Technical Support Document for 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

Allocation Support Document for Total Maximum Daily Loads for Indicator Bacteria in the Lower West Fork Trinity River

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

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List of Acronyms

AU	Assessment Unit
BMP	Best Management Practice
CFR	Code of Federal Regulations
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
FDC	Flow Duration Curve
gpcd	Gallons per capita per day
I-Plan	Implementation Plan
LA	Load Allocation
LDC	Load Duration Curve
MGD	Million Gallons per Day
mL	Milliliter
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
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
OSSF	Onsite Sewage Facility
SSO	Sanitary Sewer Overflow
SWPPP	Storm Water Pollution Prevention Plan
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
USGS	United States Geological Survey
WLA	Waste Load Allocation
WQMP	Water Quality Management Plan
WWTF	Wastewater Treatment Facility

SECTION 1
INTRODUCTION

1.1 Background

To fulfill the requirements of the federal Clean Water Act and its implementing regulations, the Texas 303(d) list identifies water bodies within the State that do not meet water quality standards, hence leading to concerns for public health, aquatic species, and other wildlife. Water bodies that are identified on the 303(d) list typically require development of a Total Maximum Daily Load (TMDL), which is the maximum pollutant load a water body can receive without exceeding the water quality standards. In addition to the TMDL an implementation plan (I-Plan) is developed, which is a description of the regulatory and voluntary management measures necessary to improve water quality and restore full use of the water body.

The Texas Commission on Environmental Quality (TCEQ) first identified the bacteria impairments within the Lower West Fork Trinity River 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)* whereas bacteria impairments within Bear Creek, Arbor Creek, Copart Branch Mountain Creek, Dalworth Creek, Delaware Creek, Estelle Creek, Johnson Creek, Kee Branch, Rush Creek, Village Creek, and West Irving Branch were all first identified in 2006 and each subsequent list through 2010. Impairments have also been noted in the 2010 *Texas Water Quality Integrated Report* for the Lower West Fork Trinity River for dioxin and polychlorinated biphenyls (PCBs) in edible tissue, which will not be addressed in this document.

This document will consider bacteria impairments in 12 water bodies (segments) consisting of 13 assessment units (AUs). The complete list of water bodies and their identifying segment_AU number are as follows:

1) Lower West Fork Trinity River 0841_01;
2) Lower West Fork Trinity River 0841_02;
3) Bear Creek 0841B_01 (entire segment);
4) Arbor Creek 0841C_01 (entire segment);
5) Copart Branch Mountain Creek 0841E_01 (entire segment);
6) Dalworth Creek 0841G_01 (entire segment);
7) Delaware Creek 0841H_01 (entire segment);
8) Estelle Creek 0841J_01 (entire segment);
9) Johnson Creek 0841L_01 (entire segment);
10) Kee Branch 0841M_01 (entire segment);
11) Rush Creek 0841R_01 (entire segment);
12) Village Creek 0841T_01 (entire segment); and
13) West Irving Branch 0841U_01 (entire segment).

Because the 11 impaired 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.

1.2 Water Quality Standards

To protect public health, aquatic life, and development of industries and economies throughout Texas, water quality standards were established by the TCEQ. The water quality standards specifically protect appropriate uses for each segment (water body), and list appropriate limits for water quality indicators to assure water quality and attainment of uses. The TCEQ monitors and assesses water bodies based on the water quality standards, and publishes the Texas Water Quality Integrated Report list biennially.

The *Texas Surface Water Quality Standards* (TCEQ, 2010b) are rules that:

- *designate the uses, or purposes, for which the state's water bodies should be suitable;*
- *establish numerical and narrative goals for water quality throughout the state; and*
- *provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals for water quality.*

Standards are established to protect designated uses assigned to water bodies of which the primary uses assigned in the *Texas Surface Water Quality Standards* to water bodies are:

- *aquatic life use*
- *contact recreation*
- *domestic water supply*
- *general use*

Bacteria are indicators of the risk of illness during contact recreation (e.g., swimming) from ingestion of water. Fecal coliforms are bacteria that originate from the wastes of warm-blooded animals. They usually live in human or animal intestinal tracts. *E. coli* (*Escherichia coli*) is a member of fecal coliform bacteria group (USEPA, 2009). The presence of these bacteria indicates that associated pathogens from the wastes may be reaching water bodies, because of such sources as inadequately treated sewage, improperly managed animal waste from livestock, pets in urban areas, aquatic birds, wildlife, and failing septic systems (TCEQ, 2006).

On June 30, 2010 the TCEQ adopted revisions to the *Texas Surface Water Quality Standards* (TCEQ, 2010b) and on June 29, 2011 the U.S. Environmental Protection Agency (EPA) approved the categorical levels of recreational use and their associated criteria. Recreational use consists of four categories:

- Primary contact recreation is that with a significant risk of ingestion of water (such as swimming), and has a geometric mean criterion for *E. coli* of 126 most probable number (MPN) per 100 mL;
- Secondary contact recreation 1 covers activities with limited body contact and a less significant risk of ingestion of water (such as fishing), and has a geometric mean criterion for *E. coli* of 630 MPN per 100 mL;

- Secondary contact recreation 2 is similar to secondary contact 1, but activities occur less frequently. It has a geometric mean criterion for *E. coli* of 1,030 MPN per 100 mL; and
- Noncontact recreation is that with no significant risk of ingestion of water, where contact recreation should not occur due to unsafe conditions. It has a geometric mean criterion for *E. coli* of 2,060 MPN per 100 mL (TCEQ, 2010b).

1.3 Report Purpose and Organization

The Lower West Fork Trinity River Watershed TMDL project was initiated through a contract between the TCEQ and Texas Institute for Applied Environmental Research (TIAER). The tasks of this project were to (1) acquire existing (historical) data and information necessary to support assessment activities; (2) perform the appropriate activities necessary to allocate *E. coli* loadings; and (3) assist the TCEQ in preparing the TMDL. Using historical bacteria and flow data, this portion of the project was to: (1) review the characteristics of the watershed and explore the potential sources of *E. coli* bacteria for the impaired segments; (2) develop an appropriate tool for development of bacteria TMDLs for the impaired segments; and (3) submit the draft and final technical support document for the impaired segments. The purpose of this report is to provide technical documentation and supporting information for developing the bacteria TMDLs for the Lower West Fork Trinity watershed. This report contains:

- information on historical data,
- watershed properties and characteristics,
- summary of historical bacteria data that confirm the State of Texas 303(d) listings of impairment due to presence of indicator bacteria (*E. coli*),
- development of load duration curves, and
- application of the load duration curve approach for the pollutant load allocation process.

SECTION 2
HISTORICAL DATA REVIEW AND WATERSHED PROPERTIES

2.1 Description of Study Area

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 261 square miles and includes many smaller order streams. By definition the Lower West Fork Trinity River is simply a reach of the Trinity River. Many of the study 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 also contains numerous large reservoirs that effectively alter the hydrology and remove a very significant amount of downstream streamflow and loadings of bacteria. Because of the hydrologic and bacteria loading connectivity of upstream segments with downstream segments and the disruption of this connectivity by the presence of large reservoirs, the total contributing drainage 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 2-1).

The upstream hydrologic terminuses of the contributing drainage area occur at the major reservoirs, which are labeled on Figure 2-1. These major reservoirs, which were 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.

The 2010 Texas Water Quality Integrated Report provides the following segment and AU descriptions for the water bodies considered in this document:

- 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 a point immediately upstream of the confluence of the Elm Fork Trinity River in Dallas County to a point immediately upstream of the confluence of Johnson Creek in Dallas County.
    - 0841_02 – Lower West Fork Trinity River from a point immediately upstream of the confluence of Johnson Creek in Dallas County to a point immediately upstream of the confluence of Village Creek in Tarrant County
- Segment 0841B – a 12-mile stretch of Bear Creek running upstream from the confluence with the West Fork Trinity River, to the confluence with Little Bear Creek just upstream of Highway 183 in Euless, Tarrant County.
- Segment 0841C – a 2.2-mile stretch of Arbor Creek running upstream from the confluence with Johnson Creek to approximately 0.5 miles upstream of the Tarrant/Dallas County Line,

- Segment 0841E – a 2.8 mile stretch of Copart Branch Mountain Creek upstream from the confluence with Mountain Creek to approximately 0.3 miles upstream of Camden Road on former Dallas Naval Air Station, Dallas County.
- Segment 0841G – A 2.2 mile stretch of Dalworth Creek running upstream from the confluence with the Lower West Fork Trinity River to County Line Road in Grand Prairie, Dallas County
- Segment 0841H– An 8.5 mile stretch of Delaware Creek running upstream from the confluence with the Lower West Fork Trinity to Finley Road in Irving.
- Segment 0841J– A 4 mile stretch of Estelle Creek running upstream from the confluence with Bear Creek to Valley View Lane in Irving, Dallas County.
- Segment 0841L– A 4 mile stretch of Johnson Creek running upstream from the confluence with Arbor Creek to just upstream of IH 30 in Arlington, Tarrant County.
- Segment 0841M– A 6 mile stretch of Kee Branch running upstream from the confluence with Rush Creek to the upper end of the creek.
- Segment 0841R– A 5 mile stretch of Rush Creek running upstream from the confluence with Village Creek to the confluence with Kee Branch in Arlington, Tarrant County.
- Segment 0841T– A 7 mile stretch of Village Creek running from the confluence with the West Fork Trinity River to SH 303 approximately 0.75 mile downstream of Lake Arlington., and West Irving Branch
- Segment 0841U– A 4 mile stretch of West Irving Branch running upstream from approximately 0.4 mile downstream of Oakdale Road to just south of Sowers Road in Irving, Dallas County.

This study incorporates a watershed approach where the drainage area of the entire stream is considered. For purposes of this study, each of the bacterial impaired AUs listed above will be considered geographically as extending to the upper end of the water body unless another TCEQ segment lies upstream. As an example, for this study the entire drainage area of Johnson Creek (0841L) will be considered rather than terminating the water body at IH 30 as provided in the description of the Johnson Creek AU. The rational is that the entire Johnson Creek drainage area is contributing to the bacteria in the stream.

It should be noted that Big Bear Creek (Segment 0841B), Dry Branch Creek (Segment 0841I), Mountain Creek (Segment 0841O), and Vilbig Lake (Segment 0841S) are also designated as unclassified water bodies within the study area shown in Figure 2-1 for Segment 0841, but these water bodies are not included in this TMDL project. 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, 2010c). 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 are being collected on Vilbig Lake, and its status and the need for a TMDL will be assessed following completion of additional sampling. Vilbig Lake will not be addressed in this TMDL document.

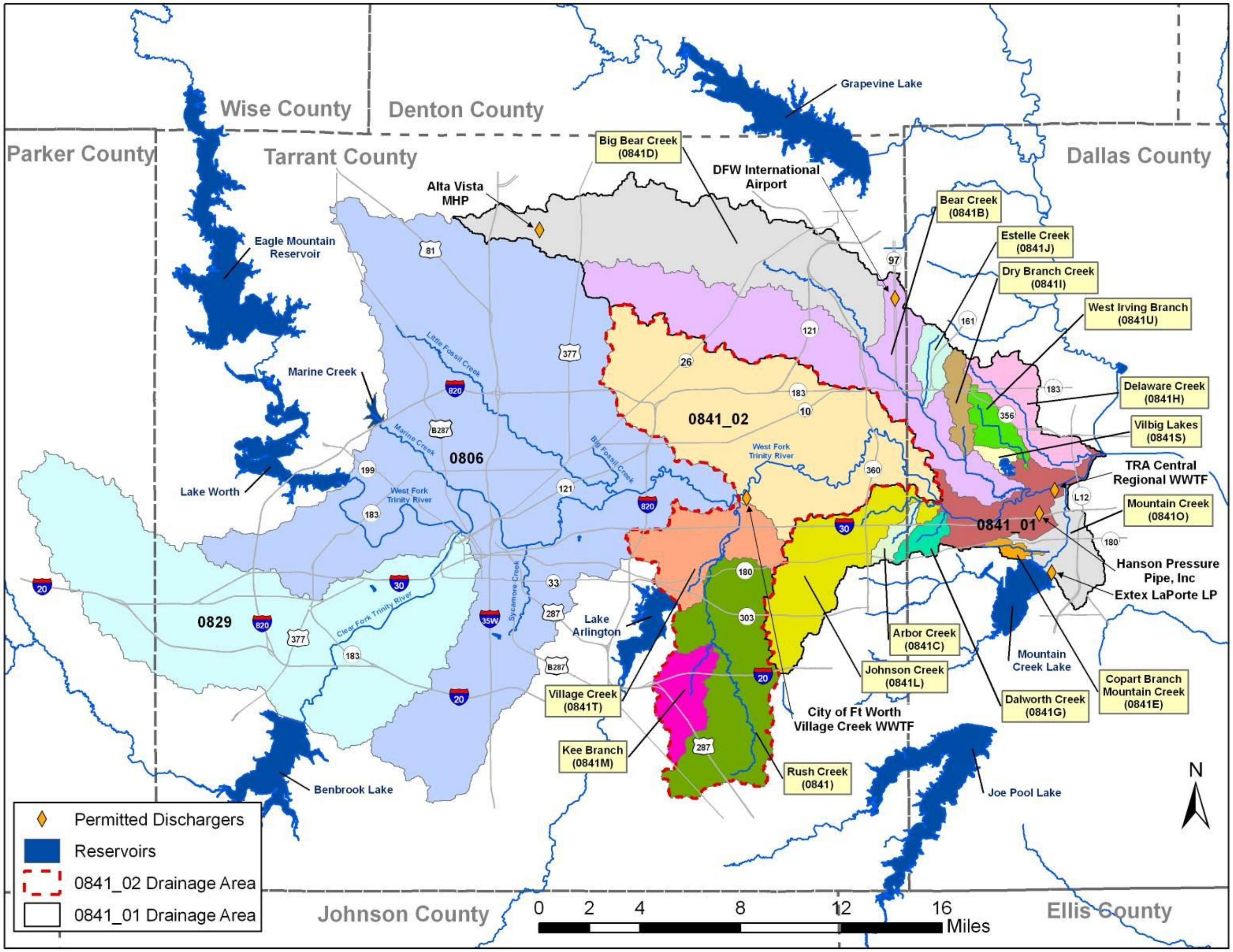

Figure 2-1. Total contributing drainage area for the study, including Segments 0806, 0829, and 0841

The 13 AUs listed above comprise the TMDL area addressed in this report. The phrase "TMDL watersheds" will be used when referring to the area of all 13 impaired AUs addressed in this report, and "Lower West Fork Trinity River watershed" will be used when referring to the combined TMDL watersheds, non-impaired watersheds, and the Vilbig Lake watershed.

As an additional note, the boundaries for the two AUs of the Lower West Fork Trinity River changed after publication of the 2010 *Texas Water Quality Integrated Report*. Assessment results prior to and including the 2010 assessment defined 0841_02 as a point from the Tarrant/Dallas County line upstream to the confluence of Village Creek. Due to lack of safe access at road crossings and changes in monitoring objectives water samples had not been routinely collected in this AU. The AU boundary for 0841_02 was moved to include the West Fork Trinity River from the confluence of Johnson Creek upstream to the confluence of Village Creek. Prior to the change in the AU boundary, data for 0841_02 indicated attainment of the contact recreation use criterion, however, more data became available after the change in the AU boundary for 0841_02 and those additional data indicate nonsupport of the contact recreation criterion. The change in the AU boundary of 0841_02 also necessitated an AU boundary change in downstream 0841_01. The assessment results prior to and including the 2010 assessment for 0841_01 defined this AU's boundary as being from the a point immediately upstream of the confluence of the Elm Fork Trinity River in Dallas County to a point immediately upstream of the confluence of Village Creek in Tarrant Count. As a result of moving the AU boundary of 0841_02 the boundary definition for 0841_01 was changed to include the West Fork Trinity River from the confluence of the Elm Fork Trinity River to the confluence of Johnson Creek. Data obtained from stations within the previous and current AU definitions for 0841_01 indicate nonsupport for the contact recreation use. Additional information on the assessment of bacteria data is provided later in this report section.

2.2 Watershed Climate and Hydrology

"Generally, streamflow in the Trinity River Basin follows the rainfall pattern of the area" (Trinity River Authority (TRA), 2012a). Although the Trinity River Basin has moderate rainfall and runoff on average, its hydrology is notoriously 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). According to the Trinity River Authority (2012a), "the natural flow in the great majority of streams in the Trinity Basin is highly variable" and "most of the smaller streams in the basin cease to flow within a few days or weeks without rain, depending on the season and drainage area." Many of the Trinity River's tributaries, and the river itself below Dallas, have a base flow which 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 permitted 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 100ºF; however, the low temperature rarely exceeds 80ºF at night (NWS, 2012). During winter, the average low temperature bottoms out at 33ºF 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).

Weather data obtained from the NWS that spans a period 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 out the year in which air temperatures will be at or exceed 100°F and 33 days of temperatures at or below freezing.

2.3 Review of Lower West Fork Trinity River Watershed Routine Monitoring Data

2.3.1 Data Acquisition

Ambient *E. coli* data were obtained from the TCEQ Surface Water Quality Monitoring Information System (SWQMIS). The data represented the routine ambient *E. coli* and other water quality data collected in the project area. General assessment criteria methodologies established by TCEQ were used in data evaluations.

2.3.2 Analysis of Bacteria Data

Recent environmental monitoring within the Lower West Fork Trinity River watershed (0841_01, 0841_02, 0841B, 0841C, 0841E, 0841G, 0841H, 0841J, 0841L, 0841M, 0841R, 0841S, 0841T, and 0841U) has occurred at numerous TCEQ monitoring stations (Figure 2-2). *E. coli* data collected at these stations over the seven-year period of December 1, 2001 through November 30, 2008 were used in assessing attainment of the primary contact recreation use as reported in the *2010 Texas Integrated Report* (TCEQ, 2010c) and as summarized in Table 2-1. For the purposes of this study the current boundary definition of AUs 0841_01 and 0841_02 were used , which moved Station 17669 from being located in 0841_01 into 0841_02 (Figure 2-2), and this relocation is reflected in the data summarization in Table 2-1. 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).

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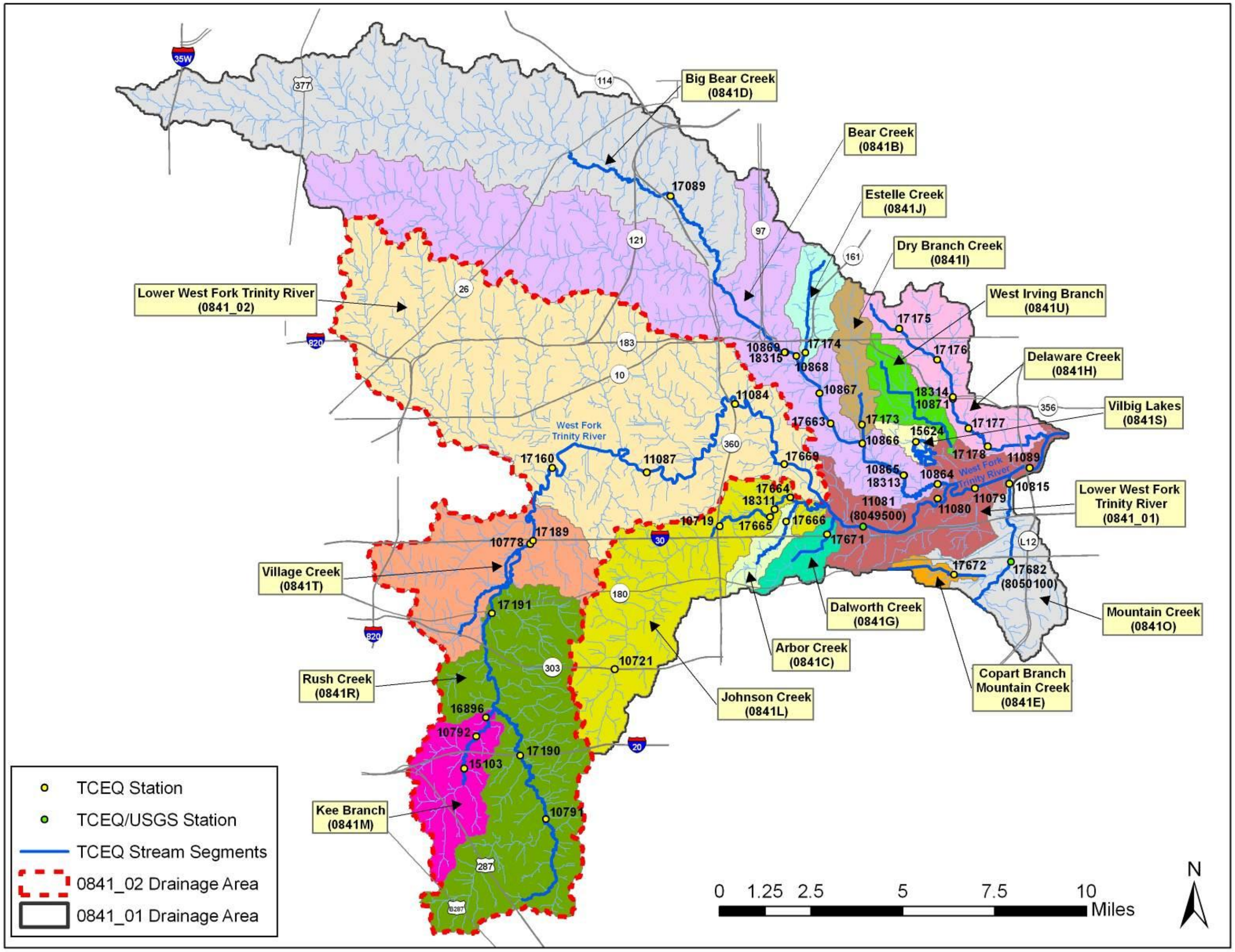

Figure 2-2. Lower West Fork Trinity River watershed showing monitoring stations and streamflow gages

Table 2-1. 2010 Integrated Report Summary for the Lower West Fork Trinity River watershed.

Water Body	Assessment Unit (AU)	Station	No. of Samples	Data Date Range	Station Geometric Mean (MPN/100 mL)	No. of Samples in AU	AU Geometric Mean (MPN/100 mL)
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		
	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		
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	0841J	17174	32	2001-2004	342	32	342

Water Body	Assessment Unit (AU)	Station	No. of Samples	Data Date Range	Station Geometric Mean (MPN/100 mL)	No. of Samples in AU	AU Geometric Mean (MPN/100 mL)
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 *	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 Lakes	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

* 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.

2.4 Land Use

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) 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** – Commercial includes land occupied by hotels, large stadiums, office and retail buildings.
- **Industrial** – Industrial includes land occupied by industrial complexes.
- **Residential** – Residential is property that contains single-family and multi-family housing units and mobile homes.

- **Government/Education**- Government/Education includes land includes institutional buildings and group quarters.
- **Airports** – Airports includes land occupied by airports and associated runways.
- **Undeveloped** – Undeveloped includes land that is either vacant or under construction and may include expanded parking areas.
- **Infrastructure** – Infrastructure includes roadways and utility structures.
- **Dedicated**- Dedicated includes land that is occupied by parks and landfills.
- **Water** – Water includes all areas of open water.

The 2005 land use/land cover data from the NCTCOG is provided for the Lower West Fork Trinity River watershed in Figure 2-3, and in both tabular and map form for each of the TMDL watersheds included in this study (Tables 2-2 – 2-14; Figures 2-4 – 2-16). The dominate 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 dominate category. In some of the smaller watersheds, such as Arbor Creek and Copart Branch Mountain Creek, other land uses besides 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 2-2. Land/Use Land Cover within Lower West Fork Trinity River (0841_01)

Description	Area (ha)	% of Total
Undeveloped	1,264	43.9
Residential	367	12.7
Infrastructure	337	11.7
Dedicated	293	10.2
Water	249	8.7
Industrial	152	5.3
Commercial	141	4.9
Total	2,883	100

Table 2-3. Land/Use Land Cover within Lower West Fork Trinity River (0841_02)

Description	Area (ha)	% of Total
Residential	4714	29.8
Undeveloped	3709	23.5
Infrastructure	2930	18.5
Dedicated	1184	7.5
Commercial	1179	7.5
Industrial	877	5.6
Government/Education	753	4.8
Water	458	2.9
Total	15,803	100

Table 2-4. Land/Use Land Cover within Bear Creek (0841B)

Description	Area (ha)	% of Total
Residential	3852	35.3
Undeveloped	3051	28.0
Infrastructure	1893	17.3
Airports	550	5.0
Commercial	397	3.6
Dedicated	354	3.2
Industrial	350	3.2
Government/Education	250	2.3
Water	217	2.0
Total	10,912	100

Table 2-5. Land/Use Land Cover within Arbor Creek (0841C)

Description	Area (ha)	% of Total
Industrial	149	31.1
Infrastructure	143	29.8
Undeveloped	70	14.5
Residential	65	13.6
Commercial	44	9.2
Dedicated	6	1.2
Government/Education	3	0.5
Water	0.3	0.1
Total	479	100

Table 2-6. Land/Use Land Cover within Copart Branch Mountain Creek (0841E)

Description	Area (ha)	% of Total
Government/Education	91	36.6
Commercial	54	21.6
Infrastructure	44	17.8
Industrial	29	11.8
Undeveloped	29	11.7
Residential	1	0.6
Dedicated	0.05	0.02
Total	248	100

Table 2-7. Land/Use Land Cover within Dalworth Creek (0841G)

Description	Area (ha)	% of Total
Residential	211	37.2
Infrastructure	159	28.0
Undeveloped	103	18.2
Commercial	29	5.1
Industrial	29	5.0
Government/Education	22	4.0
Dedicated	14	2.5
Water	0.4	0.1
Total	567	100

Table 2-8. Land/Use Land Cover within Delaware Creek (0841H)

Description	Area (ha)	% of Total
Residential	1137	49.5
Infrastructure	496	21.6
Government/Education	213	9.3
Commercial	181	7.9
Dedicated	122	5.3
Undeveloped	101	4.4
Industrial	46	2.0
Water	3	0.1
Total	2,297	100

Table 2-9. Land/Use Land Cover within Estelle Creek (0841J)

Description	Area (ha)	% of Total
Undeveloped	356	43.5
Infrastructure	192	23.5
Residential	114	13.9
Airports	69	8.5
Commercial	44	5.4
Government/Education	21	2.5
Industrial	19	2.4
Dedicated	2	0.2
Water	1	0.1
Total	817	100

Table 2-10. Land/Use Land Cover within Johnson Creek (0841L)

Description	Area (ha)	% of Total
Residential	1441	29.2
Infrastructure	1093	22.1
Commercial	677	13.7
Undeveloped	543	11.0
Industrial	542	11.0
Government/Education	344	7.0
Dedicated	282	5.7
Water	18	0.4
Total	4,940	100

Table 2-11. Land/Use Land Cover within Kee Branch (0841M)

Description	Area (ha)	% of Total
Residential	927	50.0
Infrastructure	432	23.3
Undeveloped	281	15.1
Government/Education	96	5.2
Commercial	92	4.9
Dedicated	20	1.1
Industrial	5	0.3
Water	2	0.1
Total	1,855	100

Table 2-12. Land/Use Land Cover within Rush Creek (0841R)

Description	Area (ha)	% of Total
Residential	3165	44.8
Infrastructure	1289	18.3
Undeveloped	1240	17.6
Dedicated	420	6.0
Commercial	417	5.9
Government/Education	287	4.1
Industrial	210	3.0
Water	35	0.5
Total	7,063	100

Table 2-13. Land/Use Land Cover within Village Creek (0841T)

Description	Area (ha)	% of Total
Residential	1305	35.5
Undeveloped	878	23.9
Infrastructure	722	19.7
Dedicated	421	11.5
Government/Education	153	4.2
Commercial	135	3.7
Water	42	1.1
Industrial	16	0.4
Total	3,673	100

Table 2-14. Land/Use Land Cover within West Irving Branch (0841U)

Description	Area (ha)	% of Total
Residential	533	49.5
Infrastructure	201	18.7
Government/Education	95	8.8
Undeveloped	91	8.4
Commercial	59	5.5
Dedicated	58	5.4
Industrial	26	2.4
Water	13	1.2
Commercial	1,075	100

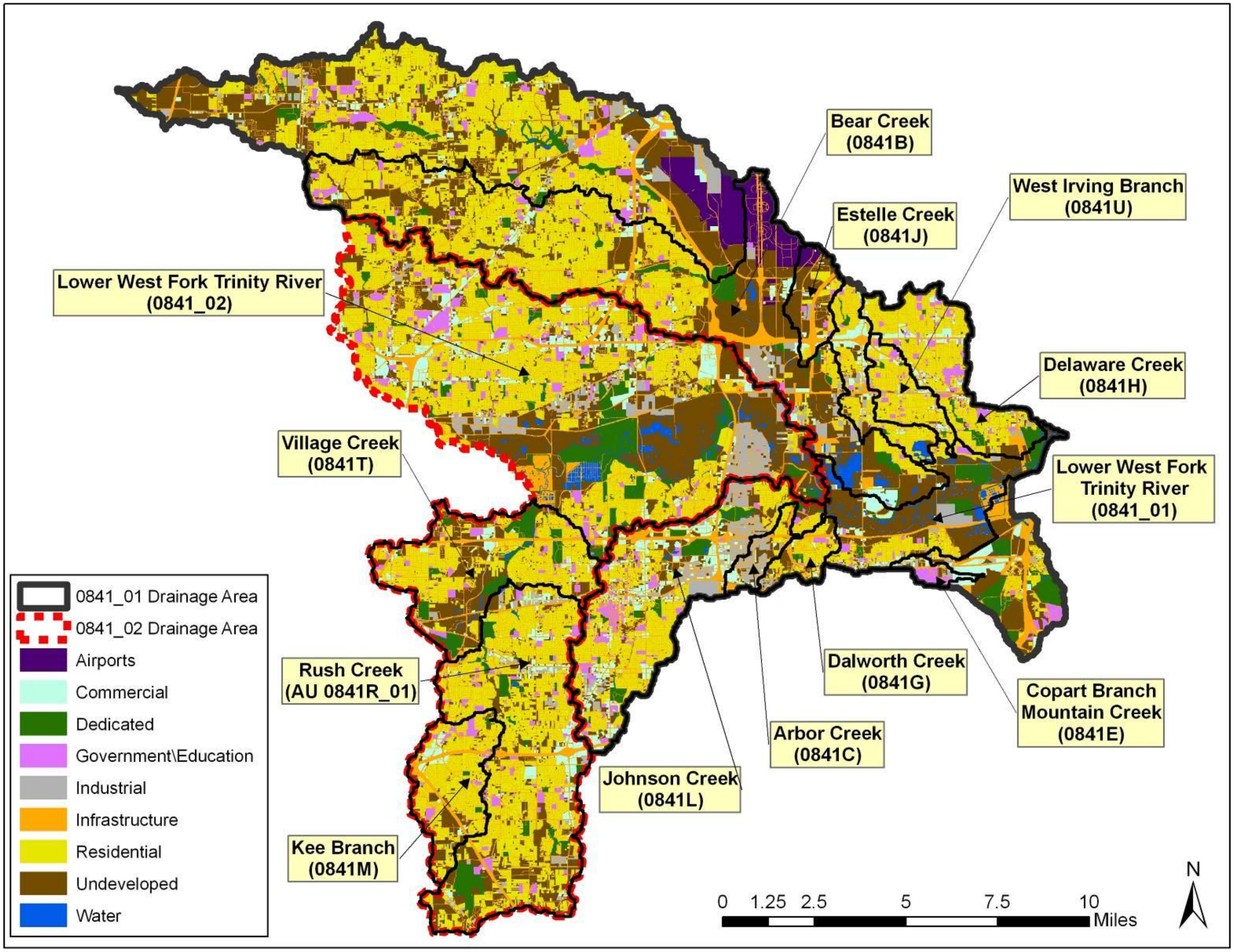

Figure 2-3. Land use/land cover within Lower West Fork Trinity River watershed showing TMDL watersheds.

