For Public Comment, June 2013

Thirteen Total Maximum Daily Loads for Indicator Bacteria in the Lower West Fork Trinity River Watershed

Segments 0841, 0841B, 0841C, 0841E, 0841G, 0841H, 0841J, 0841L, 0841M, 0841R, 0841T, and 0841U

Assessment Units: 0841_01, 0841_02, 0841B_01, 0841C_01, 0841E_01, 0841G_01, 0841H_01, 0841J_01, 0841L_01, 0841M_01, 0841R_01, 0841T_01, and 0841U_01

Water Quality Planning Division, Office of Water

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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This TMDL report is based in large part on the report titled:
"Contractor Draft Report Thirteen Total Maximum Daily Loads for Indicator Bacteria in the Lower West Fork Trinity River Watershed"
prepared by the Texas Institute for Applied Environmental Research.

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Abbreviations

AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
CFR	Code of Federal Regulations
cms	cubic meters per second
DMR	Discharge Monitoring Report
DSLR	days since last rain
ECHO	Enforcement & Compliance History Online
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency (U.S.)
FDC	flow duration curve
FG	future growth
GIS	geographic information system
gpcd	gallons per capita per day
ha	hectare
I/I	inflow and infiltration
I-Plan	implementation plan
LA	load allocation
LDC	load duration curve
mL	milliliter
MGD	million gallons per day
MOS	margin of safety
MPN	most probable number
MS4	municipal separate storm sewer system
NCTCOG	North Central Texas Council of Governments
NEIWPCC	New England Interstate Water Pollution Control Commission
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
OSSF	onsite sewage facility
SSO	sanitary sewer overflow
SWMP	Stormwater Management Program
SWPPP	Storm Water Pollution Prevention Plan
SWQMIS	Surface Water Quality Monitoring Information System
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TIAER	Texas Institute for Applied Environmental Research
TMDL	total maximum daily load
TPDES	Texas Pollutant Discharge Elimination System
TRA	Trinity River Authority
USGS	United States Geological Survey
WLA	wasteload allocation
WQMP	Water Quality Management Plan
WWTF	wastewater treatment facility

Thirteen Total Maximum Daily Loads for Indicator Bacteria in Lower West Fork Trinity River Watershed

Executive Summary

This document describes total maximum daily loads (TMDLs) for the Lower West Fork Trinity River and its tributaries 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 impairments to the Lower West Fork Trinity River in the *1996 State of Texas Clean Water Act Section 303(d) List (TCEQ, 1996)*. The tributaries to the Lower West Fork Trinity River were first listed in subsequent *Texas Water Quality Inventory and 303(d) Lists (TCEQ, 2006, 2010)*. The impaired segments and corresponding assessment units (AUs) are:

- Lower West Fork Trinity River (0841_01);
- Lower West Fork Trinity River (0841_02);
- Bear Creek (0841B_01);
- Arbor Creek (0841C_01);
- Copart Branch Mountain Creek (0841E_01);
- Dalworth Creek (0841G_01);
- Delaware Creek (0841H_01);
- Estelle Creek (0841J_01);
- Johnson Creek (0841L_01);
- Kee Branch (0841M_01);
- Rush Creek (0841R_01);
- Village Creek (0841T_01); and
- West Irving Branch (0841U_01).

The Lower West Fork Trinity River is a perennial freshwater stream approximately 27 miles in length from the confluence of the Elm Fork Trinity River in Dallas County to the confluence of Village Creek in Tarrant County. The Lower West Fork Trinity River watershed is 259 square miles, includes many smaller order streams, and is predominately located in the urbanized Dallas/Fort Worth Metroplex area.

Six regulated facilities are located in the Lower West Fork Trinity River watershed; three facilities treat domestic wastewater, two facilities are permitted to discharge stormwater, and one facility discharges both industrial wastewater and stormwater. The Trinity River Authority (TRA) and City of Fort Worth each operate a domestic wastewater treatment facility (WWTF) that discharges

directly into the Lower West Fork Trinity River, and these plants will be considered in the waste load allocation. The third domestic WWTF, Alta Vista Mobile Home Park, does not discharge to an impaired stream, but will be considered in the waste load allocation since it is located in the Lower West Fork Trinity River watershed.

Currently there are no authorized domestic wastewater dischargers located within the watersheds of any of the impaired tributaries of the Lower West Fork Trinity River.

The discharges authorized by the industrial wastewater and stormwater 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 load allocations.

Escherichia coli (*E. coli*) are the preferred indicator bacteria for assessing the contact recreation use in freshwater, and were used for development of the TMDLs. 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).

Historical ambient water quality data for indicator bacteria were evaluated for TCEQ water quality monitoring stations in the watershed of the Lower West Fork Trinity River and its tributaries. The geometric means of *E. coli* ranged from 16 (MPN/100 mL) to 1,548 MPN/100 mL. The geometric mean of stations within Big Bear Creek, Dry Branch Creek, and Mountain Creek were less than 126 MPN/100 mL, indicating that these water bodies support primary contact recreation. For the other water bodies examined, the geometric mean of the samples for stations within each water body exceeded 126 MPN/100 mL indicating non-support of primary contact recreation.

The most probable sources of indicator bacteria within the watersheds of the impaired AUs are stormwater runoff from regulated storm sewer sources, dry weather discharges (illicit discharges) from storm sewers, sanitary sewer overflows, and unregulated sources such as wildlife, unmanaged feral animals, and pets.

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

The wasteload allocation for WWTFs was established as the permitted flow multiplied by one-half the geometric mean criterion for the indicator bacteria.

Future growth of existing or new domestic point sources was determined using population projections. The TMDL calculations in this report will guide determination of the assimilative capacity of each stream under changing conditions, including future growth. Wastewater discharge facilities will be evaluated case by case.

The wasteload allocation for regulated stormwater was based on the percentage of each watershed regulated under a Phase I or Phase II Texas Pollutant Discharge Elimination System (TPDES) stormwater permit.

Compliance with these TMDLs is based on keeping the indicator bacteria concentrations in the selected waters 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 to the contact recreation use due to exceeding indicator bacteria criteria in the Lower West Fork Trinity River and eleven of its tributaries. The TMDL applies to all water bodies in the Lower West Fork Trinity River watershed (Figure 1).

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, these TMDLs will become an update to the state's Water Quality Management Plan (WQMP).

Problem Definition

The TCEQ first identified bacteria impairments within AUs of the Lower West Fork Trinity River watershed (Figure 1) in the 1996 and each subsequent edition through 2010 of the *Texas Water Quality Integrated Report for Clean Water Sections 305(b) and 303 (d)* (formerly called the *Texas Water Quality Inventory and 303(d) List*) (TCEQ, 2010a). An AU is the smallest geographic area of use support reported in the TCEQ assessment of surface water quality. The upper AU of the Lower West Fork Trinity River (0841_02) is not identified as impaired for elevated bacteria concentrations on the *2010 Integrated Report*. However a review of the AU boundaries for 0841_01 and 0841_02–the lower and upper portions, respectively, of Segment 0841–determined that an AU description revision was warranted. The AU boundary change, from the Tarrant/Dallas county line to just upstream of Johnson Creek, resulted in both portions of the Lower West Fork Trinity River being identified for bacteria impairments on the draft *2012 Integrated Report*. Therefore, AU 0841_02 is included in this TMDL report.

Bacteria impairments within Bear Creek, Arbor Creek, Copart Branch Mountain Creek, Dalworth Creek, Delaware Creek, Estelle Creek, Kee Branch, and West Irving Branch were all first identified in 2006 and each subsequent list through 2010 (TCEQ 2006, 2010a). Johnson Creek, Rush Creek, and Village Creek were first listed in 2010 (TCEQ 2010a). Bear Creek, Arbor Creek, and Copart Mountain

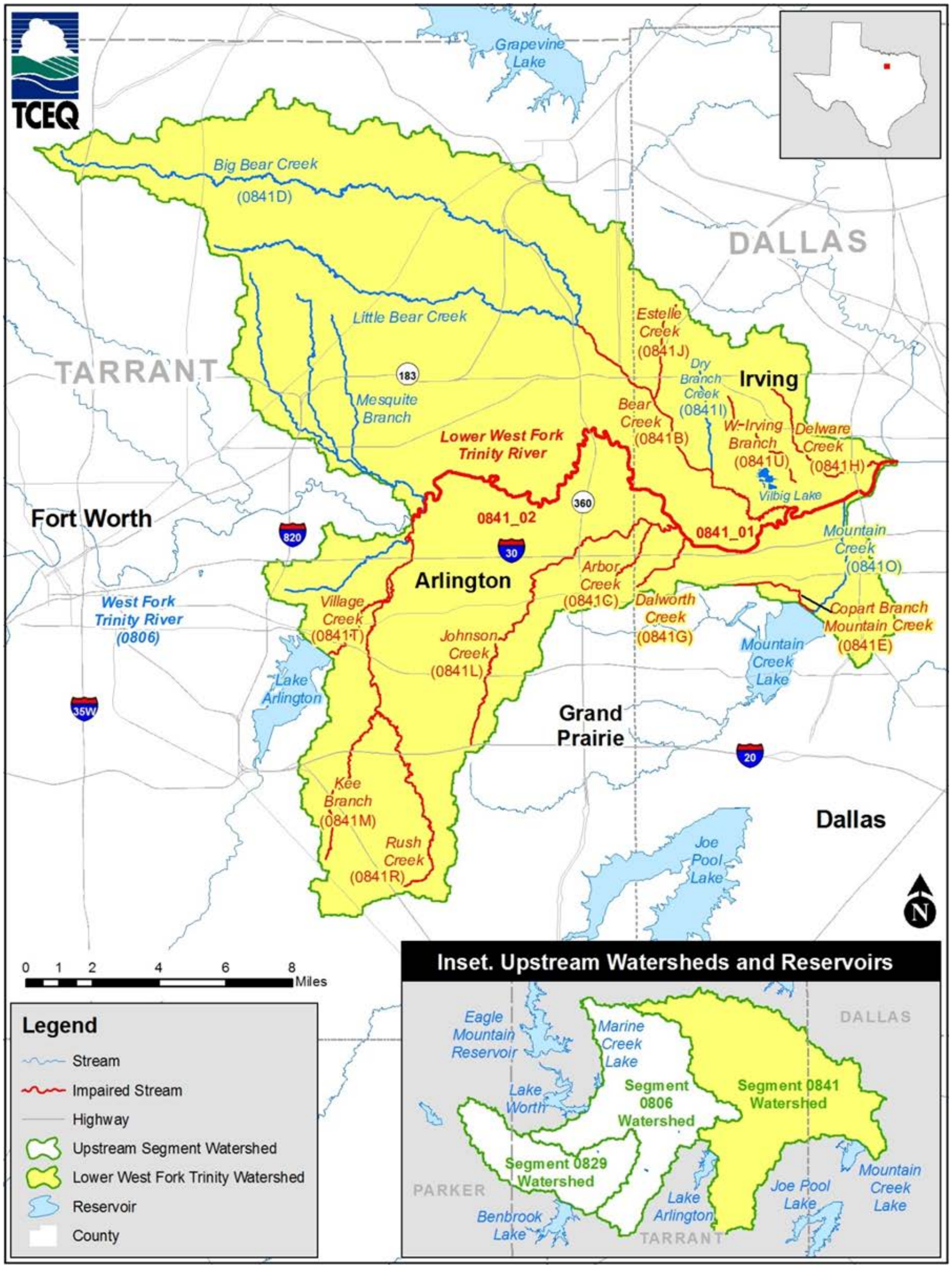

Figure 1. Lower West Fork Trinity River watershed

Branch Creek are not listed in the draft 2012 *Texas Integrated Report*, but these TMDLs were developed based primarily on the *2010 Texas Integrated Report*. Impairments have also been noted in the *2010 Texas Integrated Report* for the

Lower West Fork Trinity River for dioxin and polychlorinated biphenyls (PCBs) in edible tissue. The dioxin and PCB impairments will not be addressed in this document.

This report will consider bacteria impairments in 12 water bodies (segments) consisting of 13 AUs (Figure 1) based on data used in the *2010 Texas Integrated Report*. Table 1 identifies the 13 TMDL AUs and relevant 303(d) listing information from the *Texas Integrated Report*.

Table 1. TMDL segments and AUs for Lower West Fork Trinity watershed

Texas Integrated Report level of support for contact recreation use

AU	Segment Name	2010 Integrated Report Level of Support	Draft 2012 Integrated Report Level of Support
0841_01	Lower West Fork Trinity River	Non-supporting	Non-supporting
0841_02	Lower West Fork Trinity River	Fully supporting	Non-supporting
0841B_01	Bear Creek	Non-supporting	Fully supporting
0841C_01	Arbor Creek	Non-supporting	Fully supporting
0841E_01	Copart Branch Mountain Creek	Non-supporting	Fully supporting
0841G_01	Dalworth Creek	Non-supporting	Non-supporting
0841H_01	Delaware Creek	Non-supporting	Non-supporting
0841J_01	Estelle Creek	Non-supporting	Non-supporting
0841L_01	Johnson Creek	Non-supporting	Non-supporting
0841M_01	Kee Branch	Non-supporting	Non-supporting
0841R_01	Rush Creek	Non-supporting	Non-supporting
0841T_01	Village Creek	Non-supporting	Non-supporting
0841U_01	West Irving Branch	Non-supporting	Non-supporting

Because the 11 tributary segments are each comprised of only one AU that encompasses the entire segment, the AU descriptor (_01) is unnecessarily cumbersome and from this point forward will not be included in the identification of these segments. For example, Bear Creek, 0841B_01, will hence forth be referred to as 0841B.

Based on the *2010 Texas Integrated Report*, the segment drainage area for Lower West Trinity River includes:

- Streams that are non-supporting (impaired) of the contact recreation use;
- Streams that are fully supporting the contact recreation use; and
- Streams that have not been evaluated for use support due to lack of data.

This report includes TMDLs for those 13 AUs determined to be impaired, based on the *2010 Texas Integrated Report* data. The report applies to all water bodies within the Lower West Trinity River watershed as defined by Figure 1. TMDLs were not explicitly developed for those segments fully supporting the contact recreation use in 2010. Those streams that have not been evaluated for contact recreation use support are considered to be part of the stream segment that receives their discharge. Additional TMDLs may be allocated for other segments in the Lower West Fork Trinity River watershed if new contact recreation impairments are identified in future Texas Integrated Reports. Figure 2 distinguishes the "TMDL watersheds" from the "non-TMDL watersheds" in the drainage area for Lower West Fork Trinity River.

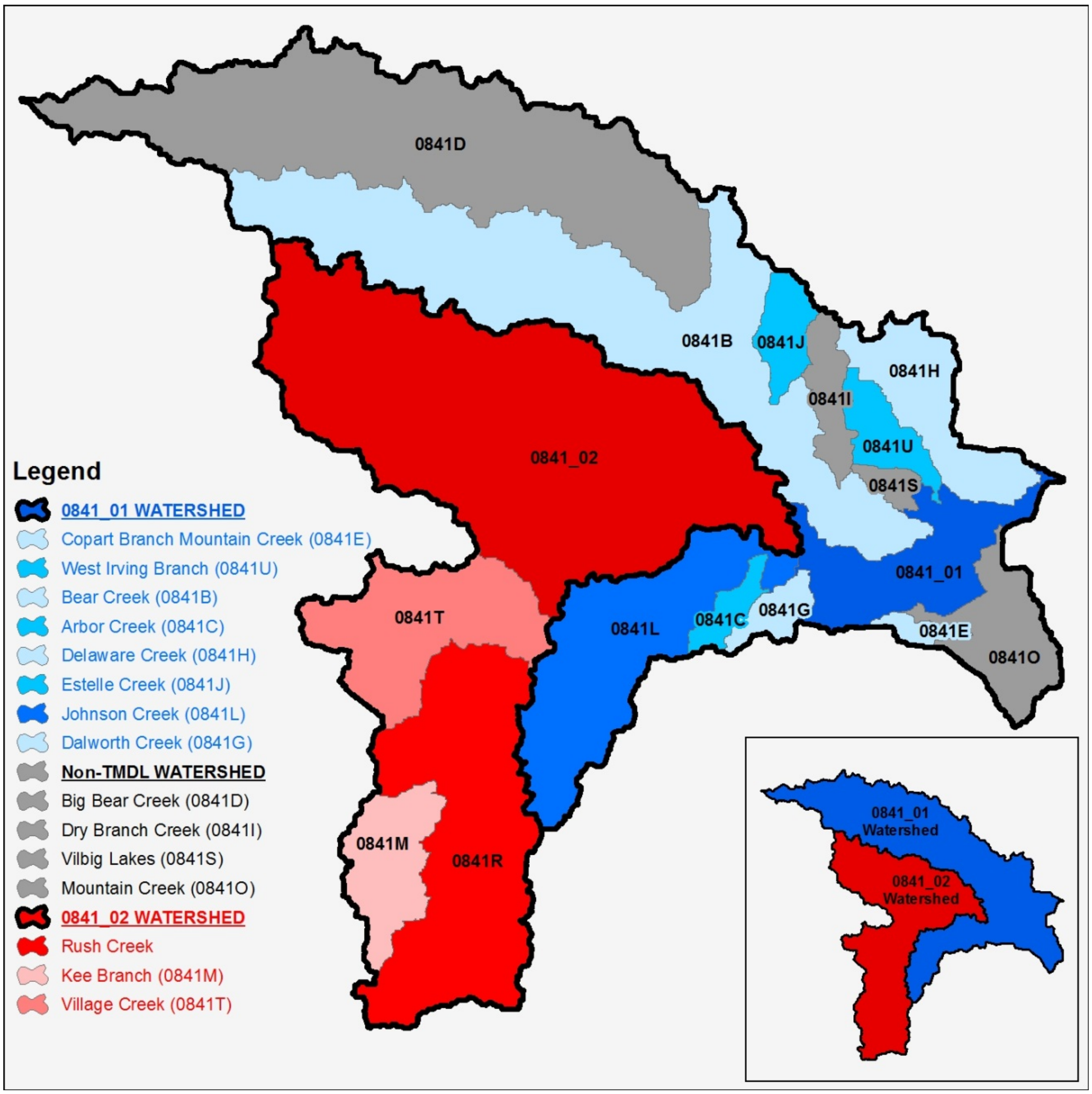

Figure 2. Assessment unit watersheds

The 12 segments and associated 13 AUs are listed due to impairment of the primary contact recreation use caused by elevated levels of indicator bacteria. The standards for water quality are defined in the *Texas Surface Water Quality Standards* (TCEQ, 2010b). *E. coli* are the preferred indicator bacteria for assessing the recreational use in freshwater, and were used for analysis to support TMDL development for the Lower West Fork Trinity River watershed. The criteria for assessing attainment of the primary contact recreation use are expressed as the number (or "counts") of *E. coli* bacteria, typically given as the MPN. For the *E. coli* indicator, if the minimum sample requirement is met, the primary contact recreation use is not supported when the geometric mean of all *E. coli* samples collected during ambient conditions exceeds 126 MPN per 100 mL.

Ambient Indicator Bacteria Concentrations

Table 2 presents a summary of historical ambient indicator bacteria data from the TCEQ Surface Water Quality Monitoring Information System (SWQMIS) database for monitoring stations in the Lower West Fork Trinity River watershed. The individual station data are also aggregated to the AU level in Table 2.

Table 2. Summary of routine monitoring, *E. coli* data

Data from December 1, 2001 through November 30, 2008. MPN=most probable number/100 mL.

Water Body (AU)	Station[1]	No. of Samples	Data Date Range	Station Geometric Mean (MPN)	No. of Samples in AU	AU Geometric Mean (MPN)
Lower West Fork Trinity River (0841_01)	11079	4	2002	36	115	177
	11080	33	2001-2004	170		
	11081	71	2001-2008	216		
	11089	7	2005-2006	70		
Lower West Fork Trinity River (0841_02)	17669	90	2001-2008	164	106	135
	11084	11	2001-2002	56		
	11087	1	2002	97		
	17160	4	2002	23		
Bear Creek (0841B)	10864	5	2002	224	316	152
	10865	27	2005-2008	78		
	10866	31	2001-2004	225		
	10867	81	2001-2008	209		
	10868	27	2001-2007	77		
	10869	12	2005-2008	66		
	17663	83	2001-2008	192		
	18313	25	2002-2004	136		
	18315	25	2002-2004	106		

Water Body (AU)	Station[1]	No. of Samples	Data Date Range	Station Geometric Mean (MPN)	No. of Samples in AU	AU Geometric Mean (MPN)
Arbor Creek (0841C)	17666	68	2001-2007	139	68	139
Big Bear Creek (0841D)	17089	25	2002-2008	98	25	98
Copart Branch Mountain Creek (0841E)	17672	79	2001-2008	156	79	156
Dalworth Creek (0841G)	17671	52	2001-2008	720	52	720
Delaware Creek (0841H)	10871	7	2001-2002	1,055	168	383
	17175	31	2001-2004	1,120		
	17176	32	2001-2004	227		
	17177	30	2001-2004	504		
	17178	43	2001-2008	178		
	18314	25	2002-2004	405		
Dry Branch Creek (0841I)	17173	32	2001-2004	46	32	46
Estelle Creek (0847J)	17174	32	2001-2004	342	32	342
Johnson Creek (0841L)	10719	37	2001-2008	179	222	128
	10721	26	2002-2008	291		
	17664	80	2001-2008	136		
	17665	22	2001-2005	93		
	18311	57	2003-2008	73		
Kee Branch (0841M)	10792	26	2002-2008	188	38	196
	15103	6	2007-2008	261		
	16896	6	2007-2008	173		
Mountain Creek[2] (0841O)	10815	89	2001-2008	49	245	32
	17681	76	2001-2008	16		
	17682	80	2001-2008	38		
Rush Creek (0841R)	10791	25	2002-2008	101	74	148
	17190	25	2002-2008	207		
	17191	24	2002-2008	156		
Vilbig Lake (0841S)	15624	31	2001-2004	1,548	31	1,548
Village Creek (0841T)	10778	5	2005	142	32	137
	17189	27	2002-2008	136		
West Irving Branch (0841U)	17179	35	2002-2008	357	35	357

[1] Station location descriptions may be found in Table 3-2 of *Technical Support Document for Total Maximum Daily Load for Indicator Bacteria in the Lower West Fork Trinity River Watershed* (Millican and Hauck 2012).

[2] Station 17681 is located on Mountain Creek, but on the stretch between Joe Pool Lake and Mountain Creek Lake, which is not within the Lower West Fork Trinity River watershed (0841_01). With station 17681 removed from 0841O, the number of samples = 169 and the geometric mean = 43 MPN/100mL.

TCEQ monitoring stations are depicted on Figure 3. *E. coli* data collected at these stations were used in assessing attainment of the primary contact recreation use as reported in the *2010 Texas Integrated Report* (TCEQ, 2010a). The 2010 assessment data indicate non-support of the primary contact recreation use because of geometric mean concentrations exceeding the geometric mean criterion of 126 MPN/100 mL for all assessed AUs within the Lower West Fork Trinity River study area, with the exception of Big Bear Creek (0841D), Dry Branch Creek (0841I), and Mountain Creek (0841O).

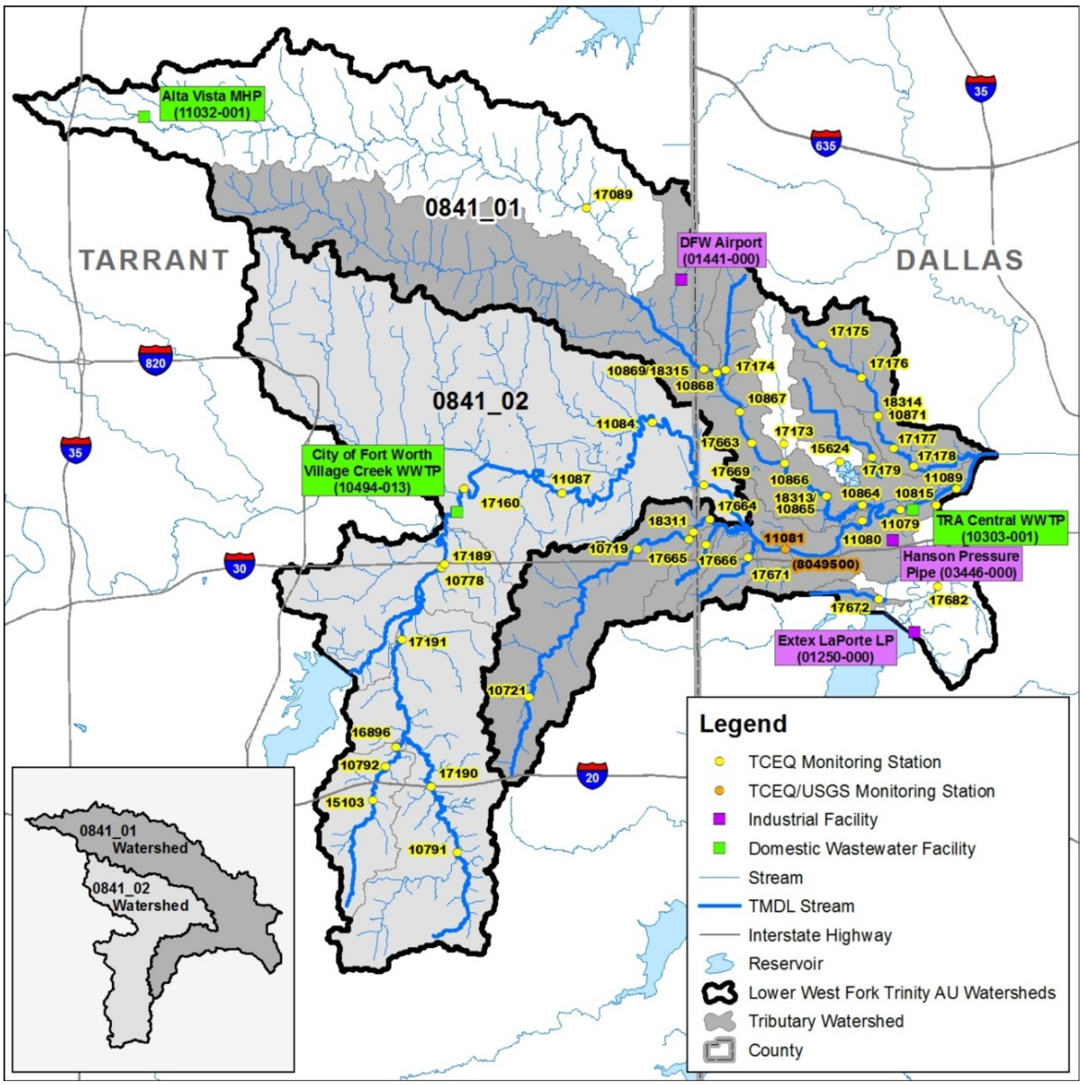

Figure 3. Watershed monitoring stations and regulated facilities

Watershed Overview

The Lower West Fork Trinity River (Segment 0841) is a perennial freshwater stream approximately 27 miles in length from the confluence of the Elm Fork Trinity River in Dallas County to the confluence of Village Creek in Tarrant

County. The Lower West Fork Trinity River watershed is 259 square miles and includes many smaller order streams (Figure 1). By definition the Lower West Fork Trinity River is simply a reach of the Trinity River. Many of the segments within the Lower West Fork Trinity River watershed are geographically positioned where another segment lies upstream complicating the definition of the study area, because of the hydrologic connectivity of an upstream segment with a downstream segment. Also, the Lower West Fork Trinity River watershed, itself, is not the most upstream classified segment on the West Fork Trinity River. The Trinity River Basin in the Dallas/Fort Worth area contains several segments; some of those are upstream sources of bacteria loading in the Lower West Fork segment. There are also numerous large reservoirs that alter the downstream hydrology and remove a very significant amount of flow and loadings of bacteria in the river segments below them.

The hydrologic and bacteria loading connectivity of upstream segments with the Lower West Fork and the disruption of this connectivity by the presence of large reservoirs complicated determination of the appropriate study area. Consequently, the total contributing area considered within this report will be defined by the drainage areas of Segment 0841, for which TMDL bacteria load allocations are to be developed, and of upstream Segments 0806 (West Fork Trinity River below Lake Worth) and 0829 (Clear Fork Trinity below Lake Benbrook; Figure 1 inset).

The upstream hydrologic terminuses of the contributing drainage area occur at the major reservoirs, which are labeled on Figure 1 inset. These major reservoirs, which are assumed to effectively remove the majority of downstream bacteria loading, include Mountain Creek Lake on Mountain Creek, Lake Arlington on Village Creek, Lake Benbrook on the Clear Fork, Marine Creek Lake on Marine Creek, and Lake Worth on the West Fork Trinity River.

The *Draft 2012 Texas Water Quality Integrated Report* (TCEQ, 2012) provides the segment and AU descriptions for the water bodies considered in this document. The 2012 AU descriptions are used because they correct errors in the 2010 Integrated Report.

- Segment 0841 – Lower West Fork Trinity River from a point upstream of the confluence with the Elm Fork Trinity River in Dallas County to a point immediately upstream of the confluence of Village Creek in Tarrant County.
    - 0841_01 – Lower West Fork Trinity River from the confluence of the Elm Fork Trinity River to the confluence with Johnson Creek.
    - 0841_02 – Lower West Fork Trinity River from the confluence with Johnson Creek upstream to the confluence of Village Creek.
- Segment 0841B – Bear Creek from confluence with West Fork Trinity River, to the confluence of Big Bear and Little Bear Creek just upstream of HWY 183 in Euless, Tarrant County, TX.

- Segment 0841C – Arbor Creek from confluence with Johnson Creek upstream to Duncan Perry Road in Grand Prairie, TX.
- Segment 0841E – Copart Branch Mountain Creek from confluence with unnamed oxbow (NHD RC 12030102044758) to approximately 0.3 miles upstream of Camden Road on the former Dallas Naval Air Station property, Dallas County.
- Segment 0841G – Dalworth Creek from confluence with Lower West Fork Trinity to headwaters area just west of 22nd Street NW in Grand Prairie, Dallas County.
- Segment 0841H– Delaware Creek from confluence with Lower W. Fork Trinity to Finley Road in Irving.
- Segment 0841J– Estelle Creek from confluence with Bear Creek upstream to Valley View Lane in Irving, Dallas County.
- Segment 0841L – Johnson Creek from confluence with the Lower West Fork Trinity River upstream to just south of Mayfield Road in Arlington, Tarrant County.
- Segment 0841M – Kee Branch from confluence with Rush Creek to upper end of the creek (NHD RC 12030102000165).
- Segment 0841R – Rush Creek from confluence with Village Creek to headwater area just east of Calender Road in Arlington, Tarrant County.
- Segment 0841T – Village Creek from confluence with West Fork Trinity River to SH 303 approx. 0.75 mi. downstream of Lake Arlington.
- Segment 0841U – West Irving Branch from approx. 0.4 mi. downstream of Oakdale Rd. to headwater area in Wyche Park (NHD RC 12030102044201) in Irving, Dallas County.

