Infrastructure Framework

WATER

SANITARY SEWER

STORMWATER MANAGEMENT

INTRODUCTION

The infrastructure available to Warrenton residents contained in this framework include public potable water, public sanitary sewer, and stormwater management. Public infrastructure is an important foundation of quality of life in Warrenton, though largely taken for granted. Efficient facilities are vital to most daily activities and require regular maintenance and upgrading both to meet the demands of a growing population and to be sensitive to environmental resources.

The quality and availability of these services influence the type, timing, and density of development in the future. Conversely, development patterns can have a significant impact on the ability of a City to pay and maintain these services in the future. The primary purpose of the Infrastructure Framework chapter is to define and plan for new public infrastructure systems to serve the community through 2030.

Framework Structure

For the Comprehensive Plan Update, three types of infrastructure services have been assessed in this Framework chapter, they include:

- Public Potable Water encompasses water supply, treatment, storage and water delivery to residents.
- Public Sanitary Sewer Service systems collect wastewater from all sources and convey it to the treatment facility for residents.
- Stormwater Management encompasses managing runoff from rain events to control or mitigate conveyance, treatment, recharge, mitigation, reuse and management of events for residents.

PUBLIC POTABLE WATER SERVICE

Water System

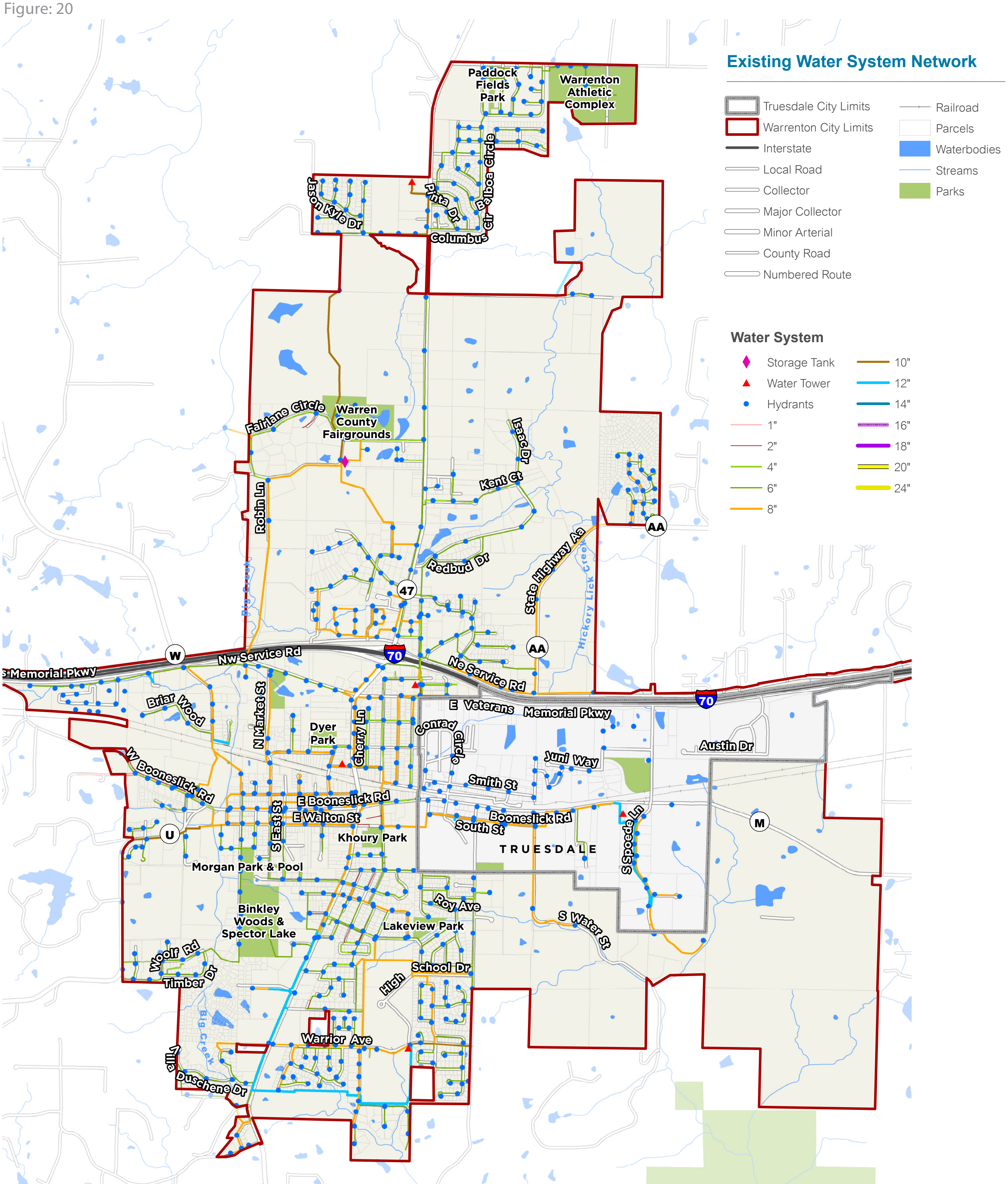
The City of Warrenton owns and operates a water distribution system that serves the cities of Warrenton and Truesdale. A *Water System Improvements Plan* (Plan) was completed in 2010 by Cochran Engineers. As part of this Plan, the capacities of the current water distribution system were also analyzed for the design year of 2039. Historical water usage rates from the 2010 Cochran report showed ~106 gpcd in 2009. Current water usage rates may be only marginally higher.

The water system is separated into 2 pressure zones and consists of water mains ranging in size from 2-inch diameter to 12-inch diameter of varying pipe material, 5 deep wells, 2 booster stations, 2 pressure reducing valves, and 6 storage tanks (1 ground storage tank and 5 elevated water storage tanks). The current average daily use is approximately 800,000 gallons per day. The adjacent map presents the existing water system network within the city limits.