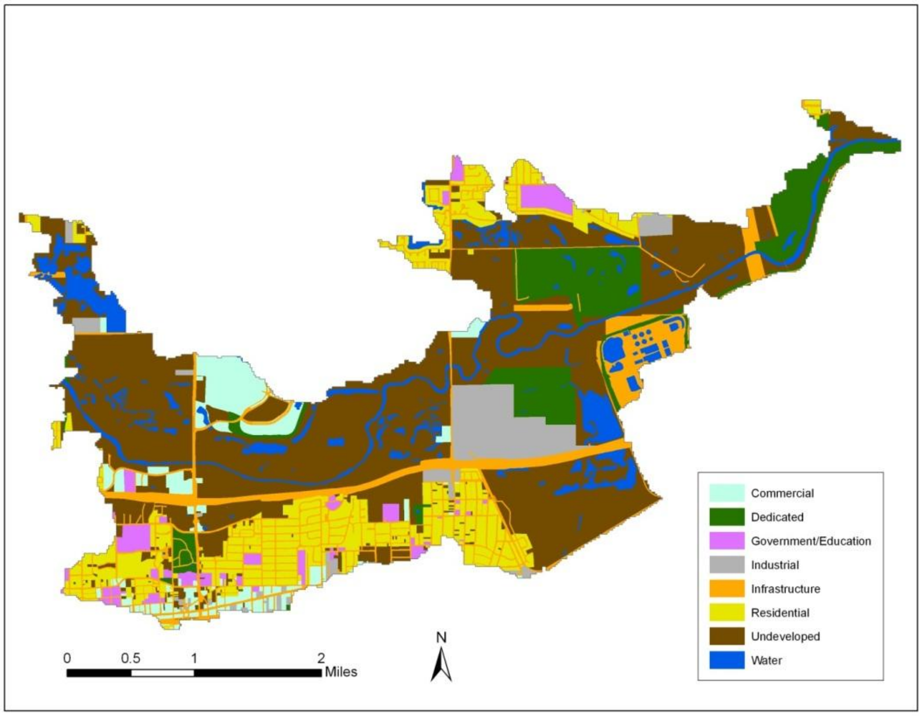

Figure 2-4. Land use/land cover within 0841_01, Lower West Fork Trinity River

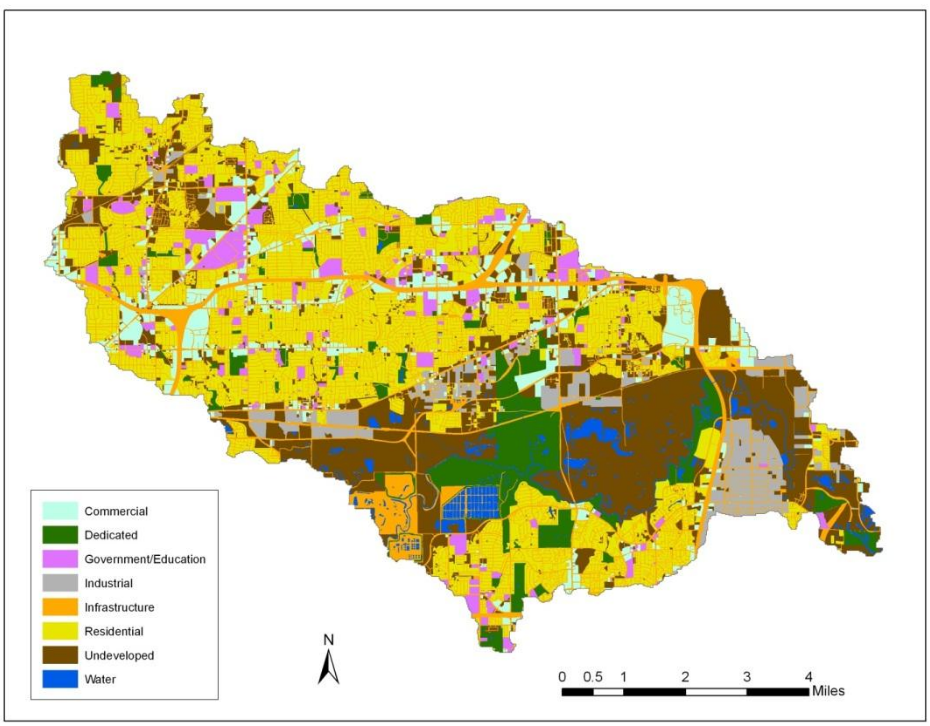

Figure 2-5. Land use/land cover within 0841_02, Lower West Fork Trinity River

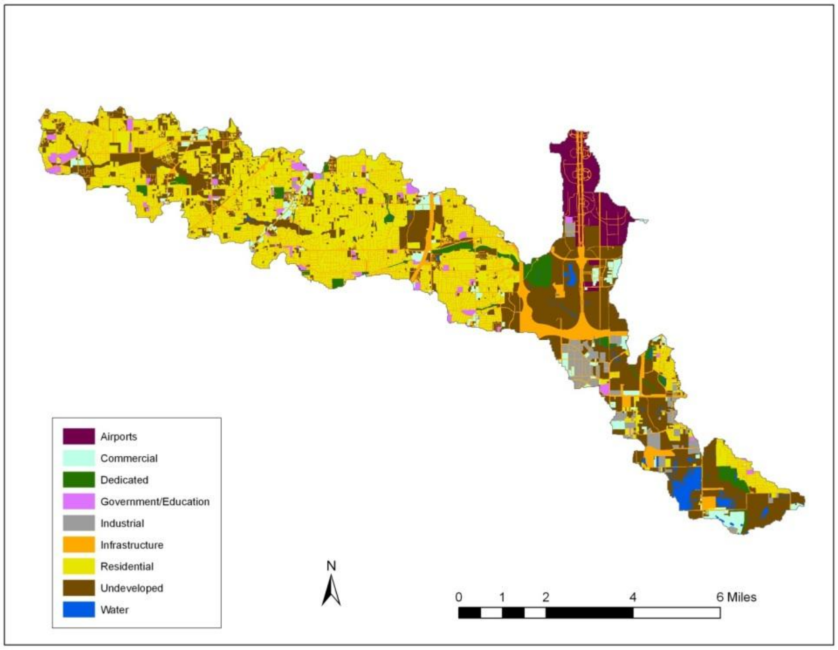

Figure 2-6. Land use/land cover within 0841B, Bear Creek

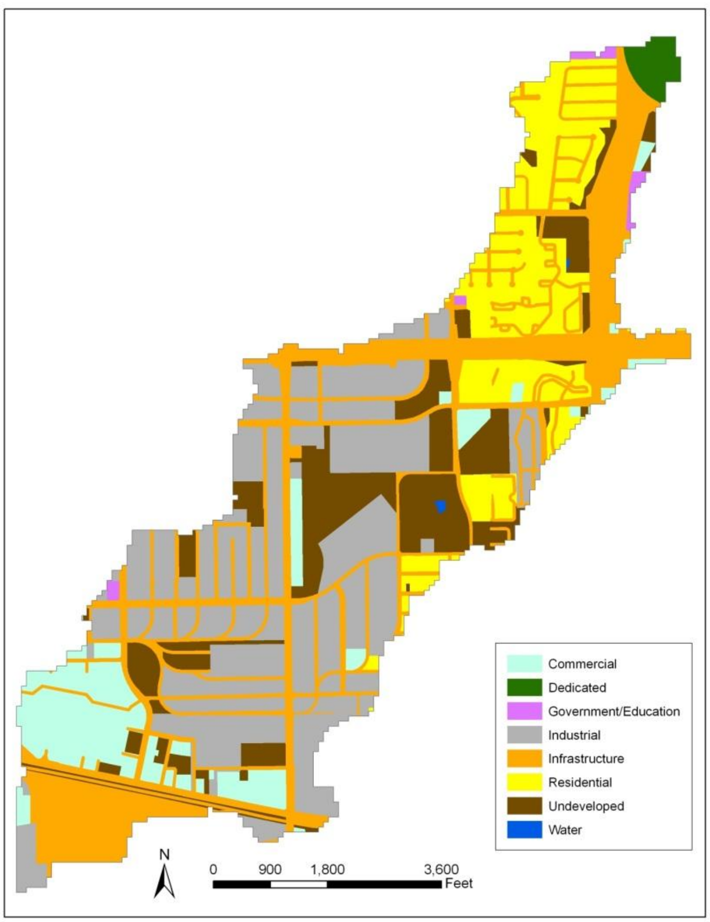

Figure 2-7. Land use/land cover within 0841C, Arbor Creek

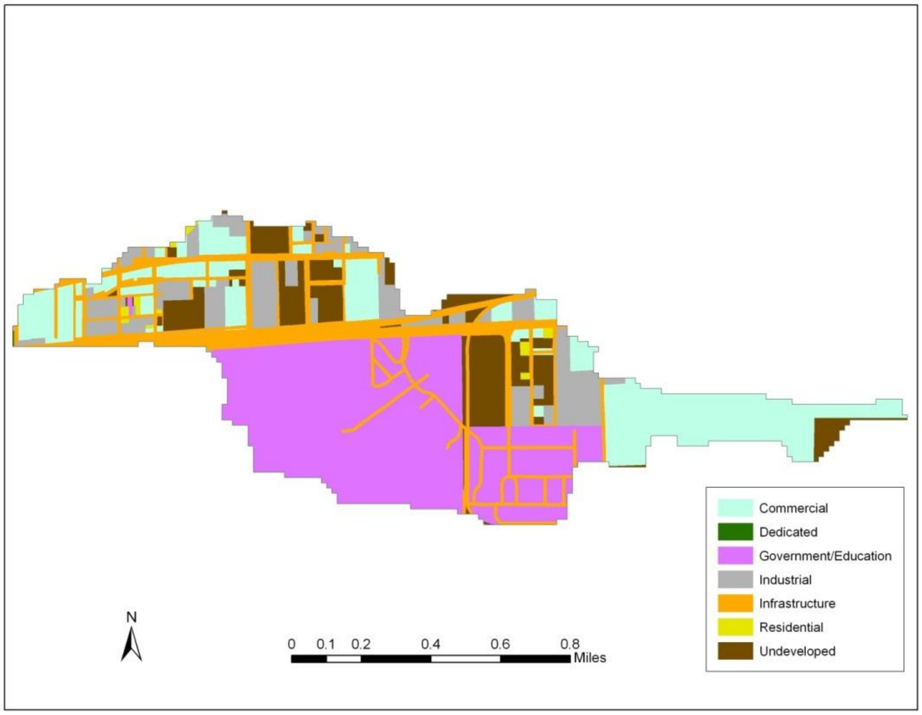

Figure 2-8. Land use/land cover within 0841E, Copart Branch Mountain Creek

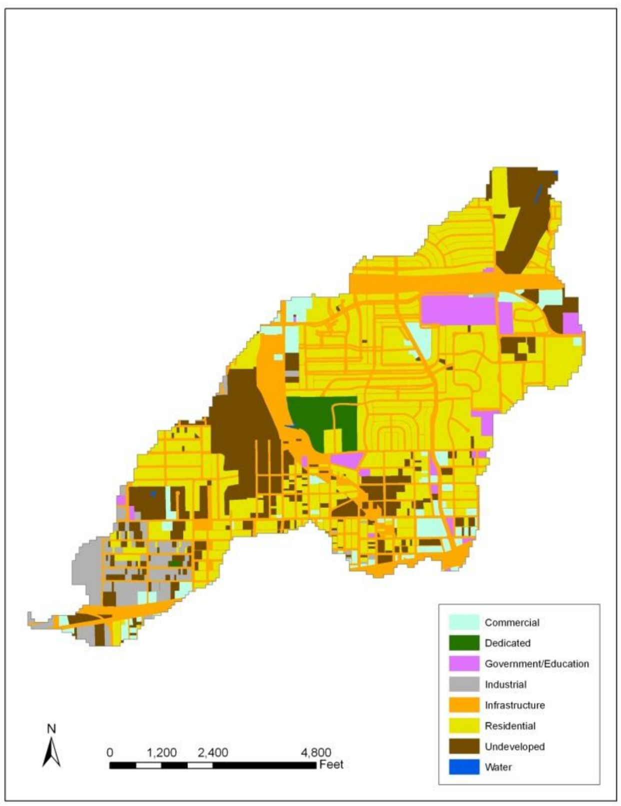

Figure 2-9. Land use/land cover within 0841G, Dalworth Creek

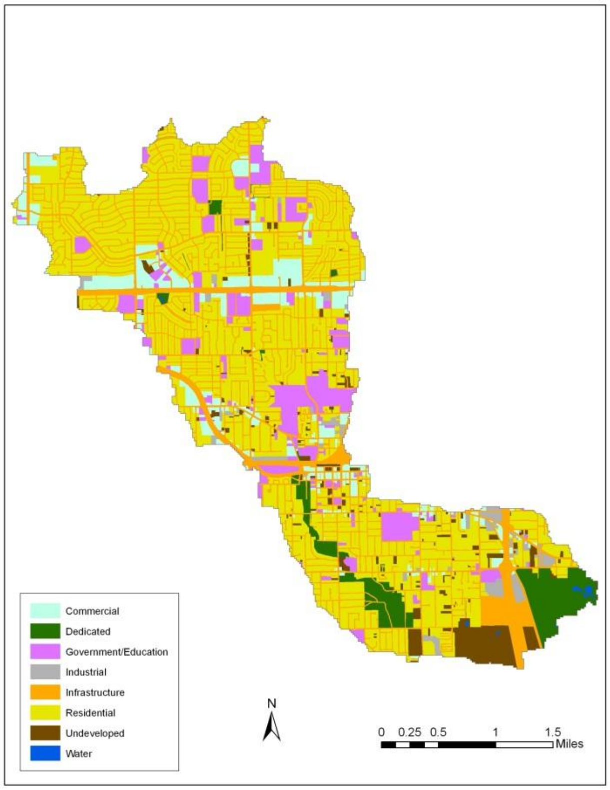

Figure 2-10. Land use/land cover within 0841H, Delaware Creek

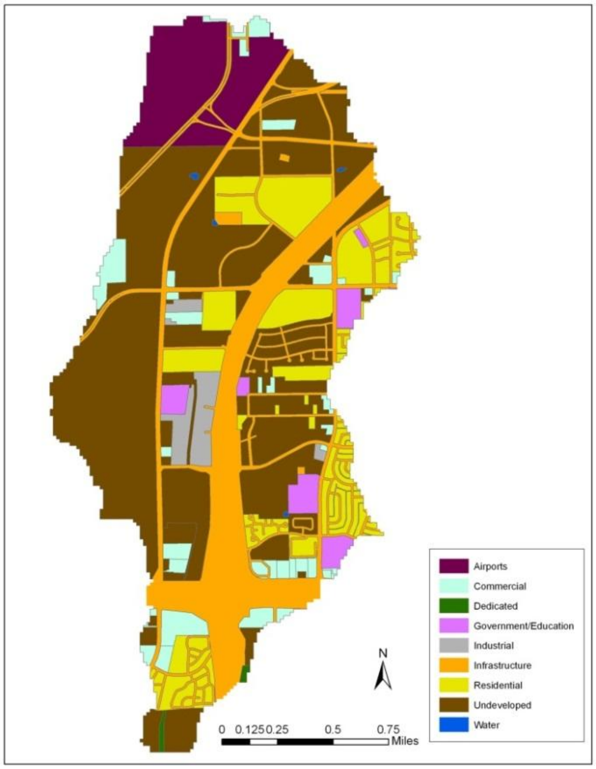

Figure 2-11. Land use/land cover within 0841J, Estelle Creek

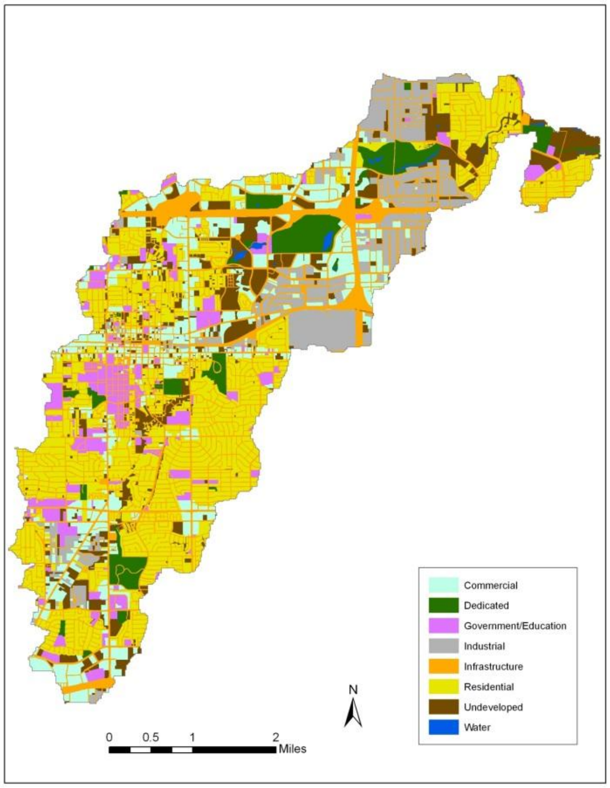

Figure 2-12. Land use/land cover within 0841L, Johnson Creek

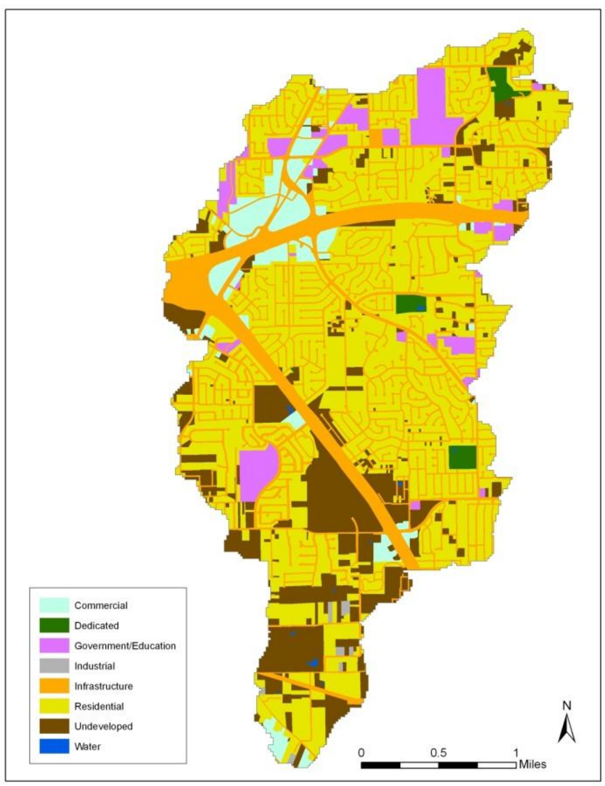

Figure 2-13. Land use/land cover within 0841M, Kee Branch

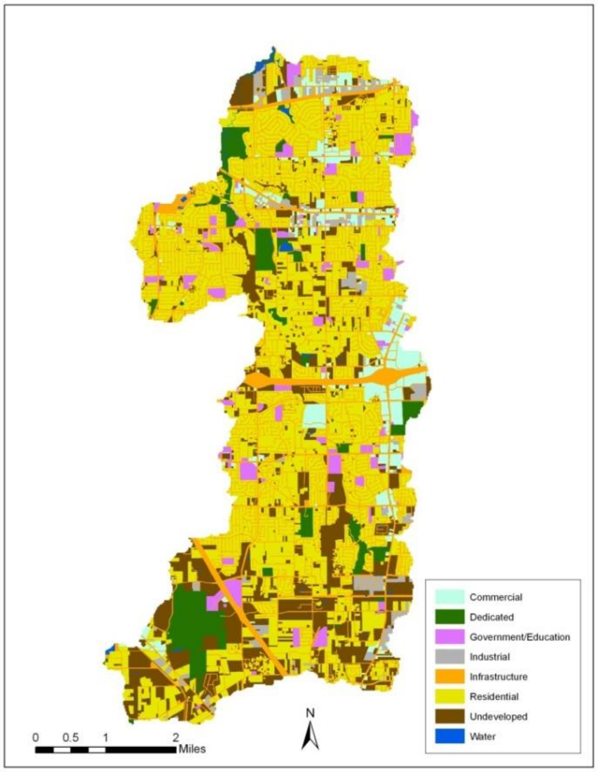

Figure 2-14. Land use/land cover within 0841R, Rush Creek

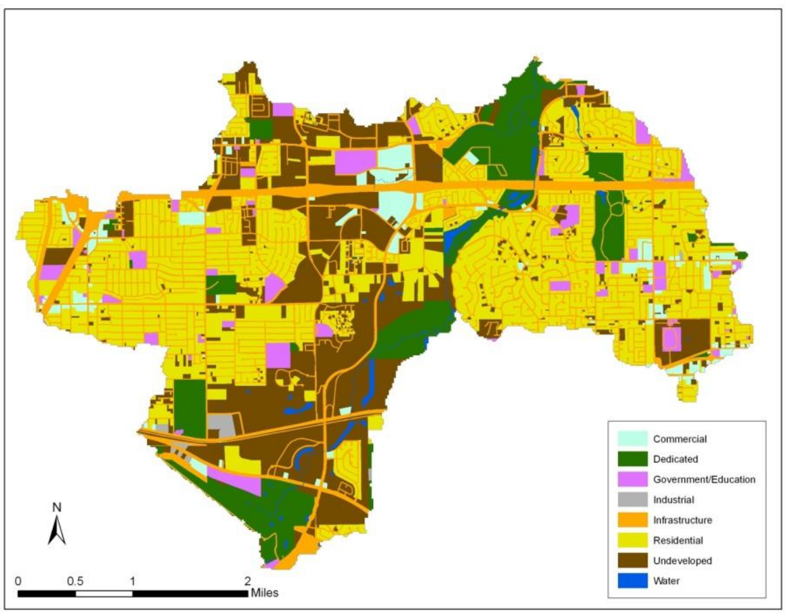

Figure 2-15. Land use/land cover within 0841T, Village Creek

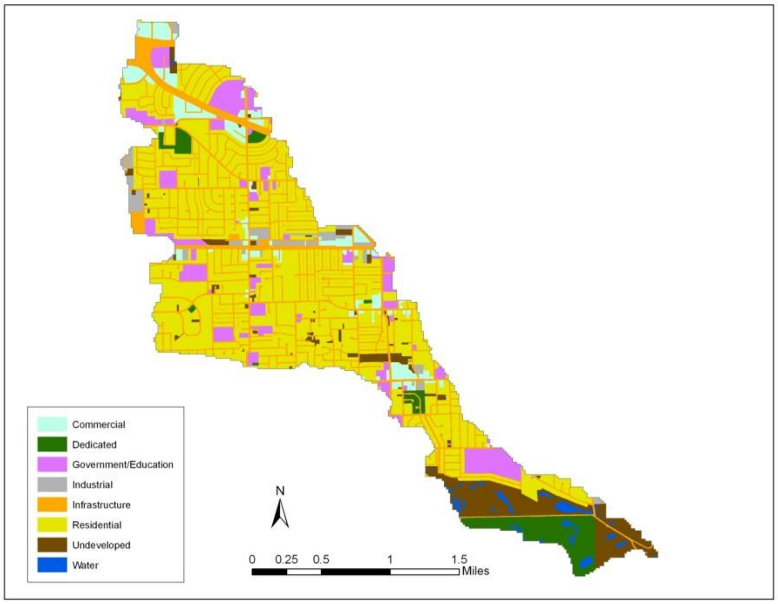

Figure 2-16. Land use/land cover within 0841U, West Irving Branch

2.5 Source Analysis

Potential sources of indicator bacteria pollution can be divided into two primary categories: *regulated* and *unregulated*. Pollution sources that are regulated have permits under the Texas Pollutant Discharge Elimination System (TPDES) and National Pollutant Discharge Elimination System (NPDES) programs. Examples of regulated sources are wastewater treatment facility (WWTF) discharges and storm water discharges from industries, construction, and municipal separate storm sewer systems (MS4s) of cities.

Unregulated sources are typically nonpoint source in nature, meaning the pollution originates from multiple locations and is usually carried to surface waters by rainfall runoff. Nonpoint sources are not regulated by permit.

With the exception of WWTFs, which receive individual WLAs (report Section 4.7.2.3 Regulated Wastewater Treatment Facility Computations), 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 interpreted as precise inventories and loadings.

2.5.1 Regulated Sources

Permitted sources are regulated by permit under the TPDES and the NPDES. WWTF outfalls and storm water discharges from industries, construction, and MS4s represent the permitted sources in the Lower West Fork Trinity River watershed.

2.5.1.1 Domestic and Industrial Wastewater Treatment Facility Discharges

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 (Table 2-15; Figure 2-1). The Trinity River Authority (TRA) Central Regional Wastewater Treatment Facility discharges into Lower West

Fork Trinity River (0841_01), the City of Fort Worth Village Creek Wastewater Treatment Facility discharges into Lower West Fork Trinity River (0841_02), and the Alta Vista Mobile Home Park Wastewater Treatment Facility discharges into Big Bear Creek (0841D), which is an non-impaired tributary of Bear Creek (0841B). Currently there is no authorized domestic wastewater discharger 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 Storm Water Permit. The Extex LaPorte LP Mountain Creek Lake Steam Electric Station has an industrial stormwater permit that authorizes stormwater discharges into non-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 the permit, the industrial outfalls will be treated as part of the TPDES-permitted storm water discharge load (discussed below).

Table 2-15. Permitted domestic and industrial wastewater operations in Lower West Fork Trinity River watershed.

TPDES Permit No.	Facility	Effluent Type[a]	AU	Final Permitted Discharge (MGD)	Actual (MGD)[c]
WQ0010303-001	TRA 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

[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

2.5.1.2 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 data typically contains an estimate of the total gallons spilled, responsible entity, and a general location of the spill. 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 2-17 and are summarized in Table 2-16 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.

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Table 2-16. Summary of SSO incidences reported in the Lower West Fork Trinity River watershed from January 2005 – February 2010.

Volumes are presented in gallons which were estimated by the 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

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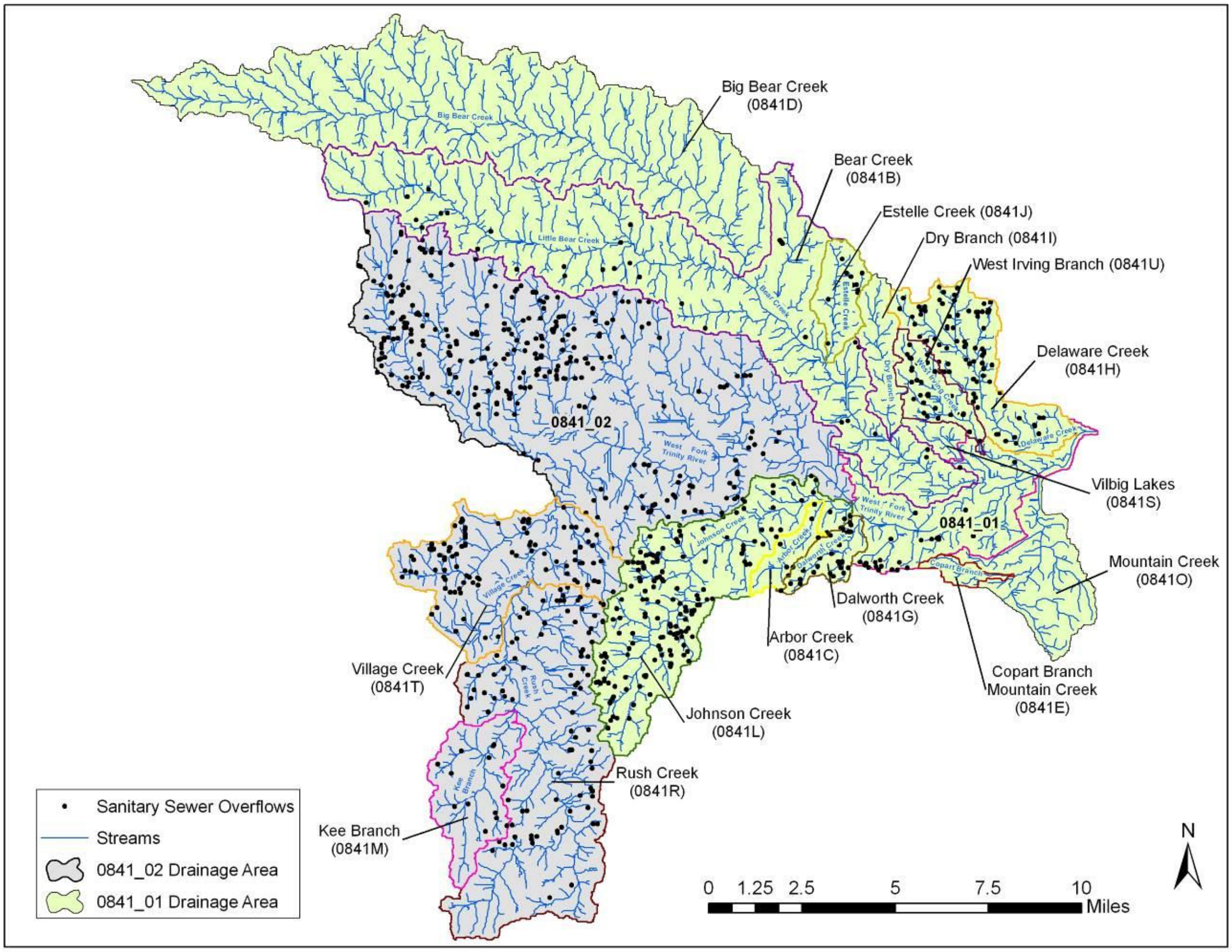

Figure 2-17. Reported SSO incidences within the Lower West Fork Trinity River watershed (SOURCE: NCTCOG)

2.5.1.3 TPDES-Regulated Stormwater

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

1) stormwater subject to regulation, which is any stormwater originating from TPDES-regulated Phase I or Phase II MS4, stormwater discharges associated with industrial activities, and stormwater discharges from regulated construction activities; and
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. 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 2000 Census Urbanized Area (Figure 2-18). The TMDL watersheds contain entities that are regulated under either Phase I individual MS4 permits or Phase II general permits (Table 2-17). The percentage of land area under the jurisdiction of storm water permits for each of the TMDL watersheds is presented in Table 2-18.

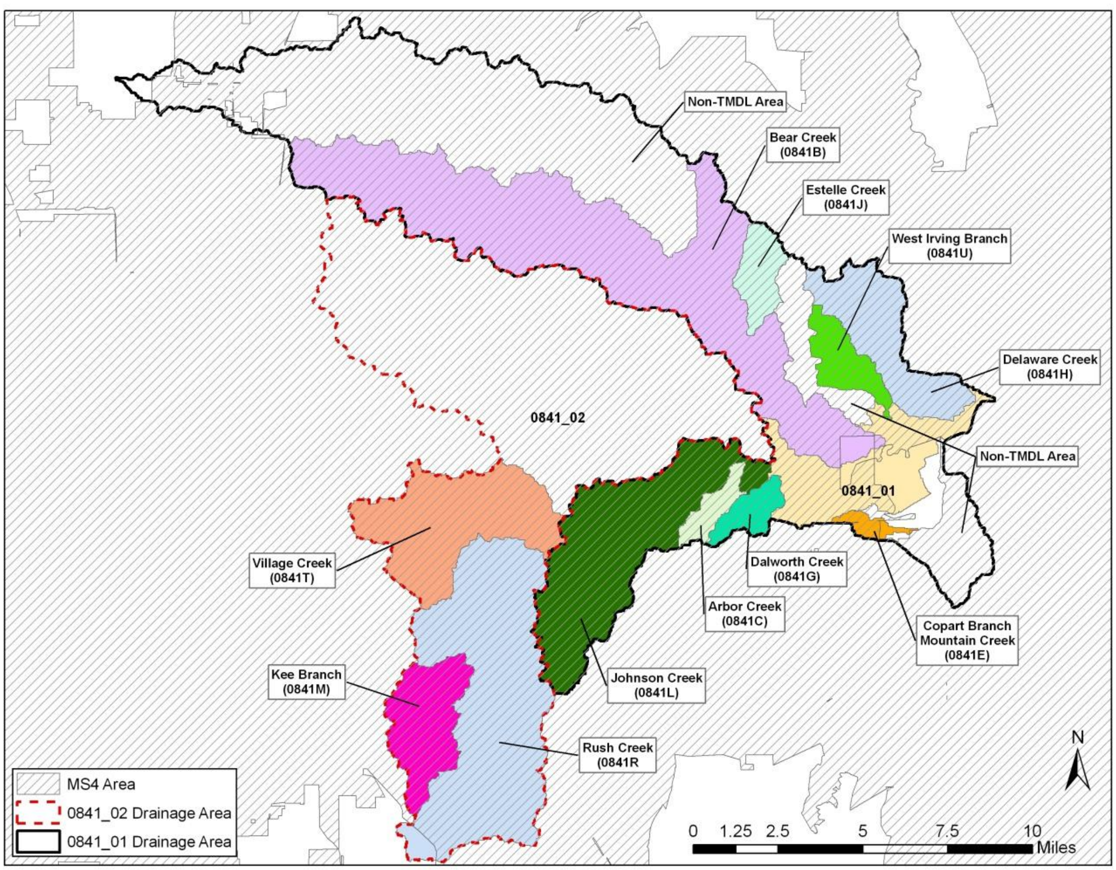

Figure 2-18. Lower West Fork Trinity River watershed showing MS4 permitted area

Table 2-17. TPDES MS4 permits associated with the TMDL area watersheds

Entity	TPDES	NPDES
City of Arlington	WQ0004636-000	TXS000301
City of Bedford	Phase II General Permit	TXR040119
City of Colleyville	Phase II General Permit	TXR040023
City of Dallas	WQ0004396-000	TXS000701
City of Dalworthington Gardens	Phase II General Permit	TXR040015
City of Euless	Phase II General Permit	TXR040211
City of Fort Worth	WQ0004350-000	TXS000901
City of Grand Prairie	Phase II General Permit	TXR040065
City of Grapevine	Phase II General Permit	TXR040114
City of Hurst	Phase II General Permit	TXR040039
City of Irving	WQ0004691-000	TXS001301
City of Keller	Phase II General Permit	TXR040017
City of Kennedale	Phase II General Permit	TXR040006
City of Mansfield	Phase II General Permit	TXR040207
City of North Richland Hills	Phase II General Permit	TXR040113
City of Richland Hills	Phase II General Permit	TXR040089
City of Southlake	Phase II General Permit	TXR040007
Dallas Area Rapid Transit	Phase II General Permit	TXR040232
Dallas County	Phase II General Permit	TXR040120

Entity	TPDES	NPDES
Dallas County Flood Control District 1	Phase II General Permit	TXR040255
Dallas Fort Worth International Airport Board	Phase II General Permit	TXR040044
Tarrant County College District	Phase II General Permit	TXR040380
Tarrant County	Phase II General Permit	TXR040052
Texas Department of Transportation (TxDOT) Fort Worth District	Phase II General Permit	TXR040184
Town of Pantego	Phase II General Permit	TXR040325

Table 2-18. Area under the jurisdiction of MS4 permits for TMDL Watersheds

AU	Area under jurisdiction of MS4 permits (ha)	Total watershed area (ha)	Percentage of drainage area under jurisdiction of MS4 permits (%)
0841_01	2,184	2,883	76
0841_02	39,050	39,050	100
0841B	19,819	19,994	99
0841C	1,183	1,183	100
0841E	187	248	75
0841G	1,402	1,402	100
0841H	5,639	5,639	100
0841J	2,018	2,018	100
0841L	12,205	12,205	100
0841M	4,583	4,583	100
0841R	6,863	7,063	97
0841T	9,075	9,075	100
0841U	2,656	2,656	100

2.5.1.4 Dry Weather Discharges/Illicit Discharges

Bacteria loads from regulated stormwater can enter the streams from permitted outfalls and 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 storm water, except discharges pursuant to this general permit or a separate authorization and discharges resulting from emergency firefighting activities." Illicit discharges can be categorized as either direct or indirect contributions. Examples of illicit discharges identified in the *Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities* (NEIWPCC, 2003) includes:

Examples of direct illicit discharges:

- sanitary wastewater piping that is directly connected from a home to the storm sewer;
- materials (e.g., used motor oil) 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 municipal 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.

2.5.1.5 Review of Information on Permitted Sources

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 WWTF, City of Fort Worth Village Creek WWTF, or the Alta Vista Mobile Home Park WWTF. Unauthorized discharges reported for the TRA Central and City of Fort Worth Village Creek WWTFs were sanitary sewer overflows in the TRA or Fort Worth systems (see the "Sanitary Sewer Overflows" section of this document).

2.5.2 Unregulated Sources

Unregulated sources of indicator bacteria are generally nonpoint and can emanate from wildlife, various agricultural activities, agricultural animals, land application fields, urban runoff not covered by a permit, failing onsite sewage facilities (OSSFs), and domestic pets.

2.5.2.1 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.

2.5.2.2 Failing On-Site Sewage Facilities

Failing onsite sewage facilities (OSSFs) were not considered a major source of bacteria loading in the TMDL watersheds because nearly the entire drainage areas of the Lower West Fork Trinity River Watershed 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 southmost tip of Rush Creek was not included in areas serviced by centralized wastewater treatment and sewered collection areas.

2.5.2.3 Non-Permitted 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). It should be noted that the data in Table 2-19 are for the entirety of Dallas and Tarrant Counties, which is the lowest level of spatial data available on livestock. As countywide data the tabular values 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 compare to the more rural portions of Dallas and Tarrant Counties. Activities, such as livestock grazing close to water bodies and farmers' use of manure as fertilizer, can contribute *E. coli* to nearby water bodies. The county-wide livestock numbers in Table 2-19 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 2-19. Livestock statistics in Dallas and Tarrant Counties (Note: Countywide data, values not exclusively for the Lower West Fork Trinity River watershed.)

Livestock	Dallas	Tarrant
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

Note: W denotes withheld by USDA 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 (US Census Bureau, 2010). 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.

Fecal matter from dogs and cats is transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 2-20 summarizes the estimated number of dogs and cats for each segment of the watershed with elevated bacteria levels. 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 fecal coliform loads from pets reaching the water bodies of the TMDL watersheds is unknown.

Table 2-20. Estimated households and pet populations within TMDL watersheds

AU	Estimated Number of Households	Estimated Dog and Cat Population	
		Dogs	Cats
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

2.5.2.4 Bacteria Survival and Die-off

Bacteria are living organisms that survive and die. Certain enteric bacteria can survive and replicate in organic materials if appropriate conditions prevail (e.g., warm temperature). Fecal organisms can survive and replicate from improperly treated effluent during their transport in pipe networks, and 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.

SECTION 3
BACTERIA TOOL DEVELOPMENT

This section describes the rationale of the bacteria tool selection for TMDL development and details the procedures and results of load duration curve development.

3.1 Model Selection

The TMDL allocation process for bacteria involves assigning bacteria, e.g., *E. coli*, loads to their sources such that the total loads do not violate the pertinent numeric criterion protecting contact recreation use. To perform the allocation process, a tool must be developed to assist in allocating bacteria loads. Selection of the appropriate bacteria tool for impaired AUs in the TMDL watersheds considered availability of data and other information necessary for supportable application of the selected tool and guidance in the Texas bacteria task force report (TWRI, 2007). In general, two basic tools are commonly used for bacteria TMDLs—mechanistic computer models and an empirical approach referred to as the load duration curve.

Mechanistic computer models provide analytical abstractions of a real or prototype system. Mechanistic models, also referred to as process models, are based on theoretical principles that provide for representation of governing physical processes that determine the response of certain variables, such as streamflow and bacteria concentration such as precipitation. Under circumstances where the governing physical processes are acceptably quantifiable, the mechanistic model provides understanding of the important biological, chemical, and physical processes of the prototype system and reasonable predictive capabilities to evaluate alternative allocations of pollutant load sources.

The load duration curve (LDC) method allows for estimation of existing and allowable loads by utilizing the cumulative frequency distribution of streamflow and measured pollutant concentration data (Cleland, 2003). In addition to estimating stream loads, the load duration curve method allows for the determination of the hydrologic conditions under which impairments are typically occurring. This information can be used to identify broad categories of sources (point and nonpoint) that may be contributing to the impairment. The LDC method has found relatively broad acceptance among the regulatory community, primarily due to the simplicity of the approach and ease of application. The regulatory community recognizes the frequent information limitations with bacteria TMDLs that constrain use of the more powerful mechanistic models. Further, the bacteria task force appointed by the TCEQ and the Texas State Soil and Water Conservation Board (TSSWCB) supports application of the load duration curve method within their three-tiered approach to TMDL development (TWRI, 2007). The LDC method lacks the predictive capabilities to evaluate alternative allocation approaches to reach TMDL goals, nor can it be used to quantify specific source contributions and instream fate and transport processes. The method does, however, provide a means to estimate the difference in bacteria loads and relevant criterion, and can give indications of broad sources of the bacteria, i.e., point source and nonpoint source.

Based on sufficient availability of discharge information for municipal WWTFs and the quantity of ambient *E. coli* data, the decision was made to use the LDC method over a more complex mechanistic watershed loading and hydrologic/water quality model. This decision also conforms to the guidance of the bacteria task force (TWRI, 2007).

3.1.1 Situational Limitations of Mechanistic Modeling

Because the present surface water bacteria standards for AUs within the TMDL watersheds, as most Texas waters, do not restrict under what streamflow conditions the primary contact recreation criteria should be met, the allocation process must consider all streamflow conditions ranging from low flows to high flows. The allocation tool, therefore, must be capable of characterizing streamflows and bacteria loads at desired locations under the wide variety of environmental conditions experienced in the TMDL watersheds. If a mechanistic modeling tool is applied, it must be capable of simulating response of bacterial loadings to hydrologic (streamflow) conditions during base flow as well as during times of response to rainfall runoff and those intermediate conditions between well-defined base flow and strong rainfall-runoff response. The type of mechanistic tool with capabilities to simulate all these complexities is often referred to as a combined watershed loading and hydrologic/water quality model. These models simulate the hydrologic response of the watershed's land uses and land covers to rainfall, route runoff water through the conveyance channels of the watershed, add in point source contributions, and may include other hydrologic processes such as interaction of surface waters with shallow ground water.

The bacteria component of the model is in many ways even more complex than the hydrologic component and typically must include many different processes. Point sources and nonpoint sources of bacteria need to be defined and simulated by the model. Movement or washoff of bacteria from the various landscapes (e.g., urban yards, roads, pastures, wooded areas, areas of animal concentration), potential illegal connections of sewage lines to stormwater lines, broken sewer lines, and sewer overflows in response to rainfall are only some of the sources possibly needing to be represented in the model. Streamflow transport of the bacteria in tributaries and in the main stem river and the response of the bacteria while in transport to settling, die-off, resuspension, regrowth in the water column, regrowth in the sediment, etc. need to be defined with adequate certainty to allow proper model representation for each of these physical and biological processes.

While admittedly the hydrologic processes requiring simulation are complex, these processes are generally better understood and more readily simulated within needed levels of confidence by a mechanistic model than the bacterial processes. The hydrologic processes regarding response of the landscape to rainfall are well studied over many decades because of implications on transport of waterborne constituents, of which bacteria is only one of many. But even more importantly, these hydrologic processes are well investigated because of needs to design reservoirs and flood-control structures, define floodplains, and design the myriad of other structures required to direct and retain stormwater in both urban and rural situations. While each watershed is unique, the experienced hydrologist is able to readily and successfully apply these mechanistic models to most watersheds.

Mechanistic bacteria modeling has evolved over the last several decades beginning in the late 1960s to early 1970s as increasing computer resources made such endeavors possible. Regrettably for the application of mechanistic bacteria models, while the numerical equations to represent many pertinent processes exist and are incorporated in readily available models, these processes are appreciably more watershed specific than hydrologic processes. As one simple example, whether or not there are failed on-site treatment systems, such as septic systems, in a watershed rarely makes measurable differences to streamflow, but can dramatically impact *E. coli* concentrations present in the same streamflow. In the vast majority of circumstances, and the Lower West Fork Trinity River watershed is no exception, only very limited watershed-specific information is available to define many of the physical and biological processes that affect bacteria concentrations and loadings. Consequentially, the operator of the mechanistic model must specify, in many circumstances, numerous input parameters governing bacteria processes for which actual numeric values may not be known within a reasonable range of certainty. Compounding implications of these data limitations, the bacteria concentrations and loadings predicted by the model, which potentially contain high uncertainty, will of necessity be used in direct comparison to the relevant numeric criteria that protect the contact recreation use.

3.1.2 Lower West Fork Trinity River Data Resources

Streamflow and *E. coli* data availability were used to provide guidance in the allocation tool selection process. As already mentioned, the necessary information and data are largely unavailable for Lower West Fork Trinity River watershed to allow adequate definition of many of the physical and biological processes influencing in-stream bacteria concentrations for mechanistic model application, and these limitations became an important consideration in the allocation tool selection process.

Hydrologic data in the form of daily streamflow records are available for the main stem portions of the Lower West Fork Trinity River (0841_02 and 0841_01); however, there is an absence of streamflow records available for the impaired tributary AUs within the Lower West Fork Trinity River watershed. Streamflow records for the main stem portions of the Lower West Fork Trinity River are collected and made readily available by the U.S. Geological Survey (USGS), which operates two streamflow gauges in the Lower West Fork Trinity River watershed (Table 3-1; Figure 2-2). USGS streamflow gauge 08049500 is located along the mainstem of the Lower West Fork Trinity River within 0841_02 and serves as the primary source for streamflow records used in this document. USGS streamflow gauge 08050100 is located on Mountain Creek (0841O) which is a non-impaired tributary to 0841_01. Streamflow records from the Mountain Creek USGS gauge were not utilized in development of TMDLs for the TMDL watersheds.

Table 3-1. Basic information on USGS streamflow gauges in project area

Gauge No.	Site Description	Segment Location	Drainage Area (sq. mi.)	Daily Streamflow Record (beginning & end date)
08049500	West Fork Trinity River at Grand Prairie, TX	0841	3,065	Apr. 1925 – present
08050100	Mountain Creek at Grand Prairie, TX	0841	298	Oct. 1960 – present

Self-reporting data in the form of monthly discharge information for a period exceeding 25 years was available for the Village Creek and Central Regional WWTFs and approximately 12 years of self-reporting data was available for the small Alta Vista MHP WWTF.

Ambient *E. coli* data used for the 2010 Texas Water Quality Inventory was provided by TCEQ. Additional historical ambient *E. coli* data used for development of LDCs was obtained through the

TCEQ Surface Water Quality Monitoring Information System (SWQMIS) and was used in developing LDCs for stations within the TMDL watersheds (Table 3-2).

Table 3-2. Summary of historical data set of *E. coli* concentrations. Only those stations with 24 or more *E. coli* data values are presented in the table.

Water Body	Assessment Unit (AU)	Station	Station Location	No. of Samples	Data Date Range
Lower West Fork Trinity River	0841_01	11080	S. MacArthur Blvd., Irving, TX	33	2001-2004
		11081	Beltline Rd., Grand Prairie, TX	146	2000-2011
		11089	194 M downstream of SH Loop 12, Dallas, TX	60	2000-2006
	0841_02	17669	Roy Orr Blvd., Grand Prairie, TX	180	2001-2011
Bear Creek	0841B	10865	W. Hunter Ferrell Rd, Irving, TX	112	2001-2011
		10866	S. Beltline Rd., Irving, TX	31	2001-2004
		10867	Rock Island Rd., Irving, TX	112	2002-2011
		10868	Valley View Ln., Irving, TX	31	2001-2007
		17663	Shady Grove Rd., Grand Prairie, TX	84	2002-2008
		18315	County Line Rd., Irving, TX	25	2002-2004
Arbor Creek	0841C	17666	Egyptian Way, Grand Prairie, TX	68	2001-2007
Copart Branch Mountain Creek	0841E	17672	Idlewild Rd., Grand Prairie, TX	106	2001-2011
Dalworth Creek	0841G	17671	West Palace Pkwy., Grand Prairie, TX	74	2001-2011
Delaware Creek	0841H	17175	N. Story Rd., Irving, TX	31	2001-2004
		17176	N. MacArthur Blvd., Irving, TX	32	2001-2004
		17177	E. Shady Grove Rd., Irving TX	30	2001-2004
		17178	E. Oakdale Rd., Irving, TX	60	2001-2004
		18314	W. 2nd St., Irving, TX	25	2002-2004
Estelle Creek	0841J	17174	Pioneer Dr., Irving, TX	32	2001-2004
Johnson Creek	0841L	10719	SH 360, Arlington, TX	54	2001-2011
		10721	SH 303, Arlington, TX	32	2002-2011
		17664	N. Carrier Pkwy, Grand Prairie, TX	112	2001-2011
		10718	Ave. J, Arlington, TX	30	2009-2011
		18311	Duncan Perry Rd., Arlington, TX	60	2003-2008
Kee Branch	0841M	10792	W. Pleasant Ridge Rd., Arlington, TX	32	2002-2011
Rush Creek	0841R	10791	W. Sublett Rd., Arlington, TX	33	2002-2011
		17190	IH 20, Arlington, TX	33	2002-2011
		17191	SH 180, Arlington, TX	32	2002-2011
Village Creek	0841T	17189	IH 30, Arlington, TX	35	2002-2011
West Irving Branch	0841U	17179	W. Vilbig St., Irving, TX	42	2002-2009

3.1.3 Allocation Tool Selection

Based on good availability of historical daily streamflow records, discharge information for large municipal WWTFs, and ambient *E. coli* data and deficiencies in data to describe bacterial landscape and in-stream processes, the decision was made to use the load duration curve method as opposed to a mechanistic watershed loading and hydrologic/water quality model.

3.2 Methodology for Flow Duration & Load Duration Curve Development

To develop the flow duration curves (FDCs) and load duration curves (LDCs), the previously discussed data resources were used in the following series of sequential steps.

- **Step 1:** Determine the hydrologic period of record to be used in developing the flow duration curves.
- **Step 2:** Determine desired stream locations for which flow and load duration curves will be developed. (The stream locations will be at monitoring stations along the impaired AUs of the mainstem and tributaries of the Lower West Fork Trinity River for which adequate *E. coli* data are available and the outlets [downstream most end] and, where appropriate, inlets [upstream most end that coincides with the inlet of another AU] of each impaired AU.)
- **Step 3:** Develop daily streamflow records at desired stream locations using the daily gauged streamflow records and municipal WWTF self-reporting data.
- **Step 4:** Develop FDCs at desired stream locations, segmented into discreet flow regimes.
- **Step 5:** Develop the allowable bacteria LDCs at the same stream locations based on the relevant criteria and the data from the streamflow duration curve.
- **Step 6:** Superpose historical bacteria data, if such data exist at the location, on the allowable bacteria LDCs.

Additional information explaining the LDC method may be found in Cleland (2003) and NDEP (2003).

3.2.1 Step 1: Determine Hydrologic Period

Daily hydrologic (streamflow) records were available for two USGS gauge locations in the Lower West Fork Trinity River watershed for periods of 50 years more, which is more than adequate to capture a reasonable variation in meteorological patterns of high and low rainfall periods. Two important confounding factors, however, are present in the contributing drainage area of Segment 0841—rapid urbanization and development of large water storage reservoirs. Both of these factors will alter the hydrologic response of streams under base flow and stormwater runoff conditions. Over the past 50 years population growth has been great within the major metropolitan areas of Dallas and Tarrant counties (Table 3-3). Commensurate with this urban growth have been increases in the amount of impervious cover resulting in greater amounts of runoff from rainfall events and also increases in municipal WWTF discharges as service population increased. Several large reservoirs have also become operational within upstream drainage areas contributing to the Lower West Fork Trinity River watershed (Table 3-4). Because of the population growth, increased WWTF discharges, and development of reservoirs, the hydrology of the Lower West Fork Trinity River watershed has experienced changes. An anticipated trend of increasing base flow was borne out by plotting the time sequence of yearly minimum monthly flow at USGS gauge 08049500 located at Belt Line Road in the lower end of Segment 0841 (Figure 3-1). The resulting plot indicates a strong positive trend in minimum monthly flow.

Optimally the period of record to develop flow duration curves should include as much data as possible in order to capture extremes of high and low streamflows and hydrologic variability from high to low precipitation years, but the flow during the period of record selected should also be representative of conditions experienced when the *E. coli* data were collected. However, the positive trend in base flow indicated that a bias would be introduced into the flow duration curves if the selected period of record includes all possible historical data going back 50 or more years. A 25-year period of record from July 1986 through June 2011 was selected in an effort to capture extremes of high and low streamflows while also reducing the influence of population increase on streamflow.

Table 3-3. U.S. Census Bureau population data for Dallas and Tarrant Counties (1960-2010).

County	1960	1970	1980	1990	2000	2010
Dallas	951,527	1,327,321	1,556,390	1,852,810	2,218,774	2,368,139
Tarrant	538,495	716,317	860,880	1,170,103	1,446,219	1,809,034

Table 3-4. Major reservoirs on tributaries to the Trinity River

Reservoir Name	Tributary	Year Impoundment Began	Conservation Pool Storage (Acre-Feet)
Lake Worth	West Fork Trinity River	1914	12,290
Lake Benbrook	Clear Fork Trinity River	1952	88,250
Lake Arlington	Village Creek	1957	39,930
Mountain Cr. Lake	Mountain Creek	1937	22,840

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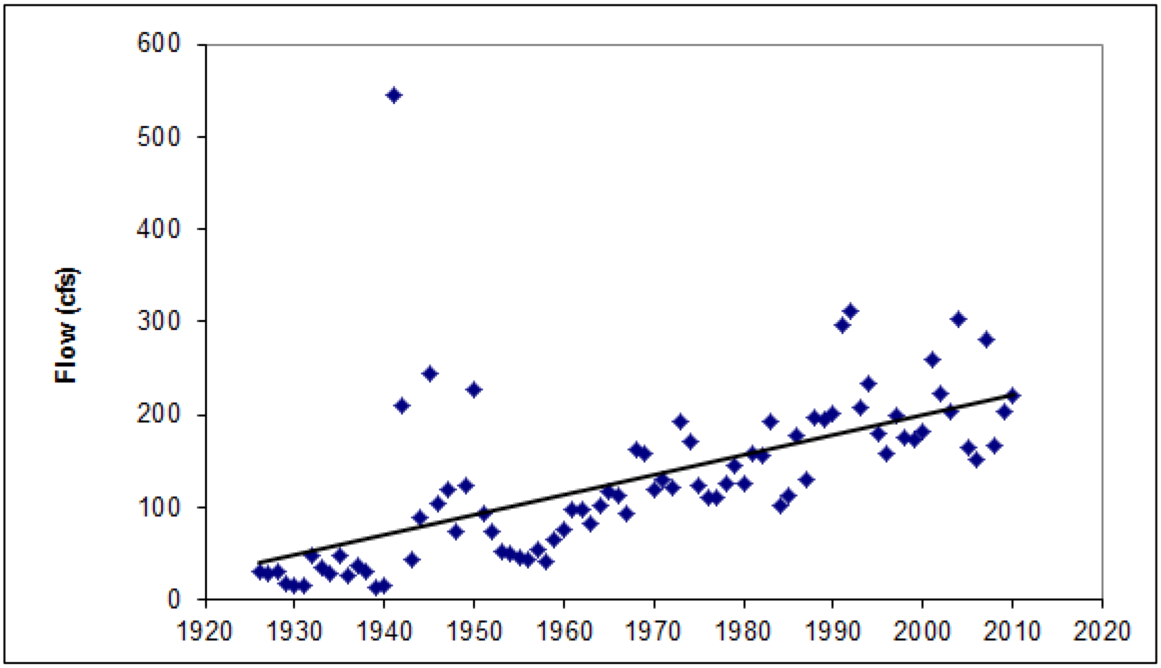

Figure 3-1. Yearly minimum monthly flow at USGS gauge 08049500 (West Fork Trinity River at Belt Line Road), Segment 0841

3.2.2 Step 2: Determine Desired Stream Locations

The stations for which adequate *E. coli* data were available (see Table 3-2) determined the stream locations for which flow and bacteria load duration curves would be developed. Stations with at least 24 *E. coli* data points were deemed as having an adequate amount of data for load duration curve development. These stations were conveniently located either within or in close proximity to the impaired reaches within each AU.

3.2.3 Step 3: Develop Daily Streamflow Records

Once the hydrologic period of record and station locations were determined, the next step was to develop the 25-year daily streamflow record for each station. The daily streamflow records were developed from extant USGS records modified by the imposition of certain rules necessitated by hydrologic complicating factors. The following factors complicate the use of USGS streamflow records for developing flow and load duration curves:

- The large reservoirs on several tributaries to the Lower West Fork Trinity River not only highly impact downstream hydrology, but also effectively reduce bacteria concentrations in releases as a result of their large detention times and enhanced conditions over typical run-of-river conditions for bacterial settling and die-off.
- Two large WWTFs discharge into Segment 0841 (Table 2-2), and these facilities should be evaluated at their full permitted daily average discharge limits within the TMDL allocation process.
- The calculated TMDL allocation for each AU needs to accumulate in the downstream direction and take into account upstream loadings that enter the bacteria impaired AUs. The TMDL allocation for Lower West Fork Trinity River (0841_02), therefore, needs to

take into account the upstream allowable loading from the West Fork Trinity River (Segment 0806) and the tributary loadings from Village Creek (0841T). The TMDL allocation for Lower West Fork Trinity River (0841_01) needs to take into account the upstream allowable loading from 0841_02 and the tributary loadings from Johnson Creek (0841L), Dalworth Creek (0841), Bear Creek (0841B), West Irving Branch (0841U), Mountain Creek (0841O), and Delaware Creek (0841H) Upstream tributary loadings must also be taken into account for certain impaired tributary AUs within the study area. Those AUs that receive loadings from other tributaries include Village Creek (0841T), which receives upstream tributary loadings from Rush Creek (0841R); Rush Creek, which receives tributary loadings from Kee Branch (0841M); Johnson Creek (0841L), which receives upstream loadings from Arbor Creek (0841C); Bear Creek (0841B), which receives upstream loadings from Big Bear Creek (0841D), Estelle Creek (0841J), and Dry Branch (0841I). Mountain Creek (0841O) is a non-impaired tributary of 0841_01 whose allocation must take into account the loadings from upstream tributary Copart Branch Mountain Creek (0841E).

The method to develop the necessary streamflow record for each LDC location involved a modified drainage-area ratio approach. With this basic approach, each daily streamflow value at USGS 08049500 gauge is multiplied by a factor to estimate the flow at a station. The factor is determined by dividing the drainage area above the sampling station by the drainage area above the USGS gauge. Further WWTFs are evaluated at their full permitted discharge (Table 2-15), and their contributions to streamflow are accumulated in a downstream direction. To address the complications listed above the following modifications and rules were incorporated into this basic approach:

Action # 1: Calculate Appropriate Drainage Area Ratios (DARs) Considering Reservoirs

- To address the complications imposed by the presence of reservoirs, the drainage-area ratio approach was applied excluding the drainage area above major reservoirs from the computation, since these reservoirs substantively reduce immediately downstream flows under most hydrologic conditions. As labeled on Figure 2-1, the reservoirs impacting the ratios were Lake Worth, Benbrook Lake, Lake Arlington, Marine Creek Lake, and Mountain Creek Lake. Drainage area computations were based on the Digital Elevation Models (DEM) data downloaded from the USGS National Seamless Server (USGS, 2011). Individual drainage areas were developed using the Geographic Information System (GIS) interface called AVSWATX (Di Luzio et al., 2004), and the areas with the drainage areas above the major reservoirs excluded are provided in Table 3-5.
- On April 5, 2003 USGS gauge 0849500 was relocated 3.5 miles upstream to a location at Roy Orr Boulevard and on September 30, 2006 the gauge was moved back to its present location on Beltline Road in Grand Prairie, TX. This occurred during the period of record used to develop streamflow records for locations in which LDCs were developed. To compensate for the relocation of the USGS gauge, a DAR was utilized to “normalize” the dataset. The DAR was computed by dividing the drainage area of the USGS gauge location at Beltline Road by the drainage area of the location at Roy Orr Boulevard. Each daily streamflow record for data collected from April 5, 2003 through September 30, 2006 at USGS gauge 0849500 was multiplied by the DAR normalizing the record to a common basis.

- A DAR was computed for each needed location within the Lower West Fork Trinity River watershed by dividing the drainage area of the location by the drainage area of USGS gauge 0849500, which is the West Fork Trinity River at Beltline Road (Table 3-5).

Action # 2: Correct Streamflow Records for Actual WWTF Discharges

- To compensate for the complication from City of Fort Worth Village Creek WWTF discharge on the streamflow record at USGS gauge 0849500, that portion of the streamflow originating from this discharge was removed (subtracted) and an adjusted daily streamflow record was developed prior to applying the drainage area ratio. Because accuracy of the drainage area ratio is dependent upon similarity of hydrologic response based on similarity of landscape features such as geology, soils, and land use/land cover, point source derived flows should be removed from the flow record prior to application of the ratio. The daily streamflows for USGS gauge 08049500 were adjusted by subtracting historical monthly average Village Creek WWTF flows from the daily streamflow record. Monthly self-reported data was obtained from the TCEQ TRACs database, and a small portion of self-reported daily discharge data were obtained from the EPA Enforcement and Compliance History Online database (http://www.epa-echo.gov/echo/). The monthly discharge data were applied to each day of the month. When the subtraction process resulted in negative numbers, that daily flow was set to zero. The resulting 25-year record of daily flows included values of zero approximately 7 percent of the time. Based on qualitative analysis of the very limited instantaneous flow measurements at TCEQ monitoring stations, an occurrence of no flow about 7 percent time is reasonably representative for the water bodies in the TMDL watersheds.

Table 3-5. DARs for locations within the Lower West Fork Trinity River watershed based on the drainage area of USGS gage 08049500.

Assessment Unit	Station/ Location	Location	Station/Location Drainage Area (ha)	DAR*
0841_01	11081	Beltline Rd., Grand Prairie, TX (USGS gage 08049500)	267,460	1.000
0841_01	11080	S. MacArthur Blvd., Irving, TX	269,376	1.007
0841_01	11089	194 M downstream of SH Loop 12, Dallas, TX	341,116	1.275
0841_01	Outlet	NA	347,126	1.298
0841_02	Inlet	NA	181,469	0.6785
0841_02	17669	Roy Orr Blvd., Grand Prairie, TX	250,567	0.9368
0841_02	Outlet	NA	251,629	0.9408
0841B	18315	County Line Rd., Irving, TX	49,602	0.1855
0841B	10868	Valley View Ln., Irving, TX	49,885	0.1865
0841B	10867	Rock Island Rd., Irving, TX	53,485	0.2000

Assessment Unit	Station/ Location	Location	Station/Location Drainage Area (ha)	DAR*
0841B	17663	Shady Grove Rd., Grand Prairie, TX	54,172	0.2025
0841B	10866	S. Beltline Rd., Irving, TX	54,934	0.2054
0841B	10865/18313	W. Hunter Ferrell Rd, Irving, TX	58,647	0.2193
0841B	Outlet	NA	59,506	0.2225
0841C	17666	Egyptian Way, Grand Prairie, TX	1,064	0.0040
0841C	Outlet	NA	1,183	0.0044
0841D	Outlet	NA	28,354	0.1060
0841E	17672	Idlewild Rd., Grand Prairie, TX	531	0.0020
0841E	Outlet	NA	612	0.0023
0841G	17671	West Palace Pkwy., Grand Prairie, TX	1,160	0.0043
0841G	Outlet	NA	1,402	0.0052
0841H	17175	N. Story Rd., Irving, TX	566	0.0021
0841H	17176	N. MacArthur Blvd., Irving, TX	1,997	0.0075
0841H	18314	W. 2nd St., Irving, TX	3,629	0.0136
0841H	17177	E. Shady Grove Rd., Irving, TX	4,134	0.0155
0841H	17178	E. Oakdale Rd., Irving, TX	4,554	0.0170
0841H	Outlet	NA	5,676	0.0212
0841I	Outlet	NA	2,171	0.0082
0841J	17174	Pioneer Dr., Irving, TX	1,944	0.0073
0841J	Outlet	NA	2,018	0.0075
0841L	10721	SH 303, Arlington, TX	1,637	0.0061
0841L	10719	SH 360, Arlington, TX	9,941	0.0372
0841L	10718	Ave. J, Arlington, TX	9,964	0.0373
0841L	18311	Duncan Perry Rd., Arlington, TX	10,952	0.0409
0841L	17664	N. Carrier Pkwy, Grand Prairie, TX	11,745	0.0439
0841L	Outlet	NA	13,388	0.0501
0841M	10792	W. Pleasant Ridge Rd., Arlington, TX	3,959	0.0148

Assessment Unit	Station/ Location	Location	Station/Location Drainage Area (ha)	DAR*
0841M	Outlet	NA	4,583	0.0171
0841O	Outlet	NA	5,458	0.0204
0841R	10791	W. Sublett Rd., Arlington, TX	5,927	0.0222
0841R	17190	IH 20, Arlington, TX	8,760	0.0328
0841R	17191	SH 180, Arlington, TX	19,490	0.0729
0841R	Outlet	NA	22,035	0.0824
0841S	Outlet	NA	744	0.0028
0841T	17189	IH 30, Arlington, TX	25,677	0.0960
0841T	Outlet	NA	31,110	0.1163
0841U	17179	W. Vilbig St., Irving, TX	2,131	0.0080
0841U	Outlet	NA	2,200	0.0082

*The DAR was computed by dividing the drainage area of the station/location by the drainage area of USGS gage 08049500 which is 250,567 ha.

