Adopted January 16, 2019

One Total Maximum Daily Load for Indicator Bacteria in Sycamore Creek

Segment 0806E

Assessment Unit 0806E_01

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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"Technical Support Document for Total Maximum Daily Load for Indicator Bacteria for Sycamore Creek"
prepared by the Texas Institute for Applied Environmental Research

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Abbreviations

AU	assessment unit
BMP	best management practice
cfs	cubic feet per second
CFR	Code of Federal Regulations
DAR	drainage-area ratio
DFW	Dallas/Fort Worth
DSLP	days since last precipitation
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
FDC	flow duration curve
FG	future growth
I/I	inflow and infiltration
I-Plan	implementation plan
LA	load allocation
LDC	load duration curve
mL	milliliter
MGD	million gallons per day
MCM	minimum control measure
MOS	margin of safety
MPN	most probable number
MS4	municipal separate storm sewer system
NCTCOG	North Central Texas Council of Governments
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSSF	on-site sewage facility
s/d	seconds per day
SSO	sanitary sewer overflow
SSURGO	soil survey geographic database
SWMP	stormwater management program

SWQM	surface water quality monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	wasteload allocation
WQBEL	water quality-based effluent limits
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

One TMDL for Indicator Bacteria in Sycamore Creek

Executive Summary

This document describes a total maximum daily load (TMDL) for Sycamore Creek where concentrations of indicator bacteria exceed the criteria used to evaluate attainment of the contact recreation use. The Texas Commission on Environmental Quality (TCEQ) first identified the bacteria impairment to Sycamore Creek in 2006 and then in each subsequent edition of the *Texas Integrated Report of Surface Water Quality for Clean Water Sections 305(b) and 303(d)* (Texas Integrated Report) through 2014. This document will consider the bacteria impairment in one water body segment, consisting of one assessment unit (AU), Sycamore Creek (AU 0806E_01).

The Sycamore Creek watershed is 37 square miles in area and is located entirely within Tarrant County. The creek is perennial and flows in a roughly south to north direction from a residential area northwest of the City of Burleson to its confluence with the classified Segment 0806 West Fork Trinity River.

There are no domestic wastewater treatment facilities (WWTFs) located within the Sycamore Creek watershed. Domestic wastewater is collected by and transported to the City of Fort Worth Village Creek WWTF located outside of the Sycamore Creek watershed.

Four municipal separate storm sewer system (MS4) permits are held in the Sycamore Creek watershed, of which two are Phase I individual permits and two are Phase II general permits. The area included within these permits was used to estimate the area under stormwater regulation for construction, industrial, and MS4 permits. The Phase I and Phase II permits provide 100 percent coverage of the TMDL watershed. Based on the Sycamore Creek AU stream length and width, a small unregulated stormwater component was included for the water body.

The discharges authorized by the stormwater general permits are considered intermittent and variable (subject to precipitation and runoff), and no flow limit is specified in the permits. Given the circumstances of the permits, these outfalls will be treated as part of the regulated stormwater discharge in the wasteload allocations (WLAs).

Escherichia coli (*E. coli*) are widely used as indicator bacteria to assess attainment of the contact recreation use in freshwater bodies. The criteria for assessing attainment of the contact recreation use are expressed as the number (or "counts") of *E. coli* bacteria, typically given as the most probable number (MPN). The primary contact recreation use is not supported when the geometric mean of all *E. coli* samples exceeds 126 MPN per 100 milliliters (mL).

E. coli data, collected at one monitoring station over the seven-year period of December 1, 2005, through November 30, 2012, were used in assessing attainment of the primary contact recreation use as reported in the 2014 Texas Integrated Report (TCEQ, 2015). The 2014 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criterion at a measure of 213 MPN/100 mL.

A load duration curve (LDC) analysis was used to quantify allowable pollutant loads and specific TMDL allocations for point and nonpoint sources of indicator bacteria.

No wasteload allocation for WWTFs was established, because no permitted dischargers exist in the TMDL watershed. Due to the 100 percent coverage of wastewater collection by the City of Fort Worth WWTF that discharges outside of the TMDL watershed and the absence of any other discharges, no future growth component was required for the TMDL watershed. The TMDL calculations in this report will guide determination of the assimilative capacity of the water body under changing conditions.

Compliance with this TMDL is based on keeping the indicator bacteria concentrations in Sycamore Creek below the geometric mean criterion of 126 MPN/100 mL.

Introduction

Section 303(d) of the federal Clean Water Act requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. States must develop a TMDL for each pollutant that contributes to the impairment of a listed water body. The TCEQ is responsible for ensuring that TMDLs are developed for impaired surface waters in Texas.

A TMDL is like a budget—it determines the amount of a particular pollutant that a water body can receive and still meet its applicable water quality standards. TMDLs are the best possible estimates of the assimilative capacity of the water body for a pollutant under consideration. A TMDL is commonly expressed as a load with units of mass per period of time, but may be expressed in other ways.

The TMDL Program is a major component of Texas' overall process for managing the quality of its surface waters. The program addresses impaired or threatened streams, reservoirs, lakes, bays, and estuaries (water bodies) in, or bordering on, the state of Texas. The primary objective of the TMDL Program is to restore and maintain the beneficial uses—such as drinking water supply, recreation, support of aquatic life, or fishing—of impaired or threatened water bodies.

This TMDL addresses impairments of the primary contact recreation use due to exceedances in indicator bacteria in Sycamore Creek (Segment 0806E). This TMDL takes a watershed approach to address the indicator bacteria impairment. While TMDL allocations were developed only for the impaired AU identified in this report, the entire project watershed (Figure 1) and all regulated discharges within it are included within the scope of this TMDL.

Section 303(d) of the Clean Water Act and the implementing regulations of the U.S. Environmental Protection Agency (EPA) in Title 40 of the Code of Federal Regulations (CFR), Part 130 (40 CFR 130) describe the statutory and regulatory requirements for acceptable TMDLs. The EPA provides further direction in its *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA, 1991). This TMDL document has been prepared in accordance with those regulations and guidelines.

The TCEQ must consider certain elements in developing a TMDL. They are described in the following sections of this report:

- Problem Definition
- Endpoint Identification
- Source Analysis
- Linkage Analysis
- Margin of Safety
- Pollutant Load Allocation
- Seasonal Variation
- Public Participation
- Implementation and Reasonable Assurance

Upon adoption of the TMDL report by the TCEQ and subsequent EPA approval, this TMDL will become an update to the state's Water Quality Management Plan (WQMP).

Figure 1. Overview map showing the Sycamore Creek Segment/AU, watershed, and TCEQ water quality monitoring station.

Problem Definition

The TCEQ first identified the impairment within Sycamore Creek (Segment 0806E) in 2006, and then in each subsequent edition of the *Texas Integrated Report of Surface Water Quality for Clean Water Sections 305(b) and 303(d)* (Texas Integrated Report) through 2014 (TCEQ, 2015).

This document will consider the bacteria impairment in one segment, consisting of a single AU:

- Sycamore Creek (AU 0806E_01).

Because the impaired segment is comprised of only one AU that encompasses the entire segment, the terms AU and segment may be used interchangeably throughout this report.

Ambient Indicator Bacteria Concentration

Environmental bacteria monitoring in AU 0806E_01 has occurred at one TCEQ monitoring station within the watershed (Table 1 and Figure 1). *E. coli* data, collected at this station over the seven-year period from December 1, 2005, through November 30, 2012, were used in assessing attainment of the primary contact recreation use as reported in the 2014 Texas Integrated Report (TCEQ, 2015). The 2014 assessment data indicate non-support of the primary contact recreation use because geometric mean concentrations exceed the geometric mean criterion of 126 MPN/100 mL for *E. coli*.

Table 1. 2014 Texas Integrated Report summary for the impaired AU.

Data date range: 12/2005 - 11/2012

Water Body	Segment Number	AU	Parameter	Station	Number of Samples	Geometric Mean (MPN/100 mL)
Sycamore Creek	0806E	0806E_01	*E. coli*	17369	48	213

Watershed Overview

Sycamore Creek (0806E_01) is an unclassified, perennial freshwater stream that flows in a roughly south-to-north direction from a residential area northwest of the City of Burleson to its confluence with the classified Segment 0806 West Fork Trinity River east of the IH30 – IH35W interchange (Figure 1). The Sycamore Creek watershed has a drainage area of 37.0 square miles (23,688 acres) entirely located within Tarrant County.

The 2014 Texas Integrated Report (TCEQ, 2015) provides the following segment and AU description for Sycamore Creek:

- Segment 0806E: Sycamore Creek
  - Segment Type: Freshwater Stream
  - AU 0806E_01: A 5 mile stretch of Sycamore Creek running upstream from the confluence with the West Fork of Trinity River to the confluence with Echo Lake Tributary in Fort Worth

This study incorporates a watershed approach where the entire drainage area of Segment 0806E is considered.

Watershed Climate

The Sycamore Creek watershed is located in the Dallas–Fort Worth (DFW) Metroplex, which is classified as humid subtropical climate (NOAA, 2009). Typically, the DFW area has mild winters with the first frost occurring in late November and the last frost in mid-March; however, brief periods of extreme cold can occur. Hot summers with high temperatures exceeding 100º F are common for the DFW area, accompanied by fair skies and westerly winds. Annual precipitation predominately occurs in the form of thunderstorms that are typically brief in nature and are recurrent in the spring.

Weather data obtained from the National Climatic Data Center for the Fort Worth Meacham International Airport spanning a period from 2001 through 2016 indicate the average high temperatures typically peak in August (97.1 ˚F) with highs above 100 ˚F occurring June through August (Figure 2; NOAA, 2017). Average nightly lows range from 72.0 ˚F (June) to 76.0 ˚F (August) during these hot summer months. During winter, the average low temperature generally bottoms out at 35.5 ˚F in January. The wettest month is typically May (4.1 inches) while December (2.0 inches) is normally the driest month, with rainfall occurring throughout the year.

Watershed Population and Population Projections

As depicted in Figure 1, the Sycamore Creek watershed is geographically located entirely within Tarrant County, with 98.9 percent of the watershed covered by municipal boundaries (Fort Worth, Edgecliff Village, and Forest Hill) and 1.1 percent designated as "Other County" areas (NCTCOG, 2010). The City of Forest Hill covers only 1.38 acres or 0.006 percent of the Sycamore Creek watershed. According to the 2010 Census data (USCB, 2014), the Sycamore Creek watershed has an estimated population of 151,826 people. Approximately 97.7 percent of the estimated population (148,335 people) is located within the Fort Worth city limits, followed by 1.8 percent in Edgecliff Village with 2,782 people, indicating a largely urban watershed population.

Population projections from 2010 – 2040 were developed by utilizing data from the 2010 U.S. Census and 2040 traffic survey zone population projections developed by the North Central Texas Council of Governments (NCTCOG, 2015). Population projection increases range from 42.9 percent to 246.4 percent. Table 2 provides a summary of the 2010 – 2040 population projections.

