City of Winston-Salem
NPDES Stormwater Permit Program

Total Daily Maximum Loading (TMDL) Implementation Plan

Salem Creek Watershed

Winston-Salem

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Purpose

The purpose of this Total Daily Maximum Loading (TMDL) Implementation Plan is to reduce levels of fecal coliform contamination to the maximum extent practicable within the Salem Creek Watershed. The city of Winston-Salem strives to reduce pollutant loading to impaired surface waters by designing and implementing stormwater best management practices (BMPs). With continued implementation of stormwater BMPs within the Salem Creek Watershed, the city progresses to achieving its Waste Load Allocation (WLA) for fecal coliform reduction. For purposes of this TMDL Implementation Plan, the City develops and implements appropriate stormwater BMPs that reflect its six minimum permit measures.

Background

Salem Creek is located within the Yadkin-Pee Dee River Basin in the Piedmont physiographic region and is composed of Class "C" waters. The Salem Creek Watershed is located entirely within Forsyth County and the majority of the watershed is located within the municipal limits of the city of Winston-Salem. The watershed is located within hydrologic unit 030400101170060 and DQW subbasin 03-07-04. Salem Creek is currently impaired for fecal coliform bacteria. The impaired segment of Salem Creek originates at the Salem Lake Water Supply Dam and travels in a southwesterly direction to the confluents with Muddy Creek. Brushy Fork Creek and Peters Creek are tributaries to Salem Creek. The impairment length of Salem Creek is 12.0 miles.

The Salem Creek Watershed measures 44,894 acres, or 70.15 square miles of drainage area. A significant portion is within the municipal limits of the city of Winston-Salem. Portions of the upper and middle Salem Creek Watershed drain stormwater runoff from downtown Winston-Salem, which is considered to be high-density development. Stormwater runoff from highly-developed urban areas can contribute significant amounts of pollutants to receiving streams. However, much of this runoff is regulated by the NPDES Stormwater Phase I and II Program (EPA, 2000). This program applies to a unit of government such as a city or county, which owns or operates a municipal separate storm sewer system (MS4). All medium and large municipalities which own or operate a MS4 are issued a National Pollutant Discharge Elimination System (NPDES) permit in order to discharge stormwater to streams. Stormwater discharged from the MS4 is considered a point source discharge (i.e. water released from a pipe). North Carolina Division of Water Quality (NCDWR) issued a NPDES stormwater permit to the city of Winston-Salem in April 2013; this permit expires in February 2018.

Pollutant of Concern

Fecal coliforms are naturally-occurring bacteria that live in intestinal tracts of warm-blooded animals (including humans). The presence of elevated fecal coliform concentrations within streams indicates possible contamination of sewage from four possible sources (or combination thereof) - humans, domestic pets, livestock, and

wildlife. Excessive fecal coliform contamination possesses a human health risk as well as degrading receiving biotic ecosystems.

Point sources of fecal coliform consist primarily of large and small industries, wastewater treatment plants, and MS4s. As authorized by the Clean Water Act, the DWR regulates the NPDES permit program to control water pollution due to point sources. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. NPDES-Regulated Municipal and Industrial Wastewater Treatment Facilities Discharges from wastewater treatment facilities may contribute fecal coliform to receiving waters. Municipal treatment plants and industrial treatment plants are required to meet surface water quality criteria for fecal coliform in their effluent. When effluent coliform concentrations exceed surface water quality criteria, and result in permit violations, action will be taken through the NPDES unit of North Carolina's Division of Water Quality. NPDES general permitted facilities are required to develop pollution prevention plans to discharge domestic wastewaters from single-family residences and other domestic discharges. The permitted flow of these facilities may not in any case exceed 1,000 gallons per day. The facilities are required to measure BOD5, total suspended residue, fecal coliform, and total residual chlorine (NCDENR).

Fecal coliform from nonpoint sources include those sources that cannot be identified as entering the water body at a specific location. Nonpoint source pollution can include both urban and agricultural sources and human and non-human sources. The nonpoint sources of fecal coliform in the water bodies include wildlife, livestock (land application of agricultural manure and grazing), urban development (stormwater runoff, including sources from domestic animals), failing septic systems, and sewer line systems (illicit connections, leaky sewer lines and sewer system overflows).