Action # 3 Apply DARs and Add Full Permitted WWTF Discharges

- To account for WWTFs at their daily permitted discharge limit, as required in the TMDL, the drainage area ratio approach was applied at each LDC location and to that calculated streamflow record was added the summation of the permitted daily average discharges from any upstream WWTFs.

The computations of the daily record for each location outlined above compensated in a consistent manner for large complexities that precluded calculation of consistent streamflows required for the TMDL allocations from a simpler application of the drainage-area ratio approach without any adjustments.

3.2.4 Step 4: Flow Duration Curve and Load Duration Curve Methods

FDCs and LDCs are graphs indicating the percentage of time during which a certain value of flow or load is equaled or exceeded. To develop a FDC for a location the following steps were undertaken:

- order the daily streamflow data for the location from highest to lowest and assign a rank to each data point;
- compute the percent of days each flow was exceeded by dividing each rank by the total number of data point plus 1; and
- plot the corresponding flow data against exceedance percentages.

Further, when developing a LDC:

- multiply the streamflow in cubic meters per second (cms) by the appropriate water quality criterion for *E. coli* (geometric mean of 126 MPN/100 mL) and by a conversion factor (8.64×10^8), which gives a loading in units of MPN/day; and
- plot the exceedance percentages, which are identical to the value for the streamflow data points, against geometric mean criterion of *E. coli*.

The resulting curve represents the maximum allowable daily loadings for the geometric mean criterion. The next step was to plot the sampled *E. coli* data, when such data existed at the LDC locations, on the developed LDC using the following two steps:

- using the unique data for each monitoring station, compute the daily loads for each sample by multiplying the measured *E. coli* concentrations on a particular day by the corresponding streamflow on that day and the conversion factor (8.64×10^8); and
- plot on the LDC for each station the load for each measurement at the exceedance percentage for its corresponding streamflow.

The plots of the LDC with the measured loads (*E. coli* concentration times daily streamflow) display the frequency and magnitude that measured loads exceed the maximum allowable loadings for the geometric mean criterion. Measured loads that are above a maximum allowable loading curve indicate an exceedance of the water quality criterion, while those below a curve show compliance.

3.3 Flow Duration Curves for Sampling Stations within TMDL Watersheds

FDCs were developed for monitoring stations within Lower West Fork Trinity River (0841_02) and tributaries that are associated with this AU (Figures 3-2 through 3-5). Applying the DAR method to calculate streamflows used to develop the FDCs provides the anticipated increases in flow as watershed drainage areas increase. As an example, this increase in flow with increased drainage area is apparent in the FDC developed for stations within the Rush Creek watershed in that flow at the downstream station located at State Highway 180 in Arlington (station 17191) are greater than those at the upstream stations located at Interstate 20 (station 17190) and West Sublett Road in Arlington (station 10791) (Figure 3-3). The FDCs for stations along Kee Branch (0841M), Rush Creek (0841R), and Village Creek (0841T) indicate an absence of flow at exceedances above approximately 90%. Based on best professional judgment and instantaneous flow measurements frequently taken when water quality data are collected, the 7% absence of measureable flow indicated on these FDCs appeared to be reasonable and reflective of the intermittent nature of most streams in the Lower West Fork Trinity River watershed that do not receive supplemental flow from WWTF discharges. The influence of the Village Creek WWTF discharge on streamflows at the station located on the Lower West Fork Trinity River at Roy Orr Boulevard (station 17669) is apparent with nearly constant flows between 7 and 11 cubic meters per second (cms) at flow exceedances above 50% (Figure 3-5).

The FDCs were also developed for monitoring stations within Lower West Fork Trinity River (0841_01) and tributaries associated with this AU (Figures 3-6 through 3-14). Because of the consistency of the DAR method, these FDCs display similar characteristics to those presented for stations within the watershed of 0841_02. The Alta Vista Mobile Home Park WWTF discharges into non-impaired Big Bear Creek (Segment 0841D), a tributary of Bear Creek (Segment 0841B).

As a result constant flows of 0.0035 cms are indicated for flow exceedances above 93% corresponding to the full permitted discharge of the WWTF (Figure 3-6). Similar to the FDC for the station located at Roy Orr Boulevard in 0841_02 (station 17669) the FDC for the three monitoring stations along the mainstem of 0841_01 indicate nearly constant flows at flow exceedances above 50% (Figure 3-14). The close proximity of stations located along the Lower West Fork Trinity River at South MacArthur Boulevard (station 11080) to the station located at Beltline Road (station 11081) and lack of significant inflows between the two stations results in nearly identical FDCs at these two stations. Both stations are located below the watersheds of Johnson Creek and Dalworth Creek and the outfall of the City of Fort Worth Village Creek WWTF. The station located 194 meters downstream of State Highway Loop 12 (station 11089) is the most downstream station in 0841_01, and it is below the watersheds of Vilbig Lake, Bear Creek, West Irving Branch, Mountain Creek, and Delaware Creek and below the outfall of the TRA Central Regional WWTF. The additional flows from these watersheds and the large WWTF that are above the location of the station located downstream of station 11089 results in a FDC that displays significantly larger flows than FDCs developed for the upstream stations located at South MacArthur Boulevard and Beltline Road (stations11080 and 11081) in 0841_01 (Figure 3-14)

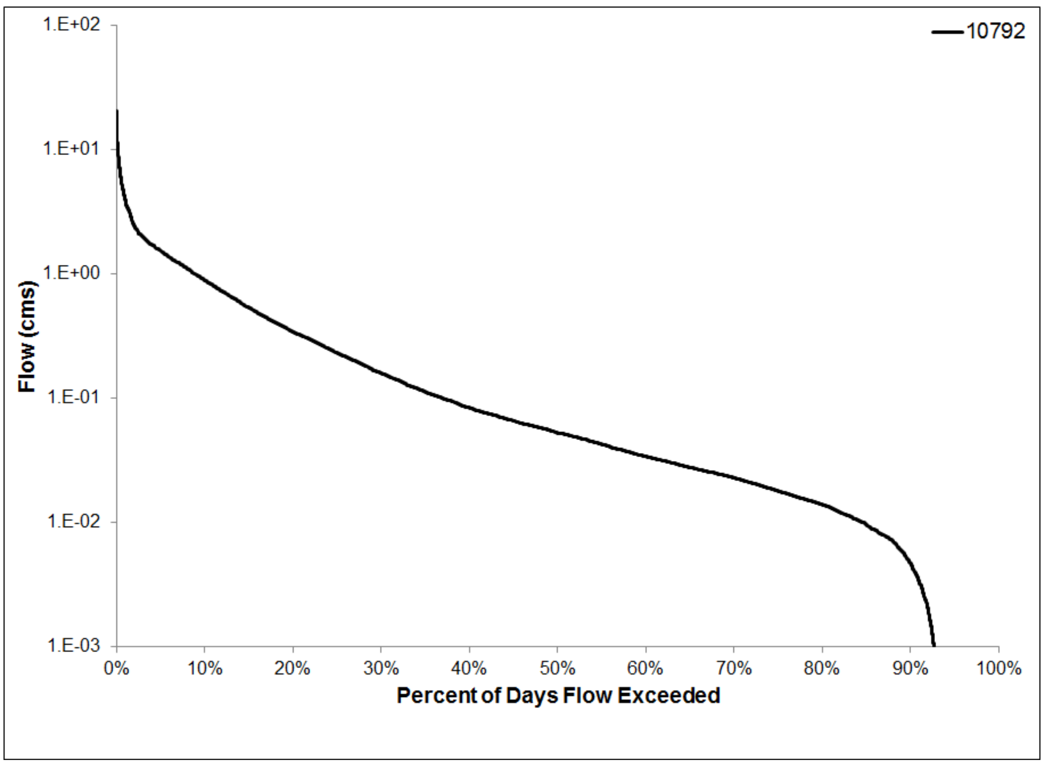

Figure 3-2. Flow duration curve at the monitoring station on Kee Branch (0841M).

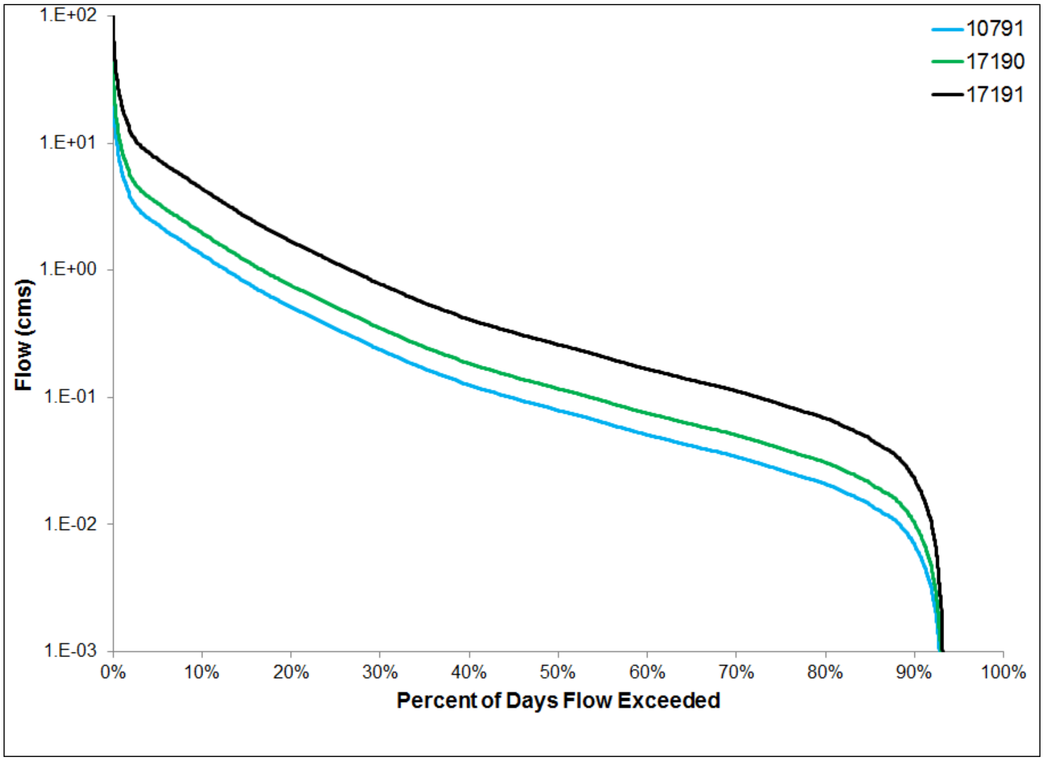

Figure 3-3. Flow duration curves at monitoring stations along Rush Creek (0841R).

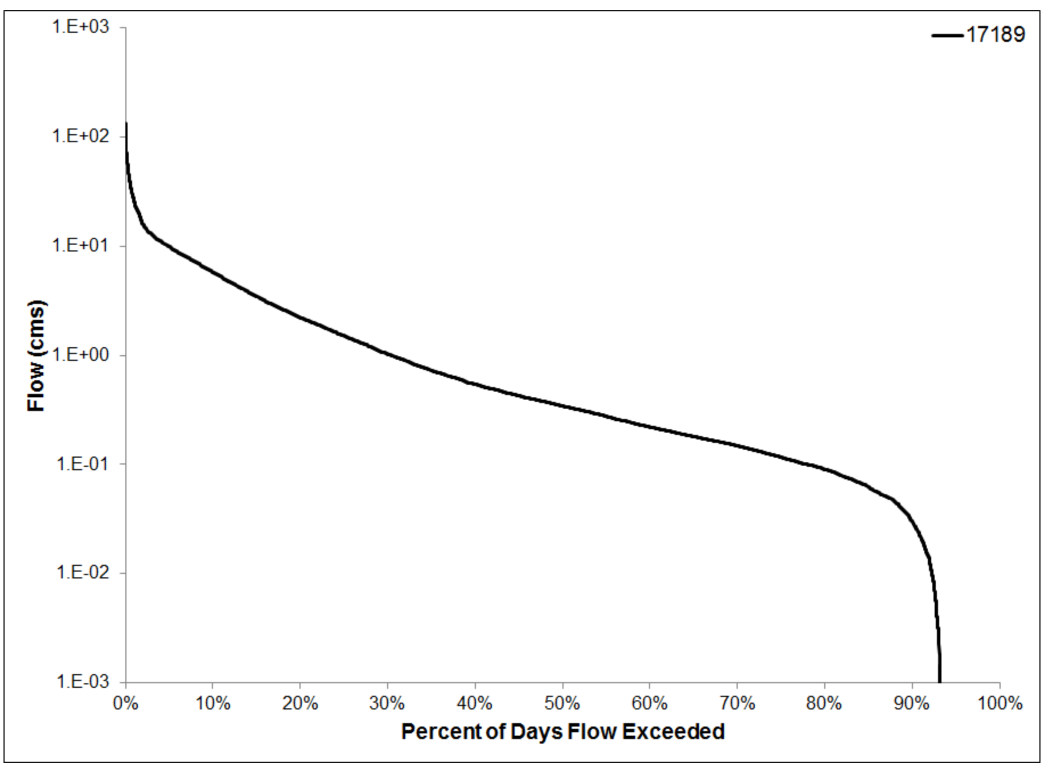

Figure 3-4. Flow duration curve at monitoring station on Village Creek (0841T).

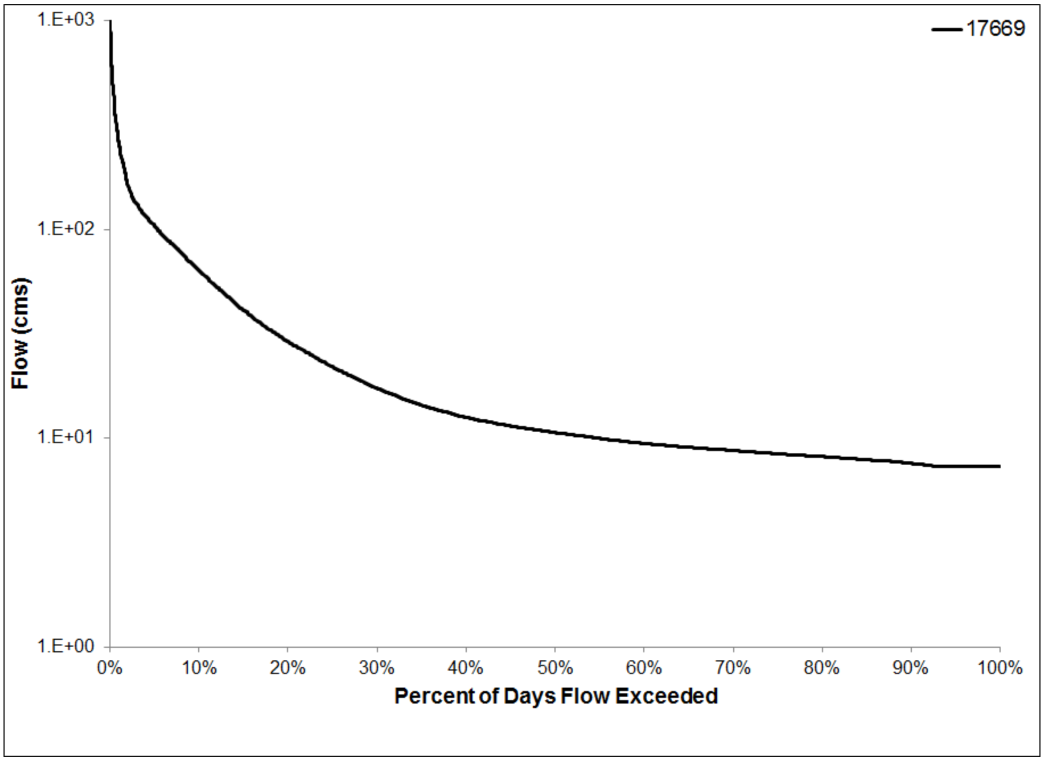

Figure 3-5. Flow duration curve at the monitoring station on Lower West Fork Trinity River (0841).

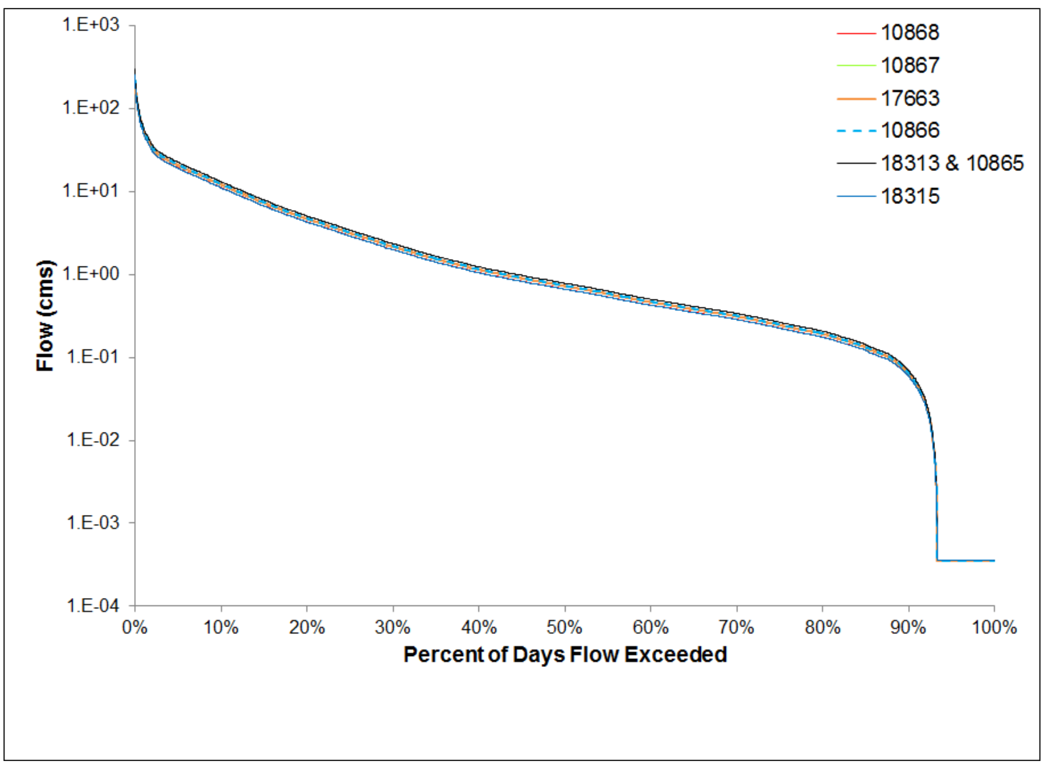

Figure 3-6. Flow duration curve at monitoring stations along Bear Creek (0841B).

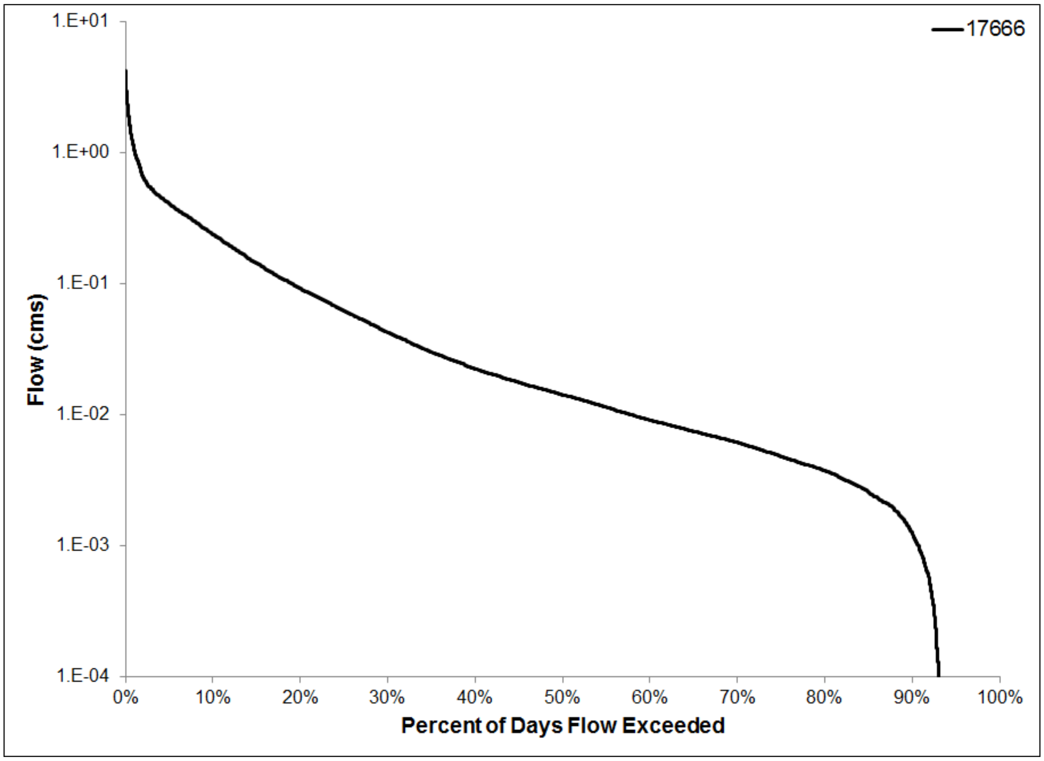

Figure 3-7. Flow duration curve at water quality monitoring station along Arbor Creek (0841C).

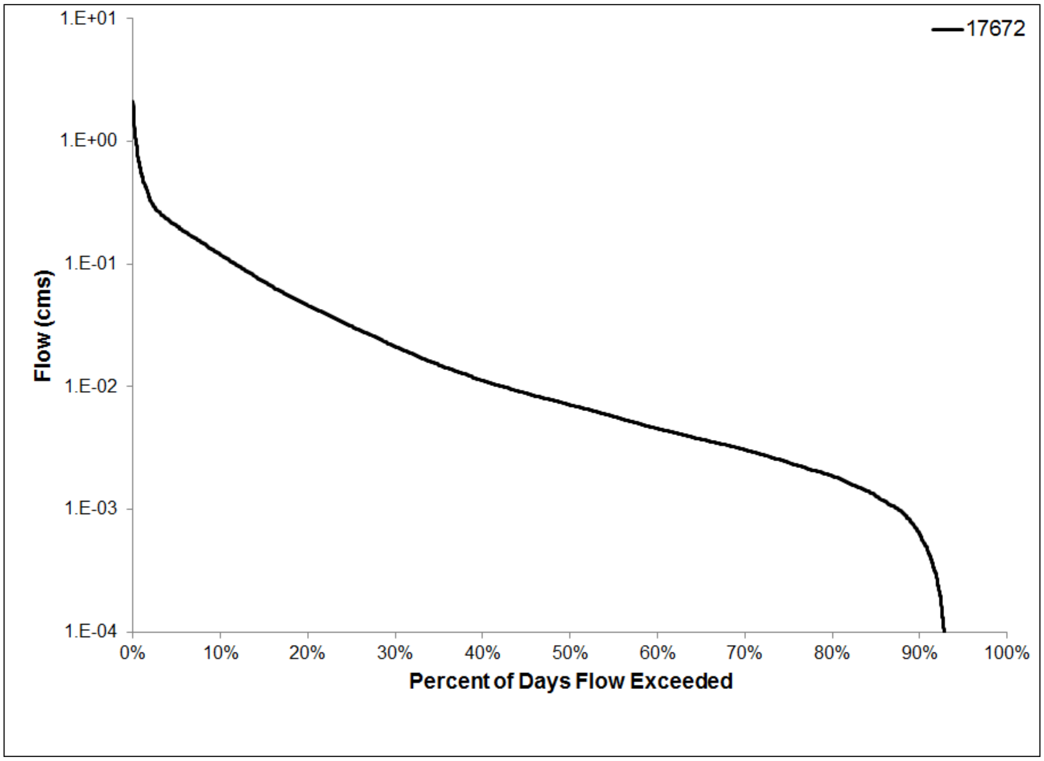

Figure 3-8. Flow duration curve at water quality monitoring station along Copart Branch Mountain Creek (0841E).

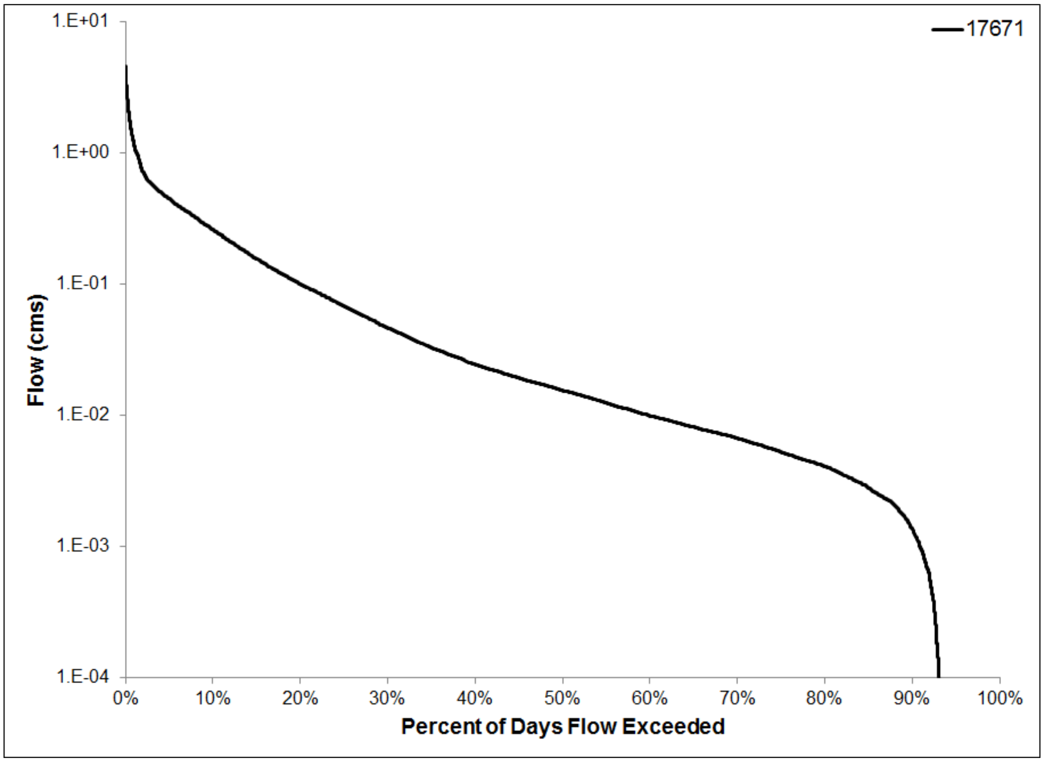

Figure 3-9. Flow duration curve at the monitoring station on Dalworth Creek (0841G).

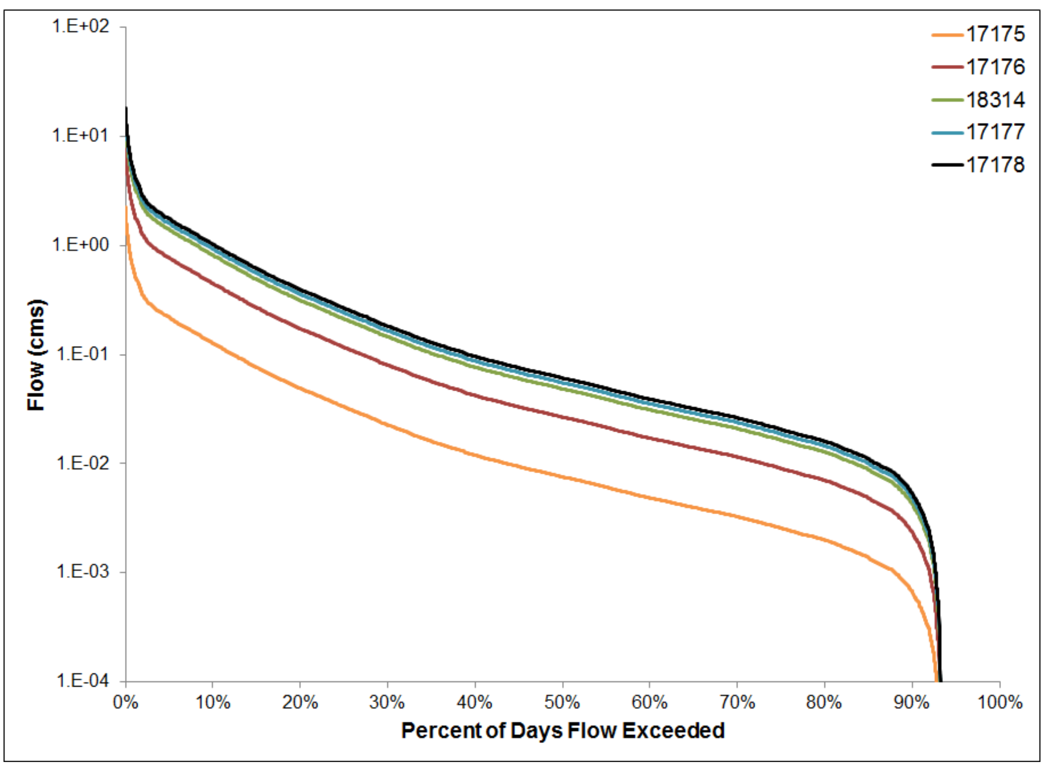

Figure 3-10. Flow duration curve at the monitoring station along Delaware Creek (0841H).

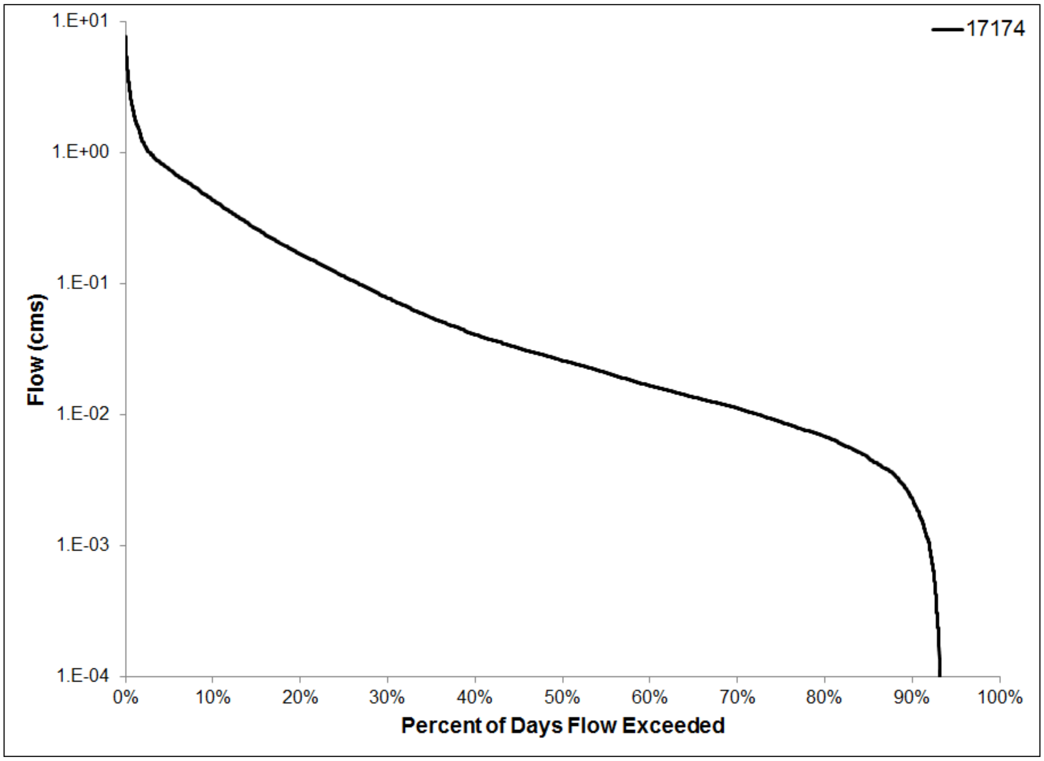

Figure 3-11. Flow duration curve at the monitoring station on Estelle Creek (0841J).

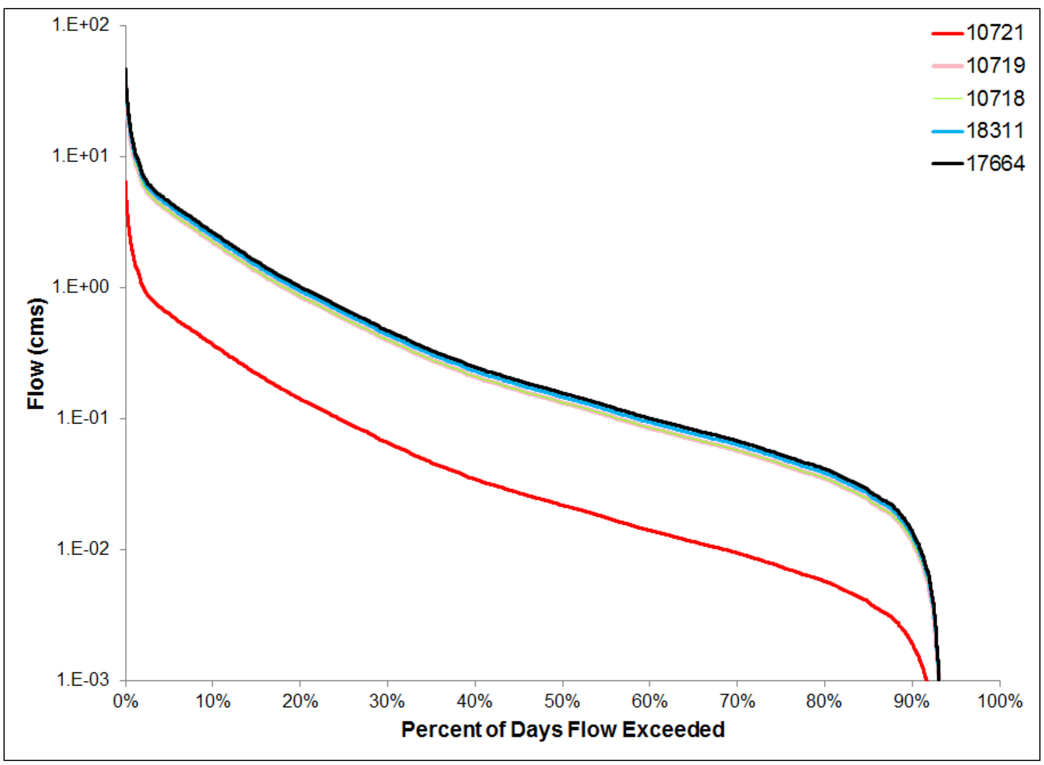

Figure 3-12. Flow duration curve at water quality monitoring station on Johnson Creek (0841L).

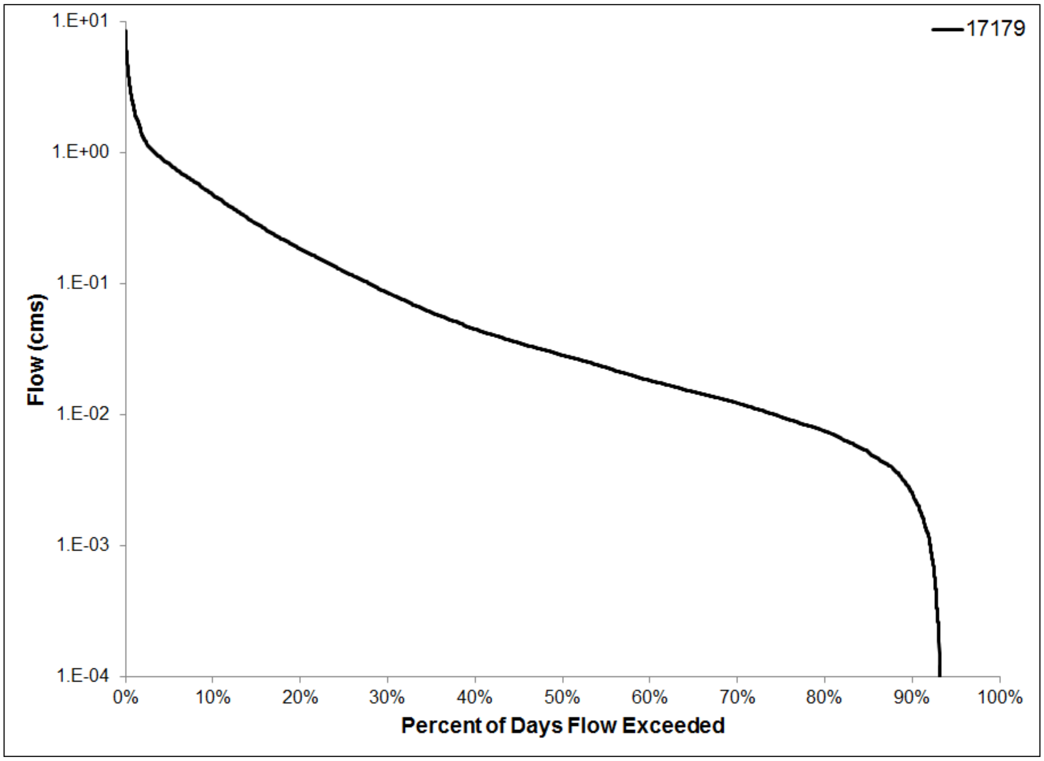

Figure 3-13. Flow duration curve at the monitoring station on West Irving Branch (0841U).

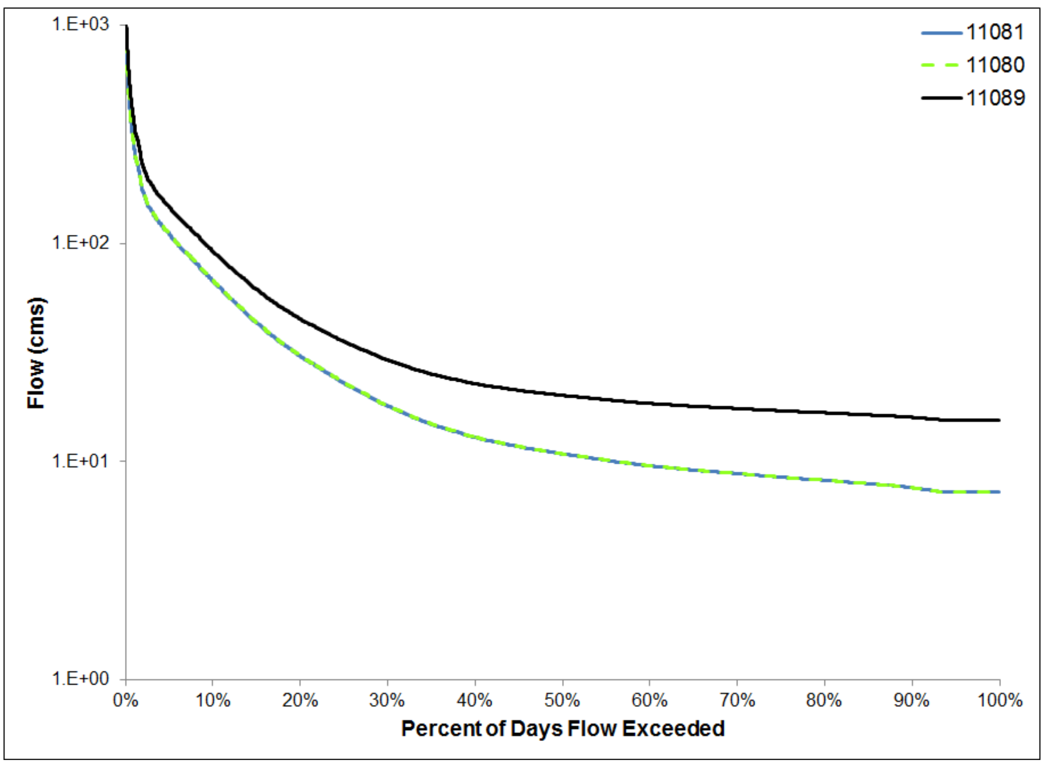

Figure 3-14. Flow duration curve at monitoring stations along Lower West Fork Trinity River (0841_01).

3.3.1 Flow Duration Curves for Outlet and Inlet Locations within the TMDL Watersheds

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 will be defined through inlet locations to that water body. An inlet does not need to be defined for any TMDL watershed that receives no flows and bacteria except from within its watershed.

FDCs outlets and inlets of TMDL watersheds were also developed using the DAR method (Figures 3-15 through 3-20). Note that an inlet is 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). These FDCs display a similar pattern to those developed for the water quality monitoring stations with flow increasing with increasing drainage areas and nearly constant flows at mid-range and low flow conditions when upstream WWTF discharges are present.

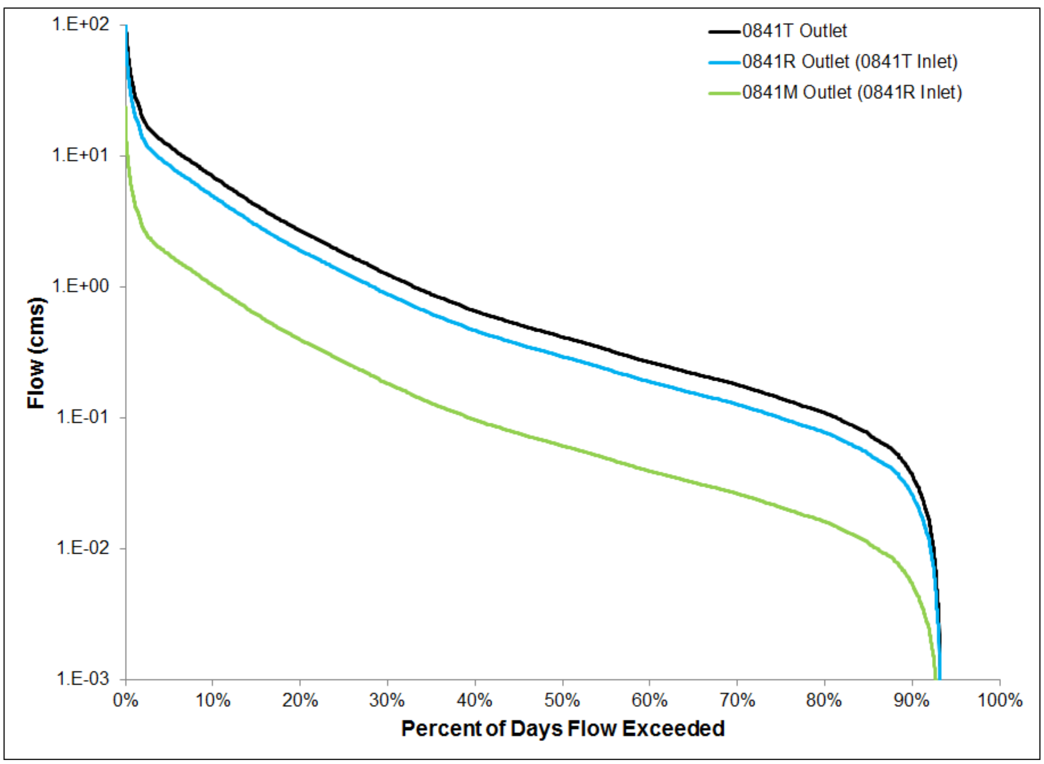

Figure 3-15. Flow duration curves at the inlets and outlets of Village Creek (0841T), Rush Creek (0841R), and Kee Branch (0841M).

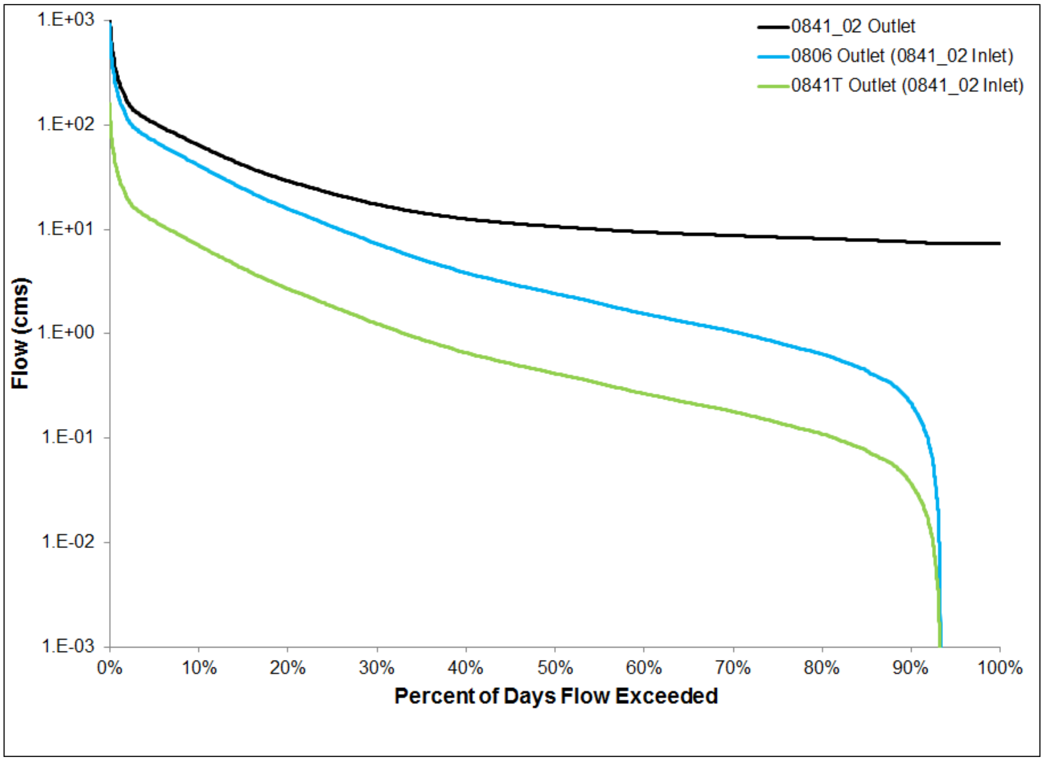

Figure 3-16. Flow duration curves at the inlets and outlets of West Fork Trinity River (0806) and Lower West Fork Trinity River (0841_02) and Village Creek (0841T).

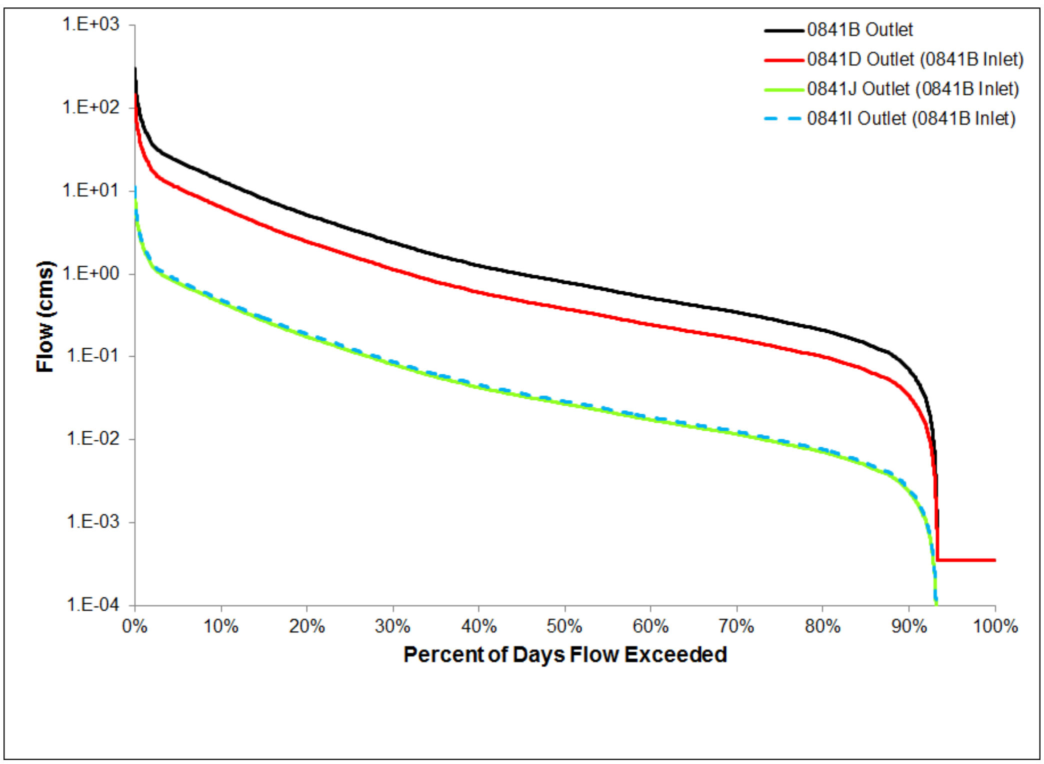

Figure 3-17. Flow duration curves at the inlets and outlets of Bear Creek (0841B), Big Bear Creek (0841D), Estelle Creek (0841J), and Dry Branch (0841I).