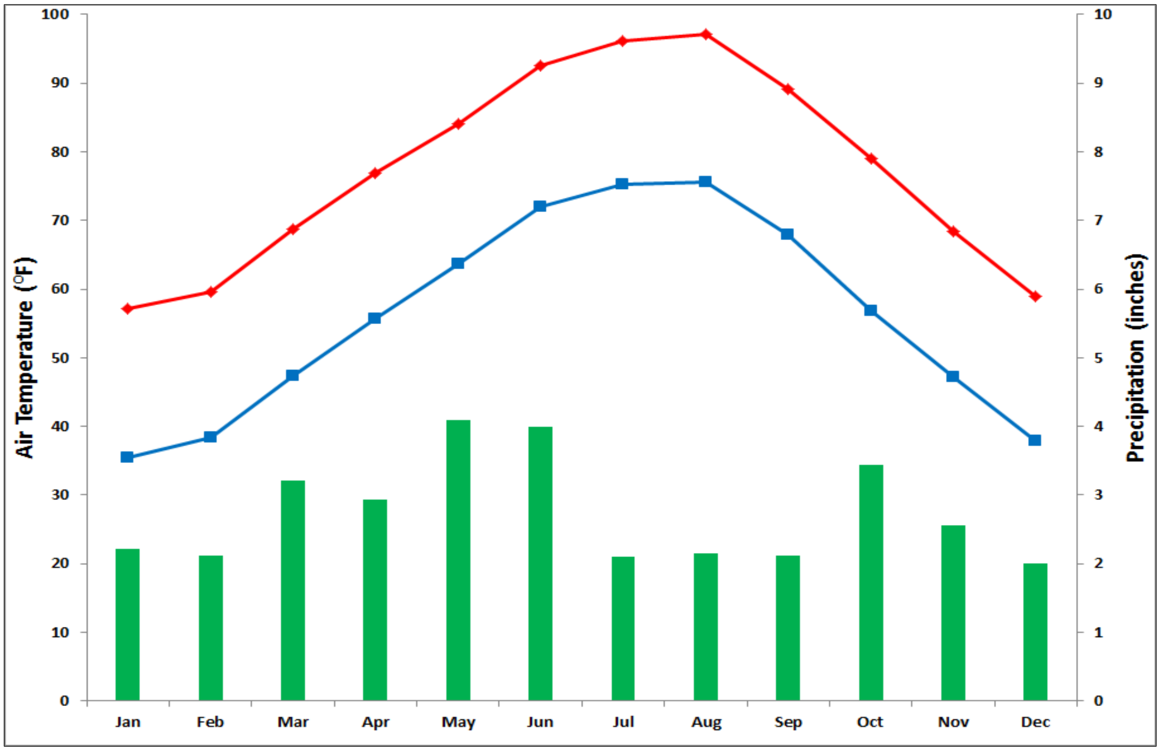

Figure 2. Average minimum (blue square) and maximum (red diamond) air temperature and total precipitation (green bar) from Jan. 2001-Dec. 2016 for Fort Worth Meacham International Airport.

Table 2. 2010 Population and 2010-2040 Population Projections for the Sycamore Creek watershed.

Location[a]	**2010 U. S. Census Population**	**2040 Population Projection**	**Projected Population Increase** (2010 - 2040)	**Percent Change**
Fort Worth	148,335	212,004	63,669	42.9%
Edgecliff Village	2,782	5,114	2,332	83.8%
Tarrant County	709	2,454	1,745	246.1%
Watershed Total	151,826	219,572	67,746	44.6%

[a] The City of Forest Hill, with only 1.38 acres in the Sycamore Creek watershed, which is only 0.006% of the watershed area, was not considered in the watershed population information in this table

Land Use

The land use/land cover data for the Sycamore Creek watershed were obtained from NCTCOG and represent land use/land cover estimates for 2010 (NCTCOG, 2013). The land use/land cover is represented by the following categories and definitions:

- **Acreage/Improved** – Acreage/Improved includes land that is mostly undeveloped yet includes a non-residential structure with road access as a minor part of the use.
- **Commercial/Industrial** – Commercial/Industrial includes land occupied by office, retail, industrial (manufacturing, warehouses, salvage yards, quarries, and mines), utilities (sewage/water treatment plants, power infrastructure), stadiums, communication (radio, television, cable, and phone infrastructure), construction sites, and parking.
- **Flood Control** – Flood control structures including levees, flood channels, and dams.
- **Group Quarters** – Group Quarters includes land occupied by nursing homes, dormitories, jails, military personnel quarters, and hotels/motels.
- **Residential** – Residential includes land occupied by single family, multi-family, and mobile home residences.
- **Institution** – Institution includes land occupied by churches, schools, museums, hospitals, medical clinics, libraries, government facilities, and military bases.
- **Transit** – Transit includes land occupied by roads, rail lines, rail stations, bus lines and bus facilities.
- **Airport** – Airport includes land occupied by airport terminals and runways.
- **Dedicated** – Dedicated includes land occupied by public and private parks, golf courses, tennis courts, pools, campgrounds, amusement parks, and cemeteries.
- **Vacant** – Vacant includes land that is undeveloped with the potential to be developed or reserved for recreational use.
- **Ranch/Farmland** – Ranch/Farmland includes land occupied by livestock or crops.
- **Water** – Water includes land covered by lakes, rivers, and ponds.

The 2010 land use/land cover data from the NCTCOG is provided for the entire Sycamore Creek watershed in Figure 3. A summary of the land use/land cover data for Sycamore Creek watershed is provided in Table 3. Residential and Transit are the dominant land uses within the Sycamore Creek watershed.

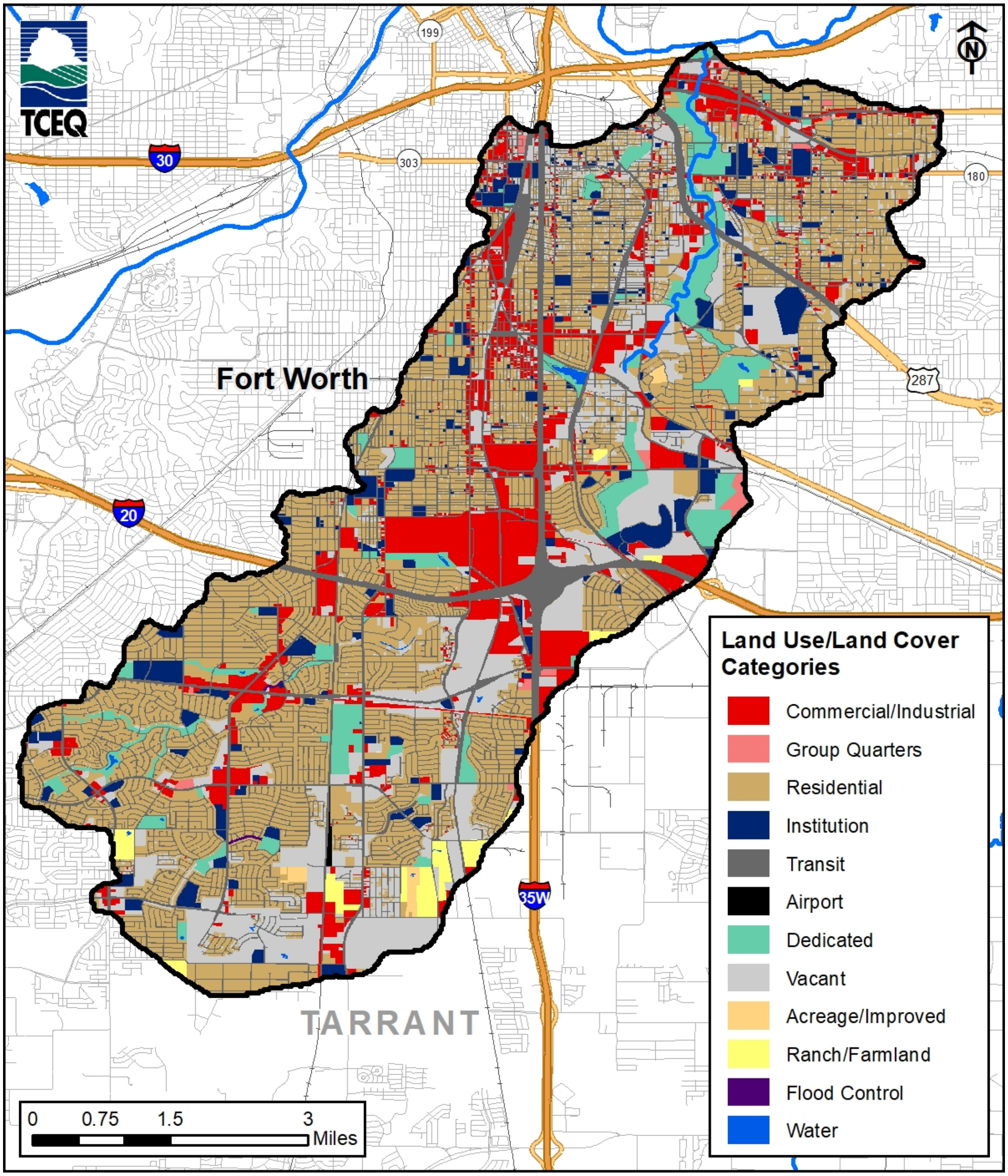

Figure 3. 2010 land use/land cover within the Sycamore Creek watershed.

Table 3. Land use/land cover within the Sycamore Creek watershed.

Source: NCTCOG (2013)

Classification	Area (Acres)	Percent of Total
Residential	8,618	36.4%
Transit	5,311	22.4%
Vacant	3,987	16.8%
Commercial/Industrial	2,699	11.4%
Dedicated	1,321	5.6%
Institution	1,217	5.1%
Ranch/Farmland	291	1.2%
Group Quarters	110	0.5%
Acreage/Improved	69	0.3%
Water	39	0.2%
Airport	16	0.1%
Flood Control	10	0.0%
Total	23,668	100.00%

Soils

Soils within the Sycamore Creek watershed, categorized by their hydrologic soil group, are shown in Figure 4. These data were obtained through the USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (NRCS, 2015).

Within the Sycamore Creek watershed, the majority of the soils are classified in Hydrologic Soil Group D, and therefore, have the following characteristics: a high runoff potential when thoroughly wet, restricted water movement though the soil, and a high shrink-swell potential (NRCS, 2007). While not as common as Soil Group D, soils classified within Hydrologic Soil Group C occur within the watershed, and these soils have a moderately high runoff potential when thoroughly wet. There exists a small amount of area within Hydrologic Soil Group B, which have only a moderately low potential for runoff when thoroughly wet.