Table 1 - Potential Sources of Fecal Coliform Bacteria in Urban and Rural Watersheds (Source: Center for Watershed Protection, 1999)

Source Origin	Type	Source
Human Sources	Sewered watershed	Combined sewer overflows
		Sanitary sewer overflows
		Illegal sanitary connections to storm drains
	Non-sewered watershed	Failing septic systems
		Poorly operating package plants
		Landfills
		Marinas
Non-human Sources	Domestic animals and urban wildlife	Dogs, cats, rats, raccoons, pigeons, gulls, geese, ducks
	Livestock and rural wildlife	Cattle, horses, poultry, beavers, muskrats, deer, waterfowl
	Other	Hobby farms

Land use can contribute to fecal coliform runoff. Agricultural land alongside a stream would contribute fecal coliform from livestock and manure applications. In addition, when cattle have direct access to streams, feces may be deposited directly into a stream. Runoff from urban surface is also a potentially significant source of fecal coliform loadings. Urban lands may contribute fecal coliform from pets such as dog and cats. Wildlife feces in runoff may be a frequent source of fecal coliform loading where forest dominates the streamside.

Fecal coliform can originate from various urban sources. These sources include pet waste, runoff through stormwater, sewers, illicit discharges/connections of sanitary waste, leaky sewer systems, and sewer system overflows. Fecal coliform contamination can be profound when sewer pipes are clogged or flooded by stormwater. Infiltration of rainfall can enter the sewer system through cracks and leaks in pipes. This additional flow volume, in combination with the existing sewer flow, can exceed the capacity of the system resulting in a sanitary sewer overflow (TMDL Final Report, NCDENR Salem Creek Watershed).

Introduction

In April 2013, the city of Winston-Salem received a revised NPDES permit from North Carolina Division of Water Quality (NCDWR). This revised NPDES permit simplified the TMDL implementation plan for stormwater Phase I communities; municipalities must develop and implement appropriate BMPs (within the NDPES permit's six minimum measures[1]) to address waste load allocations (WLA) to the maximum extent practical (MEP). As a result, the city's success of achieving its WLA is not evaluated on attaining NC Water Quality Standards (WQS). The tangible reduction of fecal coliform loadings to impaired waters will be achieved by the continued implementation of appropriate stormwater BMPs to remove pollution sources.

NCDWR has determined that 12.0 miles of Salem Creek are impaired due to fecal coliform pollution for the entire stream length. MapTech-HDR (2005) used antibiotic resistance analysis (ARA) to positively identify four sources of fecal coliform within Salem Creek - domestic pets, wildlife, humans, and livestock. When quantifying the number of identifiable statistical significant isolates found in MapTech's study, the following prevalence ranking emerges (with examples):

1. Wildlife
2. Domestic pets
3. Humans
4. Livestock

[1] The NPDES stormwater permit contains six minimum measures that a permittee must create, implement, and maintain for program compliance. These six measures include public education, public involvement and participation, illicit discharge detection and elimination, construction site runoff controls, post-construction site runoff controls, and pollution prevention and good housekeeping for municipal operations. In addition to these minimum measures, stormwater permit holders must evaluate stormwater discharges by industrial users, assess and monitor water quality within local streams, and comply with MS4 waste load allocations.

Based upon the load duration curve for Salem Creek, livestock contribute a greater loading of fecal coliforms during storm events, while human and wildlife sources dominant loadings during baseflow conditions (NCDWR 2005). The percentage of fecal coliform reduction loading from the municipal separate storm sewer system (MS4) is 93 percent, which correlates to a waste load allocation of 3.925×10^{12} colony forming units (cfu) per a day (NCDWR 2005). Table 2 summarizes this information, which is posted below.

Table 2 - Estimated Percent Reduction by Source for Fecal Coliform (represented in cfu/day) for the Salem Creek Watershed
(Source: NC Division of Water Quality, 2006)

	WLA NPDES	WLA MS4	LA	MOS	TOTAL
Existing Load (cfu/day)	4.54×10^{11}	4.22×10^{12}	1.07×10^{12}	-	5.74×10^{12}
Load Allocation (cfu/day)	4.54×10^{11}	2.95×10^{11}	7.37×10^{10}	9.14×10^{10}	9.14×10^{11}
Percent Reduction	0	93.0	93.1	-	84.1

BEST MANAGEMEMENT PRACTICES (BMPs)
For Permit Year 2013 – 2014

BMP *A* – Updated Salem Creek Watershed Maps (including the contributing tributaries of Brushy Fork Creek and Peters Creek) of Stormwater Major Outfalls and Streams

The City of Winston-Salem contracted HDR Engineering to locate, characterize, and digitalize all major outfalls within the Salem, Brushy Fork, and Peters Creek Watersheds. In addition, HDR Engineering performed hydrologic modeling of the MS4 to evaluate the MS4's hydraulic capacity during different storm event regimes. HDR Engineering completed evaluating these watersheds in 2011 with a revised reassessment date in Permit Year 2017. As a result of the assessment, 785 new major outfalls were discovered and incorporated into the city's GIS program.

In the interim, the Stormwater Division has implemented flow process mechanisms to capture new major outfall data. These measures include:

- Electronic as-built plans of infrastructure modifications from the private development community to the maximum extent practical (MEP)
- City will contract with an engineering consultant (and registered land surveyor) to perform a comprehensive field assessment to discover new major outfalls
- Confirmation of major outfall status by Stormwater technical staff during annual stream-walking observations

- Post-construction plan reviews that involve major outfall modifications
- Confirmation of major outfall status by Stormwater Inspector during industrial surface water inspections
- As a component of illicit discharge compliance program, Stormwater technical staff will perform a comprehensive assessment of an industrial (or land use zoned) facility's major outfalls (and infrastructure) and update the city's stormwater inventory system, as needed

BMP *B* – Existing Measures to reduce MS4's Waste Load Allocation

The City of Winston-Salem is implementing various structural and nonstructural BMPs to achieve its waste load allocation (WLA) for fecal coliform reduction within the Salem Creek Watershed. The Stormwater Division has commenced these BMPs for program implementation:

Existing Measures	Status	Explanation to Reduce Pollutant of Concern
Central District PTRP Wet Pond – captures first flush of runoff from the adjacent Piedmont Triad Research Park. In addition, 355 acres of ultra-urban drainage area discharges to the pond. Pond has a surface area of 2.98 acres and average depth of ten feet (in the lower pond).	100 percent complete	Designed to remove 85 percent TSS removal from influent; since fecal coliforms adhere to TSS, a reduction in TSS should yield a fecal coliform reduction of 50 percent. These reductions pertain to the PTRP drainage area only.
Utilities Construction & Maintenance Division *Pipe Bursting and Slipping Program *Lift Station Repair and Rehabilitation Program *Flood Reduction Projects – Inflow and Infiltration	100 percent complete; on-going operation	80 percent of the City's sewer collection system uses gravity for transporting sewage to the POTW. As a result, a significant portion of sewer truck lines are positioned adjacent to streams. Once implemented, engineered solutions eliminates the exposure of sewerage to surface waters.
Illicit Discharge Detection and Elimination Program (IDDE) - the Stormwater Division performs fixed interval sampling regime of 13 sites across the City – 7 sites are located in Salem, Brushy Fork, and Peters Creek Watersheds.	100 percent complete; on-going operation	By proactively finding sanitary sewer overflows (SSOs) and reducing the quantity of sewage, the amount of fecal coliform pollution is minimized. As a result, the regeneration of fecal coliform bacteria within the stream matrix is reduced, which facilitates the recovery of the biotic ecosystem at a more rapid rate.
Stream Walking (IDDE Program Component) – Stormwater staff walked approximately 13 miles of streams within the Salem, Brushy Fork, and Peters Creek Watershed.	100 percent complete; on-going operation	By proactively finding and eliminating illicit sewer discharges and connections, staff reduces the quantity of sewage released to surface waters. As a result, the total amount of released fecal coliform pollution is reduced.
Public Education – Scoop-the-Poop campaign. The public educator	100 percent complete; on-going	By making pet owners aware of the detriment of fecal coliform pollution,

highlights the detriments of fecal coliform pollution within a riverine ecosystem as well as 'factoids' of feces (e.g. the amount of fecal coliform bacteria per a gram of fecal matter, the average weight of a dog's bowel movement, etc.)	operation	the Stormwater Division wishes to facilitate a behavioral change in citizens. If citizens remove feces from the open environment, the exposure of fecal coliform bacteria to stormwater runoff has been eliminated.
Pet Waste Stations - the City's Parks and Recreation Department installed seven pet waste collection stations within green spaces throughout downtown Winston-Salem.	100 percent complete; continuous operation	Stations provide ease of access for pet owners to discard fecal waste and remove from the open environment. To further encourage participation, the City furnishes waste bags to the public, which are positioned on top of the waste reticle. By eliminating the exposure of fecal matter to the runoff, bacteria are not discharged into waterways.
Pet Waste Ordinance – the City of Winston-Salem has an in-force ordinance that requires pet owners to pick up fecal matter within its municipal boundaries.	100 percent complete; continuous operation	By requiring pet owners to pick up fecal matter from their pets, the exposure of stormwater runoff to fecal coliforms has been eliminated, thus reducing the fecal pollution load to receiving waters.
Erosion and Sediment Control Ordinance – the City of Winston-Salem has adopted and enforces its Sediment and Erosion Control Ordinance, as per the 1973 Sedimentation Control Act. Erosion control devices must be installed and maintained for disturbed areas greater than 10,000 square feet in order to retain soils on-site.	100 percent complete; continuous operation	Fecal coliforms are transported to receiving waters by soil particles. In addition, fecal coliform bacteria become resuspended once discharged into the water matrix. As a result, fecal coliform bacteria proliferate at an increased rate and degrade surface waters more rapidly. Thus, a decreased sediment load yields reduced fecal coliforms to receiving waters.
SUSTAIN Modeling Study – A consultant preformed an EPA SUSTAIN model for the Salem Creek Watershed. Eleven structural BMPs were identified for installation or retrofit.	100 percent complete	Based upon screening criteria, the consultant determined that eleven sites could be retrofitted or installed for bioretention cells or stormwater wet ponds. The modeling results showed that these eleven sites may produce a 1.9 percent reduction of fecal coliform pollution. The associated costs would total $15,113,135.
Ditch Repair and Stabilization Program – the Streets Division hires a private contractor to repair and stabilize ditches within the public right-of-way.	100 percent complete; continuous operation	The Streets Division assesses and prioritizes earthen conveyance swales that serve as drainage for ribbed and paved roadways. A private contractor restores channel capacity to the ditch by removing trash, sediment, or excessive vegetation. If needed, the contractor reestablishes vegetative cover within the ditch line in order to eliminate sedimentation to receiving waters.

Fats, Oil, and Grease (FOG) Reduction Program – the City/County Utilities Division has adopted and implemented a FOG Reduction Program to remove excess cooking and petroleum oils and grease prior to entering the sewer collection system. Responsible parties must have their grease/oil separators pumped out by licensed haulers at scheduled frequencies.	100 percent complete; continuous operation	Grease and oil are the second-leading cause of sewer overflows that reach surface waters within the City of Winston-Salem. By requiring grease/oil interceptors to be properly maintained, these passive devices can effectively retain grease from entering the sewer collective system. As a result, the quantity of released sewage (and fecal coliforms) is reduced to streams.

BMP *C* – Assessment of Available Monitoring Data

Since 2008, the Stormwater Division has collected fecal coliform samples from 52 major stormwater discharge outfalls within Salem, Peters, and Brushy Fork Watersheds. Stormwater staff performed fecal coliform sampling during dry and wet weather conditions with over 261 samples collected and analyzed. When assessing fecal coliform sample concentrations, staff observed numerous trends from the database. These observations include:

- During wet weather conditions, all fecal coliform samples were above 400 cfu/100 milliliters. A majority of this sample population exceeded 1,000 cfu/100 milliliters.
- Dry weather sampling results showed an inconsistent pattern of fecal coliform exceedences. When staff sampled the same outfall at differed time intervals, fecal coliform concentrations oscillated above or below the water quality standard for Class C waters.
- The Stormwater Division identified the positive correlation of an independent variable to fecal coliform concentrations. As ambient temperature increases, so does fecal coliform concentrations within local streams.
- A very weak correlation exists between fecal coliform concentrations and upland land use; insufficient evidence for predicting or isolating fecal coliform sources.

BMP *D* – Monitoring Plan (proposed modifications to existing plan)

The Stormwater Division performed a comprehensive program evaluation of its TMDL monitoring plan in order to become more efficient and effective. Implementation of these improved screening and trending methods is scheduled for FY 2014 – 2015. The Stormwater Division intents to implement the following proposed modifications to existing plan:

- Obtain absolute (i.e. exact) fecal coliform concentrations in stream segments to establish an impairment priority ranking, through aliquot dilution.
- Predict impaired stream segments using the GIS matrix as a starting point for sampling locations. The stream segments with the greatest raster density (based upon data points per a unit of area) become targeted sampling areas.
- Sample targeted subwatersheds during varying weather conditions. The approved Salem Creek TMDL states that fecal coliform violations occur between 10 – 75 percent of days flow exceeded.
- Concentrate sampling efforts in first order streams (near/at confluence with second order streams) and adjust future locations based upon sample results. If sample results above 400 cfu/100 milliliters (geometric mean value), move upstream to finger tributaries. If below, move downstream to the next confluence point.
- Develop a priority ranking hierarchy based upon fecal coliform loadings and raster data density (e.g. a tiered system).
- Verify that a fixed, in-stream sampling site exists for purposes of a baseline assessment within Salem Creek (e.g. Elledge WWTP); quarterly frequency is recommended.
- Include sediment samples for fecal coliform testing at fixed sampling sites.
- Instantaneous water quality indicators to be obtained at each sampling event: water temperature, solar radiation conditions (e.g. sunny, overcast) total dissolved solids, conductivity, pH, dissolved oxygen (milligrams per a liter and percent saturation), and rainfall amount or time since last rainfall.
- Limit the number of samples for same weather condition to three consecutive samples
- Once pollutant loadings have been established for impaired stream segments, compare these loadings against the GIS matrix. Determine which independent variables are causing the impairness and consider the appropriate six minimum measure(s) that could be implemented for reducing waste allocations.
- Create and implement quality control/quality assurance measures (e.g. three percent of total samples are field blanks)
- Ensure proper sampling techniques are being followed when conditions allow
- Perform before versus after sampling for fecal coliform concentrations at predetermined stormwater discharge outfalls (for nonstructural BMPs) or effluent discharge points (for structural BMPs) in order to determine the estimated waste load reduction.

BMP E – Additional Measures for Implementation

Additional Measures: The City of Winston-Salem anticipates the implementation of numerous nonstructural BMPs in order to expand current pollutant reduction strategies within the Salem Creek Watershed. By expanding current BMP strategies to the maximum extent practical, the City hopes to benefit from synergic pollutant reductions within the targeted watershed. The following matrix presents the City's expanded measures (with corresponding explanations) in order to reduce fecal coliform loadings within the Salem Creek Watershed:

Additional Measures	Explanation of Desired Outcomes	Responsible Staff for Implementation
Perform Goodhousekeeping Awareness Training with local Animal Shelters	By evaluating current business practices, the Stormwater Division wishes to provide local shelters with new or modified cleaning methods to prevent or eliminate fecal coliform exposure to the open environment.	Community Educator Stormwater Inspector
Perform a collaborated awareness program with the City's Parks and Recreation for signage and pet waste collection station implementation at frequently used municipally-owned areas. In addition, a stormwater representative will perform on-site educational presentations with park users.	The Stormwater Division wishes citizens to have a heightened awareness of the detrimental effects of bacterial pollution to receiving waters. Thus, the overarching goal of this measure is to highlight the importance of collecting pet waste and eliminating the exposure of fecal coliforms to runoff.	Community Educator Parks and Recreation staff
Facilitate a private-public partnership for pet waste receptacle placement in common areas of high density residential housing.	By having readily access to disposal bins, the Stormwater Division anticipates targeted residents to use waste stations rather than leaving fecal matter on the ground.	Community Educator
Create and implement a rain garden training program for treating runoff from residential properties.	The Stormwater Division will provide technical knowledge as well as rain garden plants and soil media for BMP construction. Stormwater runoff will infiltrate into the garden and eliminate discharge into the MS4.	Stormwater Engineer Stormwater Director
Create GIS layers for independent variables of fecal coliform contamination to validate appropriate BMPs implementation.	By importing independent variable data (e.g. sewer pipe and material type, per capita of pet ownership, etc.), the Stormwater Division analyses and prioritizes subbasins for fecal coliform contamination. This GIS analysis will allow Stormwater staff to effectively select appropriate BMPs for implementation. Hopefully, staff will be able to prove significant pollutant reduction within targeted subbasins.	Stormwater Technicians Special Projects Coordinator
Evaluate municipal operations and general stormwater-	The goal of this nonstructural control measure entails the modification of work	Stormwater Inspector

permitted industrial facilities for opportunities of fecal coliform reduction.	practices to eliminate fecal coliform exposure to the environment. By eliminating fecal coliform exposure, the overall waste load allocation is reduced.	
Generate a comprehensive list of municipal facilities that would benefit from retrofitting/constructing structural control measures. Prioritize sites and coordinate with responsible parties for measure planning and design activities.	By designing and implementing structural control measures for removing fecal coliforms from MS4 discharges, the City will reduce bacterial pollution to receiving streams.	Stormwater Inspector Stormwater Engineer City staff
Create and implement confirmation methodology for locating failing septic tank systems within the City of Winston-Salem	Failing septic tanks contribute human fecal coliform loading to the MS4, if illicit discharges are allowed to persist. By refining the City's IDDE protocols for failing septic tanks, the City will achieve greater success in obtaining its waste load allocation.	Stormwater Technicians
Create and implement a water quality sampling program for 'at-risk' areas of exfiltration from the City's sewer collection system. After significant storm events, Stormwater staff will sample the downstream stream for sewage indicator pollutants in order to minimize the quantity of released sewage.	The Utilities Division has modeled and identified areas of exfiltration within the sewer collection system. Since 80 percent of sewer collection system is adjacent to surface waters, the likelihood of a SSO remains great. Therefore, a proactive program of mitigating released sewage to waterways remains paramount.	Stormwater Technicians Utilities Construction & Maintenance Engineer
Explore new methodologies of locating and removing failing septic tank systems from discharging into receiving surface waters.	Current procedures for discovering failed septic tank systems rely on passive techniques. By utilizing GIS tools in conjunction with innovative techniques, the Stormwater Division wishes to proactively locate potential 'hot spots' of septic tank failures.	Forsyth County Department of Health Stormwater Technicians
Perform water quality sampling of stormwater discharge outfalls from municipally-owned properties that have a great potential to contribute fecal coliform pollution to streams. The purpose of this sampling effort is to confirm the justification of designing and constructing structural control measures to treat stormwater runoff.	By validating fecal coliform pollutant concentrations, the Stormwater Division is able to justify and prioritize capital improvement funds for structural control measure expenditures. The Stormwater Division can maximize the pollutant removal efficiency per a dollar spent. An overall reduction to the City's WLA is expected from implementing structural control measures.	Stormwater Technicians Stormwater Engineer
Locate, inspect, and sample treated wastewater from NPDES-permitted sand filters/package plants for fecal coliforms. If the effluent	The continuous, effective operation of an on-site wastewater treatment device is critical for achieving compliance with the WQ Redbook Standard. By sampling the effluent of these devices, the Stormwater	Stormwater Technicians Stormwater Inspector

concentrations exceed 400 cfu/100mL, report the responsible party to NCDWR.	Division is confirming effective operation. Exceedences of the WQ Standard constitute a point source load of fecal coliforms to the MS4. Removing coliform-laden discharges will assist the Stormwater Division to meet the City's WLA.	N.C. Division of Water Resources staff
Locate livestock populations within the Salem Creek Watershed. Assess the potential of stream access/proximity of livestock populations. Compile assessment results and incorporate into the Stormwater Division's GIS.	The overall goal of this action item is to evaluate the potential of fecal coliform contamination from agricultural areas. Once livestock fecal coliform sources are identified, the Stormwater Division can propose and implement non/structural control measures to treat or reduce fecal coliform loadings to Salem Creek.	Stormwater Technicians
Designate a program coordinator to oversee and manage the routine maintenance of all City-owned structural control measures within the City of Winston-Salem.	By ensuring the effective and continuous operation of City-owned wetlands, wet detention ponds, and bioretention cells, the maximum fecal coliform die-off rates can be achieved. Maintenance activities will focus on conditions for maximum mortality rates such as: minimal tree canopy cover, sediment, trash, debris removal, and promotion of riparian buffers along applicable BMPs to deter waterfowl.	Stormwater Engineer Stormwater Director
Street sweeping activities in 'hot spot' areas within the Salem Creek Watershed that focuses on strategic timing and location.	Fecal coliform bacteria are transported into receiving streams by adsorbing onto soil particles. By increasing the frequency of street sweeping in designated areas, the City will eliminate the transport mechanism, thus reducing the fecal coliform loading within the Salem Creek Watershed.	Assistant Transportation Director Stormwater Director
Continued rehabilitation of infrastructure collection systems (sanitary sewer and stormwater) for continuous and effective operation	Aging infrastructure creates conditions that permit fecal coliform pollution to persist, which include hydraulic overloading, sedimentation due to structural failures, and riverine flooding. Rehabilitation improvement projects will reduce fecal coliform loading by eliminating failure causes.	Utilities Construction & Maintenance Division Streets Division
Social media campaign to target specific demographics regarding proper handling of pet waste.	By creating and implementing an engaging social media strategy, the Stormwater Division anticipates that targeted audiences will retain take-away messages as well as increase its number of friends/subscribers/followers on social media. As a result, the Division hopes that pet owners will change their behavior and remove feces from the open environment. Thus, the exposure of fecal coliforms to rainfall will be eliminated.	Community Educator Marketing and Communications Department

BMP *F* – Implementation Plan

The City of Winston-Salem plans to implement the following structural and nonstructural BMPs in order to reduce fecal coliform pollution within the Salem Creek Watershed, in accordance with permit requirements.

Structural/Nonstructural Control Measures	Explanation of Desired Outcomes	Status and Schedule
Washington Dog Park – a 950 square feet bioretention cell will receive the first inch of stormwater runoff from the upland 3.48 acre drainage area. Storm flows greater than the first inch will be diverted to Salem Creek. Vegetative Management and Streets Drainage Divisions will perform routine maintenance on the bioretention cell.	The Washington Dog Park is located within 75 feet of Salem Creek's top of bank. The park is the only and most heavily-used dog recreational area within Winston-Salem. A pet waste receptacle is positioned at the park's only access point; the total elimination of fecal coliform bacteria from the open environment remains unachievable to obtain. Thus, the permanent installation of a bioretention cell will remove the residual fecal matter from stormwater runoff. The anticipated pollutant removal of fecal coliform bacteria should be approximately 80 percent.	Stormwater staff will seek CIP funding from the City Manager's Office for approximately $40,000. Construction activities should commence in July 2017.
Sanitation Collection Truck Storage Yard – the City's Property Maintenance Section is redesigning a new storage facility for sanitation collection trucks. Stormwater runoff from the proposed storage area will be conveyed into an oil water separator, which discharges into the facility's stormwater wet pond.	This treatment train is designed to significantly reduce fecal coliform pollution through solid separation, exposure to ultraviolet radiation, and natural predation from protozoan organisms within the wet pond.	This BMP is contingent upon bond procurement, thus an approximate implementation schedule is pending. Once funds become available, the Stormwater Division will develop a project schedule.
City of Winston Salem, Parks and Recreation Maintenance Facility/Reynolds Golf Course – a substantial Canada Geese population as well as numerous wildlife sightings/scat observations have prompted staff to design a bioretention cell for capturing and removing fecal coliform bacteria.	An area of the golf course is located adjacent to Berry Branch, a tributary of Salem Creek. By intercepting stormwater runoff and routing through a bioretention cell, fecal coliform load reduction should increase to 80 – 90 percent.	On-goings basin studies are verifying project viability. Staff will perform water quality sampling of stormwater discharge outfalls to confirm fecal coliform loading in 2015. Once confirmed, the project should commence by June 2018.

TMDL Monitoring Plan – a program evaluation was performed by staff, which revealed several information gaps within the monitoring plan. In order to devise a clearer and effective strategic TMDL masterplan, the Stormwater Division will implement new sampling procedures to identify and quantify fecal coliform loadings from contributing drainage areas.	By incorporating new procedures into its Monitoring Plan, the Stormwater Division will be able to prioritize drainage areas for stormwater management controls. In addition, Stormwater staff becomes able to determine the appropriate nonstructural/structural control measures for implementation. A pilot study may result in a statistical correlation of workload measures to actual waste load allocation reduction.	New sampling procedures have been finalized with Stormwater staff being trained on program amendments. The new sampling procedures will be implemented by July 2014.
Wildlife Management Initiative – urban wildlife constitutes the largest source of fecal coliform loading to the MS4. By implementing new nonstructural and structural control measures (in conjunction with the NC wildlife Commission), the City hopes to reduce its waste load allocation within the Salem Creek Watershed.	Since the City needs to reduce fecal coliform loadings from the MS4 by 93 percent, this isolate group provides the largest promise of waste load reduction. As a result, the City wishes to reduce fecal coliform loading to the MS4 through the combination of nonstructural and structural BMPs, such as goose deterrent systems, bioretention cells, and exclusory devices.	This program initiative is being developed by the Stormwater Division as well as the NC Wildlife Commission. Due to the complexity of this initiative, the Stormwater Division hopes to implement control measures by June 2017.
Salem Creek Structural Control Masterplan – a consultant performed an assessment of the Salem Creek Watershed in order to generate a prospective list of sites for structural control measure placement. Once identified, computer modeling was used to develop a priority ranking system for BMP type, size, and projected costs.	The masterplan serves as a long-term strategic blueprint to achieving the MS4's waste load allocation. By strategically placing structural control measures on sites with high pollutant loadings, the Stormwater Division is able to validate the cost-effectiveness and removal efficiency to the public, elected officials, and the City Manager's Office. In addition, the Stormwater Division will develop a long-term capital improvement project preforma spending plan for Council's approval.	This structural control measure masterplan was completed and delivered to the Stormwater Division in July of 2013. Due to fund availability and project prioritization order, the first designated bioretention cell for implementation is scheduled to be operational by the Summer of 2020. Since 15 sites were selected for BMP retrofit/installation opportunities, the Stormwater Division projects BMP implementation to continue until 2035.

BMP *G* – Documentation of WLA Incremental Success

The Stormwater Division plans to utilize various databases (e.g. GIS, Microsoft Excel database, and Microsoft Access database) to document, analyze, and report incremental successes to achieve WLA reduction. In addition, the geodatabase platform serves as multifunctional networking tool for other internal or external governmental entities for sharing information. The methodology used for documenting measure success (and ultimately, wasteload reduction) depends on measure type (i.e. nonstructural and structural). However, the Stormwater Division has adopted the below-posted departmental standards for validating *actual* pollutant reduction loading to the effectiveness of implemented control measures. These standards include:

- Perform water quality sampling before and after control measures have been implemented at major stormwater discharge outfalls. This methodology allows staff to determine the casual relationship of measure(s) effectiveness to actual pollutant reduction. Since water quality samples will collected during varying weather conditions, the overall trend in percent reduction should become evident over a period of time. The Stormwater Division realizes that other variables may cause anomalies or 'outliers' within trending data, but overall long-term declining percentages should be able to validate implemented control measures.
- Long-term data (four to five years) will be needed to provide observable deductions in wasteload allocation reductions within subwatersheds. Due to the dynamic nature of biological ecosystems as well as the large percentage of pollutant reduction required, the Stormwater Division needs a substantial data population (n = 20) to correlate a percent reduction.
- Fecal coliform concentrations are interval data – a common standard is used to derive colony-forming units (cfu) per 100 milliliters of sample. Therefore, every effort should be spent to use statistical correlation in order to predict source origins to select or refine appropriate BMPs for WLA reduction.
- Perform pre/post surveys to determine a percentage of heightened awareness of fecal coliform reduction methods or strategies in order to validate MEP for WLA reduction. If a pilot study is conducted for the effectiveness of public education to actual reduction within a drainage area, perform the study in accordance with the scientific method (i.e. experimental vs. control drainage area of random populations).
- Whenever possible, use scientific journal articles (or similar professionally peer-reviewed literature), quality controlled/assured laboratory analyses (from a North Carolina certified laboratory), or professional engineered-sealed material when validating reduction methodologies for this TMDL Implementation Plan. Any best professional assumptions must be qualified with footnotes within supporting documents.

In order to track and report fecal coliform load reductions, all nonstructural and structural control measures are recorded into the Stormwater Division's GIS. The City's GIS Matrix provides a quantitative representation of drainage areas with elevated fecal coliform loading as well as most probable contributing isolate source(s). These suspect outfalls will be sampled for fecal coliforms concentrations in order to create a contribution load ranking as well as developing pre-BMP implementation pollutant loadings. Once nonstructural and/or structural BMPs have been successfully implemented, staff will sample the stormwater discharge outfall (for nonstructural BMPs) or effluent discharge point (for structural BMPs) in order to obtain the eliminated waste load (and percentage) from receiving waters. A cumulative table (e.g. Excel spreadsheet) will track all removed pollutant loading within the Salem Creek (and contributing tributaries) Watershed. Staff will continue to collect fecal coliform samples at a baseline monitoring station, which is positioned within the bottom reach of the watershed. This baseline station will confirm the overall reduction of fecal coliforms concentrations within the watershed. By continued efforts of BMP implementation, the City of Winston-Salem strives to achieve its waste load allocation reduction.

The Stormwater Division envisions that the City's Geographical Information System (GIS) will serve as a central hub of tracking and reporting its WLA successes. This GIS database possesses full integration capabilities with Microsoft Access, Word, and Excel as well as statistical analysis tools, basic modeling functions, and data storage (e.g. fecal coliforms concentrations) ability. The multifunctional nature of GIS will allow for future expansion and adaptability as regulatory demands dictate program direction as well as achievable waste load reduction.