and greenways for environmental, educational, and recreational benefits, (4) provide buffers around military bases to protect the military mission, (5) acquire land that represents the ecological diversity of North Carolina, and (6) acquire land that contributes to the development of a balanced State program of historic properties. Match varies depending on the project, but is recommended as it increases applicant competitiveness.

A comprehensive list of financial resources, including grants, cost shares, and loans, has been compiled by NCDWR's Use Restoration Watershed Program in order to aid water quality project implementation. This list can be found at https://deq.nc.gov/about/divisions/water-resources/planning/basin-planning/use-restoration-watershed-programs/funding.

Depending on the level of need, the Town of Mayodan may also want to consider implementing a stormwater utility fee. Similar to water or sewer, stormwater utility fees help generate funds to support the construction, operation, and maintenance of stormwater systems. Rates are typically assessed based on the amount of impervious surface on a property. While not incredibly common in smaller towns, stormwater fees have been recognized as one of the best ways to generate local funds for stormwater maintenance and improvements. The University of Chapel Hill's Environmental Finance Center has a useful Stormwater Rates Dashboard that can be used to compare stormwater rates across the state. This dashboard can be accessed at: https://efc.sog.unc.edu/resource/2017-north-carolina-stormwater-rates-dashboard.