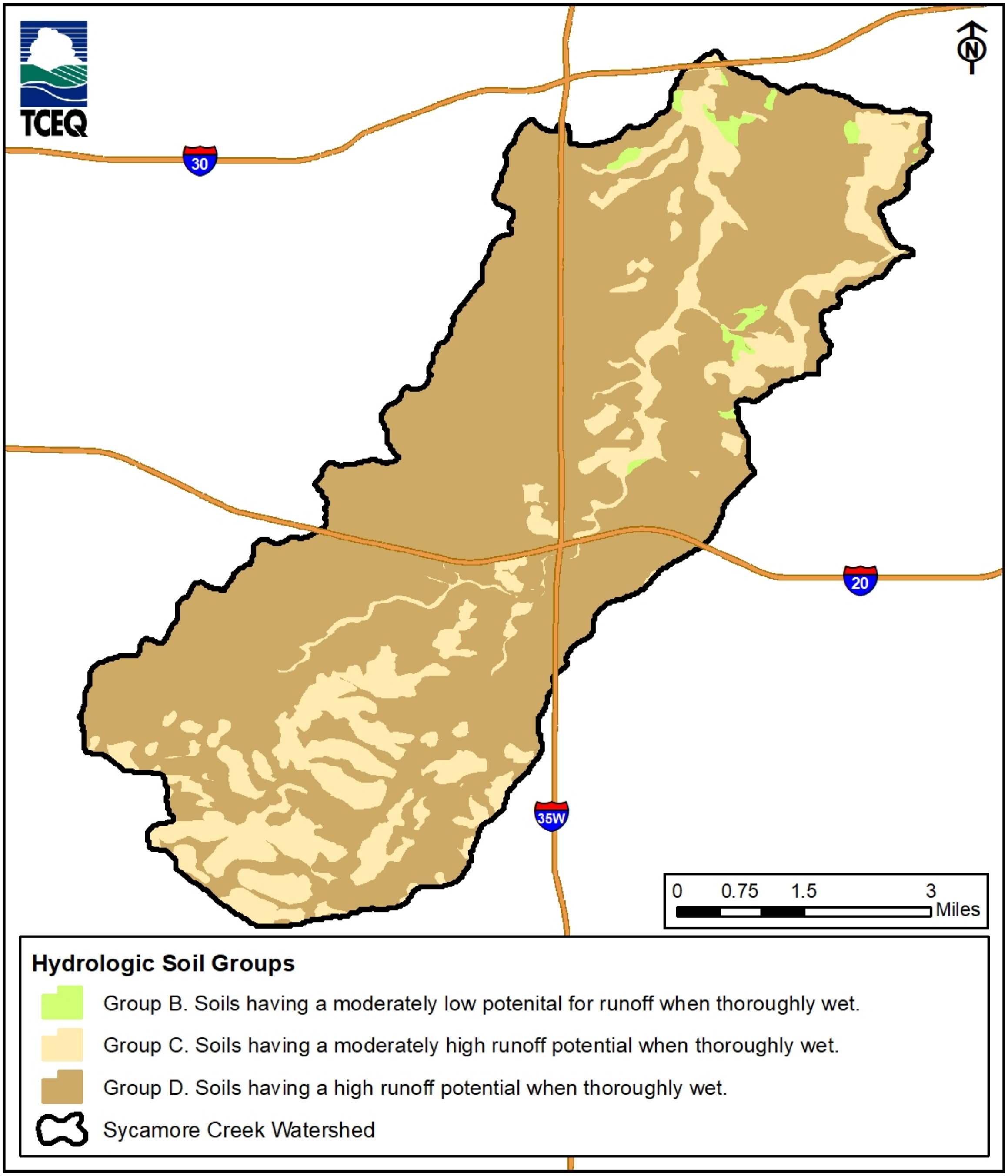

Figure 4. Hydrologic soil groups within the Sycamore Creek watershed.

Endpoint Identification

All TMDLs must identify a quantifiable water quality target that indicates the desired water quality condition and provides a measurable goal for the TMDL. The TMDL endpoint also serves to focus the technical work to be accomplished and as a criterion against which to evaluate future conditions.

The endpoint for the TMDL in this report is to maintain concentrations of *E. coli* below the geometric mean criterion of 126 MPN/100 mL, which is the criterion in the 2010 Texas Surface Water Quality Standards (TCEQ, 2010) for primary contact recreation in freshwater streams.

Source Analysis

Pollutants may come from several sources, both regulated and unregulated. Regulated pollutants, referred to as “point sources,” come from a single definable point, such as a pipe, and are regulated by permit under the Texas Pollutant Discharge Elimination System (TPDES) or the National Pollutant Discharge Elimination System (NPDES). WWTFs and stormwater discharges from industries, construction, and the separate storm sewer systems of cities are considered point sources of pollution.

Unregulated sources are typically nonpoint source in origin, meaning the pollutants originate from multiple locations and rainfall runoff washes them into surface waters. Nonpoint sources are not regulated by permit.

The regulated and unregulated sources in this section are presented to give a general account of the different sources of bacteria expected in the watershed. These are not meant to be used for allocating bacteria loads or interpreted as precise inventories and loadings.

Regulated Sources

Regulated sources are controlled by permit under the TPDES and the NPDES programs. The regulated sources in the TMDL watershed include stormwater discharges from industries, construction, and MS4s.

Domestic and Industrial Wastewater Treatment Facilities

No permitted WWTFs exist in the Sycamore Creek watershed. Domestic wastewater is collected by and transported to the City of Fort Worth Village Creek WWTF located outside the study area (Figure 5).

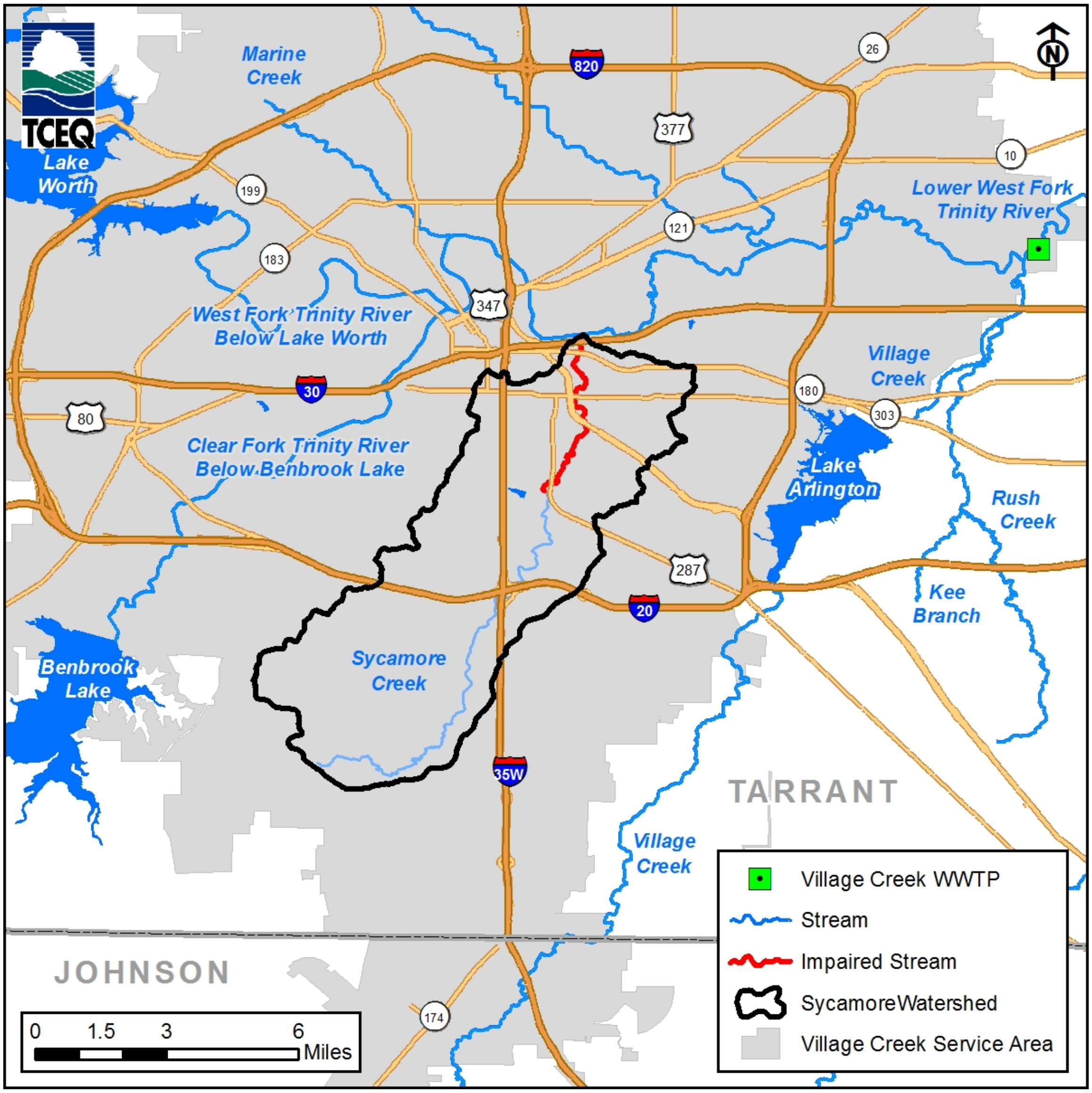

Figure 5. Service area of the Fort Worth Village Creek WWTF within the Sycamore Creek watershed.

TPDES General Wastewater Permits

Discharges of processed wastewater from certain types of facilities are required to be covered by one of several TPDES general permits:

- TXG110000 – concrete production facilities
- TXG130000 – aquaculture production facilities
- TXG340000 – petroleum bulk stations and terminals
- TXG500000 – quarries in John Graves Scenic Riverway
- TXG670000 – hydrostatic test water discharges

- TXG830000 – water contaminated by petroleum fuel or petroleum substances
- TXG920000 – concentrated animal feeding operations
- WQG100000 – wastewater evaporation
- WQG20000 – livestock manure compost operations (irrigation only)

A review of active general permit coverage (TCEQ, 2017) in the Sycamore Creek watershed, as of August 2017, found five concrete production facilities covered by the general permit. The concrete production facilities do not have bacteria reporting requirements or limits in their permits. The facilities are assumed to contain inconsequential amounts of indicator bacteria in their effluent; therefore, it was unnecessary to allocate bacteria loads to these concrete production facilities. No other active general wastewater permit facilities or operations were found in the Sycamore Creek watershed.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party, either the TPDES permittee or the owner of the collection system that is connected to a permitted system. SSOs in dry weather most often result from blockages in the sewer collection pipes caused by tree roots, grease, and other debris. Inflow and infiltration (I/I) are typical causes of SSOs under conditions of high flow in the WWTF system. Blockages in the line may exacerbate the I/I problem. Other causes, such as a collapsed sewer line, may occur under any condition.

The TCEQ Region 4 Office maintains a database of SSOs reported by municipalities. These SSO data typically contain estimates of the total gallons spilled, the responsible entity, and a general location of the spill. A summary of SSO incidents that occurred from 2009 to 2016 was obtained from the City of Fort Worth (Fort Worth, 2017) for the Sycamore Creek watershed. The SSO data contains the location of each incident and estimates of the total gallons spilled and are presented in Figure 6 and Table 4.