Big Bear Creek (Segment 0841D), Dry Branch Creek (Segment 0841I), Mountain Creek (Segment 0841O), and Vilbig Lake (Segment 0841S) are also water bodies within the study area shown in Figure 1 for Segment 0841, but are not included in the TMDL. Big Bear Creek, Dry Branch Creek, and Mountain Creek have been assessed by TCEQ and the three segments support the primary contact recreation use (TCEQ, 2010a). Vilbig Lake was listed as not supporting the contact recreation use; however, the TCEQ identified a need for additional sample collection and assessment before a TMDL is pursued on this water body. Additional bacteria data have been collected on Vilbig Lake, and its status and the need for a TMDL will be determined following assessment of the additional data. Vilbig Lake will not be addressed in this TMDL report.

Streamflow within the Trinity River Basin generally follows the rainfall pattern in the area (Trinity River Authority (TRA), 2012a). Although the Trinity River Basin has moderate rainfall and runoff on average, its hydrology is highly erratic, ranging from floods to drought. During normal years much of the rain and streamflow occur in late spring, followed by very hot, dry weather from mid-June through August, into September (TRA, 2012a).

The natural flow in the great majority of streams in the Trinity Basin is highly variable and most of the smaller streams cease to flow within a few days or weeks without rain (TRA 2012a). Many Trinity River tributaries, and the river itself below Dallas, have a base flow that consists mainly of effluent discharged from wastewater treatment facilities. The Lower West Fork Trinity River is no exception, receiving the discharge of the City of Fort Worth Village Creek facility and the TRA Central Regional facility. However, the tributaries to the Lower West Fork Trinity River do not receive any significant amounts of effluent from regulated wastewater dischargers and consequentially these streams are either intermittent in flow or contain only a small base flow.

North Central Texas has a subtropical climate characterized by hot summers and mild winters, resulting in a wide annual temperature range (National Weather Service (NWS), 2005). Average high temperatures generally reach their peak of 96°F between late July and mid-August. Fair skies generally accompany the highest temperatures of summer, which are often above 100°F; however, the low temperature rarely exceeds 80°F at night (NWS, 2012). During winter, the average low temperature is 33°F in early to mid-January and periods of extreme cold generally do not last long (NWS, 2012). The frost-free period generally lasts for about 248 days, with the last frost occurring in mid-March and the first frost occurring in mid to late November (NWS, 2012).

NWS data from 1981 through 2010 indicates that annual average precipitation for the Dallas/Fort Worth area is 36 inches. Normally May is the wettest month with an average rainfall total of 4.9 inches, while January is typically the driest with an average rainfall of 2.1 inches. Annual average wind speed is 10.5 mph and is typically out of the south. On average the Dallas/Fort Worth area will have approximately 18 days during the year in which air temperatures will be at or exceed 100°F and 33 days of temperatures at or below freezing.

The land use/land cover data for the Lower West Fork Trinity River watershed were obtained from the North Central Texas Council of Governments (NCTCOG) Geographic Information System (GIS) Data Clearinghouse website (NCTCOG, 2011) and represent land use/land cover estimates for 2005. The land use/land cover is represented by the following categories and definitions:

- **Commercial** – Land occupied by hotels, large stadiums, office and retail buildings.
- **Industrial** – Land occupied by industrial complexes.
- **Residential** – Property that contains single-family and multi-family housing units and mobile homes.
- **Government/Education** – Land includes institutional buildings and group quarters.
- **Airports** – Land occupied by airports and associated runways.

- **Undeveloped** – Land that is either vacant or under construction and may include expanded parking areas.
- **Infrastructure** – Roadways and utility structures.
- **Dedicated** – Land that is occupied by parks and landfills.
- **Water** – All areas of open water.

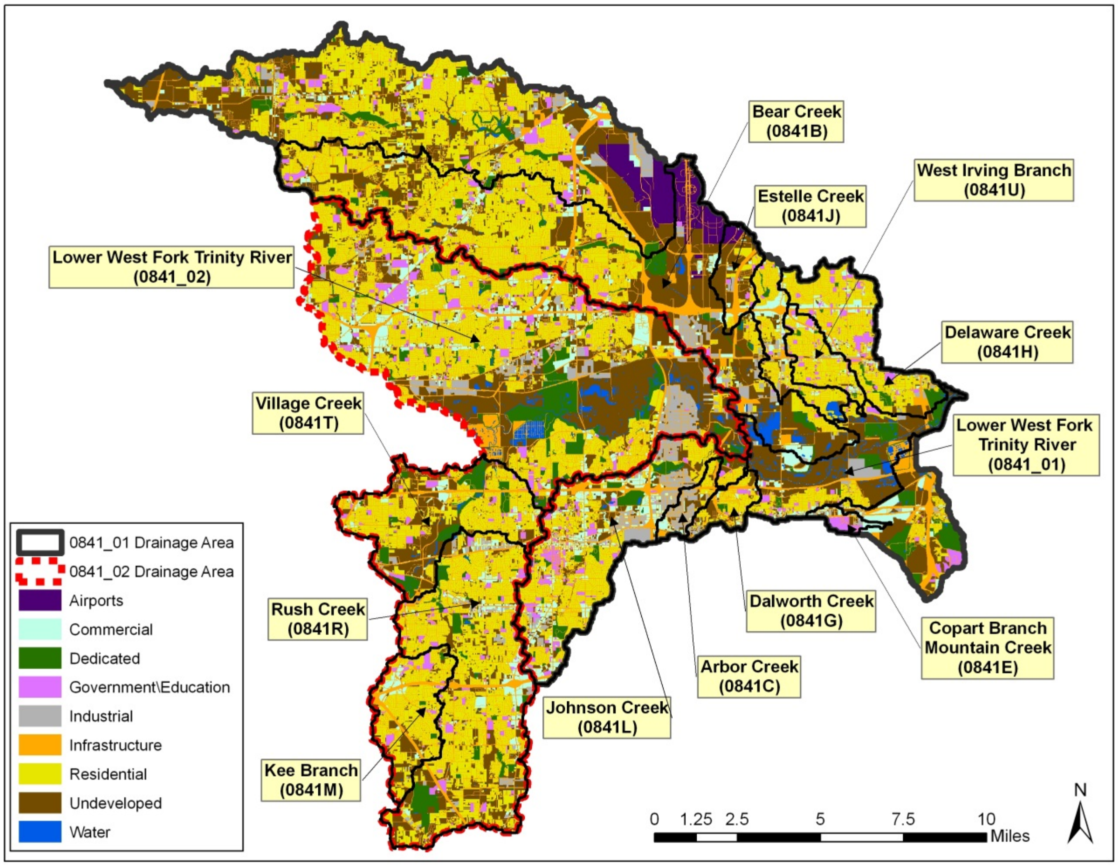

Figure 4. Land use/land cover for Lower West Fork Trinity River watershed

The 2005 land use/land cover data from the NCTCOG is provided for the Lower West Fork Trinity River watershed in Figure 4, and in tabular form in Table 3 for each of the TMDL watersheds. The dominant land use does vary between the watersheds of AUs, though Residential is generally the largest or second largest category except in stream corridor areas, such as along the West Fork Trinity River where Undeveloped is also a dominant category. In some of the smaller watersheds, such as Arbor Creek and Copart Branch Mountain Creek, land uses other than Residential and Undeveloped dominate. In summary, and as anticipated, the land use mix reflects that of a large urban area with some variations in category of dominance by geographic location.

Table 3. Percent land use/land cover for TMDL and Lower West Fork Trinity River watersheds

Percent of total watershed area by land use category. Land use estimates based on 2005 NCTCOG data.

Watershed	Commercial	Industrial	Residential	Government/ Education	Airports	Undeveloped	Infrastructure	Dedicated	Water	Totals
Lower West Fork (0841_01)	4.9	5.3	12.7	2.7	0.0	43.9	11.7	10.2	8.7	100
Lower West Fork (0841_02)	7.5	5.6	29.8	4.8	0.0	23.5	18.5	7.5	2.9	100
Bear Creek (0841B)	3.6	3.2	35.3	2.3	5.0	28.0	17.3	3.2	2.0	100
Arbor Creek (0841C)	9.2	31.1	13.6	0.5	0.0	14.5	29.8	1.2	0.1	100
Copart Br. Mnt. Cr. (0841E)	21.6	11.8	0.6	36.6	0.0	11.7	17.8	0.0	0.0	100
Dalworth Creek (0841G)	5.1	5.0	37.2	4.0	0.0	18.2	28.0	2.5	0.1	100
Delaware Creek (0841H)	7.9	2.0	49.5	9.3	0.0	4.4	21.6	5.3	0.1	100
Estelle Creek (0841J)	5.4	2.4	13.9	2.5	8.5	43.5	23.5	0.2	0.1	100
Johnson Creek (0841L)	13.7	11.0	29.2	7.0	0.0	11.0	22.1	5.7	0.4	100
Kee Branch (0841M)	4.9	0.3	50.0	5.2	0.0	15.1	23.3	1.1	0.1	100
Rush Creek (0841R)	5.9	3.0	44.8	4.1	0.0	17.6	18.3	6.0	0.5	100
Village Creek (0841T)	3.7	0.4	35.5	4.2	0.0	23.9	19.7	11.5	1.1	100
West Irving Branch (0841U)	5.5	2.4	19.5	8.8	0.0	8.4	18.7	5.4	1.2	100
Lower West Fork Trinity River (0841)	6.2	4.4	33.9	4.4	1.9	23.3	18.3	5.9	1.7	100

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 endpoints for the TMDLs in this report are to maintain concentrations of *E. coli* below the geometric mean criterion of 126 MPN/100 mL. This is the endpoint in all 13 AUs addressed by this TMDL.

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 TPDES. 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 to surface waters. Nonpoint sources are not regulated by permit.

With the exception of WWTFs, which receive individual wasteload allocations (WLAs) (see the “Wasteload Allocation” section), 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

Permitted sources are regulated by permit under the TPDES and the National Polluant Discharge Elimination System (NPDES) programs. The regulated sources in the Lower West Fork Trinity River watershed include WWTF outfalls and stormwater discharges from industries, construction, and municipal separate storm sewer system (MS4s).

Domestic and Industrial Wastewater Treatment Facilities

Among the six regulated facilities in the Lower West Fork Trinity River watershed, three facilities treat domestic wastewater, two facilities are permitted to discharge stormwater, and one facility discharges both industrial wastewater and stormwater (Figure 3). The TRA Central Regional Wastewater Treatment Facility discharges into the Lower West Fork Trinity River in 0841_01, the City of Fort Worth Village Creek Wastewater Treatment Facility discharges into the Lower West Fork Trinity River in 0841_02, and the Alta Vista Mobile Home Park Wastewater Treatment Facility discharges into Big Bear Creek (0841D), which is an unimpaired tributary of Bear Creek (0841B). Currently there are no authorized domestic wastewater dischargers located within the watersheds of any of the impaired tributaries of the Lower West Fork Trinity River.

Hanson Pressure Pipe, Inc. is a concrete pressure pipe manufacturing plant authorized to discharge process wastewater, boiler blow-down water, hydrostatic test water, and stormwater into the Lower West Fork Trinity River (0841_01). The Dallas/Fort Worth Airport has an individual stormwater permit that is targeted specifically to first-flush precipitation runoff following aircraft deicing and anti-icing activities that ultimately discharge into the Bear Creek (0841B) watershed. In addition, the Airport is also covered under the TPDES Phase II General Stormwater Permit. The Extex LaPorte LP Mountain Creek Lake Steam Electric Station has an industrial stormwater permit that authorizes stormwater discharges into non-bacteria-impaired Mountain Creek (0841O). The discharges from the three industrial wastewater permits are considered intermittent and variable (subject to precipitation and runoff), and no flow limit is specified in the permits. Given the circumstances of these permits, the industrial outfalls will be treated as part of the TPDES-regulated stormwater discharge load.

The permitted discharge limits for each facility and the actual average discharges for the period of available data from Discharge Monitoring Reports (DMRs) are provided in Table 4.

Table 4. Regulated discharge facilities in the Lower West Fork Trinity River watershed

TPDES Permit No.	Facility	Effluent Type[a]	AU	Final Permitted Discharge (MGD)	Actual (MGD)[c]
WQ0010303-001	Trinity River Authority Central Regional	WW	0841_01	189	133.2
WQ0010494-013	City of Fort Worth Village Creek	WW	0841_02	166	104.5
WQ0011032-001	Alta Vista Mobile Home Park	WW	0841D	0.008	0.006
WQ003446-000	Hanson Pressure Pipe, Inc.	IW/SW	0841_01	NA[b]	1.06
WQ0001441-001, -014, -019, -023, -025	Dallas/Fort Worth International Airport	SW	0841B	NA[b]	None Reported
WQ0001250-003	Extex LaPorte LP – Mountain Creek Lake Steam Electric Station	SW	0841O	NA[b]	0.022

Note: MGD denotes million gallons per day

[a] WW = domestic wastewater treatment facility; IW = industrial wastewater; SW = stormwater

[b] Flow is permitted as *intermittent and variable* with a requirement to measure and report

[c] Average measured discharge from Sept. 2007 through Sept. 2011

A review conducted February 2, 2012 of the EPA Enforcement & Compliance History Online (ECHO) did not reveal any non-compliance issues regarding *E. coli* permit limits for the TRA Central, City of Fort Worth Village Creek, or the Alta Vista Mobile Home Park WWTFs. Unauthorized discharges reported for the TRA Central and City of Fort Worth Village Creek WWTFs were sanitary sewer overflows from the TRA or Fort Worth collection systems.

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 SSO data reported by municipalities. This SSO database typically contains an estimate of the total gallons spilled, responsible entity, and a general location of the spill. As part of implementation planning efforts for area bacteria TMDLs, this dataset was refined by the NCTCOG by assigning latitude and longitude coordinates to each SSO event and plotted using GIS software in an effort to characterize the frequency and magnitude of SSO events within the impaired AUs covered in this report.

The location of SSO events that occurred within the Lower West Fork Trinity River watershed between January 2005 and February 2010 are shown in Figure 5 and are summarized in Table 5 for each of the impaired AUs. The much smaller median volume for each AU as compared to the average volume indicates that most of the SSO events were small. The largest total volume for SSOs occurred within the drainage areas of Lower West Fork Trinity River (0841_02), Delaware Creek (0841H), and Village Creek (0841T); however, the maximum volume from a single SSO event for each of these three AUs accounts for 65%, 90%, and 85% of the total volumes, respectively.

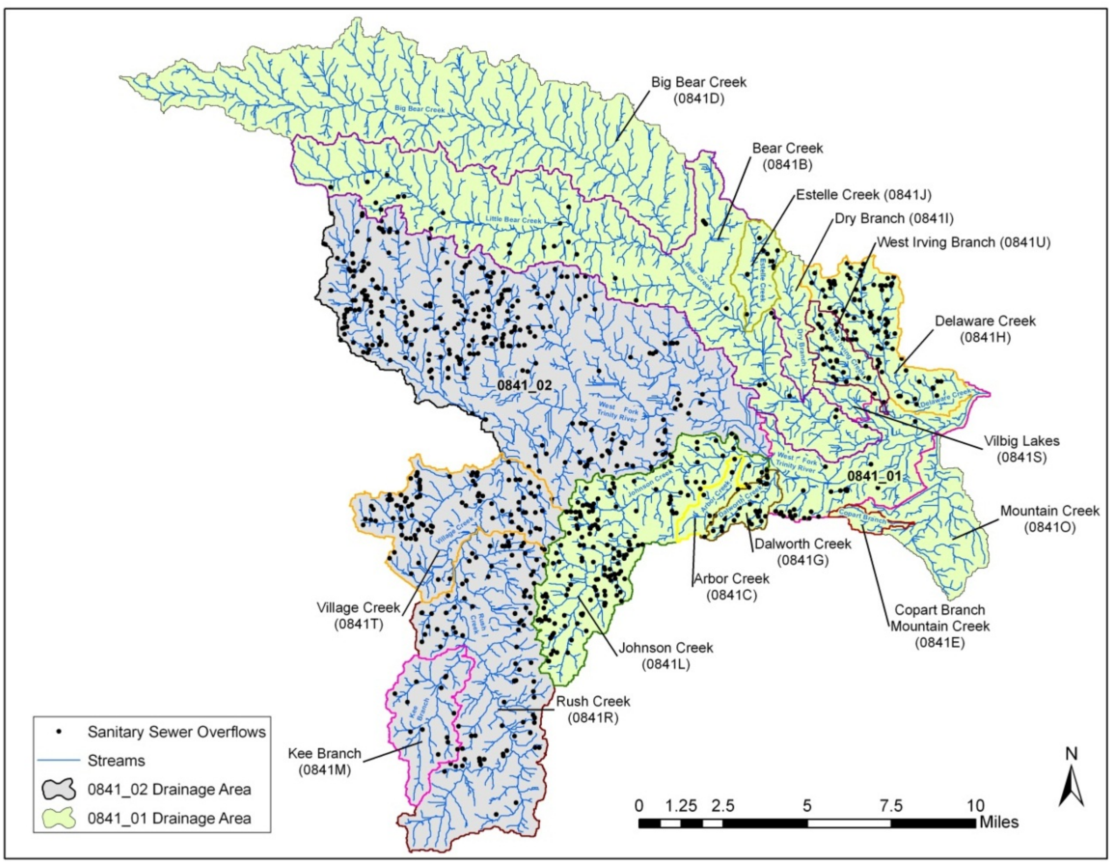

Figure 5. Reported SSO incidences within the Lower West Fork Trinity River watershed for January 2005 – February 2010

Table 5. Summary of SSO incidences reported in the TMDL watersheds

Period from January 2005 – February 2010. Estimated volumes provided by reporting entity.

AU	No. of Incidences	Total Volume (gallons)	Average Volume (gallons)	Median Volume (gallons)	Min Volume (gallons)	Max Volume (gallons)
0841_01	65	26,971	415	50	1	18,000
0841_02	391	3,090,046	7,903	150	1	2,000,000
0841B	44	37,828	860	200	1	7,000
0841C	9	1,646	183	46	15	1,000
0841E	0	NA	NA	NA	NA	NA
0841G	36	15,930	443	100	10	5,000
0841H	121	884,867	7,313	15	1	800,000
0841J	12	1,405	117	63	20	500
0841L	213	85,604	402	59	3	18,000
0841M	15	7,881	525	180	22	2,850
0841R	106	14,161	134	78	1	900
0841T	146	249,207	1,707	100	2	217,500
0841U	57	1,444	25	10	1	100

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 a TPDES-regulated MS4 system, industrial facilities covered under the TPDES Multi-Sector Industrial General Permit for Stormwater, and regulated construction activities covered under the TPDES Construction General Permit.
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 permits for their stormwater systems. Both the Phase I and II permits include any conveyance such as 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 exceeding 100,000, whereas Phase II permits are for smaller communities within an EPA-defined urbanized area that are regulated by a general permit (TXR040000). The purpose of a 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 SWMPs require specification of best management practices (BMPs) for six minimum control measures:

- Public education and outreach;
- Public participation/involvement;
- Illicit discharge detection and elimination;
- Construction site runoff control;
- Post-construction runoff control; and
- Pollution prevention/good housekeeping.

The geographic region of the TMDL watersheds 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 permits, the jurisdictional area is defined by the city limits and for Phase II permits the jurisdictional area is defined as the intersection or overlapping areas of the city limits and the 2010 Census Urbanized Area (U.S. Census Bureau, 2010a) (Figure 6). The TMDL watersheds contain entities that are regulated under either Phase I individual MS4 permits or Phase II general permits (Table 6). The percentage of land area under the jurisdiction of stormwater permits for each of the TMDL watersheds is presented in Table 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 “Any 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 are identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003).

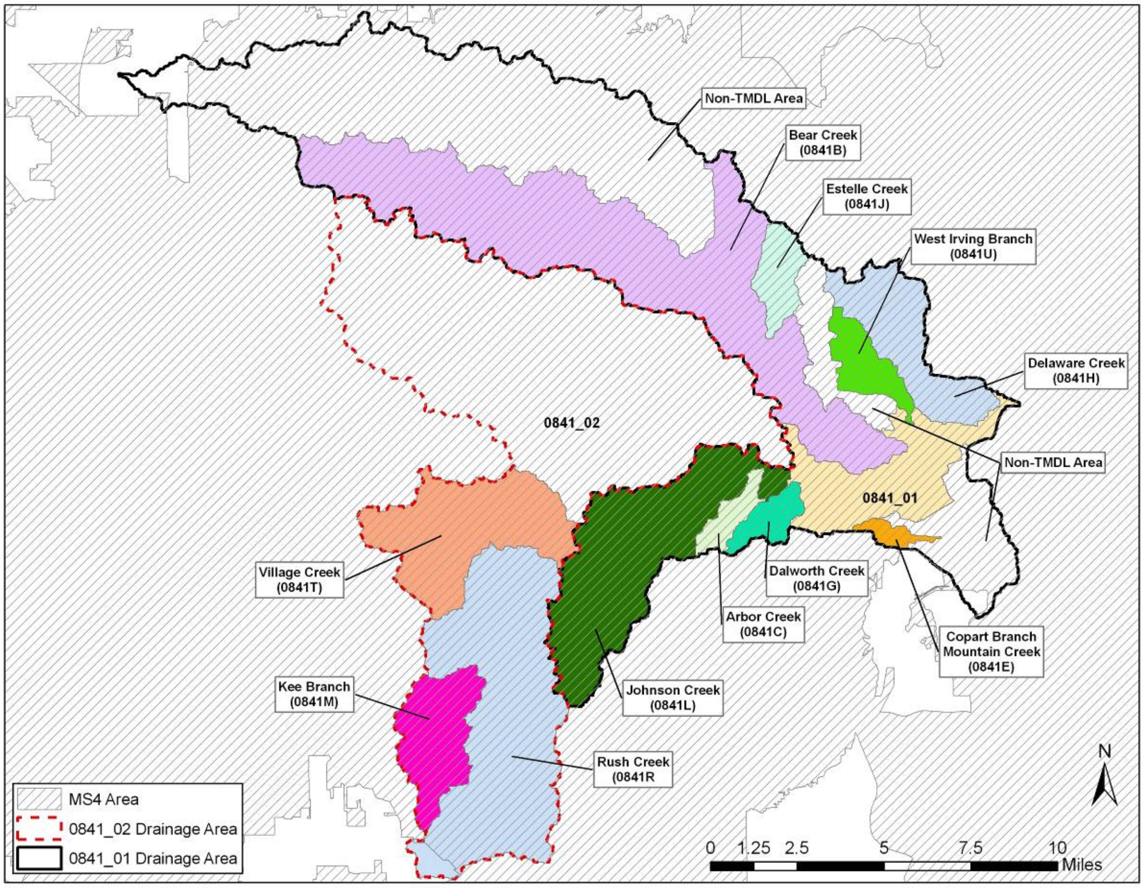

Figure 6. Lower West Fork Trinity River watershed showing MS4 regulated area

Table 6. TPDES MS4 permits associated with the TMDL watersheds

Permits list compiled November 2012.

Entity	MS4 Permit Type	TPDES	NPDES
City of Arlington	Phase I	WQ0004636-000	TXS000301
City of Bedford	Phase II	TXR040000	TXR040119
City of Colleyville	Phase II	TXR040000	TXR040023
City of Dallas	Phase I	WQ0004396-000	TXS000701
City of Dalworthington Gardens	Phase II	TXR040000	TXR040015
City of Euless	Phase II	TXR040000	TXR040211
City of Fort Worth	Phase I	WQ0004350-000	TXS000901
City of Grand Prairie	Phase II	TXR040000	TXR040065
City of Grapevine	Phase II	TXR040000	TXR040114
City of Hurst	Phase II	TXR040000	TXR040039
City of Irving	Phase I	WQ0004691-000	TXS001301

Entity	MS4 Permit Type	TPDES	NPDES
City of Keller	Phase II	TXR040000	TXR040017
City of Kennedale	Phase II	TXR040000	TXR040006
City of Mansfield	Phase II	TXR040000	TXR040207
City of North Richland Hills	Phase II	TXR040000	TXR040113
City of Richland Hills	Phase II	TXR040000	TXR040089
City of Southlake	Phase II	TXR040000	TXR040007
Dallas Area Rapid Transit	Phase II	TXR040000	TXR040232
Dallas County	Phase II	TXR040000	TXR040120
Dallas County Flood Control District 1	Phase II	TXR040000	TXR040255
Dallas Fort Worth International Airport Board	Phase II	TXR040000	TXR040044
Tarrant County College District	Phase II	TXR040000	TXR040380
Tarrant County	Phase II	TXR040000	TXR040052
Texas Department of Transportation (TxDOT) Fort Worth District	Phase II	TXR040000	TXR040184
Town of Pantego	Phase II	TXR040000	TXR040325

Table 7. Area under the jurisdiction of MS4 permits for TMDL Watersheds

MS4 areas based on 2010 U.S. Census Urbanized Areas

AU	Area under jurisdiction of MS4 permits (hectares)	Total watershed area (hectares)	Percentage of drainage area under jurisdiction of MS4 permits (%)
0841_01	2,883	2,883	100
0841_02	15,803	15,803	100
0841B	10,912	10,912	100
0841C	479	479	100
0841E	248	248	100
0841G	567	567	100
0841H	2,297	2,297	100
0841J	817	817	100
0841L	4,940	4,940	100
0841M	1,855	1,855	100
0841R	6,835	7,063	97
0841T	3,673	3,673	100
0841U	1,075	1,075	100

Examples of 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.

Examples of 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.

Unregulated Sources

Unregulated sources of bacteria are generally nonpoint. Nonpoint source (NPS) 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, failing on-site sewage facilities (OSSFs), unmanaged animals, and domestic pets.

Wildlife and Unmanaged Animal Contributions

E. coli bacteria are common inhabitants of the intestines of all warm blooded animals, including wildlife such as mammals and birds. In developing bacteria TMDLs, it is important to identify by watershed the potential for bacteria contributions from wildlife. Wildlife are naturally attracted to riparian corridors of streams and rivers. With direct access to the stream channel, the direct deposition of wildlife waste can be a concentrated source of bacteria loading to a water body. Fecal bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff.

Unregulated Agricultural Activities and Domesticated Animals

An estimate of the number of livestock that are raised in Dallas and Tarrant Counties was obtained from the 2007 Census of Agriculture (USDA, 2007) (Table 8). These data are for the entirety of Dallas and Tarrant Counties, which is the lowest level of spatial data available on livestock. The countywide data in Table 8 do not reflect actual numbers in the Lower West Fork Trinity River watershed, but do reflect anticipated relative livestock populations; e.g., more cattle and calves present in the watershed than goats. Due to the highly urbanized nature of the vast majority of the TMDL watersheds, livestock are anticipated to occur in significantly reduced numbers per unit area as compared to the more rural portions of Dallas and Tarrant Counties. Activities, such as livestock grazing close to water bodies and the use of manure as fertilizer, can contribute *E. coli* to nearby water bodies. The countywide livestock numbers in Table 8 are provided to demonstrate that livestock are a potential source of bacteria in the watershed. These livestock numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock.

Table 8. Livestock statistics in Dallas and Tarrant Counties

Note: Countywide data, values not exclusively for the Lower West Fork Trinity River watershed.

Livestock Type	Dallas County	Tarrant County
Cattle (All)	12,395	17,867
Horses and Ponies	2,463	4,518
Chickens	2,531	2,841
Goats (All)	1,429	2,122
Sheep and Lambs	703	421
Mules, Burros, and Donkeys	283	359
Rabbits	(W)	242
Turkeys	119	47
Bison	N/A	46
Deer	W*	42
Hogs and Pigs	101	275
Llamas	39	159

*W denotes withheld by U.S. Department of Agriculture to avoid disclosing data from individual farms.

Pets can also be sources of *E. coli* bacteria, because storm runoff carries the animal wastes into streams (USEPA, 2009). The number of domestic pets in the Lower West Fork Trinity River watershed was estimated based on human population and number of households obtained from the U.S. Census Bureau (U.S. Census Bureau, 2010b). The information obtained from the U.S. Census Bureau included population and household projections based on the 2010 census for tracts that encompassed the watersheds of each AU. The tract level data were multiplied by the proportion of each census tract 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 tract, which is the best estimate that can be made with the available data.

The estimated number of dogs and cats for each segment of the watershed with elevated bacteria levels are summarized in Table 9. Pet population estimates were calculated as the estimated number of dogs (0.632) and cats (0.713) per household (AVMA, 2009). The actual contribution and significance of *E. coli* loads from pets reaching the water bodies of the TMDL watersheds is unknown.

Table 9. Estimated households and pet populations within TMDL watersheds

AU	Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
0841_01	5,935	3,751	4,232
0841_02	35,089	22,176	25,018
0841B	32,344	20,441	23,061
0841C	1,410	891	1,006
0841E	321	203	229
0841G	2,823	1,784	2,013
0841H	18,254	11,537	13,015
0841J	3,941	2,490	2,810
0841L	25,612	16,187	18,261
0841M	10,425	6,589	7,433
0841R	32,278	20,399	23,014
0841T	16,437	10,388	11,719
0841U	7,508	4,745	5,353

Failing On-site Sewage Facilities

Failing OSSFs were not considered a major source of bacteria loading in the TMDL watersheds because nearly all drainage areas of the Lower West Fork Trinity River are served by centralized wastewater collection and treatment systems. Areas serviced by centralized treatment and collection systems typically contain very few OSSFs and this is the situation for the TMDL watersheds where NCTCOG information indicates that only the southern, upstream tip of the Rush Creek watershed was not included in areas serviced by centralized wastewater treatment and sewered collection areas.

Bacteria Re-growth 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 they can survive and replicate 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 re-growth is less well understood. Both processes (replication and die-off) are in-stream processes and are not considered in the bacteria source loading estimates of each water body in the TMDL watersheds.