The City is in the process of improving existing facilities and expanding their services as outlined in the Plan. The program consists of five phases and will be constructed of 8" diameter PVC or larger. These improvements should address low pressure areas identified in the report, although Node J-15 is shown at 34.9 psi after improvements, just under the MDNR required minimum pressure of 35 psi.

Existing Water System Map (2015)

Figure: 20



Water Supply

There are 5 existing deep wells used to supply water to the City:

- Well #4 is located on Ashland Street and has a pumping capacity of 210 gallons per minute (GPM).
- Well #5 is located on 1st Street. Its maximum pumping capacity is 210 GPM.
- Well #6 has a pumping capacity of 640 GPM. It is located on Powell Street near the intersection of Frick Avenue.
- Well #7 is located on Fairgrounds Road with a pumping capacity of 590 GPM.
- Well #8 is located in the Ashland Meadows subdivision in the northern part of the city. This well has a pumping capacity of 902 GPM.

The overall combined maximum capacity of the wells is 2,552 GPM. To accommodate anticipated City growth, a new well has been proposed for 2019.

Water Storage and Distribution

The City has 2.45 million gallons of water storage in the distribution system. The storage facilities are adequate to meet normal and peak demands. The City utilizes 5 elevated water tower storage tanks and 1 ground storage tank. The elevated water storage tanks have a combined capacity of 1.45 million gallons and the ground storage tank, located on Fairgrounds Road, has a storage capacity of 1 million gallons.

Currently, there are approximately 3,029 water service connections (including irrigation). Usage has decreased from 795,000 average gallons per day (AGPD) in 2009 to 746,000 AGPD in 2014, which is about 5-6%. However, there was reportedly a 5% increase in population from 2000 to 2008 and a 3% growth in the number of meters between 1999 and 2009.

The current storage requirements show that there is adequate storage in the system at this time to meet fire requirements. Projected growth over the next 30 years will create a higher demand on the system requiring future storage needs. The report projects a new well will be needed for the Year 2019 to meet demand.

Two rural water districts provide public water to portions of the unincorporated County. These districts serve relatively limited parts of the County and do not plan to increase their area of coverage. Development outside the current service areas will be reliant on wells and cisterns.

Development Issues

The current policy of all the water service providers is that as land develops, the land developers or the adjacent property owners will bear the cost for the extension of the public water mains required to serve the developing area to meet both fire protection and domestic needs and the district then charge a tap on fee for each connection made to the system. Consequently, developers would need to consider the cost associated with the extension of public water mains in their development plans.

The water model and reports should be updated regularly on 5-year intervals to track usage and allow for the City to address increases in demand as necessary. Current service rates and fees are reasonable for the area; however, with a rate study and new ordinance in 2014, rates may be re-evaluated on regular intervals.

SANITARY SEWER SYSTEM

Sanitary Sewer Study Area

The City of Warrenton owns and operates a sewage collection and conveyance system and wastewater treatment facility that serves the cities of Warrenton and Truesdale. A Wastewater System 5-Year Capital Improvement Plan (Plan) was completed by Gonzalez Companies in 2014. As part of this Plan, the capacities of the current wastewater collection and conveyance system were also analyzed for the design year of 2034.

The sewage collection and conveyance system consists of a gravity sanitary sewer collection system. The system consists of approximately 1,500 manholes and 63 lineal miles of vitrified clay pipe (VCP) and polyvinyl chloride (PVC) pipe sewers ranging in size from 4 to 18 inches in diameter. This system also utilizes 6 lift stations and over 3 miles of force main. The lift stations are identified below and have the associated pumping capacities:

- Water Street, 740 GPM
- Field of Dreams, 370 GPM
- Dry Fork, 23 GPM
- Fairlane, 1,950 GPM
- Troy, N/A
- Industrial Park, 940 GPM

The adjacent map identifies serer lines and lift station locations. The sewers convey wastewater to a City owned treatment facility located on Willow Road. This facility went online in the fall of 2004 and incorporates a multiple loop reactor oxidation ditch. The plant is permitted through 2018 for a capacity of 2 million gallons per day (MGD) average daily flow. It currently operates at approximately 1.2 MGD. An anti-degradation report is currently underway to re-rate the facility to 3.4 MGD average daily flow, which would allow for continued growth through 2029.

The Plan recommends that MDNR be approached for a NPDES Permit revision to reflect this increase capacity over their existing limit of 2.0 MGD. This re-rate of the plant capacity is currently on-going and would allow continued growth within the service area for about 15 years before capacity improvements to the WWTP would be necessary

Proposed future residential or commercial development locations and sanitary flow volumes are accounted for in the projections. However, development proposals should be carefully reviewed against existing sanitary sewer planning tools to evaluate potential negative impacts on system treatment or conveyance capacity.

A City Bond Issue was approved in 2014 to provide funds for the 5-year Capital Improvement Projects as outlined in the Plan.

Solving the infiltration and inflow problems in the existing sewer collection system is a key to maintaining sewer service for all without negative health issues, interceptor capacity issues and treatment capacity issues. A study performed by GBA in 2009 indicated that the City experienced excessive I/I in the majority of the collection system, and attributed it to capacity issues. To date, the City's remediation of I/I deficiencies, based upon GBA recommendations, is ongoing, with semi-annual reports of their efforts submitted to the MDNR.

Another issue that has and will complicate matters in the study area is when development occurs sporadically throughout the watershed. When development occurs in this manner, it becomes increasingly more difficult to bring sewer service to each individual area cost effectively. If a systemic development approach from the lower to the upper parts of the watershed can be developed, the funding of wastewater collection improvements becomes easier to achieve.

County Sanitary Sewers approved by MDNR are required for development in urban Residential zoning districts in the unincorporated area. On-site septic systems but be built to County standard's.