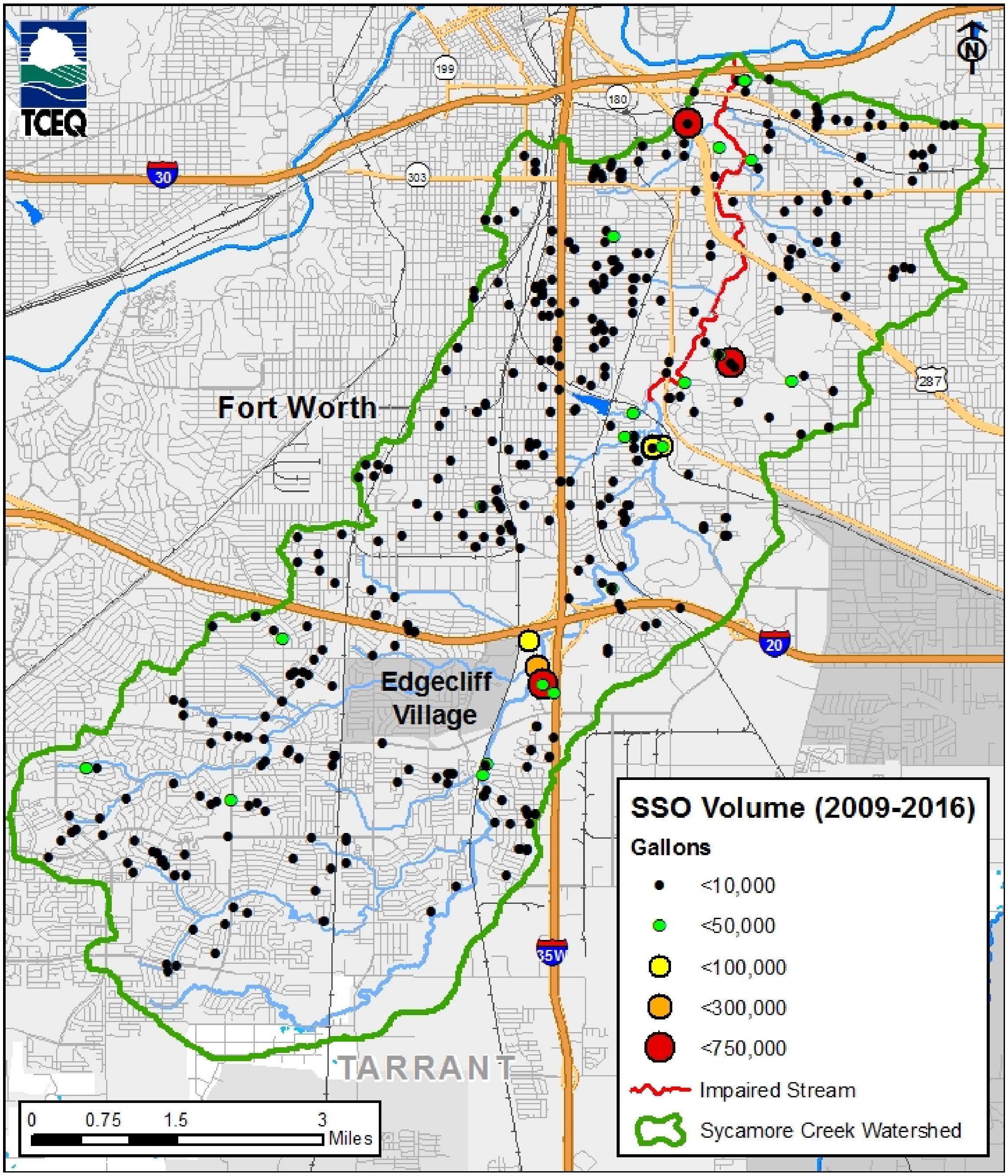

Figure 6. **Sanitary sewer overflows that occurred from January 2009 – December 2016 within the Sycamore Creek watershed.**

Table 4. **Summary of SSO incidences reported in the Sycamore Creek watershed from January 2009 – December 2016.**

Segment	No. of Incidents	Total Volume (gallons)	Average Volume (gallons)	Minimum Volume (gallons)	Maximum Volume (gallons)
0806E	547	3,454,013	6,314	<1	732,000

TPDES-Regulated Stormwater

When evaluating stormwater for a TMDL allocation, a distinction must be made between stormwater originating from an area under a TPDES or NPDES-regulated discharge permit and stormwater originating from areas not under a TPDES or NPDES-regulated discharge permit. Stormwater discharges fall into two categories:

1) Stormwater subject to regulation, which is any stormwater originating from TPDES/NPDES regulated municipal separate storm sewer system (MS4) entities, industrial facilities, and construction activities.
2) Stormwater runoff not subject to regulation.

The TPDES/NPDES MS4 Phase I and II rules require municipalities and certain other entities in urban areas to obtain permit coverage for their stormwater systems. A regulated MS4 is a publicly owned system of conveyances and includes ditches, curbs, gutters, and storm sewers that do not connect to a wastewater collection system or treatment facility. Phase I permits are individual permits for large and medium-sized communities with populations of 100,000 or more based on the 1990 U.S. Census, whereas the Phase II general permit regulates smaller communities within a U.S. Census Bureau defined urbanized area. The purpose of an MS4 permit is to reduce discharges of pollutants in stormwater to the "maximum extent practicable" by developing and implementing a Stormwater Management Program (SWMP). The SWMP describes the stormwater control practices that will be implemented consistent with permit requirements to minimize the discharge of pollutants from the MS4. The permits require that the SWMPs specify the best management practices (BMPs) to meet several minimum control measures (MCMs) that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving waterbodies. Phase II MS4 MCMs include:

- Public education, outreach, and involvement;
- Illicit discharge detection and elimination;
- Construction site stormwater runoff control;
- Post-construction stormwater management in new development and redevelopment;
- Pollution prevention and good housekeeping for municipal operations; and
- Industrial stormwater sources.

Phase I MS4 individual permits have similar MCMs organized a little differently and are further required to perform water quality monitoring.

The geographic region of the Sycamore Creek watershed covered by Phase I and II MS4 permits is that portion of the area within the jurisdictional boundaries of the regulated entity. For Phase I individual permits, the jurisdictional area is defined by the city limits. For Phase II general permit authorizations, the jurisdictional area is defined as the intersection or overlapping areas of the MS4 boundaries and the 2000 or 2010 U.S. Census urbanized areas.

The areas in the Sycamore Creek watershed containing entities with Phase II MS4 general permit authorizations and Phase I MS4 individual permits were used to estimate the regulated stormwater areas for construction, industrial, and MS4 permits (Figure 7).

A review of active stormwater general permit coverage and a review of the Central Registry for Phase I MS4 permit coverage (TCEQ, 2017) in the Sycamore Creek watershed revealed that two Phase I individual permits and two Phase II general permit authorizations exist (Table 5), providing 100 percent MS4 coverage for the Sycamore Creek watershed (Figure 7).

Illicit Discharges

Pollutant loads can enter streams from MS4 outfalls that carry authorized sources as well as illicit discharges under both dry- and wet-weather conditions. The term "illicit discharge" is defined in TPDES General Permit No. TXR040000 for Phase II MS4s as, "[a]ny discharge to a municipal separate storm sewer that is not entirely composed of stormwater, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency firefighting activities." Illicit discharges can be categorized as either direct or indirect contributions. Examples of illicit discharges identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003) include:

Direct Illicit Discharges:

- sanitary wastewater piping that is directly connected from a home to the storm sewer;
- materials that have been dumped illegally into a storm drain catch basin;
- a shop floor drain that is connected to the storm sewer; and
- a cross-connection between the sanitary sewer and storm sewer systems.

Indirect Illicit Discharges:

- an old and damaged sanitary sewer line that is leaking fluids into a cracked storm sewer line; and
- a failing septic system that is leaking into a cracked storm sewer line or causing surface discharge into the storm sewer.

Table 5. TPDES and NPDES MS4 permits in the Sycamore Creek watershed.

Entity	TPDES Permit	NPDES Permit
City of Fort Worth, Tarrant Regional Water District	WQ0004350-000	TXS000901
Texas Department of Transportation	WQ0005011-000	TXS002101
Town of Edgecliff Village	Phase II General Permit	TXR040595
Tarrant County	Phase II General Permit	TXR040052

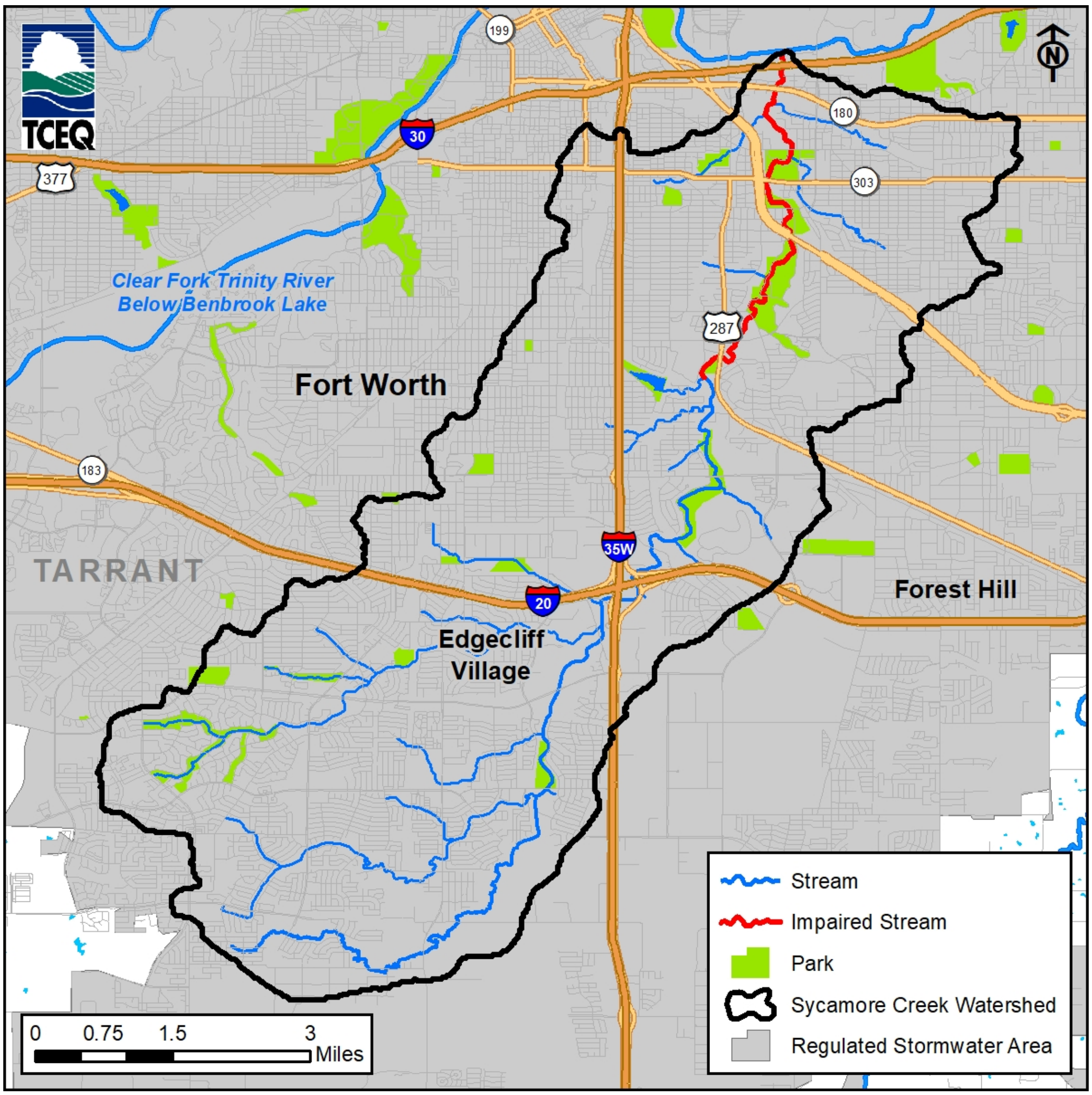

Figure 7. Regulated stormwater area based on Phase I and Phase II MS4 permits within Sycamore Creek watershed.