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. The 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. During ambient flows, these constant 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 is typically diluted, and would therefore be a smaller part of the overall concentrations.

Bacteria load contributions from regulated and non-regulated stormwater sources are greatest during runoff events. Rainfall runoff, depending upon the severity of the storm, 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 reduce because the sources of indicator bacteria are attenuated as runoff washes them from the land surface and the volume of runoff decreases following the rain event.

Load Duration Curve Analysis

Load duration curve (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. LDCs are a simple statistical method that provides a basic description of the water quality problem. The strength of this tool is that it 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. Historical bacteria data used in the LDCs included all available *E. coli* data collected at a monitoring station and were not constrained to the seven-year period used in assessing attainment in the *2010 Texas Integrated Report*. While the number of observations required to develop a flow duration curve is not rigorously specified, the curves are usually based on more than five years of observations, and encompass inter-annual and seasonal variation.

For this study, locations with at least 24 *E. coli* data points were considered as having an adequate amount of data for LDC development. Bacteria data were obtained from SWQMIS for the period of 2001 to 2011. In addition to the ambient data used in the Texas Integrated Report, non-ambient data (flow biased) was also used in the development of the LDCs. Ideally, the drought of record and flood of record are included in the observations. On numerous creeks and rivers in Texas, U.S. Geological Survey (USGS) streamflow gauging stations have been in operation for a sufficient period to be used as the source of the needed streamflow records.

The daily streamflow record from USGS gauging station 08049500 on Lower West Fork Trinity River at Beltline Road, Grand Prairie, TX (Figure 3) was used as the basis for each LDC developed in the Lower West Fork Trinity River watershed. The 25-year streamflow record from this gauge for July 1, 1986 through June 30, 2011 was selected as representing a reasonable range of extremes in high and low streamflows. The required daily streamflow record for each LDC was estimated based on application of a drainage area ratio computed as the drainage area above the LDC location divided by the drainage area of USGS gauge 08049500. Prior to application of the drainage area ratio, the USGS gauge record was corrected by removing (subtracting) the sole upstream discharge, the City of Fort Worth Village Creek WWTF, based on their DMR information.

The resulting discharge-corrected 25-year record of daily flows included values of zero approximately 7% of the time, which based on qualitative analyses of flow measurements at TCEQ monitoring stations was a reasonable representation of the occurrence of no flow for water bodies in the TMDL watersheds. After multiplication of the corrected streamflow record by the drainage area ratio, a final adjustment occurred for the purposes of pollutant load computations. The hydrologic records were adjusted to reflect full permitted flows from all upstream WWTFs and future capacity estimates that account for the probability that additional flows from WWTF discharges may occur as a result of population increases. More details on the methods used to develop the LDCs may be found in the *Technical Support Document for Total Maximum Daily Load for Indicator Bacteria in the Lower West Fork Trinity River Watershed* (Millican and Hauck, 2012).

Flow duration curves (FDCs) and LDCs were developed for the 30 TCEQ monitoring stations along the impaired AUs of the main stem and tributaries of the Lower West Fork Trinity River for which adequate *E. coli* data were available, and at the most upstream and downstream points (inlets and outlets) from within each impaired AU. The daily flow data in units of cubic meters per second (cms) were used to first develop a FDC for each station.

In order to systematically develop the TMDL allocation for each TMDL watershed, an inlet/outlet approach was used with the FDCs and LDCs that allows the accumulation of allowable loads in the downstream direction. Under this approach, each TMDL watershed has an outlet point located at the most downstream end of the water body within the watershed. It is at this outlet location that the TMDL allocation is defined through the FDC and LDC for that location.

For several of the TMDL watersheds, there exist upstream water bodies that contribute streamflow and bacteria loadings from beyond the geographic boundaries of the watershed. The loadings entering a TMDL watershed through one or more of these upstream water bodies were defined through inlet locations to that water body. An inlet was not defined for any TMDL watershed that receives no flows and bacteria except from within its watershed. An inlet was defined for each upstream and tributary inflow into an AU. For example, 0841_02 has two inlets defined – the West Fork Trinity River (Segment 0806) and Village Creek (0841T).

Each flow duration curve was generated by

- ranking the daily flow data from highest to lowest,
- calculating the percent of days each flow was exceeded (rank ÷ quantity of the number of data points + 1), and
- plotting each flow value (y-axis) against its exceedance value (x-axis).

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% occur during low flow or drought conditions while values approaching 0% occur during periods of high flow or flood conditions.

Bacteria LDCs were developed by multiplying each streamflow value along the flow duration curves 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 (cms) * conversion factor

Where:

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

Conversion factor (to MPN/day) = 864,000,000 100 mL/m^3 * seconds/day

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 LDCs at each TCEQ monitoring station, 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 flow duration curve 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 load duration curve 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.

The flow exceedance frequency can be subdivided into hydrologic condition classes to facilitate the diagnostic and analytical uses of FDCs and LDCs. The hydrologic classification scheme utilized for the Lower West Fork Trinity River TMDLs is as follows: very high flows (0 – 10%), high flows (10 – 50%), and low flows (50 – 100%). These three flow regimes were based on hydrology (slope of the FDCs and LDCs) and patterns in the historical observations (predominance of *E. coli* loading data either above or below the allowable loading). Additional information explaining the load duration curve method may be found in Cleland (2003) and NDEP (2003).

The median loading of the very high flow regime (0-10% exceedance) is used for the TMDL calculations of the impaired AUs in the Lower West Fork Trinity River watershed. The median loading of the very high flow regime (5% exceedance) is used for the TMDL calculations, because it represents a reasonable yet high value for the allowable pollutant load allocation.

Load Duration Curve Results

At the 30 TCEQ monitoring station locations with adequate *E. coli* data, load relationships and possible sources were defined through LDCs created with historical *E. coli* data and the associated flow duration curves (Appendix A). Exceedances of the geometric mean criterion of 126 MPN by the historical data were generally more common at higher flows than at lower flows at the majority of monitoring stations.

The LDCs for the inlets and outlets of TMDL watersheds do not have associated historical *E. coli* data and were constructed for developing the TMDL allocation for each of the segments (Figures 7-12). The inlet LDCs defined the upstream allowable loading entering the AUs from a defined upstream water body, and outlet LDCs define the allowable loading leaving the AU. In the Lower West Fork Trinity River watershed, many of the tributary streams contribute upstream loading to 0841_01 or 0841_02, or to another tributary as indicated in Figures 7-12. As anticipated, the allowable loading increases in the downstream direction from inlet to outlet.

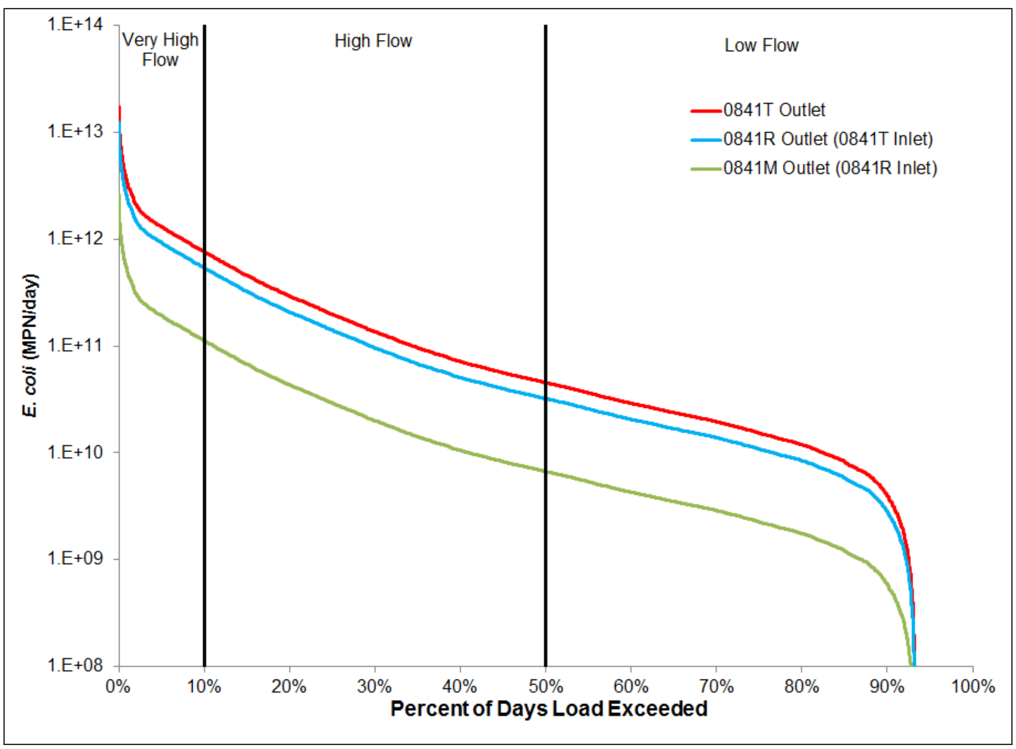

Figure 7. Load Duration Curves for the inlets and outlets of Village Creek (0841T), Rush Creek (0841R), and Kee Branch (0841M)

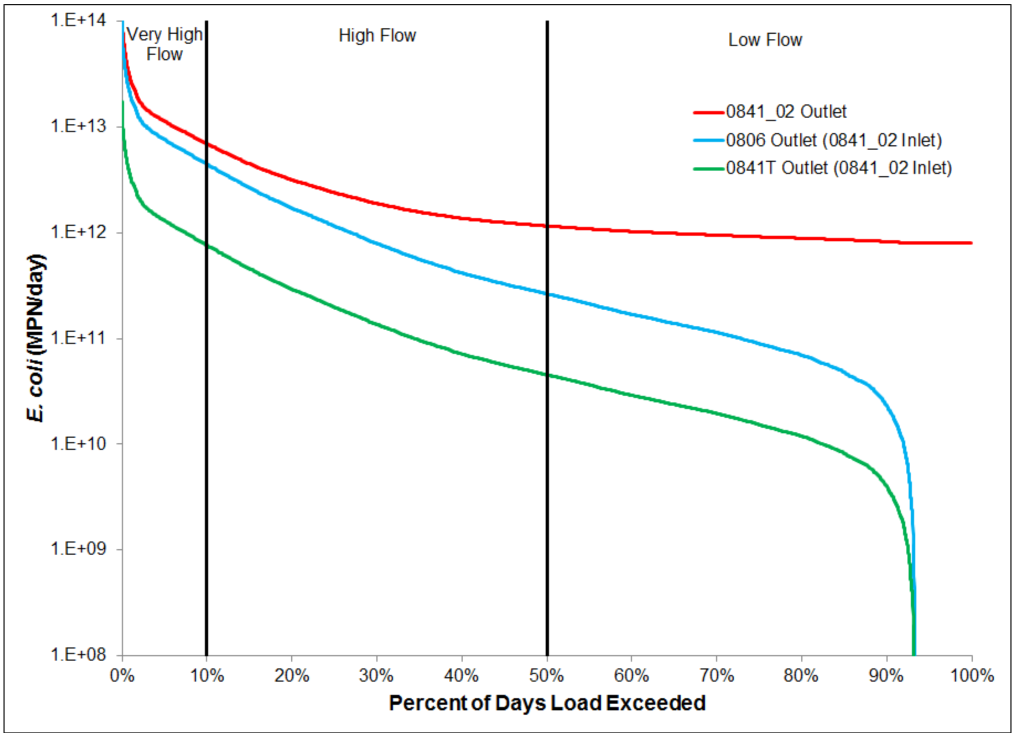

Figure 8. Load Duration Curves for the inlets and outlets of Lower West Fork Trinity River (0841_02), West Fork Trinity River (0806), and Village Creek (0841T)

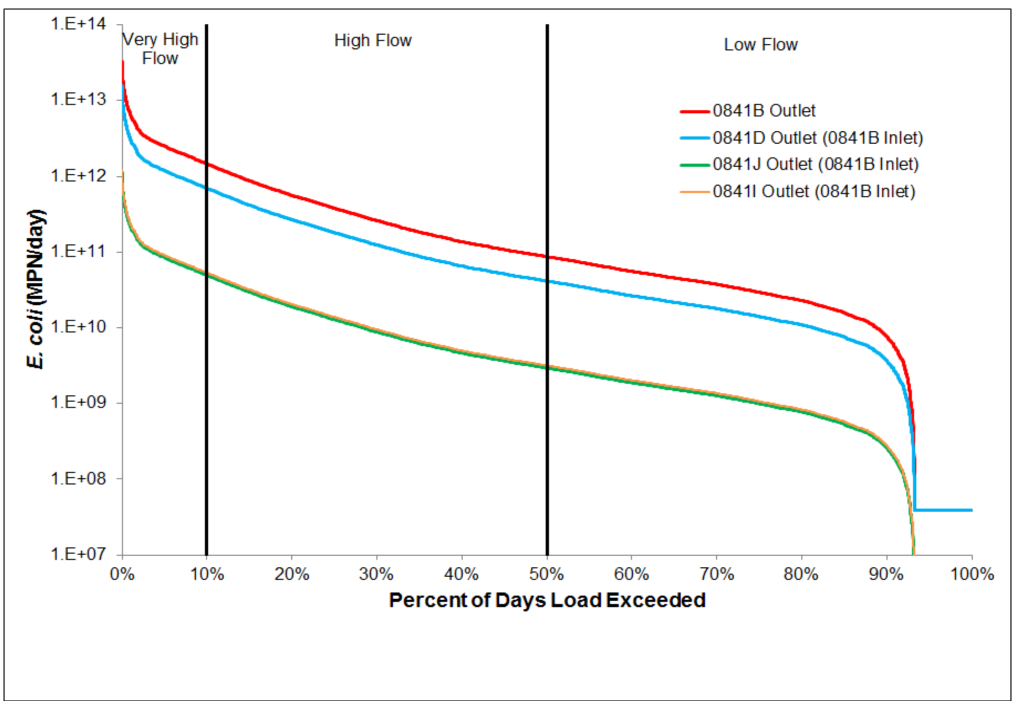

Figure 9. Load Duration Curves for the inlets and outlets of Bear Creek (0841B), Big Bear Creek (0841D), Estelle Creek (0841J), and Dry Branch (0841I)

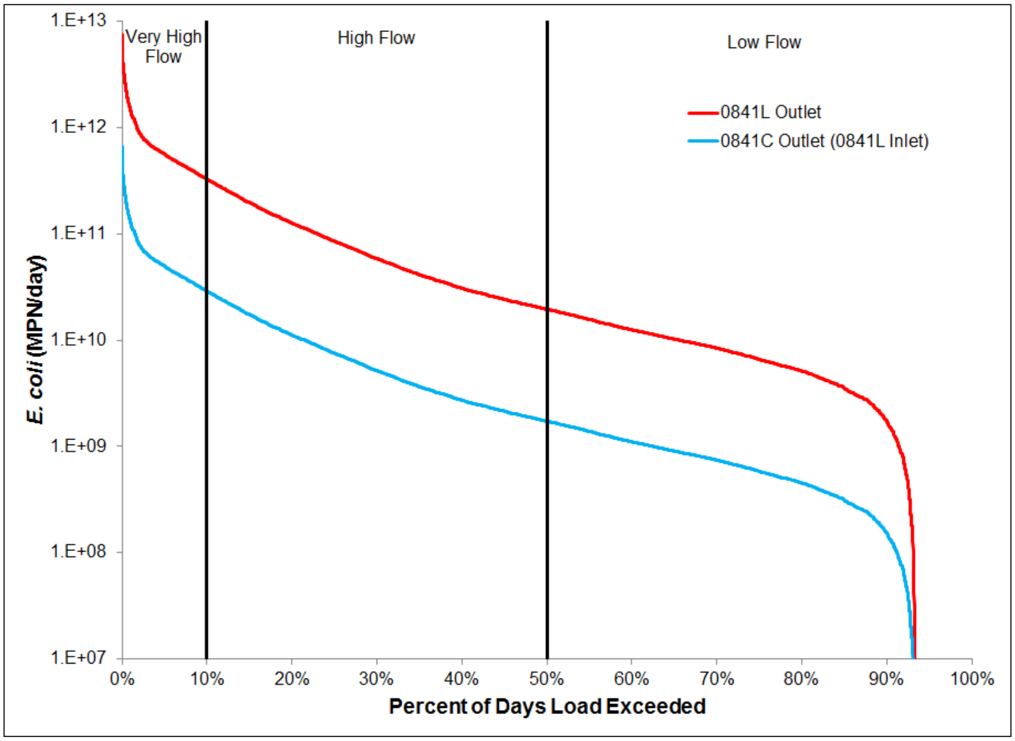

Figure 10. Load Duration Curves for the inlets and outlets of Johnson Creek (0841L) and Arbor Creek (0841C)

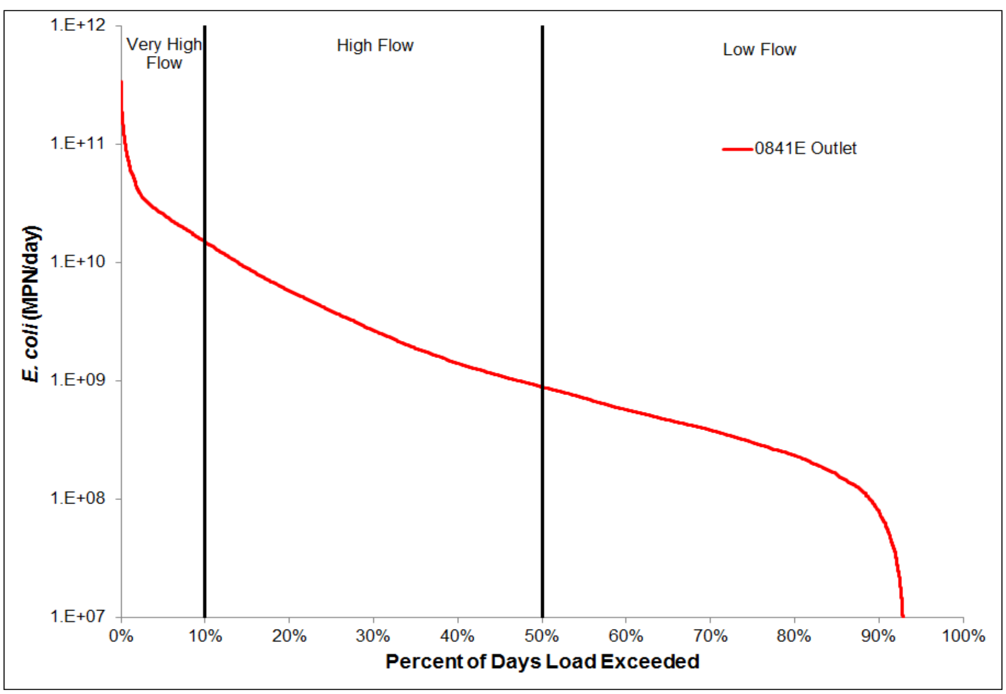

Figure 11. Load Duration Curves for the outlet of Copart Branch Mountain Creek (0841E)

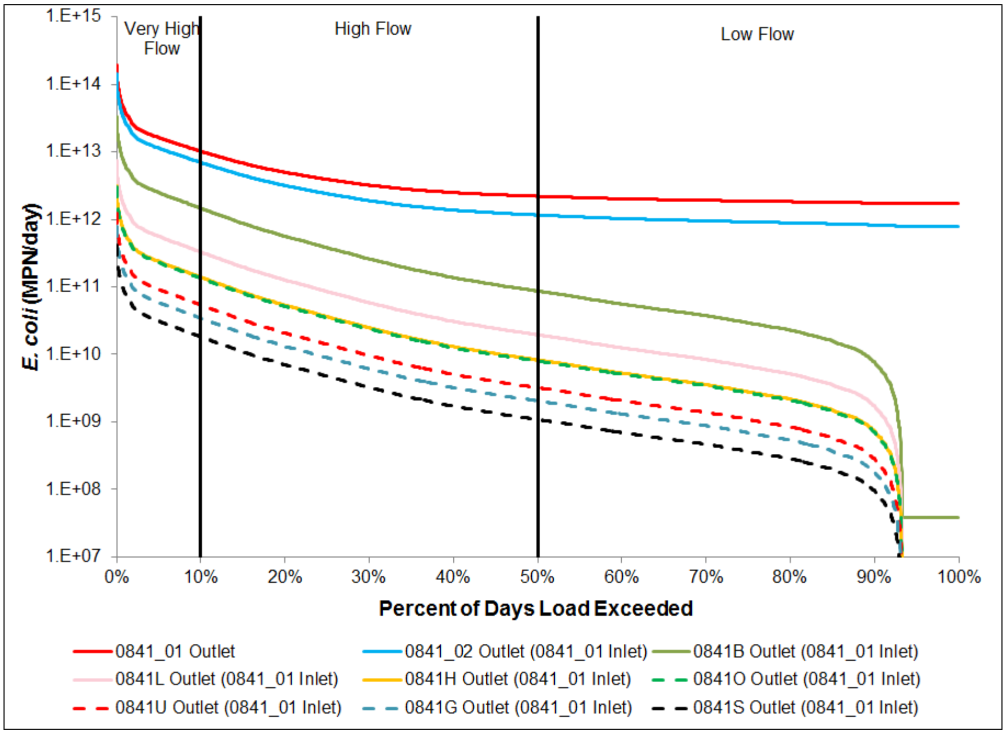

Figure 12. Load duration curves at the inlets and outlets of Lower West Fork Trinity River (0841_01 and 0841_02), Bear Creek (0841B), Johnson Creek (0841L), Dalworth Creek (0841G), West Irving Branch (0841U), Vilbig Lake (0841S), Delaware Creek (0841H), and Mountain Creek (0841O)

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 TMDLs covered by this report incorporate an explicit MOS by setting a target for indicator bacteria loads that is 5% lower than the geometric mean criterion. For contact recreation, this equates to a geometric mean target of 120 MPN/100 mL of *E. coli*. 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 13 impaired AUs were calculated using the following equation:

$$TMDL = \Sigma WLA + \Sigma LA + \Sigma FG + MOS$$

Where:

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

LA (load allocation) = the amount of pollutant allowed by unregulated or unregulated sources

FG (future growth) = 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. For *E. coli*, TMDLs are expressed as MPN/day, and represent the maximum load the stream can assimilate in a single, average day while still attaining the standards for surface water quality.

The bacteria TMDLs for the AUs covered in this report were derived using the median flow (or 5% flow) within the very high flow regime of the LDC developed for the outlet of each AU.

Wasteload Allocation

The WLA is the sum of loads from regulated sources.

WWTFs

TPDES-regulated WWTFs are allocated a daily waste load (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. This is expressed in the following equation:

$$WLAW_{WTF} = Target * Flow\ (MGD) * conversion\ factor$$

Where:

Target = 63 MPN/100 mL

Flow (MGD) = full permitted flow

Conversion factor = 37,854,000 100 mL / MGD

Three facilities that treat domestic wastewater are located within the Lower West Fork Trinity River watershed. Along the main stem of the Lower West Fork Trinity River is the City of Fort Worth Village Creek WWTF (WQ0010949-013) located within 0841_02, and the TRA Central Regional WWTF (WQ0010303-001) located within 0841_01. Loadings arising from these two facilities represent the WLA_{WWTF} allocation in the AU in which each facility discharges. The Alta Vista Mobile Home Park WWTF (WQ0011032-001) is located within the watershed of non-impaired Big Bear Creek (0841D), a tributary to Bear Creek (0841B). Loadings arising from the Alta Vista Mobile Home Park WWTF are incorporated into the upstream loading entering Bear Creek. A WLA_{WWTF} allocation is provided for the mobile home facility that discharges to Bear Creek since it is located in the Lower West Fork Trinity River watershed. The remaining 10 impaired AUs have no facilities regulated for discharge to include in the WLA_{WWTF} term.

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 these TMDLs due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of each watershed that is under the jurisdiction of stormwater permits (i.e., defined as the area designated as urbanized area in the 2010 US Census) 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. The 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}.

Discharges from Hansen Pressure Pipe (WQ003446-000) and Dallas/Fort Worth International Airport (WQ0001441-001,-014, -019, -023 & -025) are included in the WLA_{SW} category for 0841_01 and 0841B, respectively. The Extex LaPorte LP – Mountain Creek Lake Steam Electric Station (WQ0001250-003) is located within the watershed of non-impaired Mountain Creek (0841O). Therefore, loadings arising from Extex LaPorte are incorporated as tributary loadings from 0841O entering 0841_01 rather than as part of the WLA_{SW}.

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

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

Where:

ΣWLA_{SW} = sum of all regulated stormwater loads

TMDL = total maximum daily load

ΣWLA_{WWTF} = sum of all WWTF loads

LA_{USL} = sum of loading from tributary and upstream AUs

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 urbanized areas currently regulated by an MS4 permit, development and/or re-development of land in the urbanized area must implement the control measures/programs outlined in an approved SWMP. Although additional flow may occur from development or re-development, loading of the pollutant of concern should be controlled and/or reduced through the implementation of BMPs as specified in both the NPDES or TPDES permit and the SWMP.

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

TMDLs in this document will result in protection of existing beneficial uses and conform to Texas's 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 the individual WLAs through the permitting process as monitoring requirements and/or effluent limitations as required by the amendment of 30 Texas Administrative Code (TAC) Chapter 319 which became effective November 26, 2009. WWTFs discharging to the TMDL Segment AUs will be assigned an effluent limit based on the TMDL. Monitoring requirements are based on permitted flow rates and are listed in TAC §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 that implement the WLA for stormwater may be expressed as BMPs or other similar requirements, rather than as numeric effluent limits.

The November 22, 2002 memorandum from EPA relating to establishing WLAs for stormwater sources states:

> "The Interim Permitting Approach Policy recognizes the need for an iterative approach to control pollutants in stormwater discharges. Specifically, the policy anticipates that a suite of BMPs will be used in the initial rounds of permits and that these BMPs will be tailored in subsequent rounds."

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 wasteload allocation, the load allocation, and the margin of safety. 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 TCEQ's WQMP. Any future changes to effluent limitations will be addressed through the permitting process and by updating the WQMP.

Load Allocation

The load allocation is the sum of loads from unregulated sources. The load allocation is the sum of the bacteria load that arises from unregulated sources within the AU (LA_{AU}) and upstream loadings from a tributary or upstream AU that enters into an AU (LA_{USL}):

$$LA = LA_{AU} + \Sigma LA_{USL}$$

Where:

LA = allowable load from unregulated sources (predominantly nonpoint sources)

ΣLA_{USL} = sum of loading from tributary and upstream AUs

LA_{AU} = allowable loads from unregulated sources within the AU

The LA_{USL} is calculated as:

$$LA_{USL} = Criterion * Q_{Inlet}$$

Where:

Criterion = 126 MPN/100 mL

Q_{Inlet} = median value of the very high flow regime at the tributary or upstream AU outlet(s) to an impaired AU.

The unregulated loading within the AU (LA_{AU}) is calculated as:

$$LA_{AU} = TMDL - \Sigma WLA_{WWTF} - \Sigma WLA_{SW} - \Sigma LA_{USL} - \Sigma FG - MOS$$

Where:

LA_{AU} = allowable loads from unregulated sources within the AU

TMDL = total maximum daily load

ΣWLA_{WWTF} = sum of all WWTF loads

ΣWLA_{SW} = sum of all regulated stormwater loads

ΣLA_{USL} = sum of loading from tributary and upstream AUs

ΣFG = sum of future growth loads from potential regulated facilities

MOS = margin of safety load

The TMDL equation can thus be expanded to show the components of WLA and LA:

$$TMDL = \Sigma WLA_{WWTF} + \Sigma WLA_{SW} + LA_{AU} + LA_{USL} + \Sigma FG + MOS$$

Margin of Safety Equation

The margin of safety is only applied to the allowable loading for an AU and is not applied to the LA_{USL} that enters the segment as an external loading (i.e., originates outside the segment). Therefore, the margin of safety is expressed mathematically as the following:

$$MOS = 0.05 * (TMDL - \Sigma LA_{USL})$$

Where:

MOS = margin of safety load

TMDL = total maximum allowable load

ΣLA_{USL} = sum of loading from tributary and upstream AUs

Allowance for Future Growth

The future growth component of the TMDL equation addresses the requirement to account for future loadings that may occur as a result of population growth, changes in community infrastructure, and development. Specifically, this TMDL component takes into account the probability that new flows from WWTF discharges may occur in the future. The assimilative capacity of streams increases as the amount of flow increases. The allowance for future growth will result in protection of existing beneficial uses and conform to Texas's antidegradation policy.

Currently there are two facilities that treat domestic wastewater and discharge into impaired AUs within the Lower West Fork Trinity River watershed. The City of Fort Worth Village Creek WWTF discharges into 0841_02, and the TRA Central Regional WWTF discharges into 0841_01. The Village Creek WWTF is built out with no capacity for expansion beyond its current size, while the Central Regional WWTF has additional capacity for expansion.