Development Issues

Developers are responsible for providing public sanitary sewer service to developing tracts. However, a Bond Issue was approved in April 2015 to cover over $8 million in proposed Capital Improvement Plan (CIP) projects. The 5-year CIP is based on 3% growth projections. Based on the CIP, key infrastructure components (i.e. lift stations and trunk sewers) will be needed to accommodate future growth. Development of areas beyond the city limits will also likely require lift stations and force mains to convey wastewater to the existing sewer system due to the surrounding terrain. Furthermore, the capacity of the existing sewer system and the capacity of the existing treatment facility will need to be evaluated to keep up with continued growth. CIP phase 1 planning and design for sanitary improvements are currently underway.

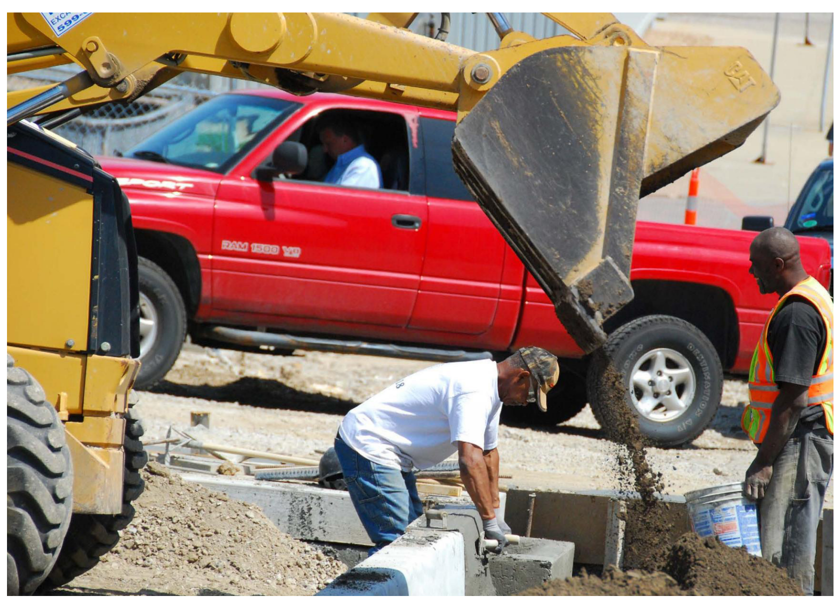
The current service rates and fees are reasonable for the area. However, rate increases will eventually be needed to cover the cost of future improvements. With new development, regular rate studies will need to be done to re-evaluate the service rates.

The City will need to maintain development goals while also providing regular maintenance to keep the existing system functioning properly. An inflow and infiltration (I/I) study of the existing system was performed in 2009 and determined that much of the I/I is related to storm sewer interconnect. The I/I study report presented recommendations for I/I removal, which is currently ongoing. Proper management of stormwater facilities is critical to removal and prevention of I/I into the sanitary sewer system.

Sporadic Development Patterns

Another issue that has and will complicate matters in the study area is when development occurs sporadically throughout the watershed. When development occurs in this manner, it becomes increasingly more difficult to bring sewer service to each individual area cost effectively. If a systematic development approach from the lower to the upper parts of the watershed can be developed, the funding of wastewater collection improvements becomes easier to achieve.

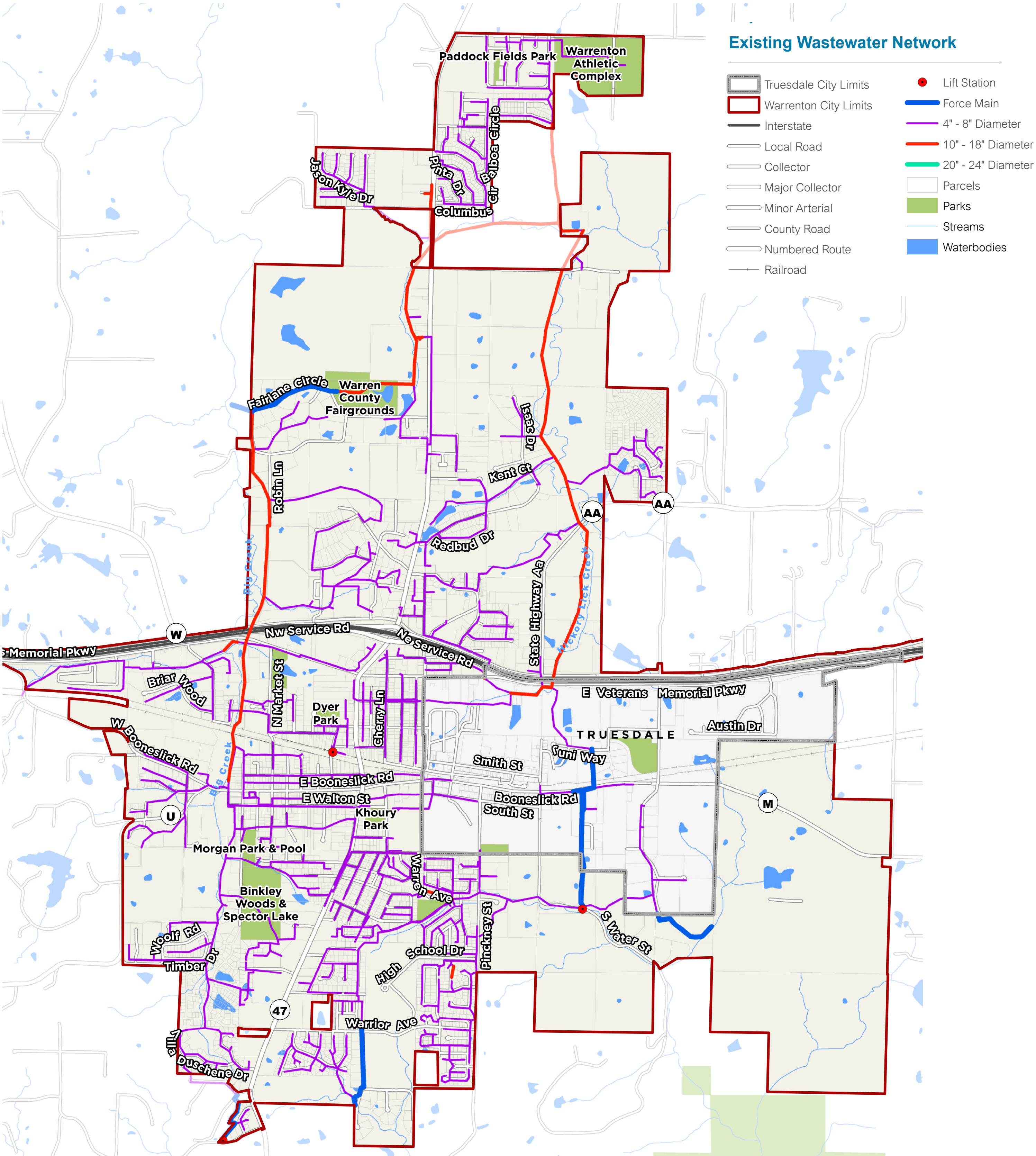
Installation of gravity sewers and treatment facilities are the most preferred, desirable and cost effective means for collecting and treating wastewater flows primarily due to health issues and system maintenance. However, due to permitting constraints with federal and state agencies as well as public opinion it is very difficult to construct new wastewater treatment facilities today. The only other alternative is to install a system of gravity sewers draining to lift stations that then pump sewage through force mains to the existing treatment facility, which is expanded as necessary. This second approach to providing sanitary sewer service limits development.



Infrastructure construction.

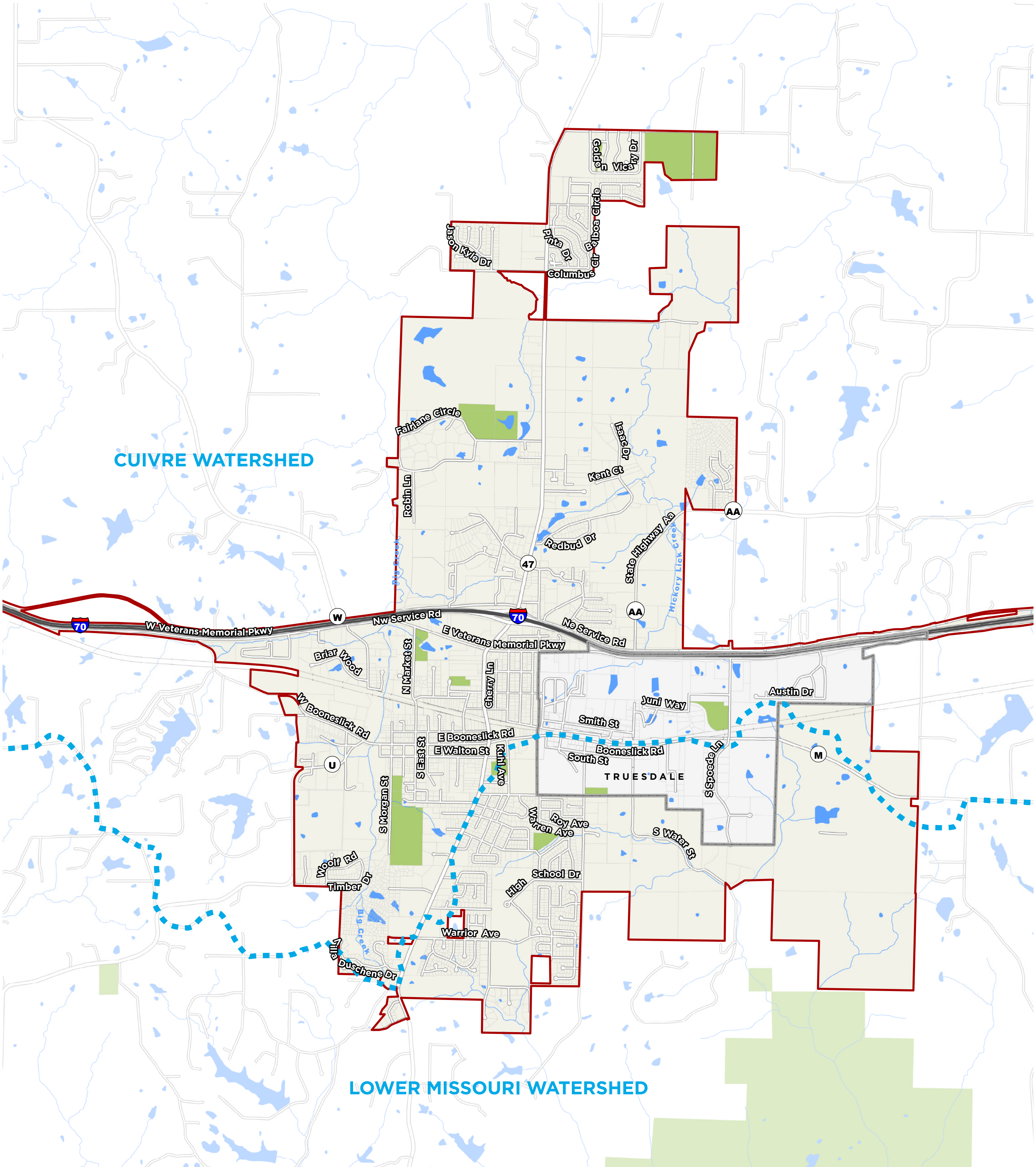
Existing Wastewater System Map (2015)

Figure: 21



Existing Watershed Map

Figure: 22



STORMWATER MANAGEMENT

The City of Warrenton lies within 2 watershed areas; the Cuivre Watershed and the Lower Missouri Watershed. The adjacent map shows existing watershed boundaries. Both watersheds are categorized by the Environmental Protection Agency (EPA) as impaired waters.

- The Cuivre Watershed, which covers over 1,200 square miles of area generally between Highway 54 and I-70 (north/south) and MO-19 and Highway 61 (west/east), is categorized as impaired due to fecal coliform.
- Covering an area of over 1,600 square miles straddling the Missouri River, the Lower Missouri Watershed was reported as having E.coli, chloride, dissolved oxygen and pH as impairments.

The City's existing Zoning Ordinance requires the following:

- Chapter 430. Stormwater Management Regulations. *This Section provides minimum standards, controls and criteria for stormwater management. The principal objective of this Section is to help minimize the harmful physical and economic effects of erosion, sedimentation and flooding from stormwater runoff.*
- Floodplain - *Section 415.040: In all areas covered by this Chapter, no development shall be permitted except through the issuance of a floodplain development permit granted by the Board of Aldermen or its duly designated representative . . .*
- Section 415.110. *Floodplain Development Permit (Required).A floodplain development permit shall be required for all proposed construction or other development, including the placement of manufactured homes, in the areas described in Article II, Section 415.040.*

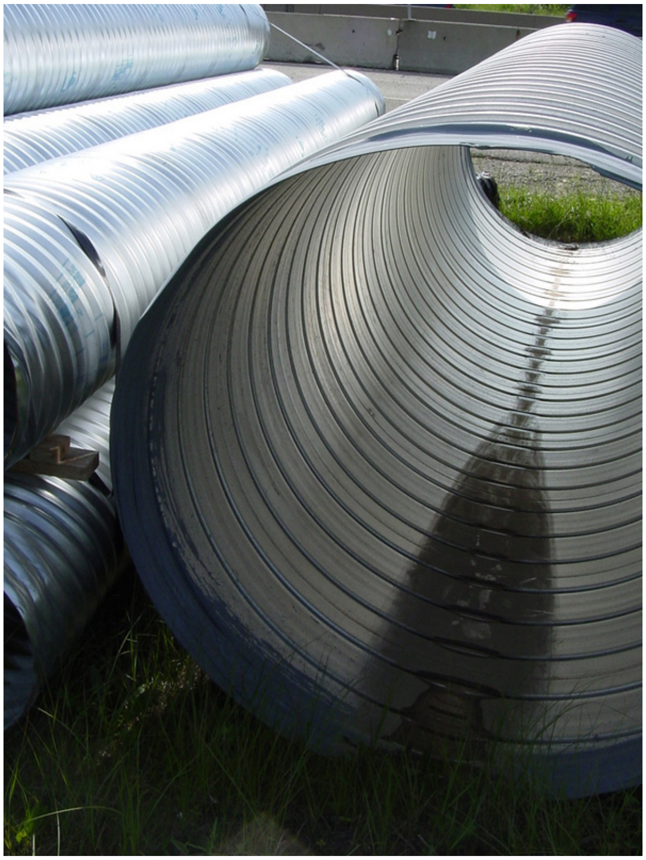
Currently, the County does not require erosion, sediment and stormwater controls during construction. Adoption of a uniform, County-wide standards and sample Stream Buffer Requirements are recommended by the County Comprehensive Plan.

To reduce further impact on the Cuivre Watershed and the Lower Missouri Watershed, the City should consider how stormwater runoff is managed.

MS4 Management

Stormwater conveyance systems typically collect untreated stormwater and discharge it into a local waterbody. As communities grow, they generate more pollutants that run off into the stormwater system and ultimately end up in streams, rivers, etc. A *Municipal Separate Storm Sewer System* (MS4) is one that is regulated by the EPA to incorporate control measures to reduce pollutants being discharged into receiving waters. The EPA requires "urbanized areas" (defined by the Bureau of the Census) to obtain a *National Pollutant Discharge Elimination System* (NPDES) permit and develop a stormwater management program.

As the City grows beyond 10,000 residents and NPDES regulations add water quality treatments, the City of Warrenton may become a permitted MS4 Community by 2024. At which time, new ordinances will be required that may restrict current development practices. Some MS4 requirements may include larger required stormwater detention volumes, stricter stormwater quality requirements, increased use of stormwater best management practices (BMPs), public participation, and city operations and record keeping.



Infrastructure construction.

MS4 Recommendations

To make the transition to MS4 regulations easier in the future, the City can take steps now to prepare.

- The City should implement internal housekeeping and recordkeeping measures to ensure information is properly documented and easily accessible.
- In addition, ordinances should be updated and current detention volume and water quality requirements should be brought to current MS4 standards.
- The City would also benefit from continued production of GIS mapping of the existing facilities, as it will be required under an MS4 permit.
- The City should work towards developing a Stormwater Master Plan that includes proposed improvements to existing facilities and serves as a guide for future development.
- Provide updated information to the public and developers about possible new requirements as new regulations get closer as part of a stakeholder process.

Example stormwater issue.

Floodplain Management

The floodplain management ordinance could limit new developments in floodplain areas. However, steps can be taken to maximize the potential alternative land uses for floodplain areas. This land can be developed for purposes such as parks and trails or recreation and athletic fields. The City could work with developers and shareholders now to come up with a strategy on flood plain development.

Example stormwater issue.

Development Issues

The current policy of the City is that as land develops, the land developers incorporate stormwater collection and detention into the site. As the City of Warrenton grows and regulations change stormwater quality treatments are likely to be required in the future. The City should take a proactive approach to stormwater management by evaluating the MS4 water quality requirements.

The floodplain management ordinance in the City limits new developments and buildings in the floodplain. This ordinance also limits the types of construction that can be permitted in the floodplain. Alternative land uses should be considered in these areas such as parks, trails, and athletic fields.

Summary

Stormwater management requires the incorporation of many different groups with differing priorities. While there are no easy solutions to stormwater management, working together to achieve a common goal is key. City and County officials working together for the good of the residents in the area is a priority.

Example stormwater issue.

STORMWATER BEST PRACTICES

Future development in Warrenton should be designed to respect the natural environment and coexist in harmony with existing natural features. Development planning should attempt to avoid engineering techniques, such as significant cut and fill to force-fit development into the environment. Instead, natural physical features should be incorporated into the overall development design, with drainage areas and other natural features left in their natural state.

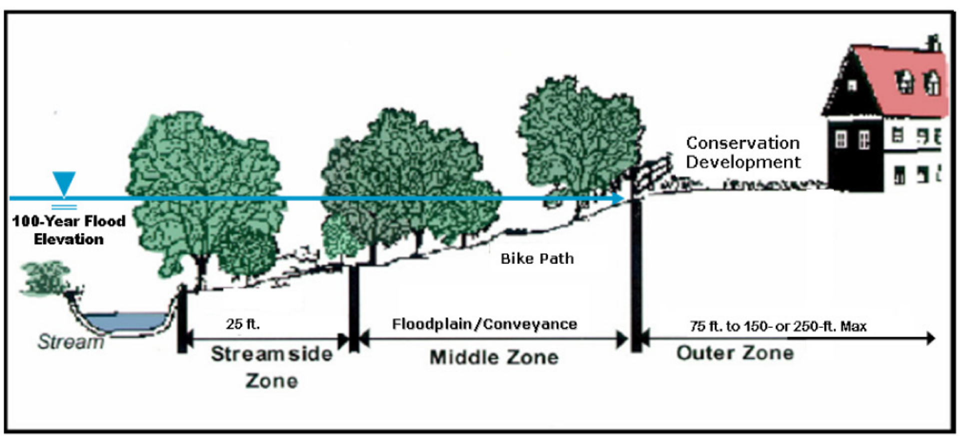
A comprehensive approach for environmental and stormwater management should be implemented in Warrenton to increase water "quality" and to reduce storm runoff "quantity". This approach will:

- Provide a system-wide series of regional stormwater facilities to reduce downstream flood damage.
- Provide localized stormwater infiltration and detention in new development areas to protect regional facilities and the streamways.
- Provide stream buffer setbacks.
- Provide areas of slope protection adjacent to streamway buffers.
- Protect environmentally and culturally sensitive areas.

Environmental Approach

Future development in Warrenton should be encouraged to retain its natural infrastructure and visual character derived from topography, woodlands, streams and riparian corridors. If found, these environmentally sensitive areas are recommended to be protected by a Stream Buffer Ordinance as permanent public or private parks, conservation easements, or common open space. In many instances, these areas to be protected could also be located under the provisions of Section 5600 APWA – Storm Drainage Systems and Facilities.

Stream Buffer Zones



- **Streamside Buffers:** Are located along identified streams. The definition on the Streamside Zone is 25-feet wide from the edge of the active channel on each side of the stream. Only utility, road, and trail crossings are allowed, as well as properly designed stormwater outfalls, access for fishing and wildlife viewing, and trail overlook areas.
- **Middle Zone:** Much of the Middle Zone is located in the 100-year floodplain or 100-year conveyance determined by an engineer, and wetlands. This Middle Zone varies based on actual stream characteristics. Activities in this zone include all uses in the Streamside Zone, plus utility corridors and recreational trails. Vegetation management and stream bank stabilization is key in this Zone.
- **Outer Zones:** Could have variable width, but it extends 75-feet from the edge of the Middle Zone, to a maximum of 150-feet (or 250 if using the open space development or conservation development). It includes slopes greater that 15% or mature riparian vegetation. If steep slopes or mature riparian vegetation extends beyond 150 feet from the edge of the Middle Zone, there are two options:
  - If the maximum is 150 feet, the Outer Zone must be protected as permanent open space.
  - If extended to a maximum of 250-feet, open space and conservation development can exist and additional flexibility for no-residential development is allowed.

Cluster Development:

A form of planned residential development that concentrates buildings on a part of the site (the cluster area) to allow the remaining land (the open space) to be used for recreation, common open space, or preservation of environmentally sensitive areas. The open space may be owned by either a private or public entity.

Low Impact Development:

Portions of Warrenton are located outside of the identified conservation areas are heavily wooded. A sensible balance must be employed with future development in these areas when providing for preservation of existing noteworthy environmental features. Areas with woodlands protection should use enhanced measures in development design to preserve significant trees or tree masses where possible. These measures may include: Cluster development design with flexible development standards such as reduced lot sizes and setbacks and alternative street designs to concentrate buildings on a part of the site (the cluster area) and allow the remaining land to be preserved as open space.

Stormwater Management Approach

An overall system design approach can address the key adverse impacts of stormwater runoff by: reducing pollutant loading from new developments; reducing stream bank and channel erosion; reducing overbank flooding; and safely passing or reducing the runoff from extreme storm events.

Overall System Design

An overall system design approach relies on the use of regional stormwater facilities combined with localized detention and Best Management Practices (BMPs) to route storm events into the floodplain. The use of multiple smaller localized stormwater storage areas constructed in conjunction with private development, instead of larger regional detention facilities, will improve the overall water quality and reduce the area and volume required for regional detention facilities. A system of smaller retention ponds will also aid in the preservation of local streams by decreasing water velocities during storm events.

Conservation development proposed.

Regional Stormwater Facilities

The construction of multiple, smaller "off-line" regional stormwater facilities is recommended as the preferred stormwater management approach. These facilities should be maintained by the public-at-large and will vary in size, capacity, and design. The facilities are designated for areas generally not considered developable, such as floodplains and stream buffers, or they may be located within the roadway or parkway right-of-way.

The specific location and capacity of the various facilities should remain flexible until preliminary engineering studies are completed to determine the most cost effective options with the least environmental impact.

Each regional facility should be:

- Designed in a manner to serve as an amenity and/or gateway feature for the development area, while accommodating the storage necessary for regional detention and improving water quality.
- Designed to include "retention" of stormwater thus providing a visual water feature, which may include a series of smaller detention facilities with pumps to recirculate water between them.
- Constructed prior to future development in the upstream watershed of the given facility.

Should land acquisition or construction cost considerations limit the locations for multiple facilities, another option may include combining multiple stormwater facilities into a single large facility. However, this option results in lower water quality due to less infiltration and the tendency for larger facilities to retain more pollutants.

Proposed stormwater solution with architectural feature.

Detention basins are another type of stormwater regional BMP.

Typical Best Management Practices (BMPs)

OPEN SPACE

- Native Vegetation
- Vegetated Open Space
- Disconnect Impervious Surfaces
- Phasing Development Grading
- Infiltration Trenches

SOURCE CONTROL

- Filter Strips
- Pervious Paving
- Rain Gardens
- Construction Management
- Storm Drain Maintenance
- Bioretention
- Regional Storm Filters

SOURCE FILTRATION

- Dry Swales and Channels
- Sediment Basins
- Localized Retention

REGIONAL RETENTION

- Wet Ponds
- Constructed Wetlands
- Extended Retention Ponds

Localized Stormwater Management:

New developments in Warrenton should be responsible for providing and maintaining localized stormwater infiltration and detention to achieve flood protection (for the impacts generated by specific development) in channel protection, overbank flood protection, and extreme flood protection events. This may be provided by a combination of detention, retention, and/or BMPs.

Example of a detention basin.

Stormwater management should be enhanced in by implementing a series of BMPs that achieve the following goals:

Increase infiltration (water absorbed by the soil) of stormwater runoff while in the basin;

Increase the amount of time for stormwater runoff to reach its receiving stream;

Reduce the potential amount of sediment/pollutants that can be carried off by stormwater runoff from rainfall; and

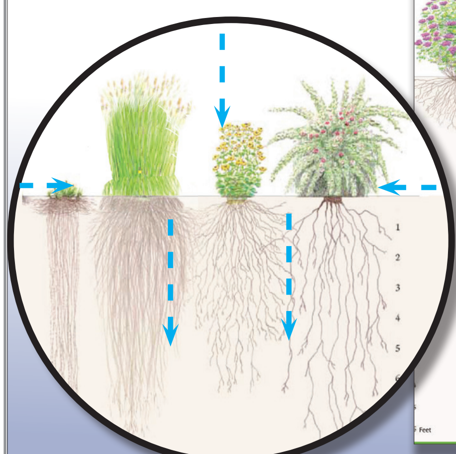
Treat stormwater runoff before it reaches the receiving stream.

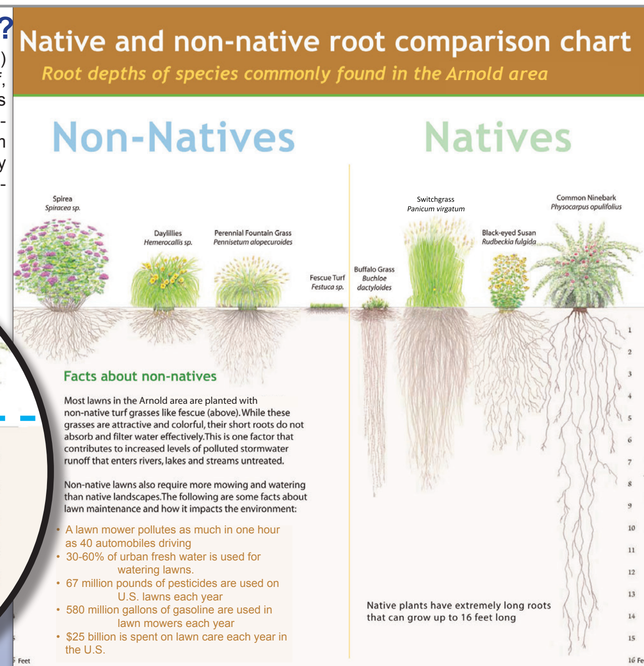
To improve water quality, BMPs should be designed and located so runoff is routed though a chain of successive treatments that remove pollutants and increase water quality as much as possible before entering the streams of the watershed. BMPs should meet the minimum requirements set forth in American Public Works Association Section 5600. Developers should submit stormwater studies that demonstrate the effectiveness of proposed BMPs in lieu of localized detention facilities.

Options to street standards allow flexibility for treating runoff.

What is a Stormwater BMP?

Stormwater Best Management Practices (BMPs) are techniques used to control stormwater runoff, sediment control, and soil stabilization, as well as management decisions to prevent or reduce non-point source pollution. They can be used in the form of rain gardens to utilize stormwater as an amenity as well as provide aesthetic value to the surrounding landscape.





Why use Stormwater BMPs?

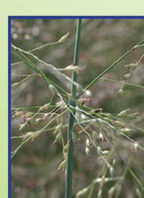
Erosion Control
- Reduces flow rates into stream channels
- Allows plant root systems to develop

Flood Control

Recharges Groundwater
- Water is allowed to infiltrate soil

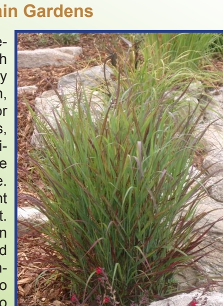
Cleans Water
- Filters out sediment and pollutants

Using Native Switchgrass in Rain Gardens



Switchgrass seed

Switchgrass is a warm-season perennial grass that is native to North America and can be found in many environments. Due to its native origin, switchgrass is highly tolerant of poor soils, flooding, drought, plant pests, and diseases making it an ideal specimen for planting areas which receive high impacts and little maintenance. The extensive root system of the plant can extend to soil depths of 10 feet. Switchgrass takes on a glossy green color during its growing season and does not require mowing. Typically, the grass is cut only annually, preferably in late February or March, to allow birds to feed on the seeds dropped during the dormant months and to reduce maintenance cost/ impacts.