Unregulated Sources

Unregulated sources of indicator bacteria are generally nonpoint sources. Nonpoint source loading enters the impaired segment through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities, agricultural animals, land application fields, on-site sewage facilities (OSSFs), unmanaged and feral animals, and domestic pets.

Direct contributions from humans is also a potential unregulated source of bacteria to the Sycamore Creek watershed. A homeless population of variable size resides at least seasonally in the northern portion of the Sycamore Creek watershed. As with other unmanaged sources, the *E. coli* contribution from the homeless population cannot be estimated based on existing information.

Unregulated Agricultural Activities and Domesticated Animals

City of Fort Worth Code of Ordinances allows livestock and fowl within the municipal boundary. The number of livestock within the Sycamore Creek watershed was estimated from county level data obtained from the 2012 Census of Agriculture (USDA NASS, 2014). The county level data were refined to better reflect actual numbers within the impaired AU watershed. Using the 2010 land use/land cover data from the NCTCOG, the refinement was performed by determining the total area of suitable livestock land cover categories of “vacant,” “acreage/improved,” and “ranch/farmland” within the Sycamore Creek watershed. A ratio was then computed by dividing the livestock total land use area of the watershed by the total area of Tarrant County. The county level agricultural census data were then multiplied by the ratio to determine the estimated livestock population within the Sycamore Creek watershed. The livestock numbers were reviewed by staff at the Texas State Soil and Water Conservation Board.

Activities such as livestock grazing close to water bodies can contribute fecal indicator bacteria such as *E. coli* to nearby water bodies. Based on proportional area, it is estimated that there may be 116 cattle/calves, 15 sheep/lambs, 12 goats, 33 horses/ponies, 3 mules/burros/donkeys, and 24 poultry. The livestock numbers demonstrate that livestock are a potential source of bacteria in the Sycamore Creek watershed. These numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock.

Pets can also be sources of *E. coli*, because storm runoff carries the animal wastes into streams (EPA, 2013). The number of domestic pets in the Sycamore Creek watershed was estimated based on human population and number of households obtained from the U.S. Census Bureau (USCB, 2014). The information obtained from the U.S. Census Bureau included population and household projections based on the 2010 census for census blocks that encompassed the Sycamore Creek watershed. The block level data were multiplied by the proportion of each census block within the watershed to generate an estimate of the watershed's population and number of households. This estimation assumes that the population/ households are uniformly distributed within the area of each census block, which is the best estimate that can be made with the available data.

Table 6 summarizes the estimated number of dogs and cats in the Sycamore Creek watershed. Pet population estimates were calculated as the estimated number of dogs (0.584) and cats (0.638) per household according to data from the American Veterinary Medical Association 2012 U.S Pet Statistics (AVMA, 2015). The actual contribution and significance of fecal coliform loads from pets reaching the water bodies of the Sycamore Creek watershed is unknown.

Table 6. Estimated households and pet populations for the Sycamore Creek watershed.

Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
55,587	32,463	35,464

Wildlife and Unmanaged Animals

E. coli bacteria are common inhabitants of the intestines of all warm-blooded animals, including feral hogs and wildlife, such as, mammals and birds. In developing bacteria TMDLs, it is important to identify by watershed the potential for bacteria contributions from wildlife and feral hogs. Wildlife and feral hogs are naturally attracted to riparian corridors of streams and rivers. With direct access to the stream channel, the direct deposition of wildlife and feral hog waste can be a concentrated source of bacteria loading to a water body. Fecal bacteria from wildlife and feral hogs are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff. The *E.coli* contribution from feral hogs and wildlife in the Sycamore Creek cannot be determined based on existing information.

Onsite Sewage Facilities

Failing OSSFs were considered a potential source of bacteria loading in the Sycamore Creek watershed. Although the entire Sycamore Creek watershed is within the service area of a centralized wastewater collection and treatment system, the southern portion of the watershed contains 222 OSSFs. (Figure 8; NCTCOG, 2012). Information on the type of treatment system indicated that most were aerobic systems with surface irrigation.

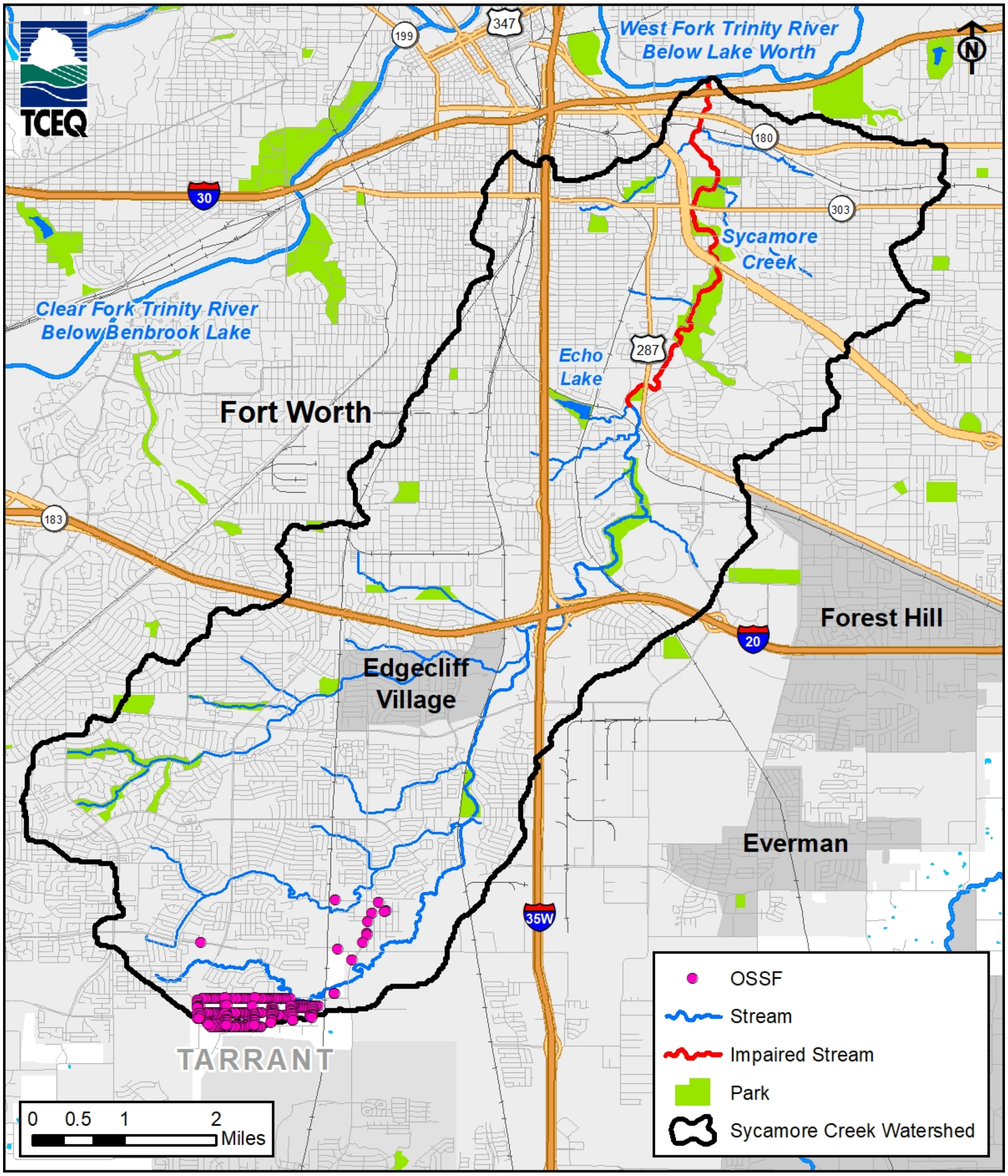

Figure 8. OSSFs located within the Sycamore Creek watershed.

Bacteria Survival and Die-off

Bacteria are living organisms that survive and die. Certain enteric bacteria can survive and replicate in organic materials if appropriate conditions prevail (e.g., warm temperature). Fecal organisms can survive and replicate from improperly-treated effluent during their transport in pipe networks and in organic rich materials such as compost and sludge. While the die-off of indicator bacteria has been demonstrated in natural water systems due to the presence of sunlight and predators, the potential for their replication is less understood. Both processes (replication and die-off) are instream processes and are not considered in the bacteria source loading estimates for the TMDL watershed.

Linkage Analysis

Establishing the relationship between instream water quality and the source of loadings is an important component in developing a TMDL. It allows for the evaluation of management options that will achieve the desired endpoint. This relationship may be established through a variety of techniques.

Generally, if high bacteria concentrations are measured in a water body at low to median flow in the absence of runoff events, the main contributing sources are likely to be point sources and direct fecal material deposition into the water body. During ambient flows, these inputs to the system will increase pollutant concentrations, depending on the magnitude and concentration of the sources. As flows increase in magnitude, the impact of point sources and direct deposition is typically diluted, and would therefore be a smaller part of the overall concentrations.

Bacteria load contributions from regulated and unregulated stormwater sources are greatest during runoff events. Rainfall runoff has the capacity to carry indicator bacteria from the land surface into the receiving stream. Generally, this loading follows a pattern of lower concentrations in the water body just before the rain event, followed by a rapid increase in bacteria concentrations in the water body as the first flush of storm runoff enters the receiving stream. Over time, the concentrations decline because the sources of indicator bacteria are reduced as runoff washes them from the land surface and the volume of runoff decreases following the rain event.

Load Duration Curve Analysis

LDC analyses were used to examine the relationship between instream water quality and the broad sources of indicator bacteria loads, and are the basis of the TMDL allocations. The strength of this TMDL is the use of the LDC method to determine the TMDL allocations. LDCs are a simple statistical method that provides a basic description of the water quality problem. This tool is easily developed and explained to stakeholders, and uses available water quality and flow data. The LDC method does not require any assumptions regarding loading rates, stream hydrology, land use conditions, and other conditions in the watershed.

The weaknesses of this method include the limited information it provides regarding the magnitude or specific origin of the various sources. Only limited information is gathered regarding point and nonpoint sources in the watershed. The general difficulty in analyzing and characterizing *E. coli* in the environment is also a weakness of this method.

The LDC method allows for estimation of existing and TMDL loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). In addition to estimating stream loads, this method allows for the determination of the hydrologic conditions under which impairments are typically occurring, can give indications of the broad origins of the bacteria (i.e., point source and stormwater), and provides a means to allocate allowable loadings.

Data requirements for the LDC are minimal, consisting of continuous daily streamflow records and historical bacteria data. A 16-year record of daily streamflow from January 1, 2001, through December 31, 2016, was selected to develop the flow duration curve (FDC), and this period includes the collection dates of all available *E. coli* data at the time this work effort was undertaken. A 16-year period is of sufficient duration to contain a reasonable variation from dry months and years to wet months and years, and at the same time is short enough in duration to contain a hydrology that is responding to recent and current conditions in the watershed. Surface Water Quality Monitoring (SWQM) station 17369, which is located near the downstream outlet of Sycamore Creek (Figure 1), is the only location within Segment 0806E where *E. coli* have been collected under a TCEQ quality assurance project plan and analyses performed by a laboratory accredited under the National Environmental Laboratory Accreditation Conference Institute. The 97 *E. coli* sampling results for station 17369 were determined to be adequate to develop pollutant load allocations and far exceed the minimum of 24 samples suggested in Jones et al. (2009). Bacteria data were obtained from Surface Water Quality Monitoring Information System (SWQMIS) for the period of January 2001 to April 2016.