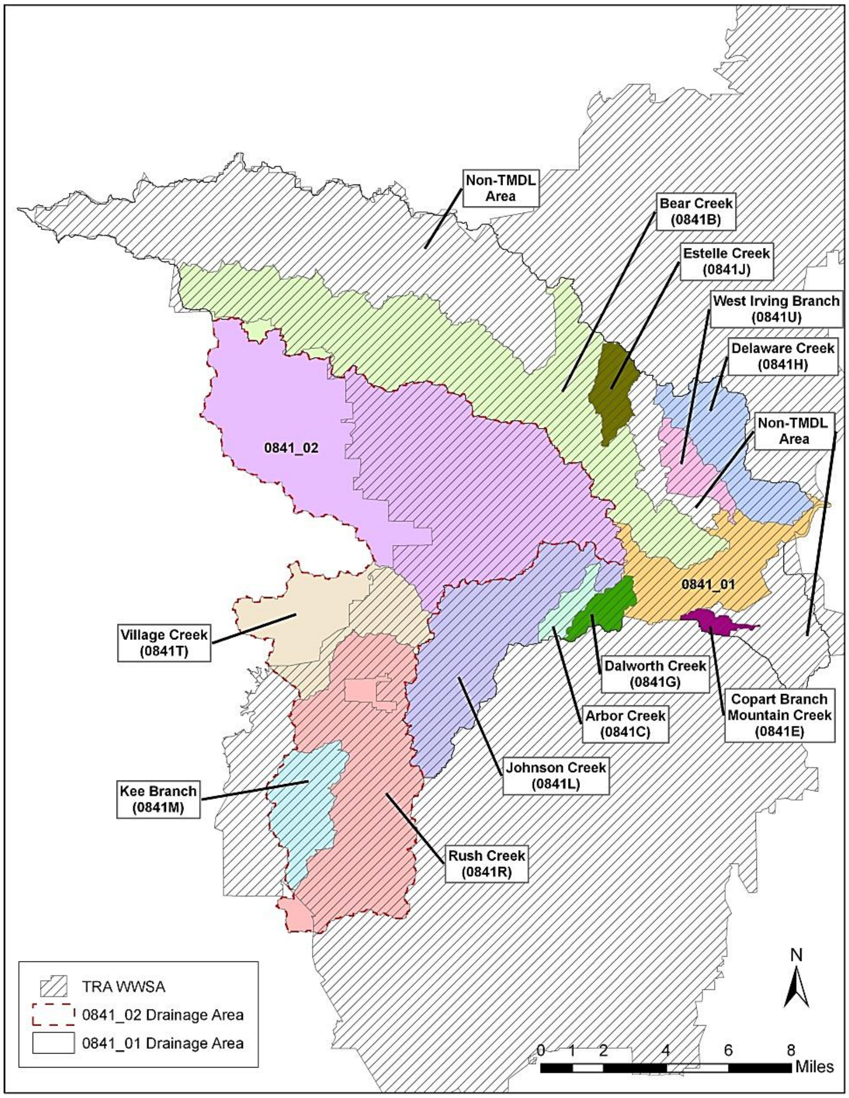

Figure 13. Wastewater service area of the TRA Central Regional WWTF within the Lower West Fork Trinity River watershed

The majority of the Lower West Fork Trinity River watershed is serviced by the TRA Central Regional WWTF (Figure 13). Planned expansions of the TRA Central Regional WWTF will increase the permitted discharge from 189 MGD to 232 MGD based on long term projections to the year 2040, which is an increase of 43 MGD (TRA, 2012b). This additional 43 MGD serves as the future growth component for those areas serviced by the TRA Central Regional WWTF and is applied to the TMDL of 0841_01 since the discharge occurs into that section of the Lower West Fork Trinity River. Since all wastewater collected within the watersheds of Arbor Creek (0841C), Copart Branch Mountain Creek (0841E), Dalworth Creek (0841G), Delaware Creek (0841H), Estelle Creek (0841J), Johnson Creek (0841L), Kee Branch (0841M), and West Irving Branch (0841U) are sent to the TRA Central Regional WWTF and subsequently discharged into

0841_01, the future growth component for these eight AUs was not explicitly derived and was set to a value of zero.

The Future Growth term of AU0841_01 was calculated using the identical equation applied to determine the WLA_{WWTF} term based on an increase in discharge of 43 MGD.

To account for the probability that new flows from WWTF discharges may occur in areas within the TMDL watersheds that are outside of the TRA Central Regional WWTF service area, a provision for future growth was included in the TMDL calculations based on population projections and per capita wastewater use. Current population projections for areas not serviced by the TRA Central Regional WWTF were obtained from the 2010 U.S. Census (U.S. Census Bureau, 2010), and 2040 projected population increases for these areas were obtained from the NCTCOG. Per capita wastewater use measured in gallons per capita per day (gpcd) was obtained from the TRA and represents projected wastewater usage for the year 2040 (TRA, 2012b).

For the remaining four AUs, 0841_02, Bear Creek (0841B), Rush Creek (0841R), and Village Creek (0841T), the future growth component for the areas within each AU that are not serviced by the TRA Central Regional WWTF was calculated based on estimated population increases from 2010 to 2040. The estimated increase in population was multiplied by the per capita wastewater usage. The resulting future wastewater flow was then converted into a loading (see Equation 3). Thus, the future growth (FG) is calculated as follows:

$$FG = Target * [POP_{2010\text{-}2040} * Use] * Conversion\ Factor$$

Where:

Target = 63 MPN/100 mL

$POP_{2010\text{-}2040}$ = estimated increase in population between 2010 and 2040

Use = average per capita water usage (101.77 gpcd)

Conversion factor = 37.854 100 mL/gallon

Compliance with these TMDLs is based on keeping the bacteria concentrations in the selected waters below the limits that were set as criteria for the individual sites. Future growth of existing or new point sources is not limited by these TMDLs as long as the sources do not cause bacteria to exceed the limits. The assimilative capacity of streams increases as the amount of flow increases. Consequently, increases in flow allow for increased loadings. The LDC and tables in this TMDL will guide determination of the assimilative capacity of the stream under changing conditions, including future growth.

TMDL Calculations

The TMDL was calculated based on the median flow in the 0-10 percentile range (very high flow regime) from the LDC developed for the outlet of each impaired AU (Figures 7-12). Each term in the TMDL equation was determined based on the equations provided previously.

Table 10 summarizes the calculation of the TMDL and LA_{USL} for each segment. For each AU with tributary and upstream load allocations, the LA_{USL} is the sum of downstream allowable loading calculated at the outlet of the applicable tributary.

The tributaries used in the LA_{USL} calculations are specified below.

- Lower West Fork Trinity River (0841_01)
  LA_{USL} = sum of the allowable loading calculated at the outlet of:
  Lower West Fork Trinity River (0841_02),
  Bear Creek (0841B),
  Dalworth Creek (0841G),
  Delaware Creek (0841H),
  Johnson Creek (0841L),
  Mountain Creek (0841O),
  Vilbig Lake (0841S), and
  West Irving Branch (0841U).
- Lower West Fork Trinity River (0841_02)
  LA_{USL} = the sum of the loading calculated at the outlet of:
  West Fork Trinity River (0806) and
  Village Creek (0841T).
- Bear Creek (0841B)
  LA_{USL} = the loading calculated at the outlet of:
  Big Bear Creek (0841D),
  Dry Branch (0841I), and
  Estelle Creek (0841J).
- Johnson Creek (0841L)
  LA_{USL} = the loading calculated at the outlet of:
  Arbor Creek (0841C).
- Rush Creek (0841R)
  LA_{USL} = the loading calculated at the outlet of:
  Kee Branch (0841M).
- Village Creek (0841T)
  LA_{USL} = the loading calculated at the outlet of:
  Rush Creek (0841R).

Based on the information in Table 10, the MOS can be computed (Table 11).

Table 10. TMDL and LA_{USL} loadings for AUs within the Lower West Fork Trinity River watershed

AU	Segment Name	Upstream Allowable Loading		Downstream Allowable Loading	
		Q_{Inlet}[a] (cms[f])	LA_{USL}[b] (Billion MPN/100 mL)	Outlet Flow[c] (cms)	TMDL[d] (Billion MPN/100 mL)
Segment 0806	West Fork Trinity River below Lake Worth[e]	not needed	not needed	70.59	7,685
0841_01	Lower West Fork Trinity River	139.54	15,191	150.59	16,390
0841_02	Lower West Fork Trinity River	82.70	9,003	105.16	11,448
0841B	Bear Creek	12.66	1,378	23.15	2,520
0841C	Arbor Creek	0	0	0.46	50.10
0841D	Big Bear Creek[e]	0	0	11.03	1,201
0841E	Copart Branch Mountain Creek	0	0	0.24	25.92
0841G	Dalworth Creek	0	0	0.55	59.37
0841H	Delaware Creek	0	0	2.21	240.4
0841I	Dry Branch[e]	0	0	0.84	91.94
0841J	Estelle Creek	0	0	0.79	85.46
0841L	Johnson Creek	0.46	50.10	5.21	567.0
0841M	Kee Branch	0	0	1.78	194.1
0841O	Mountain Creek[e]	0.24	25.92	2.12	231.1
0841R	Rush Creek	1.78	194.1	8.57	933.2
0841S	Vilbig Lake[e]	0	0	0.29	31.51
0841T	Village Creek	8.57	933.2	12.10	1,317
0841U	West Irving Branch	0	0	0.86	93.17

[a] Inlet median value from very high flow regime for all tributaries and upstream AUs

[b] Inlet allowable loading; median value from very high flow regime for all tributaries and upstream AUs

[c] Outlet median value from very high flow regime

[d] Outlet allowable loading; median value from very high flow regime

[e] Segment 0806 and non-impaired segments 0841D, 0841I, 0841O, and 0841S are not receiving individual TMDL allocations; however, their downstream loadings serve as loadings entering impaired watersheds under the LA_{USL} term.

[f] Outlet allowable loading for Big Bear Creek and inlet allowable loading for Bear Creek are reduced by the allowable loading for the Alta Vista Mobile Home Park WWTF (see Table12).

Table 11. MOS allocations for TMDL AUs

AU	Segment Name	MOS (Billion MPN/day)
0841_01	Lower West Fork Trinity River	60.15
0841_02	Lower West Fork Trinity River	122.3
0841B	Bear Creek	57.09
0841C	Arbor Creek	2.505
0841E	Copart Branch Mountain Creek	1.296
0841G	Dalworth Creek	2.969
0841H	Delaware Creek	12.02
0841J	Estelle Creek	4.273
0841L	Johnson Creek	25.84
0841M	Kee Branch	9.704
0841R	Rush Creek	36.95
0841T	Village Creek	19.22
0841U	West Irving Branch	4.658

Table 12 summarizes the daily allowable loading of *E. coli* assigned to WLA_{WWTF} based on the full permitted flow of the three regulated dischargers located within the Lower West Fork Trinity River watershed.

Table 13 summarizes the computation of the future growth loadings. As previously noted, the majority of the TMDL watersheds are serviced by the TRA Central Regional WWTF (Figure 13). The anticipated expansion of the TRA Central Regional WWTF that will result in an additional 43 MGD capacity was the basis for the future growth allocation within Lower West Fork Trinity River (0841_01). The future growth component for Arbor Creek (0841C), Copart Branch Mountain Creek (0841E), Dalworth Creek (0841G), Delaware Creek (0841H), Estelle Creek (0841J), Johnson Creek (0841L), Kee Branch (0841M), and West Irving Branch (0841U), which are serviced by the TRA Central Regional WWTF, were not explicitly derived since all wastewater collected within these AUs is subsequently discharged outside of their watersheds and into Lower West Fork Trinity River (0841_01) (Table 13). The future growth allocations for AUs within the TMDL watersheds that have portions of their area outside of the TRA Central Regional WWTF service area were calculated based on population projections and per capita wastewater use.

Based on the MS4 regulated areas (Figure 6), all of the AUs within TMDL watersheds are completely within the jurisdiction regulated by stormwater permits with the exception of the southernmost portion of Rush Creek (0841R). Table 14 summarizes the computation of the WLA_{SW} term. As noted previously, permitted stormwater discharges from the Hansen Pressure Pipe and Dallas/Fort Worth International Airport outfalls are included in the WLA_{SW} category for 0841_01 and 0841B, respectively.

Table 12. Wasteload allocations for TPDES-regulated facilities

AU	TPDES Number	NPDES Number	Facility Name	Final Permitted Flow (MGD)	WLAWWTF (Billion MPN/day)
0841_01	WQ0010303-001	TX0022802	TRA Central Regional WWTF	189	450.7
0841_02	WQ0010494-013	TX0047295	City of Fort Worth Village Creek WWTF	166	395.9
0841D	WQ0011032-001	TX0023591	Alta Vista Mobile Home Park	0.008	0.019

Table 13. Future Growth computations for the TMDL watersheds outside the TRA Central WWSA

AU	2010 Population	2040 Population Projection	Population Increase 2010 to 2040	Per Capita Wastewater Use (gpcd)	Additional Wastewater Production (MGD)	Future Growth (Billion MPN/day)
0841_01[a]	0	0	0	0	43	102.5
0841_02	89,631	119,715	30,084	101.77	3.06	7.301
0841B	3,003	3,761	758	101.77	0.077	0.1840
0841C[b]	0	0	0	0	0	0
0841E[b]	0	0	0	0	0	0
0841G[b]	0	0	0	0	0	0
0841H[b]	0	0	0	0	0	0
0841J[b]	0	0	0	0	0	0
0841L[b]	0	0	0	0	0	0
0841M[b]	0	0	0	0	0	0
0841R	4,319	7,873	3,554	101.77	0.362	0.8626
0841T	23,599	53,443	29,844	101.77	3.04	7.243
0841U[b]	0	0	0	0	0	0

[a]Future Growth for 0841_01 is based exclusively on the 43 MGD expansion of the TRA Central WWTF.

[b]Future Growth was not explicitly derived since all wastewater collected within the AU is discharged to 0841_01.

Table 14. Regulated stormwater computation for TMDL watersheds

All loads expressed as billion MPN/day

AU	TMDL	WLA_{WWTF}	Future Growth	LA_{USL}	MOS	FDA_{SWP}	WLA_{SW}
0841_01	16,394	450.7	102.5	15,191	60.15	1.000	589.6
0841_02	11,448	395.9	7.301	9,003	122.3	1.000	1,920
0841B	2,520	0	0.1840	1,378	57.09	1.000	1,085
0841C	50.10	0	0	0	2.505	1.000	47.59
0841E	25.92	0	0	0	1.296	1.000	24.62
0841G	59.37	0	0	0	2.969	1.000	56.41
0841H	240.4	0	0	0	12.02	1.000	228.4
0841J	85.46	0	0	0	4.273	1.000	81.19
0841L	567.0	0	0	50.10	25.84	1.000	491.0
0841M	194.1	0	0	0	9.704	1.000	184.4
0841R	933.2	0	0.8626	194.1	36.95	0.972	678.7
0841T	1,317	0	7.243	933.2	19.22	1.000	357.9
0841U	93.17	0	0	0	4.658	1.000	88.51

The LA_{AU} is the allowable bacteria loading assigned to unregulated sources within each TMDL watershed. With the exception of Rush Creek (0841R), the entire area of all AUs within the TMDL watersheds are regulated by stormwater permits. Therefore, the LA_{AU} term for all AUs except Rush Creek is zero. For Rush Creek (0841R), 200 ha or 2.8% of its drainage area is not regulated by stormwater permits. Table 15 summarizes the computation of the term LA_{AU}.

Table 16 summarizes the TMDL calculations for the 13 impaired AUs comprising the TMDL watersheds. Each of the TMDLs was calculated based on the median flow in the 0-10 percentile range (very high flow regime) for flow exceedance from the LDC developed for the outlet of each AU. Allocations are based on the current geometric mean criterion for *E. coli* in freshwater of 126 counts/100 mL for each component of the TMDL.

Table 15. Unregulated stormwater (LA_{AU}) allocations

AU	Segment Name	LA_{AU} (Billion MPN/day)
0841_01	Lower West Fork Trinity River	0
0841_02	Lower West Fork Trinity River	0
0841B	Bear Creek	0
0841C	Arbor Creek	0
0841E	Copart Branch Mountain Creek	0
0841G	Dalworth Creek	0
0841H	Delaware Creek	0
0841J	Estelle Creek	0
0841L	Johnson Creek	0
0841M	Kee Branch	0
0841R	Rush Creek	22.58
0841T	Village Creek	0
0841U	West Irving Branch	0

Table 16. TMDL allocation summary for impaired AUs within the Lower West Fork Trinity River watershed

All loads expressed as billion MPN/day

AU	Segment Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA_{AU}[e]	LA_{USL}[f]	LA Total	Future Growth[g]
0841_01	Lower West Fork Trinity River	16,394	60.15	450.7	589.6	0	15,191	15,191	102.5
0841_02	Lower West Fork Trinity River	11,448	122.3	395.9	1,920	0	9,003	9,003	7.301
0841B	Bear Creek	2,520	57.09	0.0191	1,085	0	1,378	1,378	0.1840
0841C	Arbor Creek	50.10	2.505	0	47.59	0	0	0	0
0841E	Copart Branch Mountain Creek	25.92	1.296	0	24.62	0	0	0	0
0841G	Dalworth Creek	59.37	2.969	0	56.41	0	0	0	0
0841H	Delaware Creek	240.4	12.02	0	228.4	0	0	0	0
0841J	Estelle Creek	85.46	4.273	0	81.19	0	0	0	0
0841L	Johnson Creek	567.0	25.84	0	491.0	0	50.10	50.10	0

AU	Segment Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA_{AU}[e]	LA_{USL}[f]	LA Total	Future Growth[g]
0841M	Kee Branch	194.1	9.704	0	184.4	0	0	0	0
0841R	Rush Creek	933.2	36.95	0	678.7	22.58	194.1	216.7	0.8626
0841T	Village Creek	1,317	19.22	0	357.9	0	933.2	933.2	7.243
0841U	West Irving Branch	93.17	4.658	0	88.51	0	0	0	0

[a] TMDL = Median flow (high flow regime) * 126 MPN/100 mL * Conversion Factor; where the Conversion Factor = 8.64E+08 100 mL/m^3 * seconds/day; Median Flow from Table 10

[b] MOS = 0.05 * (TMDL – LA_{USL}); (see Table 11)

[c] WLA_{WWTF} = Target (63 MPN/day) * Flows (MGD) * Conversion Factor; where Flow is the full permitted flow from regulated discharging facility (Table 12); Conversion Factor = 3.7854 x 10^7 100 mL/MGD

[d] WLA_{SW} = (TMDL - WLA_{WWTF} – LA_{USL} - FG - MOS) * FDA_{SWP}; (see Table 14)

[e] LA_{AU} = TMDL - WLA_{WWTF} - WLA_{SW} – LA_{USL} - FG - MOS; (see Table 15)

[f] LA_{USL} = Q_{inlet} * Criterion (126 MPN/day) * Conversion Factor (see Table 10)

[g] FG = Target * ($Pop_{2010-2040}$ * Use) * Conversion Factor; where Target = 63 MPN/100 mL; Conversion Factor = 37.854 100 mL/gallon; Use = 101.77 gpcd; and $Pop_{2010-2040}$ is from Table 13

The final TMDL allocations needed to comply with the requirements of 40 CFR 130.7 are provided in Table 17. The WLA_{WWTF} component of the final TMDL allocations includes potential future growth loadings. The LA component of the final TMDL allocations includes both tributary and upstream bacteria loadings (LA_{USL}) and loadings arising from within each segment from non-regulated sources (LA_{AU}).

In the event that the criterion changes due to future revisions in the state's surface water quality standards, Appendix B provides guidance for recalculating the allocations in Table 17. The thirteen figures (Figures B-1 – B13) of Appendix B were developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant load allocations change in relation to a number of proposed water quality criteria for *E. coli*. The equations provided, along with the figures allow calculation of new TMDLs and pollutant load allocations based on any potential new water quality criterion for *E. coli*.

Table 17. Final TMDL allocations for impaired AUs within the Lower West Fork Trinity River watershed

All loads expressed as billion MPN/day

AU	TMDL	WLA_{WWTF}[a]	WLA_{SW}	LA[b]	MOS
0841_01	16,394	553.3	589.6	15,191	60.15
0841_02	11,448	403.2	1,920	9,003	122.3
0841B	2,520	0.203	1,085	1,378	57.09
0841C	50.10	0	47.59	0	2.505
0841E	25.92	0	24.62	0	1.296
0841G	59.37	0	56.41	0	2.969
0841H	240.4	0	228.4	0	12.02
0841J	85.46	0	81.19	0	4.273
0841L	567.0	0	491.0	50.10	25.84
0841M	194.1	0	184.4	0	9.704
0841R	933.2	0.8626	678.7	216.7	36.95
0841T	1,317	7.243	357.9	933.2	19.22
0841U	93.17	0	88.51	0	4.658

[a] WLA_{WWTF} includes the future potential allocation to wastewater treatment facilities

[b] LA includes tributary and upstream bacteria loadings (LA_{USL}) and loadings arising from within each segment from non-regulated sources (LA_{AU})

Seasonal Variation

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. No statistically significant seasonal variation was found in *E. coli* data examined for the Lower West Fork Trinity River watershed (Millican and Hauck, 2012). Consequently, seasonal variation is not considered in the TMDL calculations.

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.

The TCEQ held a series of meetings with stakeholders to get their advice on elements of the project and to keep them informed of progress. Notices of meetings were posted on the project Web page and on the TMDL program's online calendar. Two weeks prior to scheduled meetings, the TCEQ issued media releases and formally invited stakeholders to attend. To ensure that absent or new stakeholders could get information about past meetings and pertinent material, the project Web page provides meeting summaries and documents produced for review at <www.tceq.state.tx.us/waterquality/tmdl/66-lwforktrinity-bacteria.html>.

An initial public meeting to outline the need for the Lower West Fork Trinity River TMDL was held at NCTCOG in Arlington, TX on January 20, 2011. The meeting introduced the TMDL process, identified the impaired segments and the reason for the impairment, reviewed historical data, and described potential sources of bacteria within the watershed. An additional public meeting to present the status of the Lower West Fork Trinity River TMDL and to discuss available results was held at NCTCOG on July 18, 2012. In addition, the meetings gave TCEQ the opportunity to solicit input from all interested parties within the study area. Information on past and future meetings for the Lower West Fork Trinity River Watershed Bacteria TMDL can be found on the TCEQ Web site at <www.tceq.texas.gov/waterquality/tmdl/66-lwforktrinity-bacteria.html>.

The NCTCOG initiated efforts in fall 2010 with the TCEQ to lead development of the Implementation Plan (I-Plan) for this TMDL project and two closely-related projects in the DFW area. These I-Plan development efforts by NCTCOG, which are discussed under Key Elements of an I-Plan later in this report, continued in parallel with the Lower West Fork TMDL development and included the same stakeholders, as well as additional stakeholders in the other project watersheds. The I-Plan effort includes a Coordination Committee and eight technical subcommittees. Between May 2011 and July 2012, NCTCOG facilitated 4 stakeholder meetings, 4 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 is scheduled to be released for a formal public review in 2013.

I-Plan meeting schedules, summaries, handouts, and associated materials can be found on the NCTCOG project website at <www.nctcog.org/envir/SEEclean/wq/tmdl/index.asp>.

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.

This TMDL applies to all segments in the Lower West Fork Trinity River watershed (Figure 1). Future water quality monitoring may identify additional segments with contact recreation use impairments not specifically addressed in this TMDL. If necessary, the TMDL allocations in this report will be revised to incorporate additional impaired segments and included in an update to the Texas WQMP.

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 permits, the TCEQ will normally establish BMPs, which are a substitute for effluent limitations, as allowed by federal rules, where numeric effluent limitations are infeasible. When such practices are established in an MS4 permit, the TCEQ will not identify specific implementation requirements applicable to a specific TPDES stormwater permit through an effluent limitation update. Rather, the TCEQ might revise a stormwater permit, require a revised SWMP or Pollution Prevention Plan, or implement other specific revisions affecting stormwater dischargers in accordance with an adopted 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 I-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. I-Plans will be adapted as necessary to reflect needs identified in evaluations of progress.

Key Elements of an I-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. I-Plans also identify the organizations responsible for carrying out management measures, and a plan for periodic evaluation of progress.

Strategies to optimize compliance and oversight are identified in an I-Plan when necessary. Such strategies may include additional monitoring and reporting of effluent discharge quality to evaluate and verify loading trends, adjustment of an inspection frequency or a response protocol to public complaints, and escalation of an enforcement remedy to require corrective action of a regulated entity contributing to an impairment.

The TCEQ works with stakeholders and interested governmental agencies to develop and support I-Plans and track their progress. Work on the Greater Trinity Bacteria I-Plan to address the TMDLs in this report began in spring 2011 and is being facilitated locally by the NCTCOG.

Ultimately, the I-Plan will identify the commitments and requirements to be implemented through specific permit actions and other means. For these reasons, the I-Plan that is approved 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 reduction 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 is working 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 are 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 Web site at <http://www.nctcog.org/envir/SEEclean/wq/tmdl/index.asp>

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Appendix A. Load Duration Curves for TCEQ Monitoring Stations in TMDL Watersheds

The LDCs for water quality monitoring stations are provided in Figures A-1 through A-30. The LDCs for the water quality monitoring stations provide a means of identifying the streamflow conditions under which exceedances in *E. co*li concentrations have occurred. The LDCs depict the allowable loadings at the stations under the geometric mean criterion (126 MPN/100 mL) and show that existing loadings often exceed the criterion.

On each graph the measured *E. coli* data are presented as associated with a "wet weather event" or a "non-wet weather event" A sample was determined to be influenced by a wet weather event based on the reported "days since last precipitation" (DSLP) 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 of the general climatic conditions.

For stations along the main stem of the Lower West Fork Trinity River, a sample taken with a DSLP value of 3 or less was defined as a wet weather event. For stations along Bear Creek (Segment 0841B), a sample taken with a DSLP value of 2 or less was defined as a wet weather event. For all other stations along tributary segments within the Lower West Fork Trinity River, a wet weather event was defined as a sample taken with an associated DSLP of 1 or less.

The rationale behind the DSLP values used to distinguish wet weather events from non-wet weather events was that the duration of influence from storm events will be directly related to watershed size in that events within smaller watersheds will exhibit shorter durations as compared to durations in a larger watershed. Note that a wet weather event can be indicated even under low flow conditions as a result of only a small runoff event during a period of very low base flow in the stream.

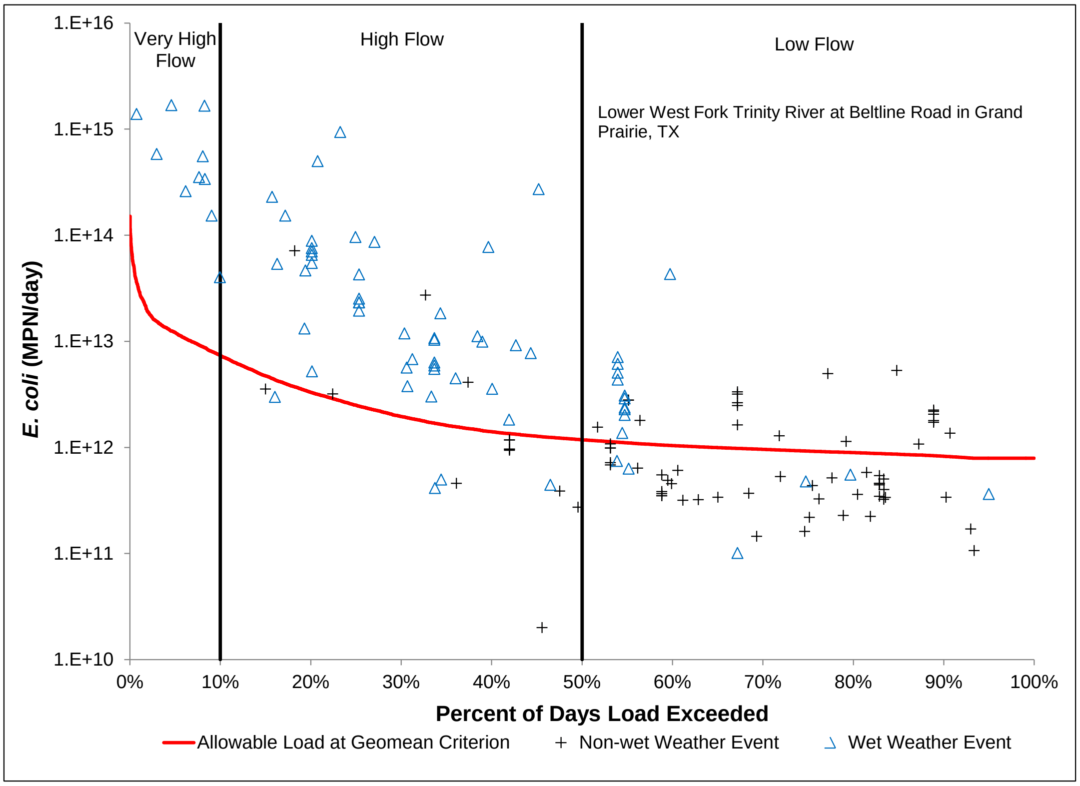

Figure A-1. Load duration curve for station 11081, Lower West Fork Trinity River (0841_01)

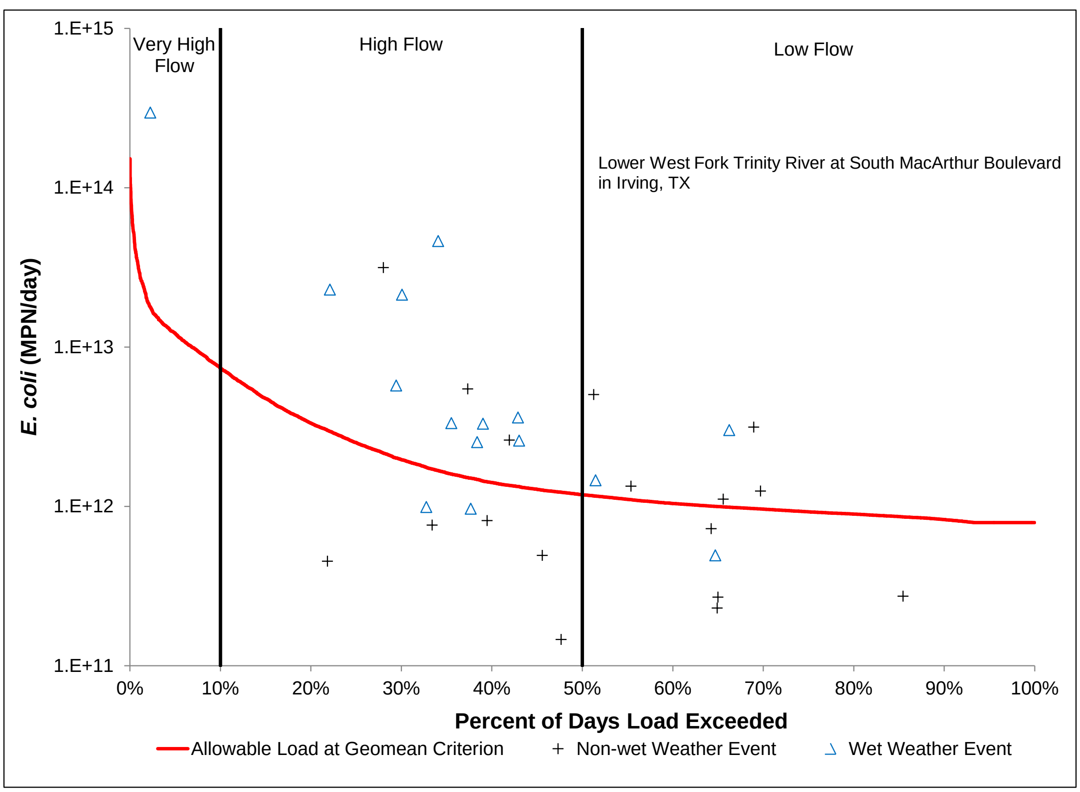

Figure A-2. Load duration curve for station 11080, Lower West Fork Trinity River (0841_01)