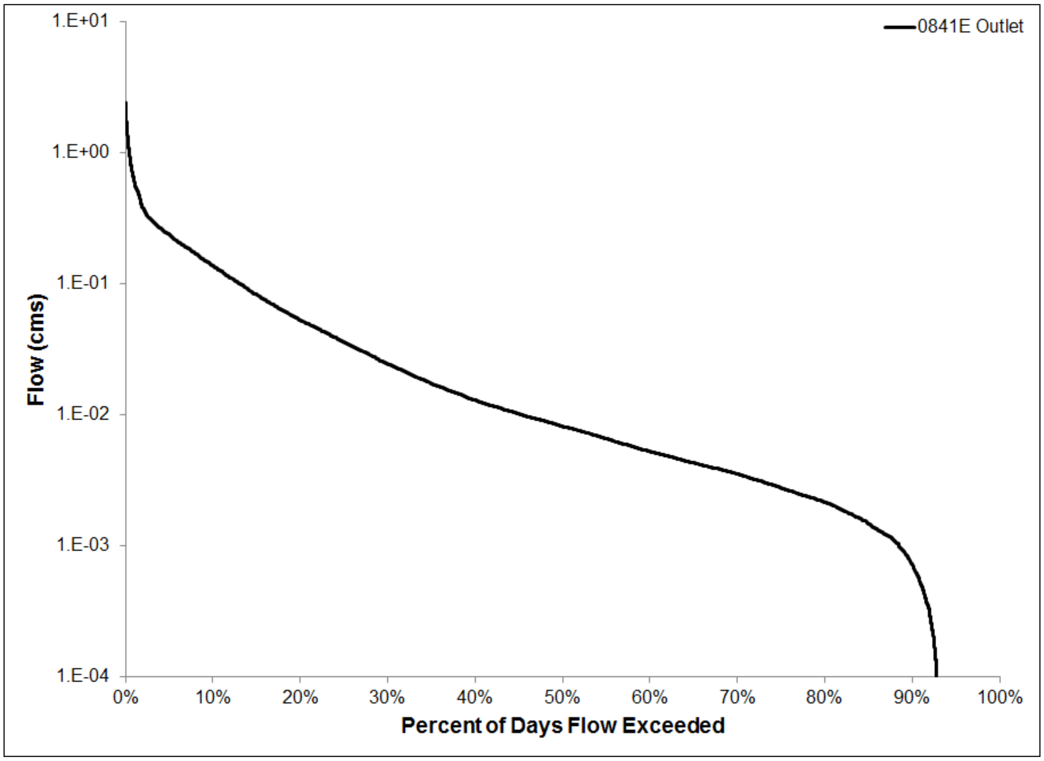

Figure 3-18. Flow duration curve at the outlet of Copart Branch Mountain Creek (0841E).

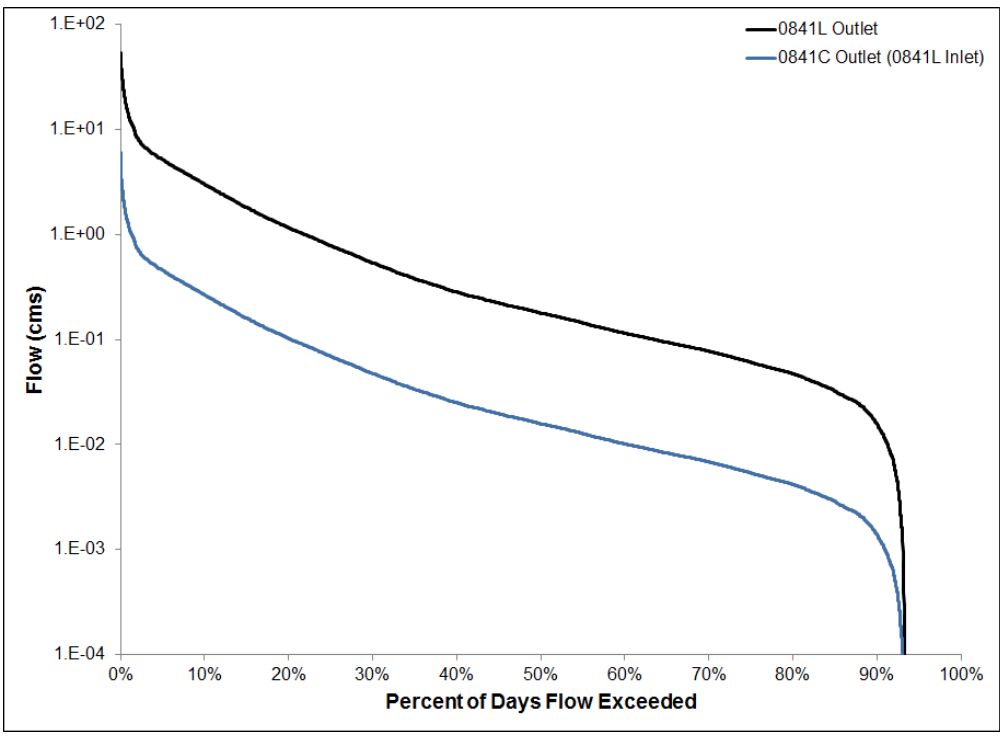

Figure 3-19. Flow duration curves at the inlets and outlets of Johnson Creek (0841L) and Arbor Creek (0841C).

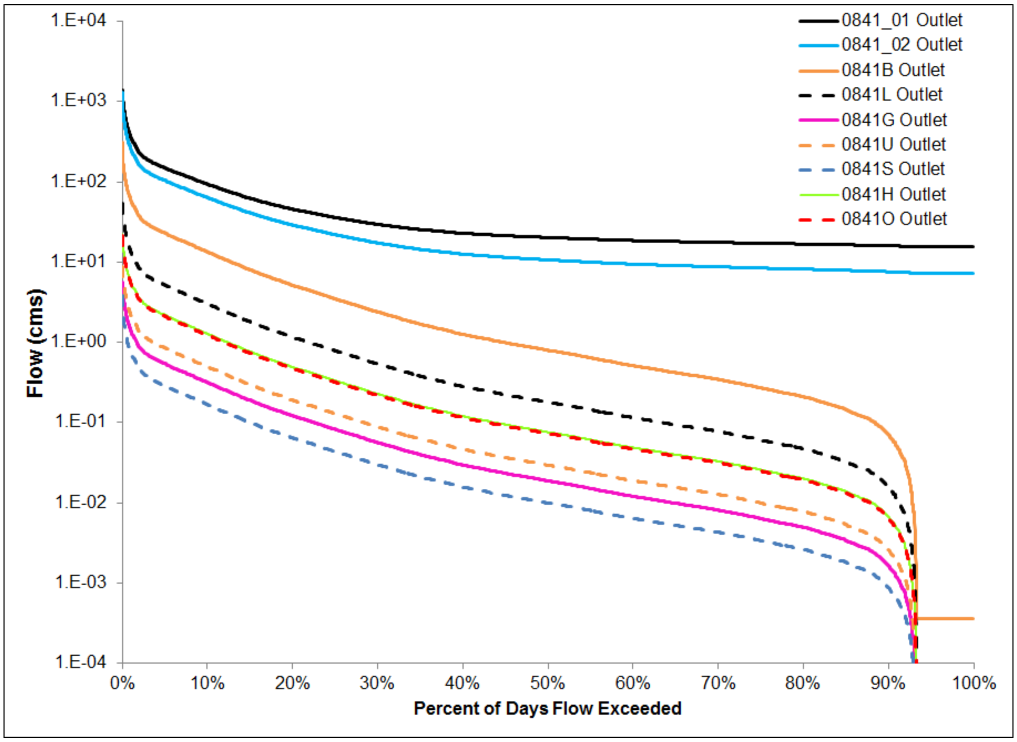

Figure 3-20. Flow duration curves at the inlets and outlets of Lower West Fork Trinity River (0841_01 and 0841_02), Bear Creek (0841B), Johnson Creek (0841L), Dalworth Creek (0841G), West Irving Branch (0841U), Vilbig Lake (0841S), Delaware Creek (0841H), and Mountain Creek (0841O).

3.4 Load Duration Curves for Monitoring Stations within the TMDL Watersheds

Following Step 4 described in Section 3.2.4, LDCs were developed for each monitoring station within the TMDL watersheds. A useful refinement of the LDC approach is to divide the curve into flow-regime regions to analyze exceedance patterns in smaller portions of the duration curves. This approach can assist in determining streamflow conditions under which exceedances are occurring. A commonly used set of regimes that is provided in Cleland (2003) is based on the following five intervals along the x-axis of the FDCs and LDCs: (1) 0 – 10% (high flows); (2) 10 – 40% (moist conditions); (3) 40 – 60% (mid-range flows); (4) 60 – 90% (dry conditions); and (5) 90 – 100% (low flows).

For the Lower West Fork Trinity River watershed a three-interval system was selected:

- Very high flow regime: 0-10 percentile range, related to flood flows
- High flow regime: 10-50 percentile range, related to high streamflow conditions
- Low flow regime: 50-100 percentile range, related to low and dry flow condition.

The selection of these three intervals was based on general observations on all the monitoring station LDCs. The 50 percentile range separating the high and low flow regimes represents a convenient point where at many stations wet weather collected data occurs more frequently below this percentile and non-wet-weather data more frequently above this percentile. (The definitions of wet weather and non-wet weather data are provided in the following paragraph.) Further at many, but not all, stations, the 50 percentile range is where *E. coli* loadings of measured data are more often above the allowable loading line to the left of the 50 percentile and more often below the allowable loading to the right. Finally, the 0-10 percentile range, representing the highest flow, is in the general area where the allowable loading line slope steepens.

The load duration curves with these three flow regimes for water quality monitoring stations are provided in Figures 3-21 through 3-50. Geometric mean loadings for the data points within each flow regime have also been distinguished on each figure to aid interpretation. 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. The streamflows and associated *E. coli* concentrations used to develop these LDCs at each of the stations are provided in Appendix A.

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 mainstem 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.

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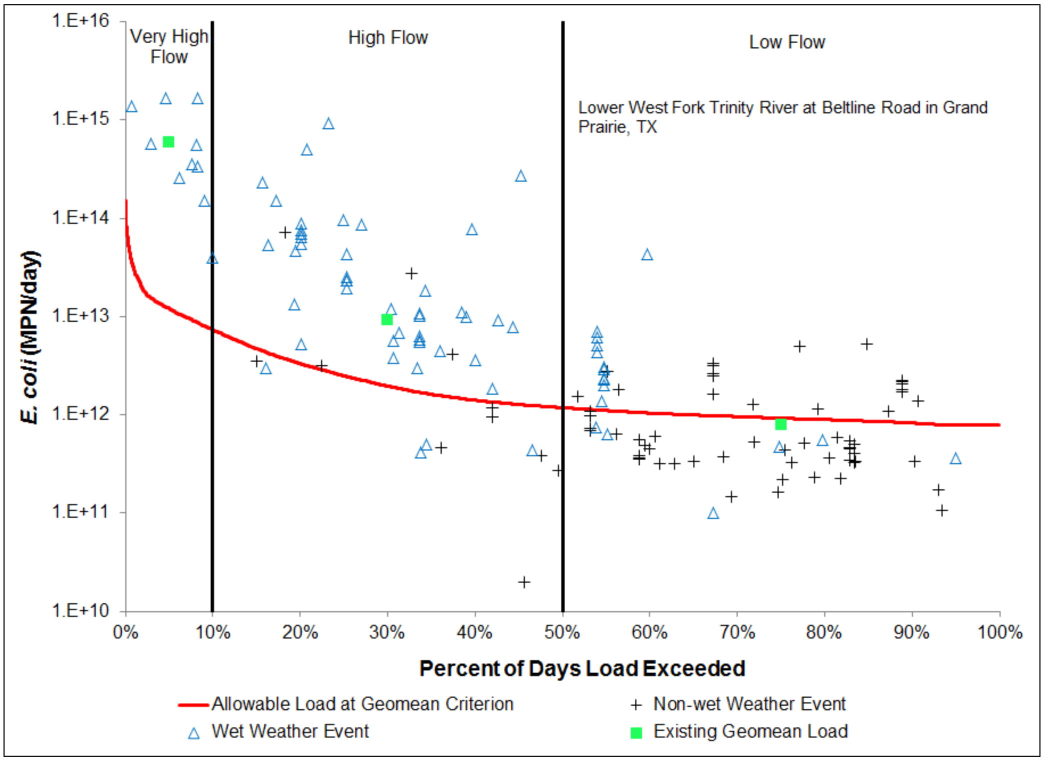

Figure 3-21. Load duration curve for station 11081, Lower West Fork Trinity River (0841_01).

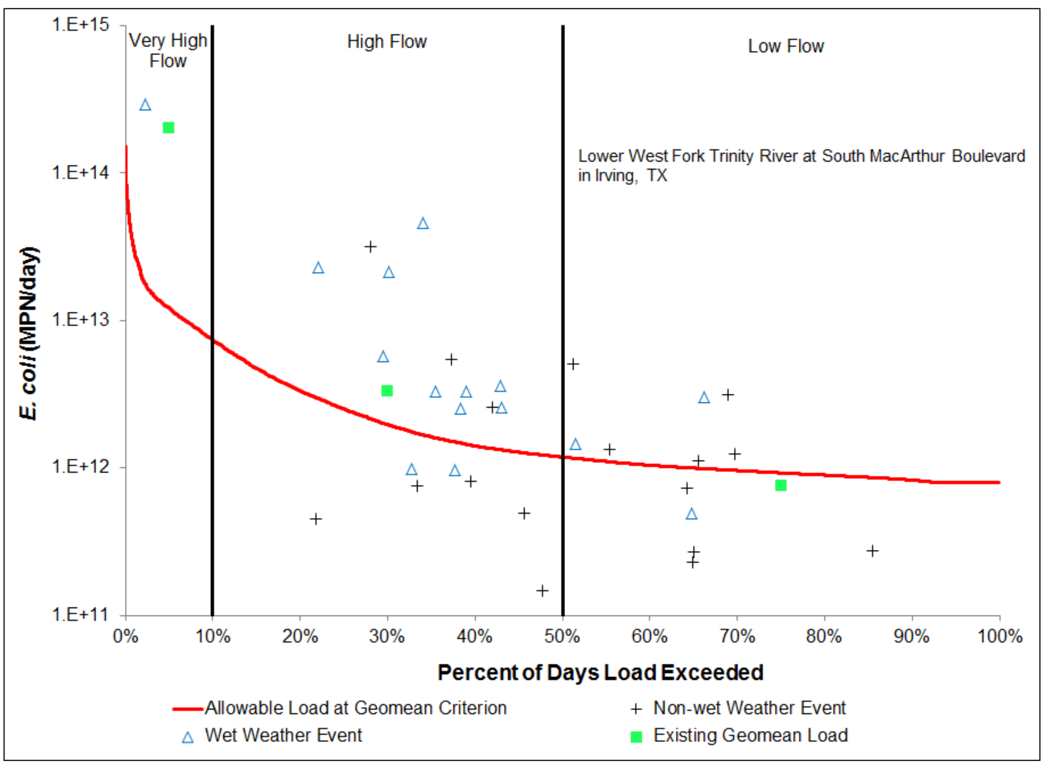

Figure 3-22. Load duration curve for station 11080, Lower West Fork Trinity River (0841_01).

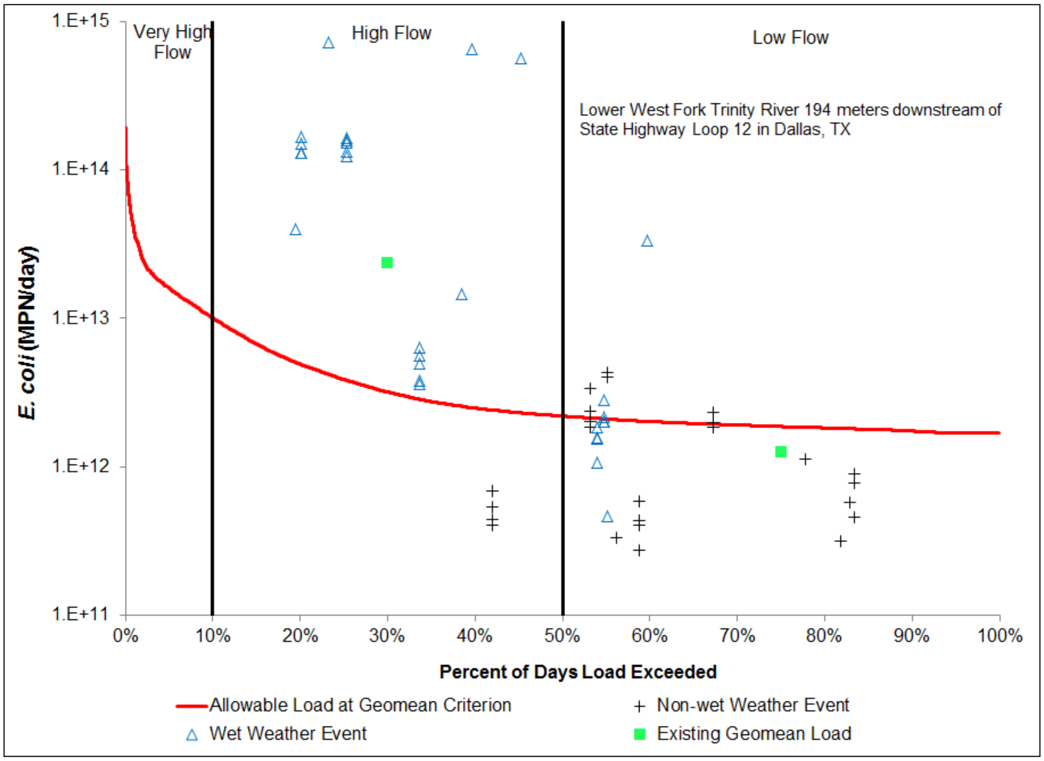

Figure 3-23. Load duration curve for station 11089, Lower West Fork Trinity River (0841_01).

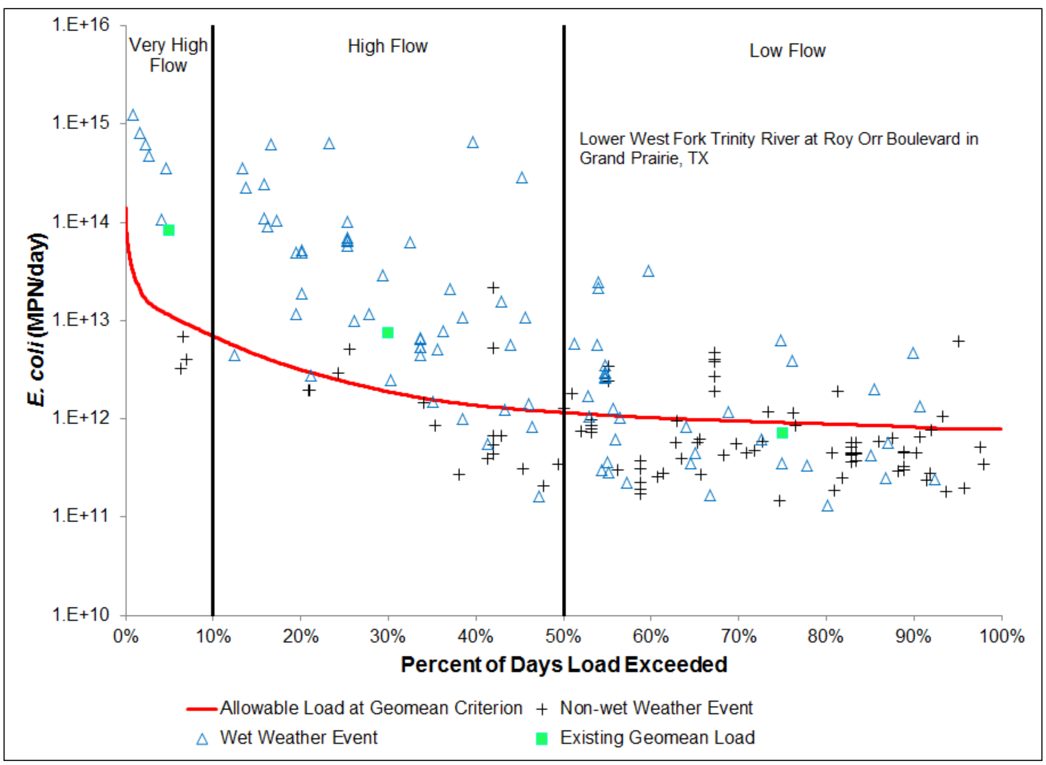

Figure 3-24. Load duration curve for station 17669, Lower West Fork Trinity River (0841_02).

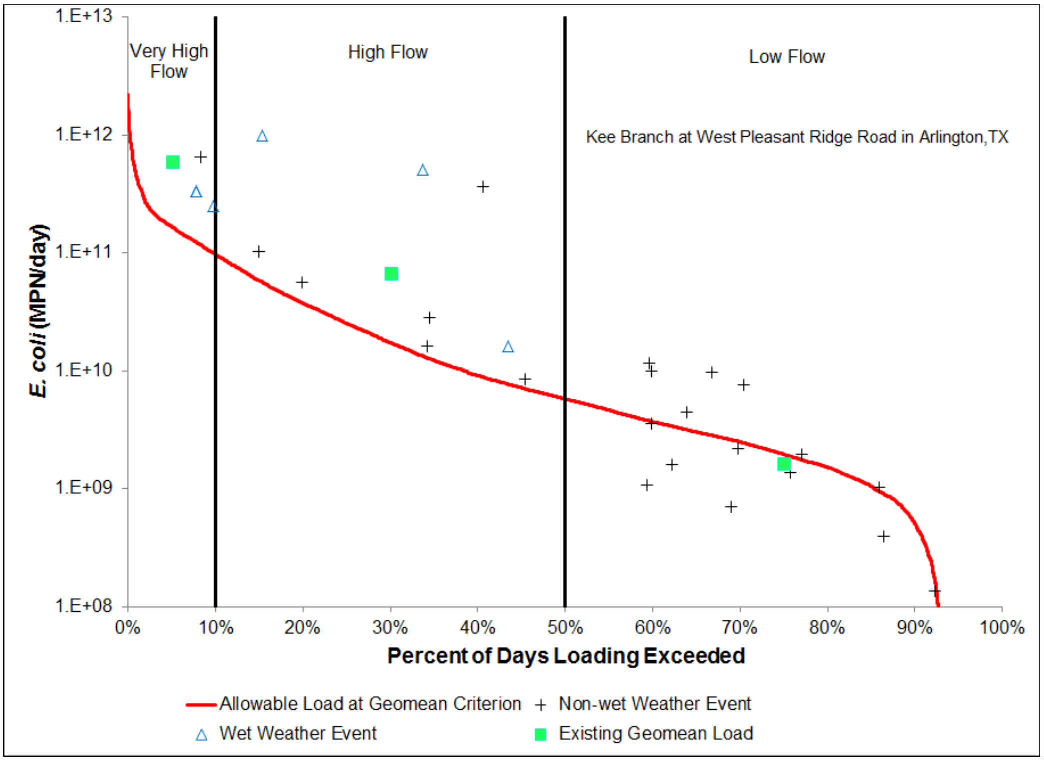

Figure 3-25. Load duration curve for station 10792, Kee Branch (0841M).

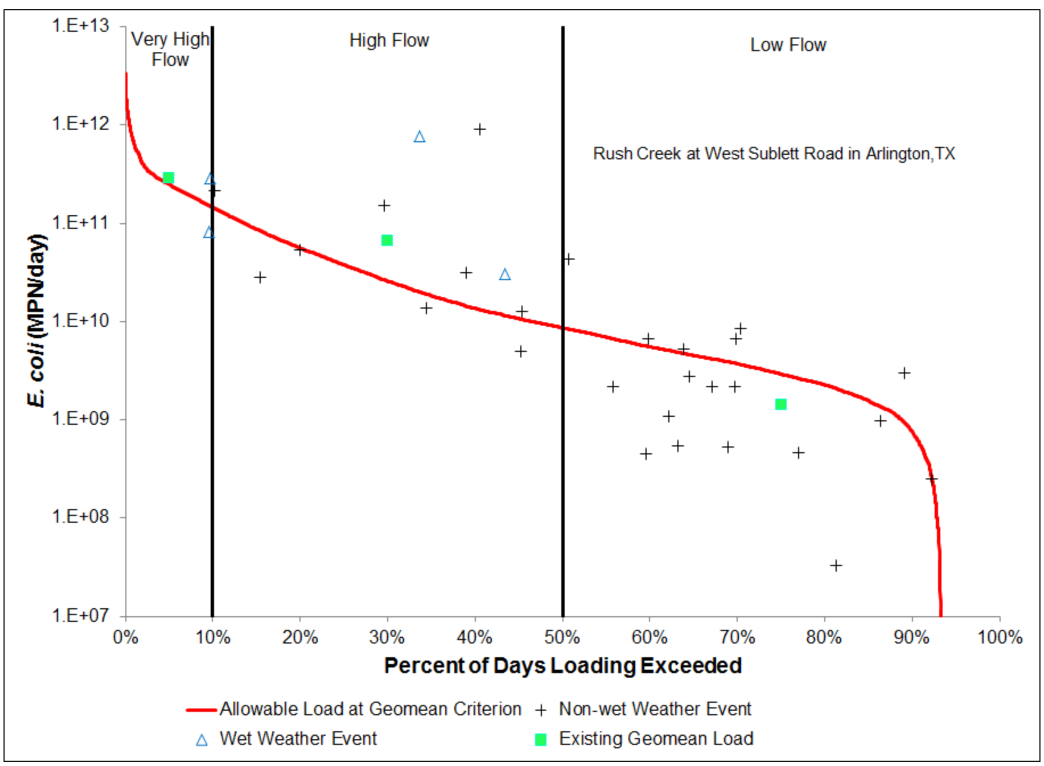

Figure 3-26. Load duration curve for station 10791, Rush Creek (0841R).

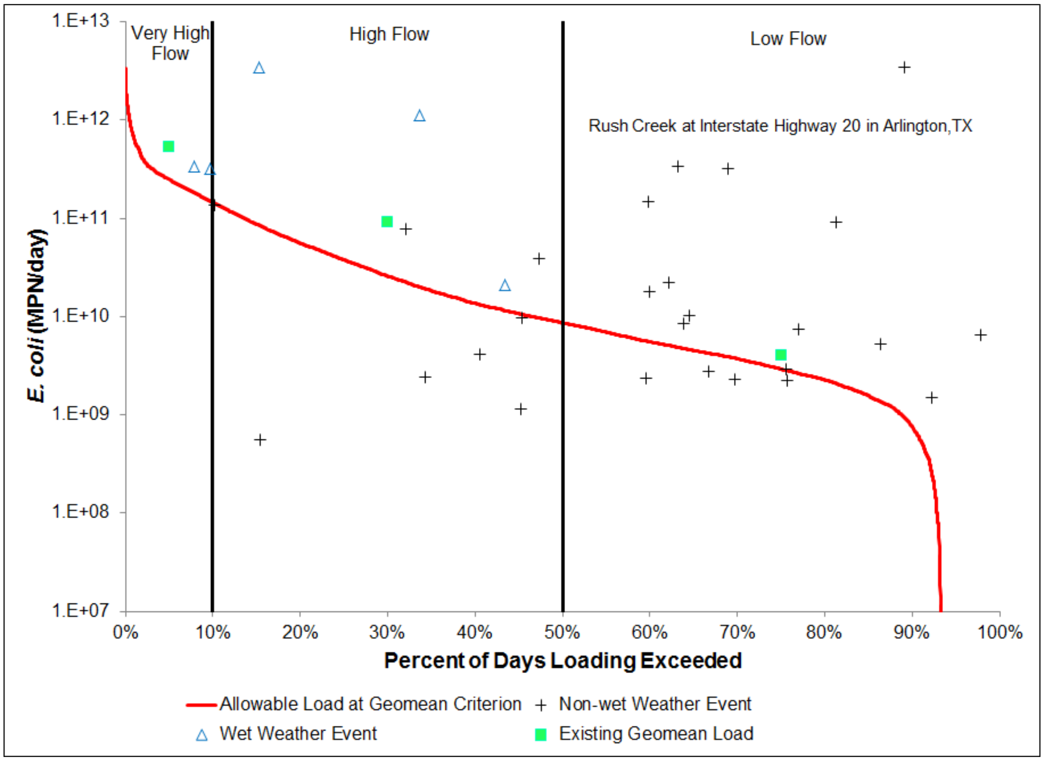

Figure 3-27. Load duration curve for station 17190, Rush Creek (0841R).

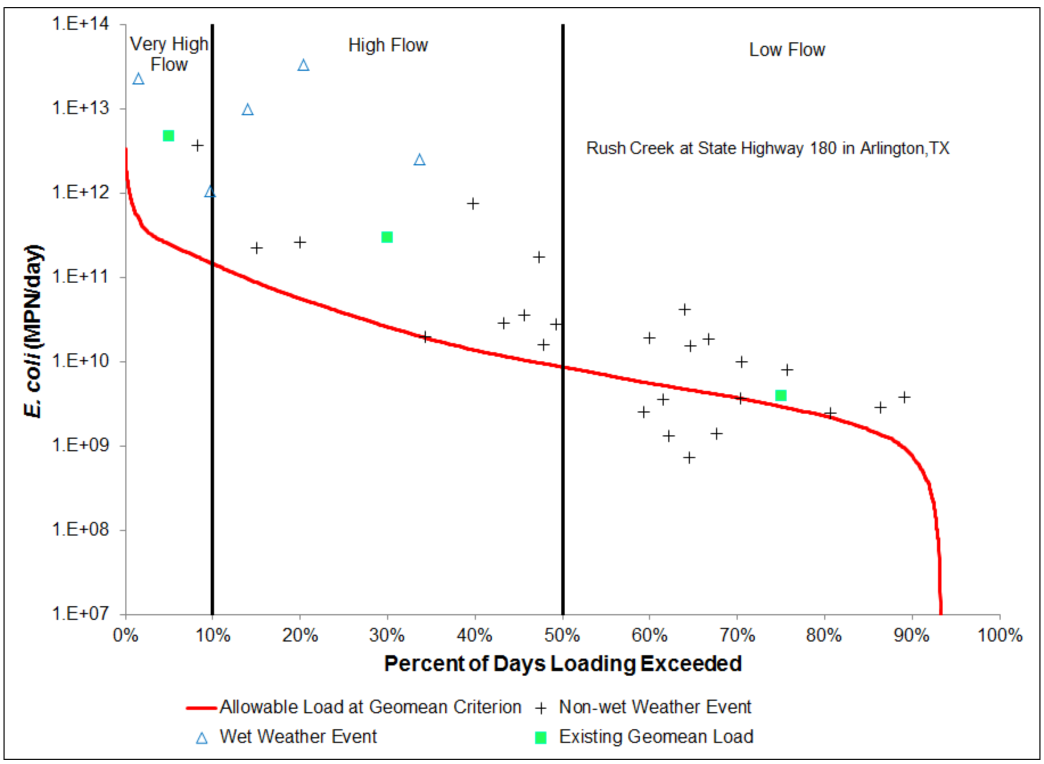

Figure 3-28. Load duration curve for station 17191, Rush Creek (0841R).

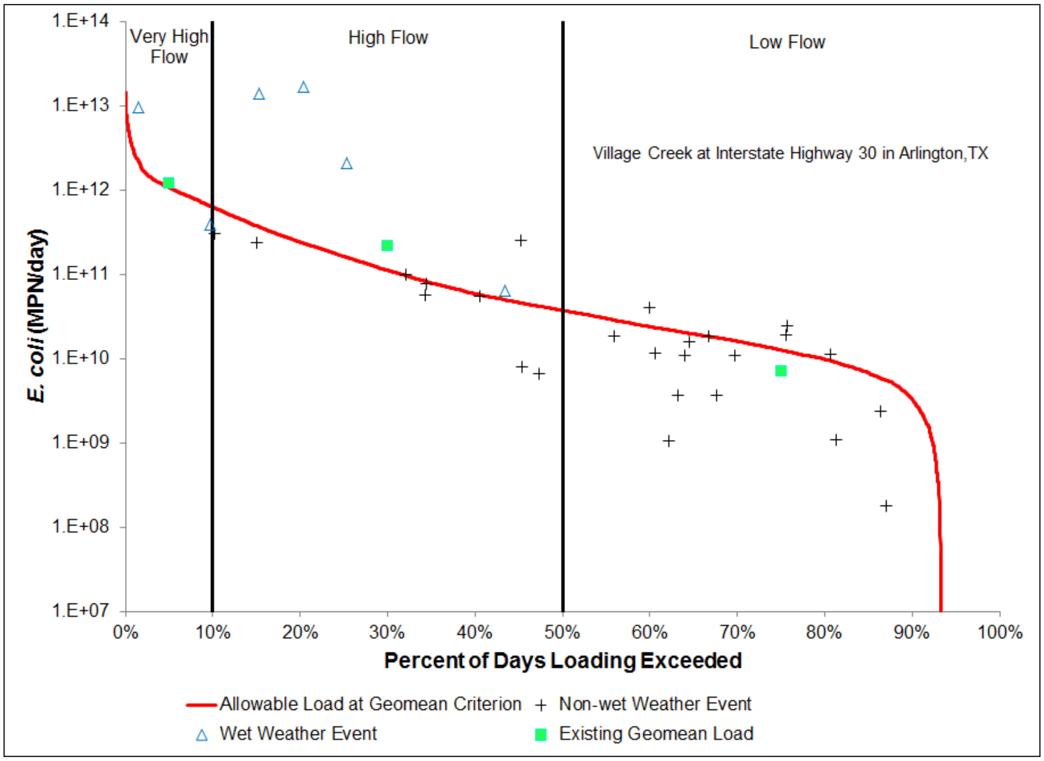

Figure 3-29. Load duration curve for station 17189, Village Creek (0841T).

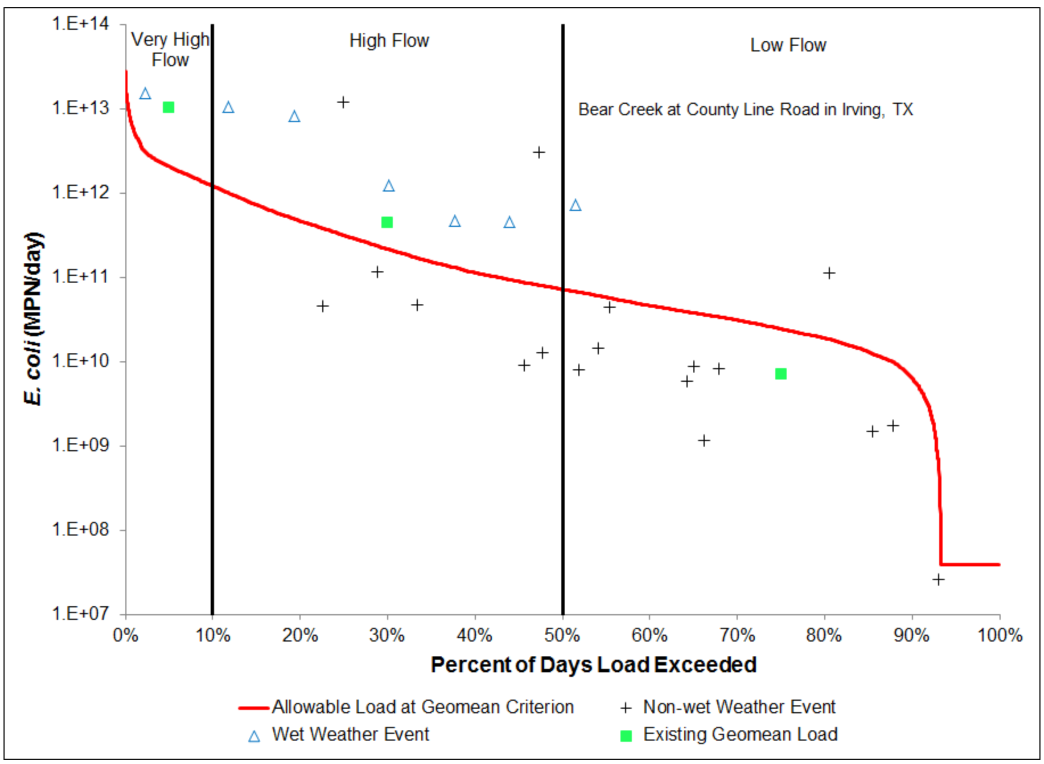

Figure 3-30. Load duration curve for station 18315, Bear Creek (0841B).

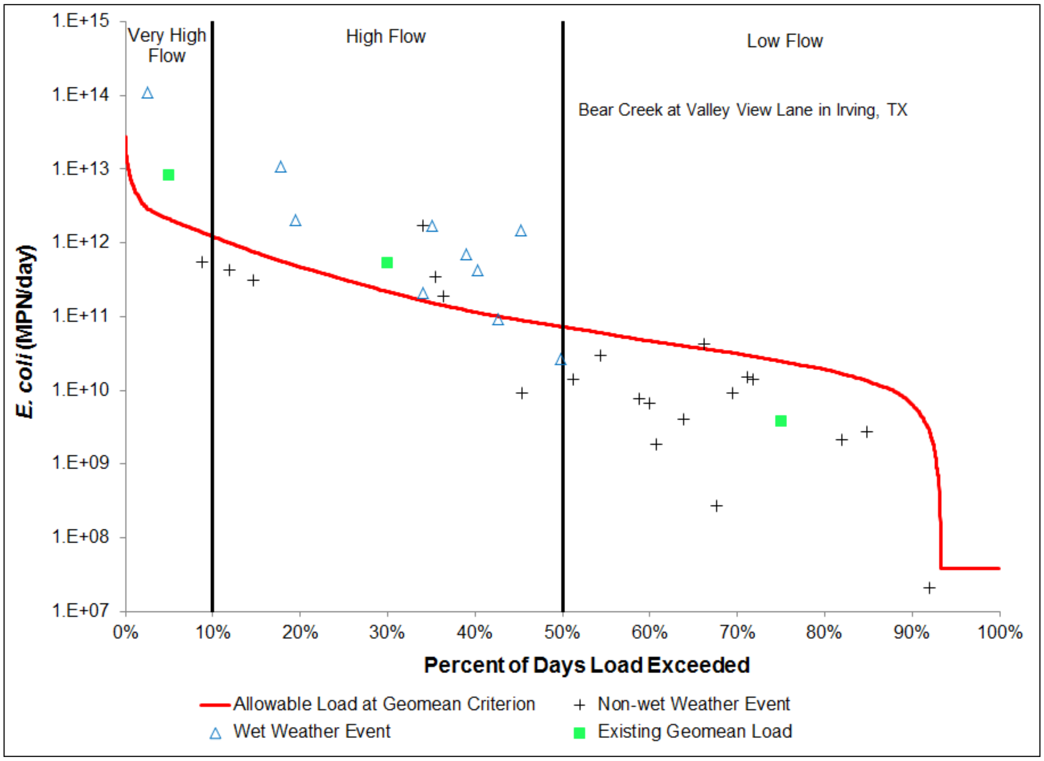

Figure 3-31. Load duration curve for station 10868, Bear Creek (0841B).

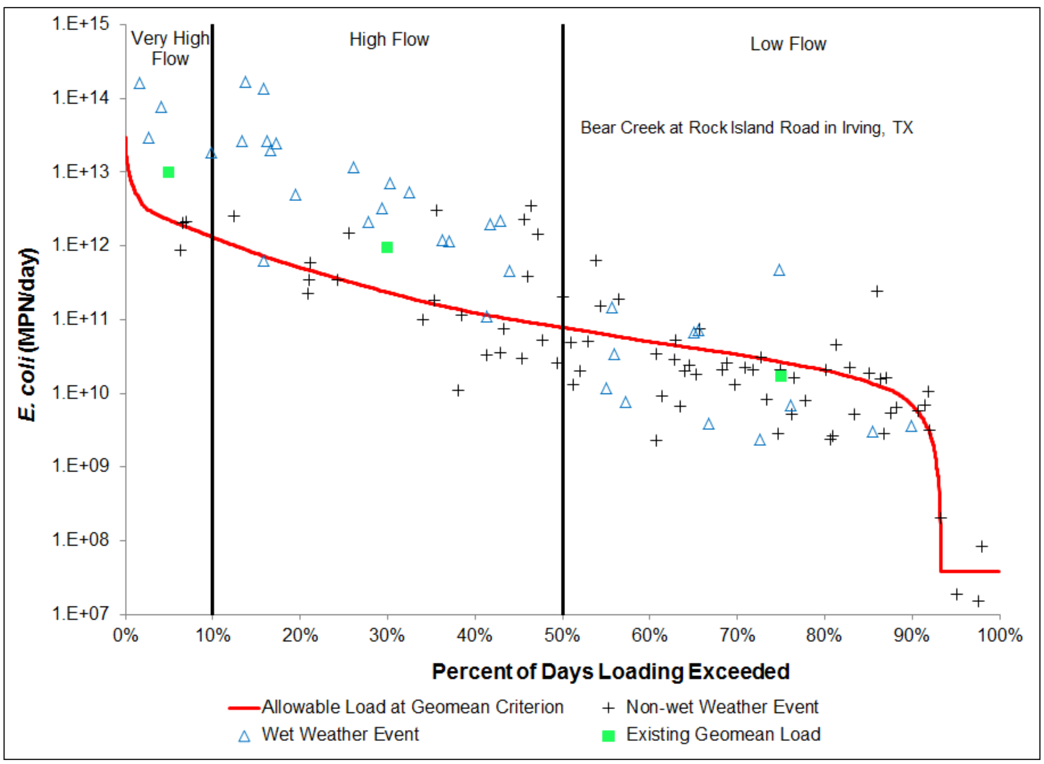

Figure 3-32. Load duration curve for station 10867, Bear Creek (0841B).

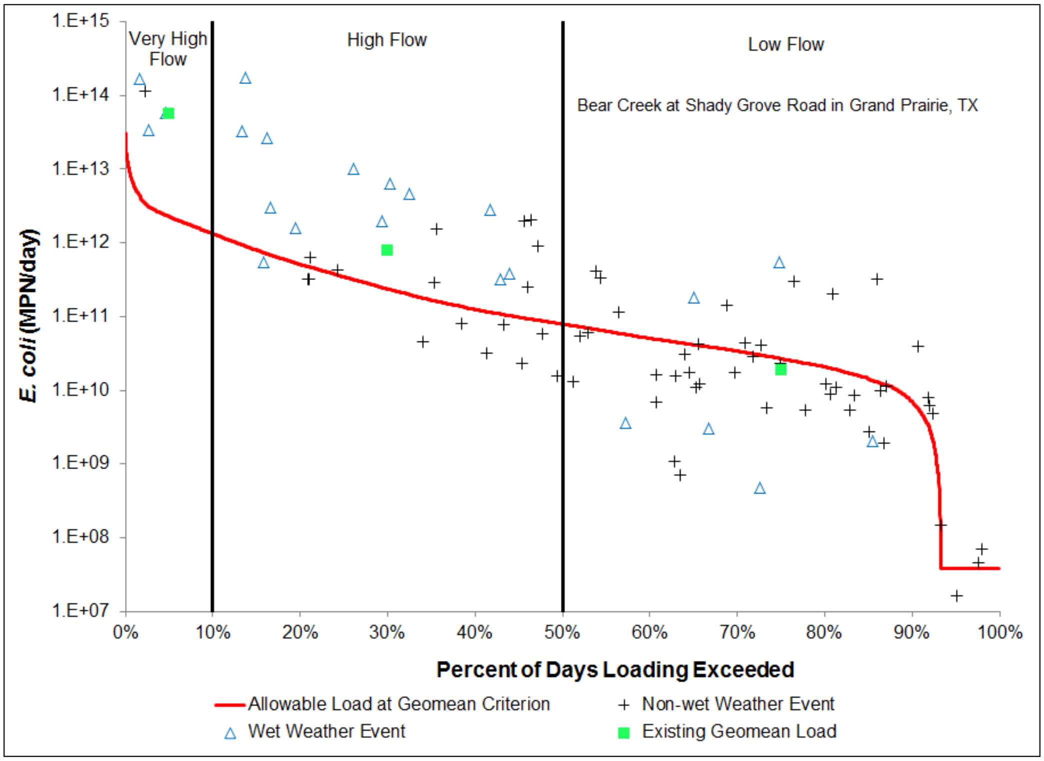

Figure 3-33. Load duration curve for station 17663, Bear Creek (0841B).

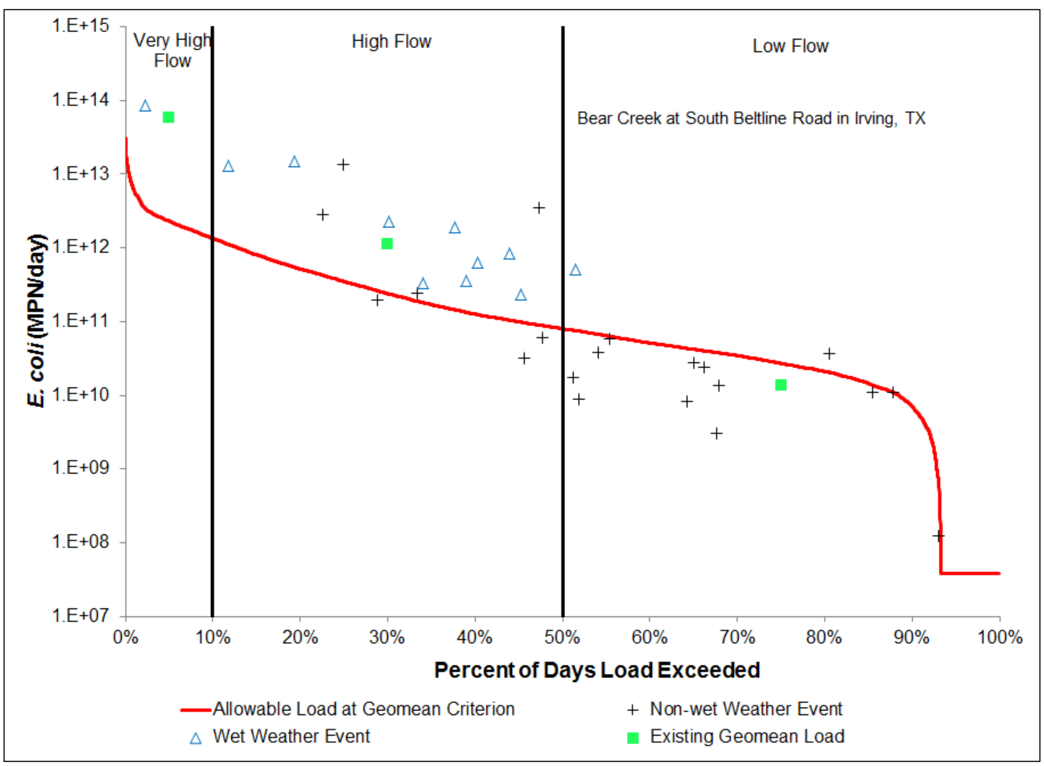

Figure 3-34. Load duration curve for station 10866, Bear Creek (0841B).

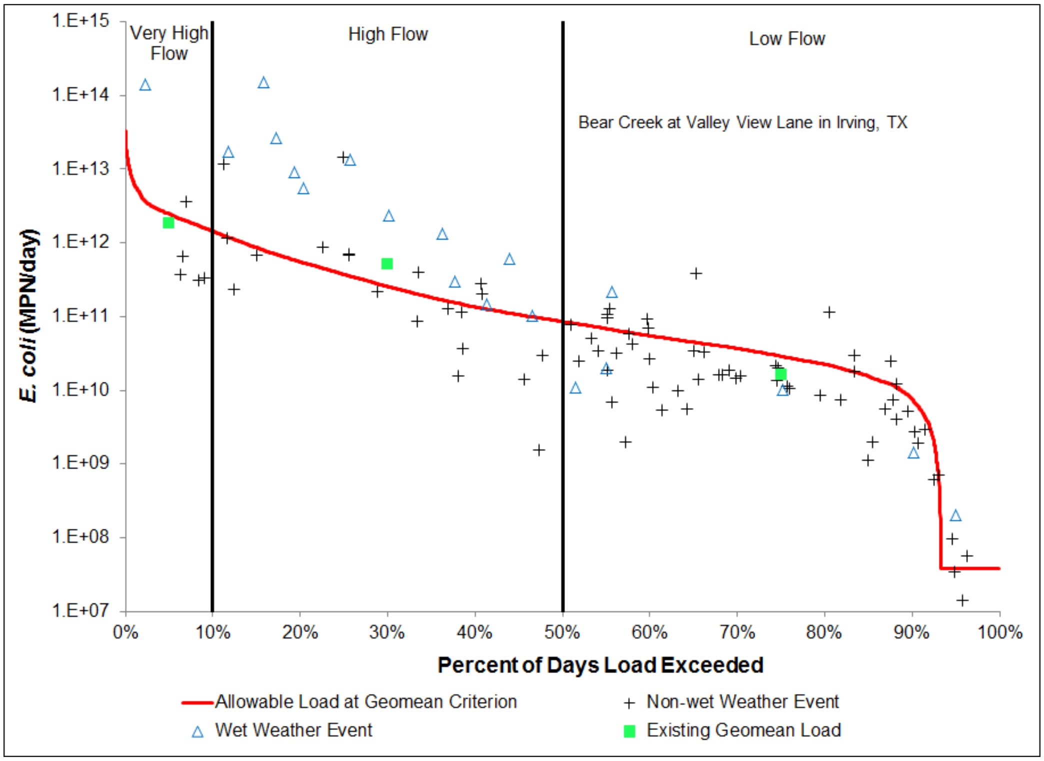

Figure 3-35. Load duration curve for stations 10868 and 18313, Bear Creek (0841B).

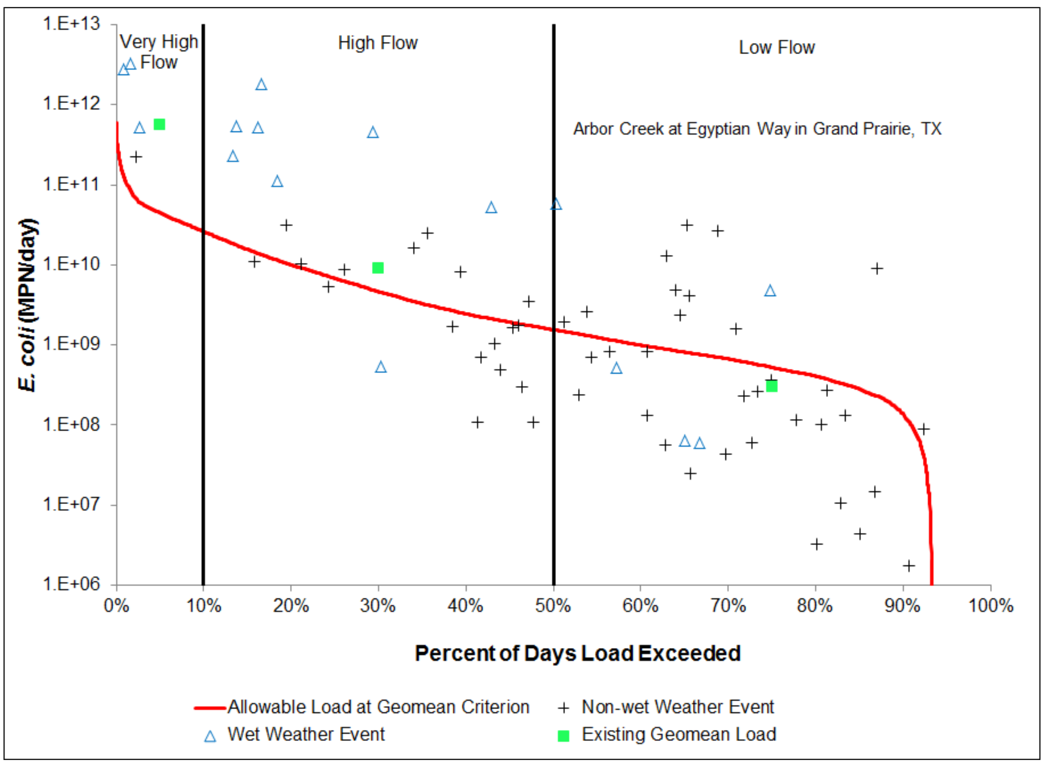

Figure 3-36. Load duration curve for station 17666, Arbor Creek (0841C).

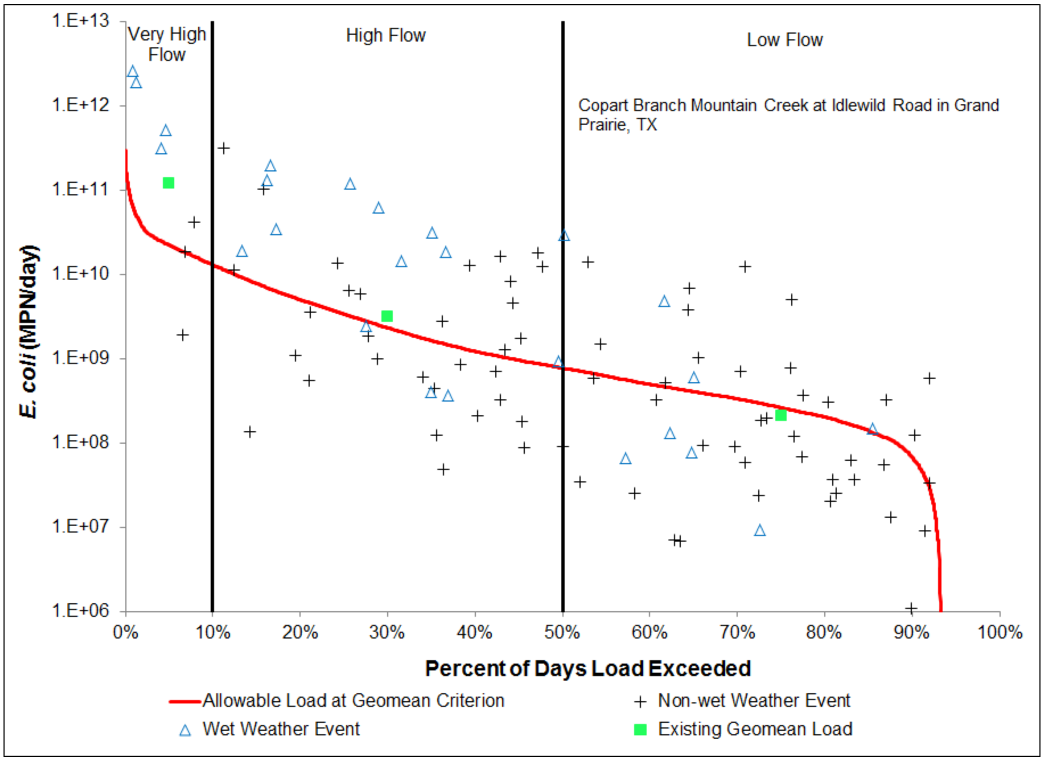

Figure 3-37. Load duration curve for station 17672, Copart Branch Mountain Creek (0841E).

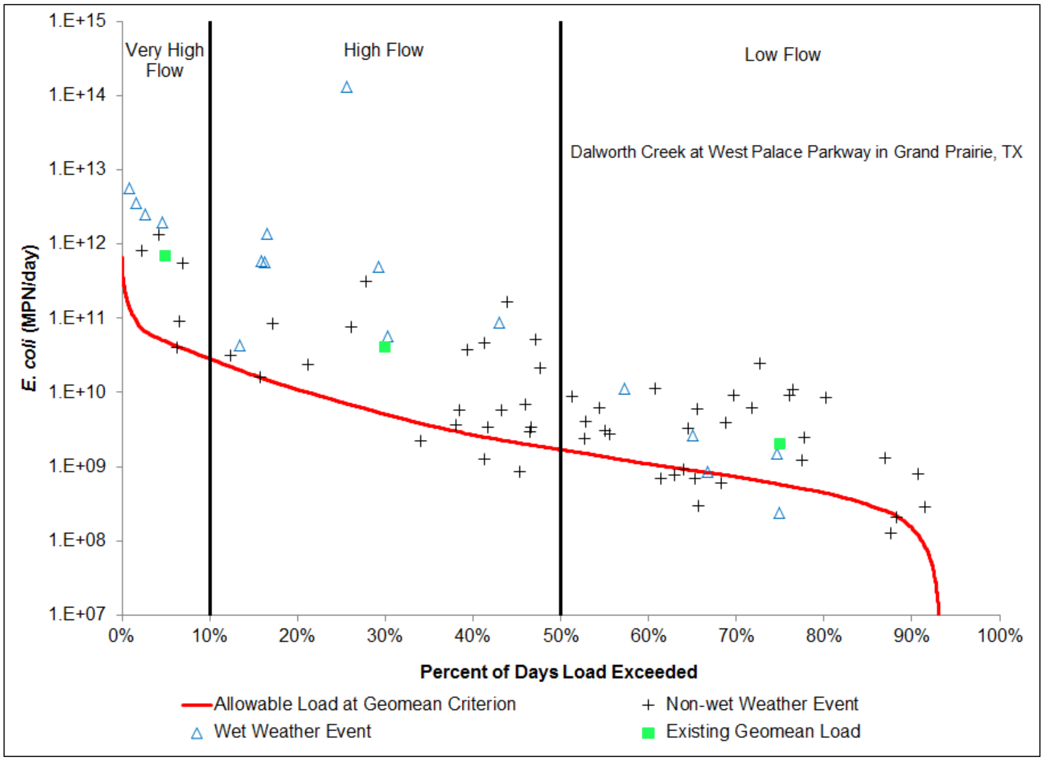

Figure 3-38. Load duration curve for station 17671, Dalworth Creek (0841G).

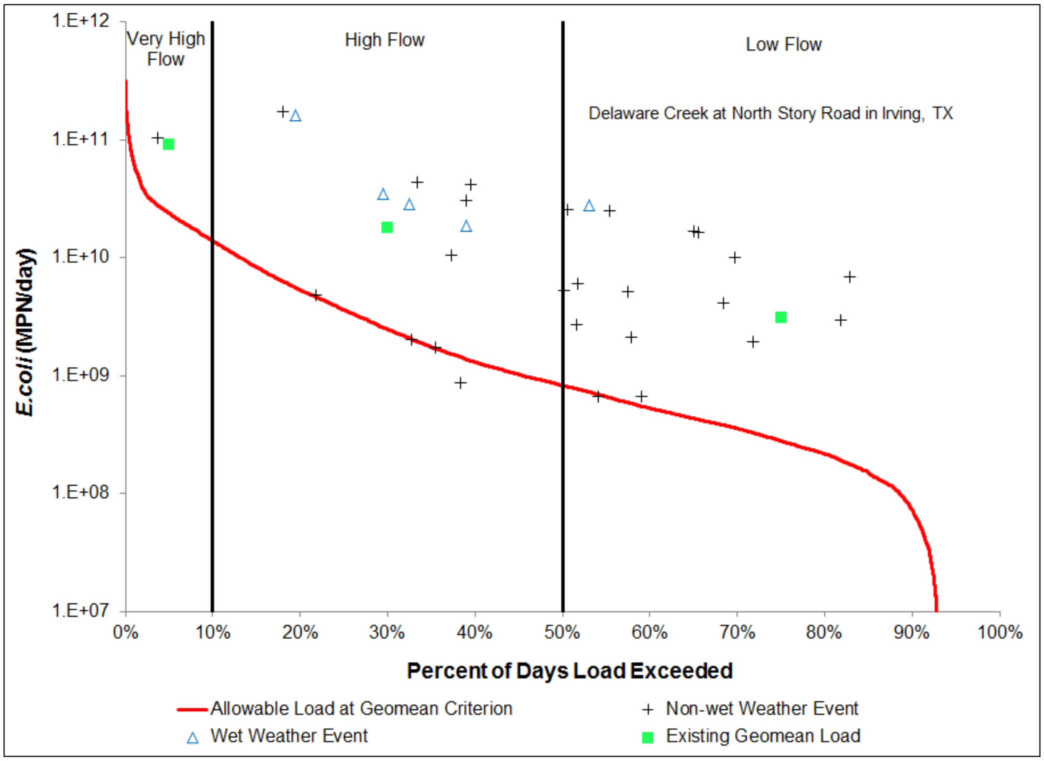

Figure 3-39. Load duration curve for station 17175, Delaware Creek (0841H).

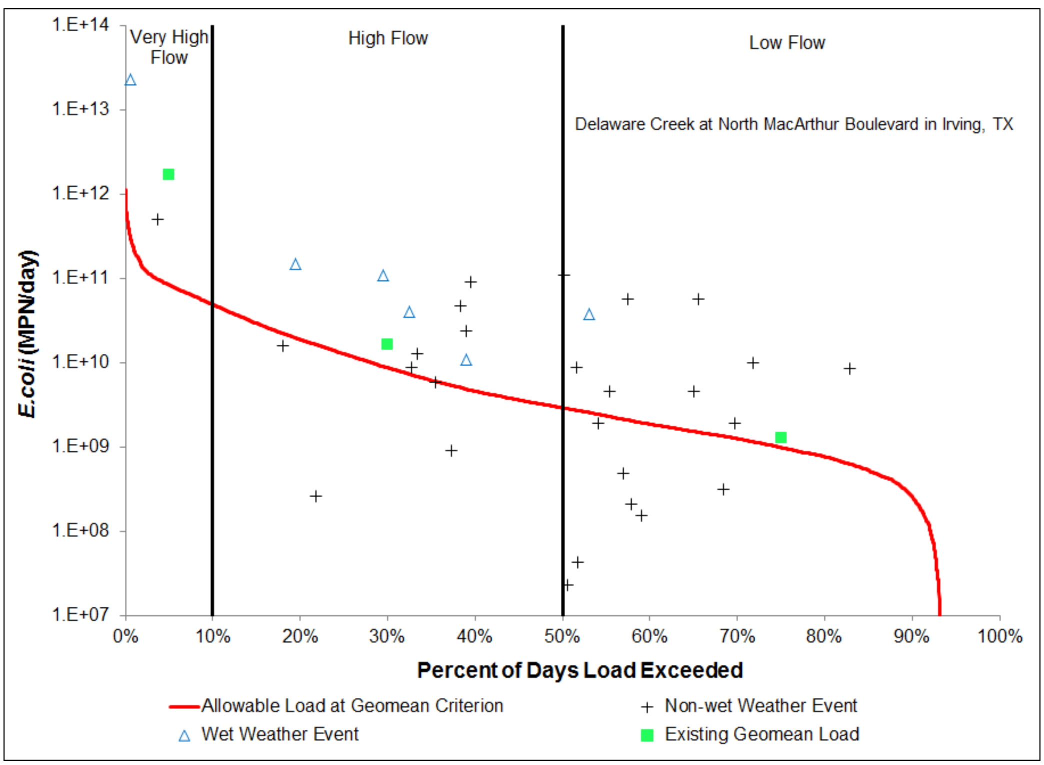

Figure 3-40. Load duration curve for station 17176, Delaware Creek (0841H).

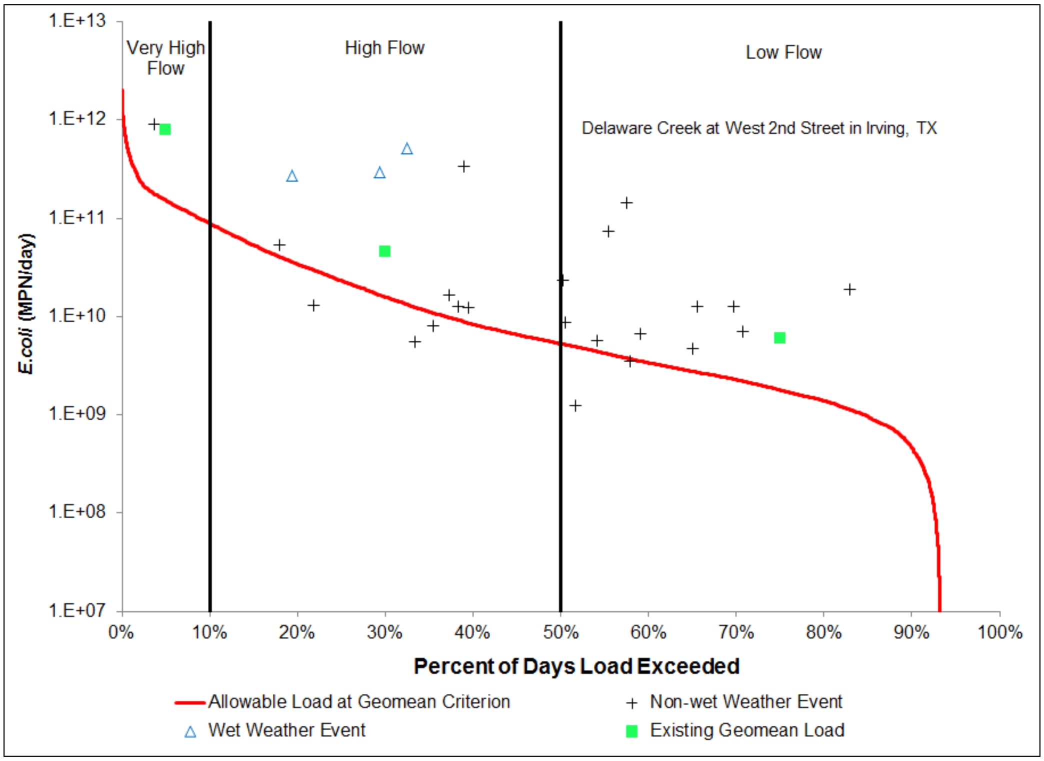

Figure 3-41. Load duration curve for station 18314, Delaware Creek (0841H).

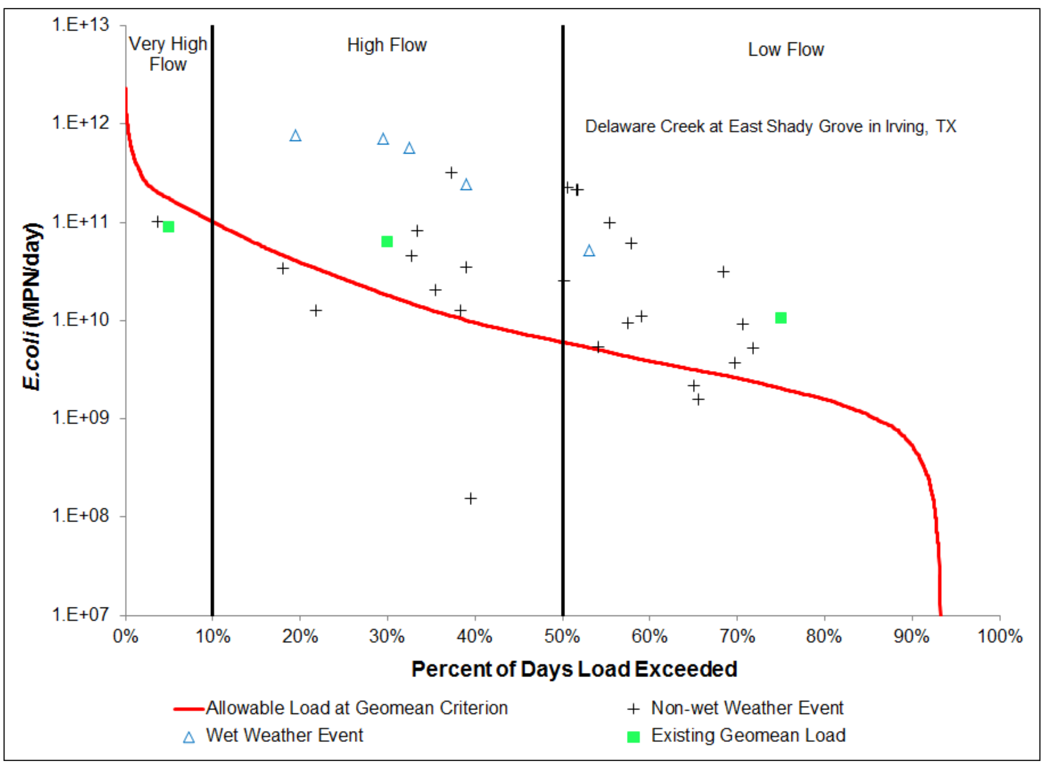

Figure 3-42. Load duration curve for station 17177, Delaware Creek (0841H).

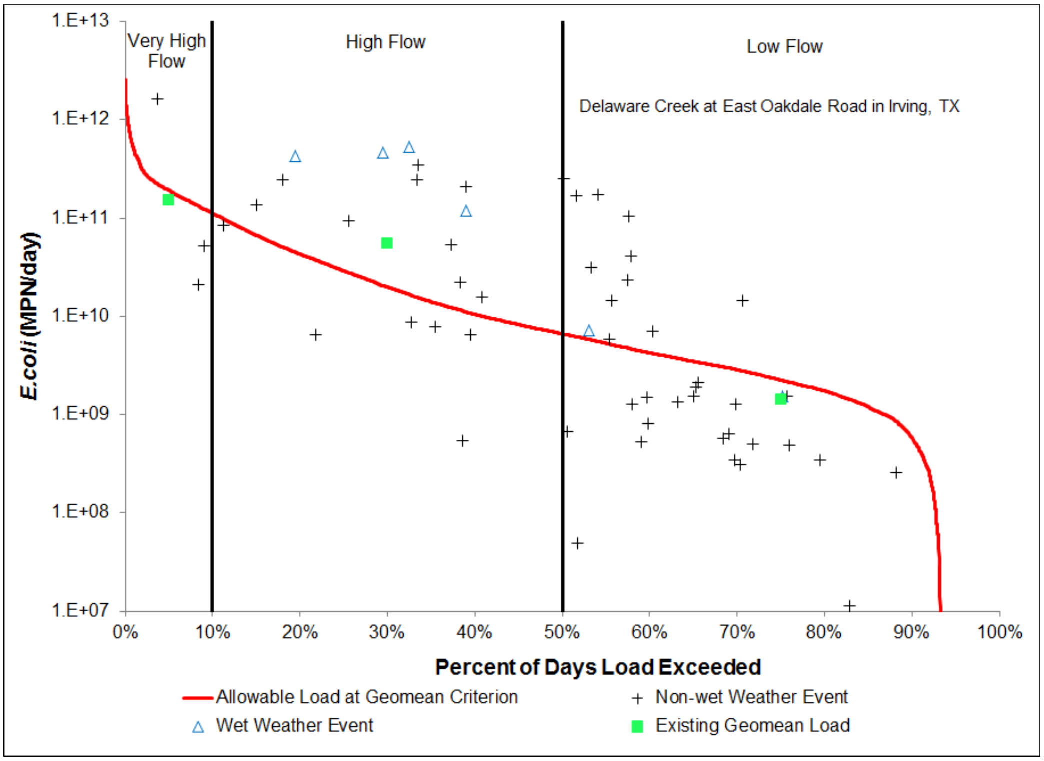

Figure 3-43. Load duration curve for station 17178, Delaware Creek (0841H).

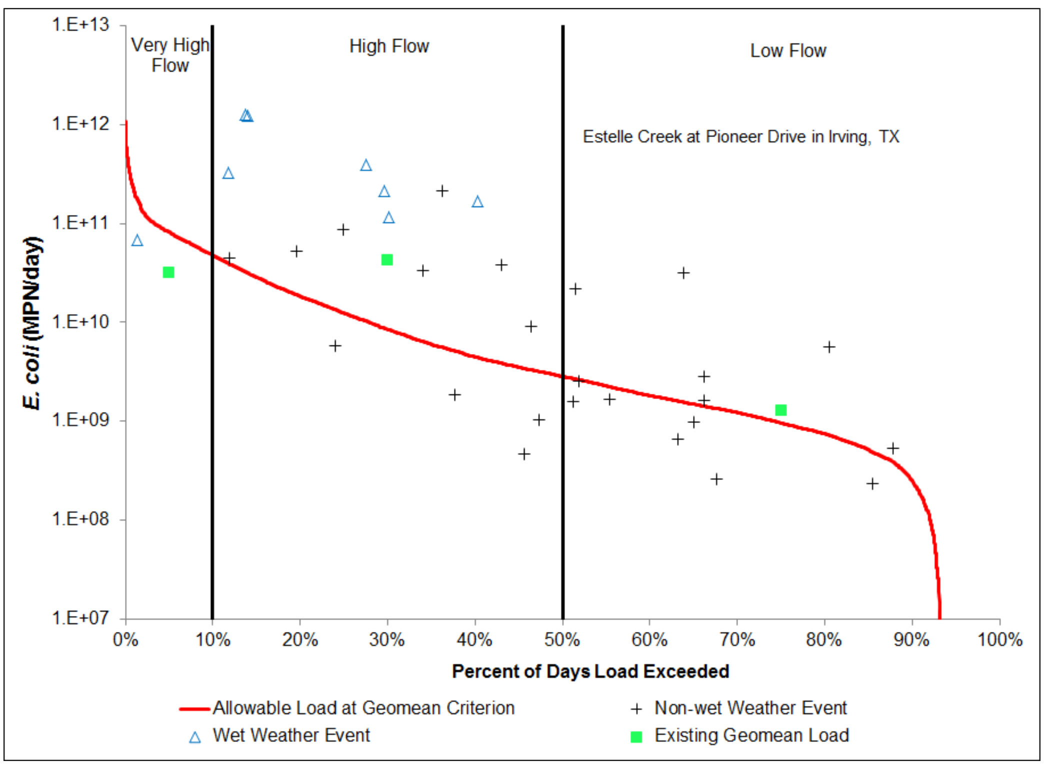

Figure 3-44. Load duration curve for station 17174, Estelle Creek (0841J).

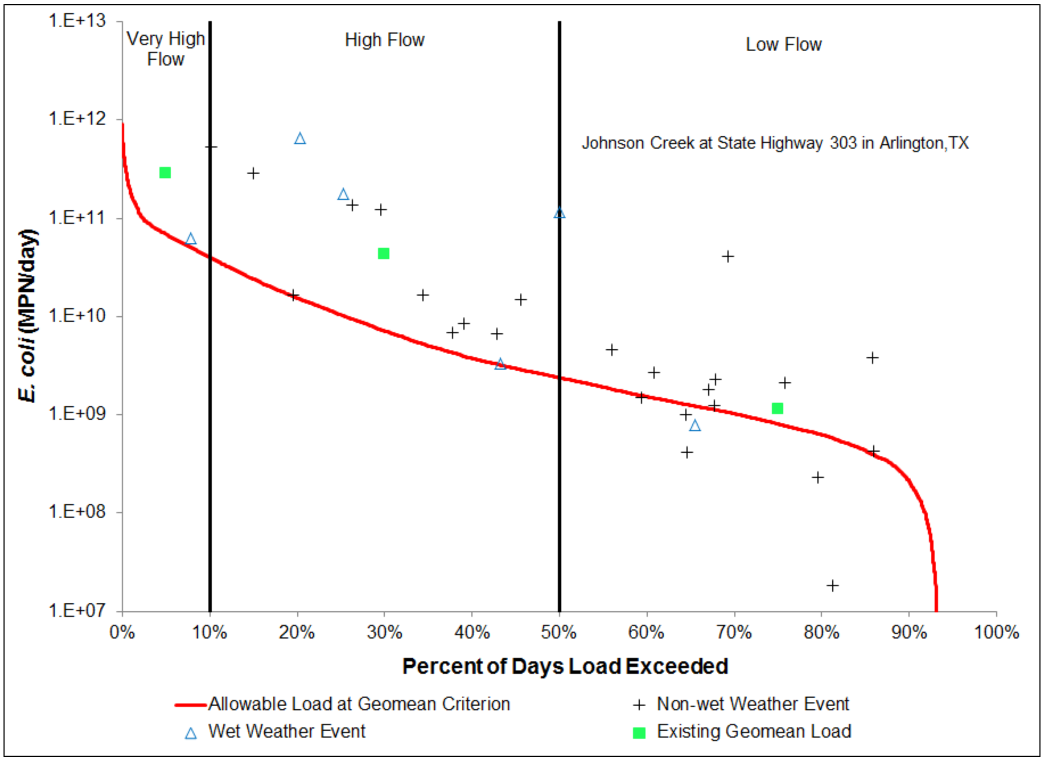

Figure 3-45. Load duration curve for station 10721, Johnson Creek (0841L).

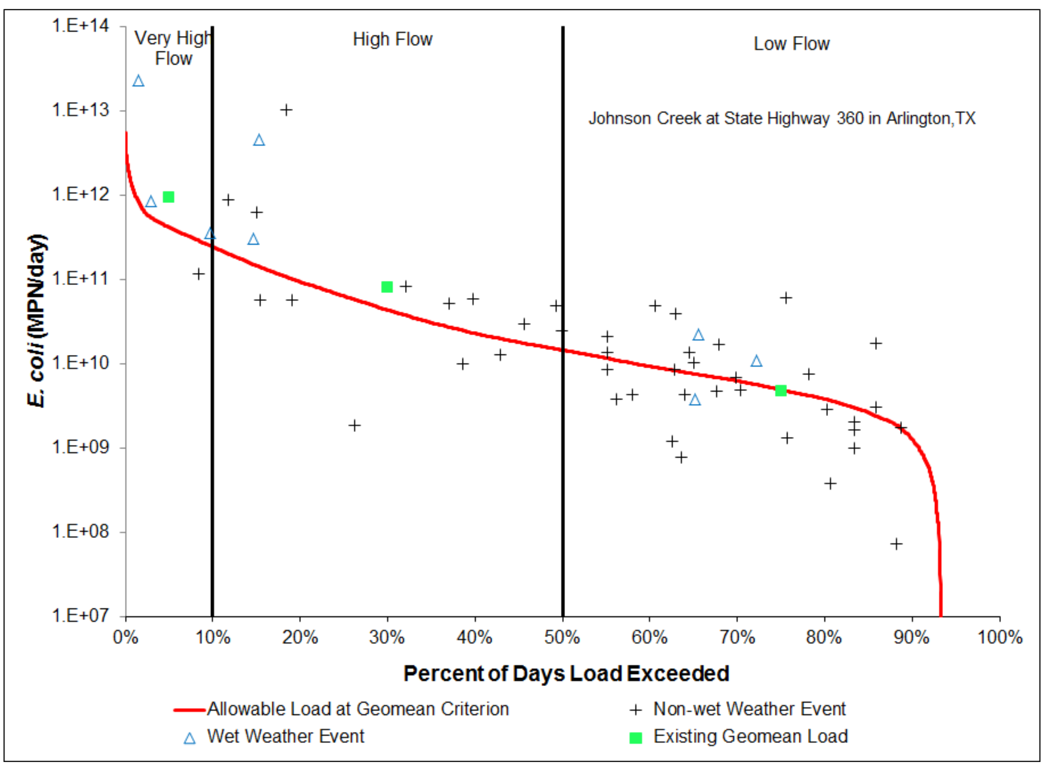

Figure 3-46. Load duration curve for station 10719, Johnson Creek (0841L).

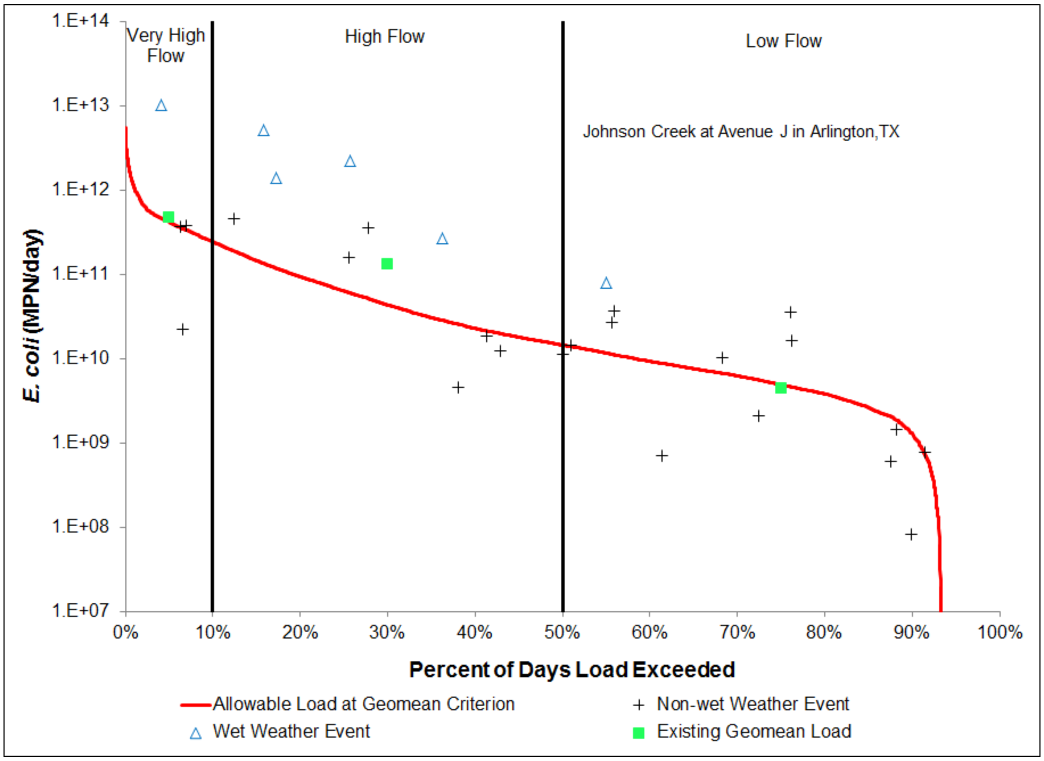

Figure 3-47. Load duration curve for station 10718, Johnson Creek (0841L).

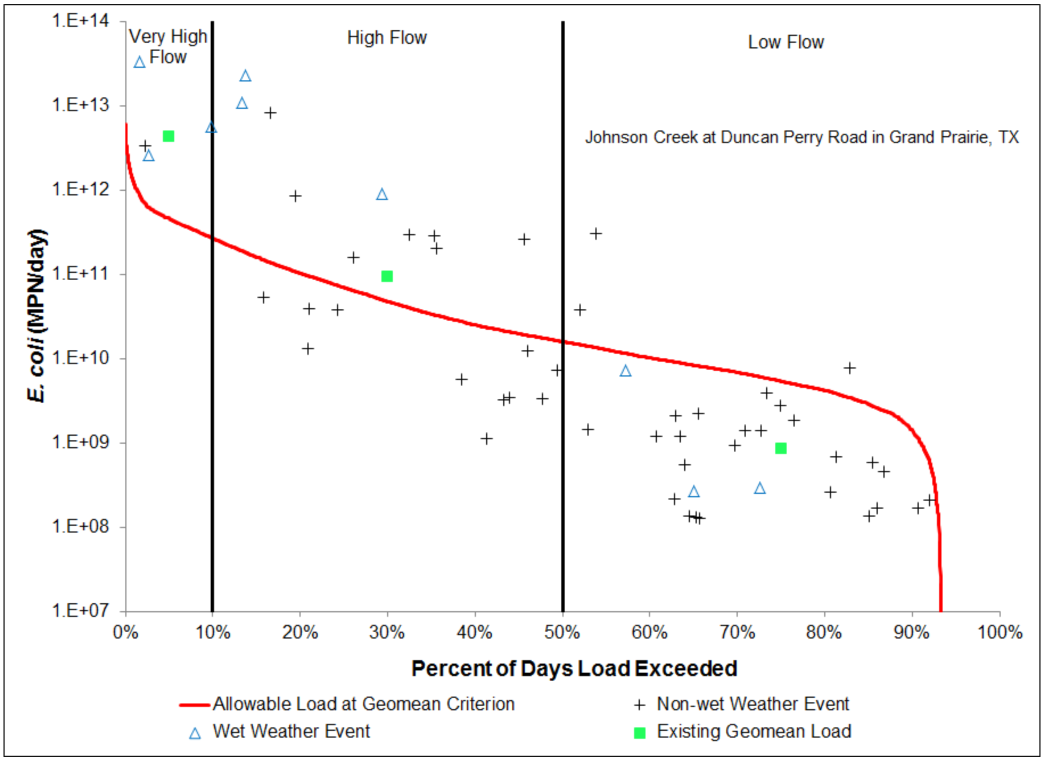

Figure 3-48. Load duration curve for station 18311, Johnson Creek (0841L).

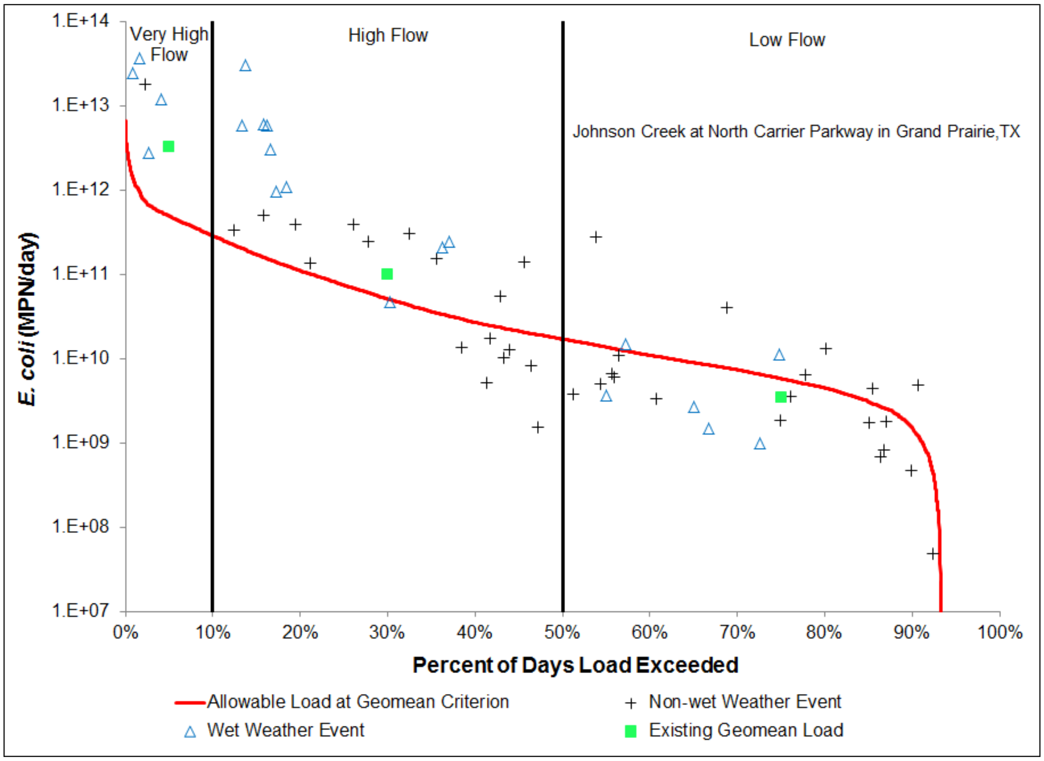

Figure 3-49. Load duration curve for station 17664, Johnson Creek (0841L).

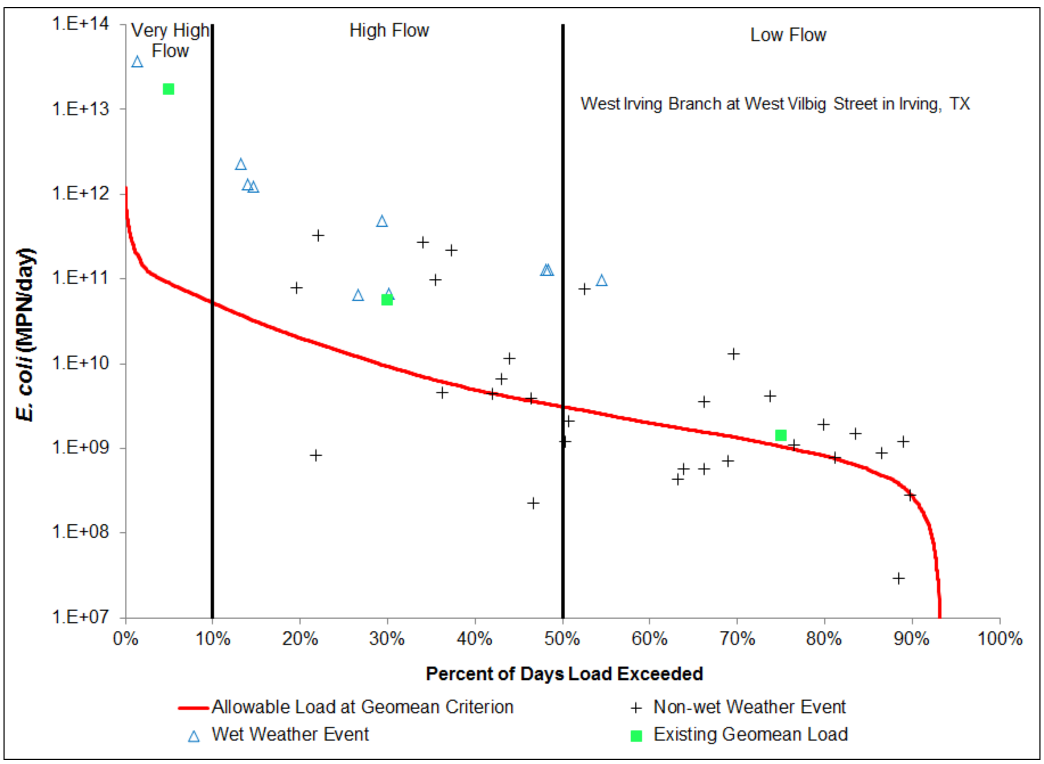

Figure 3-50. Load duration curve for station 17179, West Irving Branch (0841U).

3.4.1 Load Duration Curves for impaired AU inlets and outlets within the TMDL watersheds

Using Step 4 as explained in Section 3.2.4, the FDCs were converted into LDCs for each inlet and outlet to a TMDL watershed. These LDCs do not have associated historical *E. coli* data and were constructed for developing the TMDL allocation for each of the TMDL watersheds (Figures 3-51 through 3-56).

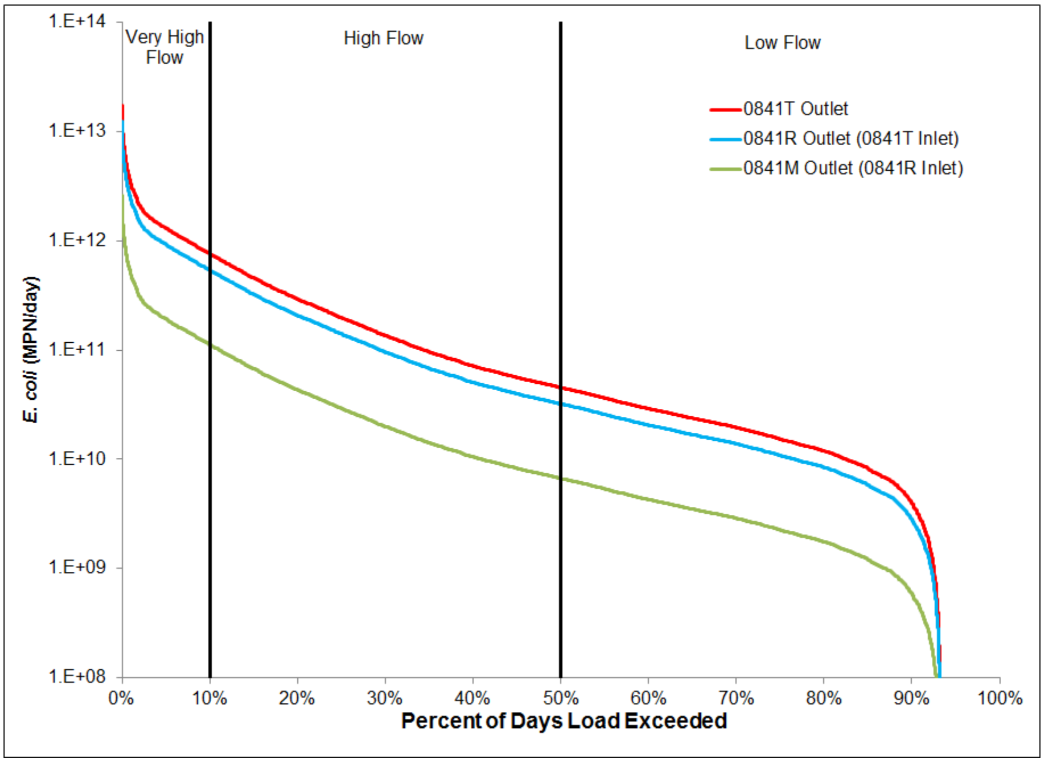

Figure 3-51. Load Duration Curves for the inlets and outlets of Village Creek (0841T), Rush Creek (0841R), and Kee Branch (0841M).

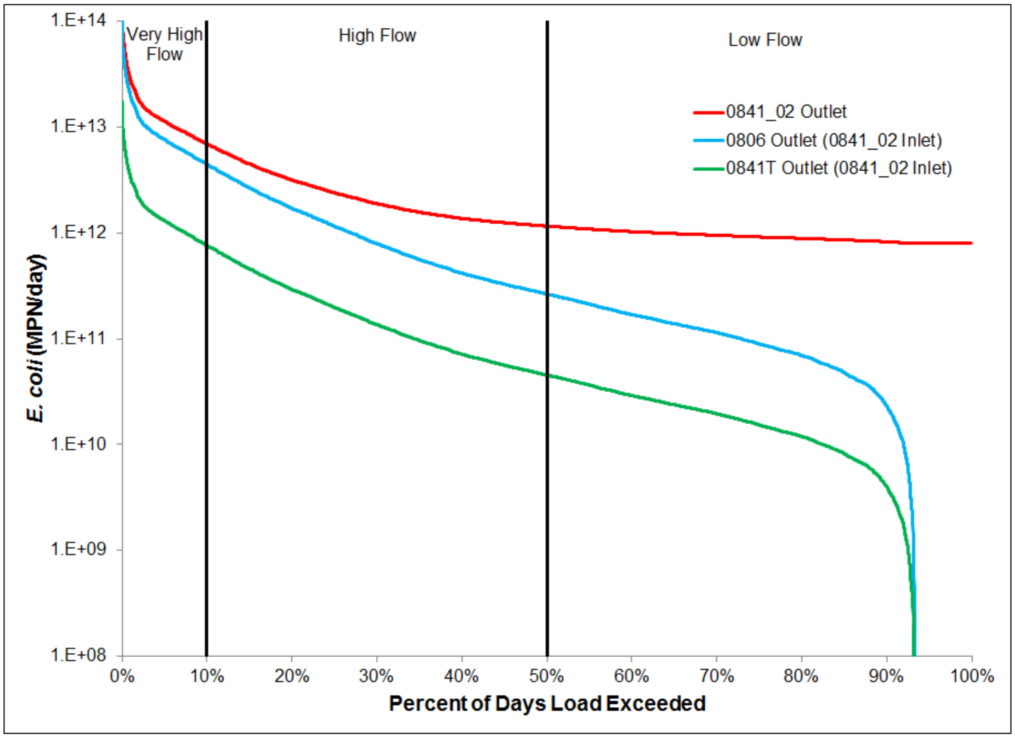

Figure 3-52. Load Duration Curves for the inlets and outlets of Lower West Fork Trinity River (0841_02), West Fork Trinity River (0806), and Village Creek (0841T).

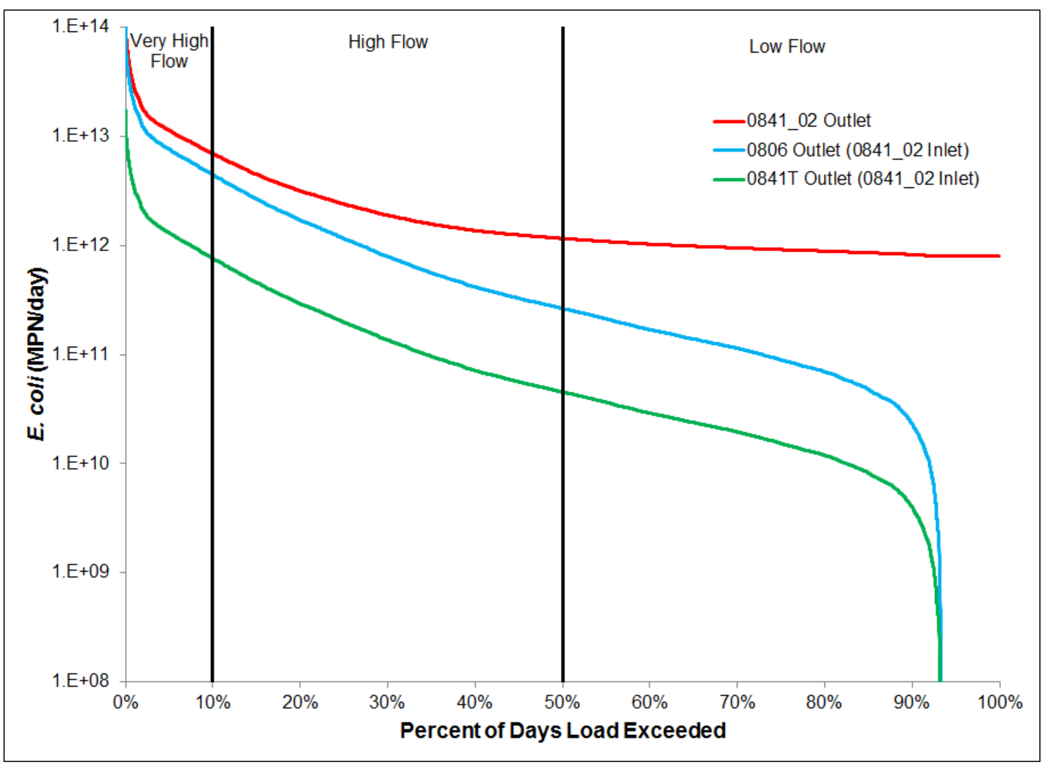

Figure 3-53. Load Duration Curves for the inlets and outlets of Bear Creek (0841B), Big Bear Creek (0841D), Estelle Creek (0841J), and Dry Branch (0841I).

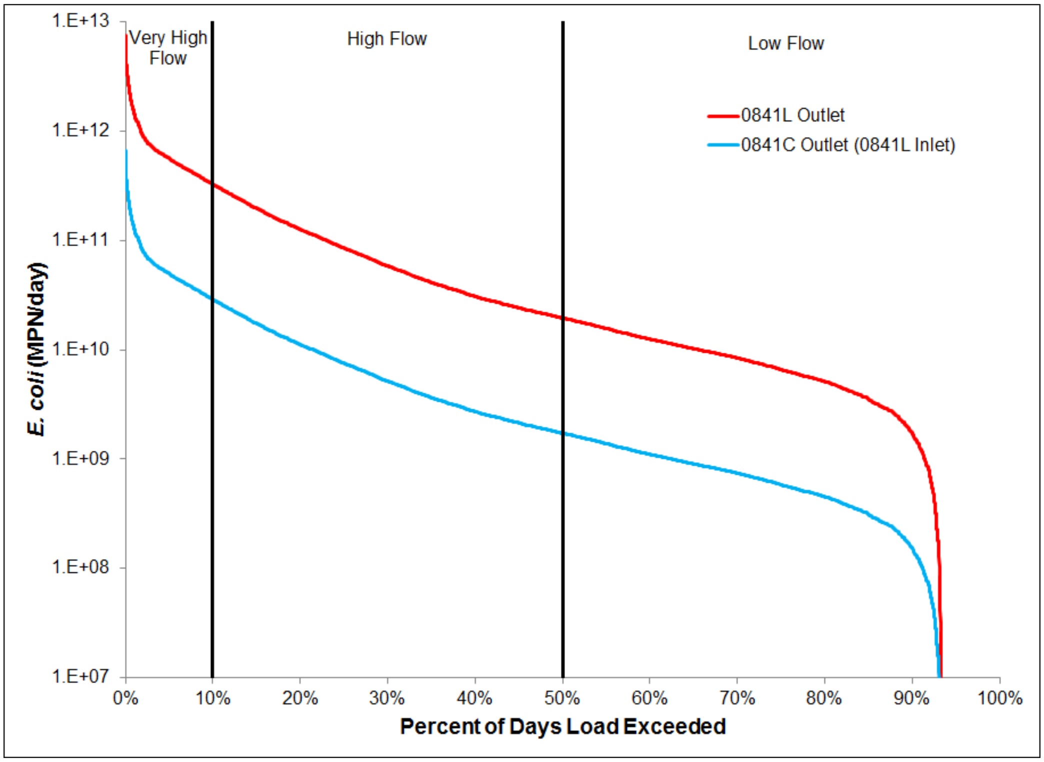

Figure 3-54. Load Duration Curves for the inlets and outlets of Johnson Creek (0841L) and Arbor Creek (0841C).

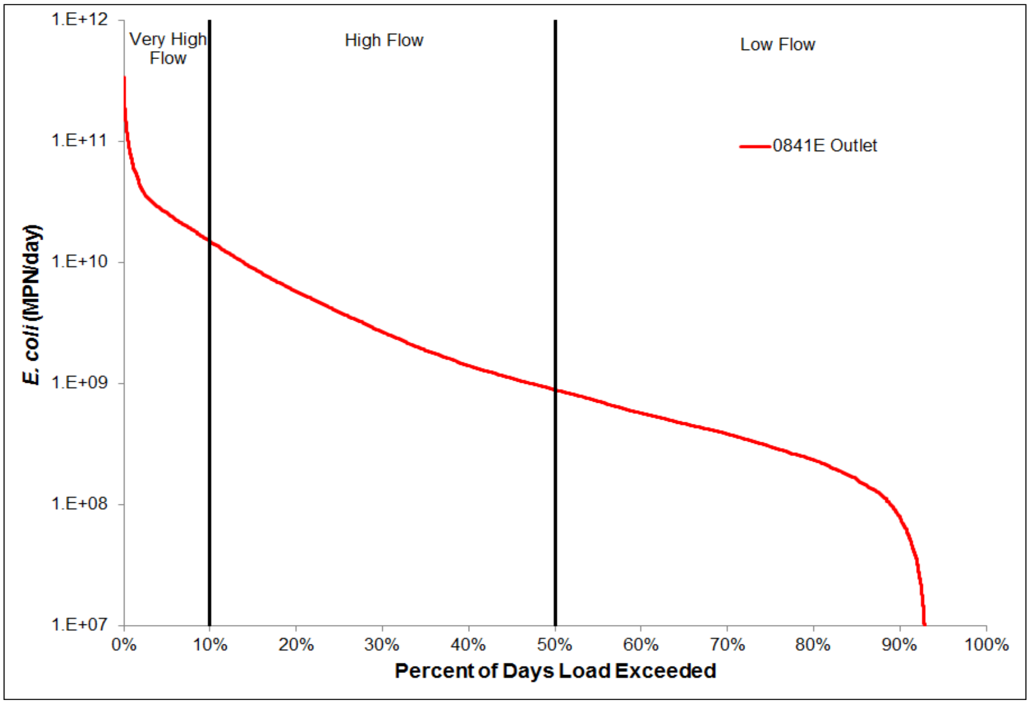

Figure 3-55. Load Duration Curves for the outlet of Copart Branch Mountain Creek (0841E).

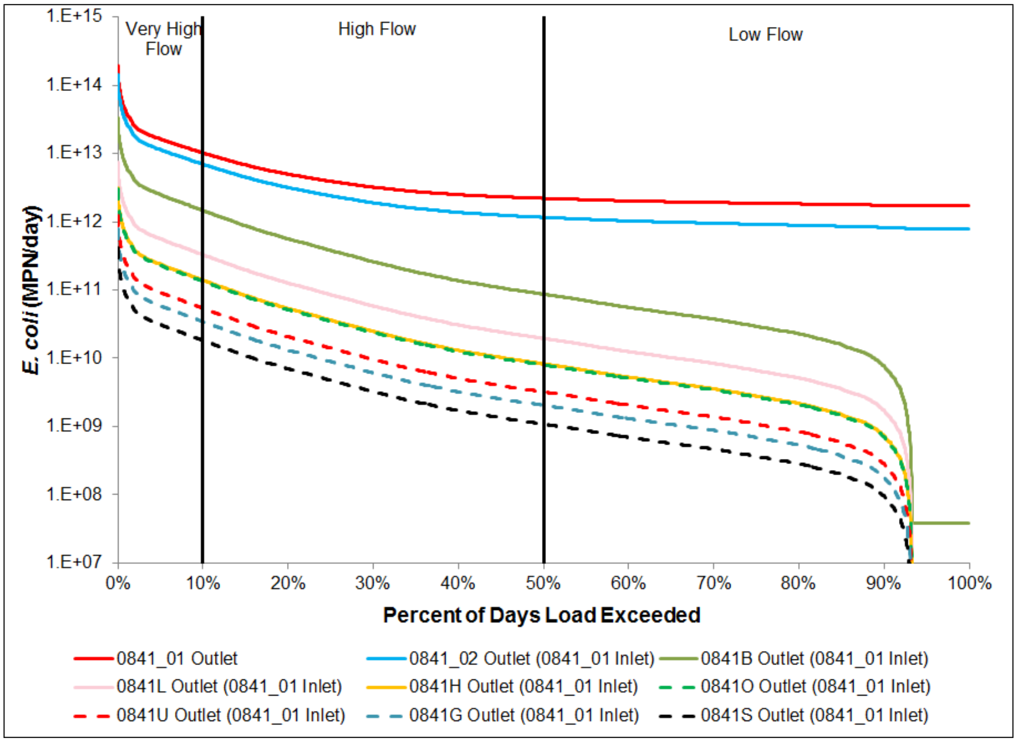

Figure 3-56. Load duration curves at the inlets and outlets of Lower West Fork Trinity River (0841_01 and 0841_02), Bear Creek (0841B), Johnson Creek (0841L), Dalworth Creek (0841G), West Irving Branch (0841U), Vilbig Lake (0841S), Delaware Creek (0841H), and Mountain Creek (0841O).

SECTION 4
TMDL ALLOCATION ANALYSIS

Within this report section is presented the development of the bacteria TMDL allocation for the 13 TMDL watersheds. The tool used for developing each TMDL allocation was the LDC method previously described in Section 3 — Bacteria Tool Development. Endpoint identification, margin of safety, load reduction analysis, TMDL allocations, and other TMDL components are described herein.

The LDC method provided a flow-based approach to determine necessary reductions in bacteria loadings and allowable loadings within the 13 TMDL watersheds. As developed previously in this report, the LDC method uses frequency distributions to assess a bacteria criterion over the historical range of flows, providing a means to determine maximum allowable loadings and the load reduction necessary to achieve support of the primary contact recreation use.

For the purpose of this study, a drainage area ratio approach using a historical streamflow gage for the reference flow record was employed to estimate the daily flow within the Lower West Fork Trinity River watershed. Within the subsequent Implementation Plan, an adaptive approach will be used to bring the necessary spatial focus to improving water quality and restoring the primary contact recreation use.

4.1 Endpoint Identification

The water bodies within the 13 TMDL watersheds have a use of primary contact recreation, which is protected by numeric criteria for the indicator bacteria *E. coli*. Indicator bacteria are not generally pathogenic and are indicative of potential viral, bacterial, and protozoan contamination originating from the feces of warm-blooded animals. *E. coli* criterion to protect freshwater contact recreation consists of a geometric mean concentration not to be exceeded of 126 MPN/100 mL (TCEQ, 2010b). All TMDLs must identify a quantifiable water quality target that indicates the desired water quality condition and provides a measurable goal for the TMDL. The TMDL endpoint also serves to focus the technical work to be accomplished and as a criterion against which to evaluate future conditions.

The endpoint for the TMDLs is to maintain concentrations of *E. coli* below the geometric mean criterion of 126 MPN/100 mL. This endpoint was applied to all 13 AUs addressed by this TMDL. This endpoint is identical to the geometric mean criterion for primary contact recreation in the 2010 Surface Water Quality Standard (TCEQ, 2010b).

4.2 Seasonality

Seasonal variations or seasonality occur when there is a cyclic pattern in streamflow and, more importantly, in water quality constituents. Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. Seasonal variation was accounted for in these TMDLs by using more than three years of water quality data and by using a 25-year period of daily streamflow data when developing flow exceedance percentiles.

Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing *E. coli* concentrations obtained from routine monitoring collected in the warmer months (May – September) against those collected during the cooler months (October – April). Data obtained from stations within the same AU were combined into one dataset for each AU. *E. coli* data were transformed using the natural log. Differences in *E. coli* concentrations obtained in warmer versus cooler months were then evaluated by performing a t-test on the natural log transformed dataset. Overall this analysis of *E. coli* data indicated that there was no significant difference (α=0.05) in indicator bacteria between cool and warm weather seasons for any of the 13 impaired AUs.

4.3 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 permitted and non-permitted storm water 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.

4.4 Load Duration Curve Analysis

Load duration curve (LDC) analyses were used to examine the relationship between instream water quality, the broad sources of indicator bacteria loads, and are the basis of the TMDL allocations. The strength of this TMDL is the use of the LDC method to determine the TMDL allocations. LDCs are a simple statistical method that provides a basic description of the water quality problem. This tool is easily developed and explained to stakeholders, and uses available water quality and flow data. The LDC method does not require any assumptions regarding loading rates, stream hydrology, land use conditions, and other conditions in the watershed. The EPA supports the use of this approach to characterize pollutant sources. In addition many other states are using this method to develop TMDLs.

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 storm water) and provides a means to allocate allowable loadings.

4.5 Margin of Safety

The margin of safety (MOS) is used to account for uncertainty in the analysis performed to develop the TMDL and thus provides a higher level of assurance that the goal of the TMDL will be met. According to EPA guidance (USEPA 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 margin of safety 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 a margin of safety.

The TMDLs covered by this report incorporate an explicit MOS by setting a target for indicator bacteria loads that is 5 percent lower than the geometric mean criterion. For primary contact recreation, this equates to a geometric mean target for *E. coli* of 120 MPN/100 mL. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced.

4.6 Load Reduction Analysis

While the TMDLs for the 13 TMDL watersheds will be developed using load allocations, additional insight may in certain situations be gained through a load reduction analysis. A single percent load reduction required to meet the allowable loading for each of the three flow regimes was determined using the historical *E. coli* data obtained from stations within the impaired reaches. For simplicity of computation and presentation, the load reduction calculations were based on concentrations rather than loadings (concentration multiplied by flow), since the flow would be identical in both the existing and allowable loadings computations and, thus, the flow would effectively cancel out of the calculations. For each station and flow regime, the percent reduction required to achieve the geometric mean criterion was determined by calculating the difference in the existing (or measured) geometric mean concentration and the 126 MPN/100 mL criterion and dividing that difference by the existing geometric mean concentration (Table 4-1).

The percent reduction for each monitoring station in a TMDL watershed with 24 or more *E. coli* data points was calculated (Table 4-1). Though not without exception, the general pattern observed in the percent reduction values is that they were highest for the very high flow regime, often at a value of 0 at the low flow regime, and in between in magnitude for the high flow regime. The most consistent exception to this general pattern was exhibited by the stations in Delaware Creek (0841H).

Table 4-1. Percent reduction calculations for stations within the water bodies of the TMDL watersheds.

Station	AU	Very High Flows (0-10%)		High Flows (10-50%)		Low Flows (50-100%)	
		Geometric Mean (MPN/100 mL)	Required Percent Reduction	Geometric Mean (MPN/100 mL)	Required Percent Reduction	Geometric Mean (MPN/100 mL)	Required Percent Reduction
17669	0841_02	903	86%	504	75%	99	0
11081	0841_01	6,186	98%	590	79%	108	0
11080	0841_01	2,090	94%	211	40%	102	0
11089	0841_01	939	87%	84	0	NA	NA
18315	0841B	626	80%	263	52%	37	0
10868	0841B	495	75%	304	59%	19	0
10867	0841B	553	77%	516	76%	81	0
17663	0841B	3,043	96%	416	70%	90	0
10866	0841B	3,110	96%	583	78%	63	0
10865/18313	0841B	92	0	249	49%	72	0
17666	0841C	1,553	92%	247	49%	73	0
17672	0841E	665	81%	171	27%	102	0
17671	0841G	1,737	93%	1,012	88%	435	71%
17175	0841H	476	74%	909	86%	1,381	91%
17176	0841H	2,513	95%	239	47%	164	23%
18314	0841H	656	81%	367	66%	424	70%
17177	0841H	64	0	438	71%	642	80%
17178	0841H	100	0	352	64%	80	0
17174	0841J	49	0	637	80%	168	25%
10721	0841L	518	76%	756	83%	179	29%
10719	0841L	280	55%	237	47%	121	0
10718	0841L	142	11%	379	67%	115	0

Station	AU	Very High Flows (0-10%)		High Flows (10-50%)		Low Flows (50-100%)	
18311	0841L	1,162	89%	249	49%	20	0
17664	0841L	826	85%	246	49%	74	0
10792	0841M	446	72%	498	75%	128	1%
10791	0841R	145	13%	322	61%	61	0
17190	0841R	179	29%	303	58%	117	0
17191	0841R	722	83%	435	71%	52	0
17189	0841T	138	9%	245	48%	70	0
17179	0841U	24,200	99%	765	84%	171	26%

4.7 Pollutant Load Allocations

The bacteria TMDL for each of the 13 TMDL watershed water bodies was developed as a pollutant load allocation based on information from the outlet and inlet LDCs at the very high flow regime. As discussed in more detail in Section 3, 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 (Eq. 1)

Where:

Criterion = 126 MPN/100 mL (*E. coli*)
Conversion factor (to MPN/day) = 864,000,000 100 mL/m3 * seconds/day

4.7.1 TMDL Definition

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 TMDL watersheds were calculated using the following equation:

$$TMDL = \Sigma WLA + \Sigma LA + \Sigma FG + MOS \quad \text{(Eq. 2)}$$

Where:

TMDL = total maximum daily load
WLA = waste load allocation, the amount of pollutant allowed by existing regulated or permitted dischargers
LA = load allocation, the amount of pollutant allowed by non-regulated or non-permitted sources
FG = loadings associated with future growth from potential permitted facilities
MOS = margin of safety

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 one-day load the stream can assimilate while still attaining the standards for surface water quality.

The bacteria TMDLs for the thirteen 303(d)-listed AUs as 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.

4.7.1.1 Waste Load Allocation

TPDES-permitted wastewater treatment facilities 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:

$$WLA_{WWTF} = Target * Flow\ (MGD) * conversion\ factor \qquad (Eq.\ 3)$$

Where:

Target = 63 MPN/100 mL
Flow (MGD) = full permitted flow
Conversion factor = 3.7854E+07 100 mL / MGD

Three facilities that treat domestic wastewater are located within the Lower West Fork Trinity River watershed. Along the mainstem of the Lower West Fork Trinity River is The City of Fort Worth Village Creek WWTF (WQ0010949-013) located within 0841_02, and the Trinity River Authority Central Regional WWTF (WQ0010303-001) located within 0841_01. 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 rather than allocated as a separate WLA_{WWTF} loading. Loadings arising from the two facilities located in 0841_01 and 0841_02 represent the WLA_{WWTF} allocation in the AU in which each facility is located .The remaining 10 non-impaired AUs have no facilities regulated for discharge to include in the WLA_{WWTF} term.

Storm water discharges from MS4, industrial, and construction areas are considered permitted or regulated point sources. Therefore, the WLA calculations must also include an allocation for permitted storm water 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 storm water loading. The percentage of each watershed that is under the jurisdiction of storm water permits is used to estimate the amount of the overall runoff load that should be allocated as the permitted storm water 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 storm water runoff and the portion allocated to WLA_{SW}.

Within the WLA_{SW} category is included Hansen Pressure Pipe (WQ003446-000) and Dallas/Fort Worth International Airport (WQ0001441-001,-014, -019, -023 & -025). 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 Laport are incorporated as tributary loadings from 0841O entering 0841_01 rather than as part of WLA_{SW}.

WLA_{SW} is the sum of loads from regulated (or permitted) stormwater sources and is calculated as follows:

$$\Sigma WLA_{SW} = (TMDL - \Sigma WLA_{WWTF} - LA_{USL} - \Sigma FG - MOS) * FDA_{SWP} \quad \text{(Eq. 4)}$$

Where:

ΣWLA_{SW} = sum of all permitted storm water loads

TMDL = total maximum daily load

ΣWLA_{WWTF} = sum of all WWTF loads

LA_{USL} = sum of loading from tributary and upstream AUs (defined immediately below)

ΣFG = sum of future growth loads from potential permitted facilities

MOS = margin of safety load

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

4.7.1.2 Load Allocation

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

$$LA = LA_{AU} + \Sigma LA_{USL} \quad \text{(Eq. 5)}$$

Where:

LA = allowable load from unregulated sources (predominately 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:

$$LA_{USL} = Criterion * Q_{Trib} \quad \text{(Eq 6)}$$

Where:

Criterion = 126 MPN/100 mL

Q_{Trib} = 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:

$$LA_{AU} = TMDL - \Sigma WLA_{WWTF} - \Sigma WLA_{SW} - \Sigma LA_{USL} - \Sigma FG - MOS \quad \text{(Eq 7)}$$

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 permitted stormwater loads

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

ΣFG = sum of future growth loads from potential permitted facilities

MOS = margin of safety load

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

$$TMDL = \Sigma WLA_{WWTF} + \Sigma WLA_{SW} + LA_{AU} + LA_{USL} + \Sigma FG + MOS \quad \text{(Eq 8)}$$

4.7.1.3 Computation of Margin of Safety

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:

$$MOS = 0.05 * (TMDL - \Sigma LA_{USL}) \quad \text{(Eq 9)}$$

Where:

MOS = margin of safety load

TMDL = total maximum allowable load

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

4.7.1.4 Future Growth

The Future Growth component of the TMDL equation addresses the requirement of TMDLs to account for future loadings that may occur as a result of population growth, changes in community infrastructure, and development. The assimilative capacity of streams increases as the amount of flow increases. Increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the contact recreation standard.

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.

The majority of the Lower West Fork Trinity River watershed is serviced by the TRA Central Regional WWTF (Figure 4-1). 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 (Equation 3).

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 Facility 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 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:

$$FG = Target * [POP_{2010\text{-}2040} * Use] * Conversion\ Factor \qquad \text{(Eq. 10)}$$

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

[Remainder of page intentionally left blank]

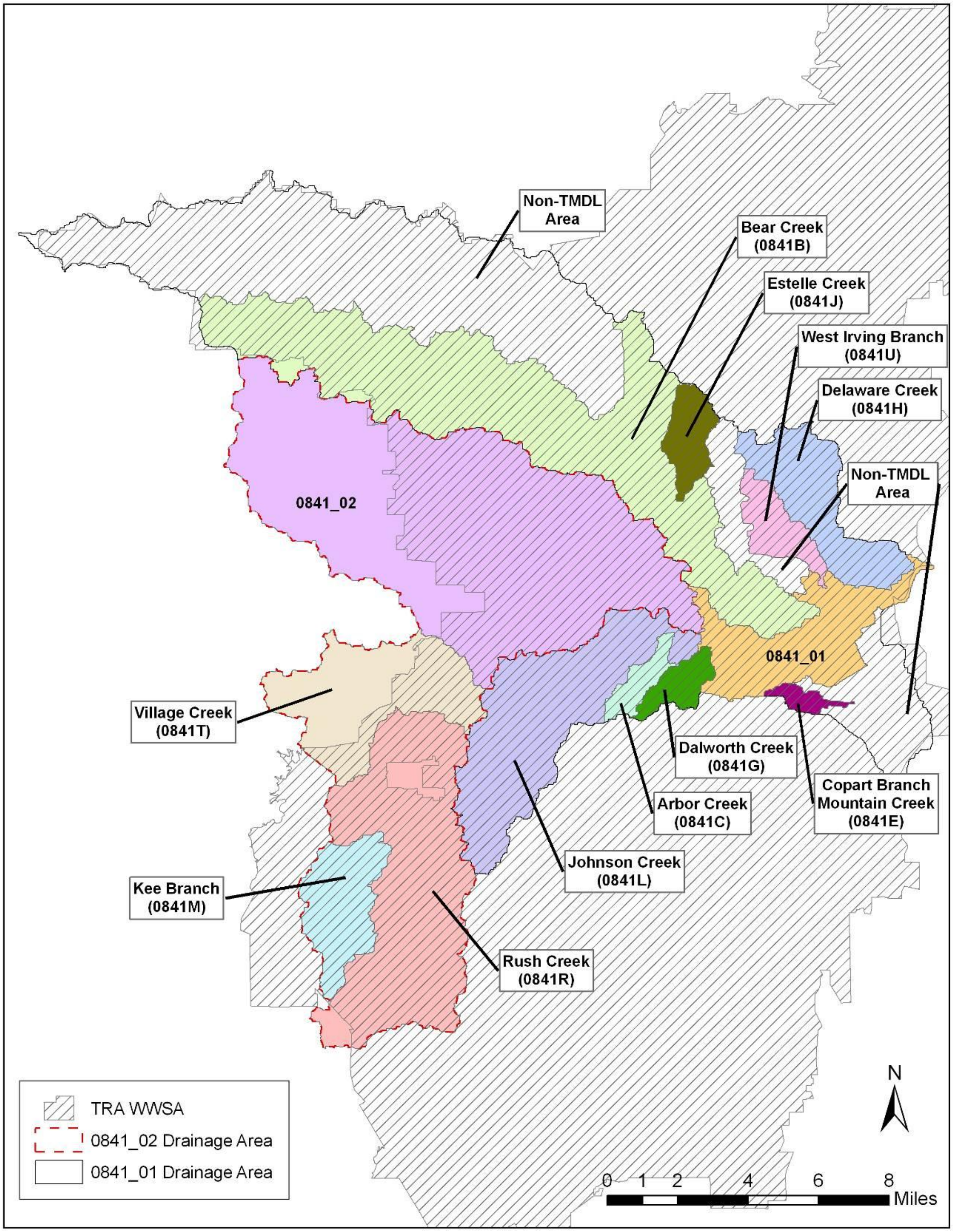

Figure 4-1. Wastewater service area of the TRA Central Regional WWTF within the Lower West Fork Trinity River watershed.

4.7.2 AU-Level TMDL Calculations

The allowable loading of *E. coli* that the 13 water bodies within the TMDL watersheds can receive on a daily basis was determined based on the median value within the very high flow regime of the FDC (or 5% flow exceedance value) for the outlet of each AU. In a similar fashion, all tributary and upstream load allocations (LA_{USL}) entering the AU can be computed using Equation 6 and the median value of the very high flow regime (Table 4-2). For each AU with tributary and upstream load allocations, the following approach was taken:

- 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).

Table 4-2. Summary of TMDL and LA_{USL} calculations for AUs within the Lower West Fork Trinity River watershed.

AU	Segment Name	Upstream Allowable Loading		Downstream Allowable Loading	
		Q_{inlet} [a] (cms)	LA_{USL} [b] (MPN/100 mL)	Outlet Flow [c] (cms)	TMDL [d] (MPN/100 mL)
Segment 0806	West Fork Trinity River below Lake Worth [e]	NA	NA	70.59	7.685E+12
0841_01	Lower West Fork Trinity River	139.54	1.519E+13	150.59	1.639E+13
0841_02	Lower West Fork Trinity River	82.70	9.003E+12	105.16	1.145E+13
0841B	Bear Creek	12.66	1.378E+12	23.15	2.520E+12
0841C	Arbor Creek	0	0	0.46	5.010E+10
0841D	Big Bear Creek [e]	NA	NA	11.03	1.201E+12
0841E	Copart Branch Mountain Creek	0	0	0.24	2.592E+10
0841G	Dalworth Creek	0	0	0.55	5.937E+10
0841H	Delaware Creek	0	0	2.21	2.404E+11
0841I	Dry Branch [e]	NA	NA	0.84	9.194E+10

AU	Segment Name	Upstream Allowable Loading		Downstream Allowable Loading	
0841J	Estelle Creek	0	0	0.79	8.546E+10
0841L	Johnson Creek	0.46	5.010E+10	5.21	5.670E+11
0841M	Kee Branch	0	0	1.78	1.941E+11
0841O	Mountain Creek[e]	0.24	2.592E+10	2.12	2.311E+11
0841R	Rush Creek	1.78	1.941E+11	8.57	9.332E+11
0841S	Vilbig Lakes[e]	NA	NA	0.29	3.151E+10
0841T	Village Creek	8.57	9.332E+11	12.10	1.317E+12
0841U	West Irving Branch	0	0	0.86	9.317E+10

[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.

4.7.2.1 Margin of Safety Computations

Using the values of LA_{USL} and TMDL for each AU provided in Table 4-2, the margin of safety may be readily computed by proper substitution into Equation 9 (Table 4-3).

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Table 4-3. Computed margin of safety for impaired AUs within the Lower West Fork Trinity River Watershed

AU	MOS (MPN/day)
0841_01	6.015E+10
0841_02	1.223E+11
0841B	5.709E+10

AU	MOS (MPN/day)
0841C	2.505E+09
0841E	1.296E+09
0841G	2.969E+09
0841H	1.202E+10
0841J	4.273E+09
0841L	2.584E+10
0841M	9.704E+09
0841R	3.695E+10
0841T	1.922E+10
0841U	4.658E+09

4.7.2.2 Future Growth Computations

As previously discussed in Section 4.7.1.4, the majority of the TMDL watersheds are serviced by the TRA Central Regional WWTF (Figure 4-1). 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). To calculate the future growth allocation for 0841_01, the 43MGD additional discharge was converted into a loading by using Equation 3. 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 4-4).

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 by applying Equation 10 (Table 4-4). The resulting future wastewater flow was then converted into a loading (see equation 2).

Table 4-4. Future Growth computations for the TMDL Watersheds

AU	2010 Population outside the TRA Central WWSA	2040 Population Projection outside the TRA Central WWSA	Population Increase 2010 to 2040 outside the TRA Central WWSA	Per Capita Wastewater Use outside the TRA Central WWSA (gpcd)	Additional Wastewater Production (MGD)	Future Growth (MPN/day)

AU	2010 Population outside the TRA Central WWSA	2040 Population Projection outside the TRA Central WWSA	Population Increase 2010 to 2040 outside the TRA Central WWSA	Per Capita Wastewater Use outside the TRA Central WWSA (gpcd)	Additional Wastewater Production (MGD)	Future Growth (MPN/day)
0841_01[a]	0	0	0	0	43	1.025E+11
0841_02	89,631	119,715	30,084	101.77	3.06	7.301E+09
0841B	3,003	3,761	758	101.77	0.077	1.840E+08
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	8.626E+08
0841T	23,599	53,443	29,844	101.77	3.04	7.243E+09
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.

4.7.2.3 Regulated Wastewater Treatment Facility Computations

The daily allowable loading of *E. coli* assigned to WLA_{WWTF} was determined based on the full permitted flow of the two WWTFs located in the TMDL watersheds using Equation 3. A WLA_{WWTF} was only applied to AUs that directly receive discharge from a WWTF. The WLA_{WWTF} calculated for the City of Forth Worth Village Creek WWTF was thus applied to the TMDL Lower West Fork Trinity River (0841_02), and the WLA_{WWTF} calculated for the TRA Central Regional WWTF was applied to the TMDL for Lower West Fork Trinity River (0841_01, Table 4-5).

Table 4-5. Waste load allocations for TPDES-permitted facilities

AU	TPDES Number	NPDES Number	Facility Name	Final Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (MPN/day)
0841_01	WQ0010303-001	TX0022802	TRA Central Regional WWTF	189	4.507E+11
0841_02	WQ0010494-013	TX0047295	City of Fort Worth Village Creek WWTF	166	3.959E+11

4.7.2.4 Regulated Storm Water Computation

Based on the MS4 permitted areas (Figure 2-18) most of the AUs within TMDL watersheds are completely within the jurisdiction regulated by storm water permits. The AUs that are not 100% within the urbanized area include Lower West Fork Trinity River (0841_01), Bear Creek (0841B), Copart Branch Mountain Creek (0841E), and Rush Creek (0841R). Table 4-6 summarizes the computation of term WLA_{SW} as calculated using Equation 4.

Table 4-6. Regulated storm water computation for TMDL watersheds

AU	TMDL (MPN/day)	WLA_{WWTF} (MPN/day)	Future Growth (MPN/day)	LA_{USL} (MPN/day)	MOS (MPN/day)	FDA_{SWP}	WLA_{SW} (MPN/day)
0841_01	1.639E+13	4.507E+11	1.025E+11	1.519E+13	6.015E+10	0.757	4.466E+11
0841_02	1.145E+13	3.959E+11	7.301E+09	9.003E+12	1.223E+11	1.000	1.920E+12
0841B	2.520E+12	0	1.840E+08	1.378E+12	5.709E+10	0.991	1.075E+12
0841C	5.010E+10	0	0	0	2.505E+09	1.000	4.759E+10
0841E	2.592E+10	0	0	0	1.296E+09	0.753	1.855E+10
0841G	5.937E+10	0	0	0	2.969E+09	1.000	5.641E+10
0841H	2.404E+11	0	0	0	1.202E+10	1.000	2.284E+11
0841J	8.546E+10	0	0	0	4.273E+09	1.000	8.119E+10
0841L	5.670E+11	0	0	5.010E+10	2.584E+10	1.000	4.910E+11
0841M	1.941E+11	0	0	0	9.704E+09	1.000	1.844E+11
0841R	9.332E+11	0	8.626E+08	1.941E+11	3.695E+10	0.972	6.814E+11
0841T	1.317E+12	0	7.243E+09	9.332E+11	1.922E+10	1.000	3.579E+11
0841U	9.317E+10	0	0	0	4.658E+09	1.000	8.851E+10

4.7.2.5 Unregulated Stormwater and Upstream Bacteria Load Computation

The LA_{AU} is the allowable bacteria loading assigned to unregulated sources within each TMDL watershed. For most of the AUs within the TMDL watersheds, their entire area is regulated by stormwater permits. Therefore, for most AUs the LA_{AU} term is 0. For Lower West Fork Trinity River (0841_01), 699 ha or 24.3% of its drainage area is not regulated by stormwater permits. For Bear Creek (0841B), 175 ha or 0.9% of its drainage area is not regulated by stormwater permits. For Copart Branch Mountain Creek (0841E), 61 ha or 24.7% of its drainage area is not regulated by stormwater permits. For Rush Creek (0841R), 200 ha or 2.8% of its drainage area is not regulated by stormwater permits. The LA_{AU} for the impaired AUs was computed using Equation 7 (Table 4-7).

Table 4-7. Computed unregulated stormwater term for AUs within the TMDL watersheds.

AU	LA_{AU} (MPN/day)
0841_01	1.430E+11
0841_02	0
0841B	9.519E+09
0841C	0
0841E	6.070E+09
0841G	0
0841H	0
0841J	0
0841L	0
0841M	0
0841R	1.988E+10
0841T	0
0841U	0

4.8 Summary of TMDL Calculations

Table 4-8 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.

The final TMDL allocations needed to comply with the requirements of 40 CFR 130.7 include the future growth component within the WLA_{WWTF} while allocations to permitted MS4 entities are designated as WLA_{sw} (Table 4-9). 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-permitted 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 4-8. Figures B-1 through B-13 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 Figures B-1 through B-13, allow calculation of new TMDLs and pollutant load allocations based on any potential new water quality criterion for *E. coli*.

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Table 4-8. TMDL allocation summary for impaired AUs within the Lower West Fork Trinity River Watershed. All loads expressed as billion MPN/day

AU	Stream Name	TMDL	MOS	WLA_{WWTF}	WLA_{SW}	LA_{AU}	LA_{USL}	LA Total	Future Growth
0841_01	Lower West Fork Trinity River	16,394	60.15	450.7	446.6	143.0	15,191	15,334	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	1,075	9.519	1,378	1,388	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	18.55	6.070	0	6.070	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
0841M	Kee Branch	194.1	9.704	0	184.4	0	0	0	0
0841R	Rush Creek	933.2	36.95	0	681.4	19.88	194.1	214.0	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

Table 4-9. 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}*	WLA_{SW}	LA	MOS
0841_01	16,394	553.3	446.6	15,334	60.15
0841_02	11,448	403.2	1,920	9,003	122.3
0841B	2,520	0.1840	1,075	1,388	57.09
0841C	50.10	0	47.59	0	2.505
0841E	25.92	0	18.55	6.070	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	681.4	214.0	36.95
0841T	1,317	7.243	357.9	933.2	19.22
0841U	93.17	0	88.51	0	4.658

*WLA_{WWTF} includes the future potential allocation to wastewater treatment facilities

Section 5
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APPENDIX A
BACTERIA DATA USED IN DEVELOPING LOAD DURATION CURVES

Table A-1 Measured *E. coli* concentration and estimated streamflow at station 10792, Kee Branch, Segment 0841M.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
16-Jan-02	34	0.024
10-Apr-02	345	1.125
10-Apr-02	345	1.125
24-Jul-02	397	0.022
15-Oct-02	137	0.009
21-Jan-04	267	0.071
21-Apr-04	428	0.026
21-Jul-04	176	0.029
20-Oct-04	109	0.023
19-Jan-05	154	0.064
4-May-05	4840	0.123
20-Jul-05	334	0.034
8-Nov-05	91	0.017
13-Feb-06	139	0.016
10-Apr-06	390	0.035
19-Jul-06	40	0.000
25-Jan-07	160	0.118
5-Jun-07	690	1.078
5-Jun-07	690	1.078
15-Aug-07	120	0.034
6-Nov-07	36	0.035
4-Mar-08	2200	0.522
24-Jun-08	98	0.002
12-Aug-08	470	0.000
12-May-09	5200	0.081
4-Nov-09	220	0.535
4-Nov-09	220	0.535
11-Mar-10	310	0.923
6-May-10	280	0.117
14-Sep-10	190	0.344
13-Dec-10	60	0.031
21-Mar-11	54	0.008

Table A-2 Measured *E. coli* concentration and estimated streamflow at station 10791, Rush Creek, Segment 0841R.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
16-Jan-02	17	0.036
11-Apr-02	67	1.402
24-Jul-02	293	0.033
16-Oct-02	398	0.009
14-Jan-03	275	0.132
16-Apr-03	60	0.097
30-Jul-03	2	0.019
22-Oct-03	76	0.042
21-Jan-04	334	0.106
22-Apr-04	65	0.038
21-Jul-04	139	0.043
20-Oct-04	72	0.035
19-Jan-05	150	0.096
4-May-05	4840	0.184
19-Jul-05	656	0.077
10-Nov-05	222	0.034
13-Feb-06	22	0.024
10-Apr-06	10	0.052
30-Jan-07	41	0.061
6-Jun-07	190	1.306
15-Aug-07	150	0.051
7-Nov-07	14	0.045
5-Mar-08	730	0.244
24-Jun-08	120	0.002
12-Aug-08	56	0.000
12-May-09	8700	0.121
5-Nov-09	43	0.769
11-Mar-10	240	1.382
6-May-10	90	0.175
14-Sep-10	120	0.515
13-Dec-10	27	0.047
21-Mar-11	91	0.013

Table A-3 Measured *E. coli* concentration and estimated streamflow at station 17190, Rush Creek, Segment 0841R.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
16-Jan-02	61	0.053
10-Apr-02	158	2.489
25-Jul-02	255	0.038
16-Oct-02	263	0.013
15-Jan-03	816	0.131
16-Apr-03	83	0.143
30-Jul-03	731	0.028
22-Oct-03	45	0.063
21-Jan-04	157	0.156
21-Apr-04	46	0.058
21-Jul-04	176	0.064
20-Oct-04	51	0.051
19-Jan-05	61	0.143
4-May-05	4840	0.271
20-Jul-05	2090	0.075
8-Nov-05	72	0.038
13-Feb-06	49	0.036
10-Apr-06	97	0.077
25-Jan-07	650	0.260
6-Jun-07	200	1.930
15-Aug-07	64	0.076
7-Nov-07	92	0.066
4-Mar-08	3500	1.155
24-Jun-08	180	0.004
12-Aug-08	870	0.000
12-May-09	230	0.179
5-Nov-09	79	1.137
11-Mar-10	180	2.042
6-May-10	100	0.258
16-Sep-10	150	0.304
13-Dec-10	19	0.069
21-Mar-11	25	0.018

Table A-4 Measured *E. coli* concentration and estimated streamflow at station 17191, Rush Creek, Segment 0841R.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
15-Jan-02	13	0.124
9-Apr-02	1740	15.258
24-Jul-02	38	0.110
16-Oct-02	151	0.029
15-Jan-03	690	0.292
15-Apr-03	131	0.314
22-Oct-03	6	0.139
22-Jan-04	96	0.350
21-Apr-04	166	0.128
20-Jul-04	129	0.138
21-Oct-04	104	0.110
20-Jan-05	64	0.286
4-May-05	4840	0.604
20-Jul-05	131	0.167
8-Nov-05	110	0.085
15-Feb-06	43	0.066
12-Apr-06	340	0.142
10-Oct-06	24000	1.640
25-Jan-07	39	0.579
5-Jun-07	800	5.306
21-Aug-07	26	0.158
6-Nov-07	17	0.171
3-Mar-08	4000	2.900
18-Jun-08	34	0.000
13-May-09	120	0.269
4-Nov-09	100	2.633
11-Mar-10	270	4.543
10-May-10	2100	0.415
14-Sep-10	180	1.695
13-Dec-10	10	0.154
21-Mar-11	80	0.041

Table A-5 Measured *E. coli* concentration and estimated streamflow at station 17189, Village Creek, Segment 0841T.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
15-Jan-02	26	0.163
9-Apr-02	551	20.101
25-Jul-02	197	0.112
17-Oct-02	4	0.051
15-Jan-03	20	0.385
16-Apr-03	690	0.420
30-Jul-03	15	0.083
22-Oct-03	99	0.184
21-Jan-04	162	0.458
21-Apr-04	128	0.169
22-Jul-04	62	0.214
20-Oct-04	85	0.151
19-Jan-05	22	0.418
5-May-05	1640	1.472
20-Jul-05	209	0.220
8-Nov-05	255	0.112
15-Feb-06	148	0.087
12-Apr-06	68	0.187
19-Jul-06	27	0.000
10-Oct-06	9200	2.161
25-Jan-07	86	0.763
6-Jun-07	62	5.658
20-Aug-07	82	0.262
7-Nov-07	22	0.193
4-Mar-08	4800	3.386
18-Jun-08	2100	0.000
13-Aug-08	370	0.000
12-May-09	120	0.525
4-Nov-09	80	3.469
11-Mar-10	77	5.986
6-May-10	120	0.756
16-Sep-10	130	0.890
13-Dec-10	6	0.202
21-Mar-11	51	0.054

Table A-6 Measured *E. coli* concentration and estimated streamflow at station 17669, Lower West Fork Trinity River, Segment 0841_02.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	64	8.597
22-Jan-02	22	8.918
18-Feb-02	651	10.457
21-Mar-02	4838	301.751
23-Apr-02	119	27.094
28-May-02	1540	11.886
19-Jun-02	123	9.781
22-Jul-02	155	8.794
28-Aug-02	870	8.418
25-Sep-02	47	8.256
17-Oct-02	85	7.773
4-Dec-02	2830	37.185
22-Jan-03	17	11.054
20-Feb-03	167	17.129
24-Mar-03	121	14.320
17-Apr-03	86	11.173
28-May-03	192	10.260
24-Jun-03	35	10.050
29-Jul-03	19	8.143
20-Aug-03	107	9.096
23-Sep-03	120	10.241
22-Oct-03	45	9.063
19-Nov-03	4610	15.713
16-Dec-03	145	11.229
22-Jan-04	122	11.767
25-Feb-04	3870	107.976
23-Mar-04	37	12.197
20-Apr-04	58	9.031
26-May-04	87	7.822
28-Jun-04	3970	138.333
14-Jul-04	22	10.977
18-Aug-04	35	8.979
30-Sep-04	73	9.011
20-Oct-04	73	8.741
18-Nov-04	4838	193.662

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Dec-04	113	14.857
19-Jan-05	32	11.351
15-Feb-05	89	13.070
16-Mar-05	27	9.705
23-Mar-05	82	10.214
23-Mar-05	90	10.214
23-Mar-05	96	10.214
23-Mar-05	98	10.214
23-Mar-05	110	10.214
5-Apr-05	42	12.071
5-Apr-05	52	12.071
5-Apr-05	64	12.071
5-Apr-05	510	12.071
5-Apr-05	2100	12.071
14-Apr-05	33	9.947
15-Apr-05	36	9.805
19-Apr-05	21	9.522
19-Apr-05	23	9.522
19-Apr-05	27	9.522
19-Apr-05	38	9.522
19-Apr-05	46	9.522
27-Apr-05	560	11.646
4-May-05	340	15.035
4-May-05	410	15.035
4-May-05	410	15.035
4-May-05	500	15.035
4-May-05	510	15.035
17-May-05	300	9.995
17-May-05	310	9.995
17-May-05	340	9.995
17-May-05	350	9.995
17-May-05	410	9.995
25-May-05	120	9.174
1-Jun-05	770	28.747
1-Jun-05	2000	28.747
1-Jun-05	2100	28.747
14-Jun-05	52	7.991

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Jun-05	62	7.991
14-Jun-05	64	7.991
14-Jun-05	74	7.991
14-Jun-05	82	7.991
20-Jun-05	70	7.538
21-Jun-05	210	7.509
21-Jun-05	100	7.509
28-Jun-05	46	7.651
28-Jun-05	46	7.651
28-Jun-05	50	7.651
28-Jun-05	68	7.651
28-Jun-05	70	7.651
12-Jul-05	250	8.885
12-Jul-05	350	8.885
12-Jul-05	490	8.885
12-Jul-05	520	8.885
12-Jul-05	620	8.885
21-Jul-05	80	8.998
27-Jul-05	2500	10.102
27-Jul-05	2800	10.102
10-Aug-05	280	9.947
10-Aug-05	400	9.947
16-Aug-05	3100	21.528
16-Aug-05	3500	21.528
16-Aug-05	3600	21.528
16-Aug-05	3800	21.528
16-Aug-05	5500	21.528
24-Aug-05	84	7.965
24-Aug-05	55	7.965
24-Aug-05	66	7.965
25-Aug-05	63	7.965
16-Sep-05	61000	12.644
17-Sep-05	4000	9.444
21-Sep-05	270	8.085
20-Oct-05	63	7.875
25-Oct-05	36	8.045
1-Nov-05	31000	24.191

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
2-Nov-05	29000	11.392
16-Nov-05	65	7.994
14-Dec-05	61	8.658
19-Jan-06	32	9.357
23-Jan-06	1900	30.113
24-Jan-06	960	13.095
15-Feb-06	65	8.123
16-Mar-06	37	7.777
20-Apr-06	5800	45.738
22-May-06	49	8.406
20-Jun-06	650	10.121
27-Jul-06	38	7.365
15-Aug-06	43	7.413
27-Sep-06	170	7.273
17-Oct-06	8700	47.300
16-Nov-06	80	8.547
20-Dec-06	1900	17.759
22-Jan-07	450	30.129
20-Feb-07	72	9.196
22-Mar-07	160	8.500
17-Apr-07	150	22.692
15-May-07	550	20.697
19-Jun-07	4800	151.623
25-Jul-07	3300	38.680
29-Aug-07	37	10.708
26-Sep-07	27	8.103
24-Oct-07	420	14.118
28-Nov-07	1100	11.306
19-Dec-07	83	10.359
22-Jan-08	85	8.555
25-Feb-08	50	9.148
26-Mar-08	81	27.603
23-Apr-08	84	27.240
21-May-08	70	14.209
18-Jun-08	55	7.272
23-Jul-08	980	7.272
20-Aug-08	20000	36.236

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
24-Sep-08	83	7.272
22-Oct-08	120	7.403
19-Nov-08	120	8.329
18-Dec-08	300	7.847
14-Jan-09	730	7.571
18-Feb-09	160	8.339
18-Mar-09	65	11.893
15-Apr-09	200	10.498
20-May-09	140	10.595
24-Jun-09	44	7.703
22-Jul-09	650	13.886
19-Aug-09	29	7.272
24-Sep-09	710	19.196
27-Oct-09	1100	113.987
18-Nov-09	280	21.224
22-Dec-09	24	13.240
27-Jan-10	35	9.312
17-Feb-10	91	87.998
24-Mar-10	100	51.356
28-Apr-10	42	90.511
25-May-10	55	85.242
22-Jun-10	31	7.272
20-Jul-10	550	8.346
26-Aug-10	1800	13.535
22-Sep-10	53	12.189
20-Oct-10	37	7.443
18-Nov-10	73	9.853
16-Dec-10	56	8.822
20-Jan-11	42	9.964
22-Feb-11	20	8.431
23-Mar-11	96	7.748
27-Apr-11	150	9.884
25-May-11	3500	34.778
21-Jun-11	7300	38.580

Table A-7 Measured *E. coli* concentration and estimated streamflow at station 18315, Bear Creek, Segment 0841B.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
1-Oct-02	6	0.005
6-Nov-02	1370	0.624
2-Dec-02	15	0.114
7-Jan-03	4840	0.744
3-Feb-03	13	0.802
5-Mar-03	15	3.507
7-Apr-03	4838	2.920
7-May-03	98	0.525
4-Jun-03	22	0.091
8-Jul-03	449	1.204
5-Aug-03	775	0.171
2-Sep-03	731	1.973
2-Oct-03	4	0.333
13-Nov-03	30	0.556
3-Dec-03	19	0.358
6-Jan-04	15	0.615
5-Feb-04	2090	4.537
1-Mar-04	1300	9.344
19-Apr-04	29	0.349
5-May-04	62	2.167
16-Jun-04	626	28.804
14-Jul-04	20	0.734
10-Aug-04	35	1.560
8-Sep-04	615	0.866
19-Oct-04	30	0.314

Table A-8 Measured *E. coli* concentration and estimated streamflow at station 10868, Bear Creek, Segment 0841B.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
23-Jan-01	166	1.303
5-Apr-01	53	6.891
23-Jul-01	25	0.125
18-Sep-01	1300	1.506
10-Dec-01	62	0.264

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
12-Dec-01	472	1.041
15-Jan-02	1	0.317
18-Feb-02	26	0.635
26-Mar-02	54	9.087
6-Jun-02	117	0.928
9-Jul-02	2090	0.821
12-Aug-02	163	1.507
10-Sep-02	731	1.110
11-Sep-02	148	0.334
12-Dec-02	291	1.371
24-Mar-03	1413	1.404
24-Jun-03	62	0.554
29-Oct-03	63	0.272
27-Jan-04	46	0.670
21-Jul-04	13	0.366
26-Oct-04	2400	5.198
19-Jan-05	13	0.812
19-Apr-05	20	0.448
20-Jul-05	18	0.429
27-Oct-05	16	0.154
19-Jan-06	5.2	0.416
27-Apr-06	36	0.296
25-Jul-06	1	0.024
22-Jan-07	520	4.551
25-Apr-07	4800	26.520
18-Jul-07	51	12.644

Table A-9 Measured *E. coli* concentration and estimated streamflow at station 10867, Bear Creek, Segment 0841B.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	86	0.283
22-Jan-02	13	0.352
18-Feb-02	22	0.680
23-Apr-02	163	4.231
28-May-02	2600	0.985
19-Jun-02	403	0.536

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
22-Jul-02	92	0.325
28-Aug-02	2240	0.245
25-Sep-02	43	0.210
17-Oct-02	176	0.107
12-Nov-02	90	0.446
4-Dec-02	4838	6.385
22-Jan-03	2090	0.808
20-Feb-03	3970	2.104
25-Mar-03	2240	1.035
17-Apr-03	4838	0.833
19-May-03	160	0.112
24-Jun-03	293	0.593
29-Jul-03	129	0.186
20-Aug-03	60	0.390
23-Sep-03	94	0.634
22-Oct-03	72	0.383
19-Nov-03	3450	1.802
16-Dec-03	520	0.845
22-Jan-04	89	0.960
26-Feb-04	1730	12.248
23-Mar-04	36	1.052
20-Apr-04	209	0.376
26-May-04	2410	0.118
28-Jun-04	1230	27.976
14-Jul-04	78	0.791
18-Aug-04	240	0.365
30-Sep-04	57	0.372
20-Oct-04	49	0.314
18-Nov-04	4838	39.787
14-Dec-04	70	1.619
19-Jan-05	40	0.871
15-Feb-05	109	1.238
16-Mar-05	17	0.520
27-Apr-05	560	0.934
25-May-05	150	0.406
21-Jun-05	130	0.051
21-Jul-05	230	0.369

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
25-Aug-05	40	0.148
21-Sep-05	300	0.174
20-Oct-05	170	0.129
16-Nov-05	170	0.155
14-Dec-05	88	0.296
19-Jan-06	6	0.445
15-Feb-06	15	0.182
16-Mar-06	30	0.108
20-Apr-06	24000	8.211
22-May-06	99	0.243
20-Jun-06	1200	0.609
15-Aug-06	400	0.030
27-Sep-06	420	0.001
17-Oct-06	3600	8.545
16-Nov-06	130	0.272
20-Dec-06	1700	2.239
22-Jan-07	1200	4.879
20-Feb-07	81	0.411
22-Mar-07	36	0.262
17-Apr-07	120	3.292
15-May-07	4800	2.866
25-Jul-07	110	6.705
29-Aug-07	40	0.734
26-Sep-07	17	0.178
24-Oct-07	2400	1.462
28-Nov-07	3100	0.862
19-Dec-07	35	0.659
22-Jan-08	10	0.274
25-Feb-08	19	0.401
26-Mar-08	60	4.340
23-Apr-08	94	4.263
21-May-08	140	1.481
18-Jun-08	270	0.000
23-Jul-08	61	0.000
20-Aug-08	3700	6.183
24-Sep-08	49	0.000
22-Oct-08	130	0.028

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
19-Nov-08	83	0.226
18-Dec-08	29	0.123
14-Jan-09	65	0.064
18-Feb-09	26	0.228
18-Mar-09	42	0.987
15-Apr-09	81	0.689
20-May-09	330	0.710
24-Jun-09	81	0.092
22-Jul-09	1000	1.412
19-Aug-09	15	0.000
24-Sep-09	960	2.546
27-Oct-09	4000	22.779
18-Nov-09	580	2.979
22-Dec-09	10	1.274
27-Jan-10	24	0.436
17-Feb-10	140	17.232
24-Mar-10	310	9.410
28-Apr-10	57	17.768
25-May-10	150	16.643
22-Jun-10	30	0.000
20-Jul-10	35	0.230
26-Aug-10	1000	1.337
22-Sep-10	120	1.050
20-Oct-10	220	0.037
18-Nov-10	72	0.551
16-Dec-10	73	0.331
20-Jan-11	24	0.575
22-Feb-11	13	0.248
23-Mar-11	60	0.102
27-Apr-11	310	0.558
25-May-11	4800	5.872
21-Jun-11	24000	6.683

Table A-10 Measured *E. coli* concentration and estimated streamflow at station 17663, Bear Creek, Segment 0841B.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	116	0.287
22-Jan-02	10	0.356
18-Feb-02	22	0.689
23-Apr-02	171	4.286
28-May-02	372	0.998
19-Jun-02	247	0.543
22-Jul-02	496	0.329
28-Aug-02	2600	0.248
25-Sep-02	29	0.213
17-Oct-02	119	0.109
12-Nov-02	41	0.452
4-Dec-02	4838	6.467
22-Jan-03	1300	0.818
20-Feb-03	3460	2.131
25-Mar-03	3110	1.048
17-Apr-03	2830	0.844
19-May-03	99	0.114
24-Jun-03	651	0.601
29-Jul-03	75	0.189
20-Aug-03	91	0.395
23-Sep-03	109	0.642
22-Oct-03	52	0.388
19-Nov-03	2910	1.825
16-Dec-03	345	0.856
22-Jan-04	91	0.972
25-Feb-04	3080	21.772
23-Mar-04	35	1.065
20-Apr-04	551	0.381
26-May-04	3110	0.119
28-Jun-04	1370	28.335
14-Jul-04	85	0.801
18-Aug-04	38	0.369
30-Sep-04	34	0.376
20-Oct-04	63	0.318
18-Nov-04	4838	40.298

Sample Date	***E. coli*** **(MPN/100 mL)**	**Estimated Daily Flow on Sampling Date (cms)**
14-Dec-04	32	1.640
19-Jan-05	30	0.882
15-Feb-05	73	1.254
16-Mar-05	8	0.526
27-Apr-05	470	0.946
25-May-05	44	0.411
21-Jun-05	880	0.052
21-Jul-05	130	0.374
24-Aug-05	66	0.150
21-Sep-05	72	0.176
20-Oct-05	24	0.131
16-Nov-05	40	0.156
14-Dec-05	170	0.300
19-Jan-06	18	0.451
15-Feb-06	55	0.184
16-Mar-06	20	0.110
20-Apr-06	24000	8.317
22-May-06	110	0.246
20-Jun-06	790	0.616
27-Jul-06	270	0.020
15-Aug-06	300	0.031
27-Sep-06	310	0.001
17-Oct-06	4400	8.654
16-Nov-06	170	0.276
20-Dec-06	1000	2.268
22-Jan-07	370	4.942
20-Feb-07	3	0.416
22-Mar-07	25	0.266
17-Apr-07	150	3.334
15-May-07	4000	2.903
19-Jun-07	4200	31.209
25-Jul-07	93	6.791
29-Aug-07	24	0.743
26-Sep-07	1300	0.180
24-Oct-07	1200	1.481
28-Nov-07	2600	0.873
19-Dec-07	94	0.668

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
22-Jan-08	2	0.278
25-Feb-08	2	0.406
26-Mar-08	86	4.396
23-Apr-08	87	4.317
21-May-08	220	1.500
18-Jun-08	230	0.000
23-Jul-08	52	0.000
20-Aug-08	570	6.262
24-Sep-08	150	0.000
22-Oct-08	250	0.029
19-Nov-08	1500	0.229
18-Dec-08	19	0.125

Table A-11 Measured *E. coli* concentration and estimated streamflow at station 10866, Bear Creek, Segment 0841B.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
12-Dec-01	651	1.146
15-Jan-02	10	0.350
18-Feb-02	29	0.699
9-Jul-02	300	0.904
12-Aug-02	237	1.659
10-Sep-02	344	1.222
1-Oct-02	26	0.005
6-Nov-02	870	0.691
2-Dec-02	99	0.126
7-Jan-03	4840	0.824
3-Feb-03	42	0.888
5-Mar-03	832	3.884
7-Apr-03	4838	3.233
7-May-03	117	0.581
4-Jun-03	127	0.100
8-Jul-03	1630	1.334
5-Aug-03	221	0.189
2-Sep-03	1230	2.185
2-Oct-03	76	0.368
13-Nov-03	72	0.616

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
3-Dec-03	24	0.396
6-Jan-04	15	0.682
5-Feb-04	3460	5.025
1-Mar-04	1450	10.349
19-Apr-04	84	0.386
5-May-04	94	2.399
16-Jun-04	3110	31.900
14-Jul-04	87	0.813
10-Aug-04	160	1.728
8-Sep-04	1034	0.959
19-Oct-04	45	0.347

Table A-12 Measured *E. coli* concentration and estimated streamflow at stations 10865 and 18313, Bear Creek, Segment 0841B.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
5-Feb-01	31	1.351
2-Apr-01	23	15.862
9-May-01	101	7.882
7-Jun-01	50	0.341
10-Jul-01	89	0.550
7-Aug-01	47	0.101
3-Oct-01	55	0.332
1-Oct-02	139	0.006
6-Nov-02	17	0.738
2-Dec-02	17	0.134
7-Jan-03	2	0.879
3-Feb-03	17	0.948
5-Mar-03	240	4.146
7-Apr-03	4838	3.452
7-May-03	236	0.620
4-Jun-03	81	0.107
8-Jul-03	247	1.424
5-Aug-03	651	0.202
2-Sep-03	1160	2.332
2-Oct-03	97	0.393
13-Nov-03	60	0.657

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
3-Dec-03	15	0.423
6-Jan-04	39	0.728
5-Feb-04	1960	5.365
1-Mar-04	1840	11.048
19-Apr-04	96	0.412
5-May-04	97	2.562
16-Jun-04	4840	34.056
14-Jul-04	39	0.868
10-Aug-04	55	1.845
8-Sep-04	690	1.024
19-Oct-04	51	0.371
16-Mar-05	4	0.570
14-Apr-05	180	0.626
14-Apr-05	34	0.626
15-Apr-05	62	0.593
16-Jun-05	9	0.142
20-Jun-05	50	0.063
21-Jun-05	40	0.056
21-Jul-05	40	0.404
10-Aug-05	180	0.626
10-Aug-05	200	0.626
24-Aug-05	130	0.163
24-Aug-05	210	0.163
25-Aug-05	210	0.163
1-Sep-05	54	0.118
9-Nov-05	52	0.256
12-Dec-05	61	0.504
4-Jan-06	46	0.184
8-Feb-06	57	0.272
9-Feb-06	49	0.253
22-Mar-06	120	11.081
10-May-06	200	1.181
9-Aug-06	650	0.000
14-Nov-06	120	0.560
15-Feb-07	13	0.612
17-May-07	250	1.832
15-Aug-07	160	0.507

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
7-Nov-07	26	0.442
28-Feb-08	61	0.353
5-Aug-08	110	0.000
20-Nov-08	1100	0.409
13-Jan-09	26	0.064
17-Feb-09	90	0.275
19-Feb-09	46	0.213
17-Mar-09	100	1.479
15-Apr-09	120	0.755
19-May-09	270	1.188
21-May-09	210	0.511
24-Jun-09	140	0.101
22-Jul-09	1000	1.548
10-Aug-09	180	0.000
18-Aug-09	40	0.018
23-Sep-09	1300	4.934
20-Oct-09	96	1.365
18-Nov-09	240	3.266
18-Nov-09	250	3.266
22-Dec-09	13	1.397
27-Jan-10	13	0.478
17-Feb-10	40	18.895
18-Feb-10	27	14.486
24-Mar-10	26	10.319
28-Apr-10	22	19.483
25-May-10	230	18.250
27-May-10	1200	11.482
22-Jun-10	46	0.000
21-Jul-10	78	0.078
18-Aug-10	310	0.000
25-Aug-10	4800	3.236
22-Sep-10	150	1.151
20-Oct-10	83	0.040
17-Nov-10	130	0.909
29-Nov-10	45	0.263
16-Dec-10	52	0.363
20-Jan-11	37	0.630

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
17-Feb-11	26	0.495
22-Feb-11	86	0.272
23-Mar-11	260	0.112
27-Apr-11	410	0.612
18-May-11	85	0.683
25-May-11	4800	6.438
21-Jun-11	24000	7.328

Table A-13 Measured *E. coli* concentration and estimated streamflow at station 17666, Arbor Creek, Segment 0841C.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	48	0.006
22-Jan-02	10	0.007
18-Feb-02	163	0.014
21-Mar-02	2600	1.250
23-Apr-02	141	0.084
28-May-02	3110	0.020
19-Jun-02	90	0.011
22-Jul-02	4838	0.006
28-Aug-02	1160	0.005
25-Sep-02	32	0.004
17-Oct-02	4838	0.002
12-Nov-02	109	0.009
4-Dec-02	4840	0.127
22-Jan-03	252	0.016
20-Feb-03	15	0.042
25-Mar-03	40	0.021
17-Apr-03	21	0.017
20-May-03	4840	0.014
24-Jun-03	68	0.012
29-Jul-03	1	0.004
20-Aug-03	731	0.008
23-Sep-03	22	0.013
22-Oct-03	356	0.008
18-Nov-03	17300	0.124
16-Dec-03	122	0.017

Sample Date	***E. coli*** **(MPN/100 mL)**	**Estimated Daily Flow on Sampling Date (cms)**
22-Jan-04	64	0.019
24-Feb-04	1230	0.105
23-Mar-04	6	0.021
20-Apr-04	10	0.007
27-May-04	409	0.023
28-Jun-04	1100	0.557
14-Jul-04	8	0.016
18-Aug-04	4	0.007
30-Sep-04	4840	0.007
20-Oct-04	8	0.006
18-Nov-04	4838	0.791
14-Dec-04	582	0.032
19-Jan-05	111	0.017
15-Feb-05	81	0.025
16-Mar-05	58	0.010
27-Apr-05	30	0.019
25-May-05	1840	0.008
21-Jun-05	2	0.001
21-Jul-05	660	0.007
24-Aug-05	52	0.003
21-Sep-05	91	0.003
20-Oct-05	2	0.003
16-Nov-05	4	0.003
14-Dec-05	310	0.006
19-Jan-06	17	0.009
15-Feb-06	32	0.004
16-Mar-06	8	0.002
20-Apr-06	3900	0.163
22-May-06	87	0.005
20-Jun-06	250	0.012
27-Jul-06	260	0.000
27-Sep-06	110	0.000
17-Oct-06	1600	0.170
16-Nov-06	13	0.005
20-Dec-06	12000	0.045
22-Jan-07	380	0.097
20-Feb-07	8	0.008

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
22-Mar-07	58	0.005
17-Apr-07	94	0.065
15-May-07	180	0.057
19-Jun-07	420	0.613
25-Jul-07	96	0.133
24-Oct-07	1000	0.029

Table A-14 Measured *E. coli* concentration and estimated streamflow at station 17672, Copart Branch Mountain Creek, Segment 0841E.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
11-Dec-01	24	0.004
23-Jan-02	37	0.004
19-Feb-02	4840	0.007
21-Mar-02	4838	0.624
23-Apr-02	99	0.042
30-May-02	1960	0.010
20-Jun-02	143	0.004
24-Jul-02	271	0.003
17-Oct-02	357	0.001
13-Nov-02	1160	0.004
4-Dec-02	2410	0.063
22-Jan-03	2600	0.008
19-Feb-03	82	0.010
24-Mar-03	2410	0.015
16-Apr-03	229	0.009
22-May-03	3110	0.023
24-Jun-03	297	0.006
23-Sep-03	2600	0.006
22-Oct-03	2090	0.004
20-Nov-03	1050	0.009
15-Dec-03	582	0.009
21-Jan-04	154	0.009
25-Feb-04	2830	0.213
20-Apr-04	187	0.004
27-May-04	1300	0.012
29-Jun-04	4840	0.459

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Jul-04	1840	0.008
16-Aug-04	231	0.014
29-Sep-04	30	0.004
20-Oct-04	34	0.003
16-Nov-04	32	0.013
14-Dec-04	43	0.016
19-Jan-05	24	0.009
16-Feb-05	22	0.011
16-Mar-05	15	0.005
26-Apr-05	110	0.026
26-May-05	1300	0.004
20-Jun-05	250	0.001
21-Jul-05	320	0.004
25-Aug-05	29	0.001
21-Sep-05	17	0.002
19-Oct-05	48	0.002
15-Nov-05	190	0.002
14-Dec-05	4840	0.003
19-Jan-06	84	0.004
15-Feb-06	13	0.002
16-Mar-06	59	0.001
24-Apr-06	110	0.006
23-May-06	200	0.002
19-Jun-06	250	0.027
26-Jul-06	150	0.000
16-Aug-06	250	0.000
27-Sep-06	130	0.000
17-Oct-06	260	0.085
16-Nov-06	79	0.003
19-Dec-06	23	0.003
22-Jan-07	26	0.048
20-Feb-07	2	0.004
22-Mar-07	87	0.003
17-Apr-07	480	0.033
16-May-07	50	0.023
20-Jun-07	320	0.150
25-Jul-07	1800	0.067

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
28-Aug-07	37	0.002
26-Sep-07	24	0.002
24-Oct-07	10	0.015
28-Nov-07	12	0.009
19-Dec-07	6	0.007
22-Jan-08	4	0.003
25-Feb-08	2	0.004
25-Mar-08	2	0.077
23-Apr-08	15	0.042
21-May-08	35	0.015
18-Jun-08	420	0.000
23-Jul-08	3500	0.000
20-Aug-08	3700	0.061
24-Sep-08	29	0.000
22-Oct-08	2400	0.000
19-Nov-08	62	0.002
18-Dec-08	140	0.001
14-Jan-09	2	0.001
18-Feb-09	2600	0.002
18-Mar-09	38	0.010
14-Apr-09	4	0.014
20-May-09	15	0.007
21-Jul-09	870	0.019
19-Aug-09	87	0.000
24-Sep-09	85	0.025
27-Oct-09	1600	0.226
18-Nov-09	250	0.030
21-Dec-09	80	0.012
26-Jan-10	6	0.005
17-Feb-10	13	0.171
24-Mar-10	140	0.093
27-Apr-10	130	0.167
27-May-10	3500	0.104
22-Jun-10	730	0.000
20-Jul-10	400	0.002
25-Aug-10	4800	0.029
21-Sep-10	150	0.007

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
20-Oct-10	29	0.000
16-Nov-10	1600	0.014
23-Feb-11	10	0.003
23-Mar-11	15	0.001
26-Apr-11	31	0.015
25-May-11	690	0.058

Table A-15 Measured *E. coli* concentration and estimated streamflow at station 17671, Dalworth Creek, Segment 0841G.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	1160	0.005
22-Jan-02	129	0.006
18-Feb-02	690	0.013
21-Mar-02	4838	1.362
23-Apr-02	300	0.090
28-May-02	4840	0.020
22-Jul-02	651	0.006
28-Aug-02	53	0.004
25-Sep-02	626	0.003
17-Oct-02	651	0.001
12-Nov-02	1370	0.008
4-Dec-02	4838	0.137
22-Jan-03	3460	0.016
20-Feb-03	1450	0.044
25-Mar-03	176	0.0208
17-Apr-03	192	0.017
28-May-03	198	0.012
24-Jun-03	551	0.012
29-Jul-03	2410	0.003
20-Aug-03	126	0.007
23-Sep-03	345	0.013
22-Oct-03	456	0.007
18-Nov-03	12000	0.134
16-Dec-03	437	0.017
22-Jan-04	321	0.020
25-Feb-04	4840	0.4648
23-Mar-04	63	0.0214
20-Apr-04	374	0.007
27-May-04	1730	0.024
28-Jun-04	4840	0.605
14-Jul-04	1450	0.016
18-Aug-04	43	0.006
30-Sep-04	101	0.007
20-Oct-04	1540	0.005
18-Nov-04	4838	0.861

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Dec-04	72	0.034
19-Jan-05	52	0.017
15-Feb-05	252	0.025
16-Mar-05	1160	0.010
27-Apr-05	9680	0.019
25-May-05	100	0.008
21-Jul-05	870	0.007
23-May-06	310	0.003
17-Oct-06	270	0.198
16-Nov-06	4800	0.006
20-Dec-06	12000	0.052
15-May-07	1400	0.066
19-Jun-07	1400	0.7133
25-Jul-07	130	0.155
19-Nov-08	2600	0.005
24-Jun-09	120	0.002
24-Sep-09	6500	0.059
27-Oct-09	3100	0.527
18-Nov-09	2400000	0.069
22-Dec-09	150	0.029
27-Jan-10	84	0.010
17-Feb-10	280	0.399
24-Mar-10	180	0.218
28-Apr-10	120	0.411
25-May-10	1800	0.385
20-Jul-10	2100	0.005
22-Sep-10	2400	0.024
20-Oct-10	420	0.001
17-Nov-10	220	0.0192
16-Dec-10	96	0.008
20-Jan-11	280	0.013
22-Feb-11	320	0.006
23-Mar-11	66	0.002
27-Apr-11	260	0.0129
25-May-11	780	0.136
21-Jun-11	4800	0.155

Table A-16 Measured *E. coli* concentration and estimated streamflow at station 17175, Delaware Creek, Segment 0841H.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	745	0.003
14-Jan-02	1370	0.003
11-Feb-02	124	0.019
10-Jul-02	4840	0.007
13-Aug-02	445	0.007
10-Sep-02	1730	0.013
7-Nov-02	456	0.005
16-Dec-02	977	0.007
9-Jan-03	3970	0.007
6-Feb-03	3650	0.052
6-Mar-03	131	0.043
9-Apr-03	870	0.014
7-May-03	4840	0.006
9-Jun-03	1730	0.024
9-Jul-03	2830	0.013
6-Aug-03	1960	0.002
7-Aug-03	4840	0.002
4-Sep-03	1100	0.005
7-Oct-03	1730	0.019
13-Nov-03	121	0.006
4-Dec-03	153	0.005
8-Jan-04	4840	0.004
3-Feb-04	130	0.016
4-Mar-04	3460	0.058
20-Apr-04	4840	0.004
6-May-04	3970	0.012
17-Jun-04	476	0.253
15-Jul-04	821	0.007
11-Aug-04	2830	0.018
9-Sep-04	76	0.013
20-Oct-04	3460	0.003

Table A-17 Measured *E. coli* concentration and estimated streamflow at station 17176, Delaware Creek, Segment 0841H.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	1100	0.011
14-Jan-02	30	0.012
11-Feb-02	152	0.066
20-Mar-02	9700	2.770
10-Jul-02	1840	0.024
13-Aug-02	403	0.025
10-Sep-02	284	0.044
7-Nov-02	13	0.019
16-Dec-02	2	0.025
9-Jan-03	1	0.026
6-Feb-03	959	0.182
6-Mar-03	2	0.150
9-Apr-03	21	0.049
7-May-03	247	0.021
9-Jun-03	1540	0.083
9-Jul-03	615	0.044
7-Aug-03	1730	0.006
4-Sep-03	3460	0.019
7-Oct-03	690	0.067
13-Nov-03	99	0.022
4-Dec-03	10	0.018
7-Jan-04	29	0.020
8-Jan-04	4800	0.014
3-Feb-04	125	0.055
4-Mar-04	91	0.205
20-Apr-04	378	0.014
6-May-04	2410	0.043
17-Jun-04	651	0.891
15-Jul-04	4840	0.026
11-Aug-04	236	0.063
9-Sep-04	1159	0.047
20-Oct-04	186	0.012

Table A-18 Measured *E. coli* concentration and estimated streamflow at station 18314, Delaware Creek, Segment 0841H.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Oct-02	398	0.020
7-Nov-02	120	0.034
16-Dec-02	32	0.045
9-Jan-03	214	0.047
6-Feb-03	959	0.331
6-Mar-03	55	0.273
9-Apr-03	213	0.089
7-May-03	2240	0.038
9-Jun-03	2240	0.151
9-Jul-03	4840	0.081
7-Aug-03	2090	0.010
4-Sep-03	4838	0.035
7-Oct-03	4840	0.122
13-Nov-03	163	0.041
4-Dec-03	242	0.032
8-Jan-04	582	0.025
3-Feb-04	94	0.099
4-Mar-04	167	0.372
20-Apr-04	217	0.025
6-May-04	181	0.079
17-Jun-04	656	1.619
15-Jul-04	570	0.048
11-Aug-04	56	0.114
9-Sep-04	171	0.085
20-Oct-04	690	0.021

Table A-19 Measured *E. coli* concentration and estimated streamflow at station 17177, Delaware Creek, Segment 0841H.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	279	0.022
14-Jan-02	1450	0.025
11-Feb-02	384	0.137
10-Jul-02	1230	0.049
13-Aug-02	4840	0.052

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Sep-02	3110	0.092
14-Oct-02	456	0.023
7-Nov-02	1840	0.039
16-Dec-02	4838	0.051
9-Jan-03	4840	0.054
6-Feb-03	2380	0.377
6-Mar-03	47	0.311
9-Apr-03	3650	0.102
7-May-03	2600	0.044
9-Jun-03	4840	0.172
9-Jul-03	437	0.092
4-Sep-03	279	0.040
7-Oct-03	4840	0.139
13-Nov-03	134	0.046
4-Dec-03	345	0.037
8-Jan-04	65	0.028
3-Feb-04	209	0.113
4-Mar-04	94	0.424
20-Apr-04	86	0.029
6-May-04	2	0.089
17-Jun-04	64	1.845
15-Jul-04	540	0.055
11-Aug-04	722	0.130
9-Sep-04	152	0.096
20-Oct-04	176	0.024

Table A-20 Measured *E. coli* concentration and estimated streamflow at station 17178, Delaware Creek, Segment 0841H.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
5-Feb-01	6	0.105
2-Apr-01	20	1.232
9-May-01	260	0.612
7-Jun-01	56	0.026
10-Jul-01	35	0.043
7-Aug-01	38	0.008
3-Oct-01	14	0.026

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	24	0.024
14-Jan-02	24	0.028
11-Feb-02	66	0.151
10-Jul-02	155	0.054
13-Aug-02	3470	0.057
10-Sep-02	1370	0.101
14-Oct-02	656	0.025
7-Nov-02	1100	0.043
16-Dec-02	1	0.057
9-Jan-03	13	0.060
6-Feb-03	1200	0.415
6-Mar-03	22	0.343
9-Apr-03	551	0.112
7-May-03	142	0.048
9-Jun-03	2830	0.189
9-Jul-03	2410	0.101
7-Aug-03	1	0.013
4-Sep-03	615	0.044
7-Oct-03	3970	0.154
13-Nov-03	3970	0.051
4-Dec-03	15	0.041
8-Jan-04	79	0.031
3-Feb-04	72	0.125
4-Mar-04	615	0.467
20-Apr-04	56	0.032
6-May-04	77	0.099
17-Jun-04	922	2.032
15-Jul-04	4840	0.060
11-Aug-04	1960	0.143
9-Sep-04	245	0.106
20-Oct-04	15	0.027
9-Nov-05	91	0.020
9-Feb-06	29	0.020
10-May-06	200	0.092
9-Aug-06	1800	0.000
14-Nov-06	2800	0.043
15-Feb-07	350	0.048

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
17-May-07	2800	0.142
15-Aug-07	24	0.039
7-Nov-07	46	0.034
28-Feb-08	27	0.027
5-Aug-08	4	0.000
20-Nov-08	69	0.032
19-Feb-09	24	0.016
21-May-09	44	0.040
10-Aug-09	10	0.000
18-Nov-09	430	0.254
18-Feb-10	54	1.125
27-May-10	110	0.892
18-Aug-10	72	0.000
29-Nov-10	87	0.020
17-Feb-11	210	0.038
18-May-11	690	0.053

Table A-21 Measured *E. coli* concentration and estimated streamflow at station 17174, Estelle Creek, Segment 0841J.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
12-Dec-01	4840	0.041
15-Jan-02	24	0.012
18-Feb-02	73	0.025
26-Mar-02	147	0.354
3-Jul-02	4840	0.300
12-Aug-02	651	0.059
11-Sep-02	255	0.013
9-Oct-02	4838	0.291
6-Nov-02	1030	0.024
2-Dec-02	60	0.004
7-Jan-03	41	0.029
3-Feb-03	17	0.031
3-Mar-03	54	0.123
7-Apr-03	870	0.114
7-May-03	94	0.021
4-Jun-03	172	0.004

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
8-Jul-03	45	0.047
5-Aug-03	977	0.007
2-Sep-03	1730	0.077
2-Oct-03	145	0.013
11-Nov-03	1230	0.036
1-Dec-03	52	0.015
6-Jan-04	122	0.024
2-Feb-04	3110	0.080
1-Mar-04	1030	0.366
19-Apr-04	82	0.014
3-May-04	344	0.175
14-Jun-04	49	1.606
12-Jul-04	344	0.030
9-Aug-04	4840	0.051
7-Sep-04	4838	0.095
18-Oct-04	2600	0.014

Table A-22 Measured *E. coli* concentration and estimated streamflow at station 10721, Johnson Creek, Segment 0841L.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
15-Jan-02	140	0.010
10-Apr-02	158	0.465
23-Jul-02	4840	0.010
15-Oct-02	137	0.004
14-Jan-03	267	0.036
15-Apr-03	651	0.026
30-Jul-03	4	0.005
22-Oct-03	99	0.012
22-Jan-04	133	0.029
22-Apr-04	197	0.011
20-Jul-04	41	0.012
19-Oct-04	259	0.010
18-Jan-05	255	0.030
5-May-05	2190	0.094
21-Jul-05	81	0.011
8-Nov-05	345	0.007

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Feb-06	45	0.006
11-Apr-06	230	0.014
10-Oct-06	5600	0.138
23-Jan-07	1800	0.087
6-Jun-07	1700	0.361
20-Aug-07	320	0.017
6-Nov-07	120	0.014
5-Mar-08	2100	0.067
11-May-09	6200	0.022
4-Nov-09	1500	0.221
4-Mar-10	130	0.148
6-May-10	400	0.048
17-Sep-10	200	0.040
22-Mar-11	1200	0.004

Table A-23 Measured *E. coli* concentration and estimated streamflow at station 10719, Johnson Creek, Segment 0841L.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
5-Feb-01	50	0.229
2-Apr-01	50	2.689
9-May-01	548	1.336
7-Jun-01	138	0.058
10-Jul-01	54	0.093
7-Aug-01	5	0.017
3-Oct-01	101	0.056
30-Oct-01	225	0.038
4-Dec-01	63	0.069
3-Jan-02	12	0.074
15-Jan-02	87	0.063
5-Feb-02	255	1.373
2-Apr-02	70	0.931
9-Apr-02	3470	7.782
6-May-02	197	4.990
25-Jul-02	1630	0.044
15-Oct-02	922	0.022
16-Jan-03	214	0.132

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
15-Apr-03	215	0.160
31-Jul-03	97	0.035
21-Oct-03	597	0.076
20-Jan-04	245	0.248
20-Apr-04	171	0.070
22-Jul-04	690	0.083
19-Oct-04	308	0.063
18-Jan-05	81	0.183
14-Apr-05	92	0.106
15-Apr-05	44	0.101
3-May-05	244	0.052
21-Jul-05	377	0.068
10-Aug-05	150	0.106
10-Aug-05	230	0.106
24-Aug-05	42	0.027
24-Aug-05	68	0.027
25-Aug-05	85	0.027
8-Nov-05	35	0.043
15-Feb-06	13	0.034
12-Apr-06	69	0.072
11-Oct-06	12000	0.988
23-Jan-07	4	0.528
7-Jun-07	550	1.854
22-Aug-07	220	0.071
8-Nov-07	18	0.077
4-Mar-08	4000	1.311
23-Jun-08	130	0.016
13-May-09	410	0.137
5-Nov-09	51	1.290
11-Mar-10	180	2.317
10-May-10	320	0.212
16-Sep-10	280	0.345
15-Dec-10	130	0.076
22-Mar-11	160	0.022

Table A-24 Measured *E. coli* concentration and estimated streamflow at station 10718, Johnson Creek, Segment 0841L.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Jan-09	8	0.012
18-Feb-09	450	0.042
18-Mar-09	79	0.184
15-Apr-09	130	0.128
20-May-09	98	0.132
24-Jun-09	96	0.017
22-Jul-09	1200	0.263
19-Aug-09	150	0.000
24-Sep-09	880	0.474
27-Oct-09	2800	4.244
18-Nov-09	330	0.555
22-Dec-09	22	0.237
27-Jan-10	10	0.081
17-Feb-10	8	3.210
24-Mar-10	300	1.753
28-Apr-10	130	3.310
25-May-10	140	3.101
20-Jul-10	980	0.043
25-Aug-10	4800	0.550
22-Sep-10	110	0.196
20-Oct-10	130	0.007
18-Nov-10	410	0.103
16-Dec-10	190	0.062
20-Jan-11	870	0.107
23-Feb-11	47	0.051
23-Mar-11	37	0.019
27-Apr-11	300	0.104
25-May-11	1500	1.094
21-Jun-11	4800	1.245

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able A-25 Measured *E. coli* concentration and estimated streamflow at station 18311, Johnson Creek, Segment 0841L.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
20-Aug-03	8	0.080
23-Sep-03	13	0.130
22-Oct-03	2	0.078
19-Nov-03	933	0.369
16-Dec-03	82	0.173
22-Jan-04	19	0.196
26-Feb-04	2600	2.508
23-Mar-04	6	0.215
20-Apr-04	4	0.077
26-May-04	8	0.024
28-Jun-04	523	5.729
14-Jul-04	24	0.162
18-Aug-04	2	0.075
30-Sep-04	2	0.076
20-Oct-04	17	0.064
18-Nov-04	4838	8.147
15-Feb-05	26	0.253
16-Mar-05	79	0.106
27-Apr-05	21	0.191
25-May-05	29	0.083
21-Jun-05	19	0.010
21-Jul-05	34	0.075
21-Sep-05	22	0.036
20-Oct-05	6	0.026
16-Nov-05	280	0.032
14-Dec-05	27	0.061
19-Jan-06	15	0.091
15-Feb-06	8	0.037
16-Mar-06	24	0.022
20-Apr-06	16000	1.681
22-May-06	64	0.050
20-Jun-06	2800	0.125
27-Jul-06	2	0.004
17-Oct-06	7300	1.750
16-Nov-06	29	0.056

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
20-Dec-06	2300	0.458
22-Jan-07	1000	0.999
20-Feb-07	3	0.084
22-Mar-07	83	0.054
17-Apr-07	65	0.674
15-May-07	310	0.587
19-Jun-07	620	6.309
25-Jul-07	45	1.373
29-Aug-07	56	0.150
24-Oct-07	780	0.299
28-Nov-07	1700	0.176
19-Dec-07	330	0.135
22-Jan-08	6	0.056
25-Feb-08	17	0.082
26-Mar-08	17	0.889
23-Apr-08	52	0.873
21-May-08	1100	0.303
20-Aug-08	7700	1.266
22-Oct-08	42	0.006

Table A-26 Measured *E. coli* concentration and estimated streamflow at station 17664, Johnson Creek, Segment 0841L.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
10-Dec-01	64	0.062
22-Jan-02	22	0.077
18-Feb-02	29	0.149
21-Mar-02	2090	13.803
23-Apr-02	170	0.929
30-May-02	291	0.216
19-Jun-02	106	0.118
22-Jul-02	651	0.071
28-Aug-02	242	0.054
25-Sep-02	163	0.046
17-Oct-02	89	0.023
12-Nov-02	39	0.098
4-Dec-02	4838	1.402

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
22-Jan-03	10	0.177
20-Feb-03	118	0.462
25-Mar-03	88	0.227
17-Apr-03	53	0.183
19-May-03	32	0.025
24-Jun-03	45	0.130
29-Jul-03	370	0.041
20-Aug-03	111	0.085
23-Sep-03	77	0.139
22-Oct-03	52	0.084
19-Nov-03	888	0.396
16-Dec-03	74	0.185
22-Jan-04	56	0.211
24-Feb-04	1100	1.163
23-Mar-04	19	0.231
20-Apr-04	38	0.082
27-May-04	141	0.255
28-Jun-04	523	6.143
14-Jul-04	249	0.174
18-Aug-04	15	0.080
30-Sep-04	60	0.082
20-Oct-04	192	0.069
18-Nov-04	4838	8.737
14-Dec-04	15	0.356
19-Jan-05	20	0.191
15-Feb-05	58	0.272
16-Mar-05	150	0.114
27-Apr-05	73	0.205
25-May-05	150	0.089
21-Jun-05	500	0.011
21-Jul-05	230	0.081
24-Aug-05	270	0.032
21-Sep-05	120	0.038
20-Oct-05	71	0.028
17-Nov-05	90	0.035
14-Dec-05	300	0.065
19-Jan-06	6	0.098

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
15-Feb-06	32	0.040
16-Mar-06	40	0.024
20-Apr-06	20000	1.803
22-May-06	40	0.053
20-Jun-06	2400	0.134
27-Jul-06	13	0.004
17-Oct-06	3600	1.876
16-Nov-06	49	0.060
22-Jan-07	420	1.071
20-Feb-07	290	0.090
22-Mar-07	120	0.058
17-Apr-07	110	0.723
15-May-07	730	0.629
19-Jun-07	3100	6.766
25-Jul-07	390	1.472
29-Aug-07	66	0.161
26-Sep-07	32	0.039
24-Oct-07	550	0.321
28-Nov-07	870	0.189
19-Dec-07	55	0.145
22-Jan-08	19	0.060
25-Feb-08	68	0.088
26-Mar-08	46	0.953
23-Apr-08	230	0.936
21-May-08	140	0.325
20-Aug-08	2600	1.358
22-Oct-08	200	0.006
18-Dec-08	190	0.027
14-Jan-09	39	0.014
18-Feb-09	160	0.050
18-Mar-09	86	0.217
15-Apr-09	270	0.151
20-May-09	400	0.156
24-Jun-09	20	0.020
22-Jul-09	780	0.310
24-Sep-09	510	0.559
27-Oct-09	2800	5.002

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
18-Nov-09	580	0.654
22-Dec-09	1200	0.280
27-Jan-10	660	0.096
17-Feb-10	200	3.784
24-Mar-10	190	2.066
28-Apr-10	87	3.902
25-May-10	270	3.655
20-Jul-10	81	0.050
26-Aug-10	980	0.294
22-Sep-10	26	0.231
20-Oct-10	46	0.008
18-Nov-10	58	0.121
16-Dec-10	35	0.073
20-Jan-11	34	0.126
22-Feb-11	37	0.054
23-Mar-11	12	0.022
27-Apr-11	63	0.122
25-May-11	870	1.289
21-Jun-11	4800	1.468

Table A-27 Measured *E. coli* concentration and estimated streamflow at station 17179, West Irving Branch, Segment 0841U.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
16-Jan-02	63	0.013
5-Feb-02	4820	0.294
5-Mar-02	472	0.010
8-Jul-02	125	0.041
12-Aug-02	4840	0.064
11-Sep-02	290	0.014
9-Oct-02	4838	0.319
4-Nov-02	4838	0.031
3-Dec-02	4838	0.031
8-Jan-03	49	0.028
4-Feb-03	8	0.033
6-Mar-03	6	0.161
9-Apr-03	4838	0.052

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
6-May-03	3460	0.026
3-Jun-03	299	0.006
7-Jul-03	4840	0.024
4-Aug-03	290	0.008
2-Sep-03	922	0.085
2-Oct-03	46	0.014
11-Nov-03	197	0.039
1-Dec-03	31	0.016
5-Jan-04	89	0.028
3-Feb-04	1960	0.058
2-Mar-04	2410	0.157
3-May-04	476	0.192
14-Jun-04	24200	1.760
12-Jul-04	134	0.033
9-Aug-04	93	0.056
8-Sep-04	358	0.037
18-Oct-04	43	0.016
17-Sep-08	130	0.007
14-Oct-08	120	0.003
19-Nov-08	140	0.009
2-Dec-08	1200	0.013
6-Jan-09	6400	0.089
4-Feb-09	10	0.003
10-Feb-09	690	0.111
23-Feb-09	430	0.003
11-Mar-09	7600	0.345
8-Apr-09	230	0.004

Table A-28 Measured *E. coli* concentration and estimated streamflow at station 11081, Lower West Fork Trinity River, Segment 0841_01.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
18-Sep-00	687	8.353
16-Oct-00	4836	36.694
20-Feb-01	2419.2	34.215
26-Mar-01	687	67.631
10-Dec-01	172	8.686

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
14-Jan-02	48	8.915
11-Feb-02	1960	16.137
11-Mar-02	775	7.939
8-Apr-02	4840	331.902
13-May-02	2410	73.560
10-Jun-02	344	13.830
8-Jul-02	171	12.408
29-Jul-02	30	8.472
5-Aug-02	45	8.410
10-Sep-02	870	13.221
7-Oct-02	4838	20.691
11-Nov-02	59	9.614
9-Dec-02	4838	84.508
13-Jan-03	222	15.727
3-Feb-03	2	11.592
10-Mar-03	37	14.370
7-Apr-03	4840	23.012
12-May-03	209	9.947
3-Jun-03	49	8.001
7-Jul-03	155	10.226
5-Aug-03	51	8.191
8-Sep-03	60	8.446
6-Oct-03	19900	29.073
10-Nov-03	775	17.764
15-Dec-03	757	11.859
12-Jan-04	65	8.503
7-Mar-05	38	15.158
23-Mar-05	76	10.413
23-Mar-05	80	10.413
23-Mar-05	110	10.413
23-Mar-05	110	10.413
23-Mar-05	120	10.413
5-Apr-05	88	12.394
5-Apr-05	90	12.394
5-Apr-05	90	12.394
5-Apr-05	110	12.394
5-Apr-05	110	12.394

Sample Date	***E. coli*** **(MPN/100 mL)**	**Estimated Daily Flow on Sampling Date (cms)**
11-Apr-05	45	11.427
14-Apr-05	72	10.127
15-Apr-05	74	9.976
19-Apr-05	42	9.674
19-Apr-05	42	9.674
19-Apr-05	44	9.674
19-Apr-05	46	9.674
19-Apr-05	66	9.674
4-May-05	410	15.559
4-May-05	440	15.559
4-May-05	470	15.559
4-May-05	770	15.559
4-May-05	800	15.559
9-May-05	84	10.299
17-May-05	230	10.178
17-May-05	260	10.178
17-May-05	270	10.178
17-May-05	330	10.178
17-May-05	350	10.178
1-Jun-05	2100	30.195
1-Jun-05	2500	30.195
1-Jun-05	2700	30.195
1-Jun-05	2900	30.195
1-Jun-05	3400	30.195
6-Jun-05	373	17.530
14-Jun-05	50	8.039
14-Jun-05	64	8.039
14-Jun-05	66	8.039
14-Jun-05	66	8.039
14-Jun-05	78	8.039
20-Jun-05	52	7.556
21-Jun-05	210	7.525
28-Jun-05	260	7.676
28-Jun-05	270	7.676
28-Jun-05	310	7.676
28-Jun-05	330	7.676
28-Jun-05	340	7.676

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
5-Jul-05	13	8.993
12-Jul-05	210	8.993
12-Jul-05	320	8.993
12-Jul-05	340	8.993
12-Jul-05	410	8.993
12-Jul-05	430	8.993
27-Jul-05	490	10.293
27-Jul-05	570	10.293
27-Jul-05	690	10.293
27-Jul-05	800	10.293
1-Aug-05	71	8.676
10-Aug-05	320	10.127
10-Aug-05	320	10.127
16-Aug-05	1000	22.490
16-Aug-05	1200	22.490
16-Aug-05	1200	22.490
16-Aug-05	1300	22.490
16-Aug-05	2200	22.490
24-Aug-05	47	8.011
24-Aug-05	73	8.011
25-Aug-05	58	8.011
12-Sep-05	78	8.230
16-Sep-05	6900	13.006
17-Sep-05	5200	9.590
3-Oct-05	83	8.127
25-Oct-05	32	8.097
1-Nov-05	43000	25.332
2-Nov-05	27000	11.670
14-Nov-05	160	8.254
12-Dec-05	55	9.568
9-Jan-06	40	9.316
23-Jan-06	1700	31.653
24-Jan-06	960	13.488
6-Feb-06	43	9.147
13-Mar-06	72	8.325
3-Apr-06	29	10.912
8-May-06	460	17.097

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
5-Jun-06	19	8.863
10-Jul-06	160	7.794
9-Aug-06	58	7.272
6-Sep-06	360	14.406
16-Oct-06	17000	114.844
6-Nov-06	24000	80.133
13-Dec-06	32	8.272
10-Jan-07	170	10.602
6-Feb-07	40	11.251
12-Mar-07	870	12.235
9-Apr-07	250	17.474
8-May-07	7900	81.492
4-Jun-07	3100	97.359
10-Jul-07	4800	140.756
6-Aug-07	140	26.486
13-Nov-07	74	9.511
19-Feb-08	1400	15.193
6-May-08	6500	40.955
18-Aug-08	320	12.902
10-Nov-08	31	15.479
11-Feb-09	200	30.130
27-May-09	1600	38.909
20-Aug-09	17	7.272
4-Nov-09	95	43.403
23-Feb-10	87	39.922
18-May-10	4900	80.021
17-Aug-10	27	7.303
9-Nov-10	39	9.461
22-Feb-11	22	8.509
11-May-11	480	31.819

Table A-29 Measured *E. coli* concentration and estimated streamflow at station 11080, Lower West Fork Trinity River, Segment 0841_01.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
11-Dec-01	62	9.181
16-Jan-02	409	8.898

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
18-Feb-02	545	10.696
8-Jul-02	242	12.444
12-Aug-02	3470	15.405
11-Sep-02	384	9.071
6-Nov-02	158	10.658
2-Dec-02	40	7.887
14-Jan-03	288	13.249
3-Feb-03	49	11.623
6-Mar-03	19	27.569
9-Apr-03	455	13.901
7-May-03	153	10.119
9-Jun-03	359	18.478
8-Jul-03	81	13.809
4-Aug-03	13	8.228
2-Sep-03	1370	17.983
1-Oct-03	29	9.167
11-Nov-03	245	12.207
3-Dec-03	91	9.212
8-Jan-04	141	9.121
3-Feb-04	263	14.650
16-Feb-04	71	16.141
2-Mar-04	977	27.149
8-Mar-04	1840	19.842
12-Apr-04	341	12.238
20-Apr-04	34	9.163
6-May-04	72	13.100
16-Jun-04	2090	163.696
14-Jul-04	15	11.255
11-Aug-04	56	15.743
9-Sep-04	216	13.556
20-Oct-04	163	8.851

Table A-30 Measured *E. coli* concentration and estimated streamflow at station 11089, Lower West Fork Trinity River, Segment 0841_01.

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
3-Oct-00	77	16.890

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
23-Mar-05	110	19.557
23-Mar-05	120	19.557
23-Mar-05	120	19.557
23-Mar-05	140	19.557
23-Mar-05	200	19.557
5-Apr-05	21	22.084
5-Apr-05	23	22.084
5-Apr-05	28	22.084
5-Apr-05	36	22.084
5-Apr-05	36	22.084
14-Apr-05	28	19.193
15-Apr-05	20	19.000
19-Apr-05	17	18.615
19-Apr-05	25	18.615
19-Apr-05	27	18.615
19-Apr-05	27	18.615
19-Apr-05	36	18.615
4-May-05	160	26.120
4-May-05	170	26.120
4-May-05	220	26.120
4-May-05	250	26.120
4-May-05	280	26.120
17-May-05	120	19.258
17-May-05	120	19.258
17-May-05	120	19.258
17-May-05	130	19.258
17-May-05	170	19.258
1-Jun-05	3400	44.787
1-Jun-05	3400	44.787
1-Jun-05	3400	44.787
1-Jun-05	3900	44.787
1-Jun-05	4300	44.787
14-Jun-05	40	16.530
12-Jul-05	120	17.747
12-Jul-05	120	17.747
12-Jul-05	130	17.747
12-Jul-05	130	17.747

Sample Date	*E. coli* (MPN/100 mL)	Estimated Daily Flow on Sampling Date (cms)
12-Jul-05	150	17.747
27-Jul-05	64	19.405
27-Jul-05	92	19.405
27-Jul-05	94	19.405
27-Jul-05	110	19.405
10-Aug-05	240	19.193
10-Aug-05	260	19.193
16-Aug-05	4100	34.960
16-Aug-05	4400	34.960
16-Aug-05	5100	34.960
16-Aug-05	5300	34.960
16-Aug-05	5500	34.960
24-Aug-05	32	16.495
24-Aug-05	54	16.495
25-Aug-05	63	16.495
16-Sep-05	33000	22.865
17-Sep-05	2100	18.509
25-Oct-05	22	16.604
1-Nov-05	22000	38.585
2-Nov-05	31000	21.161
23-Jan-06	1000	46.648
24-Jan-06	720	23.479

APPENDIX B
EQUATIONS FOR CALCULATING TMDL ALLOCATIONS FOR CHANGED CONTACT RECREATION STANDARD

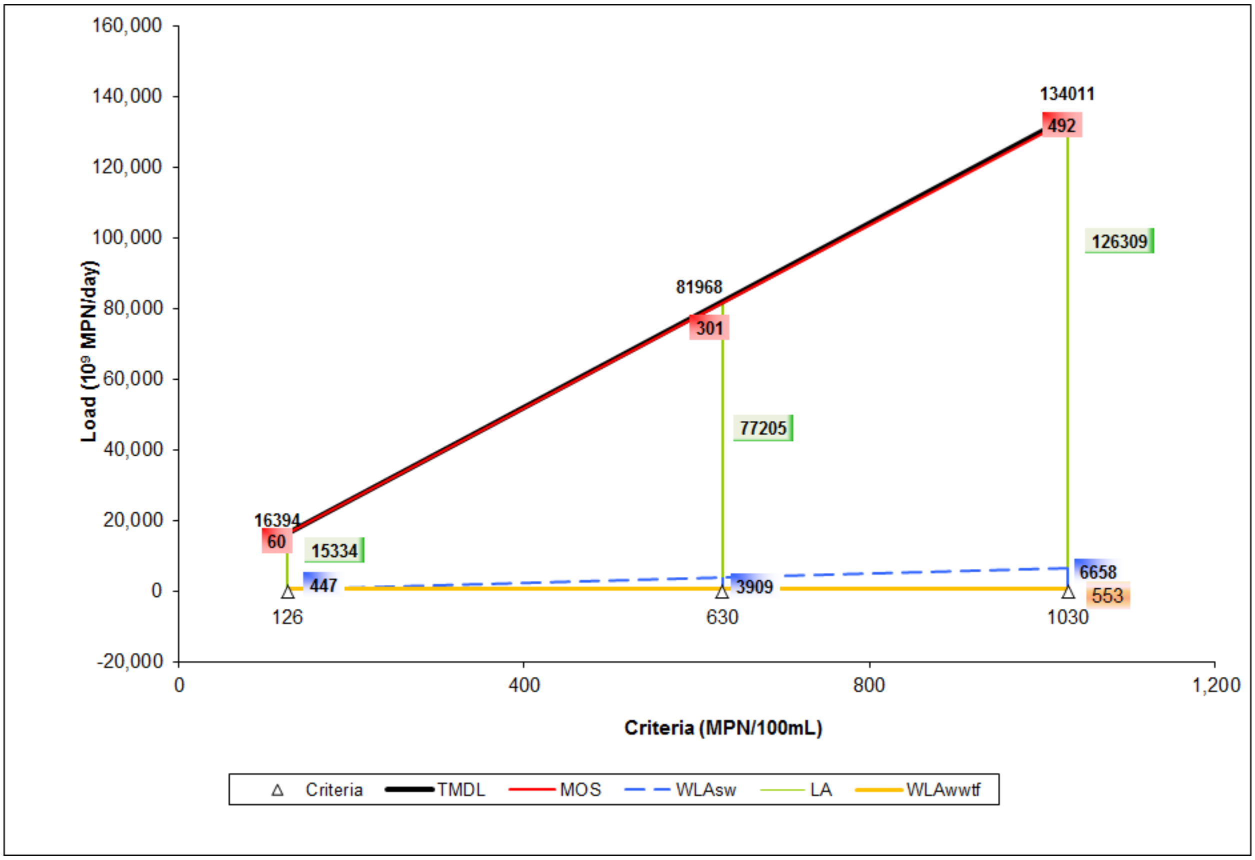

Figure B-1. Allocation loads for Lower West Fork Trinity River (0841_01) as a function of water quality criteria

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

TMDL = 130.10797 * Std
WLA_{WWTF} = 553.3
WLA_{sw} = 6.87064 * Std – 419.09
LA = 122.75995 * Std – 134.18
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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

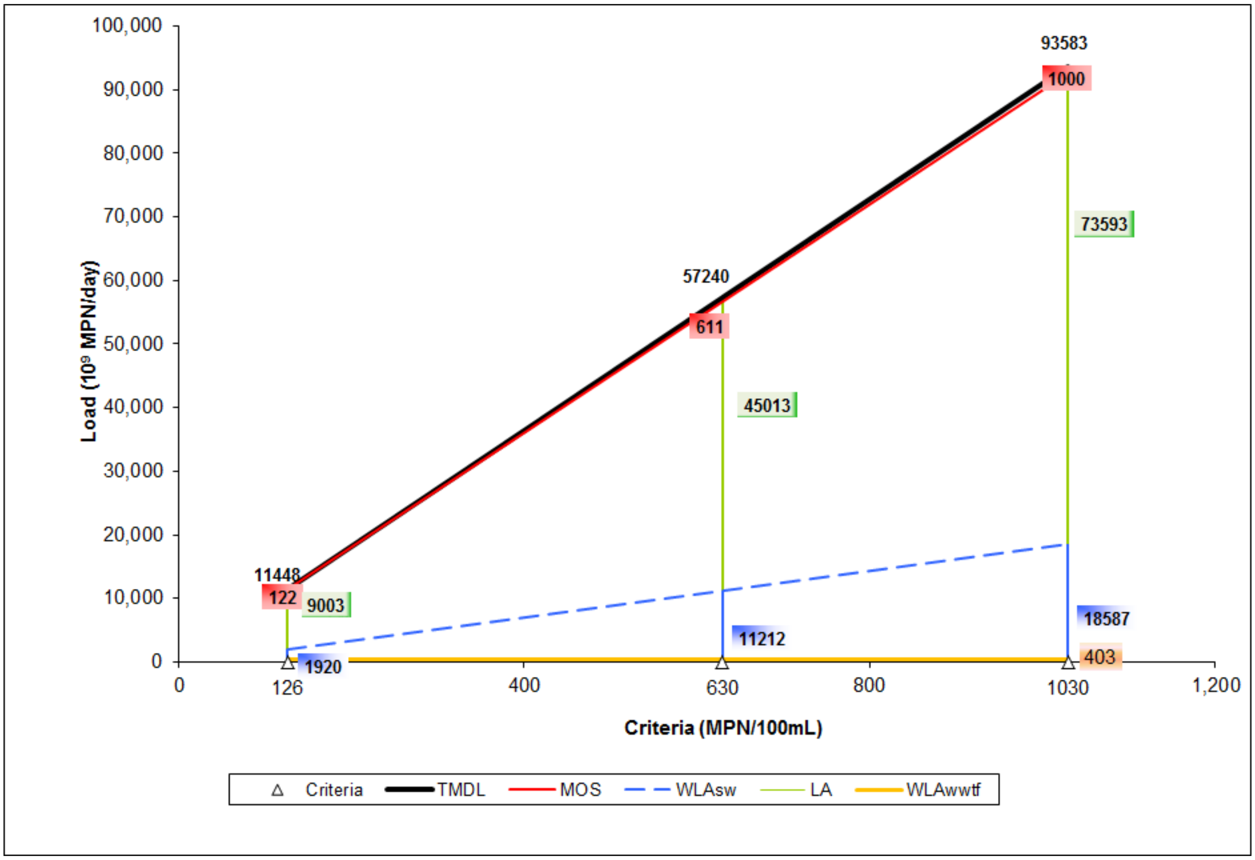

Figure B-2. Allocation loads for Lower West Fork Trinity River (0841_02) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

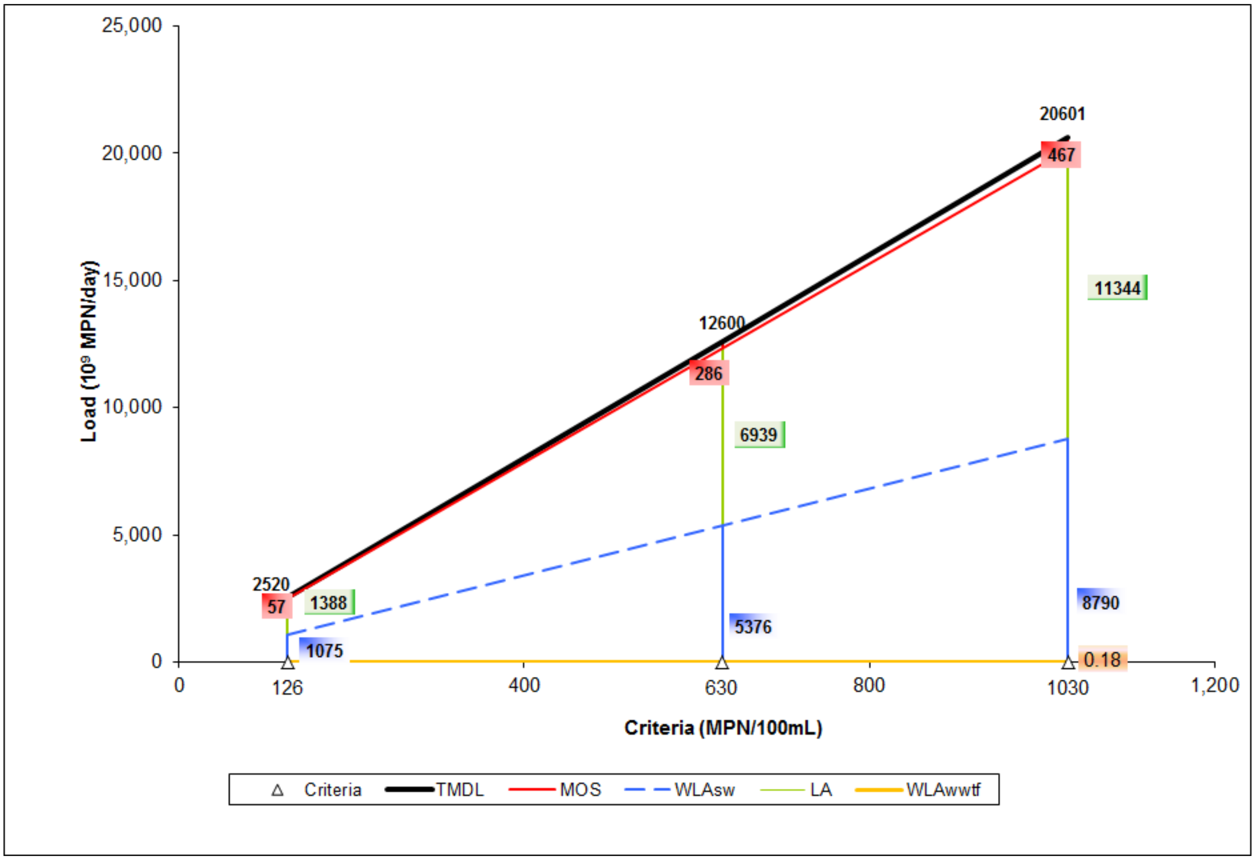

Figure B-3. Allocation loads for Bear Creek (0841B) as a function of water quality criteria

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

$TMDL = 20.0007 * Std$
$WLA_{WWTF} = 0.184$
$WLA_{sw} = 8.53377 * Std - 0.182$
$LA = 11.0138 * Std$
$MOS = 0.45312 * Std$

Where:

Std = Revised Contact Recreation Standard
WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)
WLA_{SW} = Waste load allocation (permitted storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

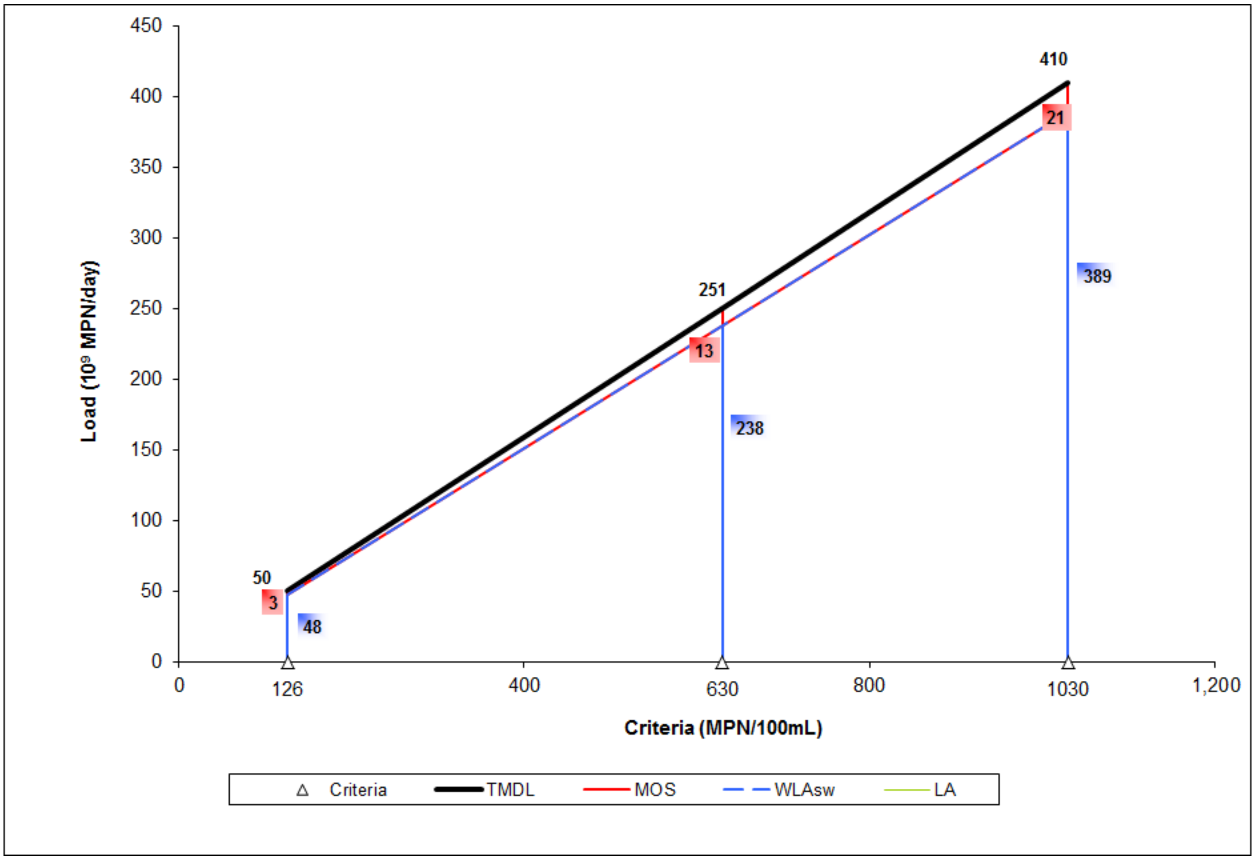

Figure B-4. Allocation loads for Arbor Creek (0841C) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

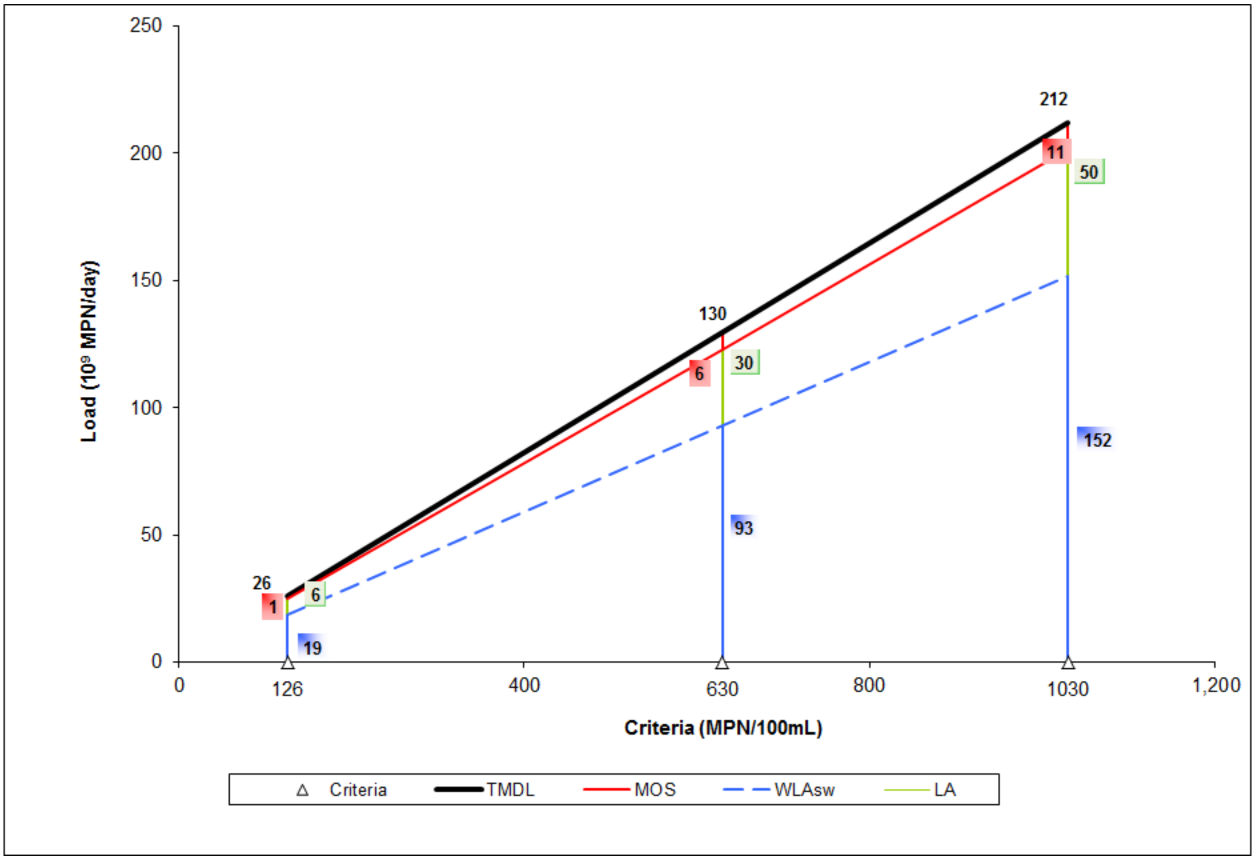

Figure B-5. Allocation loads for Copart Branch Mountain Creek (0841E) as a function of water quality criteria

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

TMDL = 0.20570 * Std
WLA_{WWTF} = 0
WLA_{sw} = 0.14724 * Std
LA = 0.04817 * Std
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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

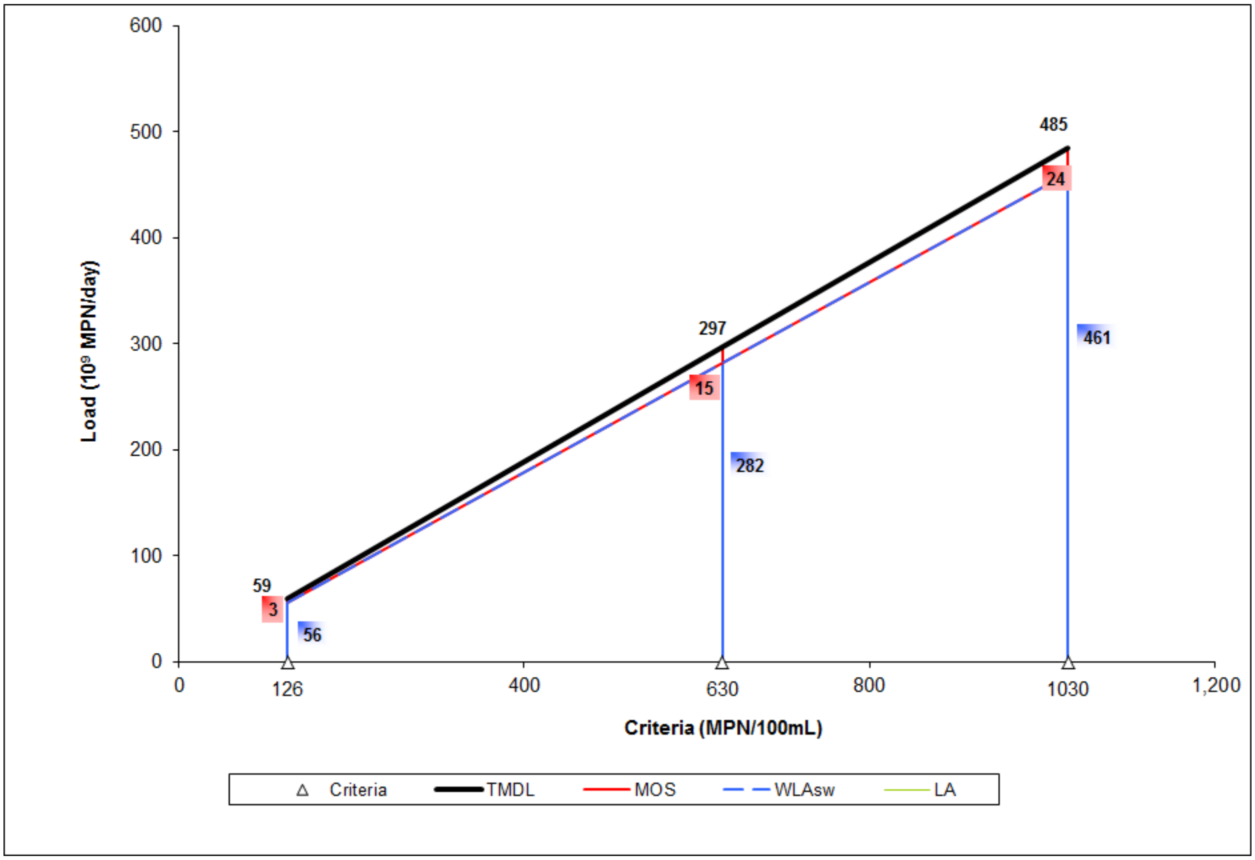

Figure B-6. Allocation loads for Dalworth Creek (0841G) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

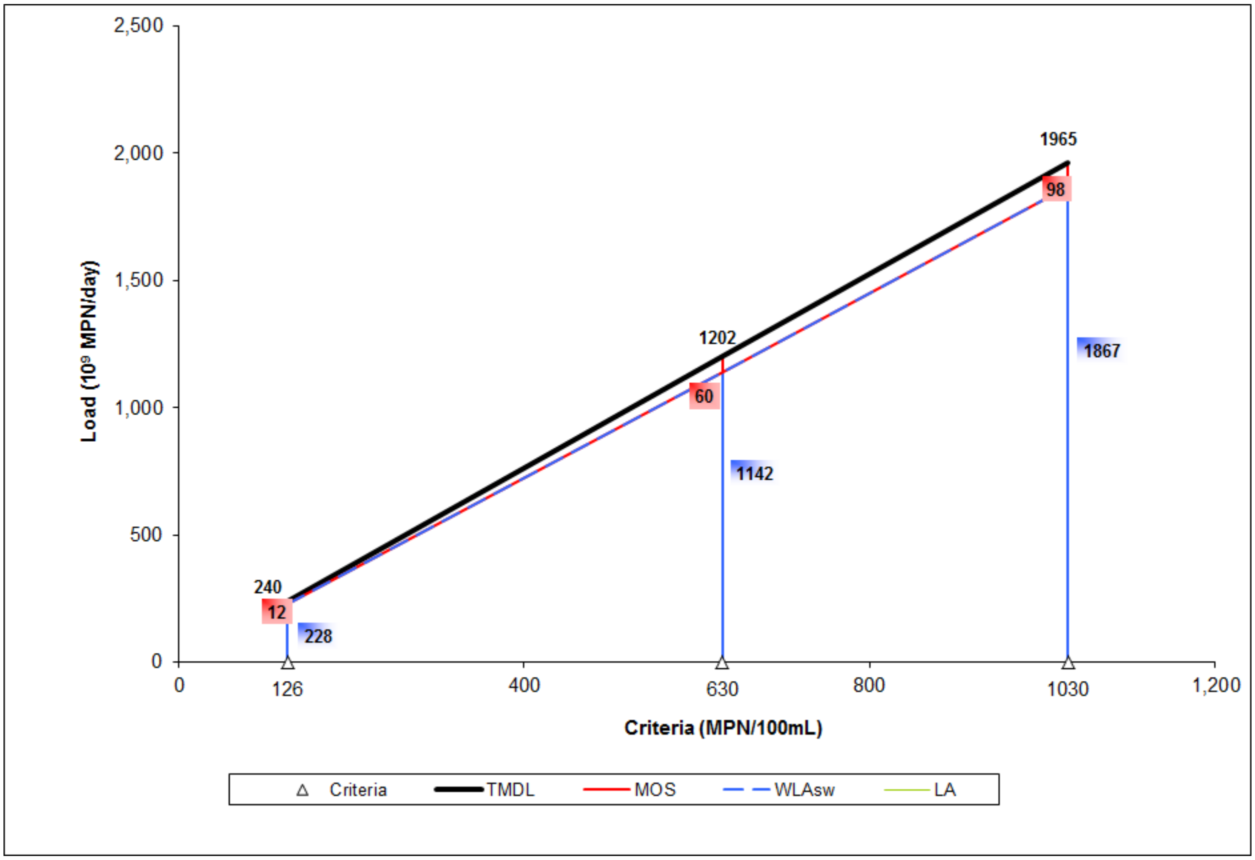

Figure B-7. Allocation loads for Delaware Creek (0841H) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

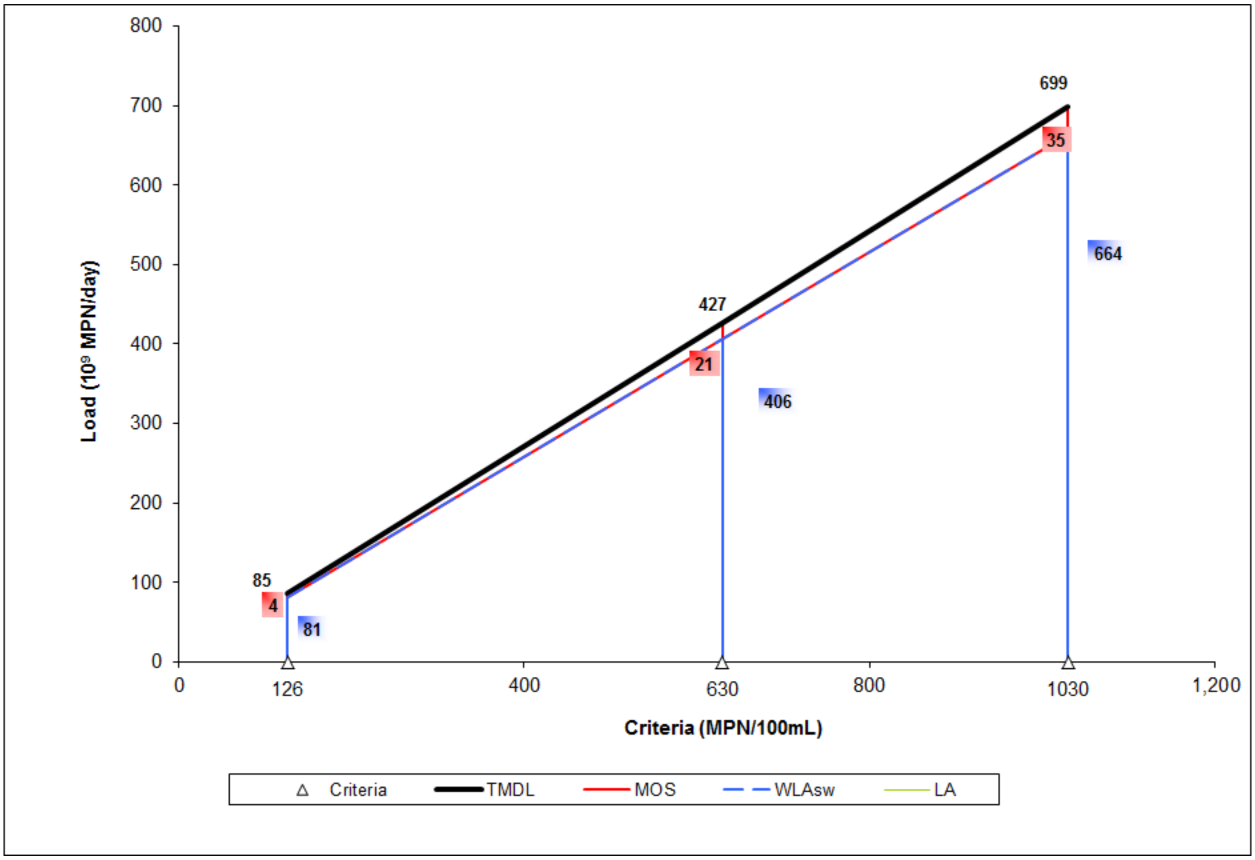

Figure B-8. Allocation loads for Estelle Creek (0841J) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

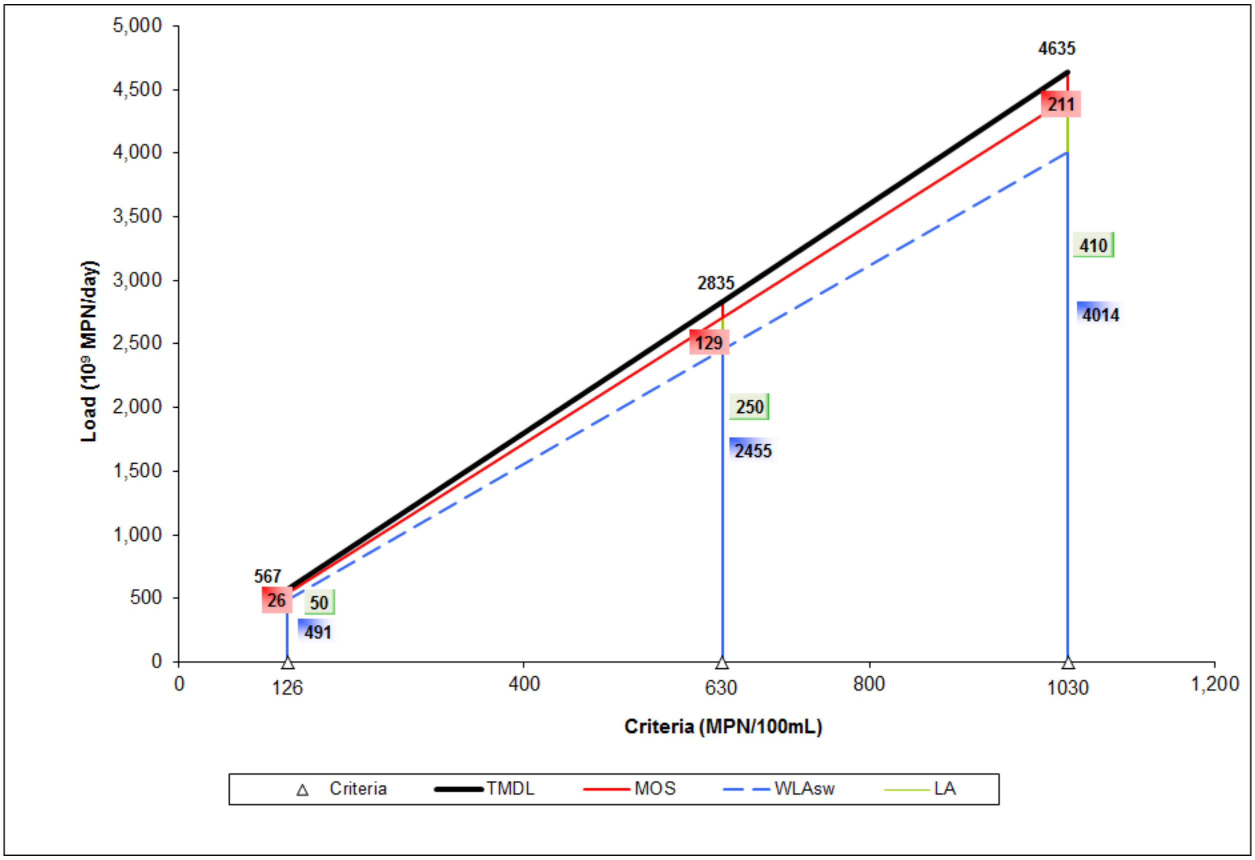

Figure B-9. Allocation loads for Johnson Creek (0841L) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

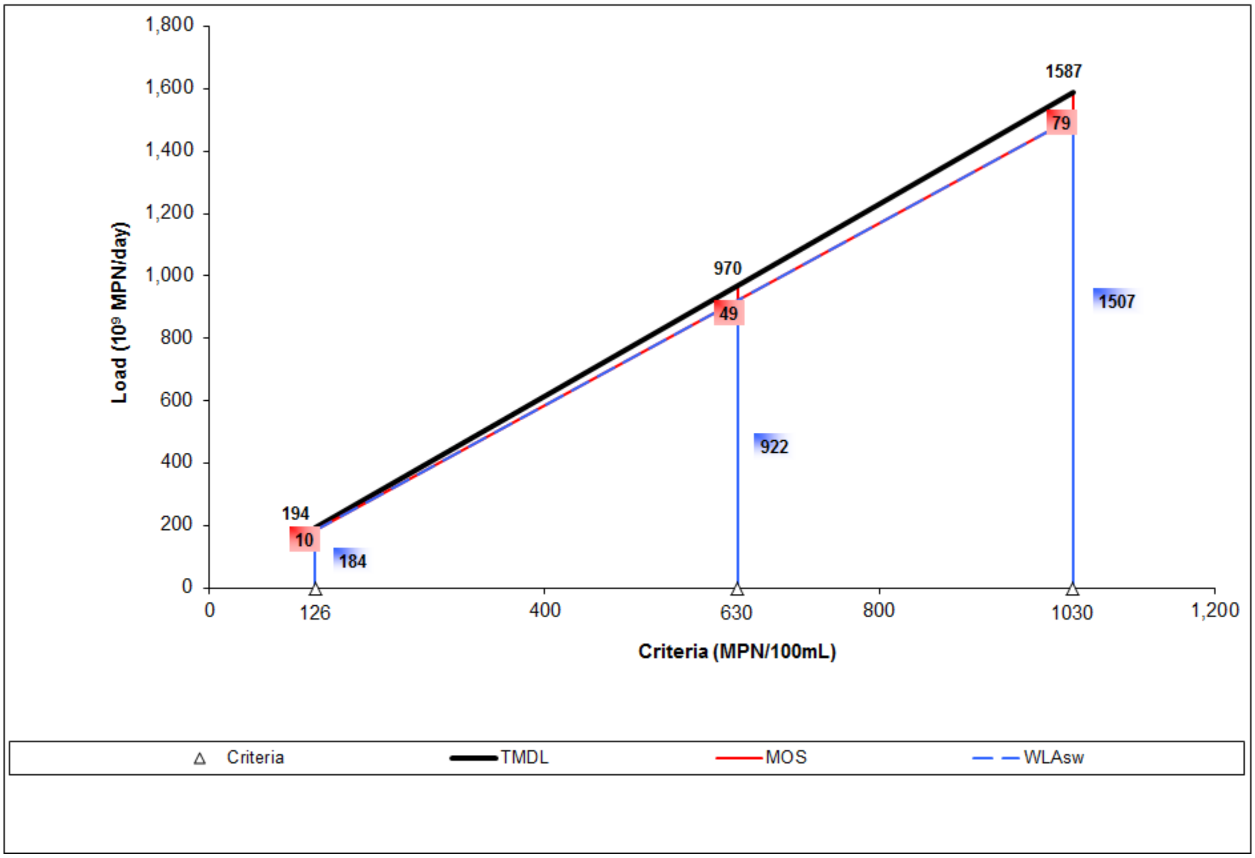

Figure B-10. Allocation loads for Kee Branch (0841M) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

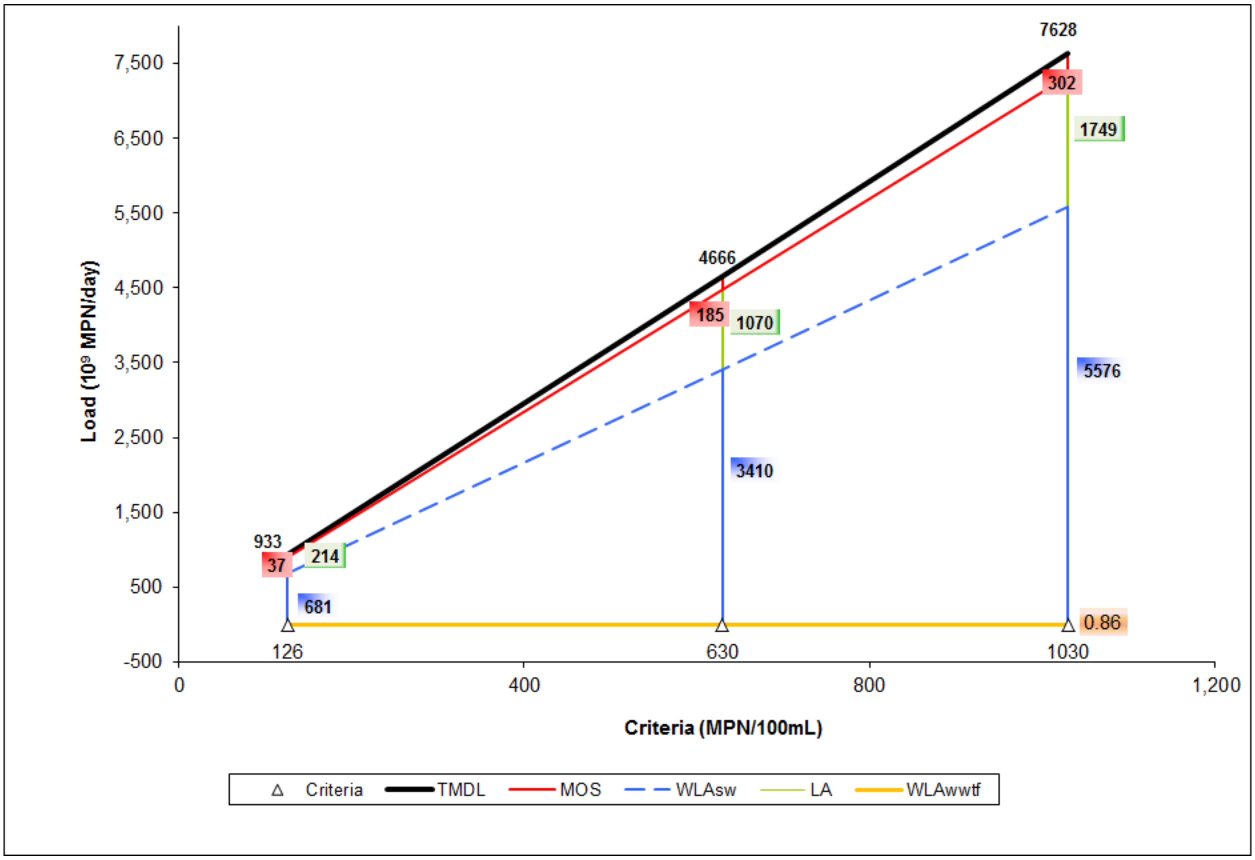

Figure B-11. Allocation loads for Rush Creek (0841R) as a function of water quality criteria

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

TMDL =7.40612 * Std
WLA_{WWTF} = 0.863
WLA_{sw} = 5.41447 * Std – 0.838
LA = 1.69836 * Std – 0.024
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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

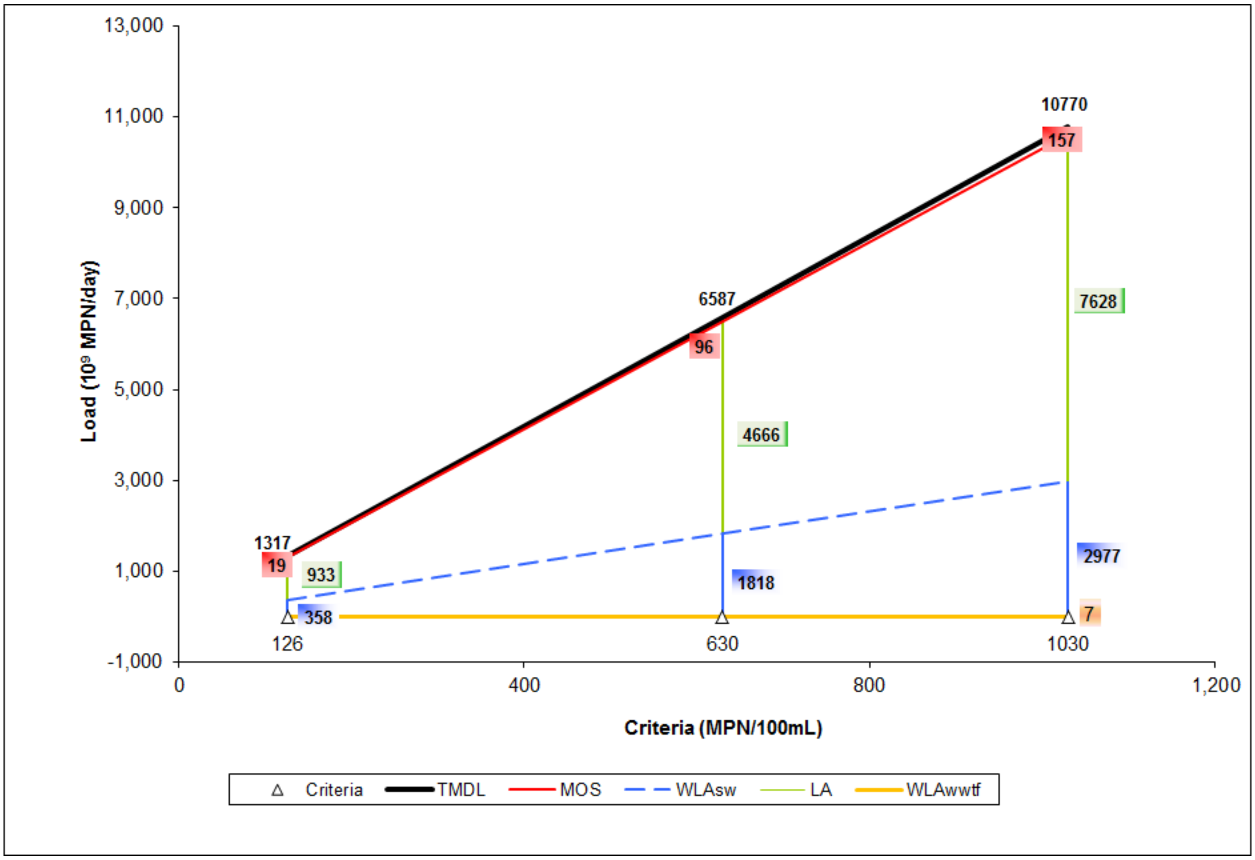

Figure B-12. Allocation loads for Village Creek (0841T) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety

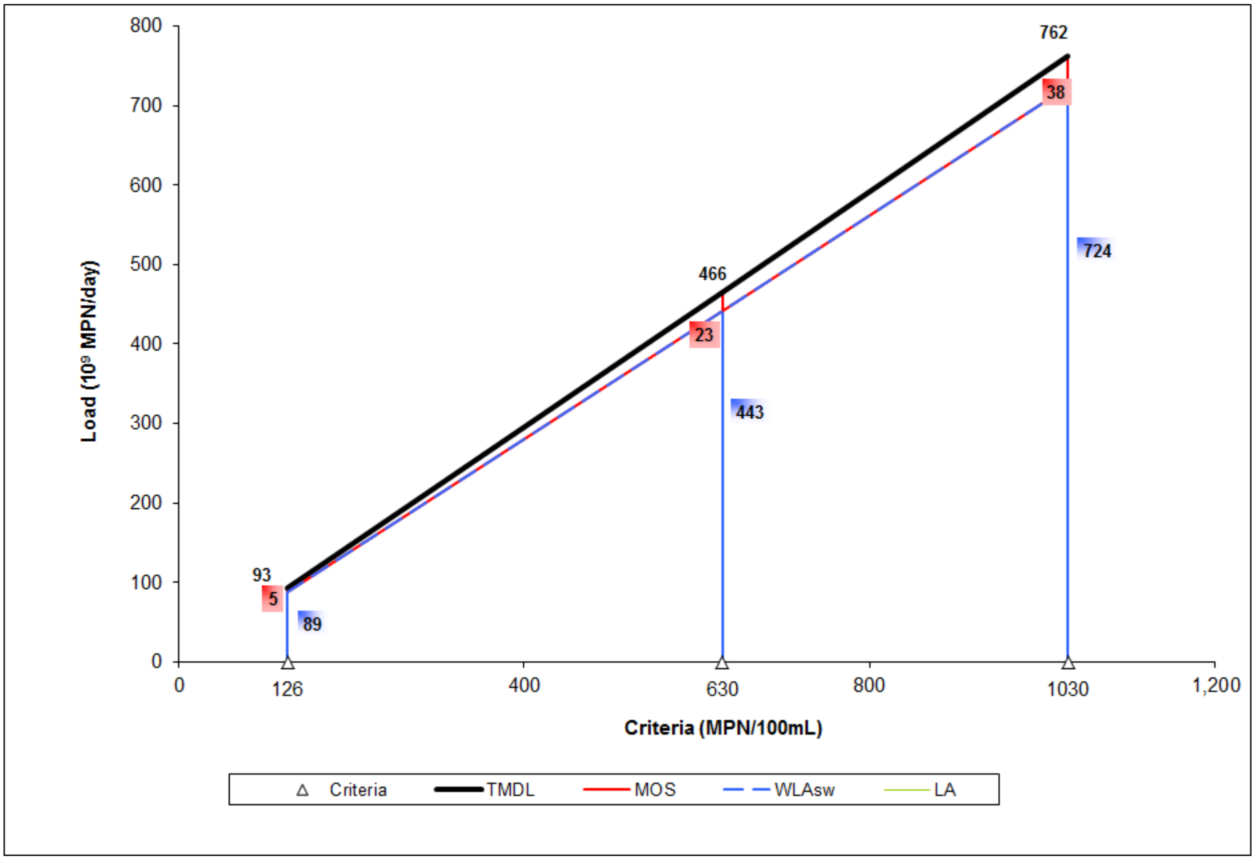

Figure B-13. Allocation loads for West Irving Branch (0841U) as a function of water quality criteria

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 storm water)
LA = Total load allocation (non-permitted source contributions)
MOS = Margin of Safety