Hydrologic data in the form of daily streamflow records were unavailable for the Sycamore Creek watershed; however, streamflow records were available for the Marys Creek and Village Creek watersheds. Streamflow records for Marys Creek and Village Creek are collected and made readily available by the U.S. Geological Survey (USGS) (USGS, 2017), which operates both streamflow gauges. USGS streamflow gauge 08047050 is located along the mainstem of Marys Creek and gauge 08048970 is located along the mainstem of Village Creek. The Village Creek watershed is in somewhat closer proximity and more comparable in land cover characteristics to the Sycamore Creek watershed than is the Marys Creek watershed. Both the Village Creek and Marys Creek watersheds are, however, more rural in their land use and land cover than the Sycamore Creek watershed. The flow record for Village Creek indicated more numerous instances of no flow conditions than is anticipated for Sycamore Creek based on observations by field staff and flow measurements obtained during routine monitoring. While not as close in proximity as the Village Creek gauge, the Marys Creek gauge had much fewer recordings of no flow conditions. A determination was made to use streamflow records from both Village Creek and Marys Creek as the primary source for streamflow records used in this document.

The method to develop the necessary streamflow record for the FDC/LDC location (SWQM station location) involved a drainage-area ratio (DAR) approach. The DAR approach involves multiplying a USGS gauging station daily streamflow value by a factor to estimate the flow at a desired SWQM station location. The factor is determined by dividing the drainage area above the desired monitoring station location by the drainage area above the USGS gauge. Since two USGS gauging stations were selected to derive the flow for the sampling station, a DAR was applied to the flow record for each gauge. The daily streamflow value with the appropriate factor applied for each gauge was then added together and the mean of the combined daily streamflow was used to represent the daily streamflow at the SWQM monitoring station. Additional information on the application of DAR method using multiple streamflow records may be found in Asquith et al. (2006).

Each FDC was generated by:

1) ordering the daily streamflow data from highest to lowest values and assigning a rank to each data point (one for the highest flow, two for the second highest flow, and so on);
2) computing the percent of days each flow was exceeded by dividing each rank by the total number of data points plus one; and
3) plotting the corresponding flow data against exceedance percentages.

Exceedance values along the x-axis represent the percent of days that flow was at or above the associated flow value on the y-axis. Exceedance values near 100 percent occur during low flow or drought conditions while values approaching 0 percent occur during periods of high flow or flood conditions.

The bacteria LDC was developed by multiplying each streamflow value along the FDC by the *E. coli* criterion (126 MPN/100 mL) and by the conversion factor to convert to loading in colonies per day. This effectively displays the LDC as the TMDL curve of maximum allowable loading:

TMDL (MPN/day) = Criterion * flow, cubic feet per second (cfs) * conversion factor

Where:

Criterion = 126 MPN/100 mL (*E. coli*)

Conversion factor (to MPN/day) = 24,465,756 mL/ft^3 * 86,400 seconds/day (s/d)

The resulting curve plots each bacteria load value (y-axis) against its exceedance value (x-axis). Exceedance values along the x-axis represent the percent of days that the bacteria load was at or above the allowable load on the y-axis.

For the LDC at TCEQ station 17369, historical bacteria data obtained from the TCEQ SWQMIS database were superimposed on the allowable bacteria LDC. Each historical *E. coli* measurement was associated with the streamflow on the day of measurement and converted to a bacteria load. The associated streamflow for each bacteria loading was compared to the FDC data to determine its value for "percent days flow exceeded," which becomes the "percent of days load exceeded" value for purposes of plotting the *E. coli* loading. Each load was then plotted on the LDC at its percent exceedance. This process was repeated for each *E. coli* measurement at each station. Points above the LDC represent exceedances of the bacteria criterion and its associated allowable loadings.

As a further refinement, the historical *E. coli* points on the LDC were symbolized according to whether the sampling event was considered to be a wet or non-wet weather event based on antecedent rainfall. A sample was determined to be influenced by a wet weather event based on the “days since last precipitation” (DLSP) as noted on field data sheets associated with each sampling event. DSLP (TCEQ water quality parameter code 72053) is a field parameter that may be noted during a sampling event to inform data users of the general climatic conditions. A wet weather event was defined as a sample collected with DSLP of two days or less.

The flow exceedance frequency can be subdivided into hydrologic condition classes to facilitate the diagnostic and analytical uses of the FDC and LDC. The hydrologic classification scheme utilized for the TMDL watershed is as follows: highest flow regime (0 – 10 percent), mid-range flow regime (10 – 80 percent), and lowest flow regime (80 – 100 percent). The selection of the flow regime intervals was based on general observations of the LDC. Both the 10 and 80 percentile divisions are convenient, as data collected during wet weather occurs more frequently below the 10^{th} percentile, and non-wet weather data occurs more frequently above the 80^{th} percentile. Additional information explaining the LDC method may be found in Cleland (2003) and NDEP (2003).

The median loading of the high flow regime (0-10 percent exceedance) is used for the TMDL calculations. The median loading of the high flow regime (5 percent exceedance) is used for the TMDL calculations, because it represents a reasonable yet high value for the allowable pollutant load allocation.

More details on the methods used to develop the LDC may be found in the *Technical Support Document for Total Maximum Daily Load for Indicator Bacteria for Sycamore Creek* (Millican and Hauck, 2017).

Load Duration Curve Results

For developing the TMDL allocation, an LDC was constructed using data obtained from station 17369. Geometric mean loadings for the data points within each flow regime have also been distinguished on Figure 9 to aid interpretation. The LDC provides a means of identifying the streamflow conditions under which exceedances in *E. coli* concentrations have occurred. The LDC depicts the allowable loadings at the station under the geometric mean criterion (126 MPN/100 mL) and shows that existing loadings often exceed the criterion. In addition, the LDC also presents the allowable loading at the station under the single sample criterion (399 MPN/100 mL).

Based on the LDC used in the pollutant load allocation process with historical *E. coli* data added to the graphs (Figure 9), the following broad linkage statements can be made. For the Sycamore Creek watershed, the historical *E. coli* data indicate that elevated bacteria loadings occur especially under the highest flow and mid-range flow regimes. There is generally some moderation of the elevated loadings under the lowest flow regime. Regulated stormwater area comprises a great majority of the Sycamore Creek watershed and must be considered a major contributor. Most likely, unregulated stormwater comprises the minority of high-flow related loadings. In some situations, elevated *E. coli* loadings under the lower flow conditions can be attributed to point sources such as WWTFs; however, this rational is nullified due to the absence of permitted dischargers within the Sycamore Creek watershed. Therefore, other sources of bacteria loadings under lower flows and in the absence of permitted discharger contributions (i.e., without WWTF contribution) are occurring, though the sources cannot be determined through this analysis.

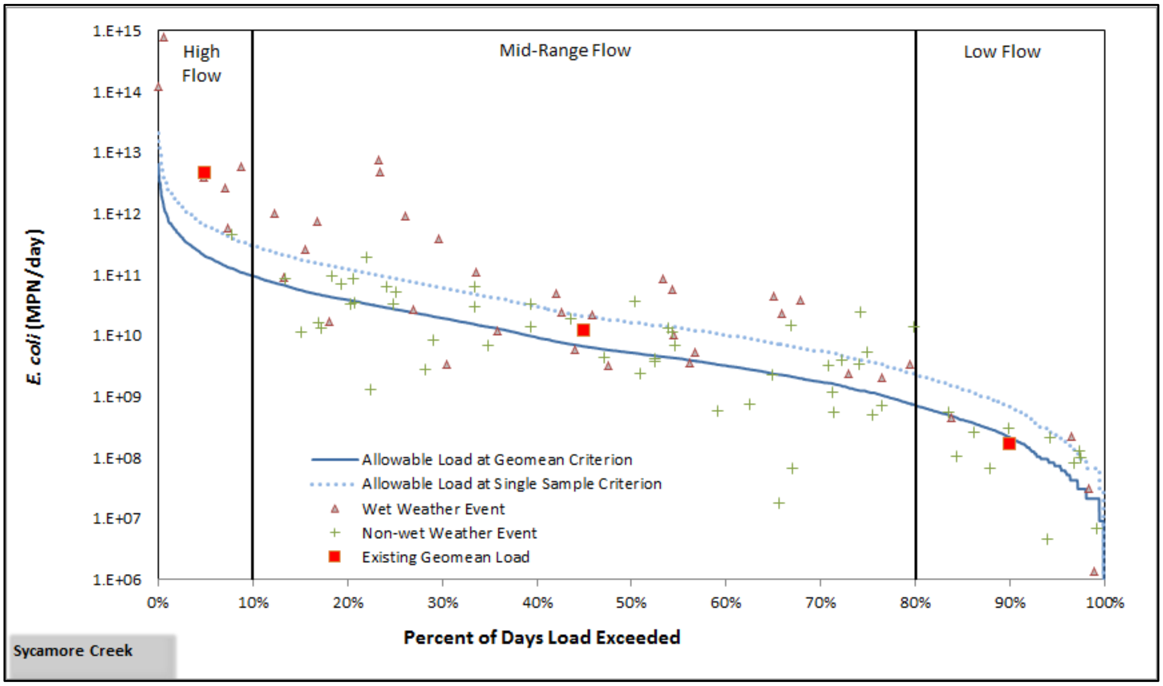

Figure 9. Load duration curve for Sycamore Creek (Station 17369).

Margin of Safety

The margin of safety (MOS) is used to account for uncertainty in the analysis used to develop the TMDL and thus provide a higher level of assurance that the goal of the TMDL will be met. According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using two methods:

1) Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
2) Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning an MOS.

The TMDL covered by this report incorporates an explicit MOS by setting a target for indicator bacteria loads that is 5 percent lower than the geometric mean criterion. For primary contact recreation, this equates to a geometric mean target for *E. coli* of 119.7 MPN/100 mL. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced.

Pollutant Load Allocation

The TMDL represents the maximum amount of a pollutant that the stream can receive in a single day without exceeding water quality standards. The pollutant load allocations for the selected scenarios were calculated using the following equation:

TMDL = WLA + LA + FG + MOS

Where:

WLA = wasteload allocation, the amount of pollutant allowed by regulated dischargers

LA = load allocation, the amount of pollutant allowed by unregulated sources

FG = loadings associated with future growth from potential regulated facilities

MOS = margin of safety load

As stated in 40 CFR 130.2(1), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures.

The TMDL components for the Sycamore Creek watershed covered in this report are derived using the median flow within the high flow regime (or 5 percent flow) of the LDC developed for SWQM station 17369. The following sections will present an explanation of the TMDL component, followed by the results of the calculation for that component.

AU-Level TMDL Computations

The bacteria TMDL for the Sycamore Creek segment was developed as a pollutant load allocation based on information from the LDC for SWQM station 17369 (Figure 9). Effectively, the “allowable load” displayed in the LDC at 5 percent exceedance (the median value of the highest-flow regime) is the TMDL:

TMDL (MPN/day) = Criterion * Flow (cfs) * Conversion factor

Where:

Criterion = 126 MPN/100 mL (*E. coli*)

Conversion factor (to MPN/day) = 283.1685 100 mL/ft^3 * 86,400 s/d

At 5 percent load duration exceedance, the TMDL values are provided in Table 7.