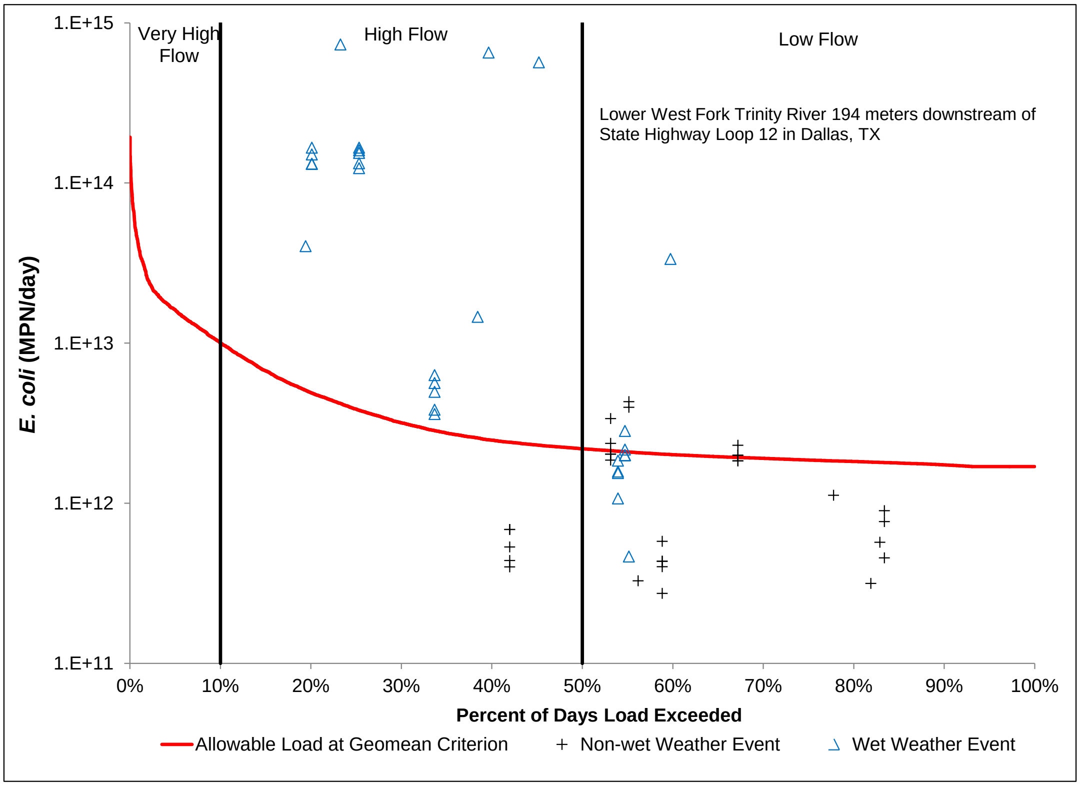

Figure A-3. Load duration curve for station 11089, Lower West Fork Trinity River (0841_01)

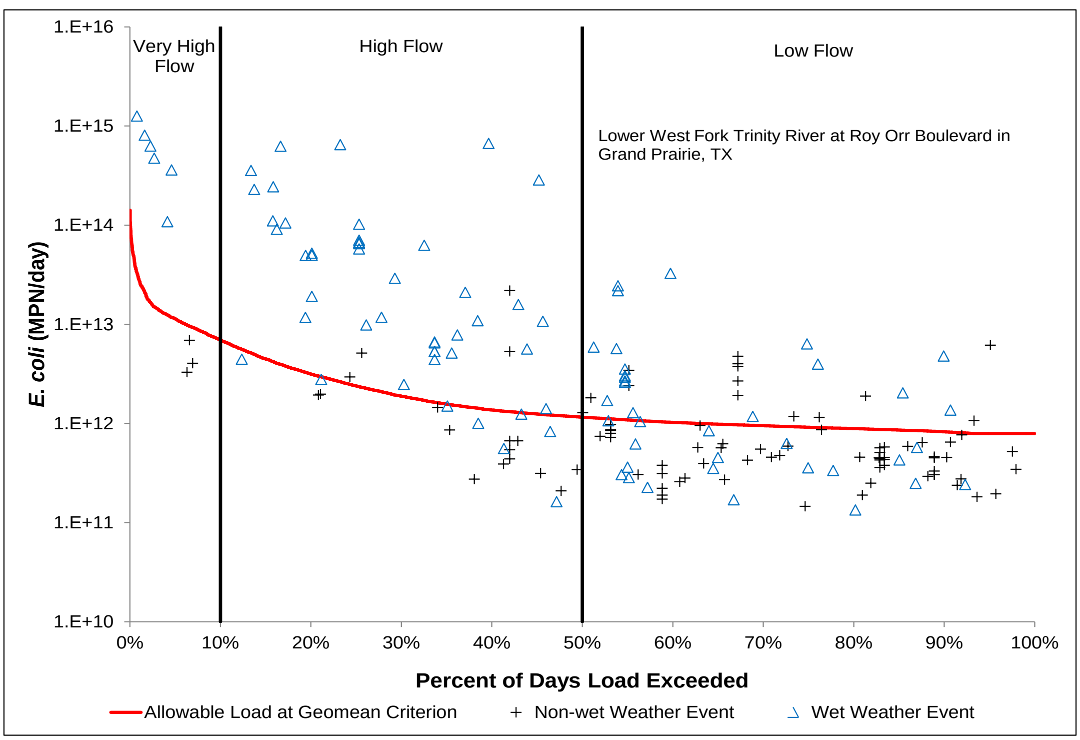

Figure A-4. Load duration curve for station 17669, Lower West Fork Trinity River (0841_02)

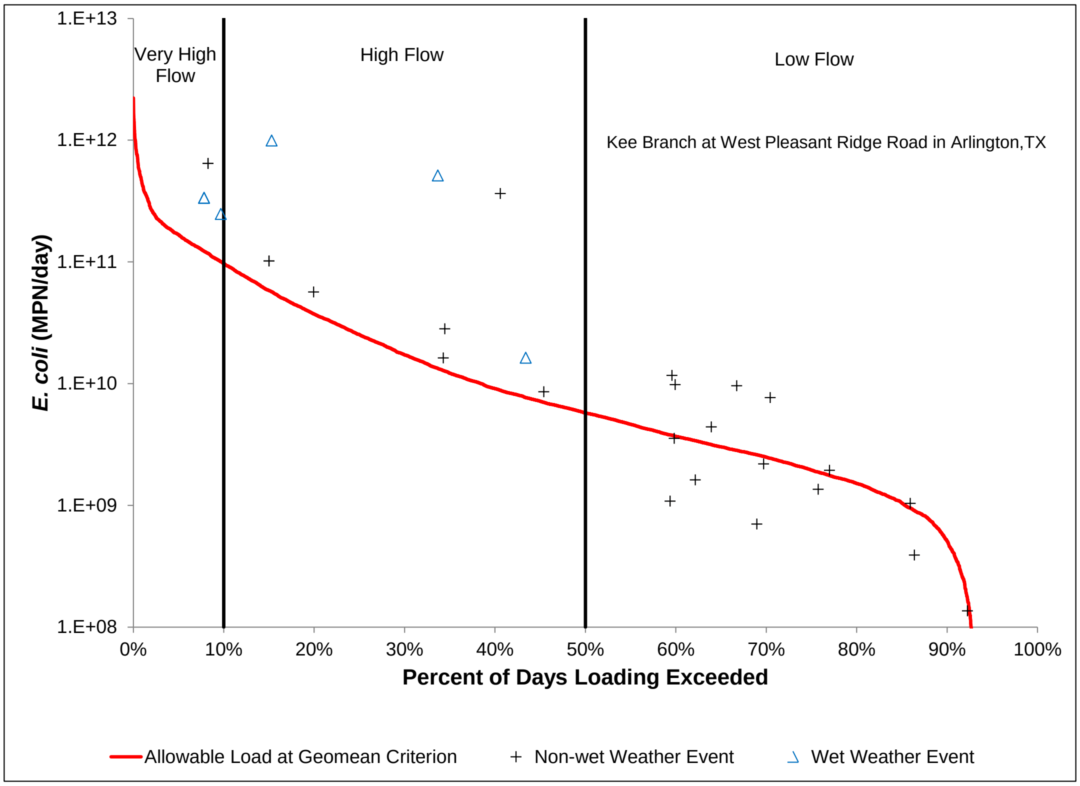

Figure A-5. Load duration curve for station 10792, Kee Branch (0841M)

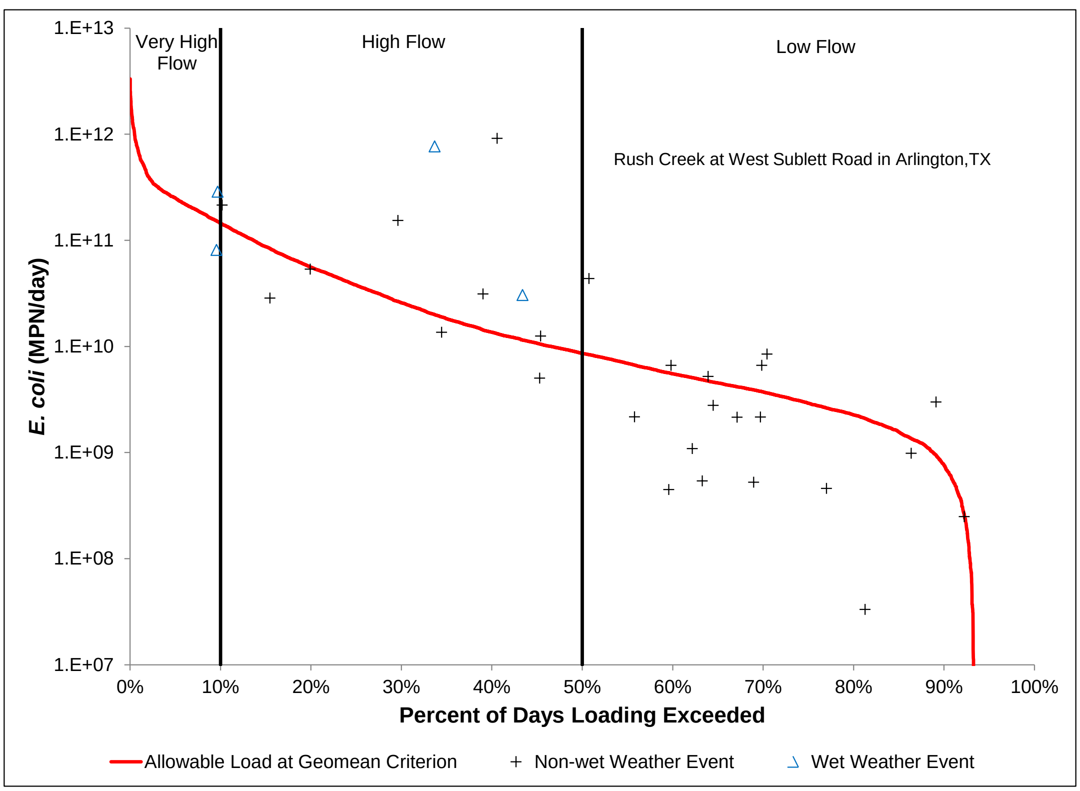

Figure A-6. Load duration curve for station 10791, Rush Creek (0841R)

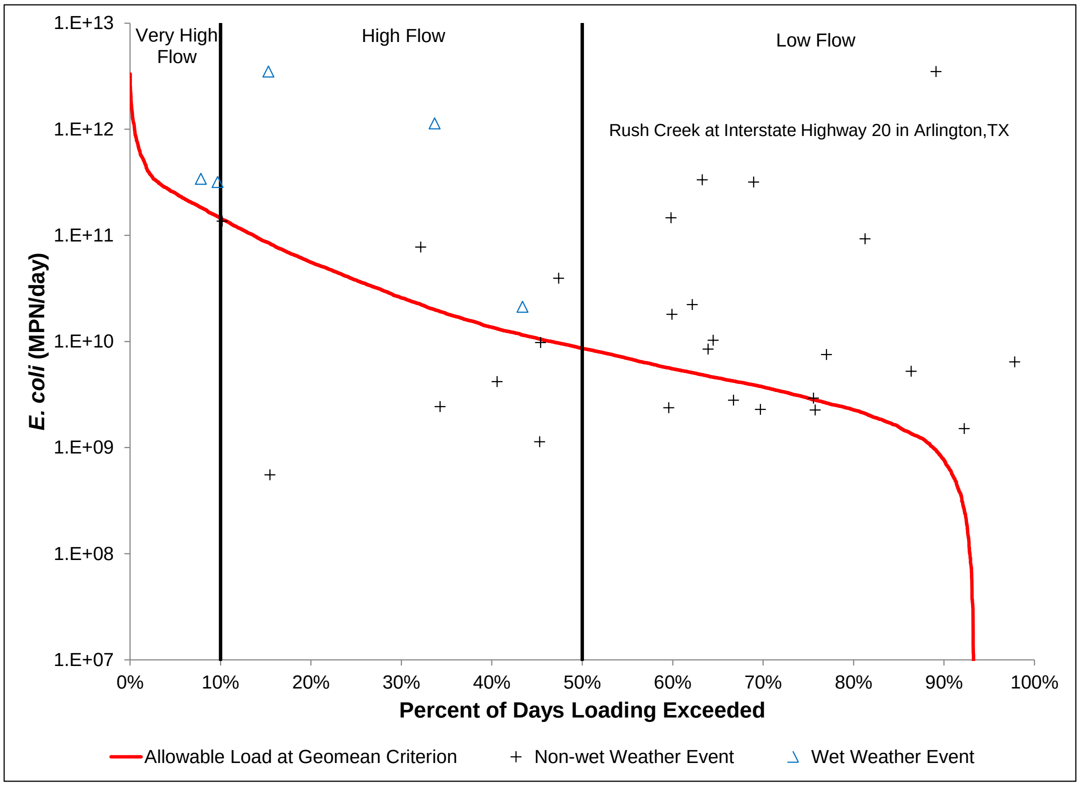

Figure A-7. Load duration curve for station 17190, Rush Creek (0841R)

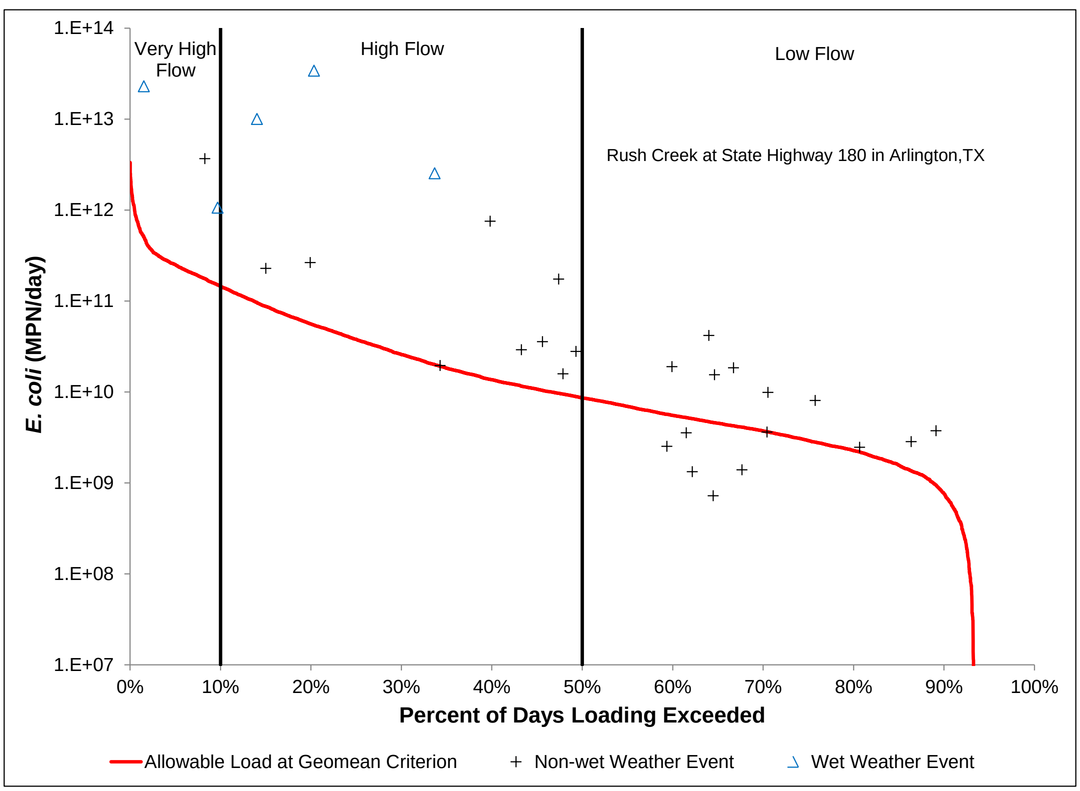

Figure A-8. Load duration curve for station 17191, Rush Creek (0841R)

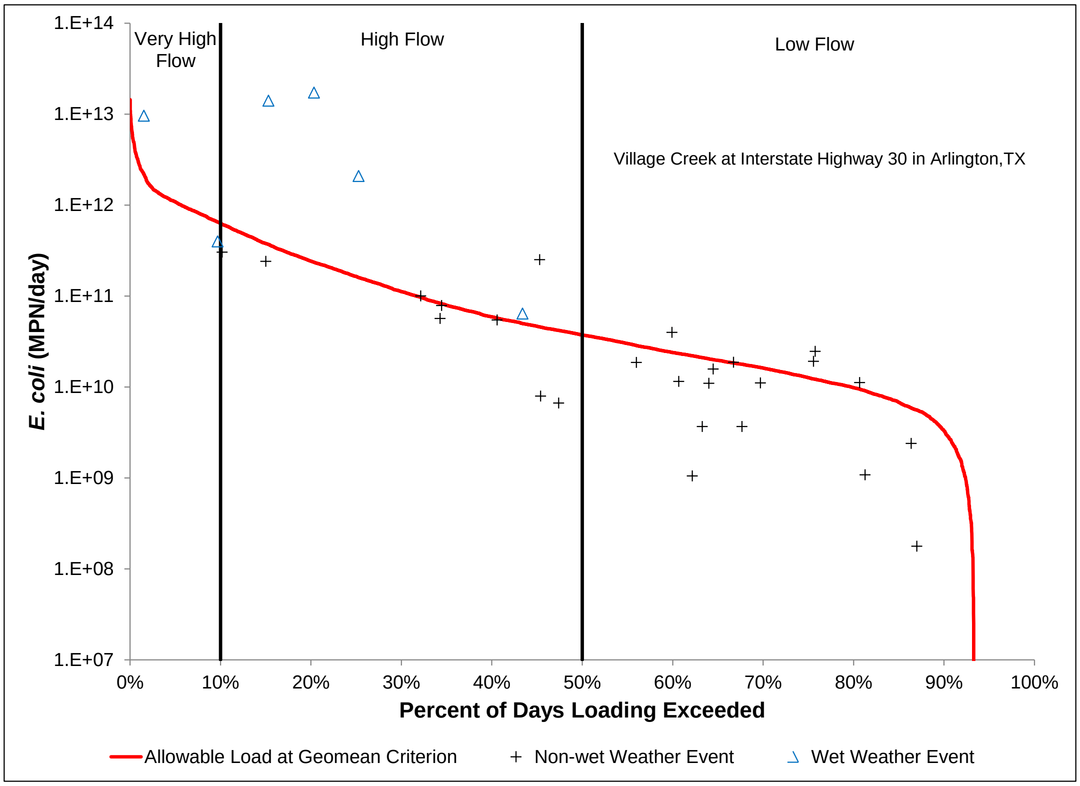

Figure A-9. Load duration curve for station 17189, Village Creek (0841T)

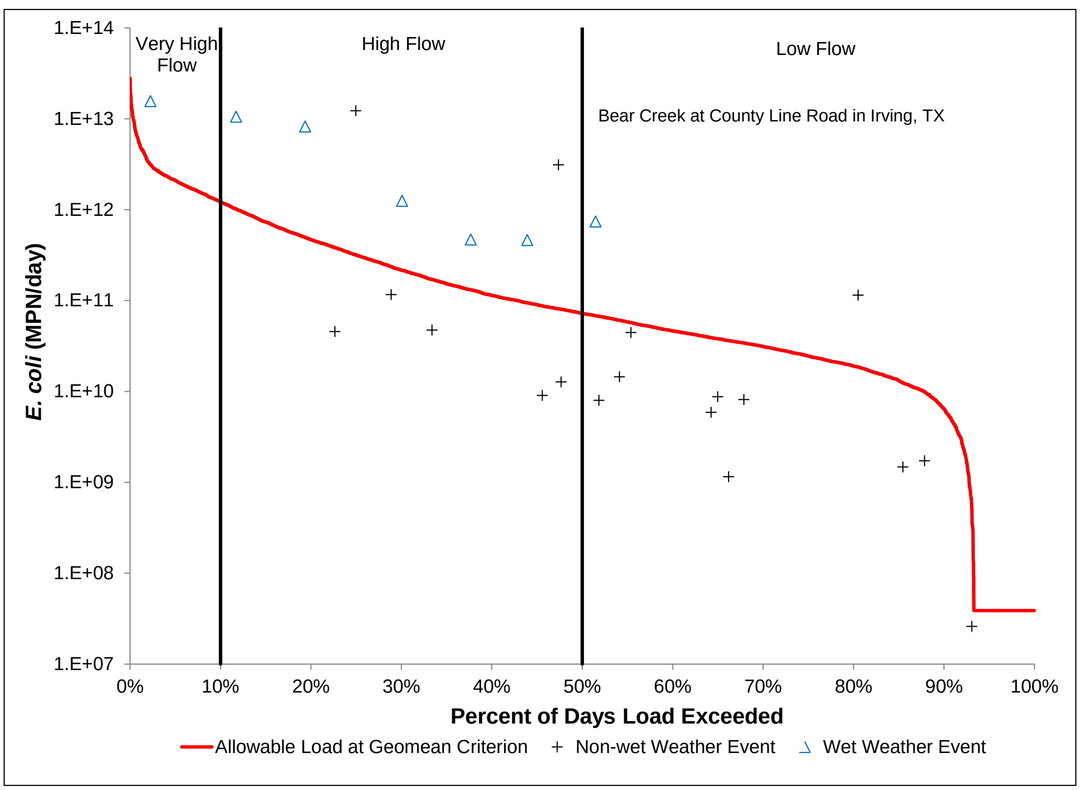

Figure A-10. Load duration curve for station 18315, Bear Creek (0841B)

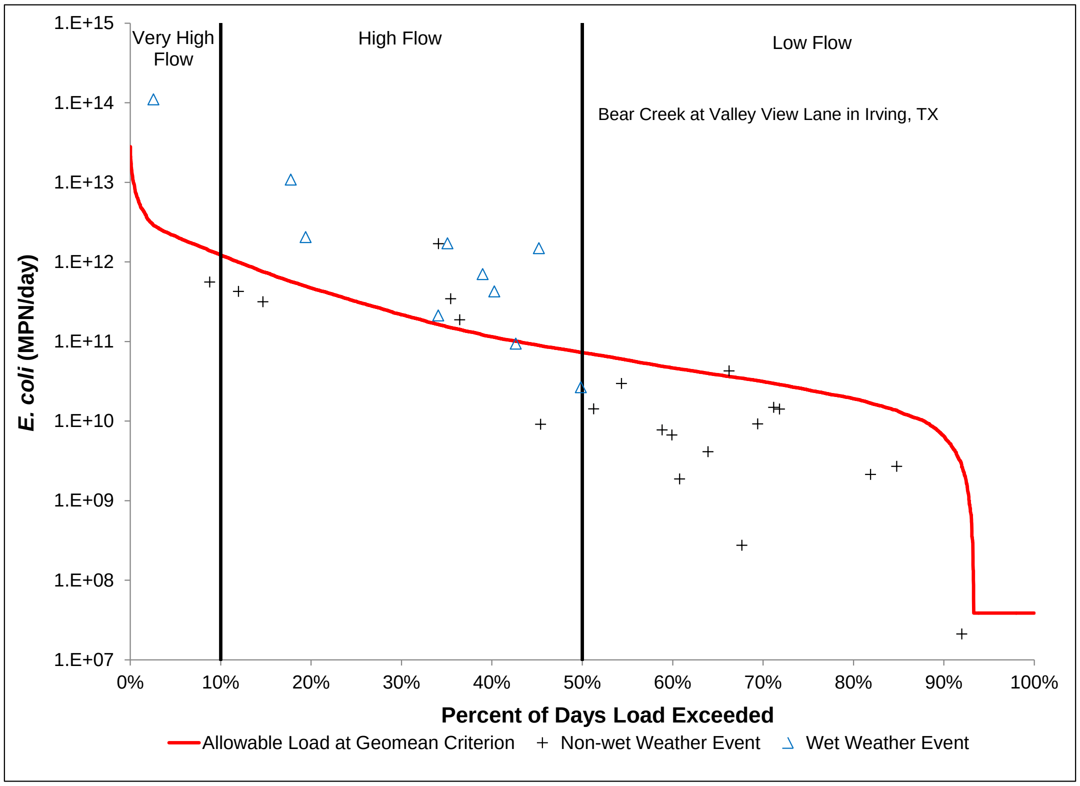

Figure A-11. Load duration curve for station 10868, Bear Creek (0841B)

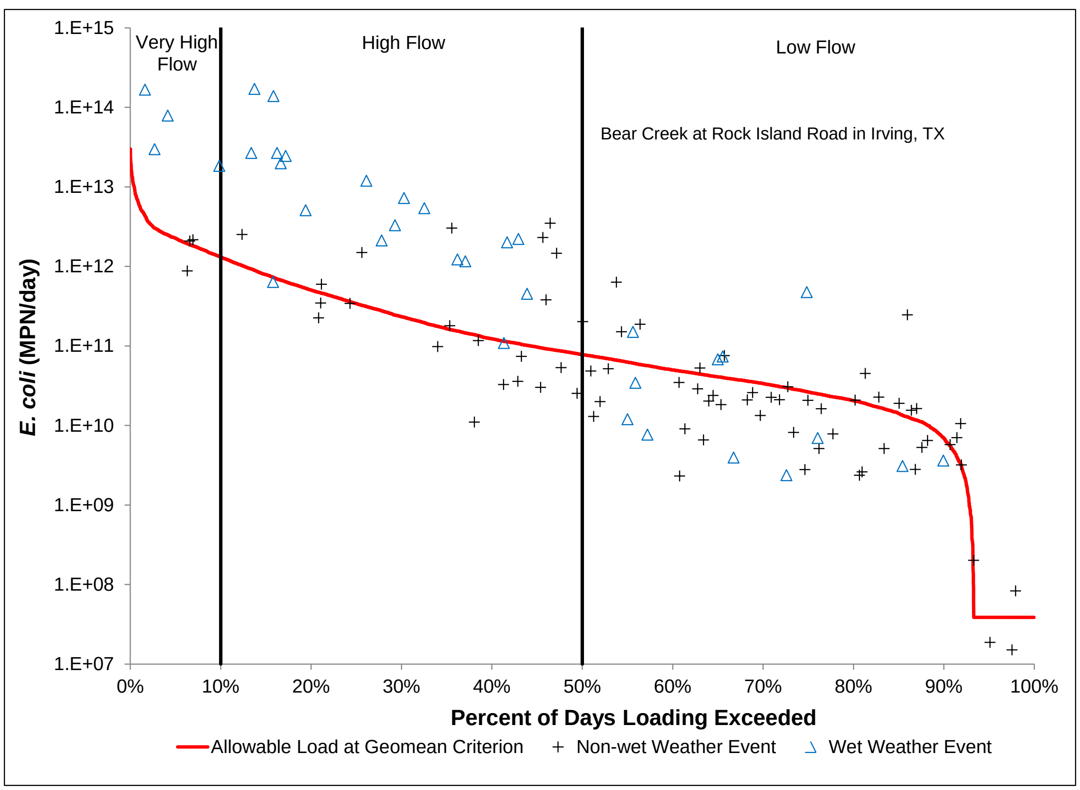

Figure A-12. Load duration curve for station 10867, Bear Creek (0841B)

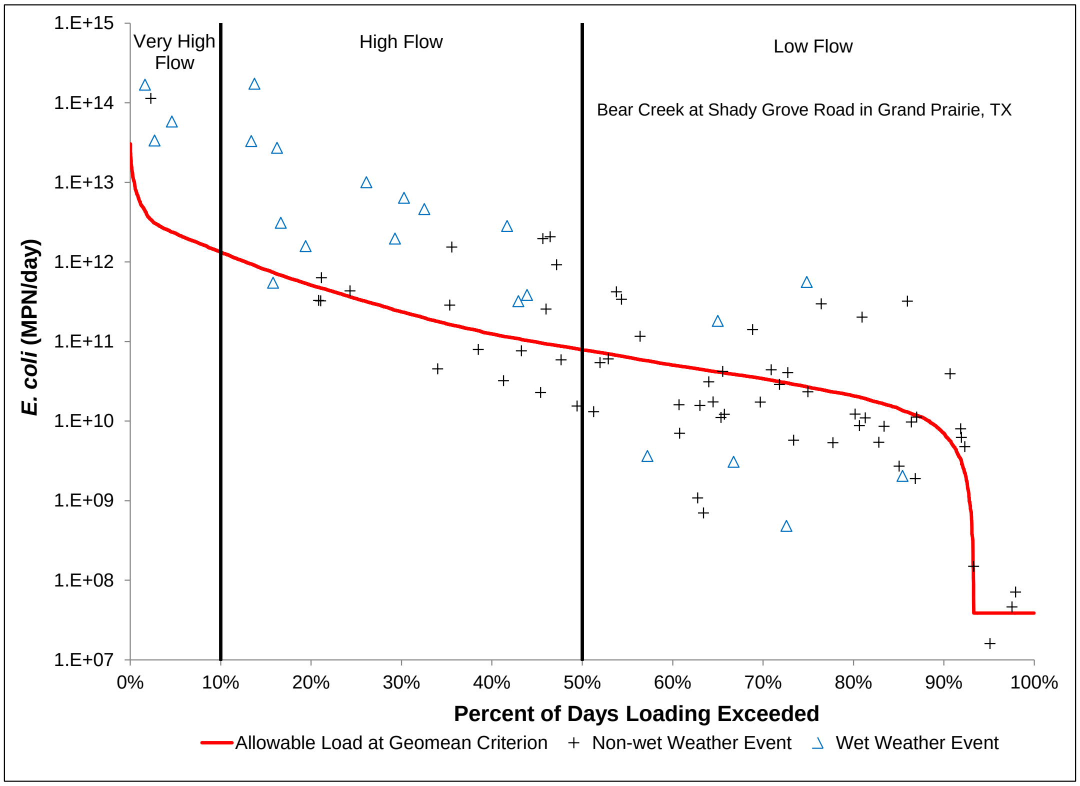

Figure A-13. Load duration curve for station 17663, Bear Creek (0841B)

