JOHN DAY RIVER BASIN TMDL

APPENDIX E: BACTERIA ASSESSMENT

Final
November 2010

DEQ
State of Oregon
Department of Environmental Quality

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1. OVERVIEW AND SCOPE

Fecal coliform bacteria sources in the John Day River Basin may include wildlife, livestock waste, failing septic systems, wastewater treatment plant malfunctions, and rural residential and urban runoff. As required by OAR 340-042-0040, this TMDL includes descriptions of the Basin or Subbasins, the pollutants responsible for impairments, standards being applied, an analysis of the sources of the pollutants, a description of data collected, loading capacity and allocations of loads and a margin of safety. The John Day River Basin Bacteria TMDL applies throughout much of the John Day River Basin in Oregon (HUC 170702). The spatial and temporal applicability is described in **Chapter 2.2 – Bacteria TMDL**. This Appendix provides the data review and analysis that the bacteria TMDL of **Chapter 2** is based on. When referring to bacteria, *E. coli* is used as the indicator bacteria and is often the term used in this chapter when discussing bacteria. The methods used in the John Day River Basin Bacteria TMDL are similar to those used in other TMDLs developed in Oregon.

1.1 Water Quality Standard Exceedances and 303(d) Listings for Bacteria

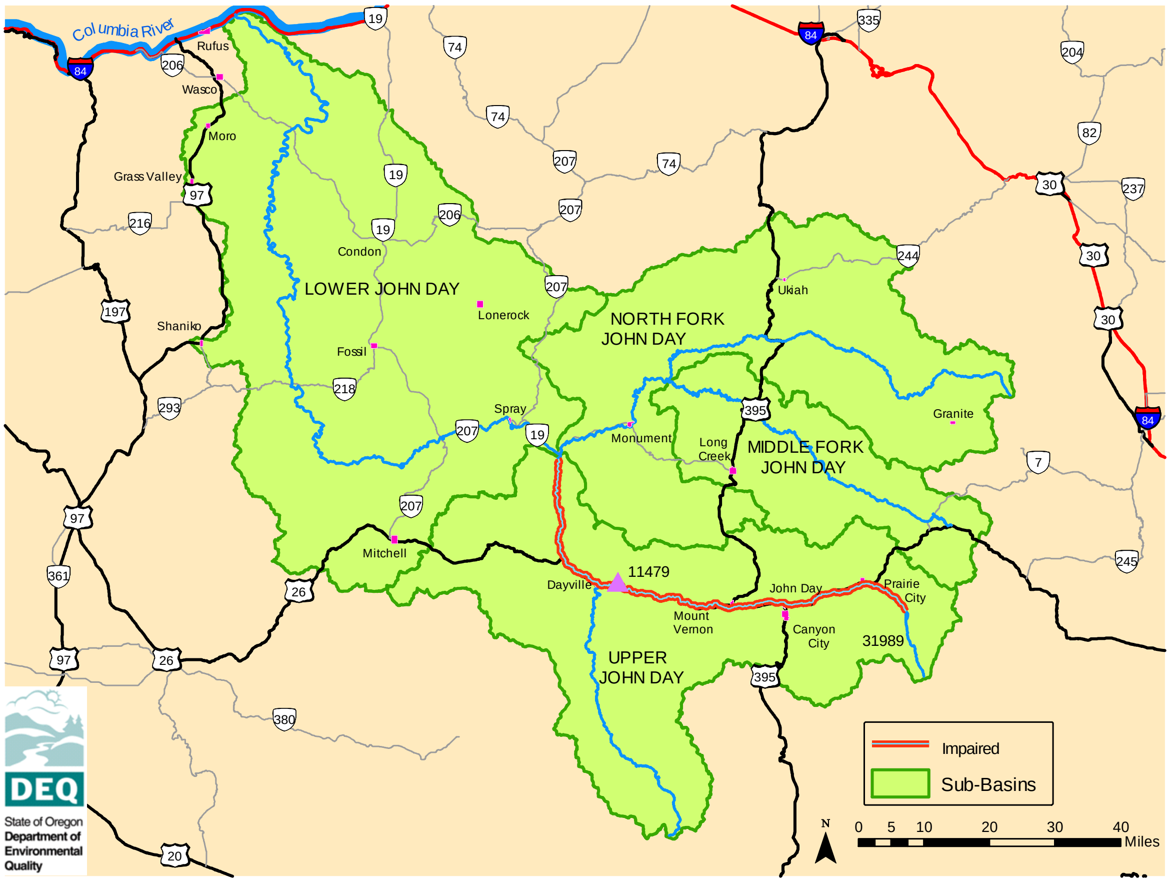
The name and location of water quality impairments, with regard to the bacteria standard, are listed in the 2004/2006 303(d) report. Both *E. coli* and fecal coliform bacteria are listed for the summer season, for the John Day River. The freshwater component of the bacteria standard is based on water contact recreation as the most sensitive beneficial use. All 303(d) listed streams for coliform bacteria in the John Day River Basin are listed in **Table E-1** and displayed in **Figure E-1**. Additional data has been collected since the release of the 2004/2006 303(d) list and a review of that data was included in the development of the John Day Bacteria TMDL.

Table E-1. Bacteria 2004/2006 303(d) listings within the John Day River Basin.

Name	River Mile	LLID	Parameter	Status/Season	Supporting Data
John Day River	182 to 265	1206499457318	*E. coli*	303(d)/2004/ Summer	2004 Data: [DEQ/QDA – Salem] LASAR 11479 River Mile 212.3: From 2/28/2996 to 12/11/2003, 2 out of 17 samples (12%) > 406 organisms; maximum 30-day log mean of 0
John Day River	182 to 265	1206499457318	Fecal Coliform	303(d)/2004/ Summer	Previous Data: DEQ Data (Site 4041581[1]; RM 215.4): 24% (6 of 25) Summer Values exceeded fecal coliform standard (400) with maximum value of 2400 between WY 1986 – 1995.

[1] STORET number that corresponds to LASAR Station 11479

Figure E-1. Map of bacteria 2004/2006 303(d) listed stream segment



2. SOURCES OF BACTERIA

2.1 Natural background Sources

Natural background sources of fecal bacteria include those sources associated with wildlife (non-domestic animals, such as deer, rats, raccoons, ducks, geese and others that live or feed near or in surface waters. For the purposes of this plan, these bacterial sources are considered natural and are part of the natural background of bacteria in the John Day River Basin.

2.2 Permitted Sources

All individual National Pollutant Discharge Elimination System (NPDES) permitted facilities in the John Day River Basin are within the scope of this TMDL. NPDES general permitted sources are not expected to be a significant source of fecal bacteria and are not allocated loads. Individual facility NPDES permitted discharges are required by Oregon law to meet the numeric water quality criteria for fecal bacteria prior to discharge to surface waters. For the municipal NDPES sources, if a digression (instance of not meeting the standard criterion) of the single-sample criteria is observed, the standard allows the permittee to take a series of consecutive samples as soon as practicable to demonstrate compliance overall (see OAR 340-041-0009(5) for details of the re-sampling protocol). The bacteria standard requires that the effluent not exceed 126 *E. coli* organisms per 100 ml based on a 30-day log mean and no single sample shall exceed 406 *E. coli* organisms per 100 ml prior to discharge, with no allowance for mixing. In addition, by rule, overflows of untreated sewage are prohibited in the summer months (November 1- May 21) except during the 1-in-10 year 24-hour storm and in the winter months (November 1- May 21). The facilities are expected to convey and treat all sewage up to the 1-in-5 year 24-hour storm. Monthly DMRs are required from all sources and are reviewed by DEQ on a regular basis. If permit limits are exceeded, DEQ may take an enforcement action.

Storm water NPDES Permits

In the John Day Basin, storm water is addressed through Oregon's NPDES program through general permits.

Confined Animal Feeding Operation

Confined Animal Feeding Operations (CAFOs) registered to the Oregon CAFO general (NPDES) permit are managed to ensure no discharge of fecal bacteria or nutrients under normal conditions (OAR 340-051-0005). Discharge is allowed under conditions of an extreme rainfall event, defined in the permit as greater than the 25-year/24-hour rainfall amount. Facilities operate and maintain their system as designed to contain all waste and precipitation up to a 25-year/24-hour rainfall event. The general permit also stipulates that during such a discharge, effluent cannot cause or contribute to a violation of water quality standards. All land application of manure and process wastewater must be done in accordance with Oregon Department of Agriculture (ODA) approved Animal Waste Management Plan (AWMP), which is required for each CAFO. Each site-specific AWMP is included in the general permit.

Each permitted CAFO receives a routine inspection from the area ODA Livestock Water Quality Inspector once a year, on average. During this inspection, the operator and inspector discuss the operation and review required plans and records. The inspector views the entire operation to assure compliance with permit terms and water quality rules and laws. The inspection reports detail permit compliance in the following areas: permitted number of animals, animal confinement requirements, manure and silage containment requirements, manure application requirements, AWMP, and record keeping. Problems in any of these areas, including incomplete record keeping, can result in the issuance of a water quality advisory or a notice of noncompliance (NON). When a discharge occurs or where there is a potential for a discharge to occur, ODA may take samples of the effluent to determine bacterial concentrations. Surface water samples are taken when visual or anecdotal evidence of discharge is present. NONs have been issued to CAFOs in the John Day River Basin. Some of these NONs have detailed potential releases of bacteria and the potential for CAFOs to impact bacteria levels in the John Day River. In the event a violation is found, the inspector works with the operator to develop a solution to the problem and a schedule to complete the corrective actions. ODA can also issue civil penalties for violations listed in NONs.

2.3 Nonpoint Sources

Nonpoint source pollution comes from spatially diffuse sources. Potential sources of fecal bacteria are wildlife, livestock waste, pets, on-site (septic) system malfunctions, and illegal discharges. Fecal bacteria can be deposited directly or via runoff or subsurface flow into a water body. An example of direct deposition in a diffuse manner into a water body is cattle defecating in or around a stream. An example of a surface or sub-surface bacteria source is a failing on-site treatment system that allows untreated waste to accumulate in a shallow water table or on the land surface. The sources of fecal bacteria are not always obvious. Many of these sources overlap in space and time; for instance, a rural residential area may have a failing septic system, livestock, pets, and wildlife. The following is a discussion of potential bacteria sources by land use.

Onsite Treatment Systems

Failing and/or improperly located on-site sewage systems can produce significant loads of fecal bacteria. An on-site system may not be visibly failing but located too close to streams to properly treat sewage. If failing or improperly located septic systems that are in direct hydraulic contact with a stream and were the dominant source of bacteria loading, bacteria concentrations would likely remain constant in the winter between rainfall events when soil is saturated due to constant loading. This pattern has not been observed in the John Day River Basin with current data. Thus, while there may be some contribution from failing on-site sewage systems, this does not appear to be the dominant source of bacteria in John Day River Basin. However, bacteria could accumulate on the soil surface from a failing septic system. This surface load would be available for transport via runoff. This source and mode of transport is considered when assessing potential sources of bacteria in the John Day Basin.

Forest Managed Lands

Bacterial contamination in forested areas can result from a variety of sources including dispersed and developed recreation, wild and domestic animal populations, and human settlements (MacDonald, Smart, & Wissmar, 1991). In forested areas, high levels of fecal bacteria usually will be associated with inadequate waste disposal by recreational users, the presence of livestock or other animals in the stream channel or riparian zone, and poorly maintained on-site treatment systems (MacDonald, Smart, & Wissmar, 1991). Much of the forestland in the John Day Basin is publically owned and managed by the US Forest Service. There are four National Forests lying partly within the John Day Basin: the Umatilla, Malheur, Wallowa-Whitman and Ochoco National Forests. Non-federal forestry is regulated by the Oregon Department of Forestry.

Agricultural Lands

Approximately 54% of the John Day River Basin is classified as agricultural, with a relatively small part as irrigated farmland. Dryland wheat farming is common in the lower Basin. Rangeland livestock use varies across the Basin. The majority of the pasture/hay land is located adjacent to the streams. Bacteria from livestock waste can be transported to the stream during rainfall/runoff events or directly deposited to streams when livestock are wading. Wildlife are also commonly associated with agricultural land. Differing management practices including those that result in large irrigation return flows or near-stream livestock management may facilitate the delivery of fecal bacteria to water bodies from agricultural lands.

Irrigation

The predominant users of irrigation are individual appropriators in the John Day River Basin. There are no irrigation districts in the Basin, and there are some “ditch companies” or associations (personal communication with Basin Water Masters: E. Julsrud, November 16, 2009; Scott White, January 12, 2010). While irrigation operations themselves are not a source of fecal bacteria, the laterals and canals that are used to convey water can play a role in transporting bacterial contamination across the landscape and into surface waters. The timing and distribution of bacteria throughout the John Day River Basin may be influenced by the movement of irrigation waters.

Rural Residential and Urban Lands

Accumulation of bacteria on the land surface in residential area may result from pets, failing on-site systems, or wildlife. These loads could be transported to a stream via runoff of storm water, lawn watering, car washing, and other mechanisms. For small municipalities and rural residential areas such as those in the John Day Basin, storm water is generally regarded as a nonpoint source and can be addressed through an array of best management practices, structural and otherwise (storm water permitting does not generally apply and monitoring is typically not required). In addition to storm water runoff, another potential concern in urbanized areas is possible illicit or cross connections of storm drains and sanitary sewers resulting in untreated discharge.

3. METHODS OF TMDL ASSESSMENT

The steps of the John Day River Basin Bacteria TMDL process are discussed next. There are three general components of the process. First was the assessment of currently available water quality data. These data were organized and analyzed using graphical and statistical methods to gain a broad picture of the condition within the basin. Next, the flow duration curves (FDCs) and load duration curves (LDC) were developed. The FDCs and LDCs are the tool used to delineate loads and estimate load reductions, where necessary. The load reductions were calculated through the surrogate measure of percent reductions. The final step was to identify the essential TMDL components (load and wasteload allocations, margin of safety and reserve capacity) and their spatial and temporal applicability (generally discussed here and formally specified in Chapter 2.2).

3.1 Bacterial Die-off

Fecal coliform bacteria, of which *E. coli* is a subset, begin to die-off once excreted into the environment. The intestine of warm-blooded animals, which is native environment for these bacteria, provides warm constant temperatures and nutrients that are conducive to bacterial growth. Once excreted from their host, fecal bacteria typically have a limited ability to survive in water bodies (Benham, et al., 2006) or on the land surface (Soupir, Mostaghimi, Yagow, Hagedorn, & Vaughan, 2006; Mishra, Benham, & Mostaghimi, 2008). The bacteria encounter limited nutrient availability, osmotic stress, large variations in temperature and pH, UV radiation, and predation (USEPA, 2001; Winfield & Groisman, 2003). All of these factors influence the death rate of the bacteria. It is usually considered sufficient to approximate the die-off rate of *E. coli* bacteria using an exponential decay equation that is a function of concentration and temperature. Low survival rates of *E. coli* in water bodies have been well documented with an approximate half-life of 1 day (Winfield & Groisman, 2003; Benham, et al., 2006).

3.2 Bacterial Re-suspension

Fecal indicator bacteria can adhere to suspended particles in water, which then settle, causing an accumulation of bacteria in the bottom sediment (Davies, Long, Donald, & Ashbolt, 1995). Numerous studies have found fecal bacteria at greater concentrations (10 to 100 times) in the bottom sediment than in the overlying water in rivers, estuaries and beaches (Stephenson & Rychert, 1982; Struck, 1988; Obiri-Danson & Jones, 2000; Byappanahalli, Fowler, Shively, & Whitman, 2003; Winfield & Groisman, 2003). Re-suspension of bottom sediments has been shown to increase fecal indicator bacteria concentrations in the water column (Sherer, Miner, Moore, & Buckhouse, Indicator bacterial survival in stream sediments, 1992; Le Fevre & Lewis, 2003).

The higher concentrations of fecal indicator bacteria in sediment are attributed to much slower die-off rates when compared to overlying water (Gerba & McLeod, 1976; LaLiberte & Grimes, 1982; Burton, Gunnison, & Lanza, 1987; Sherer, Miner, Moore, & Buckhouse, Indicator bacterial survival in stream sediments, 1992; Davies, Long, Donald, & Ashbolt, 1995; Davies, Long, Donald, & Ashbolt, 1995). Also, the usual exponential decay model was found not to be appropriate for fecal coliforms in sediment (Davies, Long, Donald, & Ashbolt, 1995). Particle size distribution, nutrients and predation were hypothesized to influence survival rates; however, no quantitative relationship of survival rates with environmental factors was presented (Davies, Long, Donald, & Ashbolt, 1995).

Two recent field studies have indicated the possibility that fecal indicator bacteria can form a stable, dividing population in sediment in a temperate environment (Whitman & Nevers, 2003; Byappanahalli, Fowler, Shively, & Whitman, 2003). Some authors concluded that “more research into the environmental requirements and potential for in situ growth is necessary before *E. coli* multiplication in temperate environments can be confirmed, but this study provides initial data supporting that hypothesis" (Whitman & Nevers, 2003).

3.3 Review of Currently Available Bacteria Data

The listing method (period and minimum data quality and number of samples) used for the 2004/2006 Water Quality Assessment was applied in the selection of stations and time frame for this bacteria analysis. The locations of the stations are shown in **Figure E-2**. Most stations are located on the mainstem of the John Day River, with several located on the upper section. Data are available for the North and South Forks of the John Day River as well. There were no stations with the sufficient amount of data available for the Middle Fork John Day River. A simplified representation of the stations locations with nearby landmarks is presented in **Figure E-3**. The downstream, to upstream order that the stations are shown in **Figure E-3** was the order used to list the stations in the tables of this chapter. The 2004/2006 Water Quality Assessment criteria states: "Data collected since 1993. A minimum of 5 representative data points available per site collected on separate days per applicable time-period." ODEQ's LASAR database reported 13 stations in the basin that met these criteria. These stations are listed in **Table E-2**. All stations shown in **Figure E-2** are on the mainstem John Day River except 11020 (South Fork) and 11017 (North Fork).

Figure E-2. Locations of stations used in the TMDL with bacteria data

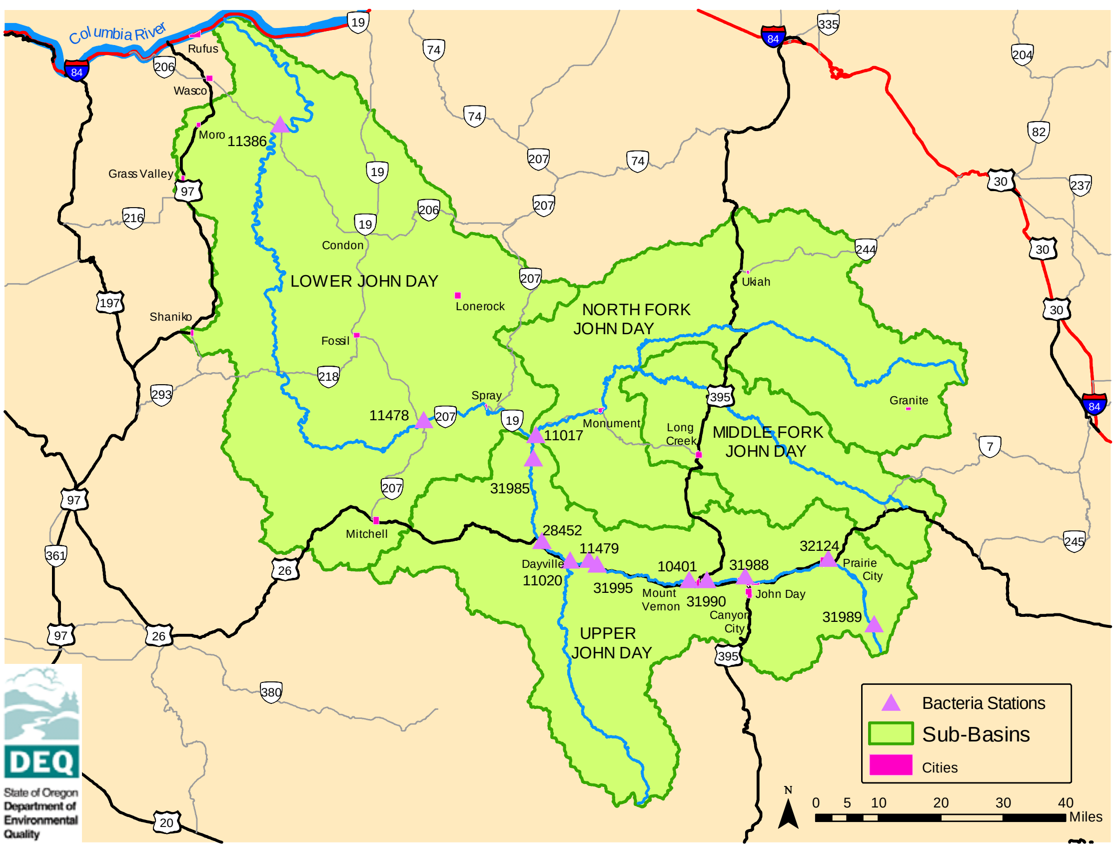


Figure E-3. Simplified diagram of station locations relative to named places

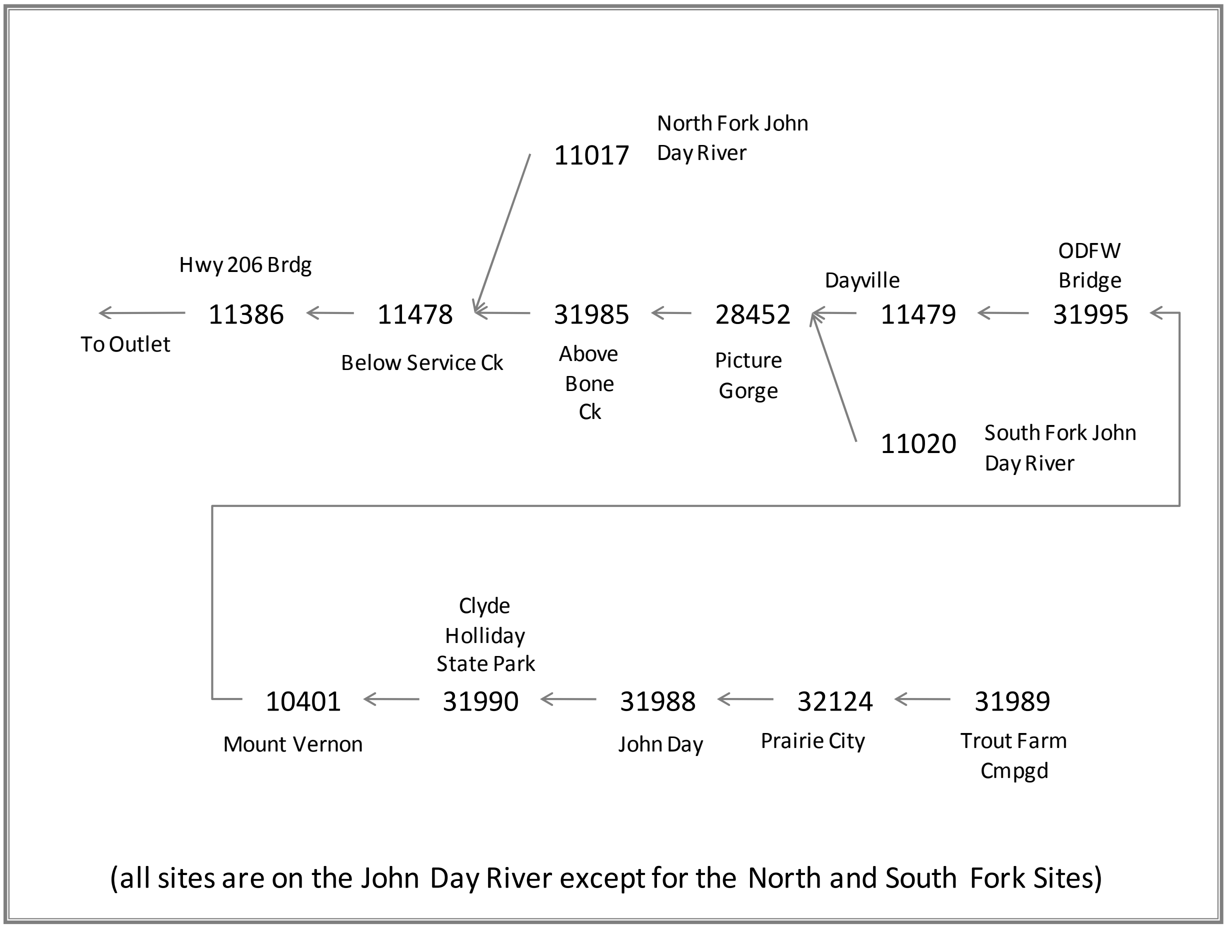


Table E-2. Stations used in bacteria TMDL

Station ID	Water Body	Description	Mainstem River Mile	Date Begin	Date End[1]	Number of Samples[2] FC/EC[3]	Ambient Station	Sub-Basin[4]
11386	John Day River	Cottonwood Bridge	39.0	2/24/1993	6/26/2008	54/74	Yes	Lower
11478	John Day River		154.5	2/24/1993	6/26/2008	54/74	Yes	Lower
11017	North Fork John Day River	Mouth at Kimberly	181.5	2/24/1993	6/26/2008	54/75	Yes	North
31985	John Day River	Near Service Creek	189.0	6/14/2005	4/27/2006	0/19	No	Upper
28452	John Day River	Picture Gorge	205.0	6/14/2005	4/27/2006	0/20	No	Upper
11020	South Fork John Day River	Dayville near mouth	212.0	2/24/1993	6/26/2008	55/75	Yes	Upper
11479	John Day River	3 miles above Dayville	215.0	2/24/1993	6/26/2008	55/94	Yes	Upper
31995	John Day River	7 miles above Dayville	218.5	6/14/2005	4/27/2006	0/20	No	Upper
10401	John Day River	Below Mt Vernon	238.0	6/14/205	4/27/206	0/20	No	Upper
31990	John Day River	Clyde Holliday State Park	241.0	6/14/2005	4/27/2006	0/20	No	Upper
31988	John Day River	City of John Day (below WWTP)	247.0	6/14/2005	4/27/2006	0/20	No	Upper
32124	John Day River	Above Prairie City	258.0	6/14/2005	4/27/2006	0/20	No	Upper
31989	John Day River	USFS Trout Farm Campground above Prairie City	279.0	6/14/2005	4/27/2006	0/19	No	Upper

[1] As off 10/7/2008
[2] Daily values of QA/QC Status B or better
[3] FC – Number of Fecal Coliform samples and EC – Number of *E. coli* samples
[4] North Fork – North Fork John Day Sub-Basin (HUC 17070202), Upper – Upper John Day Sub-Basin (HUC 17070201), Lower – Lower John Day Sub-Basin (HUC 17070204)

3.4 Use of Fecal Coliform Data

While the TMDL targets *E. coli*, fecal coliform data collected in the Basin were also used in this bacteria assessment. Prior to 1996, the bacteria water quality standard used fecal coliform as the indicator bacteria. The current standard uses *E. coli*. For the stations in the John Day Basin, there were no *E. coli* data collected before February of 1996. From 1996 through 2002, both fecal coliform and *E. coli* data were collected. After June 2002, only *E. coli* data were collected in the John Day River Basin. Rather than excluding the fecal coliform data from this analysis, the fecal coliform data were converted to equivalent *E. coli* concentrations using a regression equation. The following regression equation was developed specifically for Oregon (Cude, 2005):

$$FC = 1.82 \times EC^{0.946}$$

Where:
FC is the Fecal Coliform concentration (organisms / 100 ml) and,
EC is the *E. coli* concentration (organisms / 100 ml)

The fecal coliform concentrations collected from 1993 through 1995 were also converted to the equivalent *E. coli* concentrations, using the same equation. This was done to provide continuity of the data for longer-term conditions across the entire assessment period. For clarity, we note here that exceedance of the current standard by the estimated *E. coli* concentrations prior to 1996 would not be considered violations of the standard. The bacteria standard prior to 1996 used fecal coliform and the criteria were 200 organisms/100 ml as a 30-day log mean and a single sample criterion of 400 organisms/100 ml.

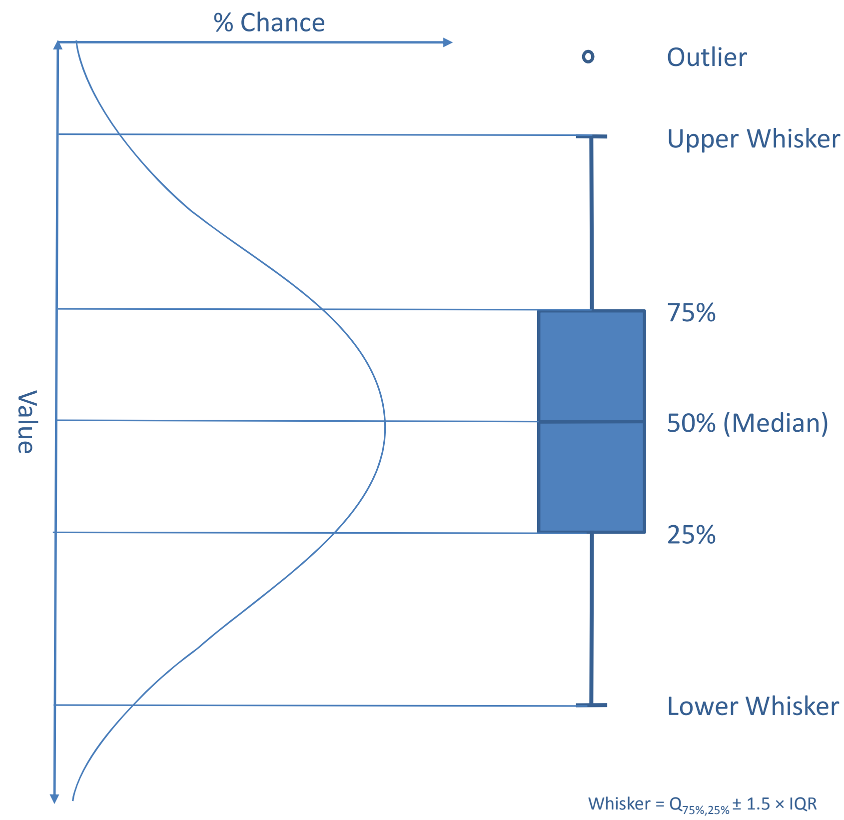
3.5 Analytical Methods Overview

DEQ developed the John Day River Basin Bacteria TMDL using data collected by DEQ, OWRD, and USGS. The *E. coli* data were collected by DEQ and flow was measured by OWRD, USGS and DEQ. All water quality data used in this TMDL have passed DEQ approved QA/QC procedures and, unless otherwise noted, have achieved a data quality level of B or better. DEQ used box and whisker plots and load duration curves in the development of the bacteria John Day River Basin TMDL. These graphic analytical techniques are described in the following sections.

Box and Whisker Plots

DEQ used box-and whisker-plots (box plots) to assess the longitudinal and temporal distribution of the bacteria data. Box and whisker plots illustrate several data characteristics, such as extreme values (outliers). Box and whisker plots use the median as a measure of central tendency and the interquartile range (the 25th percentile to 75th percentile) as a measure of dispersion. **Figure E-4** shows an example of box and whisker plots and how they are interpreted. Where sufficient data were available, box and whisker plots were created longitudinally to highlight potential spatial differences associated with land use, tributaries, or point sources along a river reach. Box and whisker plots were also created for different seasons (e.g. spring/summer or irrigation) to investigate the presence of temporal patterns in the bacteria data.

Figure E-4. Box and Whisker Plot example



Flow Duration Curves and Load Duration Curves

Load duration curves (LDC) were used to estimate bacteria loads and compare the observed loads to the water quality criteria (targets). Load duration curves are a method of determining a flow based loading capacity, assessing current conditions, and calculating the necessary reductions to comply with water quality criteria. A LDC is a plot of load (y-axis) against flow (x-axis), where flow is expressed as an exceedance probability. Examples are displayed in following sections. Flow data for the LDC are based on daily average flow for the full year over many years of record. DEQ chose the load duration curve approach because it illustrates bacteria loading under various flow and seasonal conditions and can be used to help target appropriate water quality restoration efforts (Cleland, 2002). For the LDC, each bacterial load was based on measured *E. coli* concentration. Loads were calculated by multiplying sample concentration by daily average discharge. Flow measurements were not available for all samples. The method for preparing the incomplete flow data sets is included in the following section.

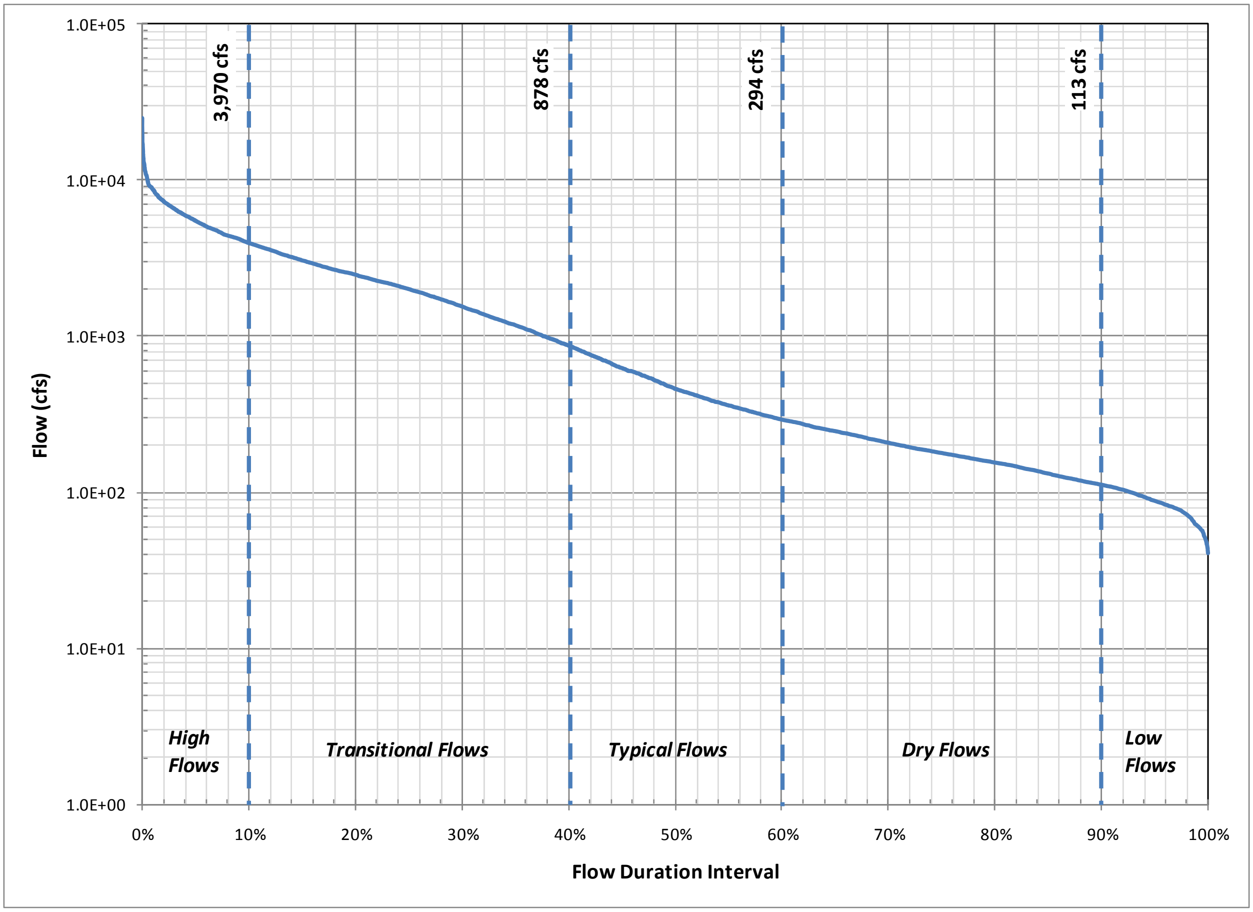
Source of Flow Data

River and stream flow data are needed to create Load Durations Curves (LDCs) for the bacteria data (Cleland, 2002). Various sources of flow data were investigated for use in the LDC development. The main source of flow data was from the USGS stream gage network (USGS, 2009). Flow data were assigned to each bacteria station and missing flow data were estimated using regression equations from near-by stations.

Flow Duration Curve Explanation

Flow duration curves provide the underpinning of load duration curves. A Flow Duration Curve (FDC) shows the percentage of time flow in a stream is likely to equal or exceed some specified value of interest. An FDC is used to estimate percent of the time that a flow will be equal to or greater the specified value (e.g. 35 cfs will be exceeded 60% of the time). The method used to calculate values for the FDC is based on ranking the ordered series of historical flows and then dividing by the total number of observations. The ratio of the rank of each historical stream flow and the total number of historical observation times 100 is the percent exceedance of the flow. An FDC was developed for each LDC station. **Figure E-5** displays an example flow duration curve. The percentile flow ranges are from previous TMDLs developed in Oregon.

Figure E-5. Example of a flow duration curve



Stations Utilized for Load Duration Curves

A number of flow stations were available to develop the LDCs for the John Day Basin. There were 24 flow stations located throughout the basin that had sufficiently recent data (collected in the past 30 years). A cutoff of 30 years was invoked in this analysis to ensure that flow and bacteria samples were collected under comparable land cover, climate and management conditions. The locations of the flow and bacteria stations are shown in **Figure E-6**. Six gaging stations were used to develop the LDCs. These stations are indicated in **Figure E-6** with a purple triangle with the gage number adjacent to the symbol. These stations were selected based on the location relative to the bacteria stations and the completeness of the flow record.

The stations and period of records for the flow data is listed in **Table E-3**. The pairings of bacteria and flow stations are listed in **Table E-4**.

Figure E-6. Potential and selected flow station and bacteria station locations

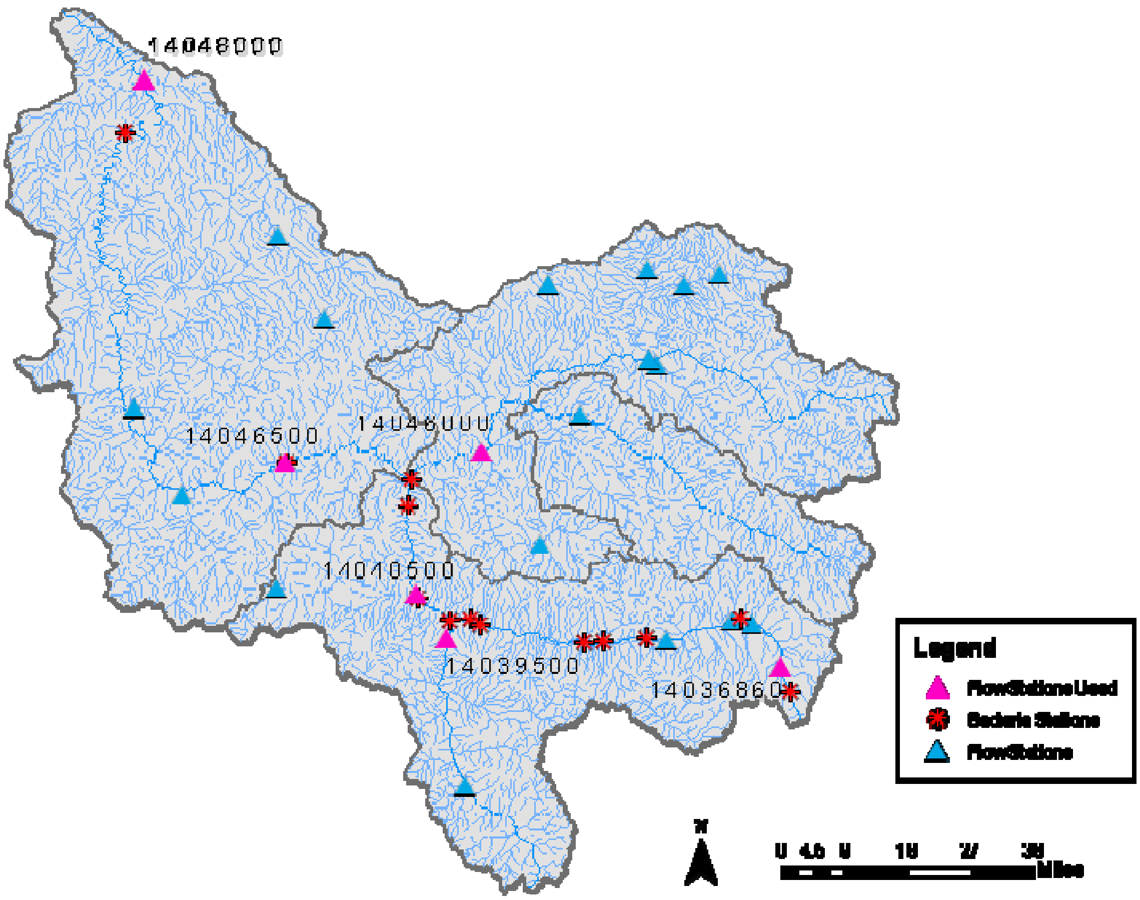


Table E-3. Flow stations used for LDC development

Station	Station Name	Period of Flow Record
14036860	John Day River at Blue Mountain Hot Springs near Prairie City, OR	1996-Present
14039500	South Fork John Day near Dayville, OR	1986-2007
14040500	John Day River at Picture Gorge near Dayville, OR	1978-1991
14046500	John Day River at Service Creek, OR	1929-Present
14048000	John Day River at McDonald Ferry, OR	1978-Present

Derived Flow Data

Since the locations of the bacteria and flow stations were generally not the same, adjustment factors were used. The factor was the ratio of the drainage area of the bacteria station to the drainage area of the flow station. The flow volume for a station was multiplied by the appropriate adjustment factor to get the flow volume at the bacteria station. The time period of flow data available at many of the stations did not completely cover the time period of bacteria data collection. On dates that bacteria samples were collected and there was no flow data recorded at the assigned flow station, the flow data was estimated using regression equations.

Table E-4. Assigned flow station for each bacteria station

Bacteria Station	Drainage Area (mi^2)	Flow Stations	Drainage Area (mi^2)	Flow Adjustment Factor
11386	6,916	14048000	7,626	0.91
11478	5,135	14046500	5,135	1.00
11017	2,634	14046000	2,530	1.04
31985	2,085	14046500	5,135	0.41
28452	1,672	14040500	1,686	0.99
11020	605	14039500[b]	596	1.01
11479	959	14040500	1,686	0.57
31995	940	14040500	1,686	0.56
10401	712	14040500	1,686	0.42
31990	574	14040500	1,686	0.34
31988	518	14040500	1,686	0.31
32124	170	14040500	1,686	0.10
31989	12	14036860	1.89	6.11

[a] Data period for assessment bacteria data was 1993 to 2008. Longer data period for flow data was used to have more data for regression analysis.
[b] All stations are from USGS except 14039500, which is operated by Oregon Water Resources Department (OWRD).

Linear regression was performed among the flow stations to develop equations. The linear regression function (lm) in the statistical software "R" (R Development Core Team, 2009), was used to perform the regressions. The approach used was to estimate missing values from nearby stations with more complete data sets. The regression equations for the 4 stations that were missing data are listed in **Table E-5**. All the regressions used data from station 14046500. The regression equations performed well, as demonstrated by the high r^2 values.

Table E-5. Regression equations for flow stations with missing data

Station	Regression Equation	r2
14040500	$0.2577 \times Q_{14046500}$	0.93
14036860	$0.0165 \times Q_{14046500}$	0.55
14039500	$0.0849 \times Q_{14046500}$	0.78
14048000	$1.071 \times Q_{14046500}$	0.95

Load Duration Curve Development

Each bacteria observation was assigned a daily flow volumetric rate. The assignment was accomplished using the “vlookup” function in MS Excel. If there was not an observed flow available for the date of the bacteria sample, the regression equations were used. The daily load for the bacteria observation is the concentration multiplied by the daily flow volume.

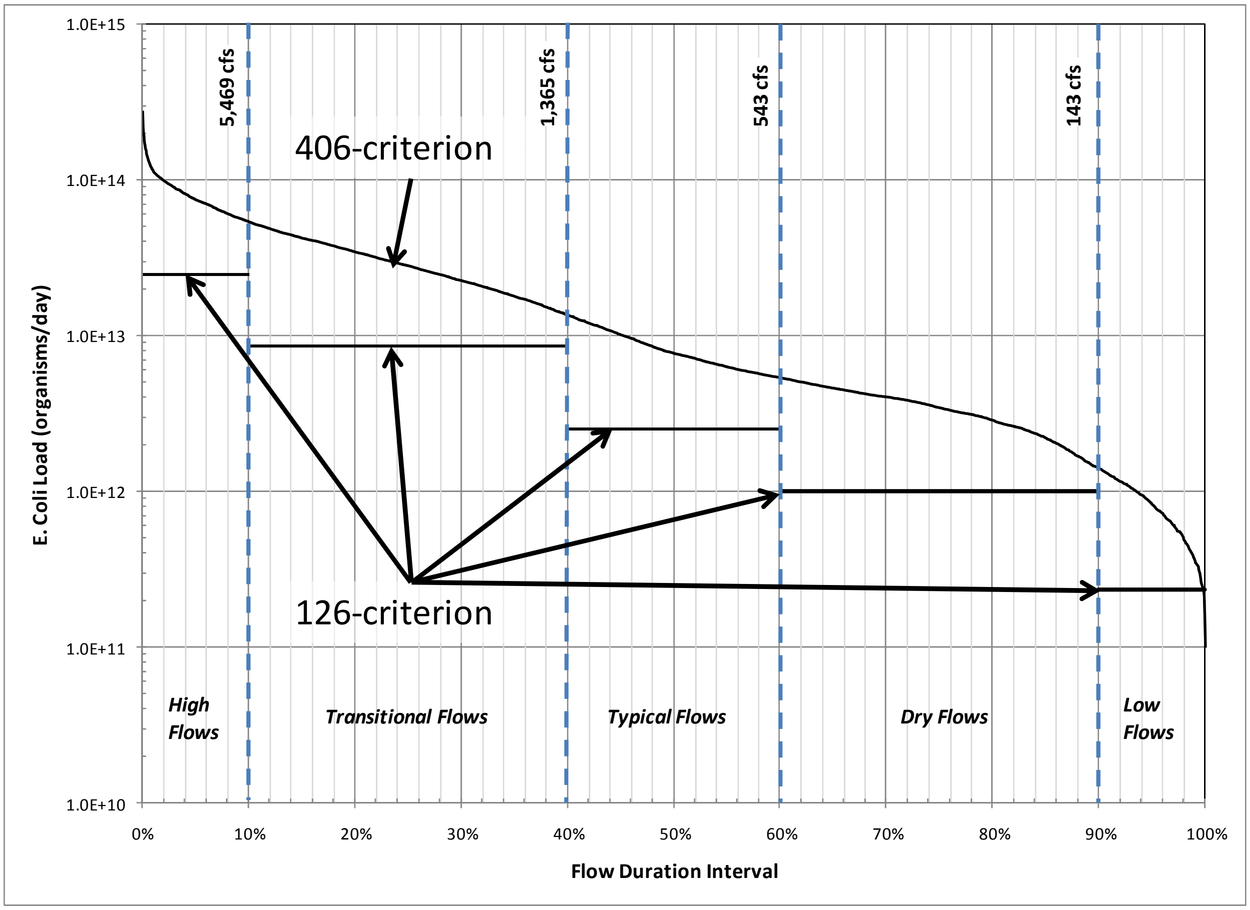
Bacterial loads are plotted in relation to the likelihood that a given flow rate will occur (exceedance probability on the x-axis) based on historical flow data. Low flows have a high exceedance probability, while high flows have a low exceedance probability. The range of observed flows was separated into five categories based on flow percentiles: high (<10%), transitional (10-40%), typical (40-60%), dry (60-90%), and low (>90%). These flow ranges were delineated by DEQ staff and have been applied in other TMDLs (DEQ 2003; DEQ 2006a; DEQ 2006b).

As mentioned previously, load duration curves can be used to make flow-based source assessments. For instance, high fecal bacteria values that occur during dry of low flow periods (60-100% flow) may be due to sources not associated with storm/snow melt runoff, such as point sources, direct deposition from animals, or irrigation return flow. Bacteria levels during high flow periods (e.g., 10-40% flow, called wet weather) are influenced by nonpoint sources from the landscape, generally associated with surface runoff events.

Loading capacity and Reduction Calculations

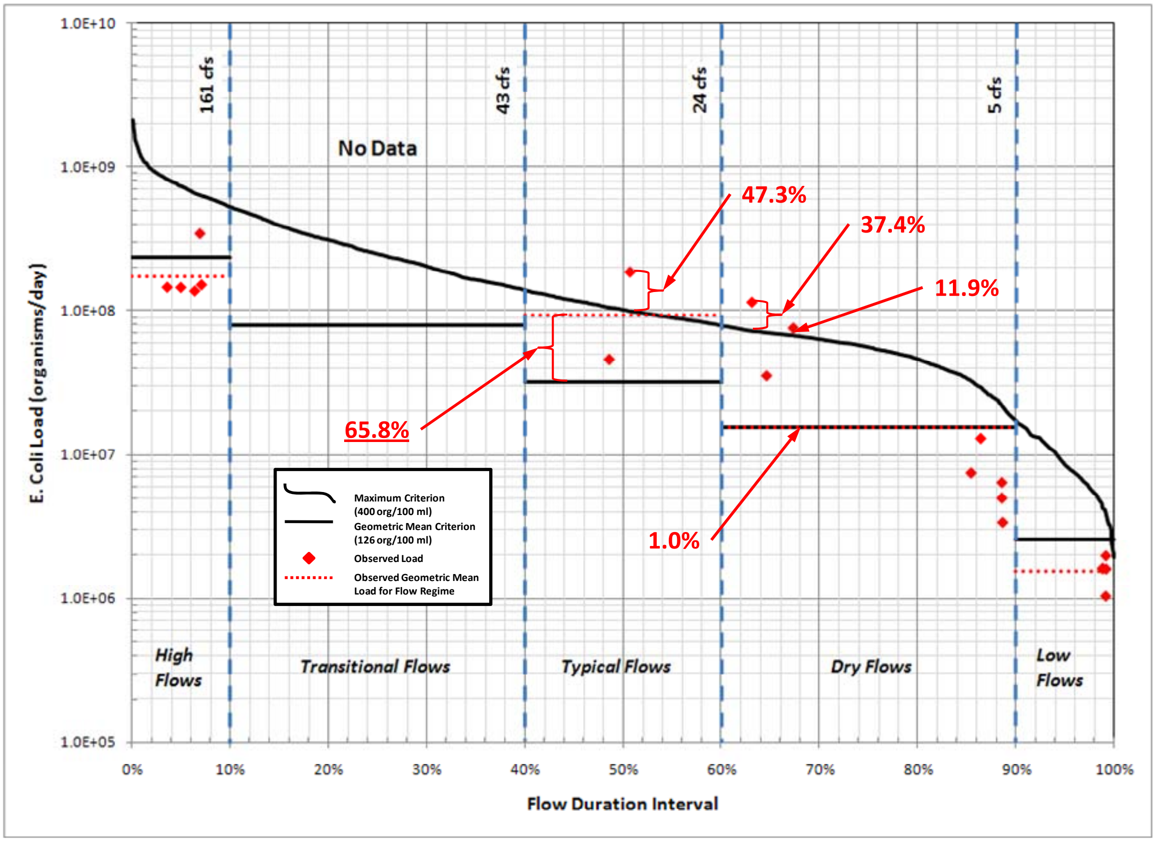
The term ‘loading capacity’ is defined as “the greatest amount of loading that a water body can receive without violating water quality standards.” [OAR 340-041-0002(30)]. Loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring a water body into compliance with standards. Loading capacities for this TMDL are based on the load duration curve method. The bacteria loading capacities are determined by multiplying the applicable criteria (126 *E. coli* /100 ml or 406 *E. coli* /100 ml) by the daily flow, expressed in terms of number of organisms per day. An example of the loading capacity for the two criteria is shown in **Figure E-7**. The continuous curve in **Figure E-7** represents the loads associated with the 406 *E. coli*/100 ml criterion. For the long-term bacteria data sets, measurements were not sufficiently frequent (30 day and at least five samples) to apply the 126 *E. coli*/100 ml criterion. The log means of the loads (assessed for each daily flow value) for each flow regime were calculated instead. The loading capacity for the 126 *E. coli*/100 ml criterion are the horizontal lines in **Figure E-7** and represent a step-function across the flow regimes.

Figure E-7. Example of LDC for loading capacity



Percent reduction targets needed to meet the loading capacity were determined by comparing the observed loads to the loading capacity. The log mean and maximum values of the observed loads within the flow intervals were compared with the 126 and 406 *E. coli* / 100ml criteria, respectively. Percent reduction targets were calculated based on the difference between the applicable criteria and observed *E. coli* loads. The reduction targets have been calculated for each of the five flow regimes and are displayed on the LDC. **Figure E-8** demonstrates the graphical representation of the observed bacteria loads as compared to the loading capacity. The red dashed-lines are the flow-range log means of observed *E. coli* loads and the red diamonds are the individual observed *E. coli* loads. In **Figure E-8**, where a reduction of bacteria is required to meet the bacteria criteria, an arrow was added, as well as the percent reduction value. The maximum reduction for a station is the maximum of all of the reductions for both criteria across all of the flow regimes.

Figure E-8. Example of LDC with loading capacity and percent reductions



Note that in this TMDL, the distinction between sources, such as wildlife, livestock, failing septic systems, urban runoff, and agricultural runoff, was not possible because of the complex movement of water around the watershed as well as the complexity of spatially overlapping sources. Therefore, all percent reduction targets generally apply to all upstream land within the specified basin or tributary watershed, and loading capacities were not separated into human-activity and natural components.

4. RESULTS

The bacteria data from the John Day Basin displayed seasonal variation and there were several stations where load reductions are needed. The locations and number of samples are show in a simplified diagram in **Figure E-9**. The general statistics for the stations are presented in **Table E-6**. The box and whisker plots were generated by station, station-303(d) assessment definition of seasons, and 3-month seasons. The LDCs for each station are presented in the next section. Six stations require reductions.

4.1 General Statistics

Five of the thirteen stations had 90 or more samples over the assessment period of Jan-1993 to Sept-2008. Eight stations had 20 or less observations over a sampling period of 2005 to 2006. ml. Seven of the thirteen stations had a maximum concentration below the 406 organisms/100 ml criterion. Except for station 32124, the 90th percentile bacteria concentration was less than the maximum criteria of 406 *E. coli*/100 ml (**Table E-6**), which indicates that the bacteria water quality criterion is being met most of the time at most of the stations. The distribution of the bacteria data is skewed, so the observations may vary over orders of magnitude, and the log means and the medians are similar. This indicates that the log mean is a better indicator of central tendency than the arithmetic mean. Therefore, a logarithmic scale was used for the y-axis (concentration and load data) of graphs rather than a linear one.

4.2 Box and whisker plots

Box and whisker plots were made using three different groupings of the data: by station, by season used in the 303(d) methodology, and by the standard 3-month season. A $\log_{10}$ scale was used for the y-axis of all the box and whisker plots.

4.3 By Station

Most of the observations were below the maximum criterion of 406 *E. coli*/100 ml (See **Figure E-10**). Many of the observations were identified as outliers (see **Figure E-4** for outlier definition) at the upper data range. These observations may not be outliers and may be an artifact of the skewed data set. Of all the stations, 11479 generally had the largest observed concentrations and 31989 the lowest (**Figure E-10**). As a general observation, the digressions above the maximum criterion occur at several stations but do not occur frequently at any of these stations. This may indicate the occurrence of acute conditions that cause the digression rather than a chronic problem, which would cause persistent digressions of the criterion.

4.4 By stations then Season

Bacteria concentrations were generally greater during the summer (defined in the 303(d) list methodology as June 1 – Sept 30) season (**Figure E-11**). At stations 11478 and 31985, the median for the summer were lower than the Fall/Winter/Summer medians, but the maximum values occurred in the summer at both stations. All of the digressions of the maximum criterion occurred in the summer season, except at station 11479, which had some digressions in the Fall/Winter/Summer season. The high concentrations in the summer may be related to low flow conditions. Small sources of bacteria entering the stream during low flow conditions could cause sharp spikes in concentration. The predominance of higher concentrations in the summer is more apparent for the 3-month seasons used in **Figure E-12**. The digressions of the maximum criterion only occur during the summer at all stations, except for station 11479. At station 11479, there are some digressions during every 3-month season, with the most occurring during the summer. The digressions of the maximum criterion throughout the year at station 11479 may be the result of a persistent bacteria source.

Scatter plots were created to investigate possible temporal changes in bacteria concentration over time (**Figure E-14** through **Figure E-18**). For the stations with less than 20 observations, the scatter plots are not very useful. These data were collected over the period of 2005-2006. The data from the stations with less than 20 observations were included to convey the shortness of the sampling period (2005-2006) and when the sampling occurred. The scatter plots for the five stations with more than 20 observations (stations 11017, 11020, 11386, 11478, and 11479) do not show any distinct changes in the bacteria concentrations over the assessment period. The digressions of the maximum criteria are sporadic and occur throughout the assessment period.

The maximum concentrations for the different seasons were investigated using bar plots. The maximum concentration was investigated because it would drive the amount of load reductions required to achieve water quality criteria. Both 303(d) defined seasons (**Figure E-19** through **Figure E-22**) and the standard 3-month seasons (**Figure E-23** through **Figure E-26**) were used. As seen in the other plot grouped by the seasons, the largest values occurred in the summer and the next largest concentrations occurred in the spring or fall.

Figure E-9. Simplified diagram of station locations with number of samples

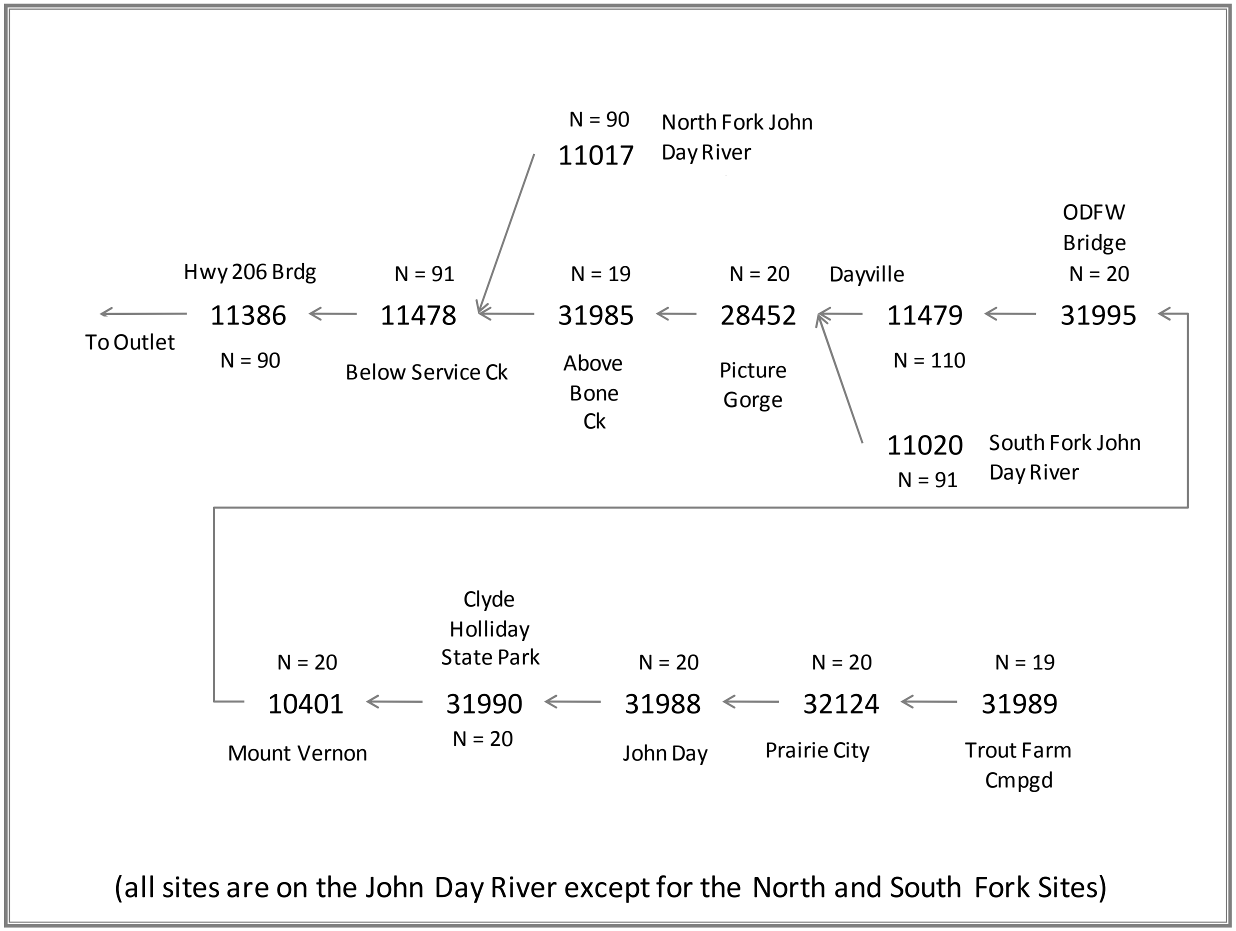


Table E-6. General statistics for bacteria data by station

Station	N	Arithmetic Mean	Log mean	Standard Deviation	Min	10th percentile	25th percentile	Median	75th percentile	90th percentile	Max
11386	90	78	9	293	1	2	2	7	22	72	1986
11478	91	28	10	55	1	2	4	8	29	56	369
11017	90	30	13	50	1	3	5	12	32	82	264
31985	19	42	32	33	6	14	19	32	50	85	137
28452	20	67	49	67	13	22	33	40	69	152	291
11020	91	66	25	152	1	4	8	29	70	123	1323
11479	110	129	64	192	1	20	33	64	139	283	1323
31995	20	72	59	59	32	34	38	50	66	162	261
10401	20	116	86	88	19	33	45	93	158	207	365
31990	20	124	74	154	20	23	35	63	140	296	649
31988	20	243	95	552	27	35	46	82	124	265	2419
32124	20	207	158	194	64	80	93	152	202	480	770
31989	19	2	2	1	1	1	1	1	3	3	6

Figure E-10. Box and whisker plots of bacteria concentrations by stations

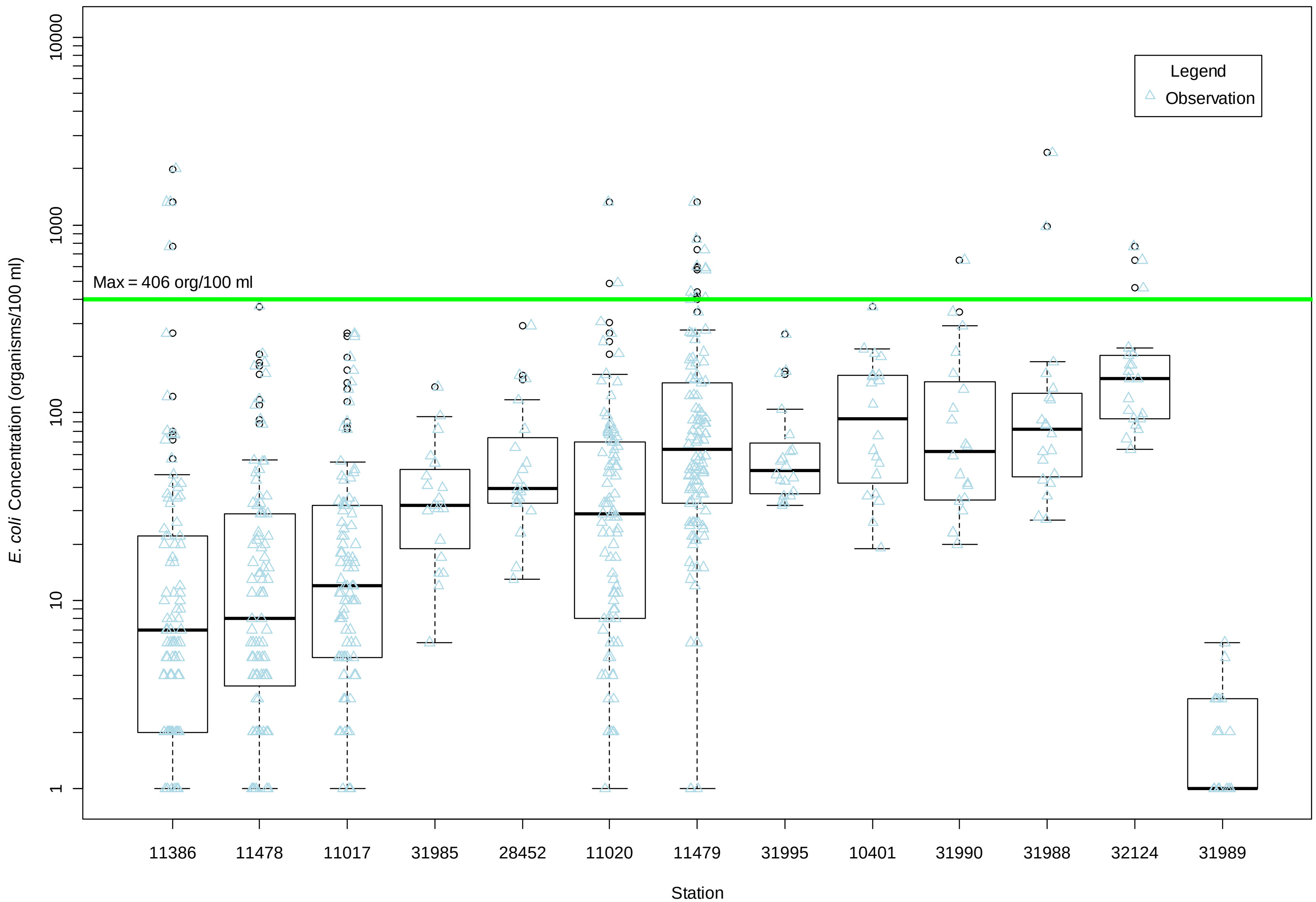


Figure E-11. Box and whisker plots by seasons used for 303(d) report

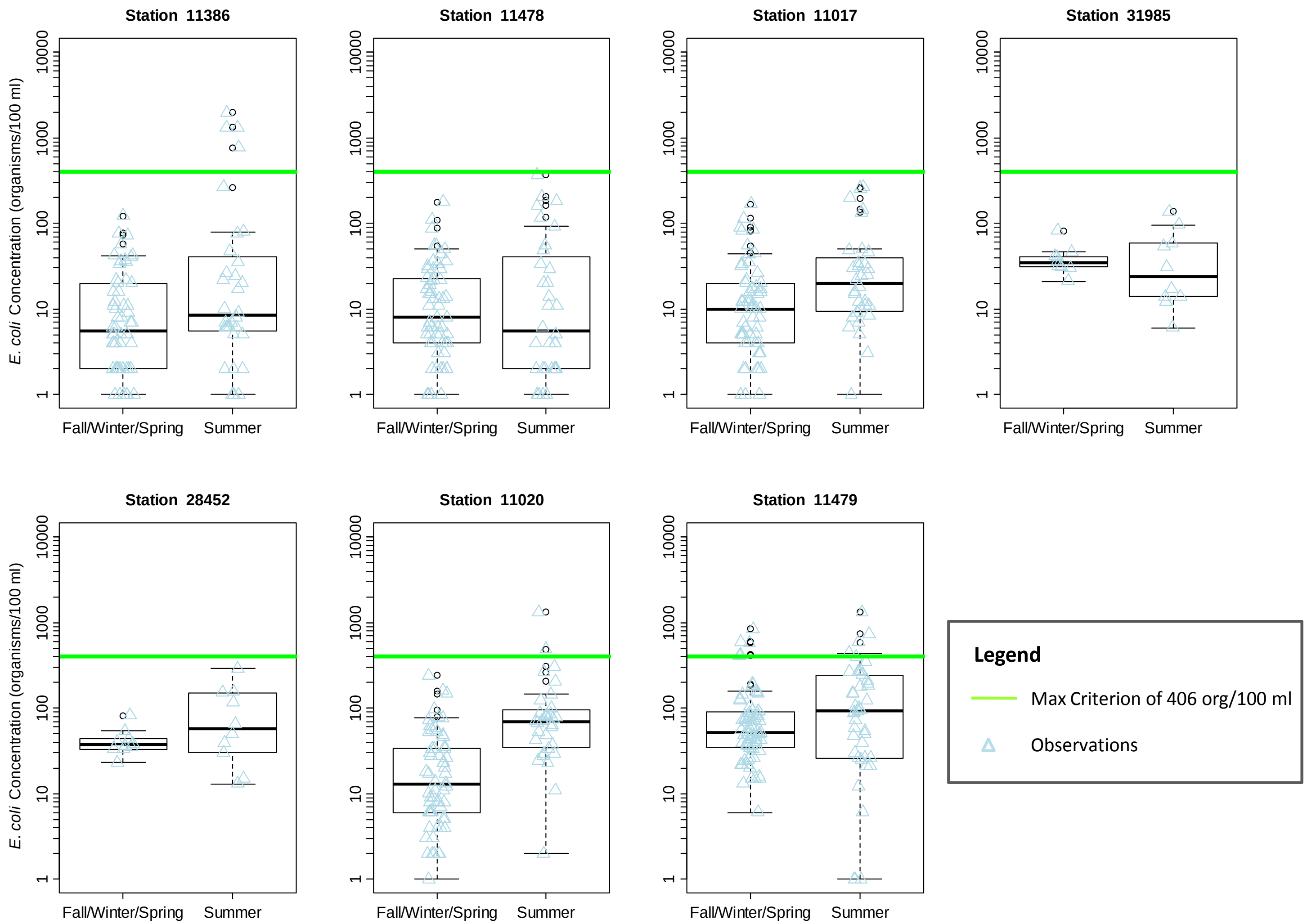


Figure E-11. Box and whisker plots by seasons used for 303(d) report (Continued)

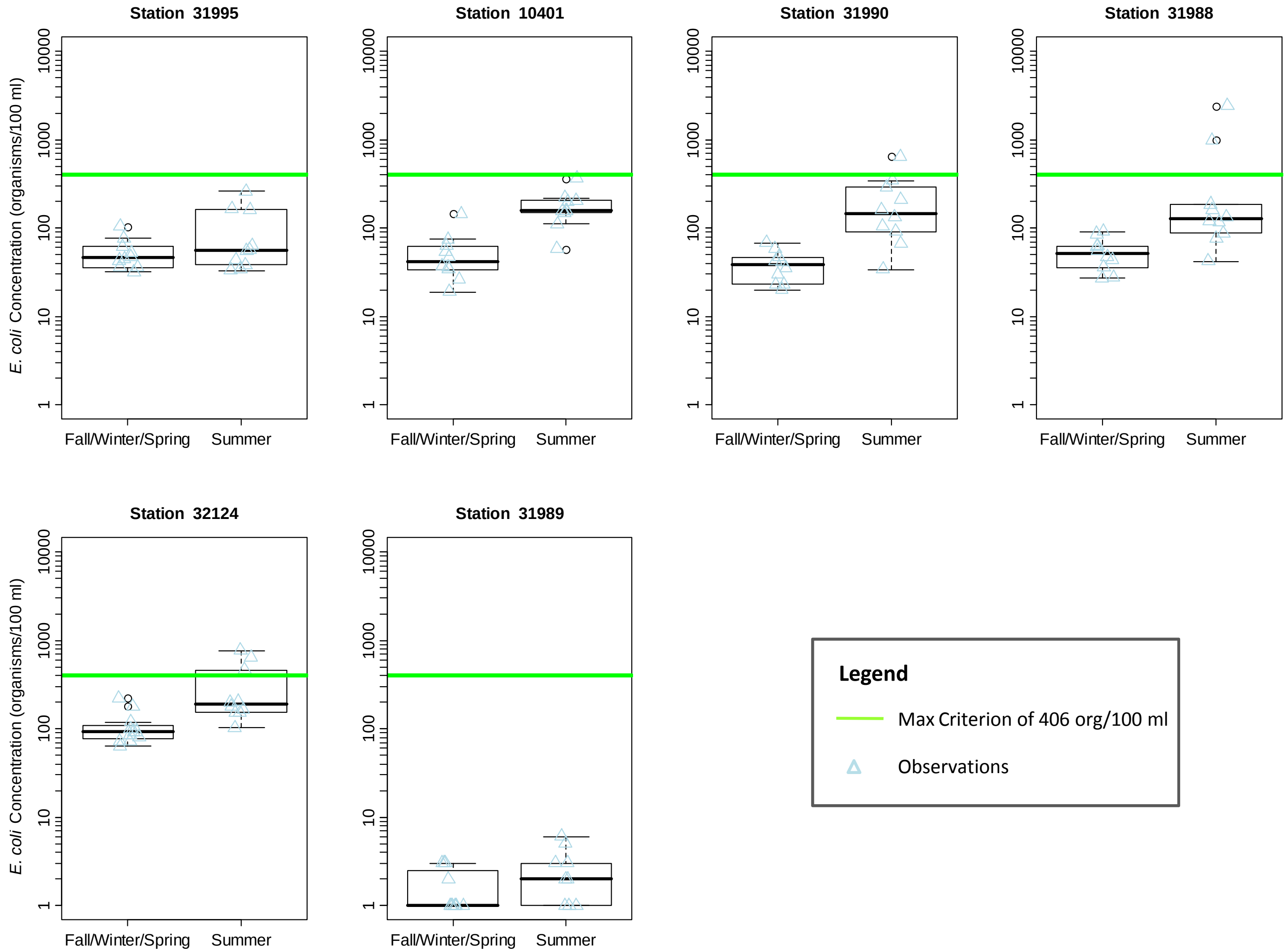


Figure E-12. Box and whisker plots by standard three-month seasons

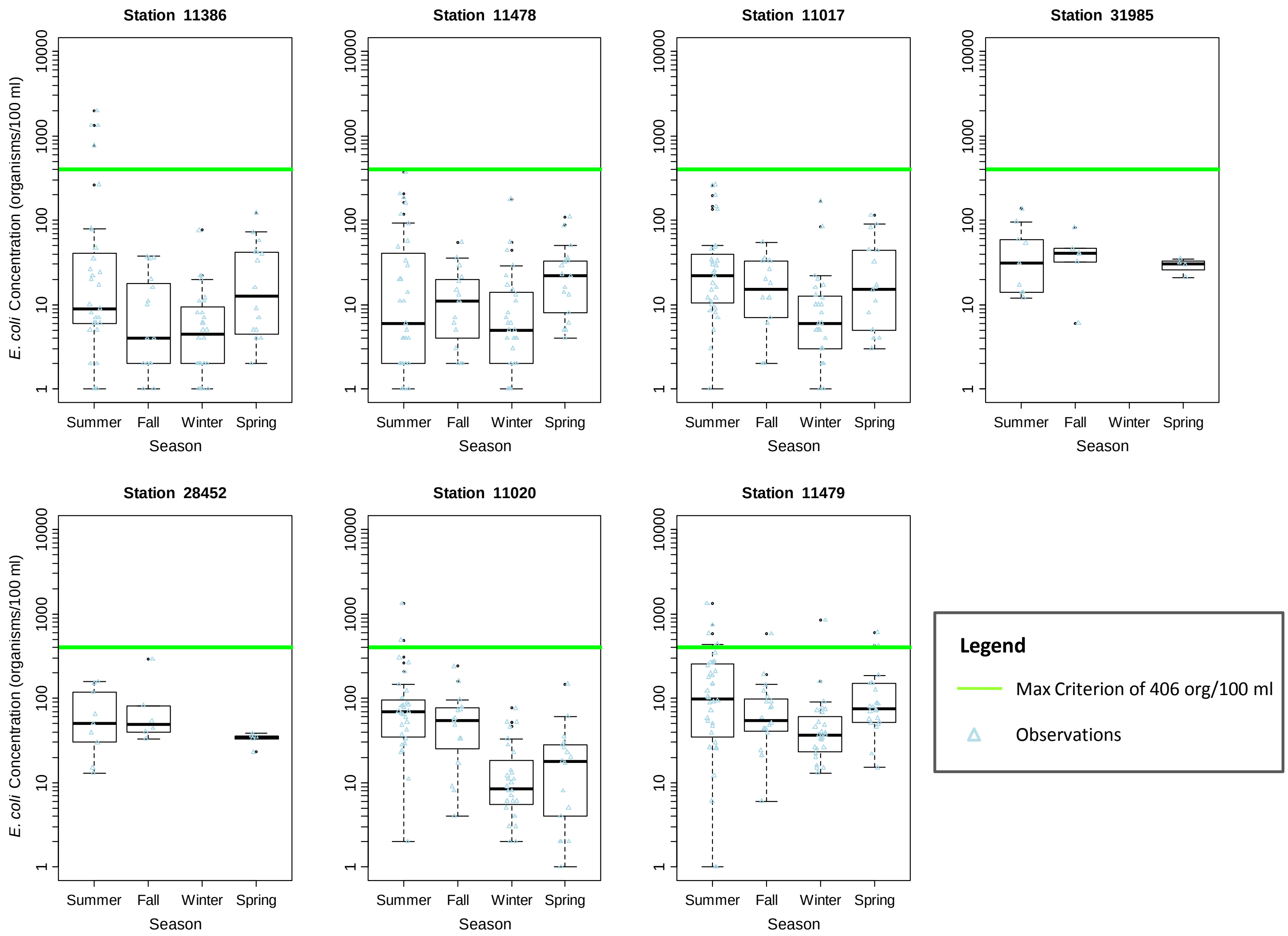


Figure E-12. Box and whisker plots by standard three-month seasons (Continued)

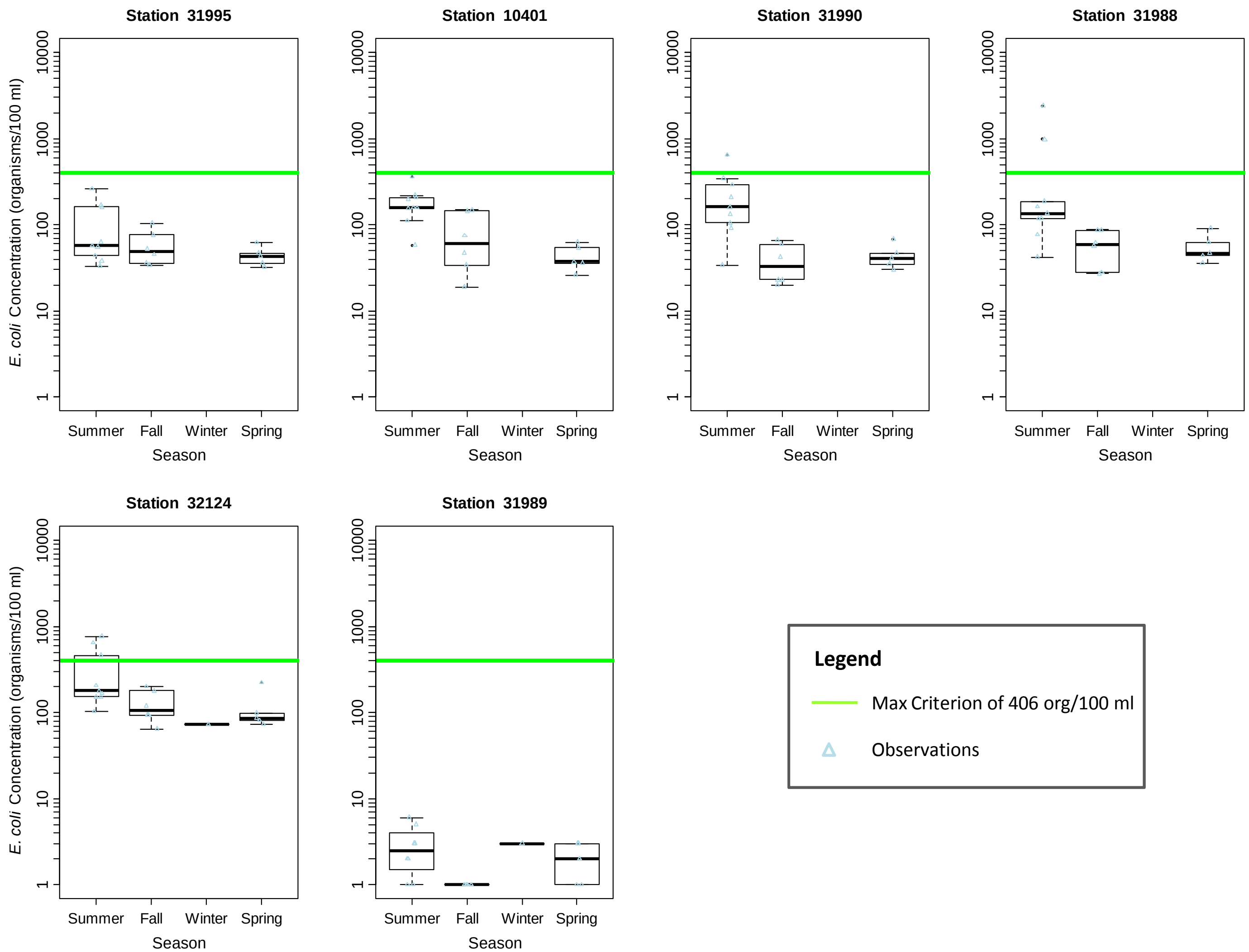


Figure E-13. Box and whisker plots of bacteria concentrations by stations for summer season only

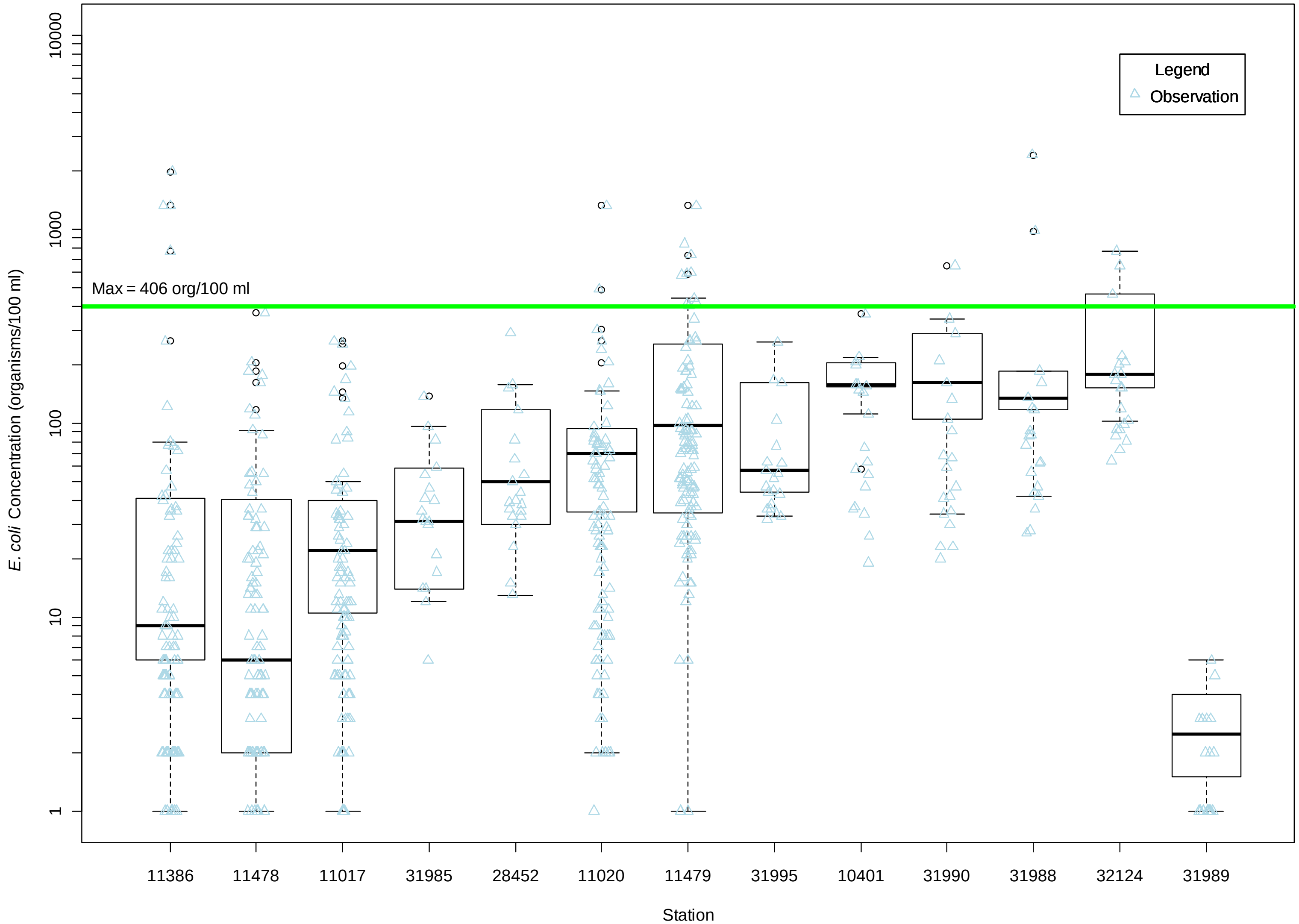


Figure E-14. Scatter plots of *E. coli* concentration versus time for stations 11386, 11478, and 11017

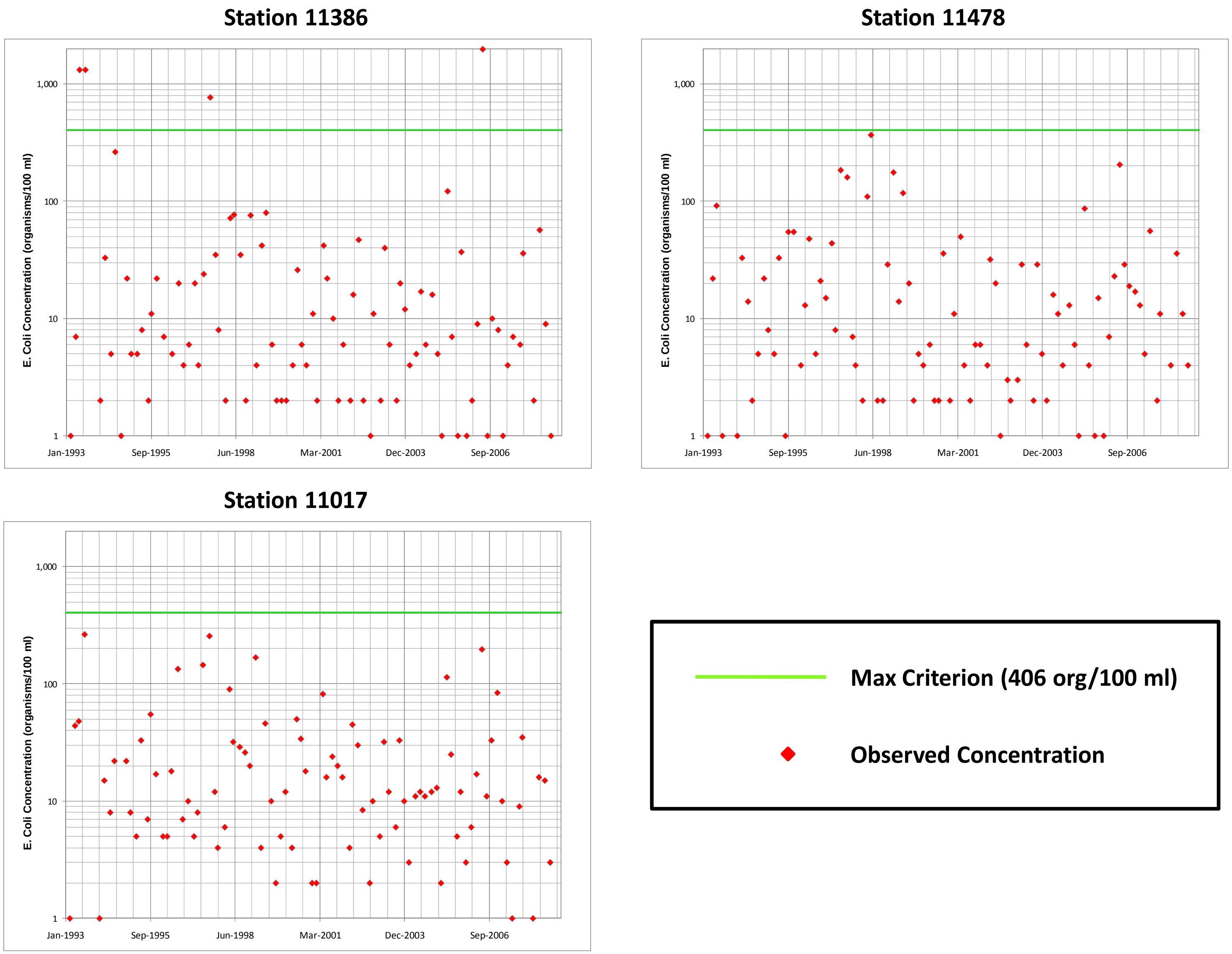


Figure E-15. Scatter plots of *E. coli* concentration versus time for stations 31985, 28452, and 11020

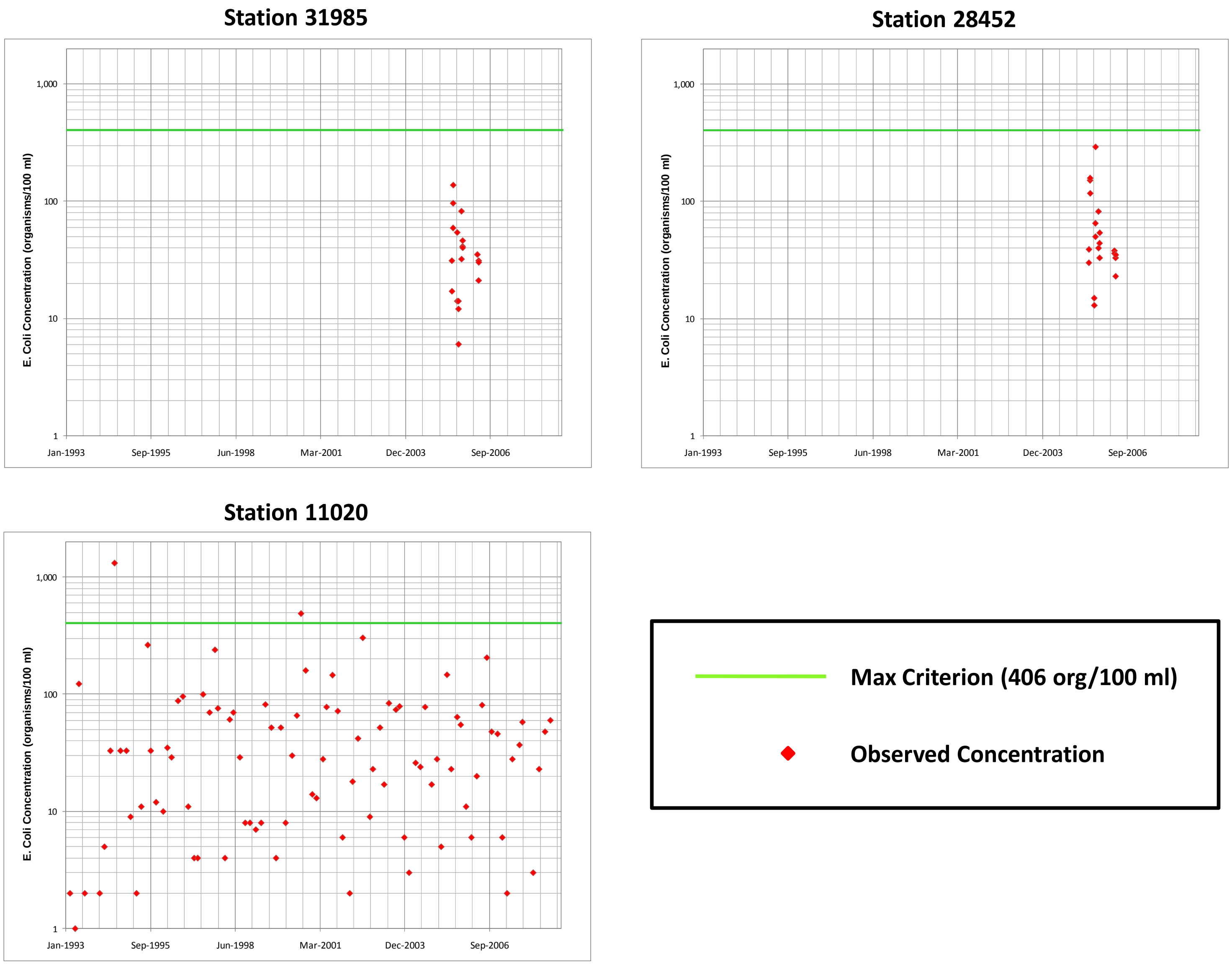


Figure E-16. Scatter plots of *E. coli* concentration versus time for stations 11479, 31995, and 10401

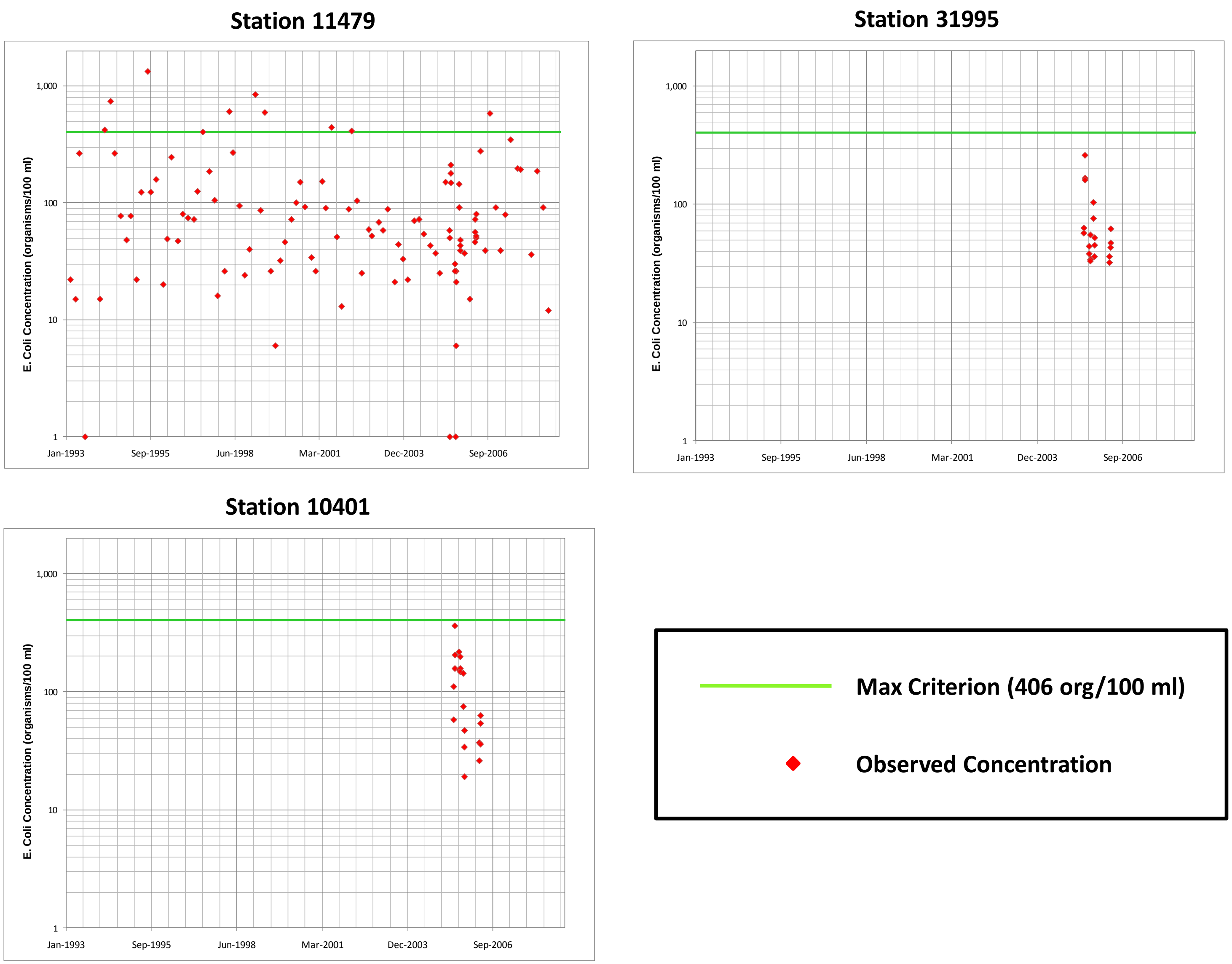


Figure E-17. Scatter plots of *E. coli* concentration versus time for stations 31990 and 31988

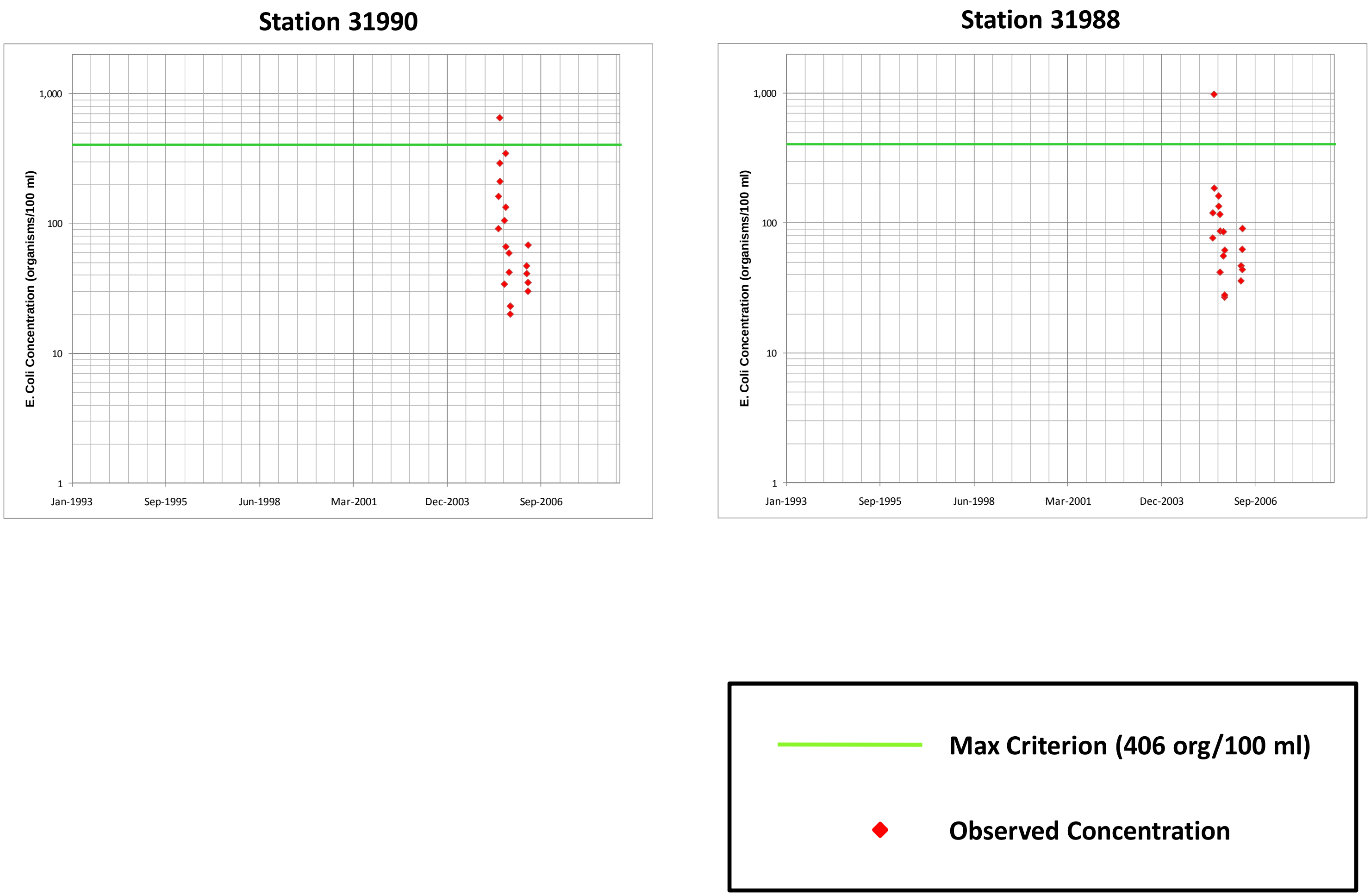


Figure E-18. Scatter plots of *E. coli* concentration versus time for stations 32124 and 31989

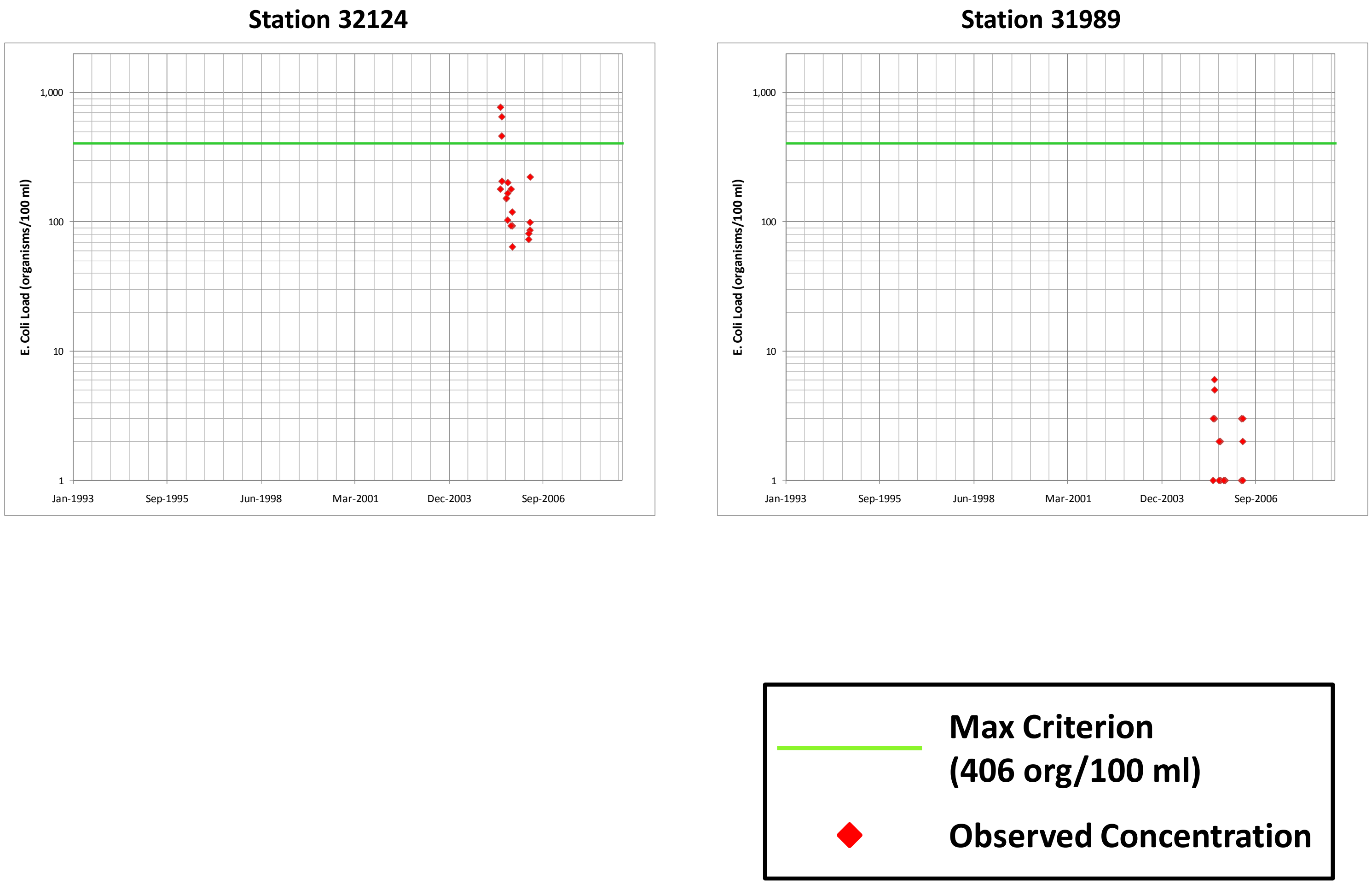


Figure E-19. Maximum E. coli concentration by seasons used in 303(d) report methodology (for stations 11386, 11478, 11017, and 31985)

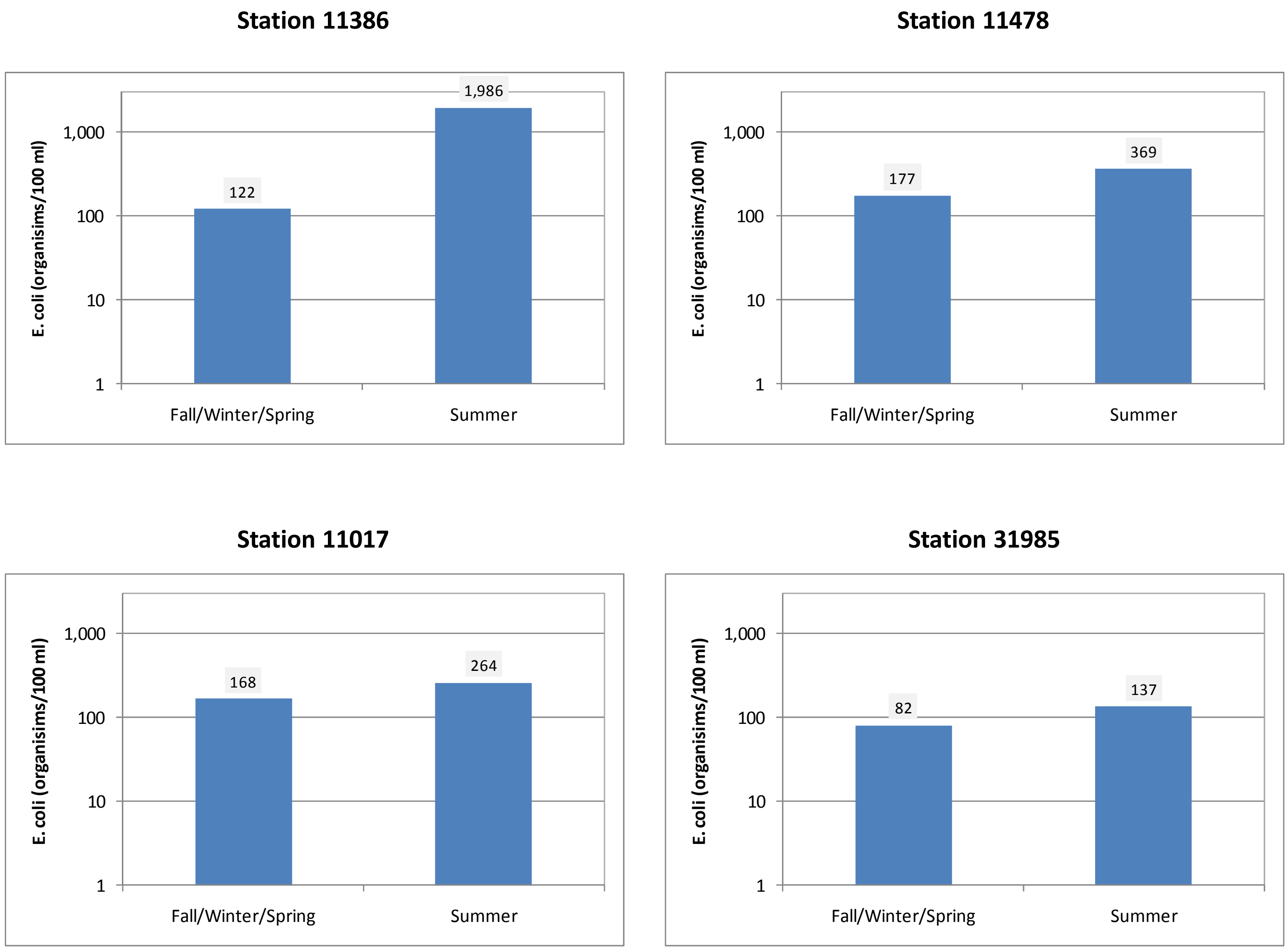


Figure E-20. Maximum E. coli concentration by seasons used in 303(d) report methodology (for stations 28452, 11020, 11479, and 31995)

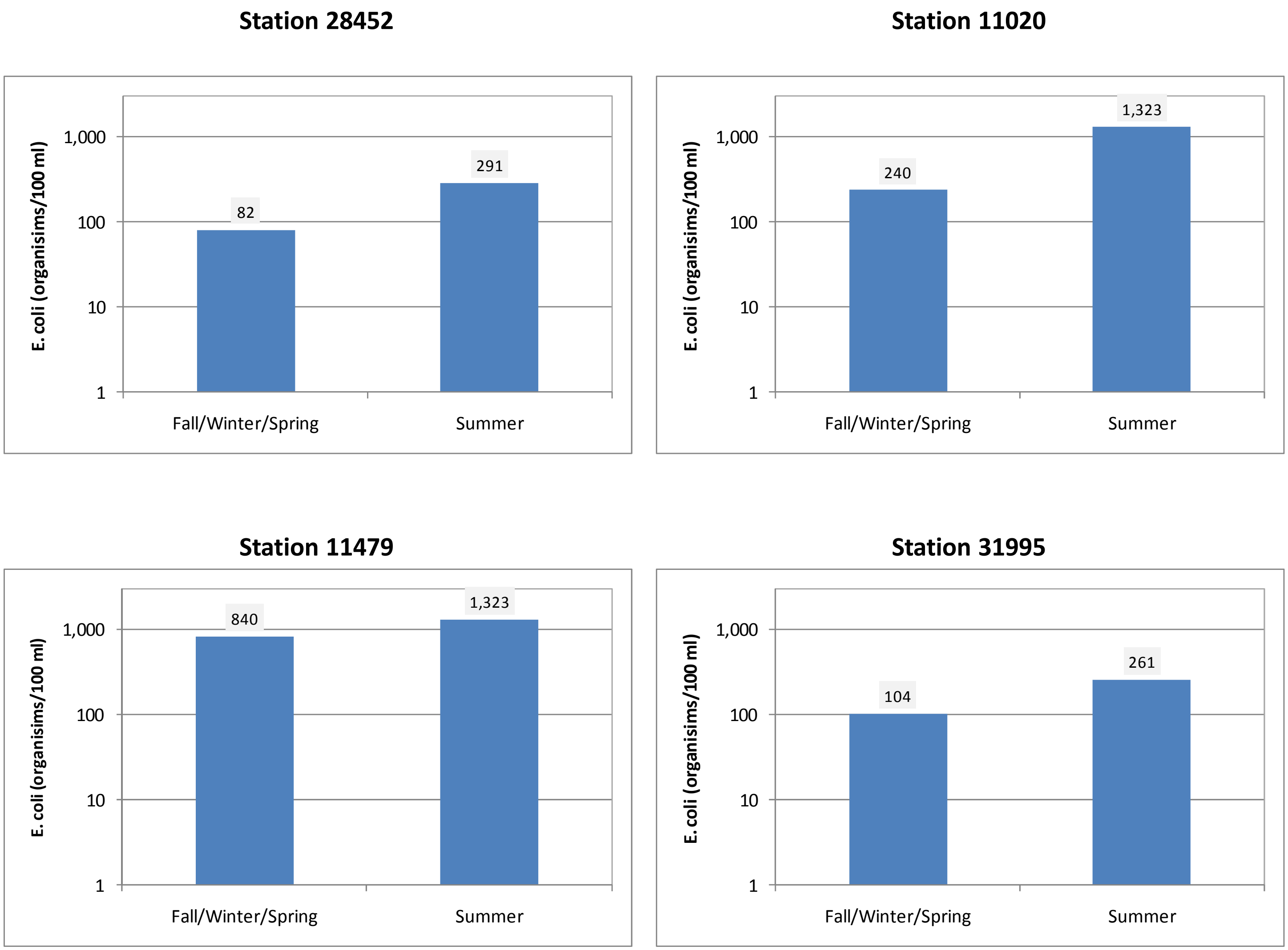


Figure E-21. Maximum E. coli concentration by seasons used in 303(d) report methodology (for stations 10401, 31990, and 31988)

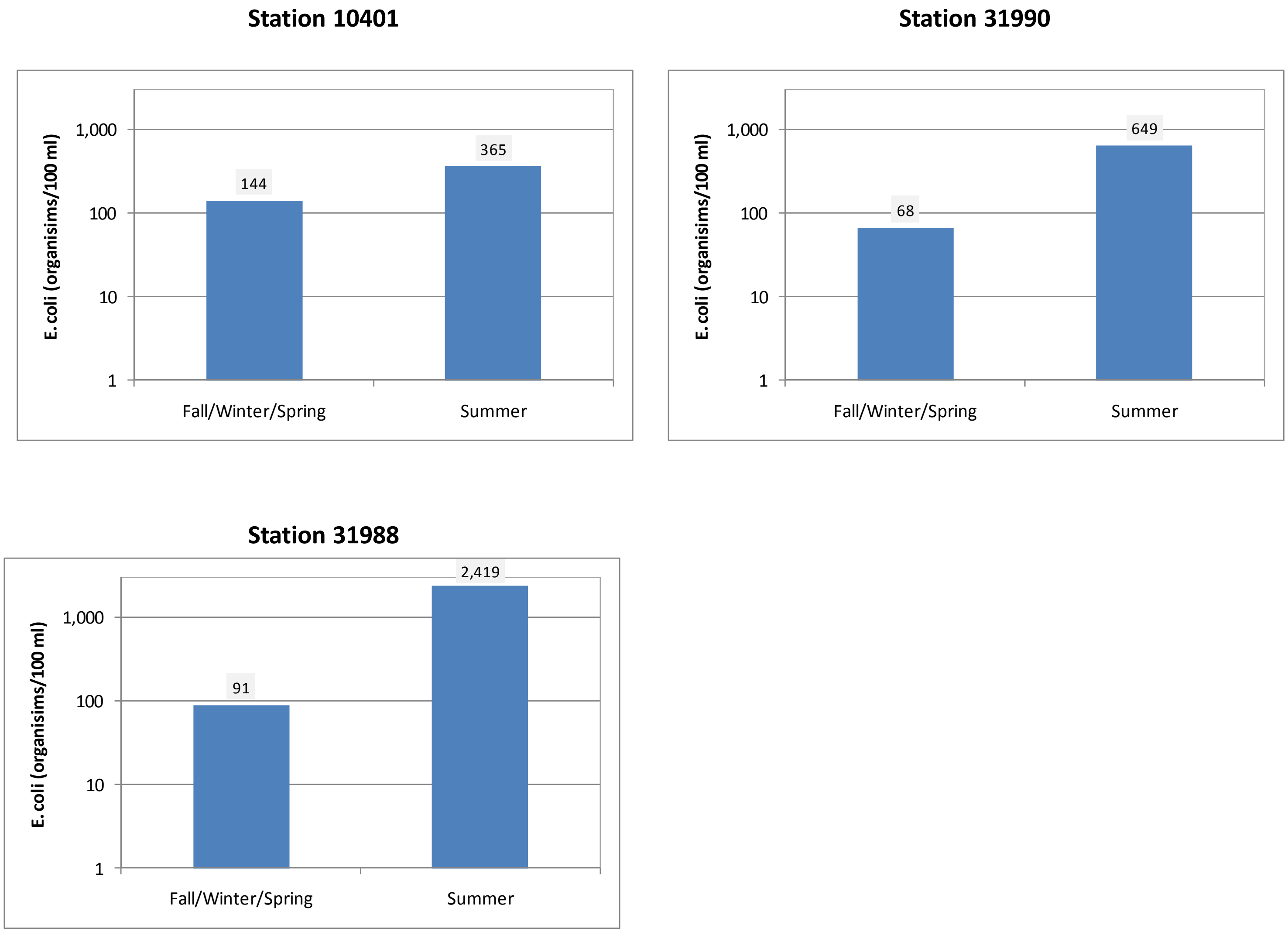
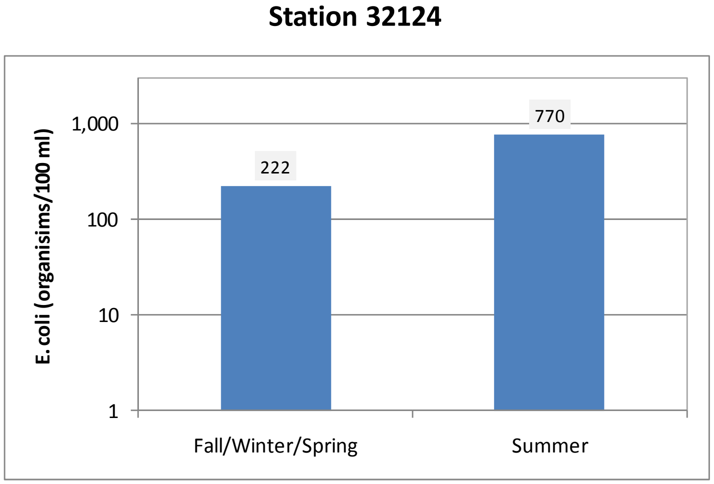


Figure E-22. Maximum E. coli concentration by seasons used in 303(d) report methodology (for stations 32124 and 31989)



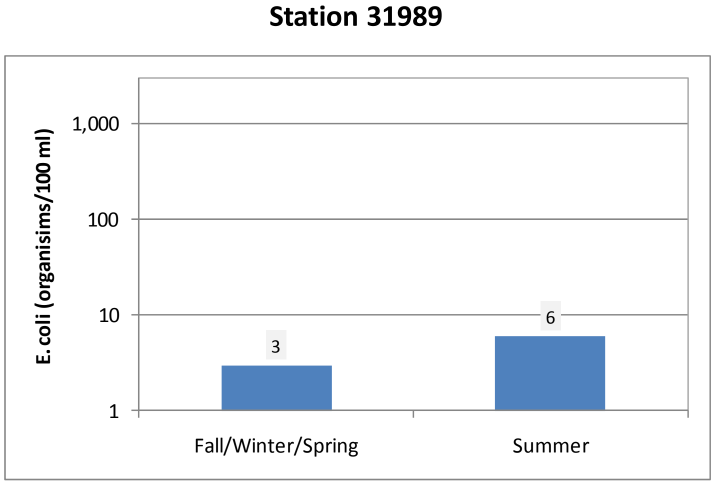


Figure E-23. Maximum E. coli concentration by standard 3-month seasons (for stations 11386, 11478, 11017, and 31985)

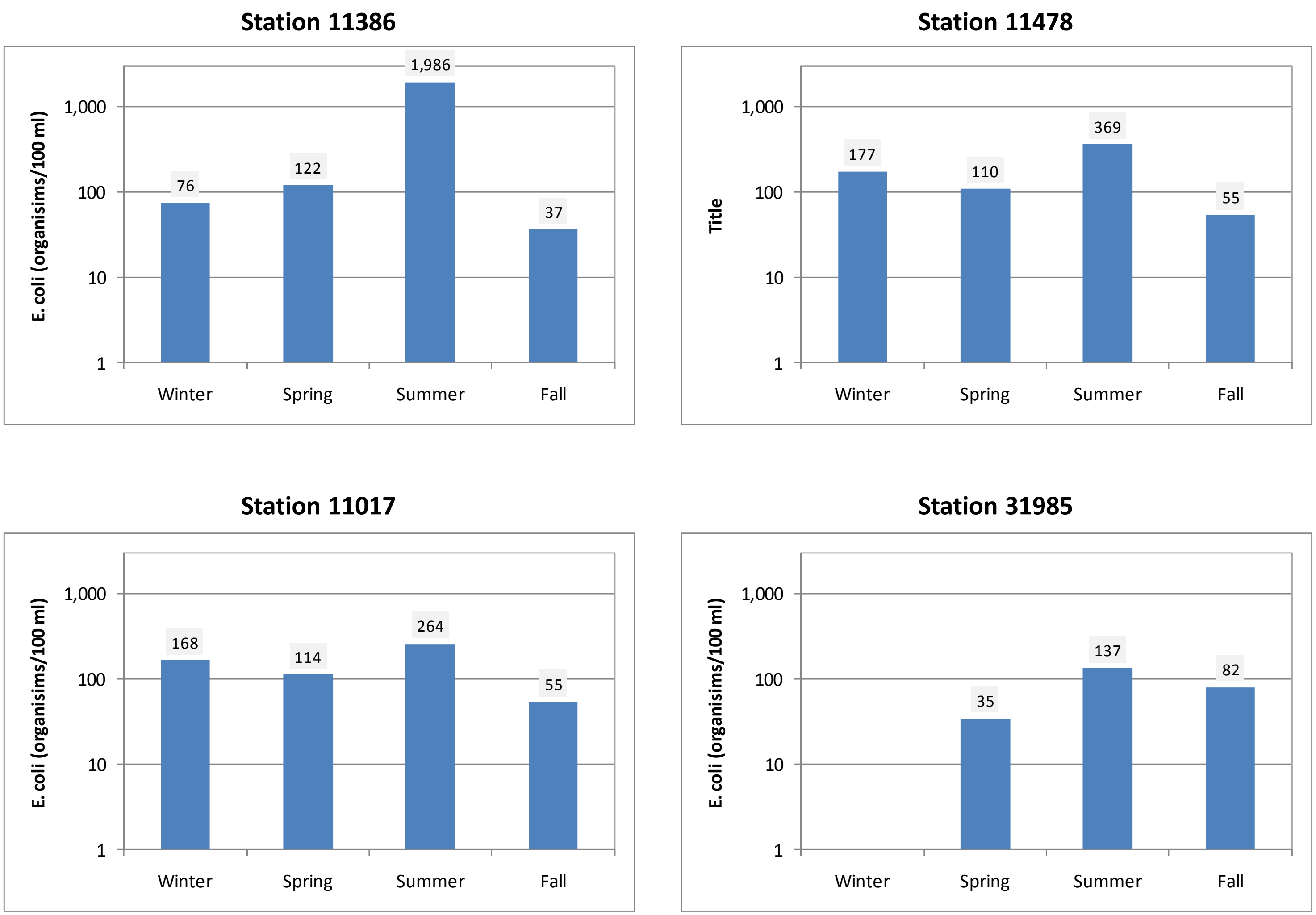


Figure E-24. Maximum E. coli concentration by standard 3-month seasons (for stations 28452, 11020, 11479, and 31995)

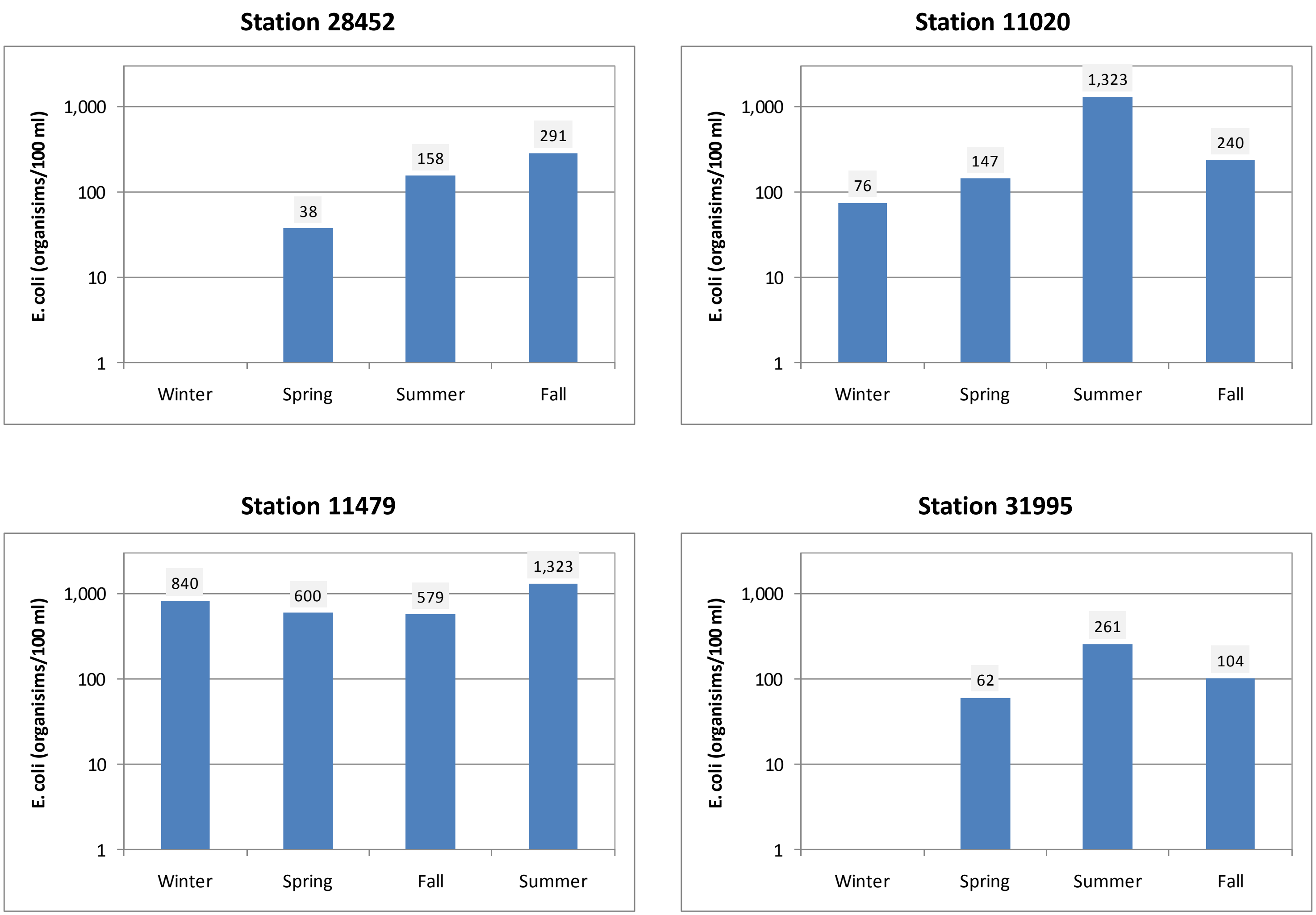


Figure E-25. Maximum E. coli concentration by standard 3-month seasons (for stations 10401, 31990, and 31988

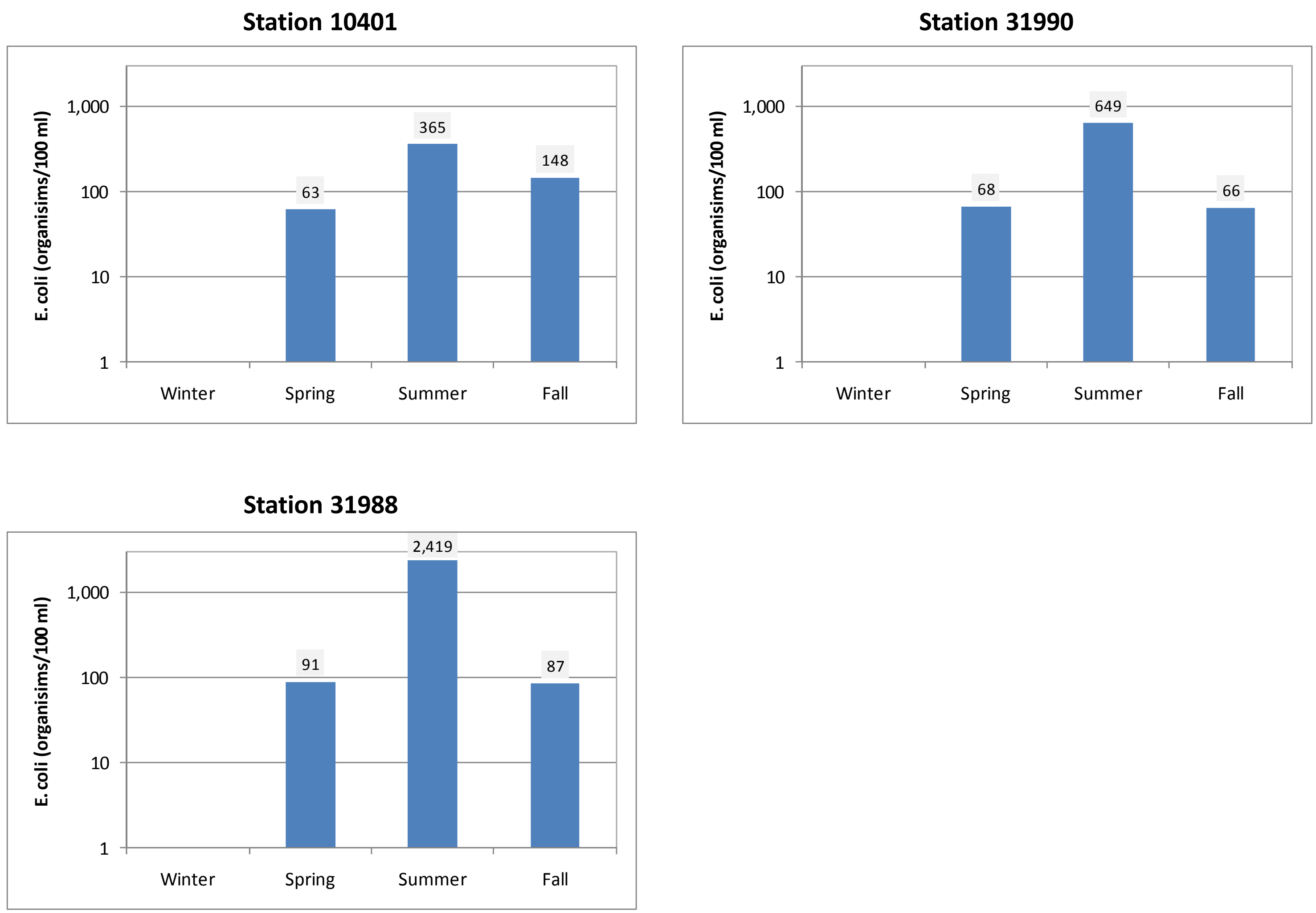
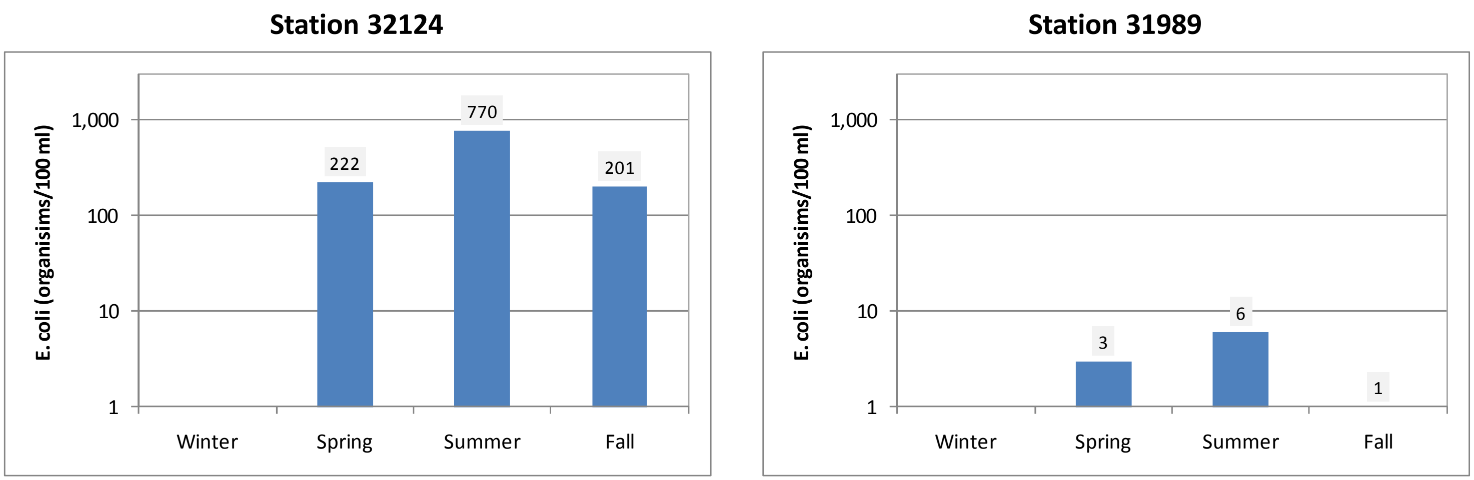


Figure E-26. Maximum E. coli concentration by standard 3-month seasons (for stations 32124 and 31989)



4.5 Load Duration Curves

The bacteria concentration and flow data were used to create load duration curves (LDCs) for each station as described previously. The LDCs were used to assess loading capacities, identify loading reductions needed for the TMDL and they inform source assessment as well. The LDCs for the stations are shown in **Figure E-27** through **Figure E-31**. For the stations with greater than 90 observations, the estimated loads are well distributed across the flow regimes (**Table E-7**). The stations with less than 20 observations do not have an estimated load for all flow regimes. Six out of 13 stations had bacteria concentrations that exceeded the bacteria criteria. Most of the stations had digressions of the maximum criterion only. Two stations exceeded both the log mean and the maximum criteria. No station had a digression of the log mean criteria only. The log mean criterion applied in the LDCs is the log mean of the observations within each flow regime. For the stations with no digressions, no patterns appear between the observed loads and stream flow regime. The relationship between observed and target loads is similar across the flow regimes. The same is not true for the stations with digressions. Most of the digressions occur during dry or low flow conditions; except at station 11479, where digressions occur for all of the flow regimes except for during high flows (**Figure E-29**). At station 32124, digressions occurred during dry and low flow conditions in summer and early fall (**Figure E-31** and **Figure E-26**). This information helps to narrow the possible sources and mechanisms that result in the digressions of the maximum criterion.

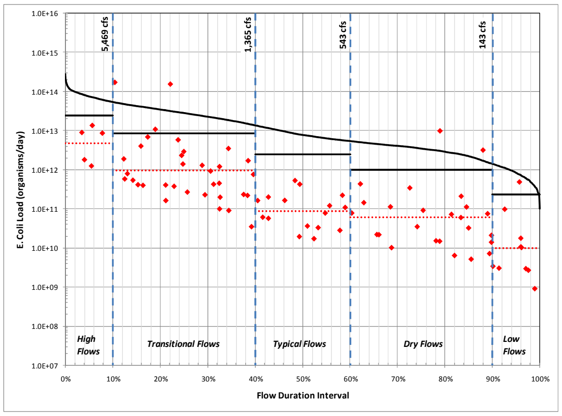
Table E-7. Number of observations and digressions of criteria by station

Station	Number of Observations	Number of Digressions of Max Criterion	Number of Digressions of Log mean Criterion[1]
11386	90	4	0
11020	91	2	0
11479	110	9	1
31990	20	1	0
31988	19	2	0
32124	20	3	2

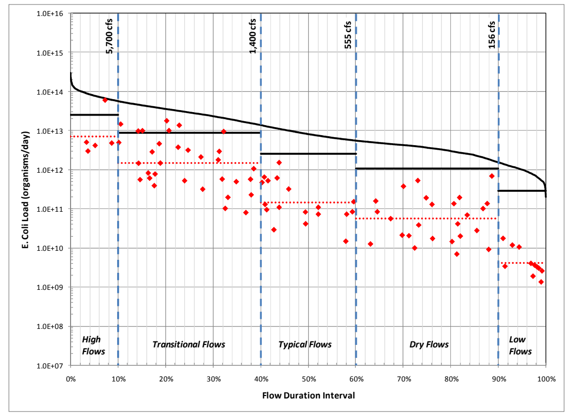
[1] Maximum number of digressions of log mean criterion is 5 because there are only 5 flow regimes considered.

Figure E-27. Load Duration Curves for Stations 11386, 11478, and 11017

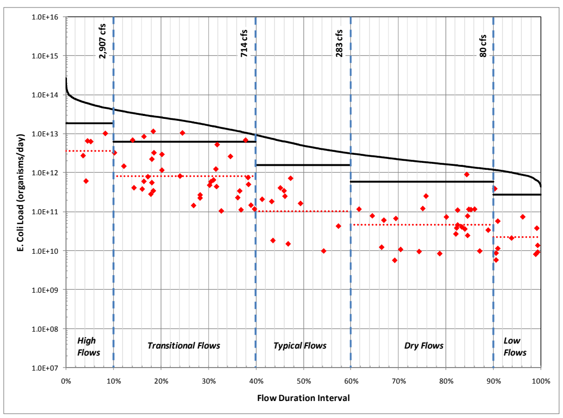
Station 11386



Station 11478



Station 11017



Legend

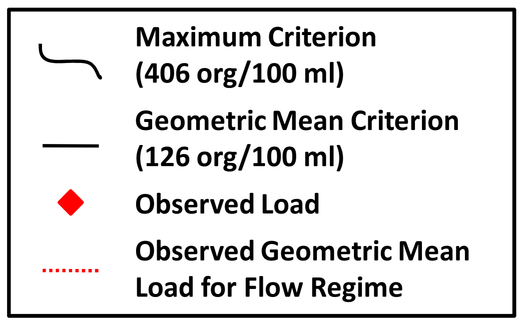
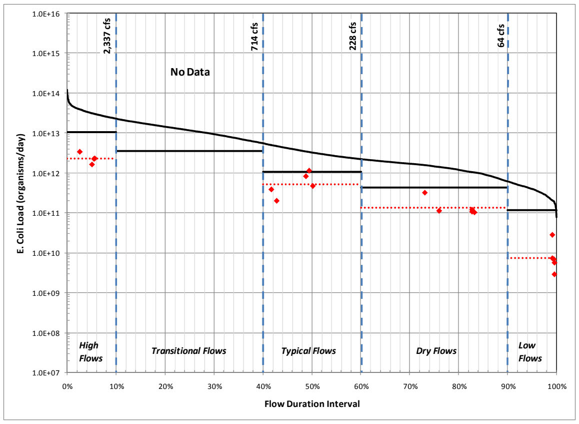
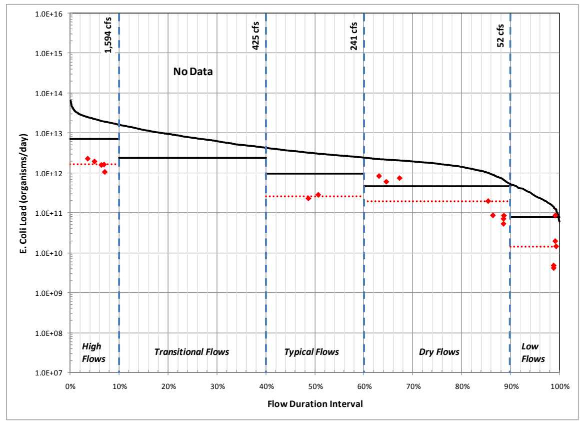


Figure E-28. Load Duration Curves for Stations 31985, 28452, and 11020

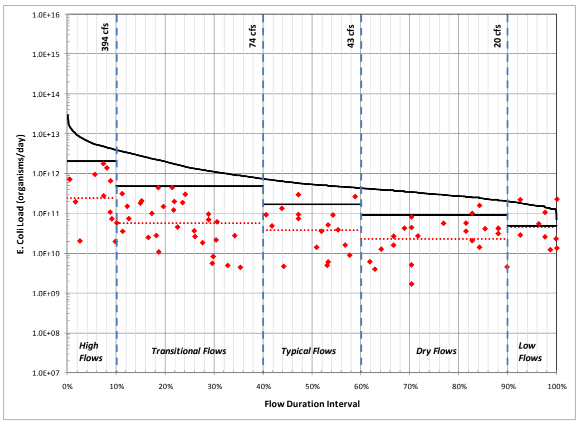
Station 31985



Station 28452



Station 11020



Legend

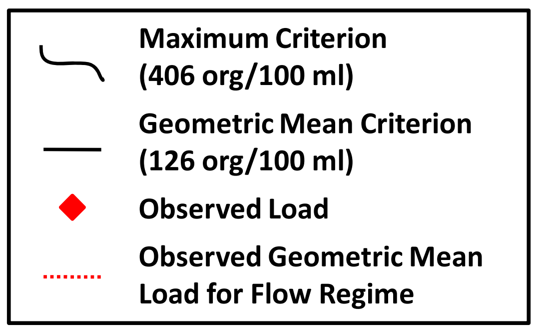
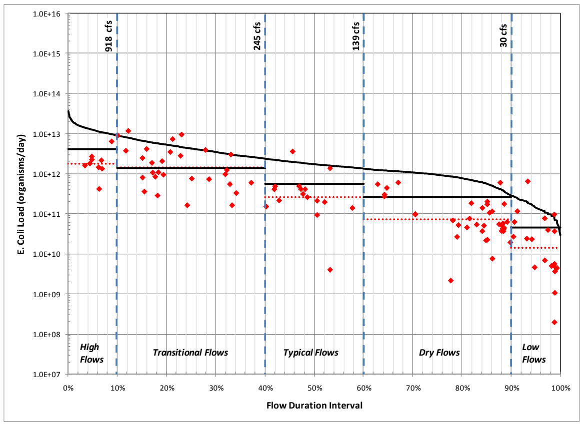
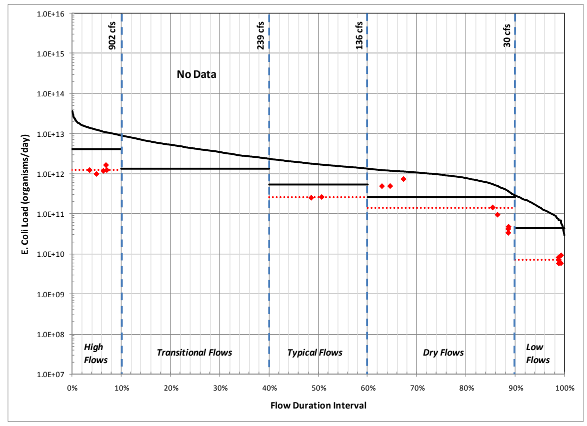


Figure E-29. Load Duration Curves for Stations 11479, 31995, and 10401

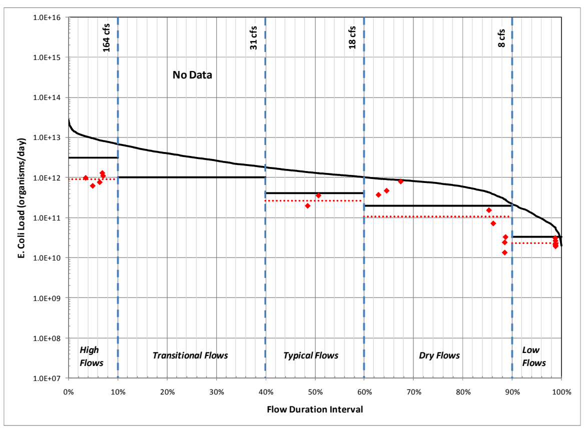
Station 11479



Station 31995



Station 10401



Legend

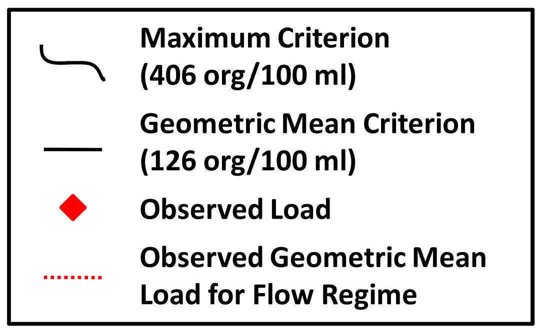
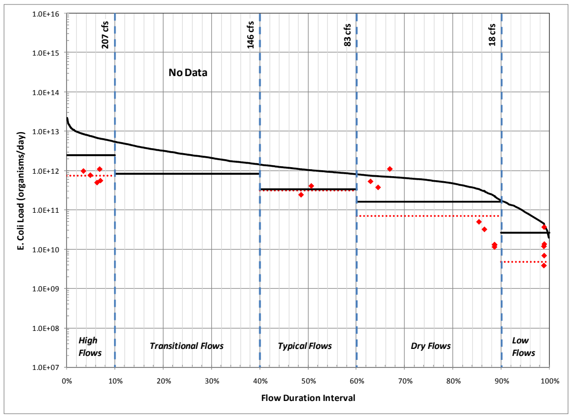
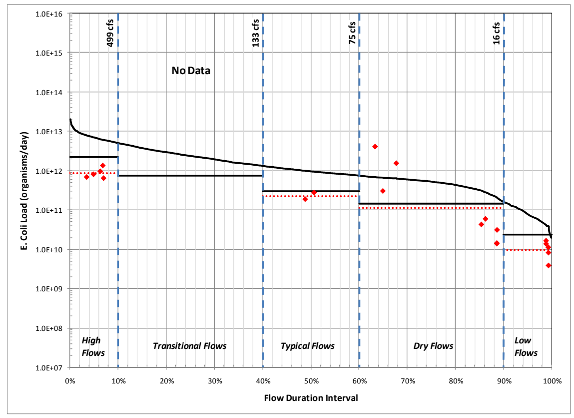


Figure E-30. Load Duration Curves for Stations 31990 and 31988

Station 31990



Station 31988



Legend

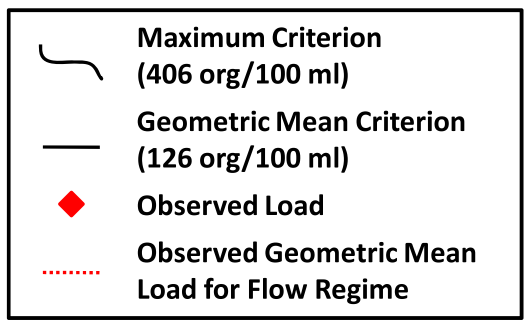
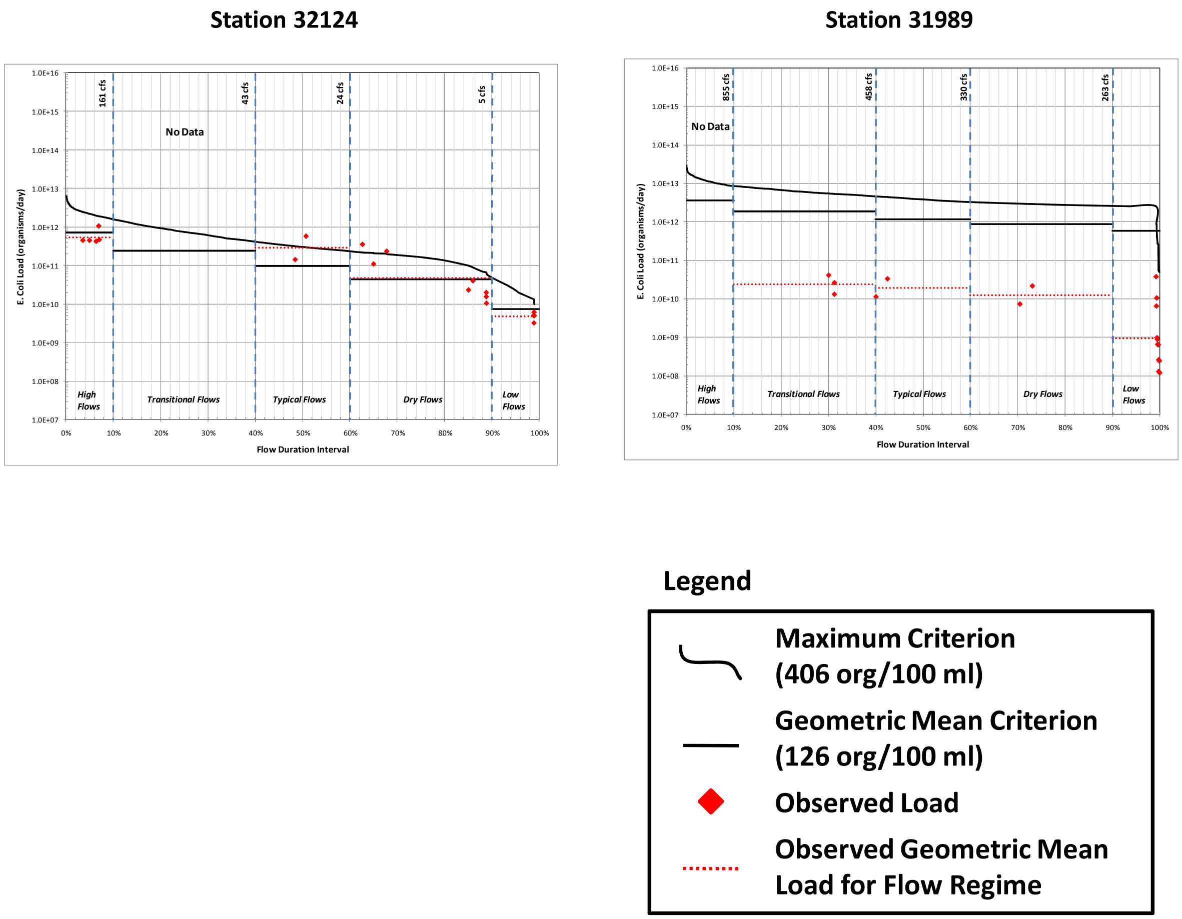


Figure E-31. Load Duration Curves for Stations 32124 and 31989



4.6 Load Reduction Assessment by Station

The percent reductions needed at each station, for sites with digressions of the *E. coli* criteria, were determined from the LDCs by selecting the largest load reduction required within each flow interval and then across flow intervals at each station. The LDCs at stations requiring load reductions are shown in **Figure E-32** through **Figure E-37**. The largest required percent reduction is underlined in each Figure. There are two reductions required for station 11020. Both of the reductions occur during low flow conditions (see **Figure E-32**). The largest percent reduction is 69.3% and is for one of the lowest flows observed. The digression for this percent reduction is for the maximum 406 *E. coli*/100 ml criterion and may represent an isolated event. Relatively small bacteria loads could result in high concentrations at extremely low flows.

There are several reductions required for station 11386. The LDC with percent reductions is shown in **Figure E-33**. The percent reductions are significant and range from 47.3% to 79.6%. The reductions occur in two separate flow regimes: dry and transitional flows. There are most likely two different source-transport mechanisms responsible for the digressions. However, there are only two reductions identified in each of two flow intervals. The circumstances that resulted in the four digressions do not seem to be persistent and may not represent a chronic problem. The percent reduction required at station 11386 is 79.6% (**Figure E-33**).

There were quite a few reductions identified for station 11479. As shown in **Figure E-34**, the percent reductions range from small (1%) to significant (69.3%). Half of the 10 reductions occurred during transitional flow conditions. The remaining 5 occurred during conditions with smaller flows (**Figure E-34**). The largest percent reduction occurs during low flow conditions and may have resulted from different circumstances than the conditions causing the digression during transitional flows. Given the range of digressions across flow regimes, there may be a persistent problem resulting from several causes.

There were only two reductions identified for station 31988. Both of the percent reductions were significant in size and occurred during dry flow conditions. As stated earlier, dry flow conditions (**Figure E-36**) often occur during summer and early fall. The largest concentration observed at station 31988 occurred during the summer (see **Figure E-21**). The percent reduction required at station 31988 is 83.2%.

Only one moderate reduction was identified for station 31990. The percent reduction of 37.4% occurred during dry flow conditions (**Figure E-36**). This reduction may be an isolated event and may not represent the typical conditions at station 31990. However, the reduction did occur during the same flow conditions (dry flows) as a majority of the reductions occurred at the other stations.

There were several reductions identified at station 32124. The range of the percent reductions was from 1% to 65.8% (**Figure E-37**). There were reductions for both bacteria criteria. The largest reduction was 65.8% for the log mean criterion during typical flow conditions, but the log mean estimate is based on two observations.

Figure E-32. Load reduction curve and percent reductions for station 11386

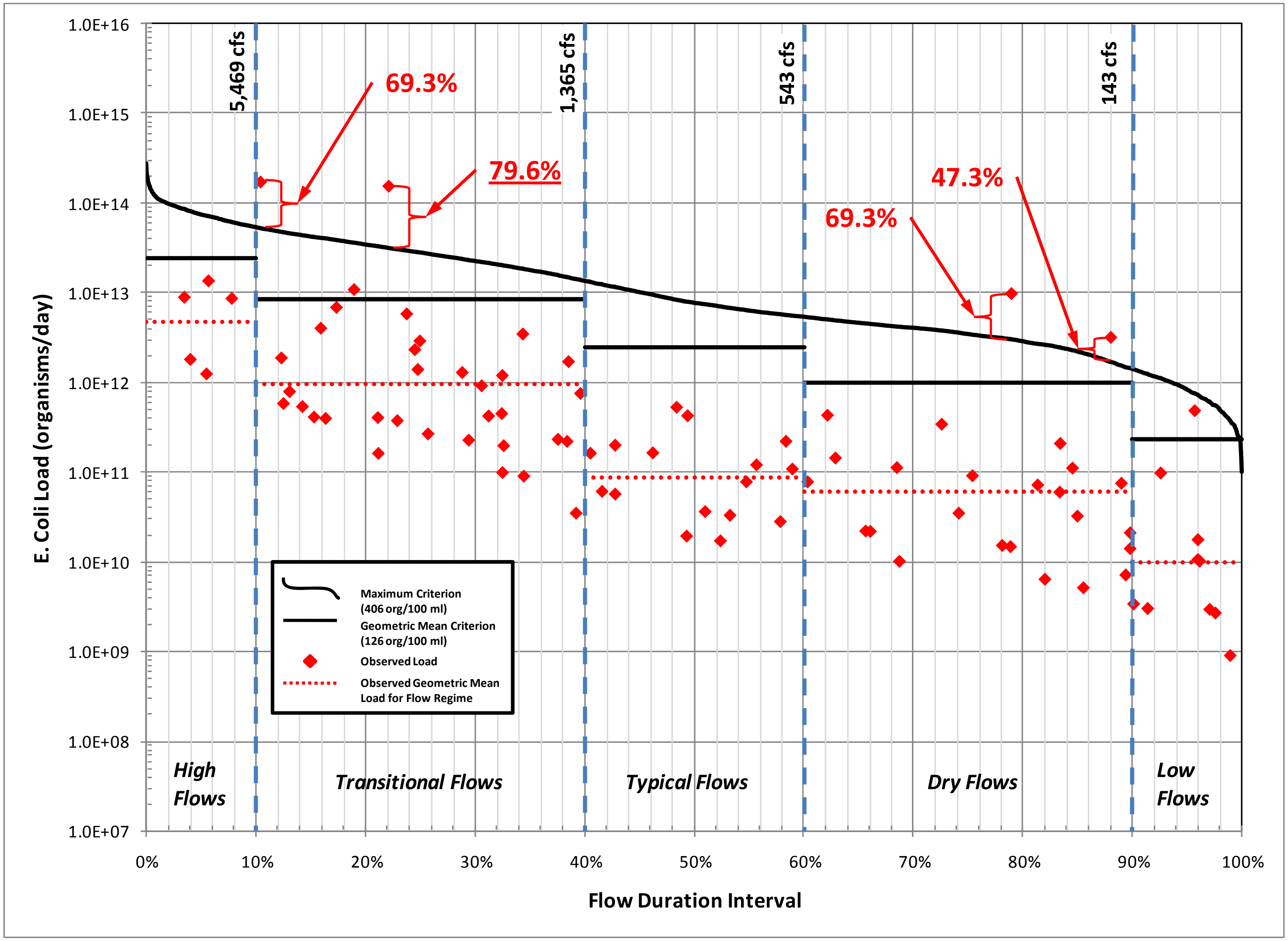


Figure E-33. Load reduction curve and percent reductions for station 11020

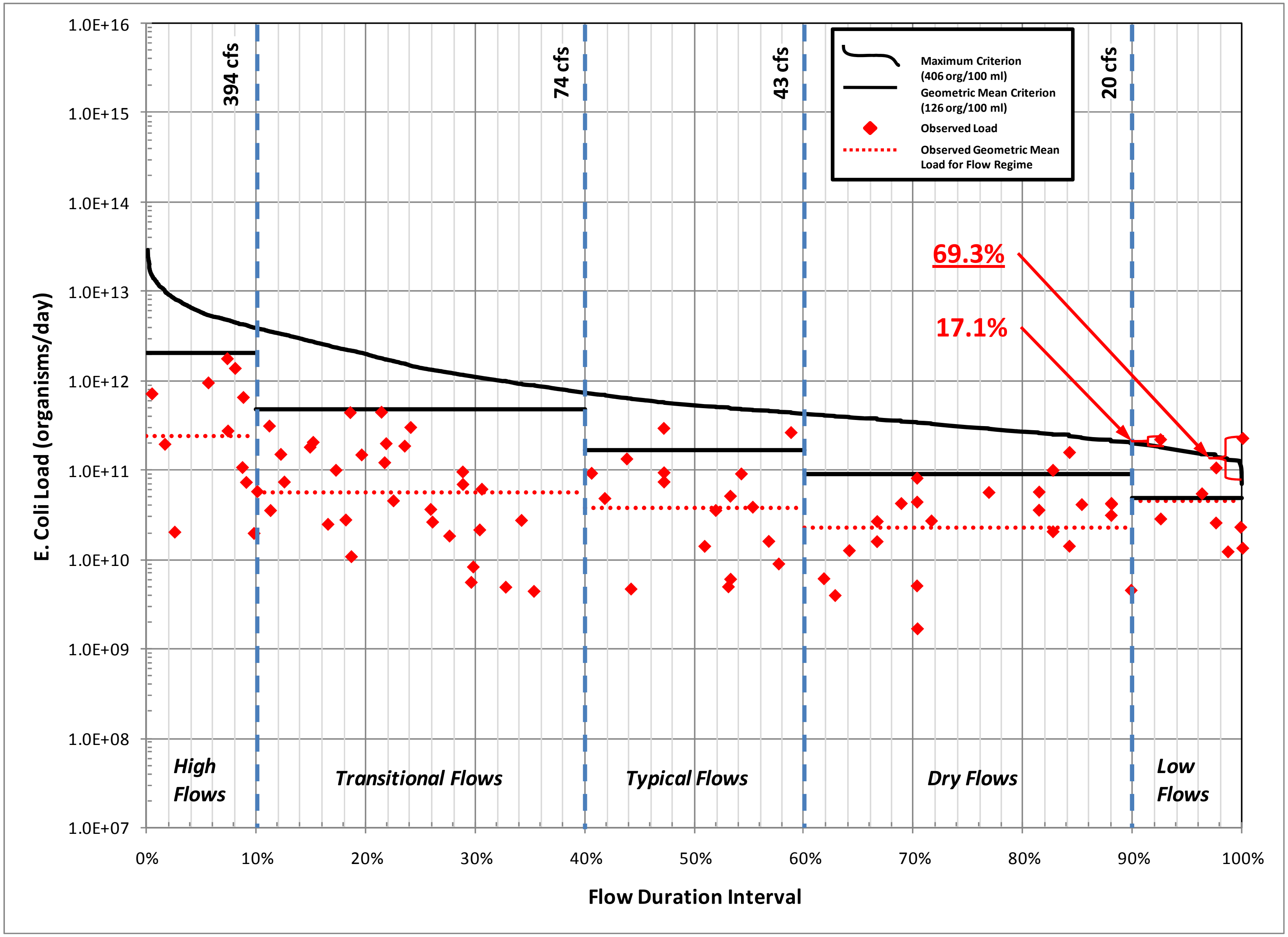


Figure E-34. Load reduction curve and percent reductions for station 11479

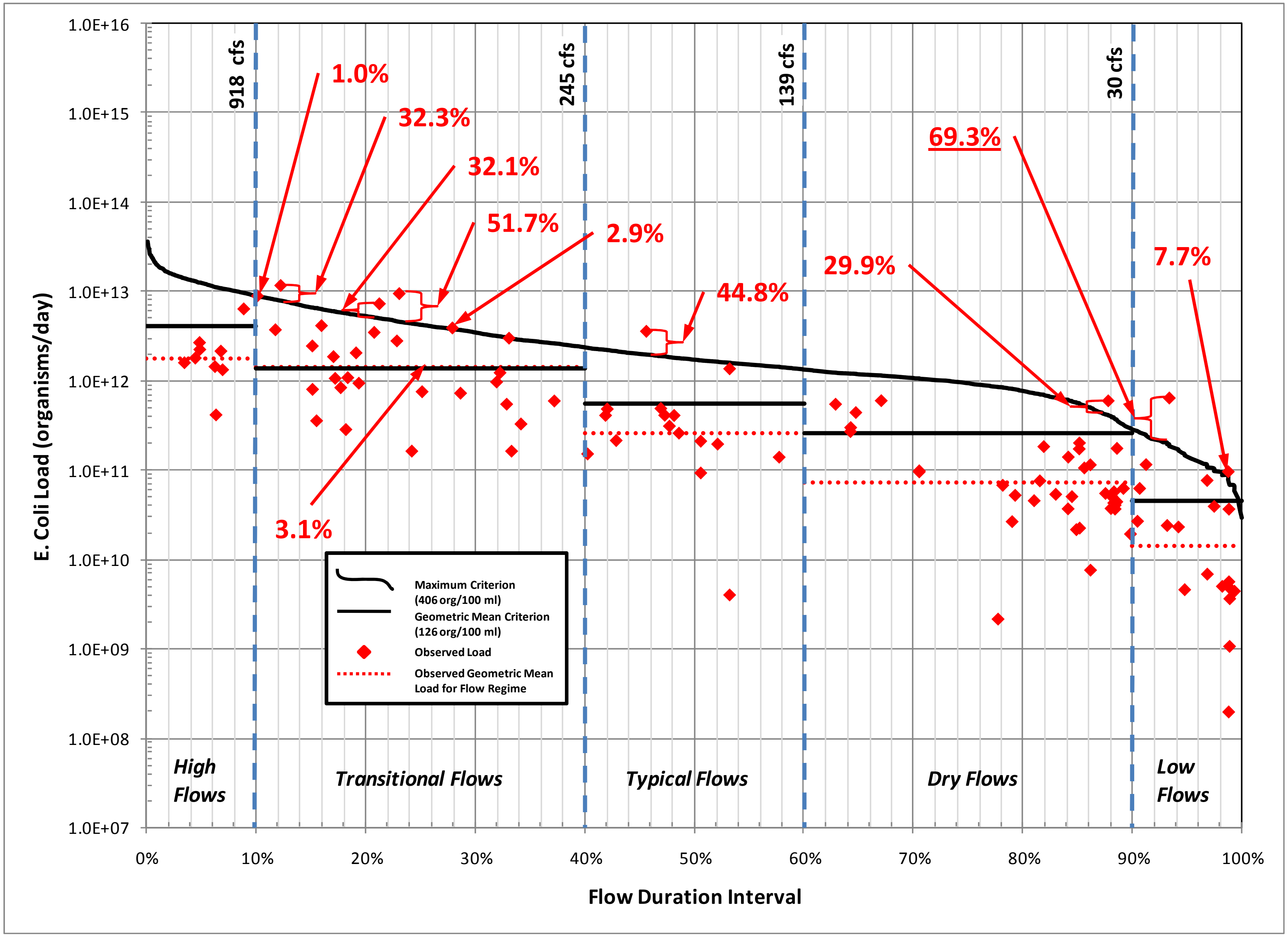


Figure E-35. Load reduction curve and percent reductions for station 31990

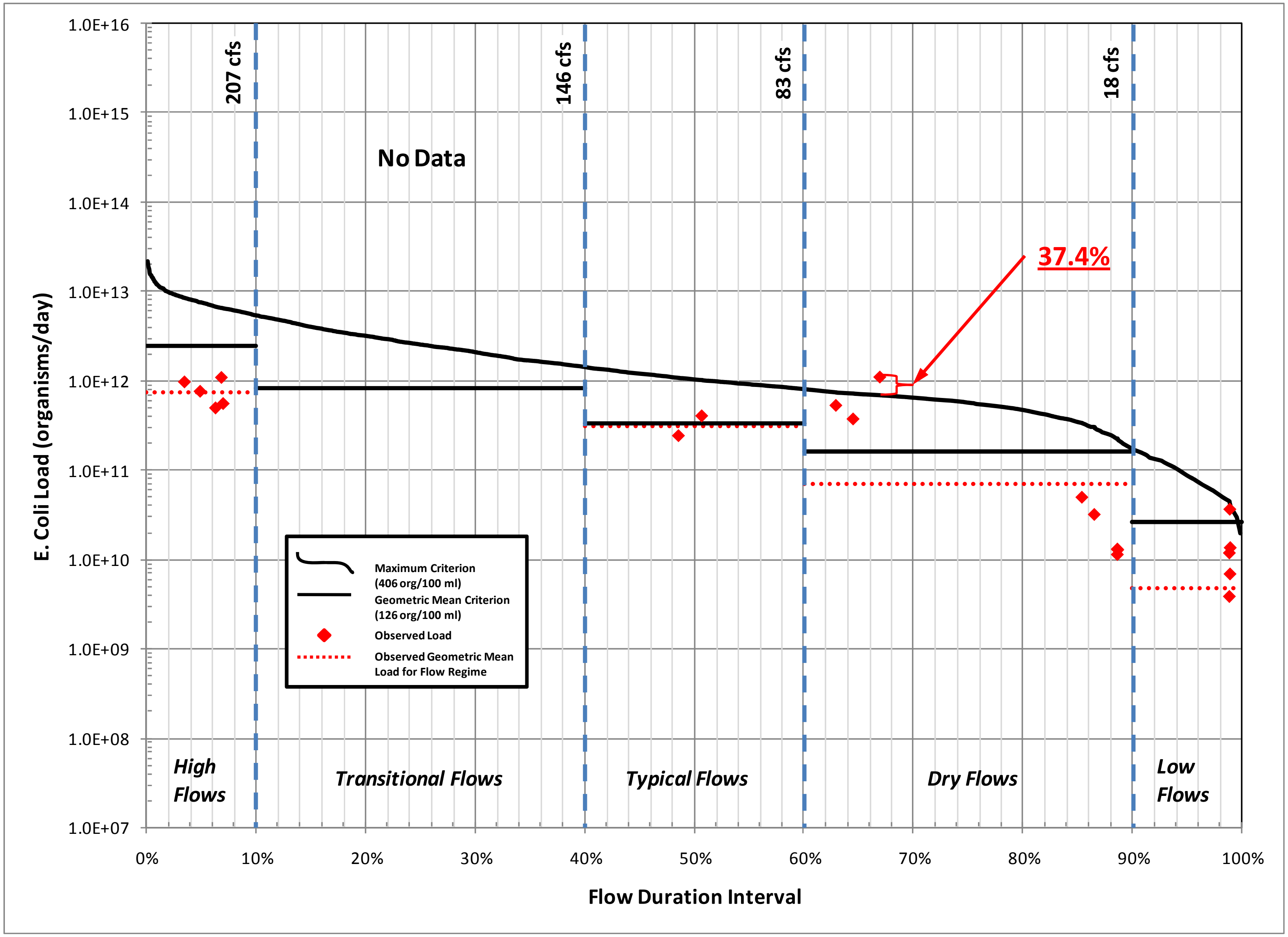


Figure E-36. Load reduction curve and percent reductions for station 31988

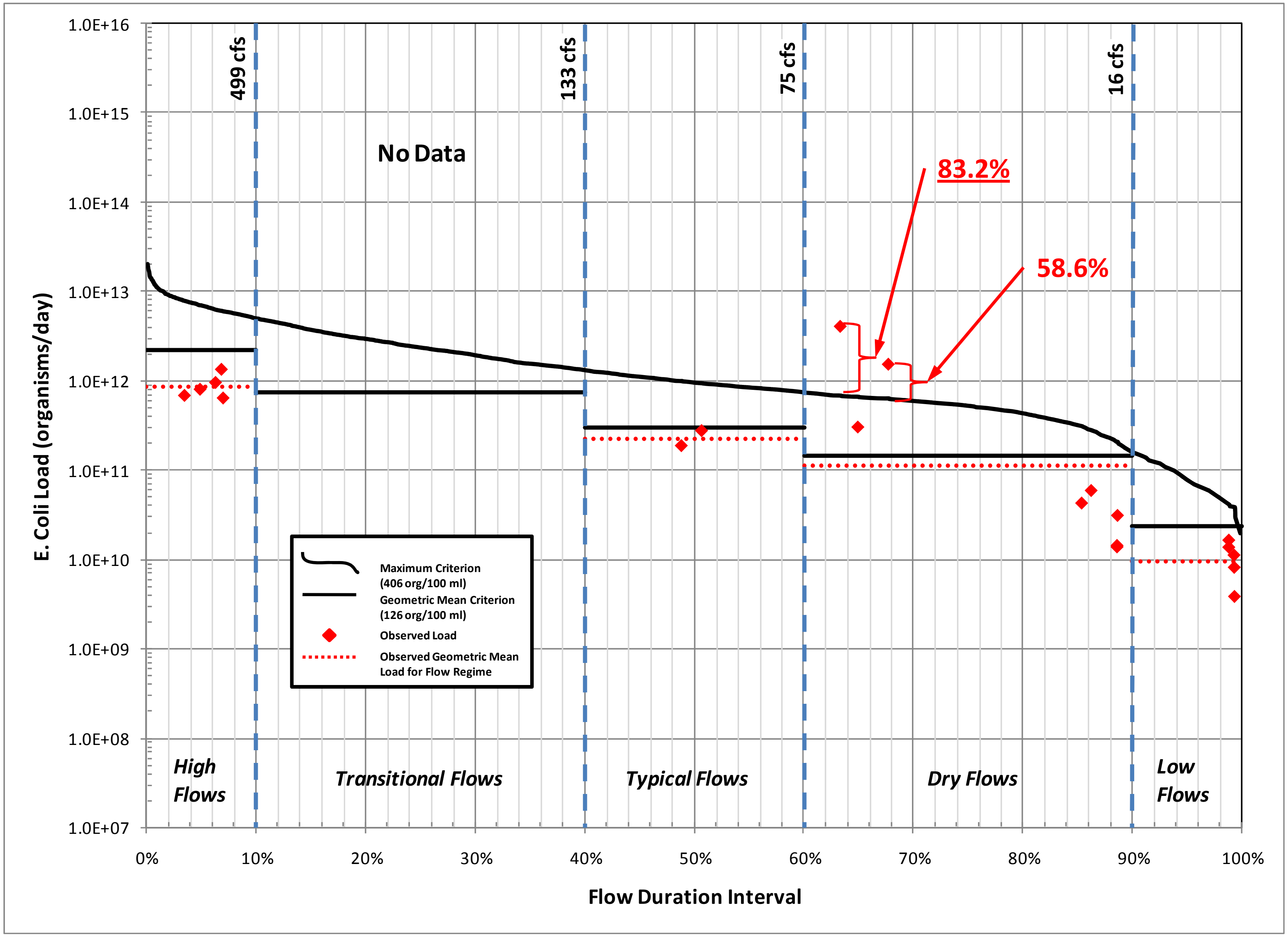


Figure E-37. Load reduction curve and percent reductions for station 32124

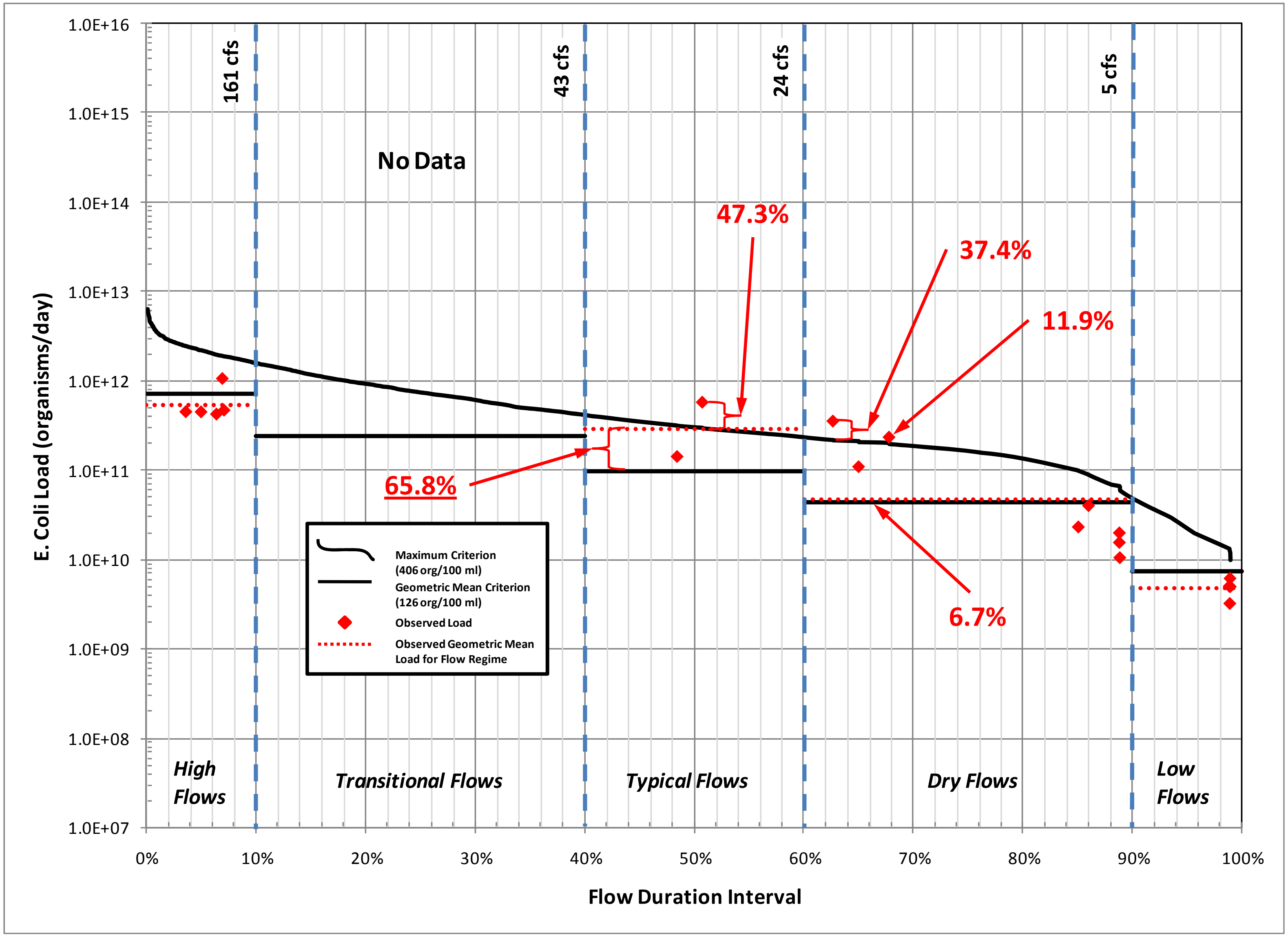
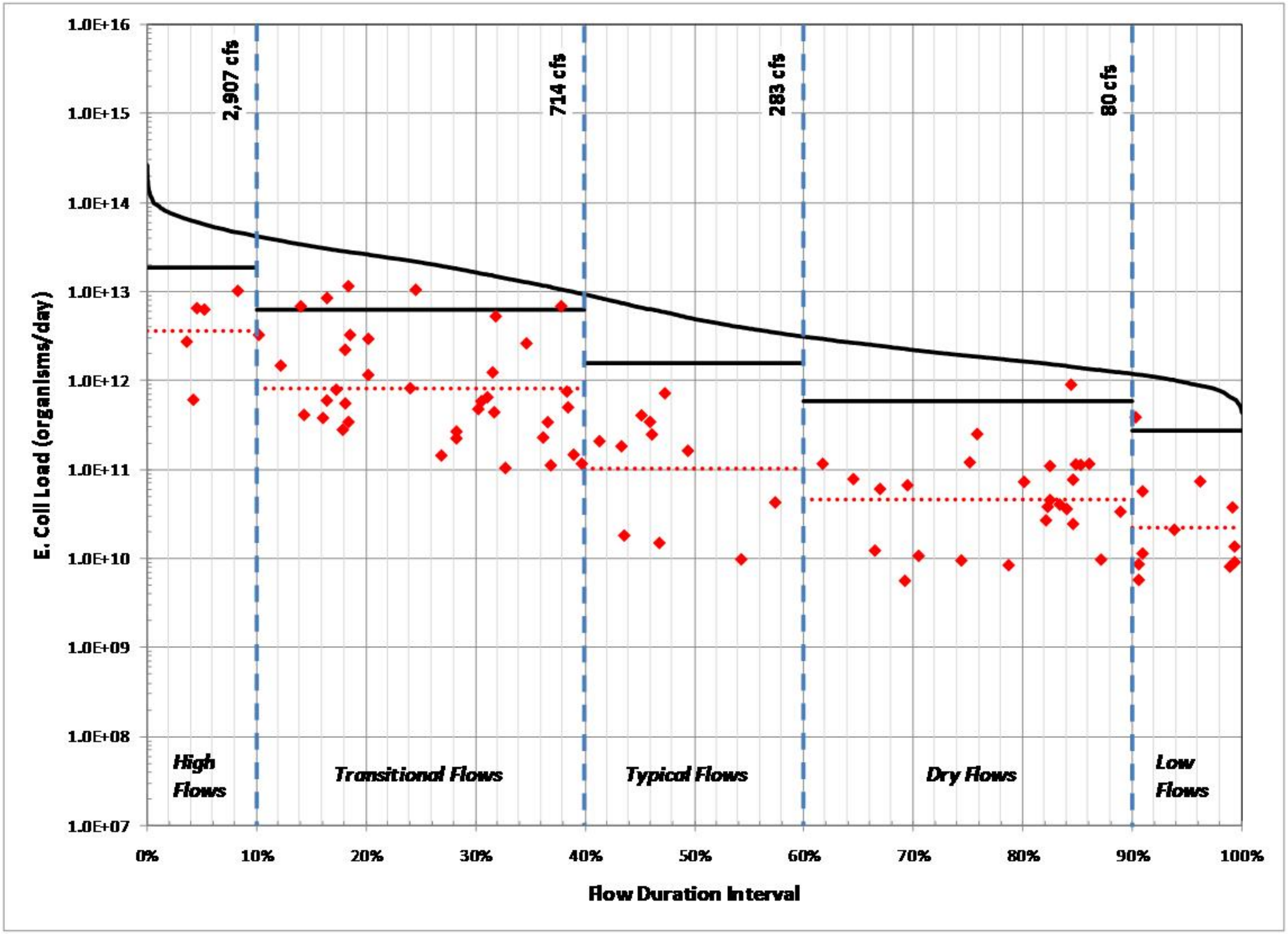


Figure E-38. Load duration curve for station 11017 (no reductions needed)



4.7 Viewing Load Reductions Collectively

For the six monitoring stations with digressions, the needed percent reductions in bacteria load are listed in **Table E-8**, for each flow interval and addressing both criteria. All six exhibited digressions from the maximum criterion. Two of the six stations also require percent reductions for the log mean criterion. Across all stations, there was only one instance where the log mean criteria drove the maximum needed percent reduction (station 32124). However, that log mean was based on only two load observations and was not considered to represent conditions at the station well. The next largest percent reduction was select as the percent reduction for station 32124.

At 4 of the 6 stations, the percent reductions occurred during low or dry flow conditions (**Table E-8**). Dry and low flow conditions are usually not driven by storm or snowmelt runoff and are often related to small quantities of bacteria load from concentrated sources.

Table E-8. Load reductions for bacteria TMDL by station

	Log mean					Max					
Station/Flow Regime	**0-10%**	**10-40%**	**40-60%**	**60-90%**	**90-100%**	**0-10%**	**10-40%**	**40-60%**	**60-90%**	**90-100%**	**Reduction**
11386	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**79.6%**	0.0%	**69.3%**	0.0%	**79.6%**
11020	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**69.3%**	**69.3%**
11479	0.0%	**3.1%**	0.0%	0.0%	0.0%	0.0%	**51.7%**	**44.8%**	**29.9%**	**69.3%**	**69.3%**
31990	0.0%	No Data	0.0%	0.0%	0.0%	0.0%	No Data	0.0%	**37.4%**	0.0%	**37.4%**
31988	0.0%	No Data	0.0%	0.0%	0.0%	0.0%	No Data	0.0%	**83.2%**	0.0%	**83.2%**
32124[1]	0.0%	No Data	**65.8%**	**6.7%**	0.0%	0.0%	No Data	**47.3%**	**37.4%**	0.0%	**47.3%**

[1] Log mean was based on only two load estimates and was not considered to represent conditions at the station well. The next largest percent reduction was select as the percent reduction for station 32124

4.8 Loading capacity

The loading capacities for the stations were calculated by flow regime. Loading capacities are based on the load duration curves for each station. The loading capacities are determined by multiplying the applicable criteria by the daily flow, expressed in terms of the number of organisms per day. As examples, the flow-range minimum loading capacities for the maximum criterion (406 *E. coli* /100 ml) are listed in **Table E-9**. The loading capacities for the log mean criterion (126 *E. coli* /100 ml) are in **Table E-10**. The method of assessing the loading capacity is described in the preceding section entitled *Loading capacity and Reduction Calculations*.

Table E-9. Minimum LC for maximum criteria for stations needing load reductions, and the North Fork

Flow Range/Station	Loading capacity (*E. coli*/day)						
	11386	**11020**	**11479**	**31990**	**31988**	**32124**	**11017**
Low Flows (90-100%)	9.9×10^{10}	6.9×10^{10}	3.0×10^{10}	2.0×10^{10}	2.0×10^{10}	9.9×10^{9}	6.9×10^{10}
Dry Flows (60-90%)	1.4×10^{12}	2.0×10^{11}	3.1×10^{11}	1.8×10^{11}	1.7×10^{11}	5.0×10^{10}	1.9×10^{11}
Typical Flows (40-60%)	5.4×10^{12}	4.3×10^{11}	1.4×10^{12}	8.2×10^{11}	7.5×10^{11}	2.4×10^{11}	4.2×10^{11}
Transitional Flows (10-40%)	1.4×10^{13}	7.4×10^{11}	2.5×10^{12}	1.5×10^{12}	1.3×10^{12}	4.3×10^{11}	7.3×10^{11}
High Flows (0-10%)	5.4×10^{13}	3.9×10^{12}	9.3×10^{12}	5.6×10^{12}	5.1×10^{12}	1.7×10^{12}	3.9×10^{12}

Table E-10. LC for geometric mean criteria for stations with load reductions, and the North Fork

Flow Range/Station	Loading capacity (*E. coli*/day)						
	11386	**11020**	**11479**	**31990**	**31988**	**32124**	**11017**
Low Flows (90-100%)	2.3×10^{11}	4.8×10^{10}	4.5×10^{10}	2.6×10^{10}	2.4×10^{10}	7.3×10^{9}	2.7×10^{11}
Dry Flows (60-90%)	1.0×10^{12}	9.1×10^{10}	2.6×10^{11}	1.6×10^{11}	1.4×10^{11}	4.4×10^{10}	5.9×10^{11}
Typical Flows (40-60%)	2.5×10^{12}	1.7×10^{11}	5.5×10^{11}	3.3×10^{11}	3.0×10^{11}	9.6×10^{10}	1.5×10^{12}
Transitional Flows (10-40%)	8.6×10^{12}	4.7×10^{11}	1.4×10^{12}	8.2×10^{11}	7.5×10^{11}	2.4×10^{11}	6.2×10^{12}
High Flows (0-10%)	2.5×10^{13}	2.0×10^{12}	4.1×10^{12}	2.5×10^{12}	2.3×10^{12}	7.3×10^{11}	1.9×10^{13}

4.9 Loading Capacity Components

The TMDL equation accounts for the contribution of different sources of the pollutant and the uncertainty inherent in the process used to estimate these contributions. Below is the form of the equation used in the John Day River Bacteria TMDL:

TMDL = LA + WLA + MOS + RC
where,
LA is the load allocation for the nonpoint sources,
WLA is the waste load allocation for point sources,
MOS is the margin of safety, and
RC is the reserve capacity.

Not all of the components of the equation were quantified explicitly in the John Day River Bacteria TMDL. Instead, surrogates or qualitative estimates were used. The load allocation surrogate does not differentiate anthropogenic and natural sources, due to lack of source information. The components of the loading capacity are reported in Chapter 2 of the John Day Basin TMDL document. In brief, the LC are the loads targeting both criteria for flow ranges, the LA is expressed as a percent reduction surrogate based on maximum instream measurements and targeting the loading capacity, direct application of the criteria serves as a substitute for wasteload allocations, and the MOS and RC are implicit in the analytical method. The load allocation surrogate is described in the following section.

Load Allocations

Rather than estimating LA directly, a percent reductions is employed as a surrogate as described above. Loading capacities were estimated for both criteria and used to identify percent reductions for each station. The maximum percent reduction among the stations of either criterion was determined. The maximum percent reduction (83% for maximum criterion at station 31988) is applied as a surrogate load allocation. An interim percent load reduction (69% for the maximum criterion at station 11479) is suggested as an initial target for implementation. This interim target was selected based on the larger amount of data available at station 11479 (N = 110) compared to the amount of data available at station 31988 (N = 20). Also, the time period covered at station 11479 (greater than 15 years) was larger than the period covered by data collection at station 31988 (approximately 2 years).

The percent reduction is applied to all estimated loads (not concentrations). For example, **Figure E-39** and **Figure E-40** illustrate that if we apply the 83 percent reduction to all observed loads, both criteria will be met. The current conditions for station 31988 are shown in **Figure E-39**. When the 83% reduction is applied to all observed loads, the resultant condition is shown in **Figure E-40**. As seen in **Figure E-40**, the observed loads and the log mean of the observed loads meet the target loads for each criterion. The reduced loads shown in **Figure E-40** will meet both concentration criteria for all flow regimes because they are below the LC for both criteria across the flow regimes.

Figure E-39. LDC for station 31988, labeled with maximum reduction needed to meet the loading capacity

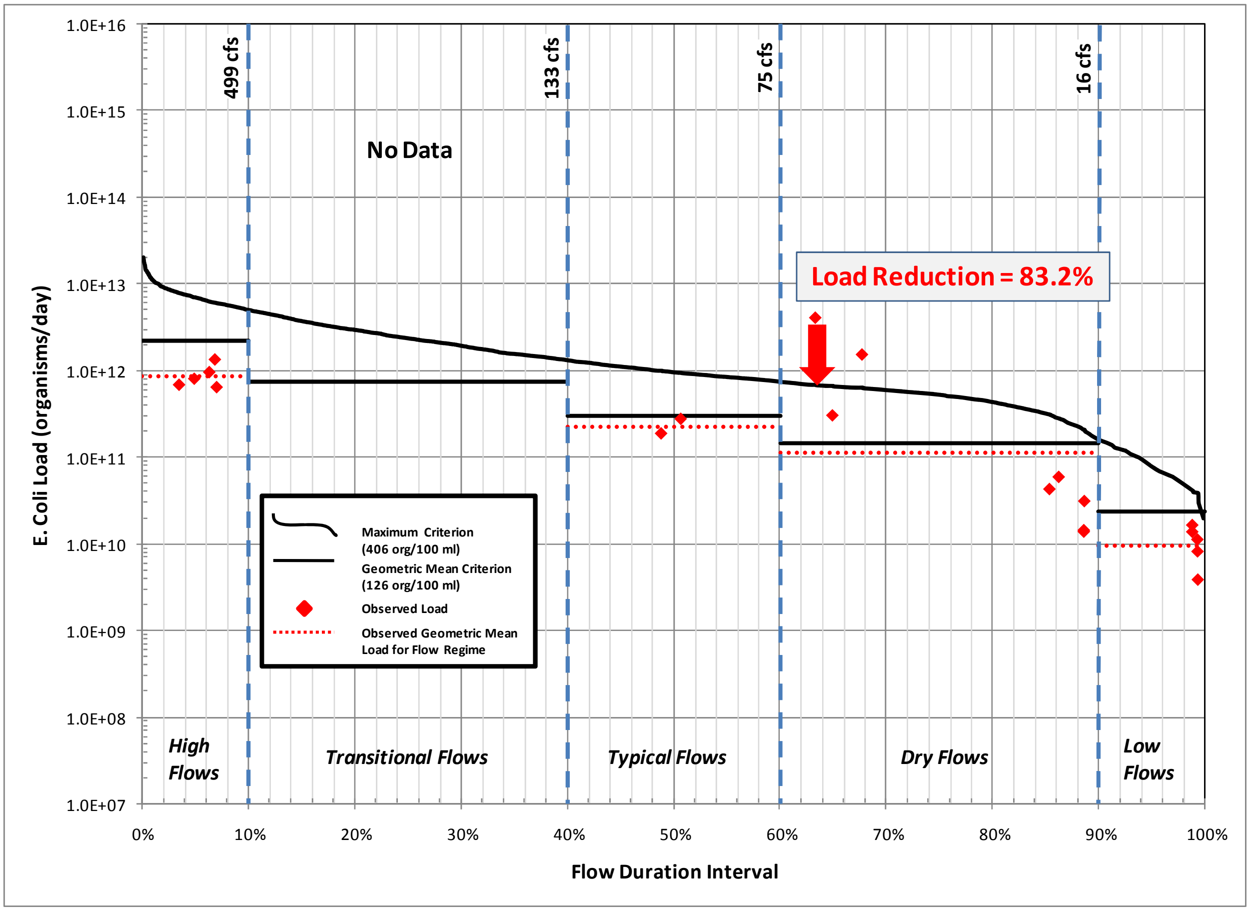
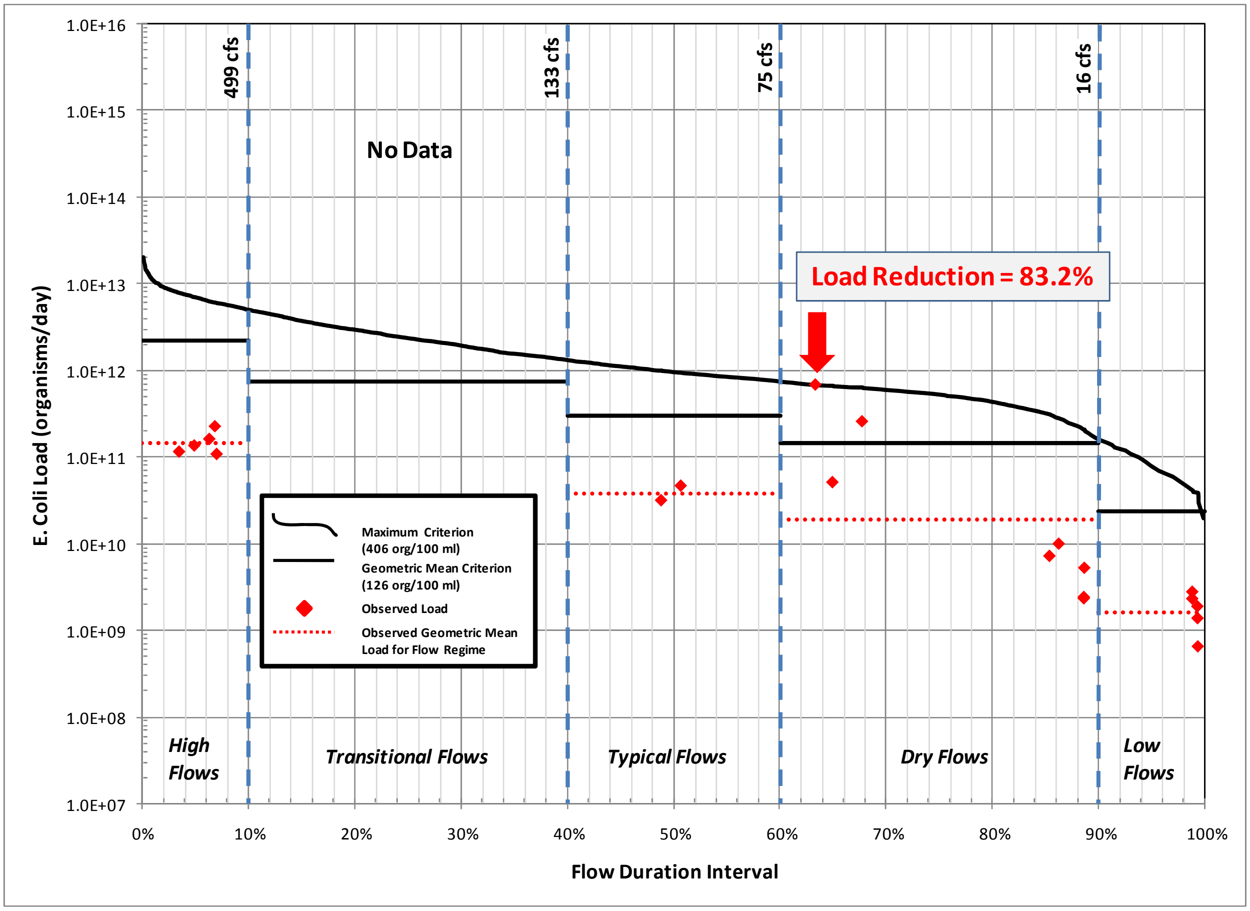


Figure E-40. LDC for station 31988 with 83.2% reduction applied



Since the 83% is the largest of all the reductions among the stations and between the criteria, the loads at the other stations should satisfy both criteria. Station 11479 serves as another example. The current conditions are shown in **Figure E-41**. The largest reduction was 69% for station 11479. The 83% reduction is applied to all loads at station 11479 and both criteria are met (**Figure E-42**).

The load reductions will be achieved through source reductions and transport controls. The sources in the Basin will develop strategies to reduce their contributions of bacteria loads by 83%. By doing this, we assume that if the sources are reduced by 83%, then in-stream loads will be reduced at least by the same percent and both criteria will be met. The Department deems it appropriate to apply one percent reduction across all flow regimes and all stations. This will lead to larger reductions than necessary for some flow regimes and for some stations, but this falls under the implicit MOS.

Figure E-41. LDC for station 11479, current conditions (prior to 83.2% reduction)

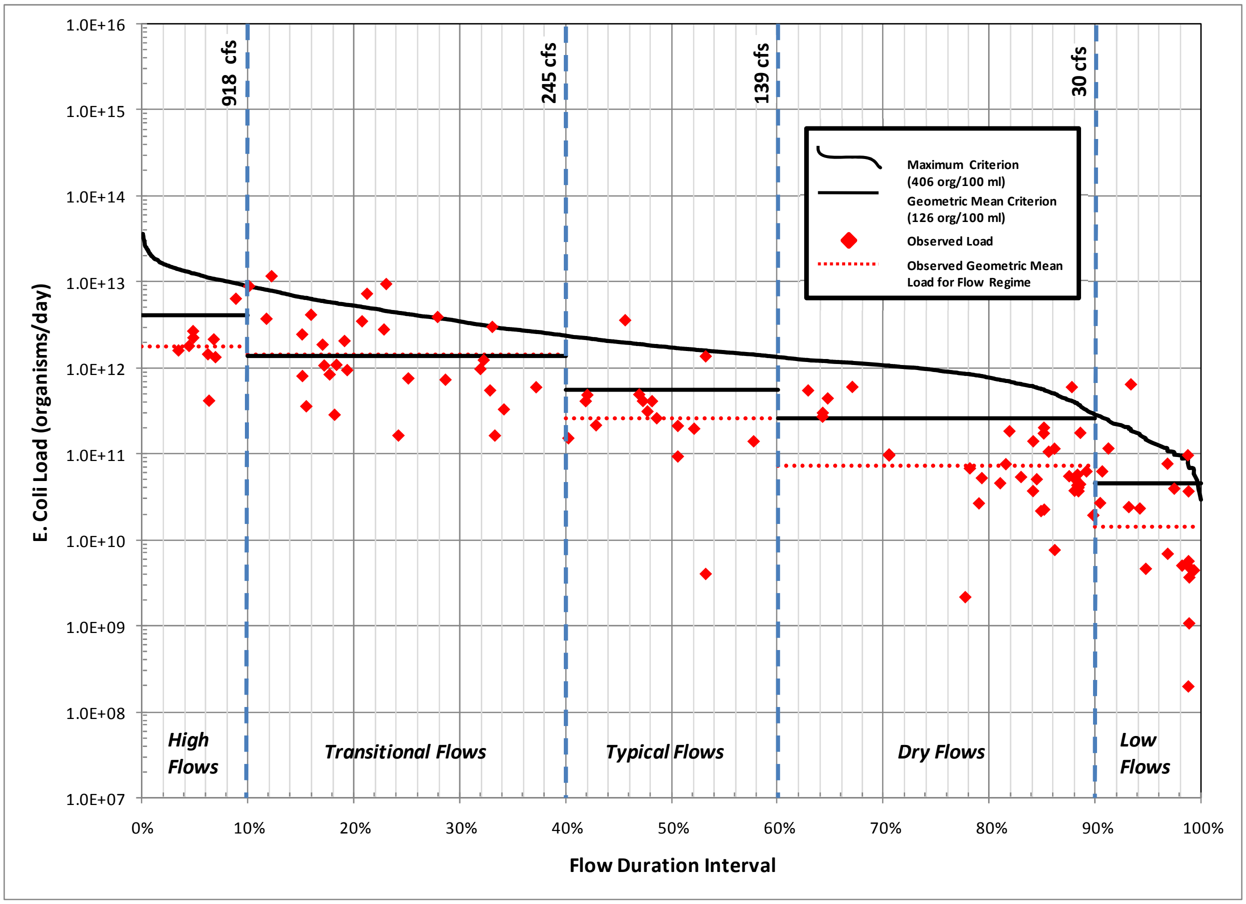
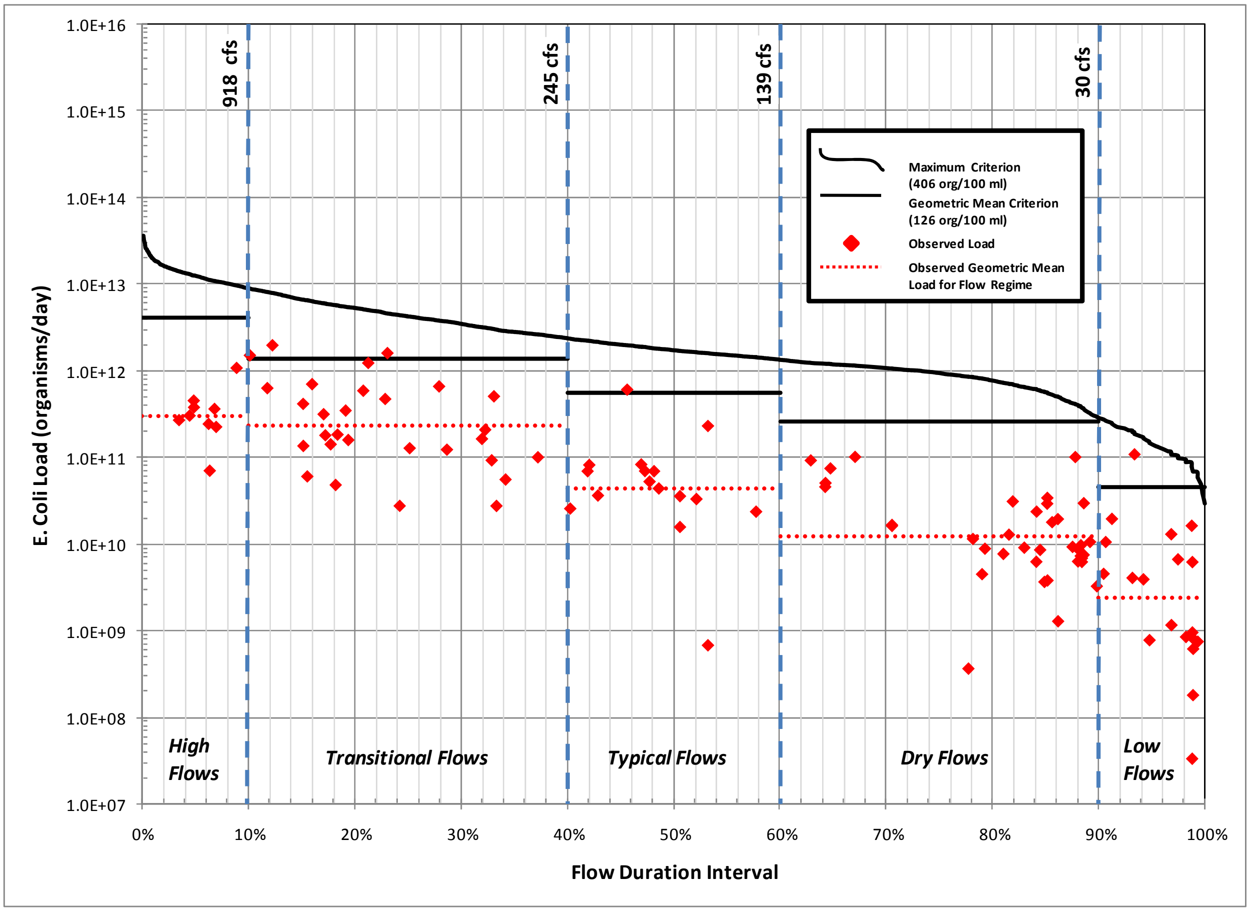


Figure E-42. LDC for station 11479 with 83.2% reduction applied



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