Table 7. Summary of allowable loading calculations for Sycamore Creek AU 0806E_01.

5% Exceedance Flow (cfs)	5% Exceedance Load (MPN/day)	Indicator Bacteria	TMDL (Billion MPN/day)
65.048	2.00523E+11	*E. coli*	200.523

Margin of Safety

The MOS is only applied to the allowable loading for a watershed. Therefore, the MOS is expressed mathematically as the following:

MOS = 0.05 * TMDL

Where:

MOS = margin of safety load
TMDL = total maximum daily load

Since the MOS is based solely on the TMDL term, the calculation is straightforward (Table 8).

Table 8. Margin of safety calculations for the Sycamore Creek watershed.

Indicator Bacteria	TMDL (Billion MPN/ day)	MOS (Billion MPN/ day)
E. coli	200.523	10.026

Wasteload Allocation

The WLA consists of two parts—the wasteload that is allocated to TPDES-regulated WWTFs (WLA_{WWTF}) and the wasteload that is allocated to regulated stormwater dischargers (WLA_{SW}).

$$WLA = WLA_{WWTF} + WLA_{SW}$$

WWTFs

TPDES-permitted WWTFs are allocated a daily wasteload (WLA_{WWTF}) calculated as their full permitted discharge flow rate multiplied by one half the instream geometric criterion. One-half of the water quality criterion (63 MPN/100mL) is used as the WWTF target to provide instream and downstream load capacity. Thus, WLA_{WWTF} is expressed in the following equation:

$$WLA_{WWTF} = Target * Flow * Conversion\ Factor$$

Where:

Target = 63 MPN/100 mL

Flow = full permitted flow in million gallons per day (MGD)

Conversion Factor (to MPN/day) = 1.54723 cfs/MGD *283.1685 100 mL/ft^3 * 86,400 s/d

Due to the absence of any permitted dischargers in the Sycamore Creek watershed, the WLA_{WWTF} component is zero.

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA for these areas was used in the development of this TMDL due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of the Sycamore Creek watershed that is under the jurisdiction of stormwater permits (i.e., defined as the area designated as urbanized area in the 2010 U.S. Census) (USCB, 2017) is used to estimate the amount of the overall runoff load to be allocated as the regulated stormwater contribution in the WLA_{SW} component of the TMDL (Figure 7). The load allocation (LA) component of the TMDL corresponds to direct nonpoint runoff and is the difference between the total load from stormwater runoff and the portion allocated to WLA_{SW}.

Thus, WLA_{SW} is the sum of loads from regulated stormwater sources and is calculated as follows:

$$WLA_{SW} = (TMDL - \Sigma WLA_{WWTF} - \Sigma FG - MOS) * FDA_{SWP}$$

Where:

WLA_{SW} = sum of all regulated stormwater loads

TMDL = total maximum daily load

ΣWLA_{WWTF} = sum of all WWTF loads

ΣFG = sum of future growth loads from potential regulated facilities

MOS = margin of safety load

FDA_{SWP} = fractional proportion of drainage area under jurisdiction of stormwater permits

In order to calculate the WLA_{SW} component of the TMDL, the fractional proportion of the drainage area under the jurisdiction of stormwater permits (FDA_{SWP}) must be determined to estimate the amount of overall runoff load that should be allocated to WLA_{SW}. The term FDA_{SWP} was calculated based on the combined area under regulated stormwater permits. As mentioned previously, the Sycamore Creek watershed is covered 100 percent by MS4 Phase II general permits and Phase I individual permits (Figure 7). However, even in highly urbanized areas such as the Sycamore Creek watershed, there remain small areas of streams within each watershed that are not strictly regulated, and which may receive direct deposition of bacteria loadings from unregulated sources such as wildlife and feral hogs. To account for these small unregulated areas in the Sycamore Creek watershed, the stream length based on the TCEQ definition of AU 0806E_01 and a stream width estimated from measurements recorded as part of a recreational use attainability analysis on Sycamore Creek (TIAER, 2010) was used to compute an area of unregulated stormwater contribution (Table 9).

Table 9. Basis of unregulated stormwater area and computation of FDA_{SWP}.

Total Area (acres)	Stream Length (feet)	Estimated Average Stream Width (feet)	Estimated Stream Area (acres)	Fraction Unregulated Area	FDA_{SWP}
23,688	26,400	30.3	18.4	0.00078	0.99922

In order to calculate WLA_{SW}, the future growth (FG) term must be known, and more details on this term are provided later in the computation. Since it is unforeseen that any regulated facilities with a human waste component will occur in the Sycamore Creek watershed, the FG term is zero. With the information provided in Tables 7 – 9 and the zero values for WLA_{WWTF} and FG, the information to calculate the WLA_{SW} term is presented in Table 10.

Table 10. Regulated stormwater calculations for the Sycamore Creek watershed.

All loads expressed as billion MPN/day *E. coli*.

TMDL	WLA_{WWTF}	FG	MOS	FDA_{SWP}	WLA_{SW}
200.523	0	0	10.026	0.99922	190.348

Once the WLA_{SW} and WLA_{WWTF} terms are known, the WLA term can be calculated as the sum of the two parts, as shown in Table 11.

Table 11. Wasteload allocation calculations for the Sycamore Creek watershed.

All loads expressed as billion MPN/day *E. coli*.

WLA_{WWTF}	WLA_{SW}	WLA
0	190.348	190.348

An iterative, adaptive management approach will be used to address stormwater discharges. This approach encourages the implementation of structural or non-structural controls, implementation of mechanisms to evaluate the performance of the controls, and finally, allowance to make adjustments (e.g., more stringent controls or specific BMPs) as necessary to protect water quality.

Implementation of WLAs

The TMDL in this document will result in protection of existing beneficial uses and conform to Texas' antidegradation policy. The three-tiered antidegradation policy in the Standards prohibits an increase in loading that would cause or contribute to degradation of an existing use. The antidegradation policy applies to point source pollutant discharges. In general, antidegradation procedures establish a process for reviewing individual proposed actions to determine if the activity will degrade water quality.

The TCEQ intends to implement any individual wasteload allocations through the permitting process as monitoring requirements and/or effluent limitations, as required by the amendment of 30 Texas Administrative Code Chapter 319 which became effective November 26, 2009. Should any WWTFs begin discharging to the TMDL watersheds, they will be assigned an effluent limit based on the TMDL. Monitoring requirements are based on permitted flow rates and are listed in Section 319.9.

The permit requirements will be implemented during the routine permit renewal process. However, there may be a more economical or technically feasible means of achieving the goal of improved water quality and circumstances may warrant changes in individual WLAs after this TMDL is adopted. Therefore, the individual WLAs, as well as the WLAs for stormwater, are non-binding until implemented via a separate TPDES permitting action, which may involve preparation of an update to the state's WQMP. Regardless, all permitting actions will demonstrate compliance with the TMDL.

The executive director or commission may establish interim effluent limits and/or monitoring-only requirements at a permit amendment or permit renewal. These interim limits will allow a permittee time to modify effluent quality in order to attain the final effluent limits necessary to meet the TCEQ and EPA-approved TMDL allocations. The duration of any interim effluent limits may not be any longer than three years from the date of permit re-issuance. New permits will not contain interim effluent limits because compliance schedules are not allowed for a new permit.

Where a TMDL has been approved, domestic WWTF TPDES permits will require conditions consistent with the requirements and assumptions of the WLAs. For NPDES/TPDES-regulated municipal, construction stormwater discharges, and industrial stormwater discharges, water quality-based effluent limits (WQBELs) that implement the WLA for stormwater may be expressed as BMPs or other similar requirements, rather than as numeric effluent limits.

The November 26, 2014 memorandum from EPA relating to establishing WLAs for stormwater sources states:

> "Incorporating greater specificity and clarity echoes the approach first advanced by EPA in the 1996 Interim Permitting Policy, which anticipated that where necessary to address water quality concerns, permits would be modified in subsequent terms to include "more specific conditions or limitations [which] may include an integrated suite of BMPs, performance objectives, narrative standards, monitoring triggers, numeric WQBELs, action levels, etc."

Using this iterative adaptive BMP approach to the maximum extent practicable is appropriate to address the stormwater component of this TMDL.

Updates to WLAs

This TMDL is, by definition, the total of the sum of the WLA, the sum of the LA, and the MOS. Changes to individual WLAs may be necessary in the future in order to accommodate growth or other changing conditions. These changes to individual WLAs do not ordinarily require a revision of the TMDL document; instead, changes will be made through updates to the state's WQMP. Any future changes to effluent limitations will be addressed through the permitting process and by updating the WQMP.

Load Allocation

The LA is the sum of loads from unregulated sources, and is calculated as:

$$LA = TMDL - WLA_{WWTF} - WLA_{SW} - FG - MOS$$

Where:

LA = allowable load from unregulated sources

TMDL = total maximum daily load

WLA_{WWTF} = sum of all WWTF loads

WLA_{SW} = sum of all regulated stormwater loads

FG = future growth loads from potential permitted facilities

MOS = margin of safety load

Within the Sycamore Creek watershed, a small area not regulated by stormwater permits was assigned as detailed in the regulated stormwater computations.

The LA for the Sycamore Creek watershed was computed using the information provided in Table 12.

Table 12. Load allocation calculation for the Sycamore Creek watershed.

Load units expressed as billion MPN/day *E. coli*

TMDL	WLA_{WWTF}	WLA_{SW}	FG	MOS	LA
200.523	0	190.348	0	10.026	0.149

Allowance for Future Growth

The future growth component of the TMDL equation addresses the requirement to account for future loadings that may occur due to population growth, changes in community infrastructure, and development. Due to 100 percent coverage of wastewater collection by the City of Fort Worth Village Creek WWTF collection system and the absence of WWTFs in the TMDL study area, the future growth component for this TMDL is zero. Communications with the City of Fort Worth confirmed that new loads from WWTF discharges are very unlikely to occur.

Compliance with this TMDL is based on keeping the bacteria concentrations in Sycamore Creek below the limits that were set as criteria. Future growth of existing or new point sources is not limited by this TMDL as long as the sources do not cause bacteria to exceed the limits.

Summary of TMDL Calculations

Table 13 summarizes the TMDL calculations for the Sycamore Creek watershed. The TMDL was calculated based on the median flow in the 0-10 percentile range (5 percent exceedance, high flow regime) for flow exceedance from the LDC developed for TCEQ station 17369 on Sycamore Creek. Allocations are based on the current geometric mean criterion for *E. coli* of 126 MPN/100 mL for each component of the TMDL.

The final TMDL allocations (Table 14) needed to comply with the requirements of 40 CFR 130.7 include the future growth component within the WLA_{WWTF}, which for the Sycamore Creek watershed was zero due to the absence of any regulated facilities and the anticipation of no future regulated facilities with a human waste component. The final TMDL allocation also included allocations to regulated MS4 entities and regulated construction and industrial activities, which are designated as WLA_{SW}. The LA component of the final TMDL allocations is comprised of the sum of unregulated stormwater loadings arising from within the Sycamore Creek watershed.

Table 13. TMDL allocation summary for the Sycamore Creek watershed (AU 0806E_01).