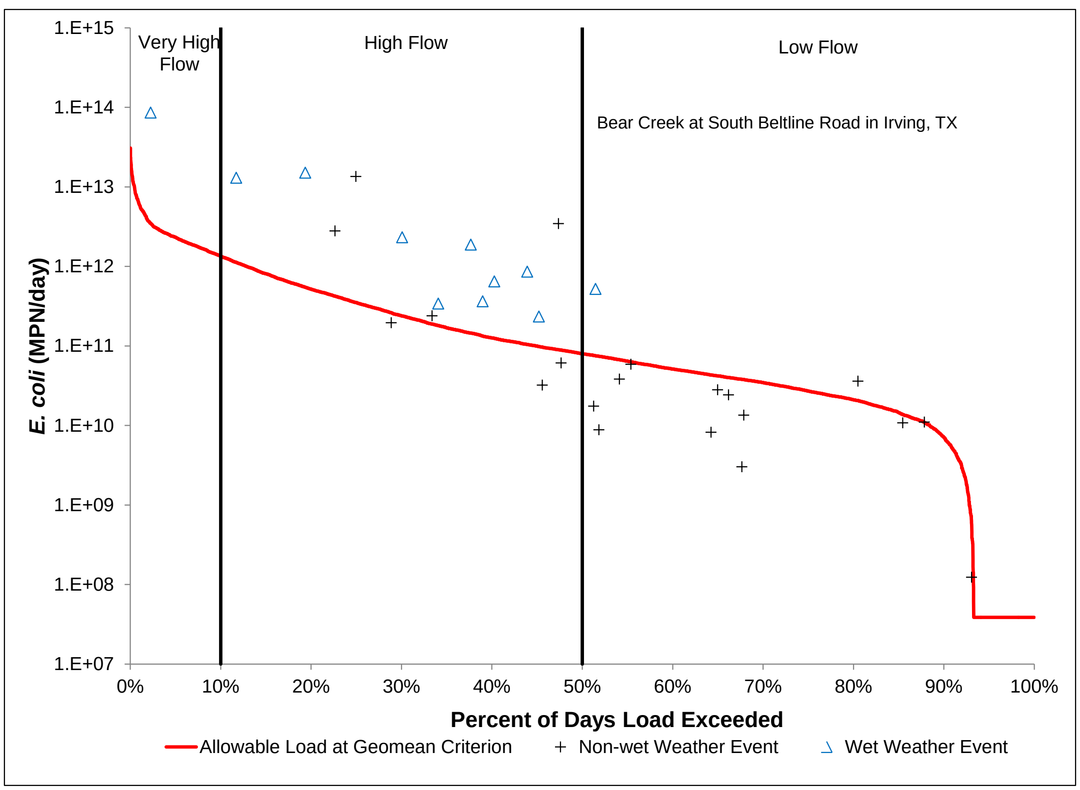

Figure A-14. Load duration curve for station 10866, Bear Creek (0841B)

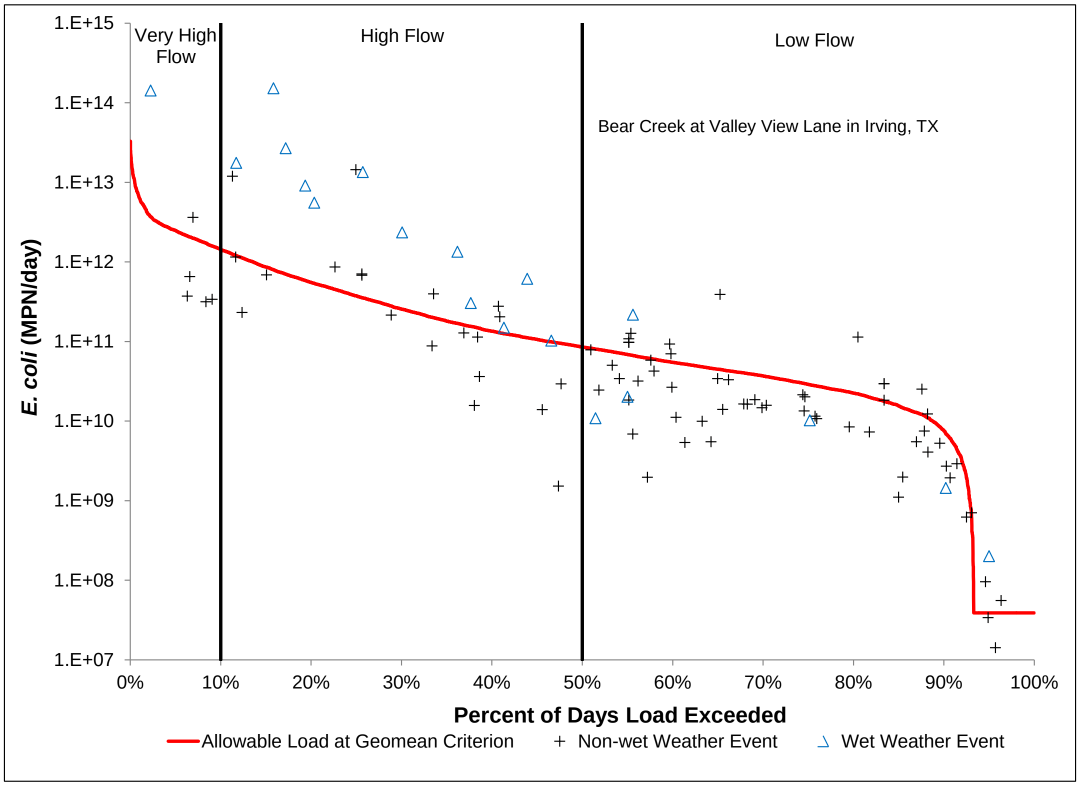

Figure A-15. Load duration curve for stations 10868 and 18313, Bear Creek (0841B)

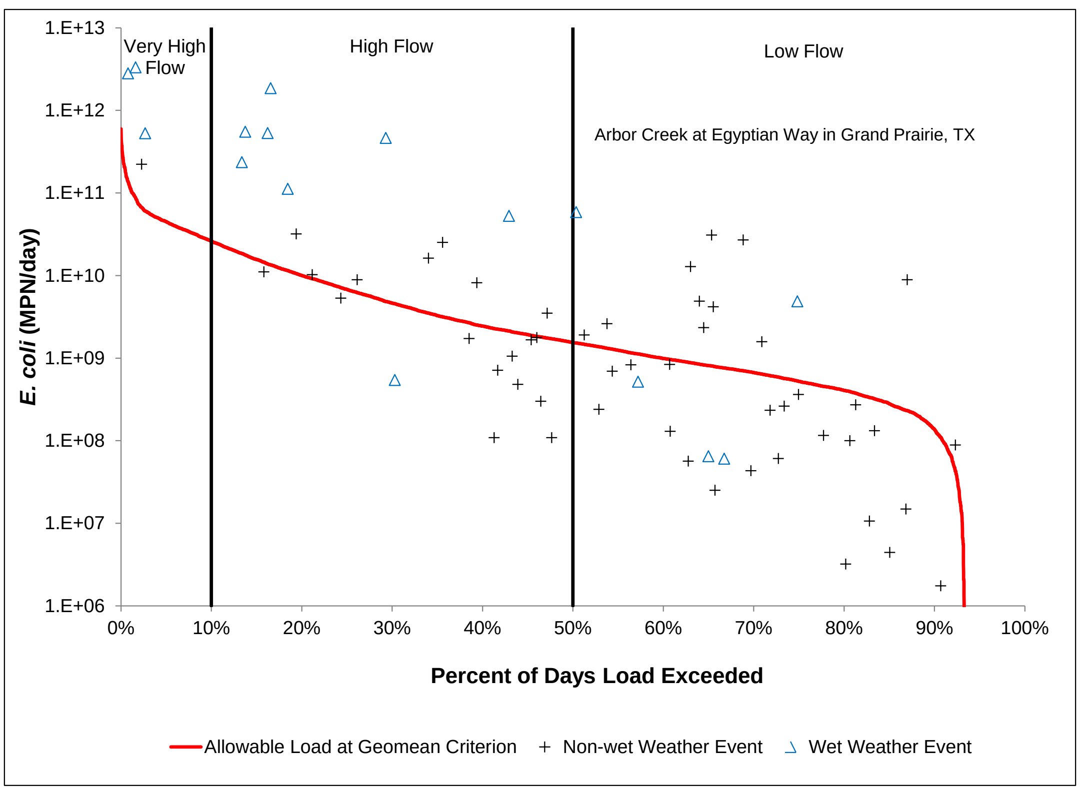

Figure A-16. Load duration curve for station 17666, Arbor Creek (0841C)

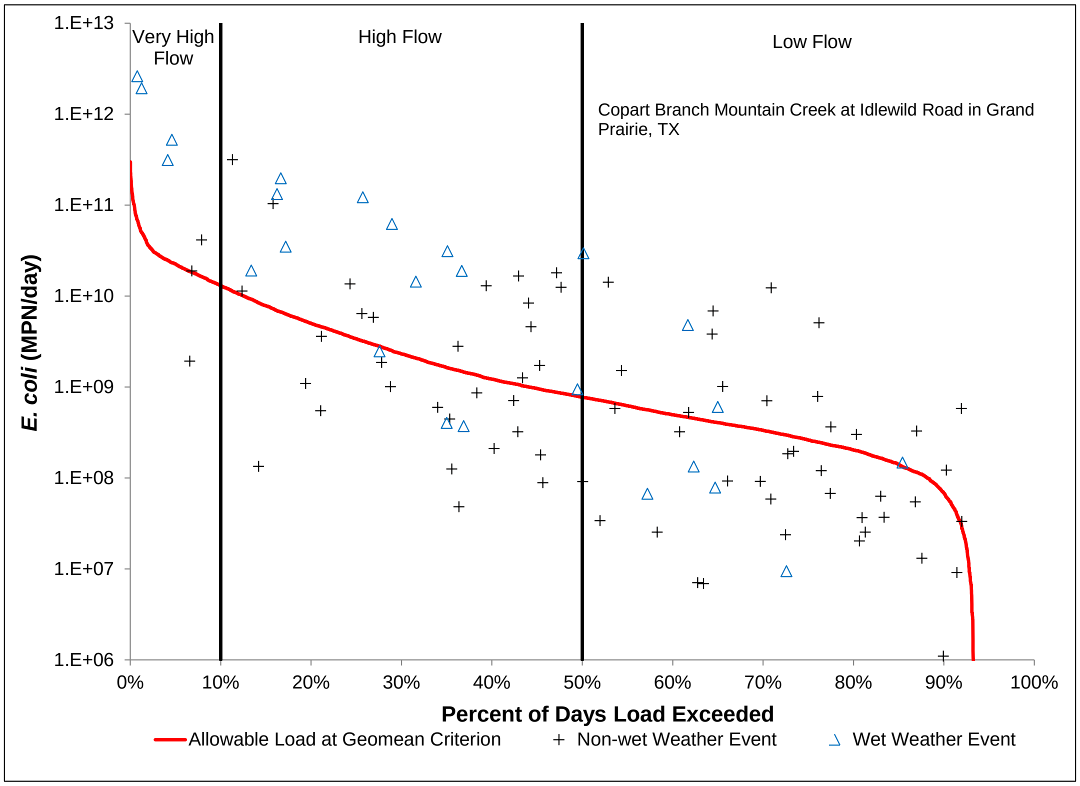

Figure A-17. Load duration curve for station 17672, Copart Branch Mountain Creek (0841E)

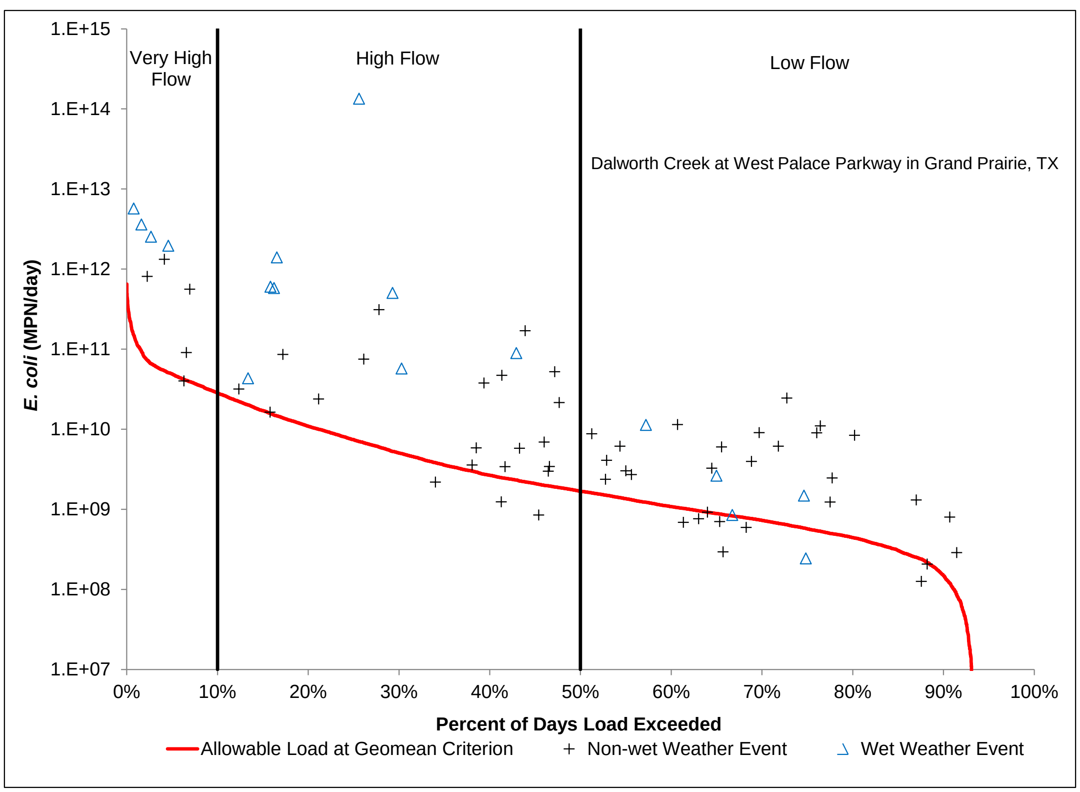

Figure A-18. Load duration curve for station 17671, Dalworth Creek (0841G)

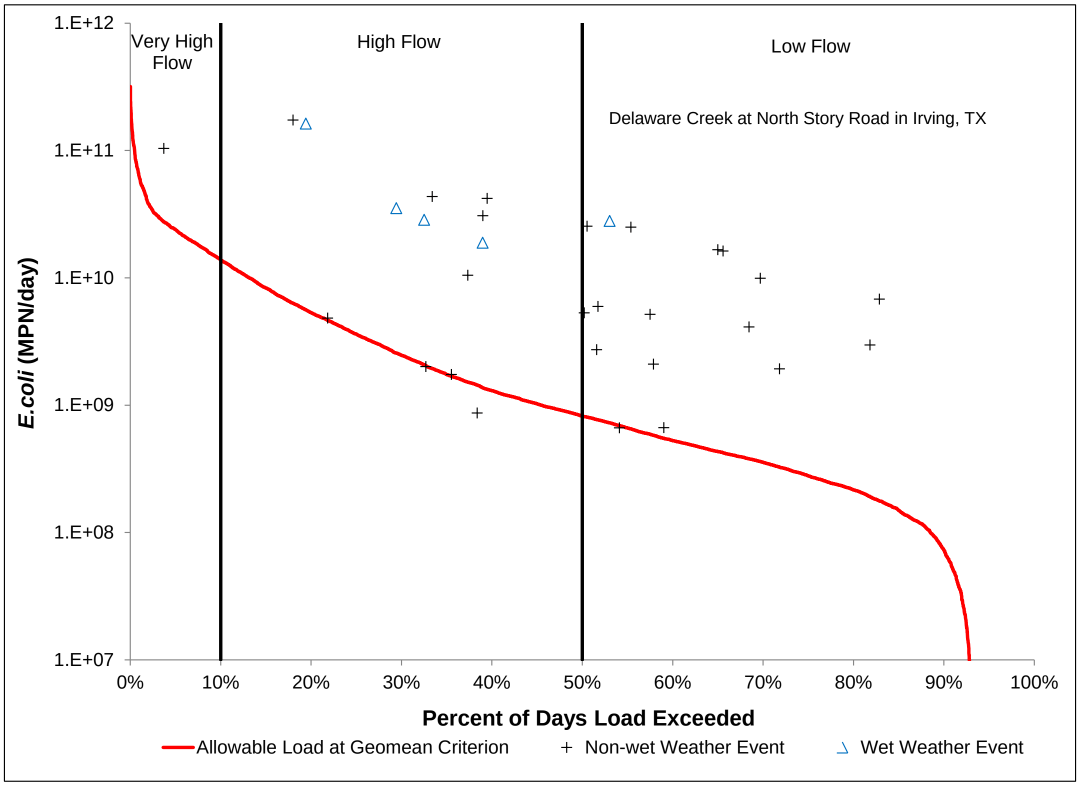

Figure A-19. Load duration curve for station 17175, Delaware Creek (0841H)

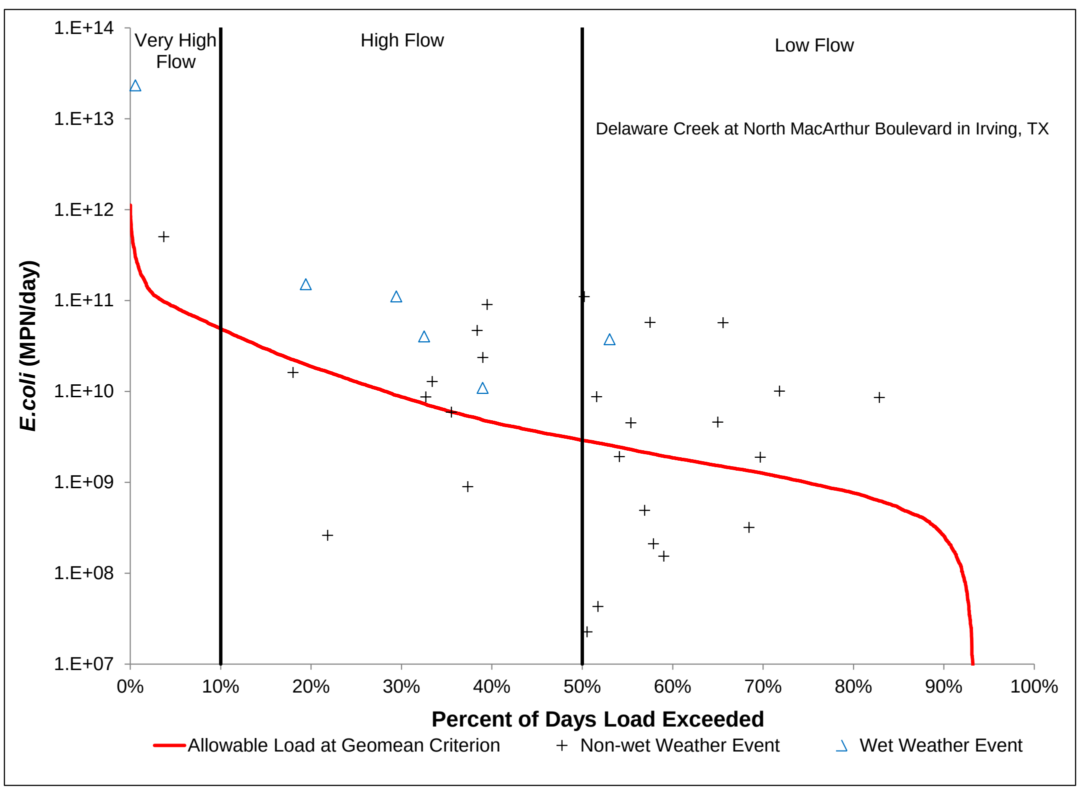

Figure A-20. Load duration curve for station 17176, Delaware Creek (0841H)

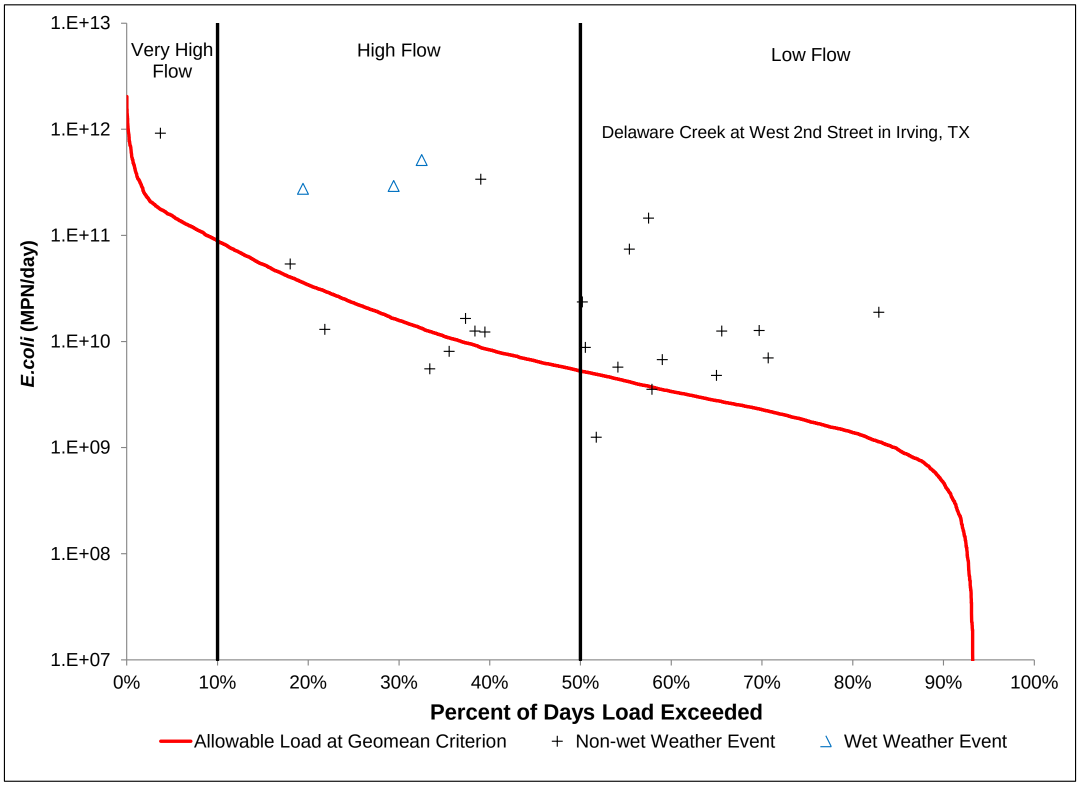

Figure A-21. Load duration curve for station 18314, Delaware Creek (0841H)

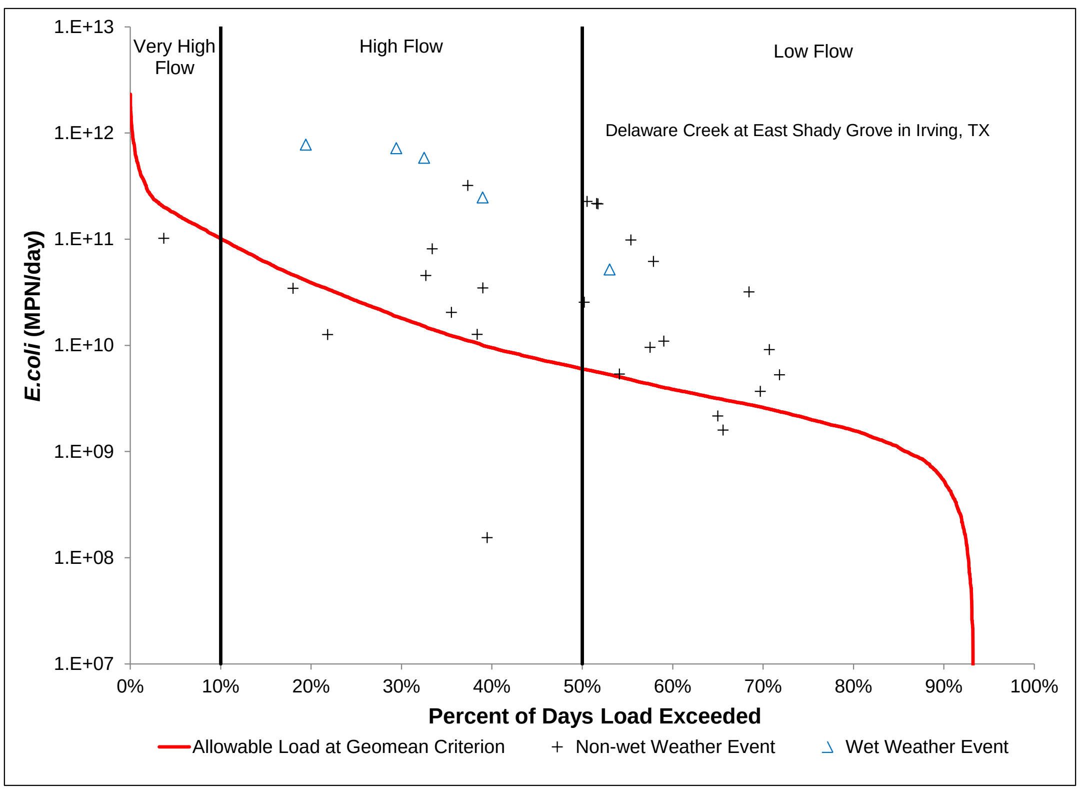

Figure A-22. Load duration curve for station 17177, Delaware Creek (0841H)

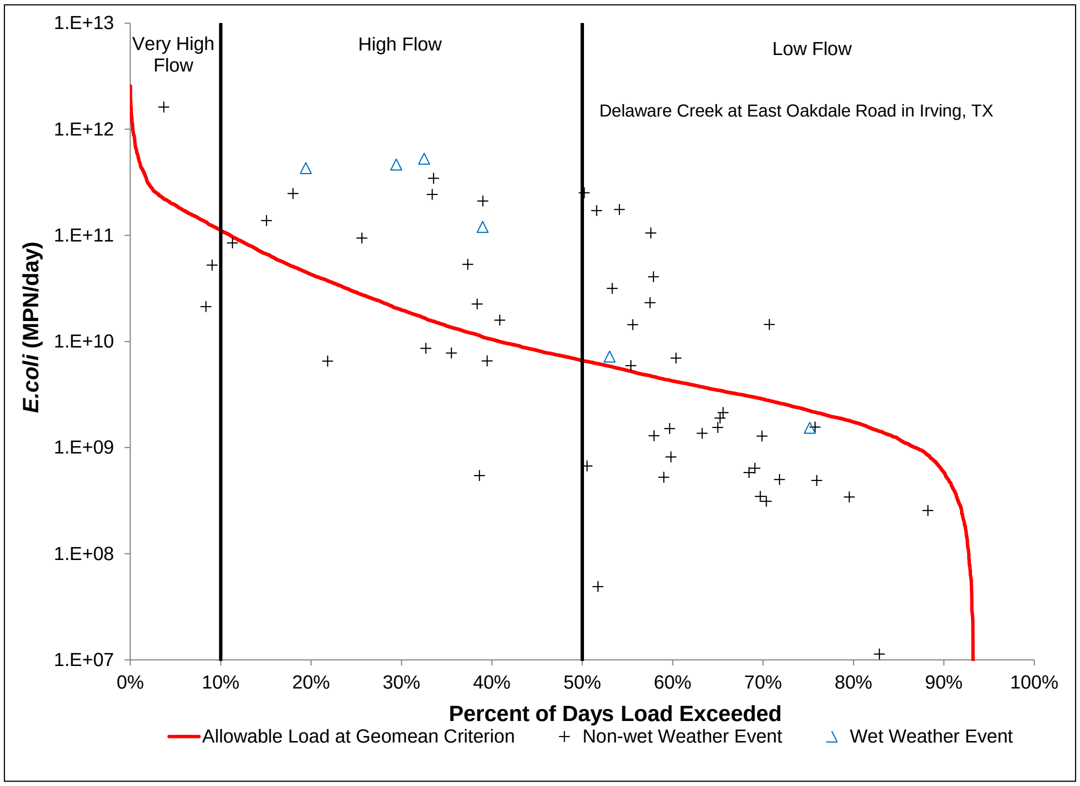

Figure A-23. Load duration curve for station 17178, Delaware Creek (0841H)