'Northwind' Switchgrass
Panicum virgatum 'Northwind'

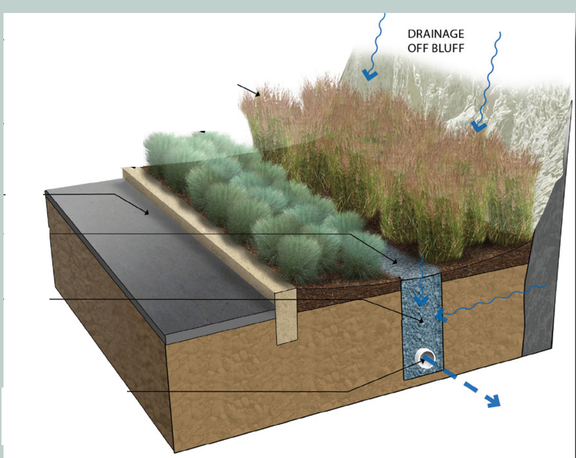
Best Management Practices

in Roadway Settings

BMP design can be incorporated throughout the city along major arterials or collectors. Rain gardens, bio-swales, and permeable paving are common types of BMP's that can also be found in commercial and residential developments.

RIGHT OF WAY

Bioswales can be used along the edge of roadways to treat stormwater by filtering it through vegetation and soils prior to it entering the storm sewer.



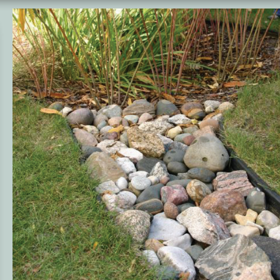
MEDIAN PLANTINGS

Bioswales can also be used within the roadway when there is ample space for a median. The advantage to this treatment is that it gets both sides of the roadway with one system. The plantings also function to calm traffic and beautify the streetscape.

Best Management Practices

in Residential Settings

BMP design can be incorporated throughout the Planning Area, especially in residential neighborhoods and along local streets. Rain gardens, permeable paving, and detention basins are common types of BMP's that can be found in residential settings.

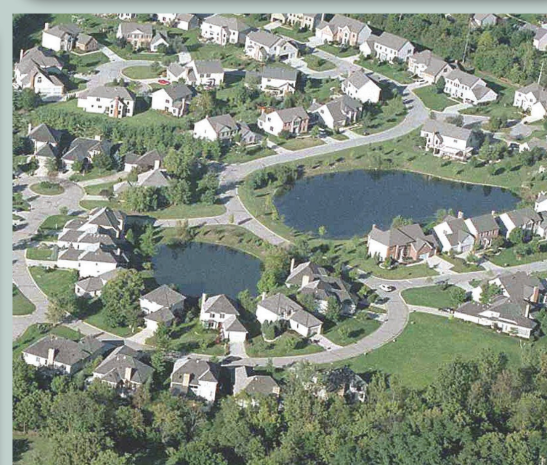


RAIN GARDEN

Planted depression designed to absorb rainwater runoff from impervious urban areas like roofs, driveways, and walkways.

DETENTION BASIN

Designed to protect against flooding and, in some cases, downstream erosion by storing water for a limited period of time. Basins can be "dry" or "wet", depending on whether they are designed to permanently retain a volume of water.



PERMEABLE PAVING

Paving method for roads, parking lots, driveways, and walkways that allows the movement of water around the paving material and into the soil.

Best Management Practices
in Commercial Settings

BMP design can be incorporated throughout the Planning Area in commercial developments and along major arterials or collectors. Rain gardens, bio-swales, and permeable paving are common types of BMP's that can be found in commercial developments.

RAIN GARDEN

Planted depression designed to absorb rainwater runoff from impervious urban areas like roofs, driveways, and walkways.

BIO-SWALE

Landscape elements designed to remove silt and pollution from surface runoff water. A common application is around parking lots, where substantial automotive pollution is collected by the paving and then flushed by rain.

PERMEABLE PAVING

Paving method for roads, parking lots, driveways, and walkways that allows the movement of water around the paving material and into the soil.

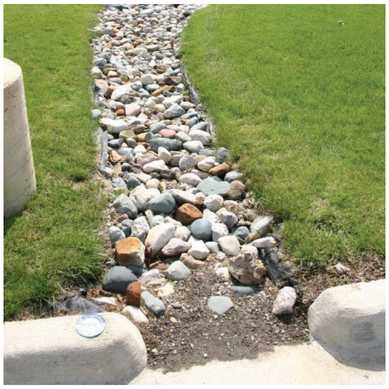
DETENTION BASIN

Basins can be "dry" or "wet", depending on whether they are designed to permanently retain a volume of water.

American Public Works Association Section 5600. Developers should submit stormwater studies that demonstrate the effectiveness of proposed BMPs in lieu of localized detention facilities.

Careful consideration of the placement of BMPs throughout any watershed must be given to ensure water quality. Most BMPs implemented to improve stormwater "quality" may also reduce the stormwater "quantity". This reduction in water "quantity" may also reduce the amount of detention storage required for the development, which in turn will reduce development costs. Potential reductions in development cost are true for many of the BMPs that could be implemented in the watershed. The use of natural buffers and native vegetation may reduce the need for grading and the need for larger enclosed pipe systems which reduces long-term maintenance needs of the City.

Localized stormwater management may also be incorporated into the design of local and collector residential streets and parking lot designs. Swales may be used in place of curbs and gutters along streets and within parking lots. Alternative street designs may also include reduced pavement widths with a concrete apron rather than raised curbs, as well as vegetated swales with plantings similar to rain gardens in lieu of enclosed stormwater pipe systems. Such alternative designs may result in reduced construction costs and achieve the objective of reducing the quantity of runoff while increasing infiltration and the quality of runoff.



This parking lot incorporates stormwater drainage into its design.

Bioretention facilities are vegetated areas where soil acts as a filter for stormwater contaminants.

Rain gardens reduce runoff by allowing stormwater to soak into the ground.