Load units expressed as billion MPN/day *E. coli*

AU	Stream Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA[e]	Future Growth[f]
0806E_01	Sycamore Creek	200.523	10.026	0	190.348	0.149	0

[a] TMDL = Median flow (highest flow regime) * 126 MPN/100 mL * Conversion Factor; where the Conversion Factor = 65.048 100 mL/ft^3 * 86,400 s/d; Median (5 percent exceedance) Flow from Table 7

[b] MOS = 0.05 * TMDL (Table 8)

[c] WLA_{WWTF} = 0 MPN/100 mL due to an absence of any WWTFs within the Sycamore Creek watershed

[d] WLA_{SW} = (TMDL - ΣWLA_{WWTF} - ΣFG - MOS) * FDA_{SWP} (Tables 9 and 10)

[e] LA = TMDL - ΣWLA_{WWTF} - ΣWLA_{SW} - ΣFG - MOS (Table 12)

[f] Future Growth = 0 MPN/100 mL since the establishment of WWTFs within the Sycamore Creek watershed is highly unlikely

In the event that the criterion changes due to future revisions in the state's surface water quality standards, Appendix A provides guidance for recalculating the allocations in Table 14. Appendix A was developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant LAs change in relation to a number of proposed water quality criteria for *E. coli*. The equations provided in Appendix A allow calculation of a new TMDL and pollutant load allocations based on any potential new water quality criterion for *E. coli*.

Table 14. Final TMDL allocations for Sycamore Creek watershed (AU 0806E_01).

Load units expressed as billion MPN/day *E. coli*

AU	TMDL	WLA_{WWTF}[a]	WLA_{SW}	LA	MOS
0806E_01	200.523	0	190.348	0.149	10.026

[a] WLA_{WWTF} includes the future growth component

Seasonal Variation

Seasonal variations (or seasonality) occurs when there is a cyclic pattern in streamflow and, more importantly, in water quality constituents. Federal regulations [40 CFR 30.7(c)(1)] require that TMDLs account for seasonal variation in watershed conditions and pollutant loading.

Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* concentrations obtained from 16 years (2001 – 2016) of routine monitoring collected in the warmer months (April – September) against those collected during the cooler months (October – March). Differences in *E. coli* concentrations obtained in warmer versus cooler months were then evaluated by performing a t-test on the natural log transformed dataset. This analysis of *E.coli* data indicated that there was a significant difference (α=0.05) in indicator bacteria between cool and warm weather seasons for Sycamore Creek (p=0.0391), with the warm season having the higher concentrations.

Public Participation

The TCEQ maintains an inclusive public participation process. From the inception of the investigation, the project team sought to ensure that stakeholders were informed and involved. Communication and comments from the stakeholders in the watershed strengthen TMDL projects and their implementation.

Through the TCEQ, the NCTCOG and members of the Coordination Committee for the Greater Trinity River Bacteria Implementation Plan (I-Plan) have remained informed about the TMDL project for the Sycamore Creek watershed. The TCEQ has coordinated the development of the TMDL with the Coordination Committee, NCTCOG, and the City of Fort Worth to ensure information related to the TMDL project has been made available to the entire Coordination Committee. Information related to the project was presented on June 16, 2016 and June 15, 2017. On June 14, 2018, the Coordination Committee, by resolution, added Sycamore Creek to their existing I-Plan.

A public meeting was held August 15, 2017, at the Ella Mae Shamblee Branch Library in Fort Worth to present preliminary TMDL information. At the meeting, the impaired segment, the reason for the impairment, historical data, and potential sources of bacteria within the watershed were presented. In addition, the meeting gave TCEQ the opportunity to solicit input from all interested parties within the study area.

Implementation and Reasonable Assurance

The issuance of TPDES permits consistent with TMDLs provides reasonable assurance that wasteload allocations in this TMDL report will be achieved. Per federal requirements, each TMDL is included in an update to the Texas WQMP as a plan element.

The WQMP coordinates and directs the state's efforts to manage water quality and maintain or restore designated uses throughout Texas. The WQMP is continually updated with new, more specifically focused plan elements, as identified in federal regulations [40 CFR Sec. 130.6(c)]. Commission adoption of a TMDL is the state's certification of the associated WQMP update.

Because the TMDL does not reflect or direct specific implementation by any single pollutant discharger, the TCEQ certifies additional elements to the WQMP after the I-Plan is approved by the commission. Based on the TMDL and I-Plan, the TCEQ will propose and certify WQMP updates to establish required water-quality-based effluent limitations necessary for specific TPDES wastewater discharge permits.

For MS4 entities, where numeric effluent limitations are infeasible, the permits require that the MS4 develop and implement BMPs under each MCM, which are a substitute for effluent limitations, as allowed by federal rules. How a regulated MS4 meets each MCM is not prescribed in detail in the MS4 permits but is included in the permittee's SWMP. During the permit renewal process, TCEQ revises its MS4 permits as needed to require the implementation of other specific revisions in accordance with an approved TMDL and I-Plan.

Strategies for achieving pollutant loads in TMDLs from both point and nonpoint sources are reasonably assured by the state's use of an implementation plan. The TCEQ is committed to supporting implementation of all TMDLs adopted by the commission.

I-Plans for Texas TMDLs use an adaptive management approach that allows for refinement or addition of methods to achieve environmental goals. This adaptive approach reasonably assures that the necessary regulatory and voluntary activities to achieve pollutant reductions will be implemented. Periodic, repeated evaluations of the effectiveness of implementation methods ascertain whether progress is occurring, and may show that the original distribution of loading among sources should be modified to increase efficiency. Implementation plans will be adapted as necessary to reflect needs identified in evaluations of progress.

Key Elements of an Implementation Plan

An I-Plan includes a detailed description and schedule of the regulatory and voluntary management measures to implement the WLAs and LAs of particular TMDLs within a reasonable time. Implementation plans also identify the organizations responsible for carrying out management measures, and a plan for periodic evaluation of progress.

As noted in the Public Participation section, this TMDL will be implemented through an existing I-Plan. The NCTCOG initiated efforts in the spring of 2011 with the TCEQ to lead development of the Greater Trinity River Bacteria I-Plan for three closely related projects in the DFW area. The I-Plan effort includes a Coordination Committee and three (formerly eight) technical subcommittees. Between May 2011 and July 2012, the NCTCOG facilitated four stakeholder meetings, four Coordination Committee meetings, and 40 technical subcommittee meetings. The Coordination Committee completed the "peer review" draft I-Plan and submitted the document to TCEQ for review in August 2012. The draft I-Plan was released for a formal public review in July 2013. The TCEQ commission approved the I-Plan on December 11, 2013. On June 3, 2015, the Coordination Committee adopted a resolution to add four streams associated with the Watersheds Upstream of Mountain Creek Lake TMDLs to the I-Plan. It is anticipated that the Coordination Committee will add Sycamore Creek to their existing I-Plan, by resolution, at a future meeting.

Ultimately, the I-Plan identifies the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the approved I-Plan may not approximate the predicted loadings identified category-by-category in the TMDL and its underlying assessment. The I-Plan is adaptive for this very reason; it allows for continuous update and improvement.

In most cases, it is not practical or feasible to approach all TMDL implementation as a one-time, short-term restoration effort. This is particularly true when a challenging wasteload or load reduction is required by the TMDL, there is high uncertainty with the TMDL analysis, there is a need to reconsider or revise the established water quality standard, or the pollutant load reduction would require costly infrastructure and capital improvements.

The NCTCOG worked with the TCEQ to lead development of the I-Plan. Through the stakeholder group led by the NCTCOG, the resources and expertise of the local organizations and individuals were brought together to set priorities, provide flexibility, and consider appropriate social and economic factors. Information on I-Plan development and related material are on the NCTCOG website at <www.nctcog.org/envir/SEEclean/wq/tmdl/index.asp>.

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Appendix A. Equations for Calculating TMDL Allocations for Changed Contact Recreation Standard

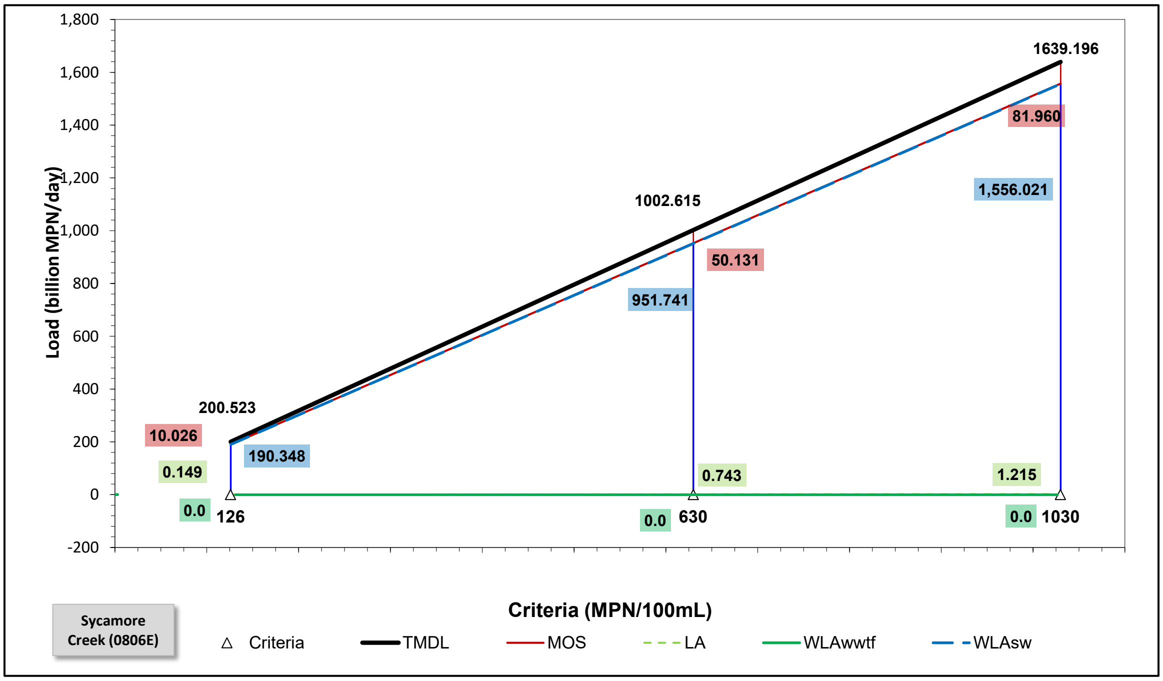

Figure A-1. Allocation loads for the Sycamore Creek watershed (0806E) as a function of water quality criteria

Equations for calculating new TMDL and allocations (in billion MPN/day)

TMDL = 1.591452 * Std
MOS = 0.07957303 * Std
LA = 0.00117918 * Std
WLA_{WWTF} = 0
WLA_{sw} = 1.510700229 * Std

Where:

Std = Revised Contact Recreation Standard
MOS = Margin of Safety
LA = Total load allocation (unregulated sources)
WLA_{WWTF} = Wasteload allocation (permitted WWTF load + future growth)
WLA_{SW} = Wasteload allocation (permitted stormwater)

Table A-1 TMDL allocations for the Sycamore Creek watershed for potential changed contact recreation standards.

Units expressed as billion MPN/day *E. coli*

Contact Recreation Criterion (MPN/day)	TMDL	WLA_{WWTF}	WLA_{SW}	LA	MOS
126	200.523	0	190.348	0.149	10.026
630	1,002.615	0	951.741	0.743	50.131
1,030	1,639.196	0	1,556.021	1.215	81.960