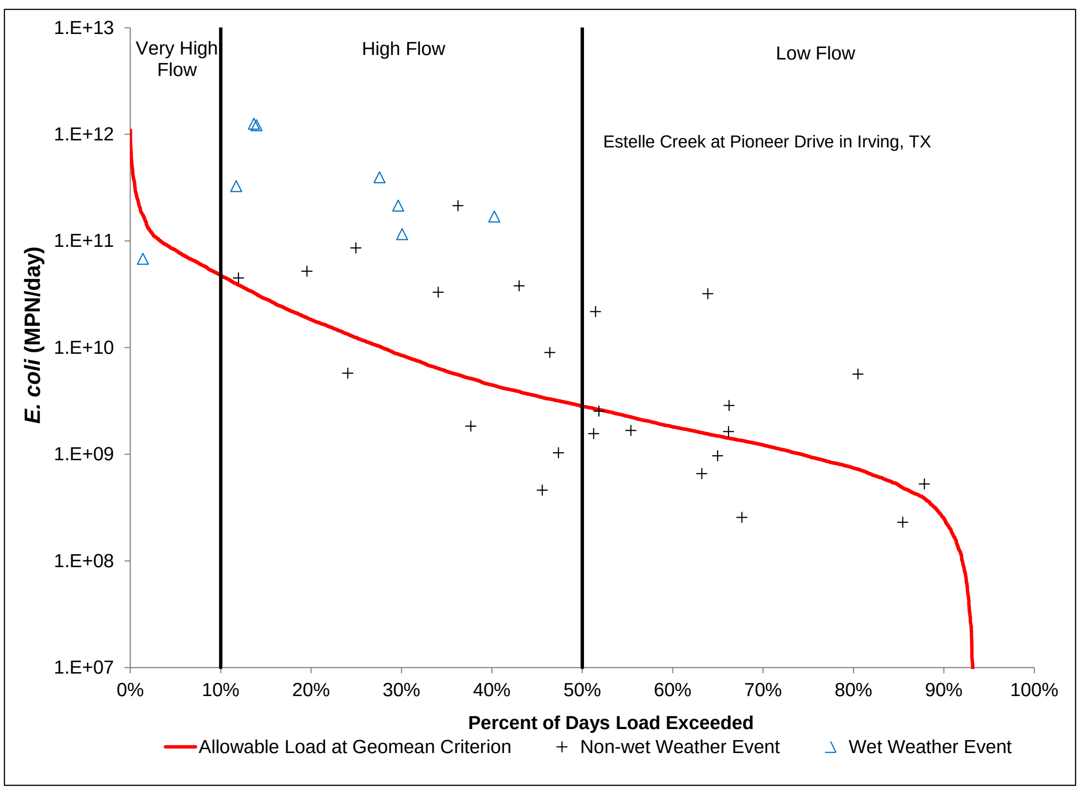

Figure A-24. Load duration curve for station 17174, Estelle Creek (0841J)

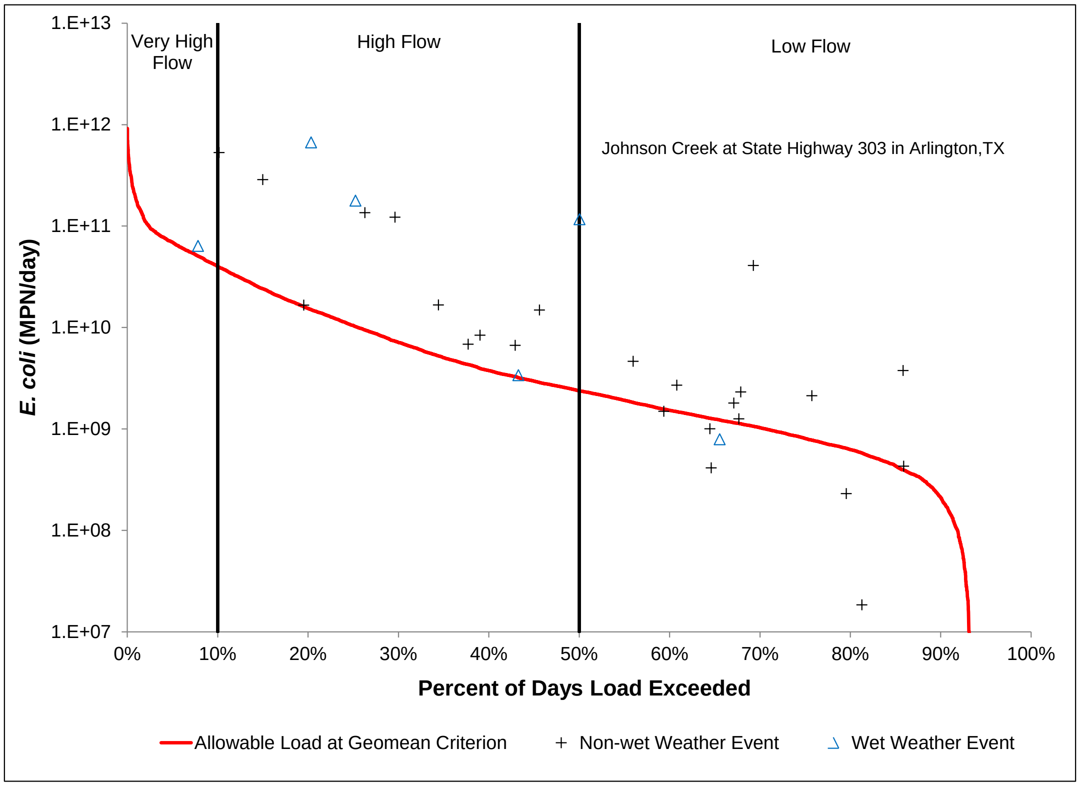

Figure A-25. Load duration curve for station 10721, Johnson Creek (0841L)

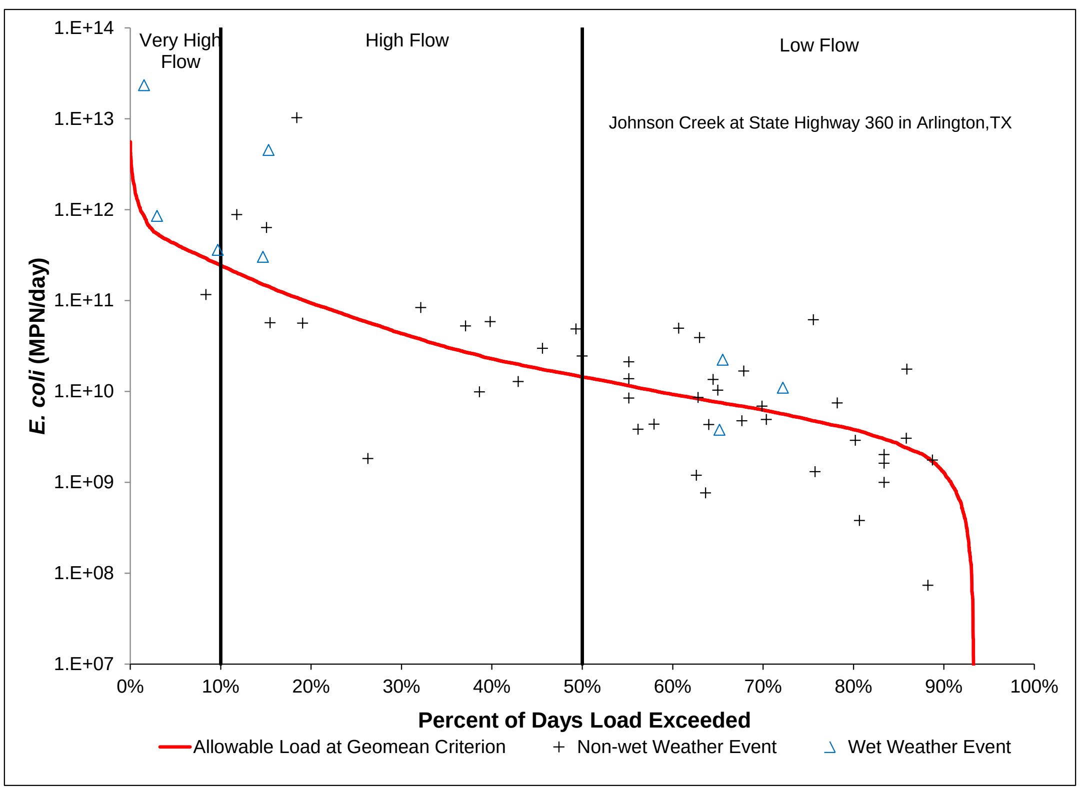

Figure A-26. Load duration curve for station 10719, Johnson Creek (0841L)

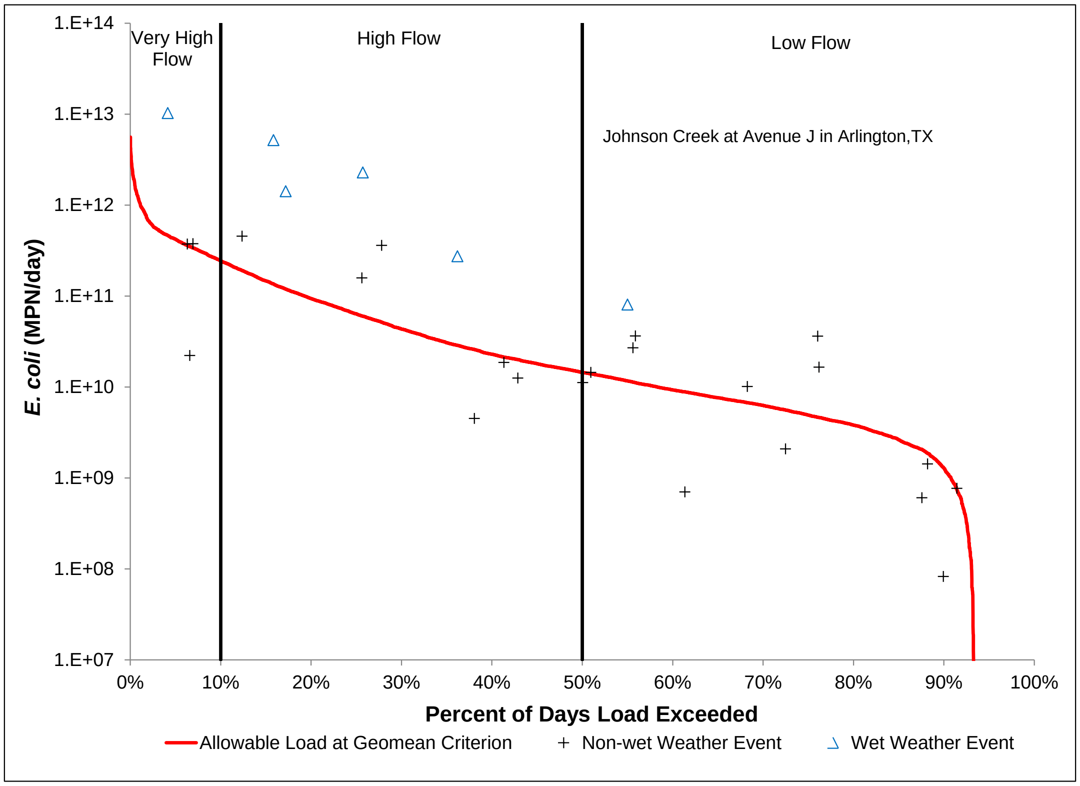

Figure A-27. Load duration curve for station 10718, Johnson Creek (0841L)

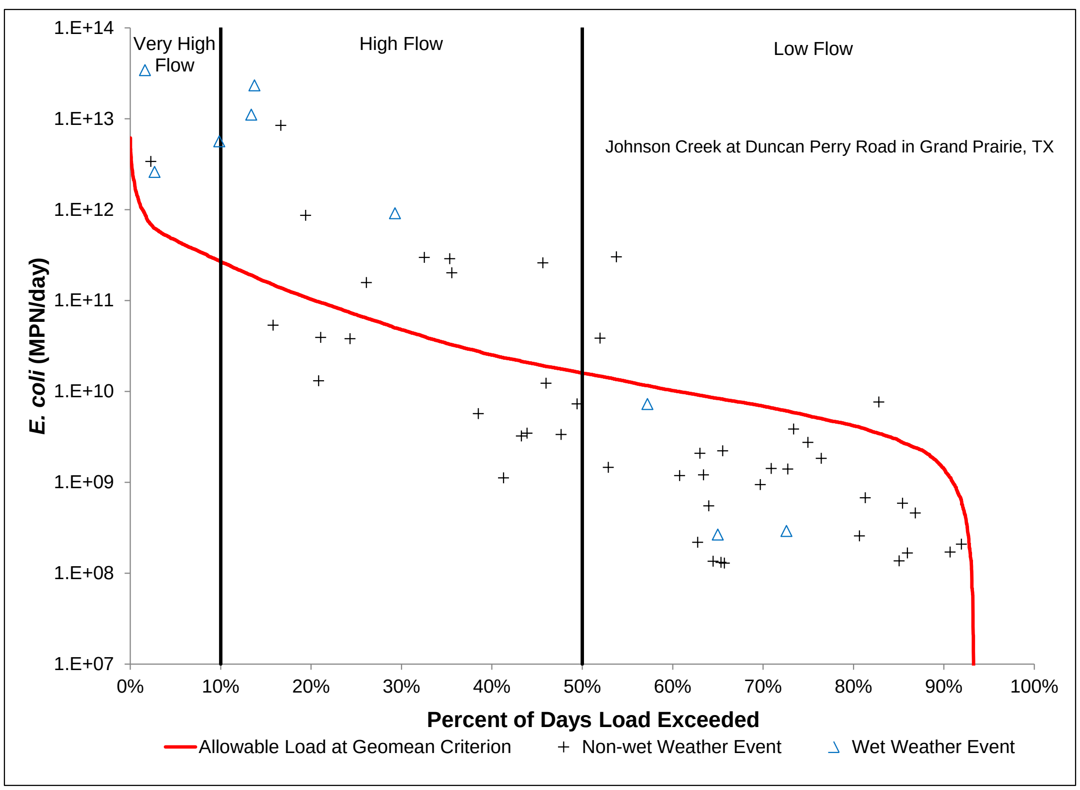

Figure A-28. Load duration curve for station 18311, Johnson Creek (0841L)

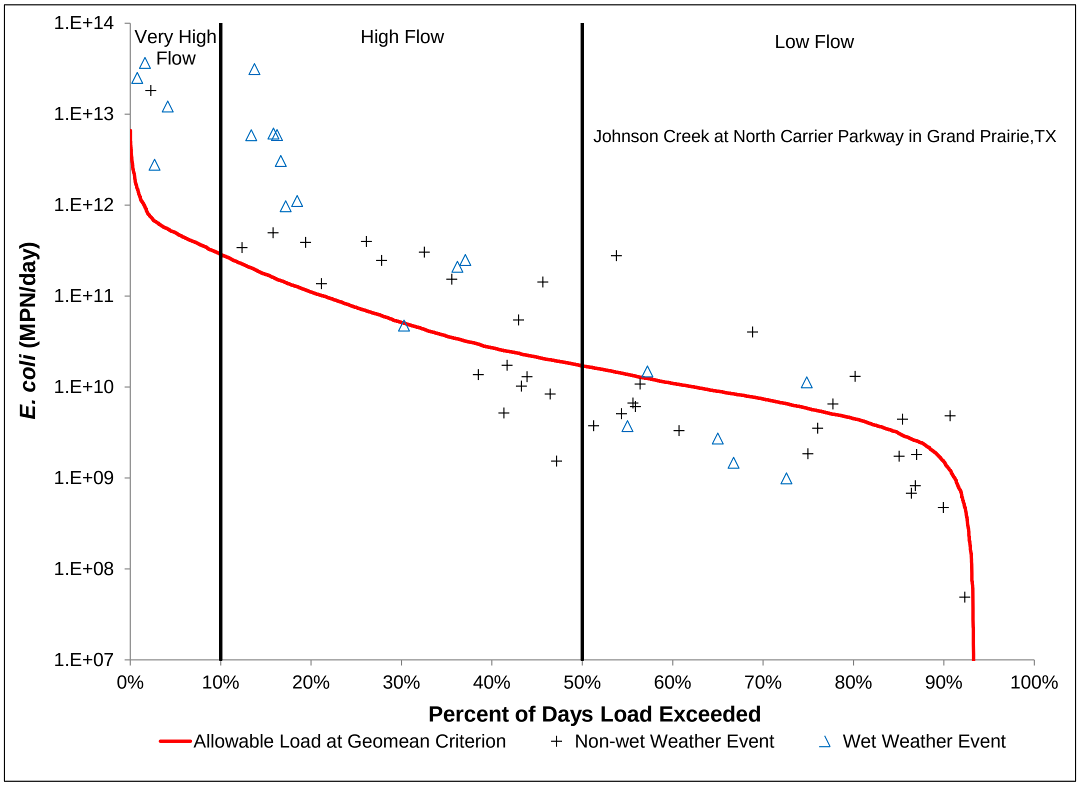

Figure A-29. Load duration curve for station 17664, Johnson Creek (0841L)

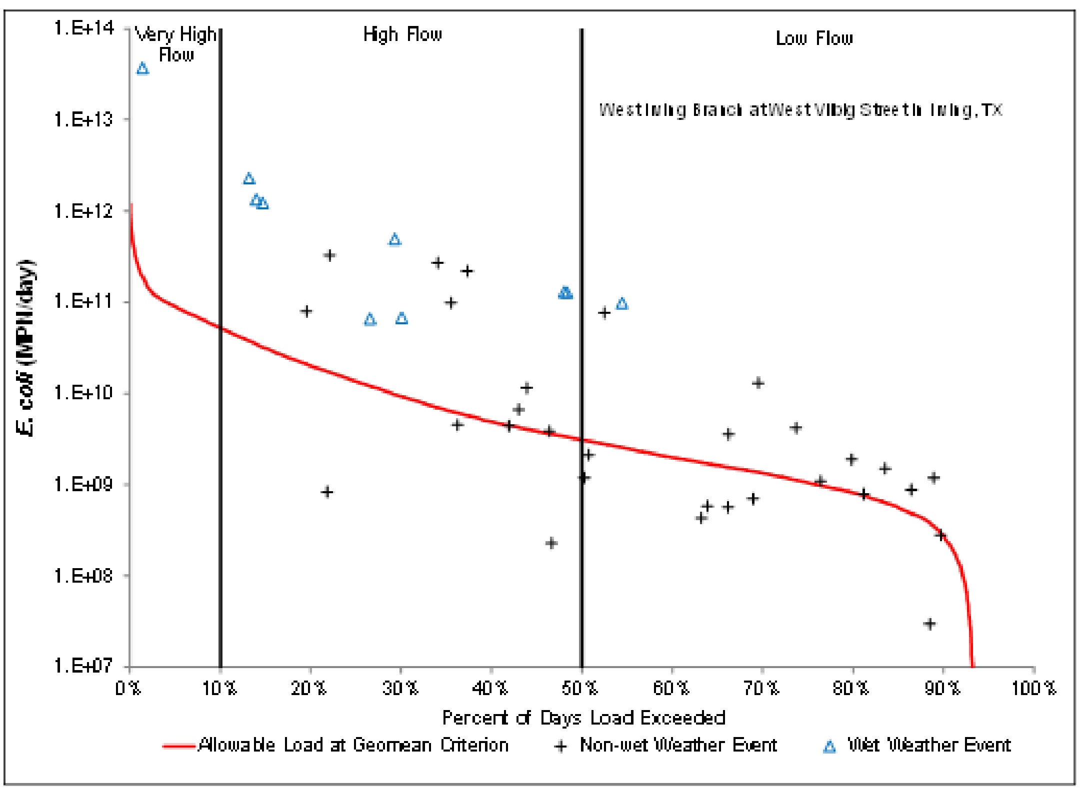

Figure A-30. Load duration curve for station 17179, West Irving Branch (0841U)

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

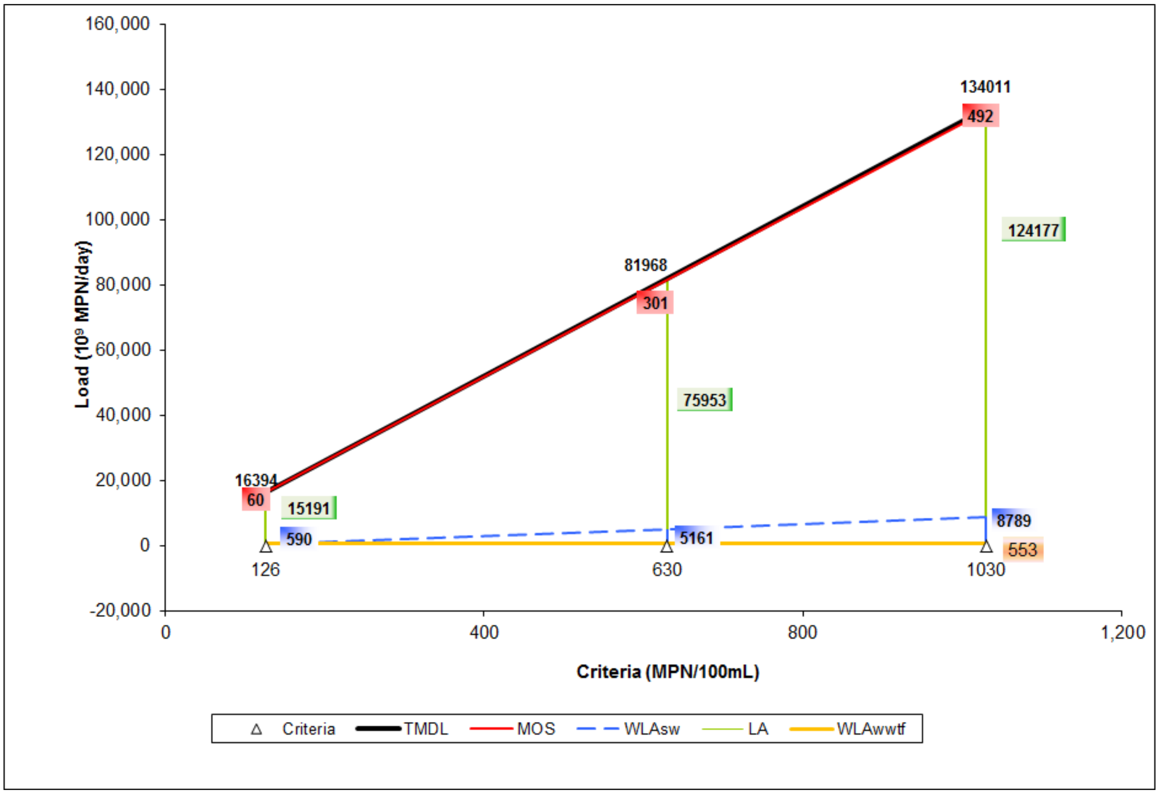

Figure B-1. Allocation loads for Lower West Fork Trinity River (0841_01) as a function of water quality criteria

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

$$TMDL = 130.10797 * Std$$

$$WLA_{WWTF} = 553.3$$

$$WLA_{SW} = 9.07041 * Std - 553.28$$

$$LA = 120.56017 * Std$$

$$MOS = 0.47739 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

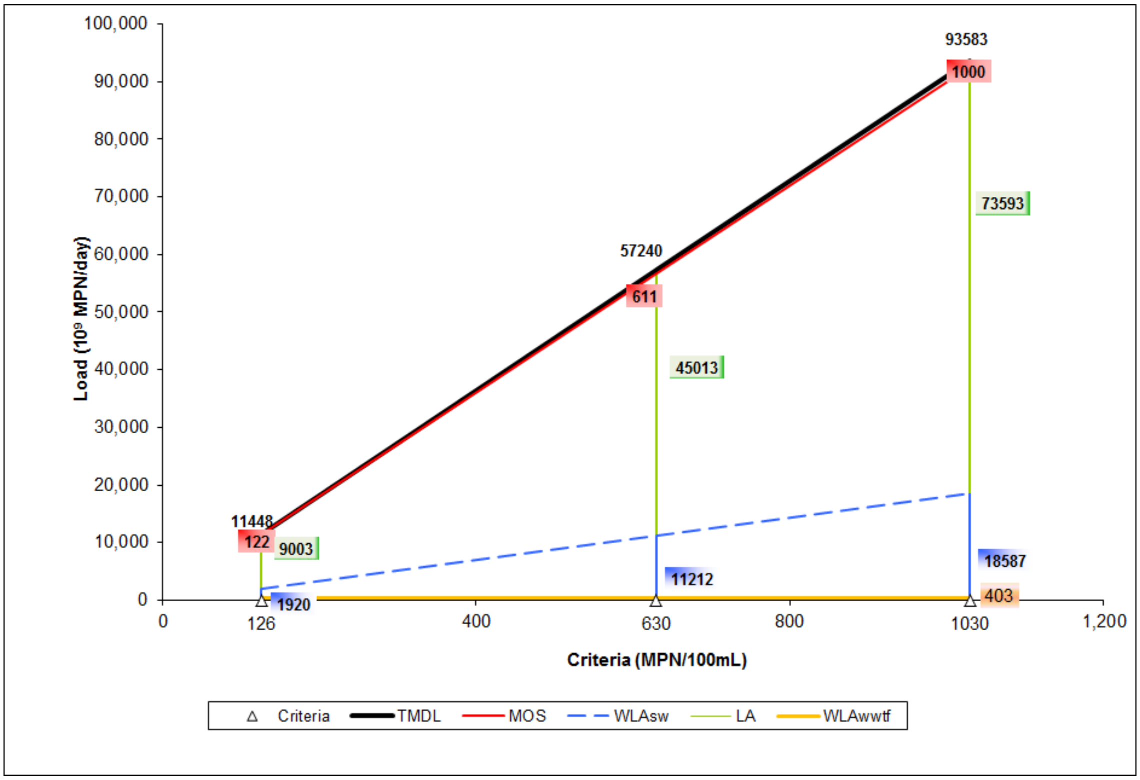

Figure B-2. Allocation loads for Lower West Fork Trinity River (0841_02) as a function of water quality criteria

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

$TMDL = 90.85707 * Std$

$WLA_{WWTF} = 403.2$

$WLA_{sw} = 18.43745 * Std – 403.2$

$LA = 71.44923 * Std$

$MOS = 0.97039 * Std$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

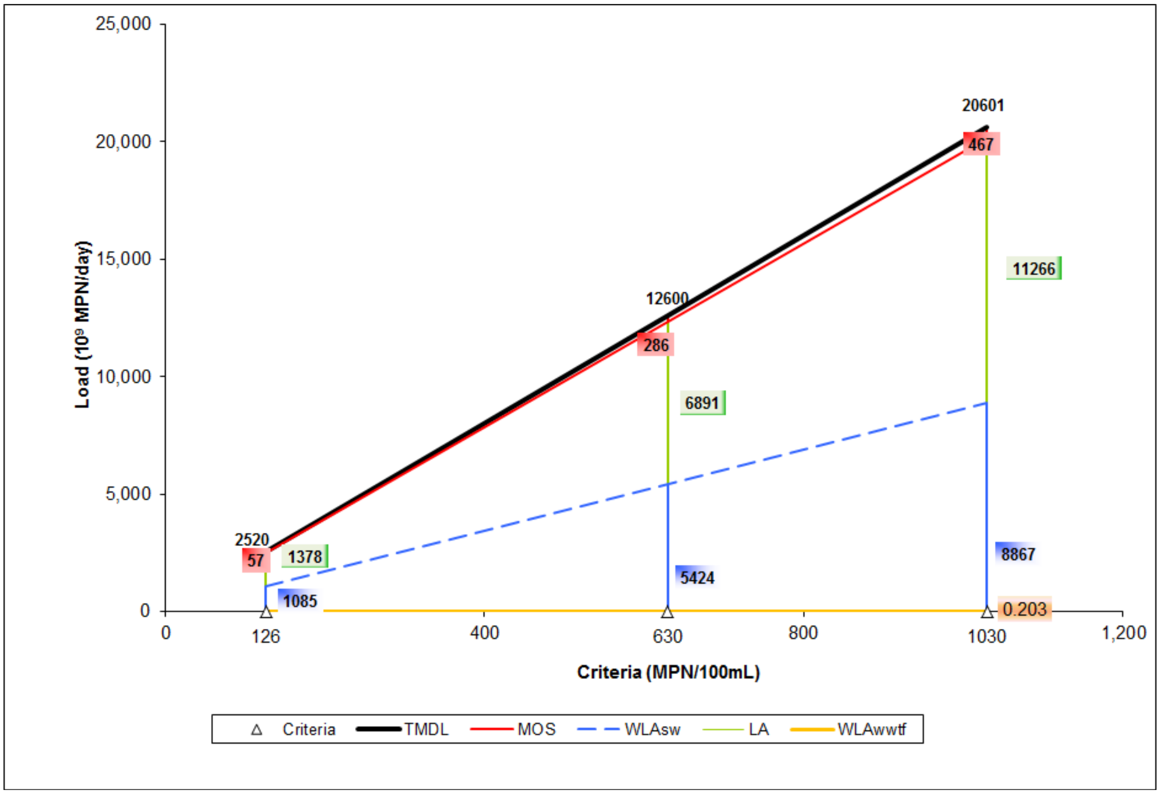

Figure B-3. Allocation loads for Bear Creek (0841B) as a function of water quality criteria

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

$TMDL = 20.0007 * Std$

$WLA_{WWTF} = 0.2031$

$WLA_{SW} = 8.60934 * Std – 0.2031$

$LA = 10.93824 * Std$

$MOS = 0.45312 * Std$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

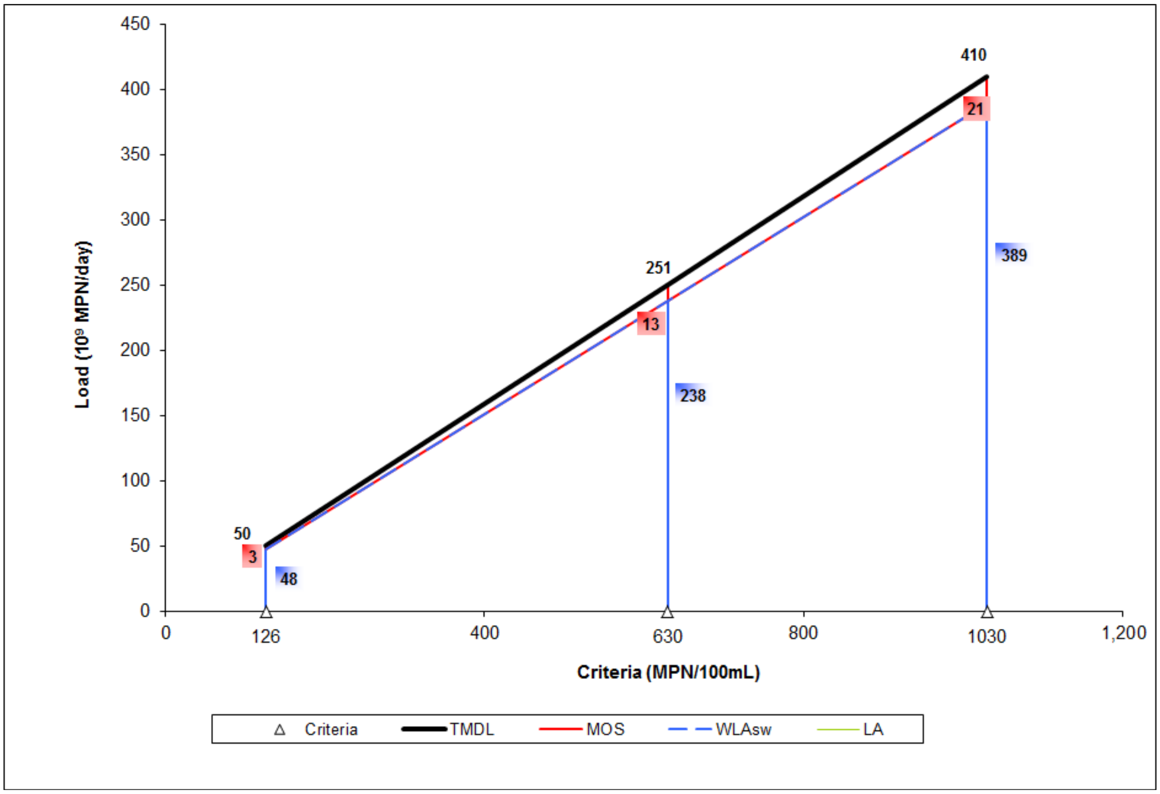

Figure B-4. Allocation loads for Arbor Creek (0841C) as a function of water quality criteria

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

$TMDL = 0.39761 * Std$

$WLA_{WWTF} = 0$

$WLA_{sw} = 0.37773 * Std$

$LA = 0$

$MOS = 0.01988 * Std$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

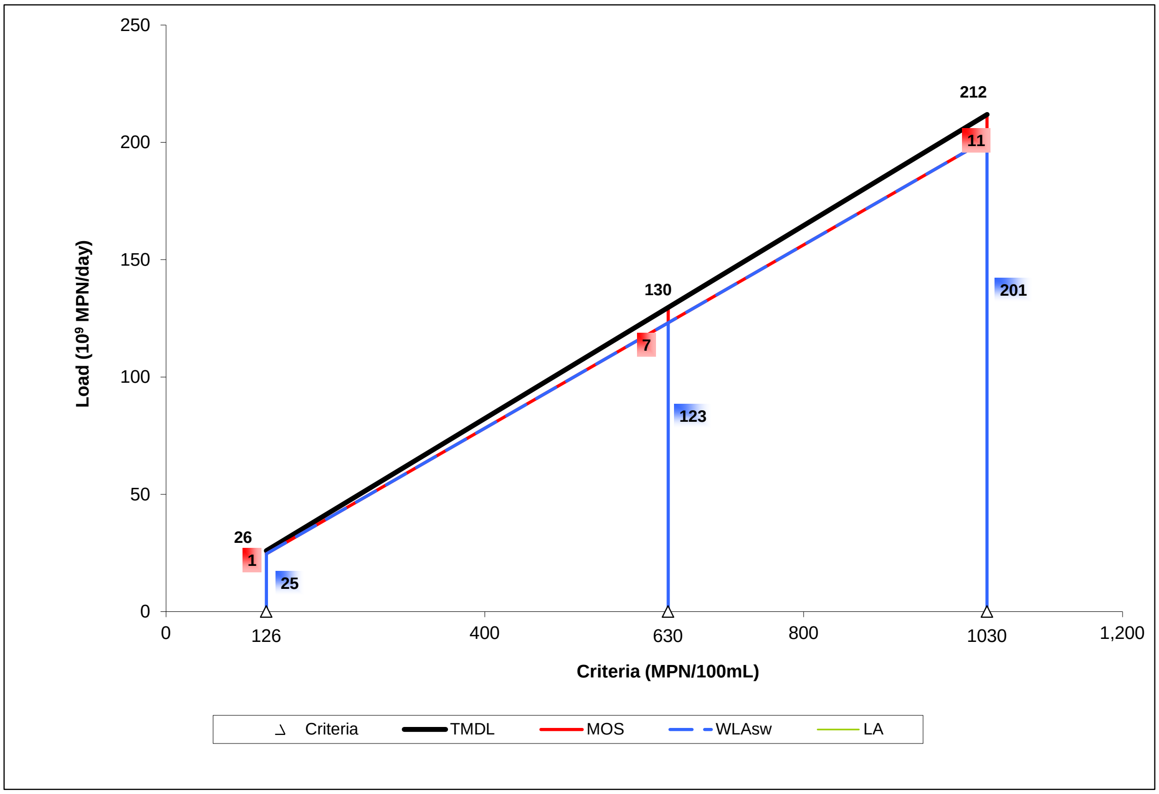

Figure B-5. Allocation loads for Copart Branch Mountain Creek (0841E) as a function of water quality criteria

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

$TMDL = 0.20570 * Std$

$WLA_{WWTF} = 0$

$WLA_{SW} = 0.19541 * Std$

$LA = 0$

$MOS = 0.01028 * Std$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

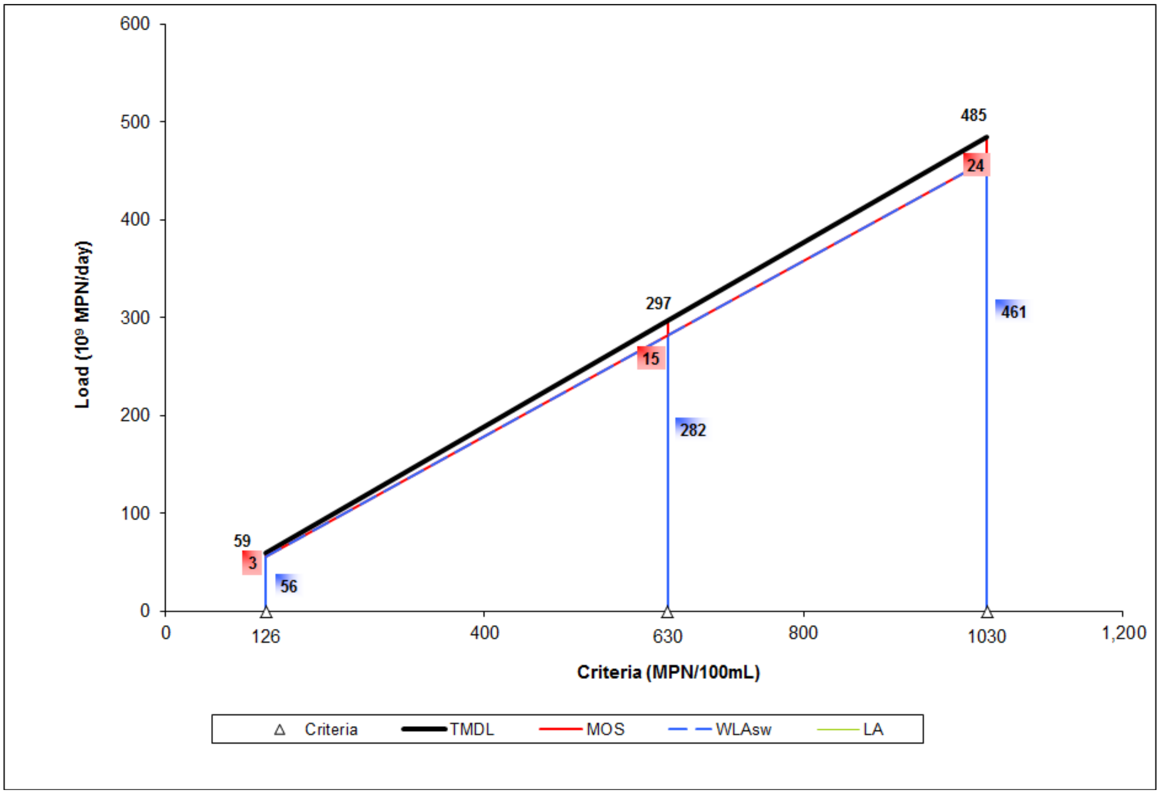

Figure B-6. Allocation loads for Dalworth Creek (0841G) as a function of water quality criteria

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

TMDL = 0.47122 * Std

WLA_{WWTF} = 0

WLA_{sw} = 0.44766 * Std

LA = 0

MOS = 0.02356 * Std

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

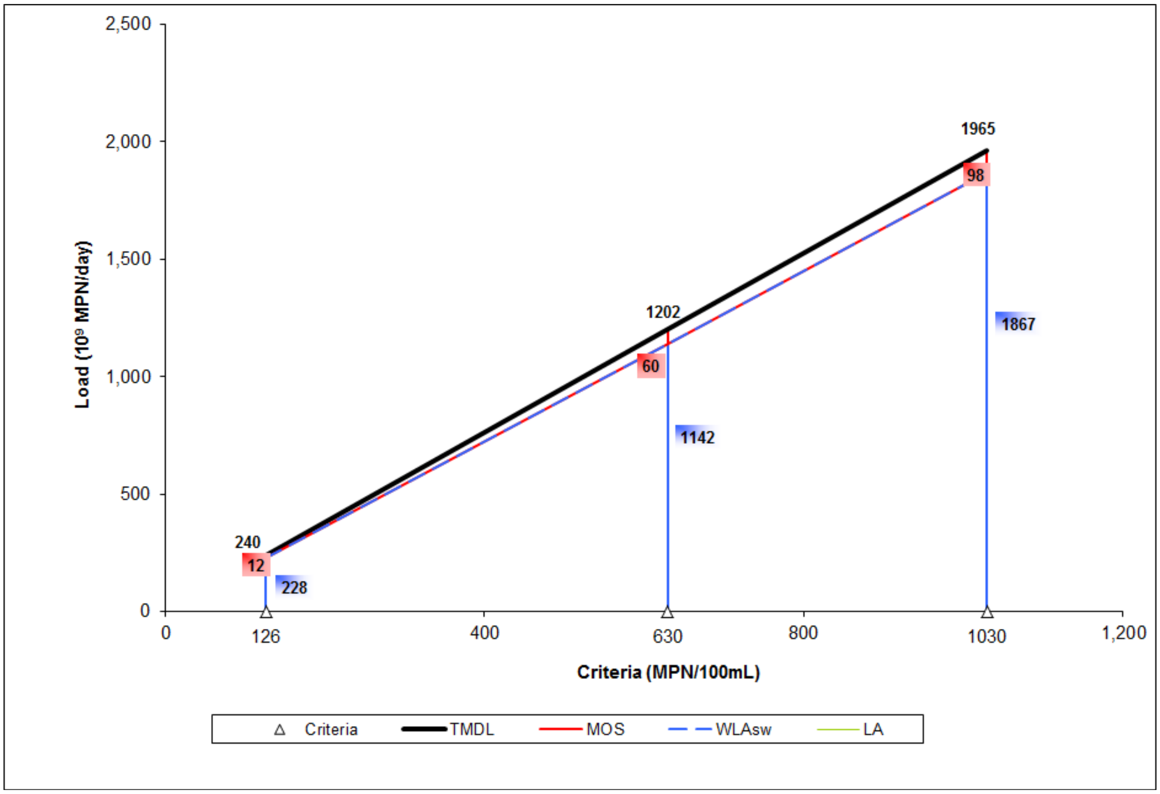

Figure B-7. Allocation loads for Delaware Creek (0841H) as a function of water quality criteria

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

$TMDL = 1.90774 * Std$

$WLA_{WWTF} = 0$

$WLA_{SW} = 1.81236 * Std$

$LA = 0$

$MOS = 0.09539 * Std$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

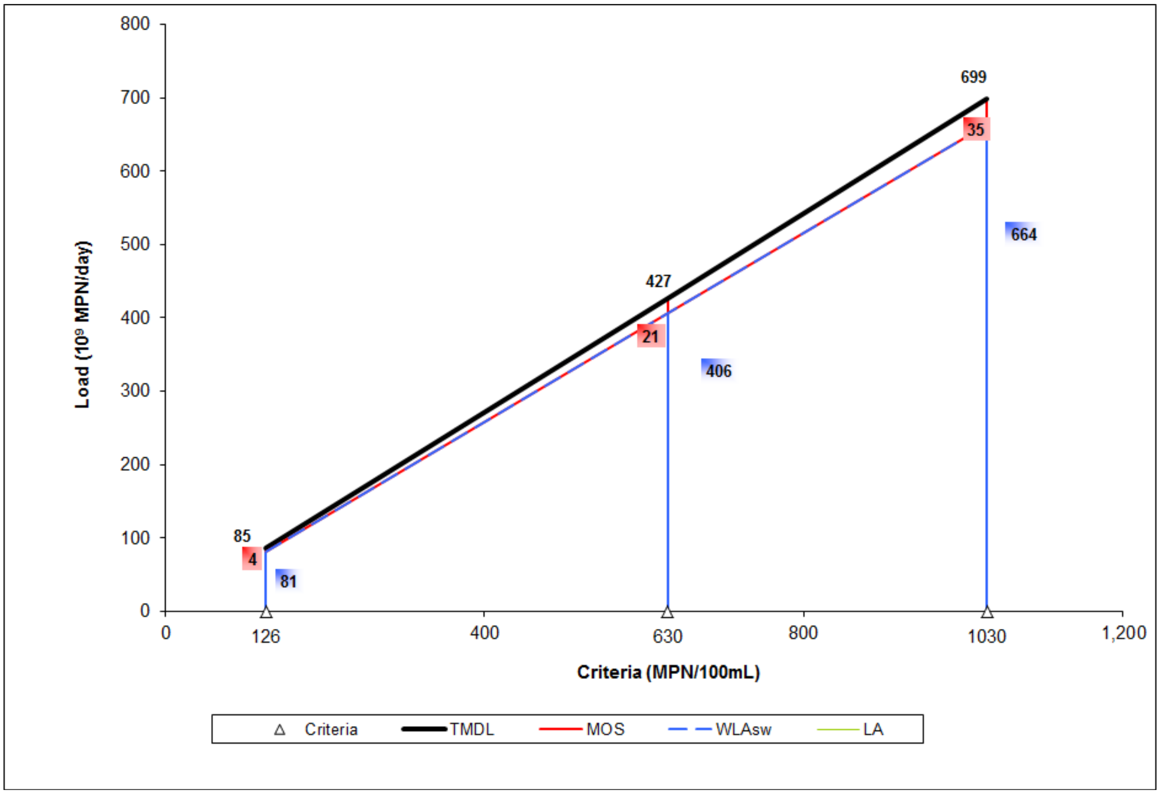

Figure B-8. Allocation loads for Estelle Creek (0841J) as a function of water quality criteria

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

TMDL = 0.67826 * Std

WLA_{WWTF} = 0

WLA_{sw} = 0.64435 * Std

LA = 0

MOS = 0.03391 * Std

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

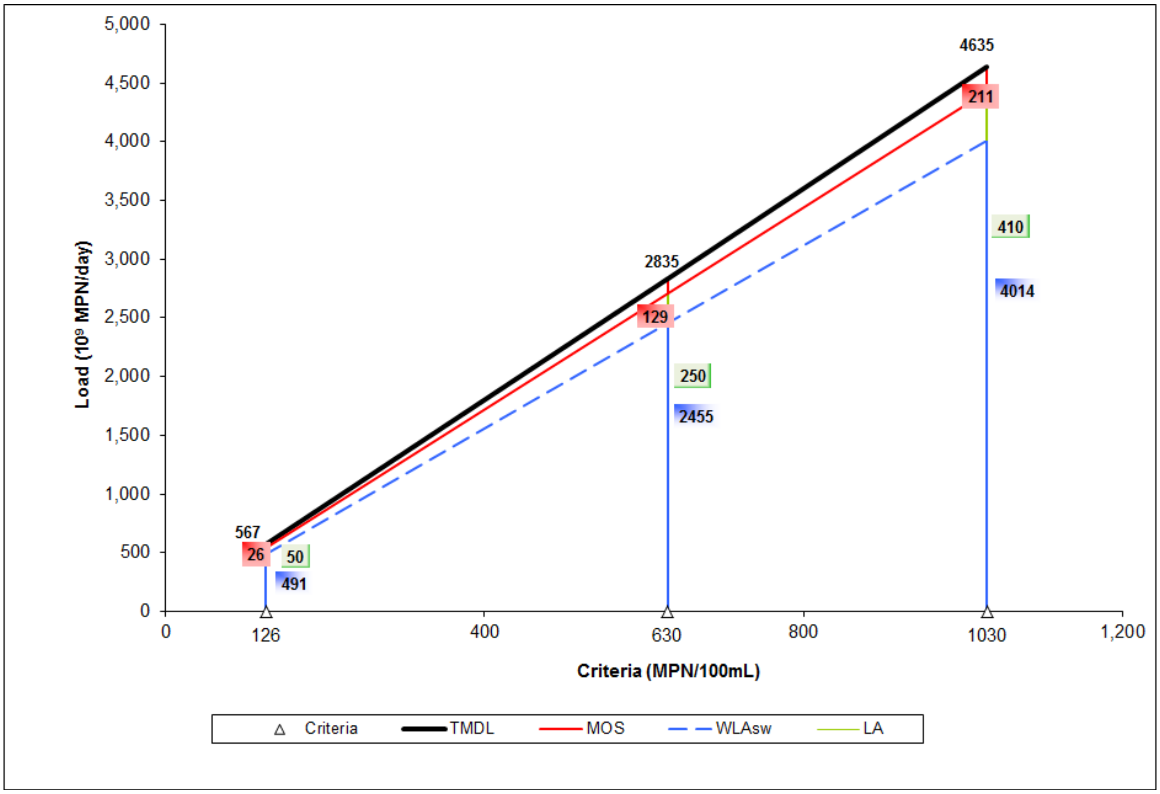

Figure B-9. Allocation loads for Johnson Creek (0841L) as a function of water quality criteria

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

$TMDL = 4.49980 * Std$

$WLA_{WWTF} = 0$

$WLA_{SW} = 3.89708 * Std$

$LA = 0.39761 * Std$

$MOS = 0.20511 * Std$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

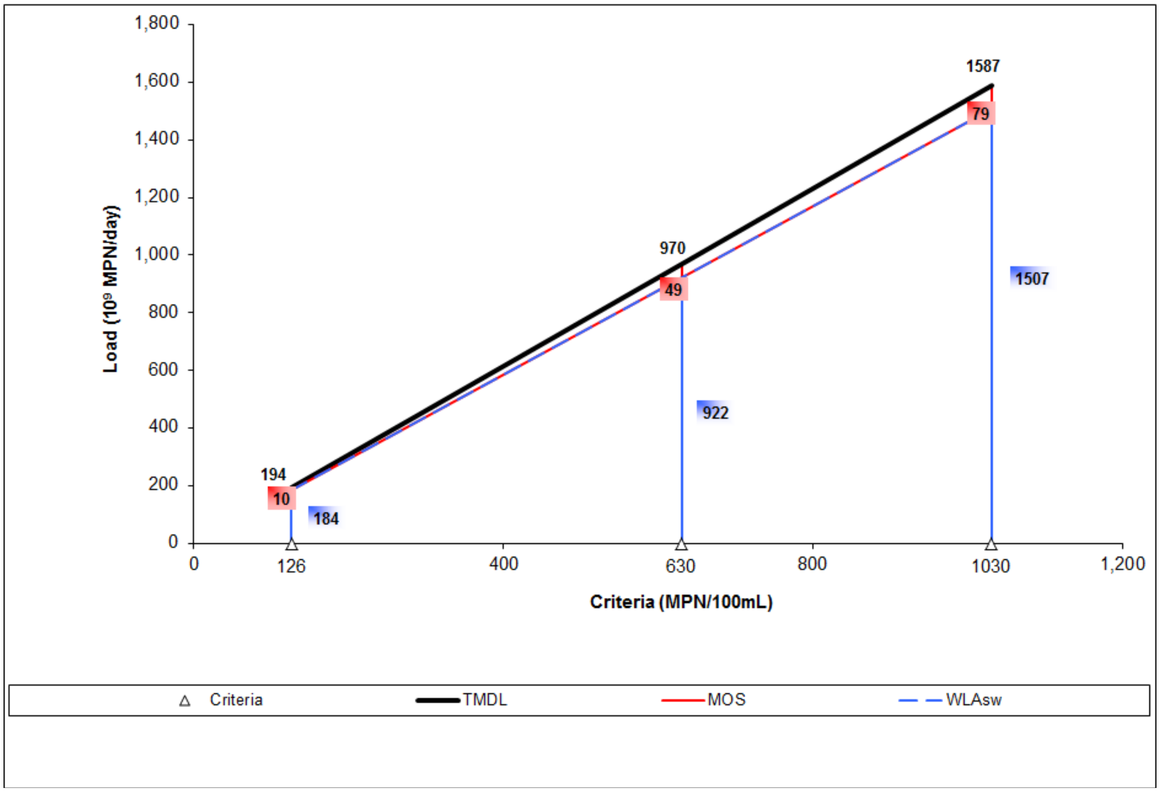

Figure B-10. Allocation loads for Kee Branch (0841M) as a function of water quality criteria

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

TMDL = 1.54038 * Std

WLA_{WWTF} = 0

WLA_{sw} = 1.46336 * Std

LA = 0

MOS = 0.07702 * Std

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

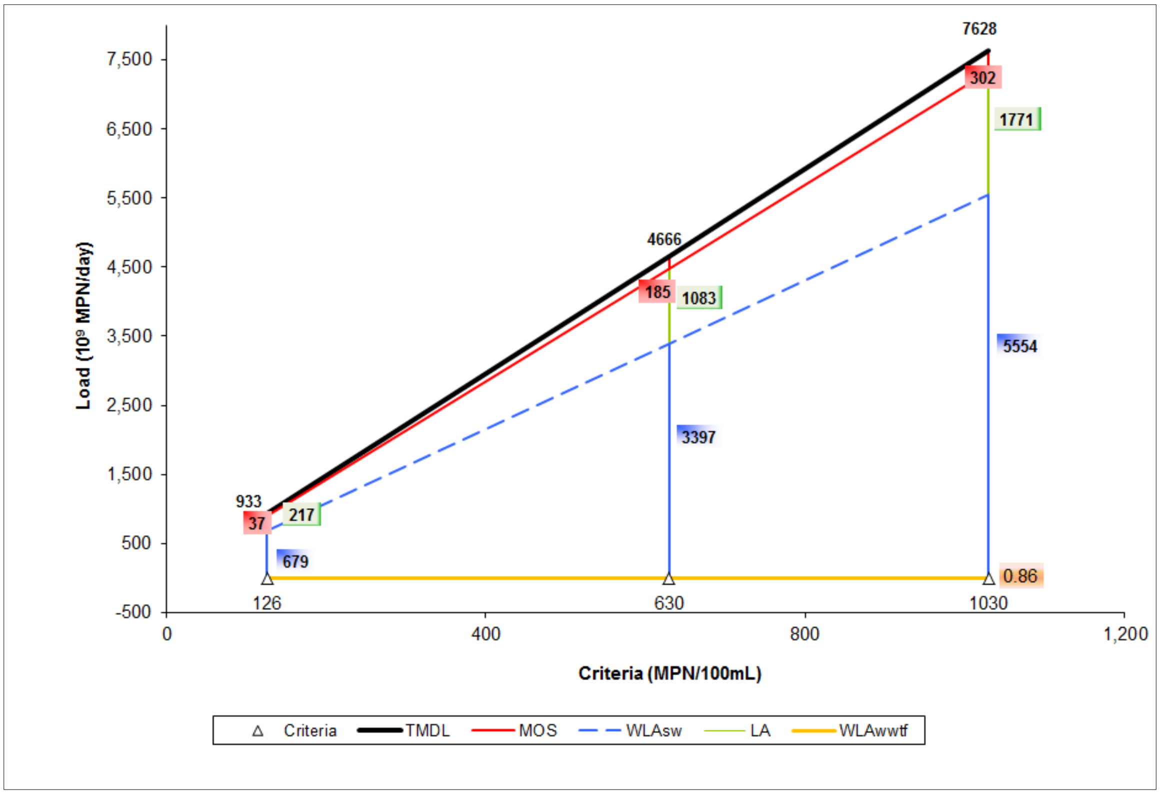

Figure B-11. Allocation loads for Rush Creek (0841R) as a function of water quality criteria

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

TMDL =7.40612 * Std

WLA_{WWTF} = 0.863

WLA_{sw} = 5.39306 * Std – 0.83480

LA = 1.71977 * Std – 0.02777

MOS = 0.29329 * Std

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

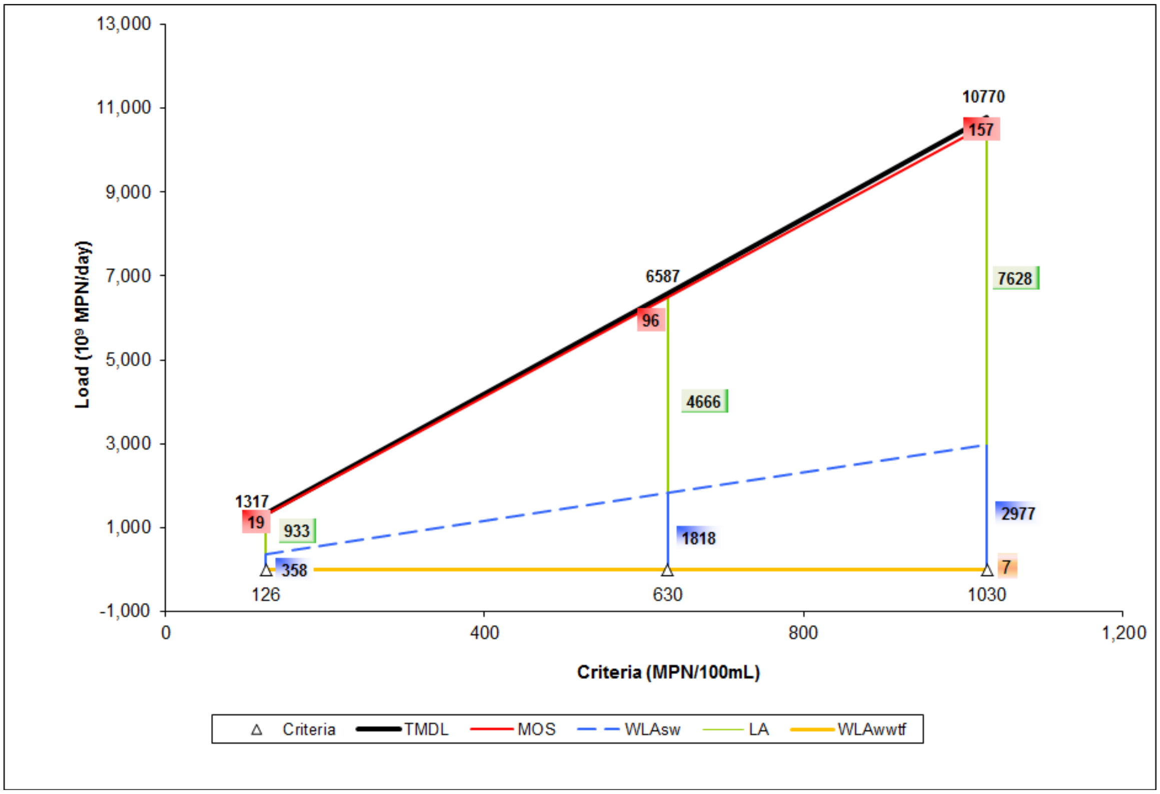

Figure B-12. Allocation loads for Village Creek (0841T) as a function of water quality criteria

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

TMDL = 10.45629 * Std

WLA_{WWTF} = 7.24

WLA_{SW} = 2.89766 * Std – 7.24

LA = 7.40612 * Std

MOS = 0.15251 * Std

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

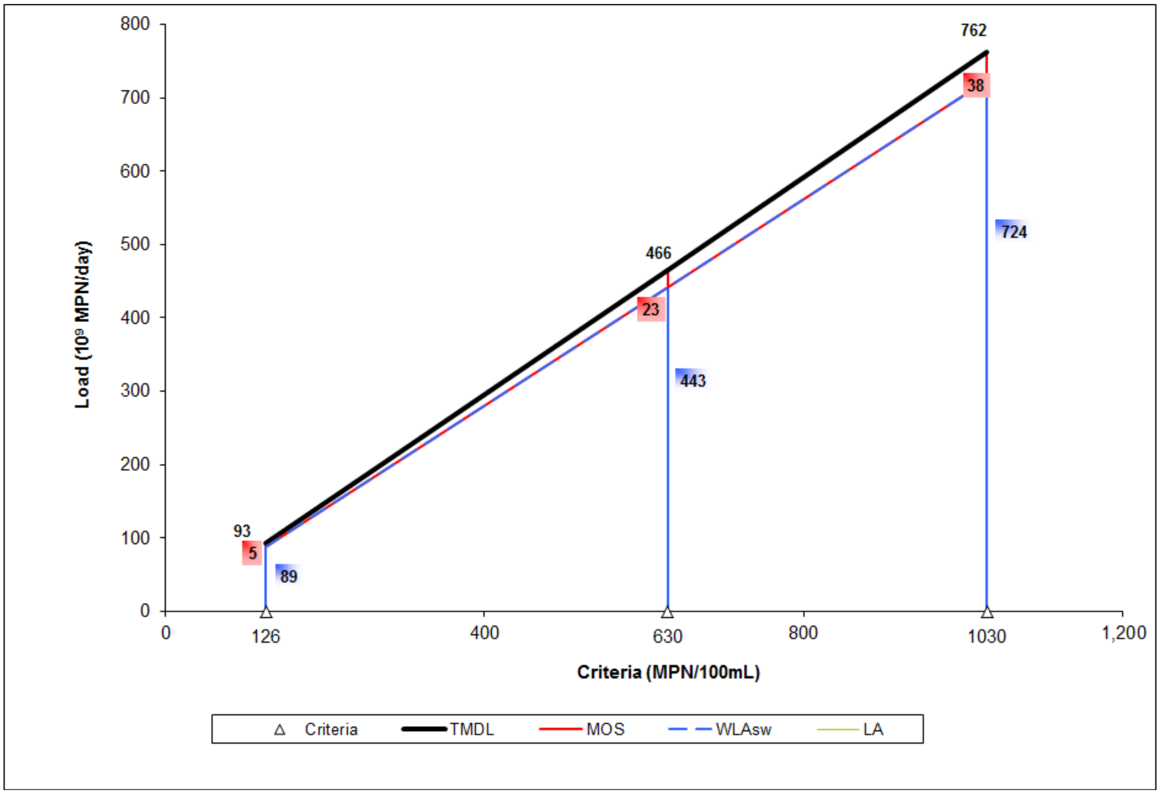

Figure B-13. Allocation loads for West Irving Branch (0841U) as a function of water quality criteria

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

TMDL = 0.73944 * Std

WLA_{WWTF} = 0

WLA_{sw} = 0.70247 * Std

LA = 0

MOS = 0.03697 * Std

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety