Joe Pool Lake Watershed Protection Plan

developed by

The Joe Pool Lake Watershed Protection Partnership

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On the cover:
Aerial view of Joe Pool Lake
Grand Prairie, Texas.

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Developed by
The Joe Pool Lake Watershed Protection Partnership

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Abbreviations

AU	assessment unit
AVMA	American Veterinary Medical Association
BMP	best management practice
BOD	biological oxygen demand
CDL	cropland data layer
CFR	Code of Federal Regulations
CFU	colony forming unit
CIP	Capital Improvement Program
CRP	Clean Rivers Program
CP	conservation plan
CWA	Clean Water Act
DFW	Dallas-Fort Worth
DMU	Deer Management Unit
DNA	deoxyribonucleic acid
DO	dissolved oxygen
EC	*E. coli*
E. coli	*Escherichia coli*
ECHO	Enforcement and Compliance History Online
EPA	Environmental Protection Agency (United States)
ESRI	Environmental Systems Research Institute
F	Fahrenheit
FDC	flow duration curve
ft	feet
FFA	Future Farmers of America
GIS	Geographic Information System
GPS	Global Positioning System
HAWQS	Hydrologic and Water Quality System
HUC	hydrologic unit codes
I/I	inflow and infiltration
IPL	Integrated Pipeline Project
ISD	Independent School District
JPL	Joe Pool Lake
LDC	load duration curve
LOADEST	Load Estimation Program
LULC	land use and land cover
MCRWS	Mountain Creek Regional Wastewater System
MGD	million gallons per day
mg/L	milligram per liter
mL	milliliter
MOS	margin of safety
MPN	most probable number
MSL	mean sea level
MS4	municipal separate storm sewer system
N/A	Not Applicable/Not Available
NASS	National Agricultural Statistics Survey
NCTCOG	North Central Texas Council of Governments
NHD	National Hydrography Dataset
NLCD	National Land Cover Database

NO_2	nitrite
NO_3	nitrate
NO_X	(NO_3 + NO_2)
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OB	optical brightener
OP	orthophosphate
OSSF	on-site sewage facility
PCR	primary contact recreation
POR	period of record
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SSO	sanitary sewer overflow
SSURGO	Soil Survey Geographic Database
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
SWQM	surface water quality monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TAC	Texas Administrative Code
TAG	Technical Advisory Group
TAMU	Texas A&M University
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TKN	total kjeldahl nitrogen
TMDL	total maximum daily load
TNRIS	Texas Natural Resources Information System
TP	total phosphorus
TPWD	Texas Parks and Wildlife Department
TRA	Trinity River Authority of Texas
TRWD	Tarrant Regional Water District
TSS	total suspended solids
TSSWCB	Texas State Soil and Water Conservation Board
TSZ	traffic survey zones
TWDB	Texas Water Development Board
µg/L	micrograms per liter
U.S.	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQMP	Water Quality Management Plan
WPP	watershed protection plan
WWTP	wastewater treatment plant
WWTF	wastewater treatment facility
yr	year

Executive Summary

Joe Pool Lake (JPL) has a total drainage area of 304 square miles and is fed by the waters of Walnut Creek and Mountain Creek. Walnut Creek's headwaters are in the City of Burleson and flow approximately 24 miles northeast, emptying into JPL in southeastern Tarrant County. Mountain Creek's headwaters originate from the City of Alvarado and flow approximately 19 miles northeast, emptying into JPL in northwestern Ellis County. The JPL watershed is comprised of urban areas in the northern end of the watershed, with industrial, municipal complexes, and agricultural use throughout the center and southern extent. Portions of 10 incorporated communities and one census-designated place call the watershed home, varying in population from nearly 72,000 to less than 400. There exists significant potential for urban growth in the southeastern, southern, and southwestern extent of the watershed in the unincorporated areas around Grand Prairie, Mansfield, Midlothian, and Venus. Currently, these areas consist of mostly undeveloped land, with pasture, grassland, cropland, and deciduous forest being prominent. In these areas, cattle are the most prominent livestock species, constituting just over 75% of the estimated livestock population in the watershed. The remainder is composed of nearly equal representation from goats and horses, in addition to a smaller population of sheep. These three species, while well-represented in more rural areas, were also observed with frequency in many lower-density urban areas in the watershed, on small-acreage properties commonly referred to as “hobby farms.” Industry appears to be most dense along United States (U.S.) Route 67 and U.S. Route 287 highway corridors, but examples of larger industrial complexes can be found throughout the watershed.

In 2014, portions of Mountain Creek (0838A) had concerns for nitrate, and Walnut Creek (0838C) did not meet state water quality standards for bacteria. Walnut Creek was delisted for bacteria in the *2018 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (Texas Integrated Report) and Mountain Creek is no longer listed for concerns for nitrate as of the 2016 Texas Integrated Report. Currently, water from JPL is withdrawn by the City of Midlothian as part of its municipal water supply. This water withdrawal is used to supply the communities of Venus, Rockett, Mountain Peak, Sardis, and parts of southern Grand Prairie. JPL is expected to be used as a future water source for many Dallas-Fort Worth (DFW) cities (TWDB, 2020). Two projects are occurring to develop a watershed protection plan (WPP) for JPL watershed to improve water quality and to mitigate future impacts of rapid urbanization.

The Need for a Plan

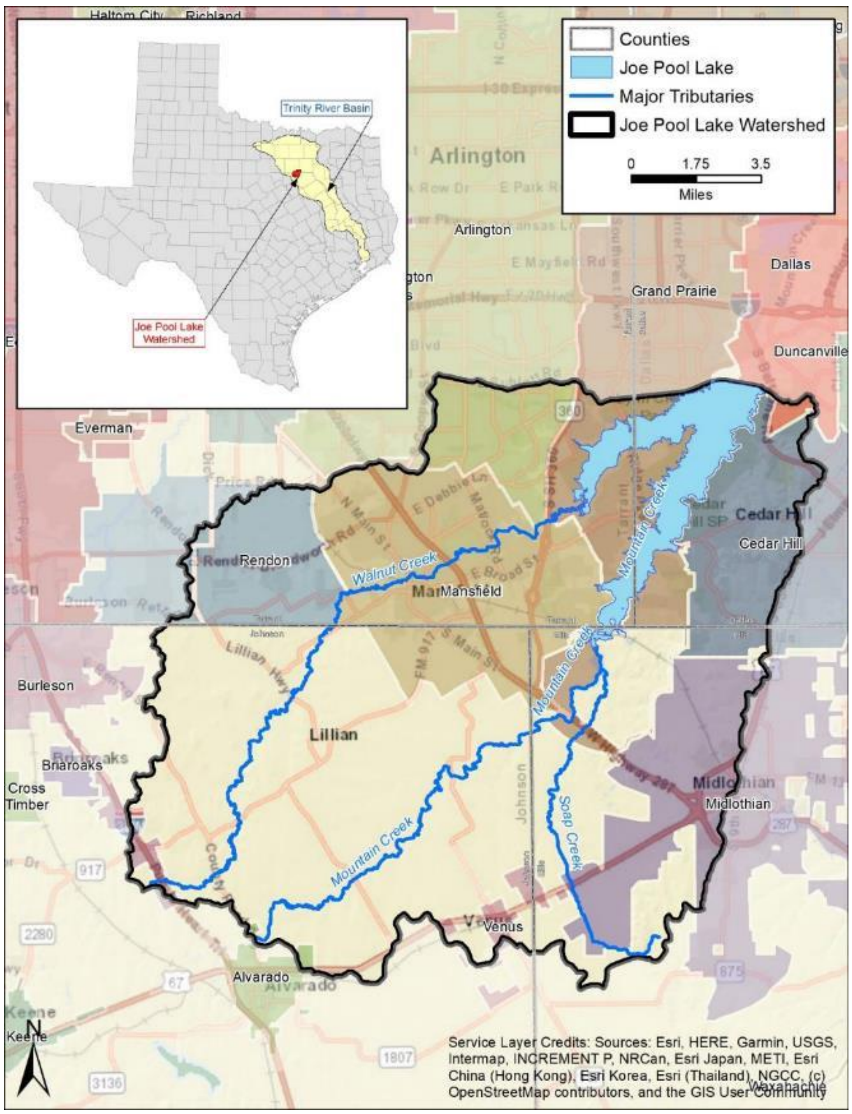
Walnut Creek, one of JPL’s two main tributaries, was first listed for a recreational use impairment due to excessive levels of *Escherichia coli* (*E. coli*) in the 2006 *Texas Commission on Environmental Quality Water Quality and 303(d) List* (TCEQ, 2007). Subsequent lists published in 2008, 2010, and 2012 indicated that the creek was consistently impaired. After the publication of the 2014 Texas Integrated Report, the impairment level had declined. The stakeholder impetus for this WPP is based on the 2014 Texas Integrated Report, which indicated the Walnut Creek geometric mean for *E. coli* was 195.60 colony forming units (cfu)/100 milliliters (mL), greater than the state standard of 126 cfu/100mL for water bodies designated for primary contact recreation 1 use (PCR1). This impairment applies to the entire water body, designated as Assessment Unit (AU) 0838C_01. At the time this project was approved for Clean Water Act (CWA) Section 319 funding, the 2016 Texas Integrated Report was not yet available for use. In the 2018 Texas Integrated Report, Walnut Creek had a geometric mean of 94.75 MPN/100mL for *E. coli* and was delisted as an impaired water body. Limited data precluded the full assessment of Walnut Creek in the 2022 Integrated Report, and it was listed as a concern for bacteria.

The second motive for the development of the WPP was the 2010 Texas Integrated Report listing of concern for nitrate screening level in the Mountain Creek arm of JPL (TCEQ, 2010). Mountain Creek arm (AU 0838_02) was listed for a nitrate concern in 2010, 2012, and 2014. The nitrate mean exceedance reported in the 2014 Texas Integrated Report was 0.74 milligram per liter (mg/L) which is greater than the state screening level of 0.37 mg/L for lakes (TCEQ, 2015a).

As of the 2016 Texas Integrated Report, nitrate is no longer a concern in the Mountain Creek arm. In summary, the 2014 Texas Integrated Report was the impetus for development of a WPP for JPL.

Stakeholders Take Action

The Cities of Cedar Hill, Grand Prairie, Mansfield, and Midlothian, in conjunction with the Trinity River Authority of Texas (TRA) and Texas Commission on Environmental Quality (TCEQ), began developing the JPL WPP in 2018. Over the course of the next three years, stakeholders gathered to form the JPL Watershed Protection Partnership, meeting to discuss priorities for water quality improvements and strategies for preventing further degradation. Development of the plan took place over the course of 19 meetings between the general Partnership and the Steering Committee. Meetings were open to the public and were attended by representatives from watershed residents, businesses, municipal and county staff, other public officials, and state/federal agency staff. From the onset, Partnership members clearly defined their goals of improving water quality in Walnut Creek and protecting water quality in JPL, while simultaneously accounting for the socio-economic needs and recreational wants of those that live, work, and play in the JPL watershed.



Basemap: ESRI World Street Map; Stream data source: National Hydrography Dataset (NHD).

Location of JPL watershed

Addressing Pollutant Sources

A watershed characterization was initiated during the first year of the project, providing additional water quality data for stakeholders to use in their quest to identify potential pollutant sources. Through the use of several pollutant load calculation techniques, it was determined that pet waste, livestock, feral hogs, and septic systems were significant sources of *E. coli.* However, after much discussion about the relative cost effectiveness of the best management practices (BMPs) associated with reducing loads for each of these pollutant source categories, stakeholders were able to adjust their priorities, focus on managing modeled sources that could be managed more efficiently, and were even able to incorporate management measures to address some important non-modeled sources, including illegal dumping, lawn wastes, and residue. While these two sources are not directly related to significant *E. coli* loads, both still present real threats to water quality if left unchecked, so stakeholders chose to make these additional priorities in addition to the efforts focused on *E. coli* load reductions.

Researchers associated with the WPP used surface water quality data to determine that an overall reduction of 94% in *E. coli* concentrations from sources such as pet waste, livestock, septic facilities, and wildlife would be needed to meet the state water quality standard for PCR1 and maintain a 10% margin of safety (MOS) to account for uncertainties inherent to the planning, research, and implementation strategies associated with the WPP effort. Data was also used to set interim milestones to guide progress in pursuit of water quality goals. Due to a lack of numeric nutrient criteria for JPL and available data, numeric goals were not set for other pollutants, but goals and interim milestones using other metrics, such as reductions in the number of sanitary sewer overflow (SSO) events, were dictated whenever it was appropriate to do so (TCEQ, 2015a). It was determined that the majority of pollutant sources in the watershed were nonpoint sources and therefore closely related to stormwater runoff. Because of this, it is likely that many of the management measures purposed for *E. coli* reductions will also reduce a number of other pollutants, including nutrients (like nitrate and total kjeldahl nitrogen (TKN)), sediments, and other substances that could become problematic in the future.

Recommended Actions

Based on their evaluation of the monitoring, modeling, and survey data collected during earlier stages of the WPP, Partnership members recommended several management practices targeted to *E. coli* reductions, with expectations that other known and emerging pollutants would also be attenuated along with *E. coli* when the management measures were applied. Additional recommendations were made to gather more information regarding illegal dumping activities, illicit discharges, and other stormwater-related sources so that efforts to address these concerns could be mobilized quickly during the implementation stages of the WPP. A summary of BMP recommendations are provided in Table 7-1

Dogs and Cats

Pets are a significant source of *E. coli* in the watershed. Stakeholders immediately recognized that efforts put towards reducing bacteria loads from pet waste, specifically from dogs as well as feral, or barn cats, would provide significant reductions with high cost-effectiveness. Recommendations made by the stakeholder group include the development and adoption of model pet waste ordinances, by-laws to help combat bad actors that leave pet waste in public areas, installation of additional pet waste stations in high-need areas throughout the watershed, and promotion and installation of pet waste digesters for homeowners to help reduce the incidence of pet waste-borne *E. coli* entering waterways from their backyards. Table 6-1 outlines the recommended BMPs for pet waste.

Illegal Dumping

Illegal dumping was a significant concern for stakeholders in the JPL watershed and addressing the problem early in implementation quickly became a priority. To support this effort, early grant funding requests are expected to incorporate support for wider-ranging and more frequent surveys of the watershed to locate popular illegal dumpsites so that the proper enforcement entities have the necessary information to move forward with cleanup efforts. Hazardous household waste pickup days for rural/unincorporated areas were also identified as a need, as was expansion of current lake cleanup events to extend into the Mountain Creek and Walnut Creek watershed to be inclusive of communities in the southern extent of the watershed. Table 6-4 outlines the recommended BMPs for illegal dumping.

Lawn Residue and Waste

Development of model lawn residue and waste ordinances and by-laws for consideration to discourage residents and businesses from disposing of organic lawn waste into stormwater drains and/or overuse lawn chemicals was seen as a priority to reduce impacts to aquatic health in the creeks and the lake. Existing landowner resources promoting land management, green infrastructure, proper irrigation, soil health, and herbicide/pesticide application were also seen as valuable resources. Table 6-5 outlines the recommended BMPs for lawn residue and waste.

Livestock

Agricultural management measures have been a mainstay of the watershed planning process and are popular options for incorporation into WPPs due to their flexibility in aggregating a number of smaller land, forage, and animal management practices into cohesive, whole-farm or whole-ranch plans that are developed by local resource technicians to meet the needs of the watershed. Table 6-2 outlines the recommended BMPs for livestock.

Feral Hogs

While feral hogs did prove to be a significant source of *E. coli* loading in the watershed, stakeholders understood that attempts to manage the population would be costly, resource-intensive, and would likely only provide minimum returns on investment. To that end, management recommendations focus on using existing or voluntary measures such as landowner agreements to construct exclusionary fencing around attractive nuisances (e.g. game feeders), and shoot-on-site tactics. In addition to limited funding identified for creation and management of a framework designed to connect landowners to a network of trappers, trapping programs, and other feral hog-related resources, Partnership members also outlined funding for a municipal trap share program, if the need and desire to move forward with a coordinated trapping program arises in the future. Table 6-3 outlines the recommended BMPs for feral hogs.

Sanitary Sewer Overflows

It is understood that the majority of corrective activities associated with SSOs falls outside of the purview of the Clean Water Act (CWA) Section 319(h) program, but stakeholders still recognized opportunities to assist wastewater infrastructure managers with identification of potential SSOs. The implementation of stormwater infrastructure assessments designed to identify illicit wastewater connections, proper placement and abundance of storm drains, and the identification of other opportunities to improve stormwater conveyance, will help minimize impacts from infiltration and inflow from stormwater systems. This assessment will help identify infiltration into wastewater infrastructure and reduce pollution from SSOs. Table 6-6 outlines the recommended BMPs for SSOs.

Septic Systems

Retrofitting and replacing failing septic systems is a proven method of reducing pollution. However, significant installation costs can quickly exhaust available implementation funding with a lower return on investment when compared with other management activities. Instead, the Partnership focused on incentivizing septic inspections and pumpouts, with system retrofits and complete replacements identified as a secondary component. Neighborhood-wide events to take advantage of cost savings for inspections and pumpouts were also identified as viable management measure. Emphasis was also placed on promotion of “septic to sewer” initiatives available for residents in areas covered by centralized wastewater systems but have yet to make the switch from their existing septic system. Table 6-7 outlines the recommended BMPs for on-site septic facilities (OSSFs).

Sediment and Flooding

Stakeholders identified sediment and flooding as an additional water quality concern within the watershed due to future growth, expansion, and development. Flood management is outside the scope of this WPP, but when flow regimes change or flooding increases, the impact of pollutant sources in the watershed can be altered. Management measures will focus on working with partners and agencies tasked with flood assessment to incorporate water quality concerns and green infrastructure in future development and planned flood mitigation projects. Table 6-8 outlines the recommended BMPs for sediment and flooding.

Education and Outreach

In general, education and outreach initiatives will be tied to the physical and programmatic management measures covered in the previous Recommended Action section of this Executive Summary and Section 6.0 Management Strategies and Associated Load Reductions. Examples include:

- Implementation of existing resources highlighting the importance of proper pet waste disposal;
- Development of educational materials for novel or under-utilized pet waste management methods;
- Land conservation education for new owners of hobby farms with no prior farming experience;
- Continued development and delivery of feral hog educational workshops;
- Coordination with other entities on existing, successful campaigns for littering and illegal dumping;
- Implementation of “Water Wise” programming for homeowners and lawn care professionals regarding proper stormwater management techniques associated with home and lawn care;
- Implementation of existing septic system maintenance training for homeowners;
- Development of new training for professionals like real estate agents to reduce the likelihood of system failure and surface water contamination; and
- Development of educational materials for sediment and flooding BMPs.

Tracking Implementation Progress

To track implementation progress and improvements in water quality, it will be necessary to continue routine water quality monitoring in the watershed. There may also be a need to supplement this broad scoped monitoring effort with more targeted monitoring, which could be catered to a specific source, location, or management measure of interest. As the needs of the watershed progress, flexibility in the monitoring program will be imperative so that researchers can adapt to the monitoring needs as new developments arise. Future changes in water quality, along with implementation updates and other relevant news, will be conveyed to stakeholders in a manner agreed upon by the Partnership. An annual newsletter will be provided over the 10-year implementation period, with meetings held on an as-needed basis.

What’s Next?

In the coming years, the Joe Pool Lake Watershed Protection Partnership will continue to convene, at a frequency and manner that is agreed upon by the Partnership, with an annual meeting at a minimum. These meetings will be designed to provide attendees with updates on implementation progress, covering active and completed projects, along with any water quality or aesthetic improvements these projects exemplified. These meetings will also serve as checkpoints to evaluate implementation progress and to determine whether adaptive management techniques will be needed to ensure projects stay on course in pursuit of water quality goals so that future generations may benefit from the work done in the present to protect the valuable resources in the JPL watershed. The JPL website will continue to be maintained and updated as necessary by TRA.

1.0 Watershed Management

1.1 Watersheds and Water Quality

A watershed is the land area that drains water to a common point such as a stream, river, lake, wetland, or ocean. Watersheds can be very small, such as part of a park that drains to the creek in your neighborhood. Many of these small watersheds combine to form much larger watersheds, such as major river basins that drain large portions of states, and in some cases, cover large portions of countries or continents. For example, several subwatersheds make up the JPL watershed, which is part of the Trinity River basin (Figure 1-1).

Figure 1-1 Conceptual interpretation of the JPL watershed system

No matter where you are on the Earth, you're in a watershed. As runoff water from storms flows across the landscape, it picks up and carries sediment and various other substances as it flows to a waterway. This means that everything we do on the land affects both water quality and quantity, and the cumulative effects can impact the function and health of the whole watershed.

An effective watershed management strategy will show a measurable effect on the water quality of the receiving water body. To accomplish this, the strategy must account for and examine the full scope of human activities and natural processes that occur within the watershed's boundary.

1.2 The Watershed Approach

Watersheds often contain parts of many municipalities and counties and may even cross state lines. This often makes it difficult for any one entity to approach and solve water quality concerns on their own. To address this constraint, many state resource agencies, in partnership with federal agencies, have adopted a *watershed approach* for managing water quality, which involves assessing the sources and impacts of water quality impairments at the watershed level. That information can be used to develop and implement BMPs that are applicable throughout the entire watershed.

Utilizing a watershed approach improves the chances of identifying and evaluating all potential pollution sources to a waterway. A key component of the watershed approach is the input from stakeholders, who may be anyone that has an interest in the watershed. These stakeholders may offer unique insights and experiences gained from either working, living, or engaging in recreation in the watershed. These insights and experiences will supplement water quality monitoring data to help inform management decisions that are put into practice. As users of the watershed, stakeholders have a vested interest in the water quality, and will also be affected by the management decisions used to address water quality issues.

1.3 Watershed Protection Planning

To support stakeholders who wish to utilize this watershed approach, the Environmental Protection Agency (EPA) has developed a list of nine key elements necessary for developing a successful WPP capable of addressing water quality issues. A WPP document outlines the coordinated efforts of all stakeholder groups as they plan to implement a prioritized set of water quality protection and restoration strategies. Details about these elements, as well as the WPP chapters they correspond to, are provided in Appendix A: Key Elements of Successful WPPs.

The intent of the JPL WPP is to empower stakeholders to implement these strategies through voluntary participation in pursuit of the environmental goals they set themselves. Public participation is a critical component throughout the process, as it is up to stakeholders to select, design, and implement management strategies best suited for the watershed from the standpoints of economic feasibility, social acceptability, and scientific credibility. The success of the JPL WPP is dependent on the continued commitment of residents, landowners, businesses, and elected officials to act as good stewards of the natural resources of the watershed.

1.4 The Joe Pool Lake Watershed Protection Partnership

Effective WPPs utilize local knowledge and expertise to guide the planning process, ensuring that the BMPs selected for implementation are relevant to the watershed's issues, applicable to the environmental setting of the watershed, and feasible for the watershed residents, given available resources. If this process is followed, local stakeholders are more likely to modify their behaviors and adopt the BMPs identified in the Plan.

1.4.1 Formation

The JPL watershed protection effort was initiated to address water quality concerns in both JPL and its tributaries. Drinking water from JPL is utilized by over forty thousand people in the City of Midlothian and the communities of Venus, Rockett, Mountain Peak, Sardis, and parts of southern Grand Prairie. In addition to this existing use by the City of Midlothian, JPL is expected to be further developed by the Cities of Cedar Hill, Duncanville, and Grand Prairie for their own municipal use. JPL has also been designated as a potential terminal storage reservoir for the Tarrant Regional Water District (TRWD) and Dallas Water Utilities, Integrated Pipeline Project (IPL), which seeks to connect three reservoirs in east Texas (Richland Chambers, Cedar Creek, and Lake Palestine) to other reservoirs in the DFW metroplex to enhance the future water supply of the region and to provide for redundancy in the water supply system.

Walnut Creek, one of JPL's two main tributaries, is listed on the 2014 TCEQ Texas Water Quality Inventory and 303(d) List due to elevated levels of *E. coli*, with its first listing occurring in 2006. The majority of the impaired segment flows through the city limits of Mansfield, who approached TRA in late 2015 as they were considering restoration options available for Walnut Creek. Walnut Creek has since been delisted for *E. coli* as of the 2020 Texas Integrated Report. Additionally, the Mountain Creek arm of JPL was listed on the 2014 Water Quality Inventory—Water Bodies with Concerns for Use Attainment and Screening Levels, for general use concerns due to elevated levels of nitrate. The cities of Cedar Hill, Grand Prairie, and Mansfield all border this segment of concern. As of the 2020 Texas Integrated Report, there is no longer a concern for nitrate in the Mountain Creek arm.

According to the Texas Water Development Board (TWDB) population projections identified during the 2016 Regional Water Planning process, the population of the four counties encompassed in this project are expected to increase a combined 60% from 4.9 million to 7.9 million people over the next 50-year water planning horizon (TWDB, 2017). Conversion of farmland and rapid development in the watershed indicate that water quality has and will continue to be negatively affected unless more vigorous management measures are put in place. To combat this degradation, local stakeholders have elected to take a proactive approach to ensure that appropriate management measures are in place to ensure that the water quality in the lake is protected.

1.4.2 Structure

The public effort for the Partnership consists of three stakeholder groups, each with its own set of responsibilities and focus areas. To ensure that watershed interests are well-represented, there is a continued effort by the project team to maintain stakeholder representation that is well-distributed, both spatially throughout the watershed, and topically amongst multiple users with varying needs.

General Membership

The Partnership functions as the overall stakeholder group, consisting of all stakeholders, including subgroup members and general members. As such, there are no formal membership requirements, and members may come and go as they please. Partnership meetings serve as a public forum for stakeholder concerns and updates on project progress.

Steering Committee

To facilitate the decision-making process, a core group of stakeholders presently act as the voting body of the Partnership, known as the Steering Committee. The Steering Committee has and will continue to vote on key watershed decisions and review potential water quality improvement BMPs for applicability in the watershed.

The intent of creating the Steering Committee is to foster a wide representation of varied focus groups, including local landowners, businesses, and government officials. These focus groups represent areas of shared knowledge and interest, capable of providing valuable feedback from a variety of perspectives. A list of members and focus groups is provided in Figure 1-2.

Steering Committee (19 members)

Contributing Partners (4)
- City #1 (Cedar Hill)
- City #2 (Grand Prairie)
- City #3 (Mansfield)
- City #4 (Midlothian)

Private Landowners (5)
- Rep #1 (Mountain Creek area)
- Rep #2 (Walnut Creek area)
- Rep #3 (Ag/Rancher)
- Rep #4 (at large)
- Rep #5 (at large)

Counties (2)
- Rep #1 (Dallas County)
- Rep #2 (Tarrant County)

Local Resource Agencies (1)
- Ag Extension (Johnson and Tarrant Co.)

Regional Authorities (2)
- Rep #1 (TRWD)
- Rep #2 (TRA)

Industry (2)
- Holcim Industries
- Halff Associates, Inc.

Education (2)
- UTA
- TCC - S/E campus

Municipalities (1)
- City of Dallas

Figure 1-2 Steering Committee membership and focus groups

Technical Advisory Group

The Partnership also saw a need to create a second stakeholder subgroup capable of providing technical guidance, resource information, and funding opportunities to both the Steering Committee and the Partnership. This technical advisory group (TAG) will serve strictly in an advisory capacity with no formal voting power, making recommendations to the Partnership and Steering Committee as needed. A list of participating entities is provided in Figure 1-3.

Technical Advisory Group (12 members)

- North Central Texas Council of Governments (NCTCOG)
- Natural Resource Conservation Service (NRCS)
- Texas State Soil and Water Conservation Board (TSSWCB)
- Texas AgriLife Extension & Research (AgriLife)
- Texas Commission on Environmental Quality (TCEQ)
- Texas A&M University - Blackland Research Center
- Texas Parks & Wildlife Department (TPWD)
- Trinity River Authority of Texas (TRA)
- Tarrant Regional Water District (TRWD)
- U.S. Environmental Protection Agency (EPA)
- U.S. Fish & Wildlife Service (FWS)
- U.S. Geological Survey (USGS)

Figure 1-3 Technical Advisory Group membership

1.4.3 Coordinated Development of the Watershed Protection Plan

Development of the watershed protection plan, "the Plan", was achieved through the combined efforts of the Steering Committee, TAG, and general Partnership through 19 meetings over the course of a 25-month period. Partnership members were instrumental in identifying BMPs and strategies that proved useful from their diverse experiences, and the TAG was useful in providing technical information towards these practices' potential benefits. The Steering Committee used information from both groups to recommend which BMPs were the best fit for the JPL watershed and its residents.

Ultimately, this information was used by the Steering Committee to evaluate the BMPs that need to be implemented to achieve the desired water quality goals. This process involves continued communication between all three groups as they identify measurable milestones for these goals and prioritize specific BMPs. This may require review and revision of the plan through the use of adaptive management techniques, as well as the effective communication of valuable information about the impacts of the Plan to other interested or affected entities, both within and outside of the watershed.

Achieving improvements in water quality will not be a short-term effort and will continue long after the initial planning period is complete. Even after the Plan's water quality goals are achieved, continued preservation of these goals and long-term protection of the watershed is necessary. As such, the Steering Committee will continue to be a functional group throughout the implementation period of the Plan, as successive components of the Plan are put into practice throughout the JPL watershed. These programs and practices will require periodic evaluation of their results through the use of continued water quality monitoring, which will be targeted to interim and long-term milestones. Through these evaluations, adaptive management techniques will be used to reassess the recommended strategies used in the watershed.

2.0 Watershed Overview

2.1 Geography

The JPL watershed is formed by two major subwatersheds, Walnut Creek to the west and Mountain Creek to the east. Walnut Creek's headwaters are located south of the town of Burleson, draining to the northeast. Mountain Creek's headwaters are located north of Alvarado, draining northward to meet Walnut Creek to form JPL. The watershed spans four counties, occupying the adjoining corners of Dallas, Ellis, Johnson, and Tarrant counties. Urban and suburban areas dominate the northern end of the watershed, along with some areas containing industrial and municipal complexes. The east side of the lake is home to a state park and is thus less developed, although some housing subdivisions are scattered though the area. Land use trends more towards agricultural use in the southern extent, with the exception of some large industrial complexes inside the Midlothian city limits on the southeast perimeter of the watershed. JPL currently serves as a drinking water source for up to 40,000 people, primarily serving the community of Midlothian. Midlothian also provides treated water to the communities of Venus, Rockett, Mountain Peak, Sardis, and parts of southern Grand Prairie.

The subwatersheds of JPL are defined by 12-digit hydrologic unit codes (HUC). These smaller HUCs then combine to form larger HUCs that are defined by 10, 8, 6, or 4 digits. For example, the JPL watershed is actually composed of several subunits of the Mountain Creek-Mountain Creek Lake watershed (10-digit HUC: 1203010206). This is part of the Lower West Fork Trinity subbasin (HUC 12031012), which is part of the Upper Trinity River basin (HUC 120301) and the Trinity River subregion (HUC 1203) (Figure 2-1).

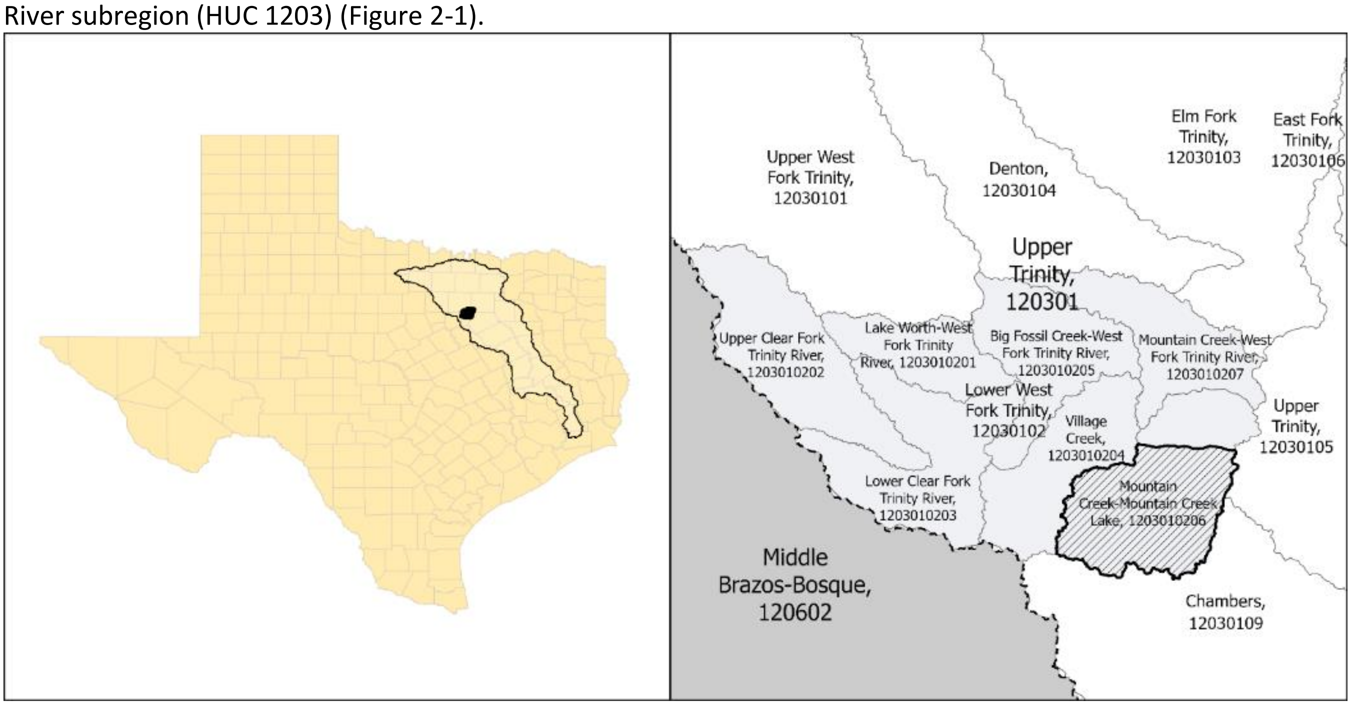
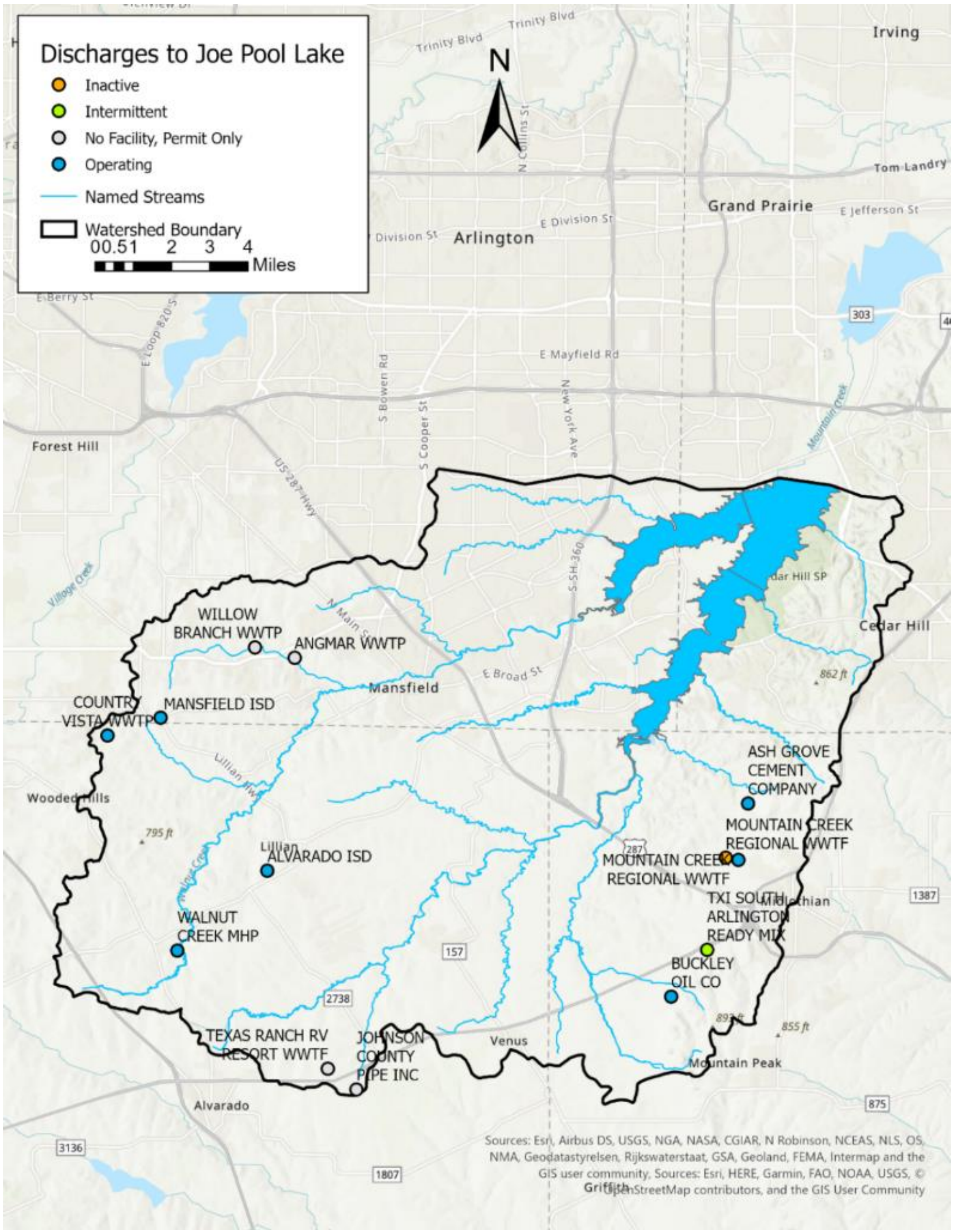


Figure 2-1 Location of the JPL watershed within the Trinity River Basin in Texas

On the left: The Trinity Basin within the context of the state, with the location of the JPL watershed highlighted. On the right, a closer view of the watersheds and nearby subbasins that interact with the JPL subdivision of the Mountain Creek-Mountain Creek Lake watershed. Data source: TWDB and TCEQ.

JPL receives 100% of its yield from natural tributaries, primarily Mountain Creek and Walnut Creek. Both creeks have multiple tributaries that regularly contribute flow, and multiple smaller tributaries feed directly into both the eastern and western sides of the lake. These incoming flows are comprised of stormwater runoff, as well as treated wastewater effluent from Mountain Creek Regional WWTF, and several smaller domestic sewage discharges within the watershed (USACE, 2019) (Figure 2-2).



Basemap: ESRI World Street Map; Stream data source: NHD; station data: EPA ECHO

Figure 2-2 Wastewater Discharges to JPL watershed

Databases maintained by EPA did not identify any discharges of cooling water, mining effluent, or concentrated animal feeding operation effluent in the watershed. Population estimates for 10 municipalities throughout the watershed are shown in Table 2-1.

Table 2-1 Population centers in the JPL watershed

City	2020 Population Estimate[a]	% of City Limits in Watershed[b]	Population in Watershed[c]
Arlington	394,266	9.90%	39,034
Venus	4,361	55.45%	2,418
Dallas	1,304,379	0.54%	7,032
Mansfield	72,602	98.64%	71,611
Alvarado	4,739	11.76%	557
Grand Prairie	196,100	21.25%[d]	41,338
Fort Worth	918,915	0.04%	368
Burleson	47,641	5.23%	2,490
Midlothian	35,125	37.51%	13,176
Cedar Hill	49,148	46.15%	22,681

(a) U.S. Census Bureau estimate based on 2020 census data.

(b) Calculated using the Texas Department of Transportation 2022 city Transportation boundary dataset.

(c) Assumes uniform population density.

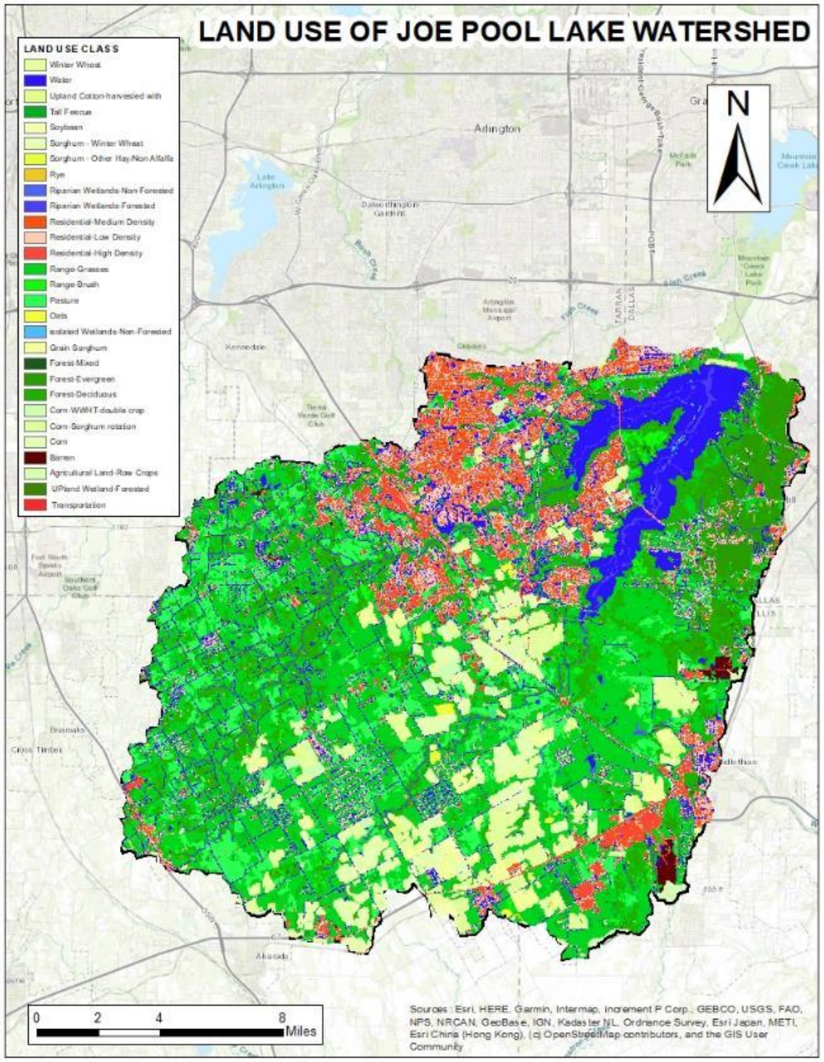
(d) Excludes part of the city limits that lie within JPL's footprint.

2.2 Geology and Soils

The JPL watershed is generally located within the Grand Prairie physiographic province according to the Physiographic Map of Texas (BEG, 1996). The majority of the watershed is underlain by units from the Austin Chalk, Eagle Ford (undivided), and Woodbine groups, with some fluviatile terrace deposits and alluvial floodplain deposits in areas underlying or near larger waterbodies. Soils in the vicinity of the lake are composed mainly of fine sandy loams and silty clays. Some of the more common upland soil groups in the watershed include Crosstell fine sandy loams, Heiden clays, Houston black clays, and Rader fine sandy loams. Several hydric soils occupy the bottom land areas of the watershed, with Trinity clays, Tinn clays, and Pulexas fine sandy loams being most common. A complete soils list and map are provided in the Analysis of Historical Data for the Joe Pool Lake Watershed Characterization Report (TRA, 2019).

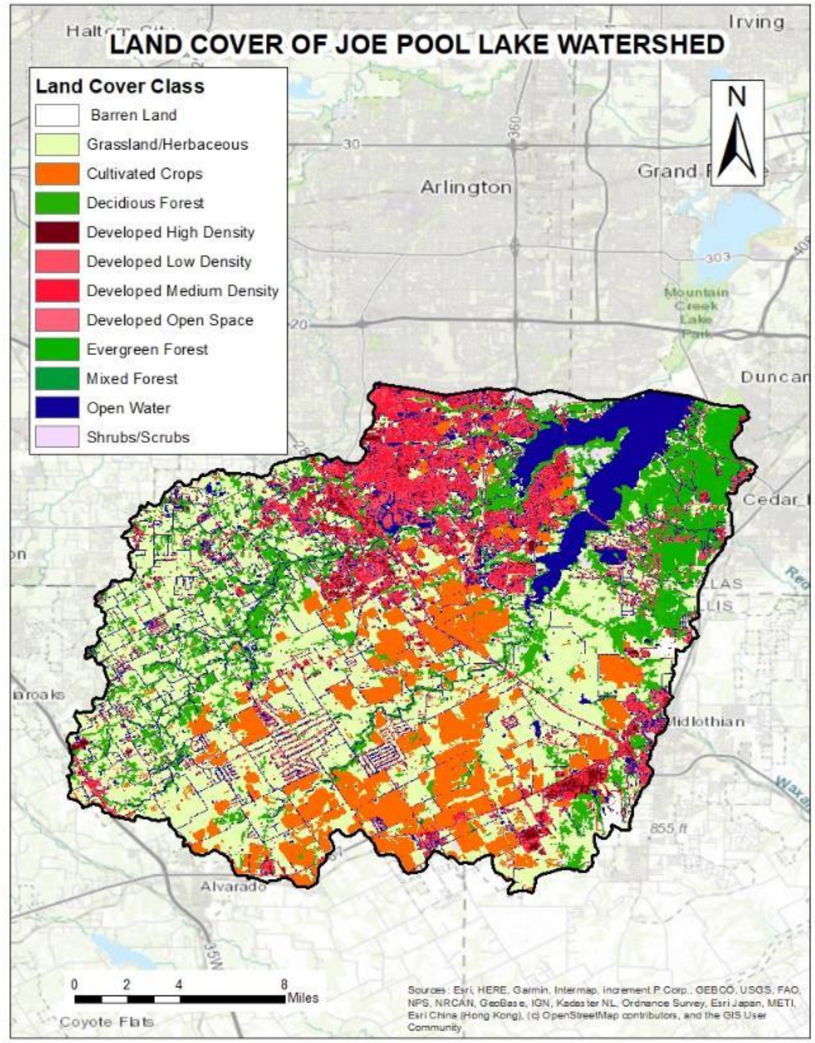
2.3 Land Use and Land Cover

The northern-central and southeastern portions of the subwatershed surrounding the lake are urbanized, while the upstream, southwestern portions of the subwatershed have remained generally rural, dominated by herbaceous cover, with some pastureland and row-crop agriculture. Much of the area east of the lake remains forested due to the existence of Cedar Hill State Park. Major population centers include the City of Midlothian and the communities of the southwest DFW metroplex, which includes portions of Mansfield, Arlington, Grand Prairie, and Cedar Hill. These population centers compose the majority of the developed land in the area, which is shown as red areas in Figure 2-4. Land use within the watershed from 2013 is depicted in Figure 2-3, which relates a use category (residential, industrial, undeveloped, etc.) to the land cover information. The urban centers previously mentioned are characterized by a high percentage of single-family homes, but a significant percentage of industrial complexes appear in the vicinity of Midlothian, with smaller examples near the center of the watershed. Outside of these urbanized areas, ranch land is dominant, with pockets of farmland and undeveloped open lots being typical. The majority of the state park area to the east of the lake is categorized accordingly as parks/recreation land. The land around the lake is owned by United States Army Corps of Engineers (USACE). The JPL watershed contains multiple parks, trails, and outdoor public spaces operated by various public and private entities (Appendix H:). Parks, trails, and public spaces provide multiple benefits to the watershed, but will also benefit from this WPP as the plan provides BMPs to reduce negative impacts to water quality.



Basemap: ESRI World Street Map; land data: USGS NLCD and USDA-NASS-CDL

Figure 2-3 Land use across the JPL watershed



Basemap: ESRI World Street Map; Land data: USGS NLCD 2016

Figure 2-4 Land cover across the JPL watershed

2.4 Ecology

The watershed is shared between the Texas Blackland Prairie and Cross Timbers ecoregions. The southwestern extent of the watershed is in the Eastern Cross Timbers ecoregion. Here, post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) are common overstory trees, with minor representation from species like black hickory (*Carya texana*), plateau live oak (*Quercus fusiformis*), eastern redcedar (*Juniperus virginiana*), and various sumac species (*Rhus spp.).* with native grasses such as bluestem (*Schizachyrium spp.*), yellow Indiangrass (*Sorghastrum nutans*), and tall dropseed (*Sporobolus asper*) in the understory and within prairie inclusions. In disturbed areas, honey mesquite (*Prosopis glandulosa*) and prickly pear (*Opuntia spp.*) are common.

The eastern extent of the watershed is within the Northern Blackland prairie ecoregion. The area was once dominated by tallgrass prairie species in upland areas, but extensive urbanization has occurred in this ecoregion. In undisturbed areas, this includes big bluestem (*Andropogon gerardii*), yellow Indiangrass, little bluestem (*Schizachyrium scoparium*), and tall dropseed. The remaining forested areas include woody species such as oak (*Quercus macrocarpa, Quercus shumardii*), ash (*Fraxinus spp.),* sugar hackberry (*Celtis laevigata*) elm (*Ulmus spp.),* pecan (*Carya illinoensis*), and eastern cottonwood (*Populus deltoides*) are common (Griffith et al., 2007).

Although no instances of critical habitat occur within the watershed for any Federally listed threatened and endangered species, a U.S. Fish and Wildlife Service Information, Planning, and Consultation report indicated the possible presence of several threatened and endangered species that may occur intermittently throughout the watershed. Of note were several endangered avian species, including the Golden-cheeked Warbler (*Dendroica chrysoparia*), Least Tern (*Sterna antillarum*), Piping Plover (*Charadrius melodus*), and Red Knot (*Calidris canutus rufa*). The list also included one species of clam, the Texas Fawnsfoot (*Truncilla macrodon*), which is currently listed as a candidate species. The full Information, Planning, and Consultation report is provided in the Analysis of Historical Data for the Joe Pool Lake Watershed Characterization Report (TRA, 2019).

In most cases, state lists of threatened and endangered species are more robust, given the increased specificity for critical populations and habitats afforded by the smaller scope of study inherent to state boundaries. As a result of this refined scope, additional avian and mollusk species appear within the state list produced by Texas Parks and Wildlife Department (TPWD) and is provided in the Analysis of Historical Data for the Joe Pool Lake Watershed Characterization Report (TRA, 2019). The state list also includes several fish, mammal, reptilian, and plant species not shown in the Federal list.

2.5 Fish and Macroinvertebrate Communities

2.5.1 Joe Pool Lake

JPL is a popular sportfishing destination, particularly for Largemouth Bass, Blue Catfish, Channel Catfish, and White Crappie. White Bass are also present in this lake in limited numbers, and Yellow Bass were collected for the first time in 2014 but have not been subsequently recaptured. TPWD stocks game fish in JPL on an occasional basis, most recently Channel Catfish in 2019 and Largemouth Bass in 2015.

Prey species include sustainable populations of Gizzard and Threadfin Shad as well as Bluegill and Longear Sunfish. Catch rates for all of these species were much lower in the most recent survey performed in 2017 than in previous collection efforts in 2015 and 2016, likely due to flooded conditions at the time of sampling that greatly reduced available habitat. Largemouth Bass also followed this pattern, exhibiting a greater than 60% decrease in catch rates from 2015 to 2017

(Brock et al., 2018). In contrast to this trend, Blue Catfish, Channel Catfish, and White Crappie all exhibited higher catch rates in 2017 than in previous surveys. TPWD plans to perform their next electrofishing survey in fall 2021 – spring 2022.

Aquatic vegetation at JPL is typically sparse, with the most recent survey in 2017 finding no significant vegetation due to the prolonged flooding over the 2015-2017 period (Brock et al., 2018). Historically, vegetation in the lake primarily included American Pondweed (*Potamogeton nodosus*), American Water-Willow (*Justica americana*), and Common Reed (*Phagmites australis*). Although a problematic invasive species, Hydrilla (*Hydrilla verticillate*) provides abundant cover where present. Hydrilla presence in JPL varies greatly year-to-year but was not observed in the most recent survey in 2017 (Brock et al., 2018).

Suitable aquatic habitat in JPL consists primarily of flooded timber in the northern portions of both lake arms, with approximately 1,800 of the lake's 7,400 acres featuring some standing timber. Additional habitat is provided by various features and structures deliberately left in place when the reservoir was filled, such as stock ponds, large brush piles, bridges, and roadbeds.

Zebra mussels, a destructive invasive species, continue to pose a threat to JPL. Although no mussel individuals or populations have been detected within the lake as of 2021, the detection of zebra mussel DNA in lake water during a 2013 survey and the continued expansion of mussel populations to other lakes in the DFW metroplex demonstrates the need for continued vigilance (Brock et al., 2018). TPWD has placed signage at public areas around the lake to help educate the public about this threat.

2.5.2 Walnut Creek Aquatic Life Monitoring

The portion of Walnut Creek upstream of JPL is classified as an intermittent stream with perennial pools that are sufficient to support significant aquatic life use (Mummert, 2011). Data collected in the summer of 2017 indicated that the stream exceeded the previously-presumed 'limited' aquatic life use level based on this classification (TRA, 2018). The habitat quality scored as "high" for both events despite the stream being in disconnected pools during the second event. This is likely due to the large size of these pools and the availability of instream cover.

For fish, an event conducted in the early summer index period produced an "exceptional" fish score for abundance and diversity, while the event conducted in the hot mid-summer critical period produced an "intermediate" score (TRA, 2018). During the second event the creek was in disconnected pools with some subsurface flow. Notable fish species included Largemouth Bass, Gambusia, Blackstripe Topminnow, Slough Darter, Bullhead Minnow, and various sunfish (Green, Longear, Bluegill, Warmouth).

Benthic macroinvertebrate genera represented included snails, worms, flatworms, leeches, fingernail clams, amphipods, mayflies, caddisflies, dragonflies (spinyleg), damselflies (dancer), beetles (riffle, marsh, whirligig), non-biting midges, and water striders. Sampling for freshwater mussels was not a component of this study.

2.6 Climate

The mean annual daily temperature from the National Weather Service database for the DFW metroplex (https://www.weather.gov/fwd/dfwclimo) is 66.0°Fahrenheit (F) for the entire period of record (POR) between 1899 and 2020. Temperatures are generally lowest in January and highest in August, with POR daily annual averages of 45.6 °F and 85.0 °F, respectively.

The mean annual precipitation for the entire DFW area is 33.4 inches for the entire POR between 1899 and 2020. The lowest yearly total was in 1921, with only 17.9 inches, with the highest yearly total occurring in 2015, when prolonged storms brought 62.8 inches of rain, along with historic flooding (TCEQ, 2015a).

2.7 Groundwater

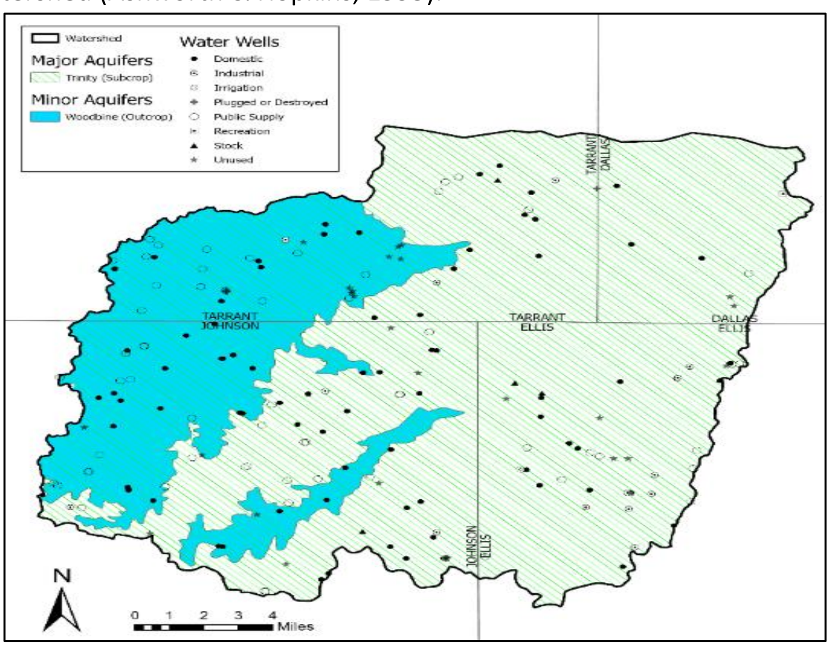
One major and one minor aquifer group exists within the JPL watershed; the Trinity group and the Woodbine group. Data provided by the TWDB indicate that wells for domestic use (76 total) are the most common and widespread water use type, closely followed by public water supply wells (70 total) (Furnans et al., 2017). Although there are a small number of wells in the northeast part of the watershed immediately surrounding JPL, most are concentrated in the more developed southern and western parts of the watershed (Figure 2-5).

2.7.1 Trinity Group

The subcrop region of the Trinity aquifer underlays the entirety of the watershed (Figure 2-5). The ongoing development within the general DFW metroplex has significantly impacted water availability in this aquifer, with levels in some areas dropping more than 550 feet (ft) from historic levels. As a consequence, many public water supply wells have been abandoned since the mid-1970s in favor of surface water supply sources. This has translated to a slight recovery for the aquifer, but areas of Johnson County remained as much as 100 ft below normal depth (Ashworth & Hopkins, 1995).

2.7.2 Woodbine Group

The outcrop zone, or upper region, of the Woodbine group is represented along approximately the western one-third of the watershed. Water within this outcrop zone often contains excessive levels of iron and is not recommended for public water supply or domestic use. Although the chemical quality of the water deteriorates quickly in well depths greater than 1,500 ft, the areas above this depth and below the outcrop zone are considered to be of overall good water quality, assuming that steps have been taken to seal off portions of the upper Woodbine that contain excessive amounts of iron. The lower two of the three zones of the Woodbine are suitable for public water supply or domestic use but are not present within the JPL watershed (Ashworth & Hopkins, 1995).



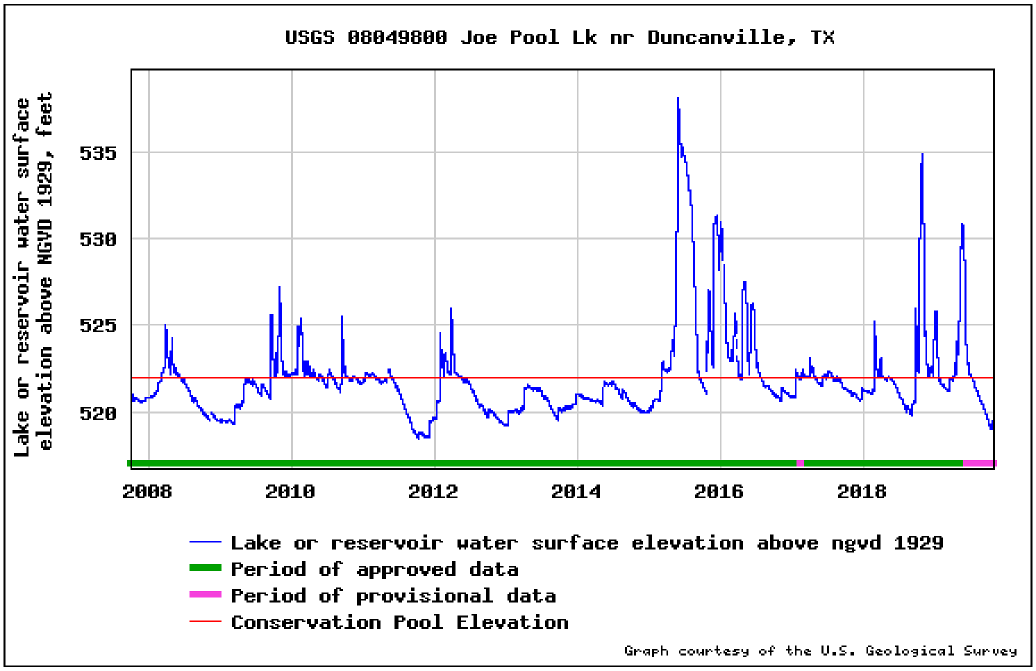
Data source: TWDB

Figure 2-5 Aquifers and known water wells in the JPL watershed

2.8 Surface Water

2.8.1 Joe Pool Lake

The normal conservation pool elevation for JPL is 522 ft above mean sea level (MSL). The flood pool elevation is 536 ft MSL, and above 541 ft MSL water will flow over an uncontrolled concrete emergency spillway. The USACE maintains a flowage easement up to approximately 541 ft. MSL contour allows operational flexibility to raise the water level to the maximum pool elevation. Historical lake elevations from 2007 to 2019 are provided in Figure 2-6.



Data source: USGS

Figure 2-6 Daily Observed Water Surface Elevation in JPL, 2007-2019

Water rights for JPL are held by TRA. TRA has contracts to sell water from JPL to the cities of Midlothian, Duncanville, Cedar Hill, and Grand Prairie, although at the current time only Midlothian is drawing a significant quantity of water from the lake. From 2015 to 2020, Midlothian withdrew anywhere from 2.5 million gallons per day (MGD) during winter months and up to 9.3 MGD during peak demand in the summer (Table 2-2) (TRA, 2021). Withdrawals by the city also include sales of the water to other communities, including southern Grand Prairie, Venus, Rockett, Mountain Peak, and Sardis throughout the year. Midlothian withdraws their water from an intake structure in the southern extent of the Mountain Creek arm of the lake. The City of Grand Prairie also draws a very small quantity of water for agricultural use at a single location. TRA has a separate intake structure in the lake built in anticipation of future needs, but it has been inactive since the lake was completed. Several other entities have interests in developing the water resources of the lake but have yet to tap into those resources. The lake is also used regularly for public recreation, with seven public boat ramps allowing for boat entry for fishing and other recreational activities (USACE, 2019).

Due to the location of JPL in relation to the IPL project, a joint project between the TRWD and the City of Dallas. The IPL project connects Lake Palestine, Cedar Creek Reservoir, and Richland Chambers Reservoirs. JPL has been designated as a potential terminal storage reservoir for Dallas Water Utilities for its share of water transported through the IPL project. Dallas has a “reserved capacity share of 150 MGD” in the IPL project. The IPL connection to Joe Pool is anticipated to be complete by 2027. Although the connection to JPL is anticipated by 2027 the volume of water to be stored and/or transported through JPL is anticipated to grow into the 150 MGD capacity share based on available supplies for Dallas

Water Utilities water supplies and water demands. The IPL project will connect three reservoirs and the water transported through the IPL will be a blended water of lake Palestine, Cedar Creek Reservoir, and Richland Chambers Reservoir. TRWD is currently evaluating water supply blends, water quality of the blends and the treatability of the water blends.

Table 2-2 Sources of supply and uses of water in JPL (TRA Northern Region DMRs, 2021)

JPL Supplies and Uses	Annual Medians (Acre/ft)	
	Inflows	Withdrawals
Natural supply from watershed	37,196,753[a]	N/A
Midlothian Water Treatment Plant	N/A	221,996[b]
TRA MCRWS WWTP	2,573[c]	N/A

(a) Median adjusted inflow value for PORPOR 2000-2019.
(b) Calculated from median of 2020 monthly withdrawal averages.
(c) Calculated from median of 2020 monthly discharge averages.

2.8.2 Lake Tributaries

JPL is fed by two large creeks, Mountain Creek and Walnut Creek, as well as their tributaries and numerous smaller creeks flowing directly into the lake. The variable topography of the JPL watershed has resulted in differing characteristics between the flat western/southwestern portions of the watershed and the rugged, hilly area to the east of the lake. While Walnut Creek and Mountain Creek tend to have fairly steady baseline flows draining a relatively wide area, the tributaries John Penn Branch, Baggett Branch, Hollings Branch, and Bedford Branch to the east of JPL have comparatively small drainage areas and flow rapidly downhill to the reservoir.

Within the Walnut Creek subwatershed, Lynn Creek, Bowman Branch, Sugar Creek, Low Branch, Walnut Creek, and its tributaries Hogpen, Willow, and Valley Branches drain a mix of suburban and rural land. At the upper end of the watershed Walnut Creek drains unincorporated areas near the I-35W corridor, progressing to more urbanized areas further north in Mansfield and the southern extremes of Arlington and Grand Prairie. Flow data for Walnut Creek is tracked continuously by a United States Geological Survey (USGS) gaging station at the Walnut Creek bridge on Matlock Road (USGS Gage #08049700), with data back to July 2007.

The upstream end of the Mountain Creek subwatershed also primarily drains unincorporated rural land, with the headwaters of Mountain Creek near the town of Alvarado. This area remains mostly rural in its southern and western extent, with extensive development mostly limited to some residential areas along the western lakeshore. Baggett Branch and Hollings Branch both also drain parts of Cedar Hill and Midlothian. Mountain Creek is also gaged (USGS Gage #08049580), with data back to 1987. Other flow data exist at other stations throughout the watershed within TCEQ Surface Water Quality Monitoring Information System (SWQMIS) that will be used to supplement the USGS dataset, where appropriate. In addition to natural runoff, the Mountain Creek Regional Wastewater System (MCRWS), located near Midlothian, contributes steady baseflow to JPL through discharges to a small tributary of Soap Creek. This wastewater treatment plant is operated by the TRA and serves the cities of Midlothian, Venus, and parts of Grand Prairie and Mansfield.

3.0 Water Quality Assessment

The EPA requires states to develop a list (commonly called the 303(d) List) describing water bodies in or bordering Texas for which effluent limitations are not stringent enough to implement water quality standards (40 CFR § 130.7). In accordance with CWA (33 USC § 1251.303), States may create and apply their own water quality standards, but these must first be approved by the EPA. In Texas, these water quality standards and the designated uses they are designed to support are defined in the Texas Water Code, in fulfillment of the requirements laid out by the CWA. Addressing waterways impaired by pollution and hazardous substances is at the heart of the CWA, which requires standards that: 1) maintain and restore biological integrity; 2) ensure that all waterbodies remain “swimmable and fishable” by protecting fish, wildlife, and recreational uses, and 3) assess the many uses of a water of the state (public water supply, agricultural, industrial, wildlife, recreation) from both a use and value standpoint.

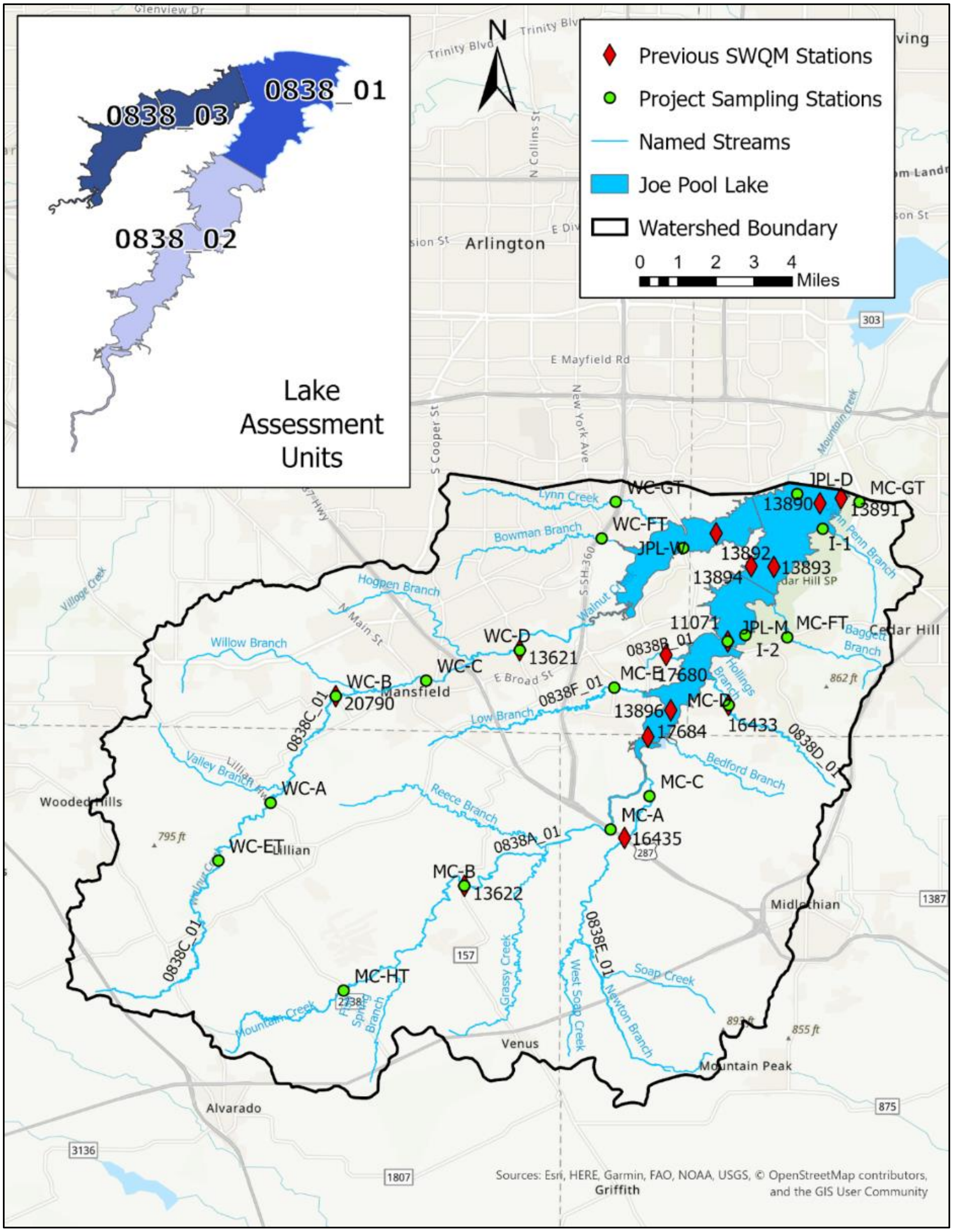
EPA also requires that states develop acceptable strategies for restoring water quality in its impaired waterbodies (40 CFR § 130.7). One acceptable strategy is the use of a regulatory mechanism for developing total maximum daily loads (TMDLs) that sets budgets for pollutants in a water body. These budgets identify the water body’s maximum pollutant loading capacity and the reduction required to meet standards for applicable uses. TMDLs accomplish this by allocating the pollutant load budget to a variety of pollutant sources and establishing the maximum allowable loads from those sources. An alternative strategy involves the use of non-regulatory methods, such as a WPP. This allows stakeholders to identify and address water quality impairments, along with other water quality concerns in the watershed, with more autonomy in comparison to a TMDL. Due to the wider scope allowed with WPPs, established water quality goals may also include protections for unimpaired waters in addition to the goal of restoring impaired water bodies.

3.1 Water Body Assessments

In compliance with Sections 305(b) and 303(d) of the CWA, TCEQ conducts biennial assessments of Texas waterbodies, with results provided in the Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d) List (Texas Integrated Report). A range of water quality conditions and assessment status is expressed by a level of support established in each assessment unit for each use and parameter combination. Support status reflects when (1) data are not sufficient to allow assessment, (2) only a concern can be established from limited data, and (3) the assessment can confidently establish the level of support.

The 2020 Texas Integrated Report for the Trinity River covers a seven-year assessment period from December 1, 2011 to November 30, 2018 (TCEQ, 2020). In cases where additional data were needed to meet minimum data requirements and make an informed assessment, data from an additional three-year period beginning December 1, 2008 were used. Water quality was evaluated according to the methods described in the *2020 Guidance for Assessing and Reporting Surface Water Quality in Texas* (TCEQ, 2019a).

Water bodies assessed in Texas are given a segment identification number, which is then subdivided into one or more AUs. The JPL watershed consists of several TCEQ-designated segments, including JPL (0838), a classified segment, and six unclassified segments: Mountain Creek (0838A), Sugar Creek (0838B), Walnut Creek (0838C), Soap Creek (0838D), Hollings Branch (0838E), and an unnamed tributary (0838F). While JPL contains three AUs, 0838_01 through 0838_03, each of the unclassified stream segments only contain a single AU (Figure 3-1).



Basemap: ESRI World Street Map; Stream data source: NHD; station data: TCEQ

Figure 3-1 Assessment units, segments, and surface water quality monitoring stations in JPL watershed

3.2 Texas Surface Water Quality Standards

TCEQ is responsible for establishing numeric and narrative criteria for water quality in the state of Texas. These criteria are described in TCEQ's Texas Surface Water Quality Standards (TSWQS) which are codified in the Texas Administrative Code (TAC), Title 30, Chapter 307, hereto referred to as TAC 307 (TCEQ, 2018). The TSWQS are effective for Clean Water Act purposes when they are approved by the EPA.

Bacteria

The Primary Contact Recreation 1 (PCR1) use is evaluated using a numeric criterion of 126 cfu per 100 mL of water, although newer bacteria enumeration methods use MPN/100 mL metric. The two should be considered equivalent for the purposes of this project. The presumption of a PCR1 use and associated numeric criteria are applied to all freshwater systems in Texas unless site-specific standards have been developed. This numeric criterion is compared to the geometric mean (geomean) of the surface water quality dataset, which must include a minimum of 20 samples over a seven-year period (TCEQ, 2015a). The risk level associated with PCR1 is based on epidemiological data (from the Great Lakes and lakes in Oklahoma) which indicates the instance of gastrointestinal illness in eight individuals out of a population of 1000 engaged in PCR1 activities (swimming, diving, or children wading) (EPA, 1986).

TCEQ performed a Recreational Use Attainability Analysis on Walnut Creek (0838C) in the summer of 2010. As a result TCEQ adopted a change in recreational use from PCR1 to Secondary Contact Recreation 1 (SCR1) use based on physical stream site characteristics and observed patterns of recreational use. This newly adopted state change in recreation use has not been approved by the EPA so the stream remains designated as PCR1.

Total Dissolved Solids

Total dissolved solids (TDS) is a rudimentary measurement of all the dissolved ions within a water body, such as chloride, sulfate, and other dissolved salts. While it does provide a very rough indicator of general water quality for evaluating aquatic life and public water supply uses, it cannot reveal the specific source or composition of the ions in the sample.

Other Measurements

Several additional parameters are often measured routinely to assess general use, support of aquatic life, and for public water supply use. These include DO, water temperature, pH, chloride, and sulfate. Chloride and sulfate are components of TDS, with excessive levels of each posing similar concerns for both aquatic life and public water supply uses. The site-specific numeric chloride criterion for JPL (Segment 0838) is 100 mg/L. The sulfate numeric criterion for the lake is 250 mg/L, but there are no site-specific numeric criteria for the streams feeding into the lake (TCEQ, 2018). Water temperature and pH are similarly important for a variety of uses. Healthy aquatic habitats in Texas typically fall within a pH range of 6.5-9.0. The pH values can be heavily dependent on water temperature, with excessively high water temperatures (>95 °F) indicating conditions that are stressful for aquatic organisms. This association is also evident with DO, which is vital to the survival of fish and other aquatic fauna, being affected by both temperature and nutrient concentrations. For JPL, a 24-hour DO average of 5.0 mg/L and minimum of 3.0 mg/L must be maintained to support its aquatic life use.

3.3 Nutrient Screening Levels and Reference Criteria

Currently, no numeric criteria have been adopted for nutrients in streams in the state of Texas. Numeric criteria for chlorophyll-*a* have been adopted by TCEQ and approved by EPA for 39 of 75 reservoirs in the state; however, JPL is not one of these approved reservoirs. In such situations where no numeric criteria have been adopted or are in the process of being developed, controls such as narrative criteria and antidegradation considerations are often used. Despite this lack of numeric criteria, TCEQ continues to screen for parameters such as nitrogen, phosphorus, and chlorophyll-*a* as preliminary indicators for concern. To support this effort, nutrient screening levels and reference conditions are often used to compare a water body to reference values at a local, regional, or national level. Table 3-1 provides screening values from various sources. The Texas Nutrient Screening Levels are based on statistical analyses of Surface Water Quality Monitoring (SWQM) data. They are based on the 85th percentile values for each parameter in freshwater streams, tidal streams and reservoirs without numeric criteria throughout the state of Texas (TCEQ, 2015a).

The EPA Reference Criteria for streams are based on data from streams within specific ecoregion units and those for reservoirs are based upon nutrient criteria models (EPA, 2001a, 2020). While most EPA Reference Criteria are lower than those for state screening levels, surpassing them may not necessarily indicate a concern.

Table 3-1 TCEQ Screening Levels and EPA reference criteria for nutrients

Parameter		TCEQ Screening Levels		EPA Reference Criteria			
		Lake/Reservoir	Stream	Lake/Reservoir		Stream	
TKN	mg/L	-	-	0.38[a]	0.41[b]	0.3[a]	0.4[b]
NO_3-	mg/L	0.37	1.95	-	-	-	-
NO_2^-+NO_3^-	mg/L	-	-	0.017[a]	0.01[b]	0.125[a]	0.078[b]
TP	mg/L	0.2	0.69	0.02[a]	0.019[b]	0.037[a]	0.038[b]
NH_3	mg/L	0.11	0.33	-	-	-	-
Chlorophyll-*a*	µg/L	26.7	14.1	5.18[a]	2.875[b]	0.93[a]	1.238[b]

(a) Reference conditions for aggregate Ecoregion IX waterbodies, upper 25th percentile of data from all seasons, 1990-1999.

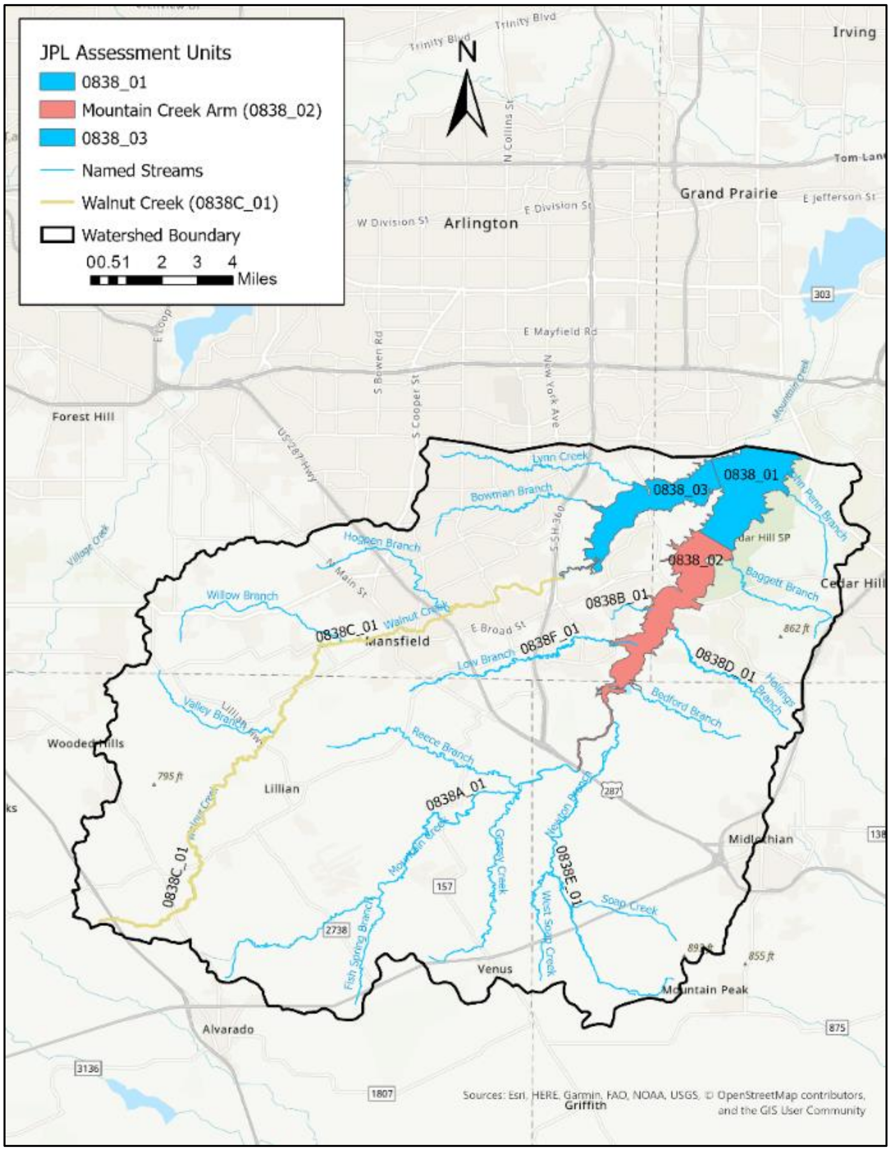
(b) Reference conditions for level III Ecoregion 29 waterbodies, upper 25th percentile of data from all seasons.

Historical trends in chlorophyll-*a* were assessed by TRA between January 1997 and April 2020 for all JPL sites. Statistically-significant increasing trends were detected for chlorophyll-*a* in JPL. However, the majority of chlorophyll-*a* measurements remained well-below the TCEQ Screening Level of 26.7 µg/L and a trend analysis of chlorophyll-*a* from April 2010 to April 2020 failed to show any significant trends (TRA, 2020).

3.4 Segment Impairments and Concerns

When a sufficient number of elevated surface water quality measurements cause the water body to surpass the water quality criteria (min, max, average, or geomean), the waterbody is considered impaired and may not be supportive of one or more of its designated uses. Although the most recent assessment period covered by the 2020 Texas Integrated Report did not identify concerns or impairments, the impetus to conduct water quality monitoring in JPL watershed was based on the 2014 Texas Integrated Report that did identify concerns and an impairment (TCEQ 2015b). This impairment was for elevated bacteria counts in Walnut Creek (0838C_01) (TCEQ 2015b, 2019b) (Table 3-2).

If more than 20% of a water body's samples from the assessment period exceed a screening level, then on average, it will experience higher pollutant concentrations than 85% of the streams in Texas and thus is considered to have a concern for elevated nutrients. For the same 2014 assessment period, there was one AU in the lake (Mountain Creek arm, Segment 0838_02) with a concern for nitrate. No water quality concerns were identified in JPL or other tributaries in the watershed in the 2020 Texas Integrated Report (TCEQ 2020).



Basemap: ESRI World Street Map; Stream data source: NHD; AU source: TCEQ

Figure 3-2 Historically impaired segments and water quality concerns in the JPL watershed

Table 3-2 Record of impairments and concerns in the JPL watershed

Texas Integrated Report	Mountain Creek Arm (AU 0838_02)		Walnut Creek (AU 0838C_01)	
	Geomean Exceedance	TCEQ Screening Level	Geomean Exceedance	TCEQ Criteria
Recreation Impairment - *E. coli* (cfu/100 mL)				
2006	-	-	284.00	126
2008	-	-	284.00	
2010	-	-	256.63	
2012	-	-	285.01	
2014	-	-	195.60	
2016	-	-	126.62	
General Concern - nitrate (mg/L)				
2006	Concern[a]	0.37	-	-
2008	-[a]		-	-
2010	0.76		-	-
2012	0.86		-	-
2014	0.74		-	-
2016	1.52[b]		-	-

(a) Parameter was assessed but means values were not reported in the assessment for this year.
(b) This geomean is composed of 3 carry-forward samples from the 2014 assessment, no new samples were included in this assessment.

4.0 Potential Pollutant Sources

Pollutants from human activities and natural processes can be grouped into two categories, based on their origin:

Point source pollution is a discharge that can be traced back to a single point of origin. This can be a pipe, drain, or outfall and is typically discharged directly into a waterway. Because point sources are tied to human activity, they regularly contribute flow to a system regardless of the native flow conditions. In fact, point sources may constitute most or all the baseflow in some systems, particularly in urban watersheds where large or regional wastewater treatment facilities (WWTFs) provide consistent effluent flows.

Point source pollution is regulated through a permitting process; in Texas this is administered through TCEQ. One example of a permitted discharge is effluent from WWTFs. Here, the treated effluent must remain within specific pollutant limits so that the facility's impact on the receiving water body is minimized. Other examples of point source include wastewater infrastructure issues, like a break in a wastewater pipeline, or a SSO. These sources bypass WWTFs and can have either short-term or long-term effects on water quality depending on when they're identified and how quickly they're addressed.

Nonpoint source pollution, by contrast, tends to be more challenging to manage since it cannot be traced back to a single point of origin. Instead, pollutants that are dispersed over the land (either through human activity or natural processes) are carried into waterways with runoff from storm events. Several factors may influence the types and amounts of pollutants that ultimately end up in a waterway, but they are primarily dependent on land use and land cover (LULC). Sources of pollutants may include excess agricultural or residential fertilizers, fluids from leaking vehicles, pet waste from yards or urban public areas, or waste from wildlife, livestock, and feral hogs.

When considering the impacts of pollutant sources, it is important to account for the source's proximity to waterways. This is accomplished by estimating the percentage of the *E. coli* load that could realistically be transported from source to waterways through surface water or groundwater transport. In the JPL WPP, weighted percentages for each source location were applied using the Spatially Explicit Load Enrichment Calculation Tool (SELECT). This approach weights riparian zones more heavily than those in upland zones to account for the increased impacts from sources in riparian zones. For additional information on SELECT and how source loads were calculated for both point and nonpoint sources, see Appendix C:.

4.1 Prioritizing Pollutant Sources

Likely pollutant sources in the watershed were identified through the historical data review, water quality monitoring, and source identification/load calculation efforts. These results were interpreted and refined with the help of watershed stakeholders, including project partners, the Steering Committee, and the TAG (Figure 4-1, Table 4-1). As discussions with stakeholders progressed throughout the planning process, it became clear that stakeholder priorities for water quality did not always run parallel with the results of water quality monitoring and modeling efforts. For example, feral hog contributions to *E. coli* loads were ranked 4th overall in volume, but stakeholders understand the difficulty of controlling wild animals as a management measure, and thus chose to focus their efforts and funding on more easily controllable sources. In addition, reducing illegal dumping were a stakeholder priority, but this source could not be included in the modeling due to a lack of reliable data on illegal dumping as a source of water contamination. Similar allowances were made when considering acute contamination problems from high volume runoff events vs. chronic contamination problems from low but consistent volumes. Further, sedimentation and flooding were also considered a water quality concern due to future growth, expansion, and development in the watershed but could not be included in the modeling and are outside the scope of this WPP. Stakeholders spent substantial time and effort considering these situations as they sorted through their collective priorities. They used a tiered approach to group priorities of similar urgency, based on perceived need, probability of success, and economic advantages.

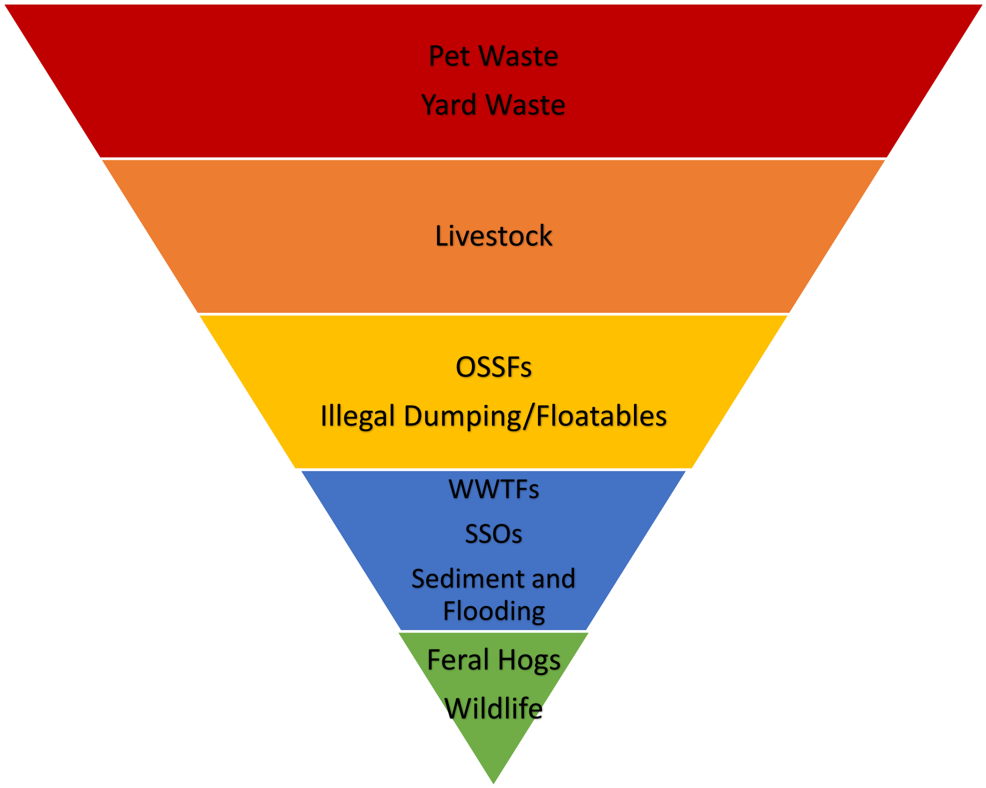


Figure 4-1 Continuum for prioritizing pollutant sources in the JPL watershed, from highest priority (red) to lowest (green)

Table 4-1 Summary of potential pollutant sources in the watershed and associated management priority

Source	Concerns	Potential Impacts	Rank[1]	Priority[2]
Pets	Improper disposal of pet waste Disease transmission and public safety Lack of education on impacts and proper disposal	(1) Indirect *E. coli* loading to water body from yards, public greenspaces, kennels, and shelters; (2) spread of disease amongst/between species	1	1
Livestock	Increased runoff from overgrazing of upland areas Manure transported to water body by runoff Direct manure deposition in water body Riparian buffer zone degradation	(1) Direct/indirect *E. coli* loading to water body; (2) loss of natural pollutant mitigation capabilities	2	2
OSSFs	"Straight pipes" and other illegal wastewater discharges Improperly treated aerobic effluent applied to land Failure due to age, improper design, or lack of maintenance	(1) Direct/indirect loading of untreated wastewater to water body; (2) local groundwater resource degradation	3	3
Feral Hogs	Manure transported to water body by runoff Displacement/predation of native species Direct manure deposition in water body Riparian buffer zone degradation	(1) Direct/indirect *E. coli* loading to water body; (2) loss of natural pollutant mitigation capabilities; (3) loss of natural species diversity	4	5
Wildlife	Manure transported to water body by runoff Riparian buffer zone degradation Direct manure deposition in water body	(1) Direct/indirect *E. coli* loading to water body; (2) loss of natural pollutant mitigation capabilities	5	5
WWTF	Failure due to age, stormwater I&I, or lack of maintenance Overloads from population growth or illicit connections	(1) Direct loading of untreated wastewater to water body	6	4
Yard Waste and Residue	Improper disposal of yard clippings Excessive fertilizer, herbicide, or pesticide application	(1) Direct/indirect contamination of water body from *E. coli*, nutrients, and hazardous materials; (2) impacts to aquatic wildlife	-	1
SSOs	Failure due to age, land erosion, or construction damage Failure due to stormwater I&I issues	(1) Direct/indirect *E. coli* loading to water body; (2) human health hazards	-	4
Illegal Dumping	Household/construction waste disposal in/near waterbody Animal carcass/hunting remains disposal in/near water body Disposal of large items (furniture, appliances, vehicles)	(1) Direct/indirect contamination of water body from *E. coli*, nutrients, and hazardous materials; (2) localized human health hazards; (3) Flow obstruction/alteration	-	3
Sediment and Flooding	Sediment loading and increased risk in flooding in developing areas Loss of natural areas/green spaces	(1)Impact to aquatic life (2) impact to water supply and flood supply capacity in JPL, (3)Direct/indirect nutrient and bacteria loading to waterbodies from runoff and erosion events, (4) public health and safety (5) erosion, (6) infrastructure damage	-	4

(1) Relative impact of *E. coli* load on the watershed, as ranked by the SELECT analysis. Sources noted by '-' could not be included in the SELECT analysis.

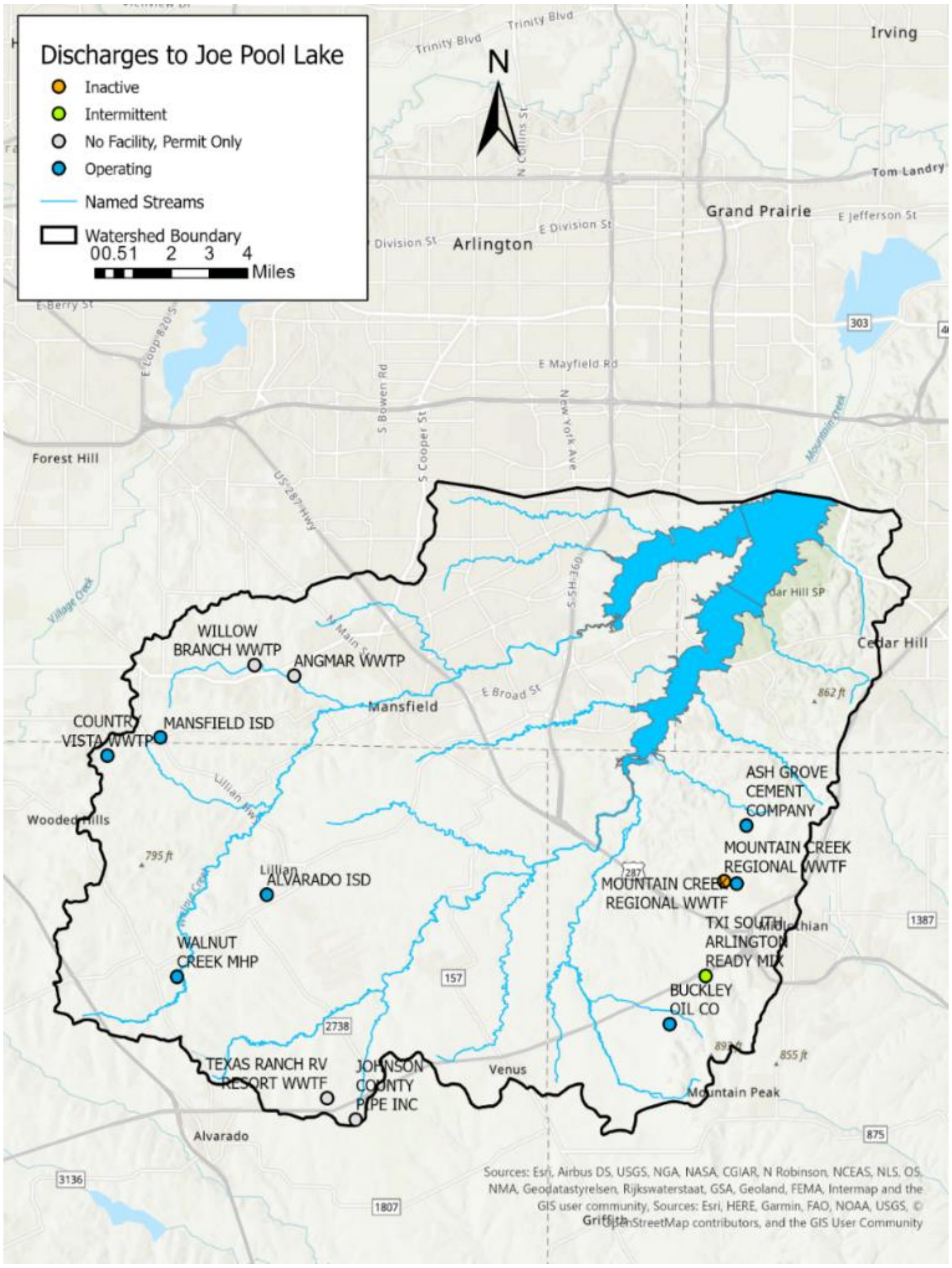
(2) Water quality restoration priorities, as identified by watershed stakeholders.

4.2 Point Source Pollution

4.2.1 Permitted Discharges

Wastewater facility outfall data was obtained from the Discharge Monitoring Report (DMR) database via EPA's Enforcement and Compliance History Online (ECHO) website; see Appendix C for additional information. Thirteen total wastewater discharges exist in the JPL watershed; four are inactive (Figure 4-2). Details about the active WWTFs and any associated permit limit exceedances for water quality parameters are provided in Table 4-2. Of these facilities, only one is considered a municipal discharger, the Mountain Creek Regional Wastewater Treatment Facility, with a permitted average daily flow of 3 MGD. Ash Grove Cement Company is a discharger, but its effluent is characterized as cement and hydraulic byproduct water. The other facilities are smaller plants that treat wastewater from mobile home parks and independent school districts (ISD). These maintained a reported average daily discharge of <0.025 MGD.

Recent permit exceedances for these facilities for *E. coli*, total suspended solids (TSS), 5-day biological oxygen demand (BOD_5), and ammonia are provided in Table 4-2. The significance of the WWTF locations in this watershed is that both arms of JPL contain some portion of wastewater effluent constituting their baseflow throughout the year (Figure 4-2). Stormwater inflow and infiltration (I/I) issues associated with the wastewater infrastructure connected to the WWTF can be the most common cause of elevated *E. coli* concentrations leaving facilities above the permitted effluent limits. This exceedance of treatment capacity can also be caused by unknown illicit connections delivering inconsistent additional flows, or from continued urbanization stressing the WWTF beyond its original design capacity.



Basemap: ESRI World Street Map; Stream data source: NHD; station data: EPA ECHO

Figure 4-2 Permitted discharges in the JPL watershed

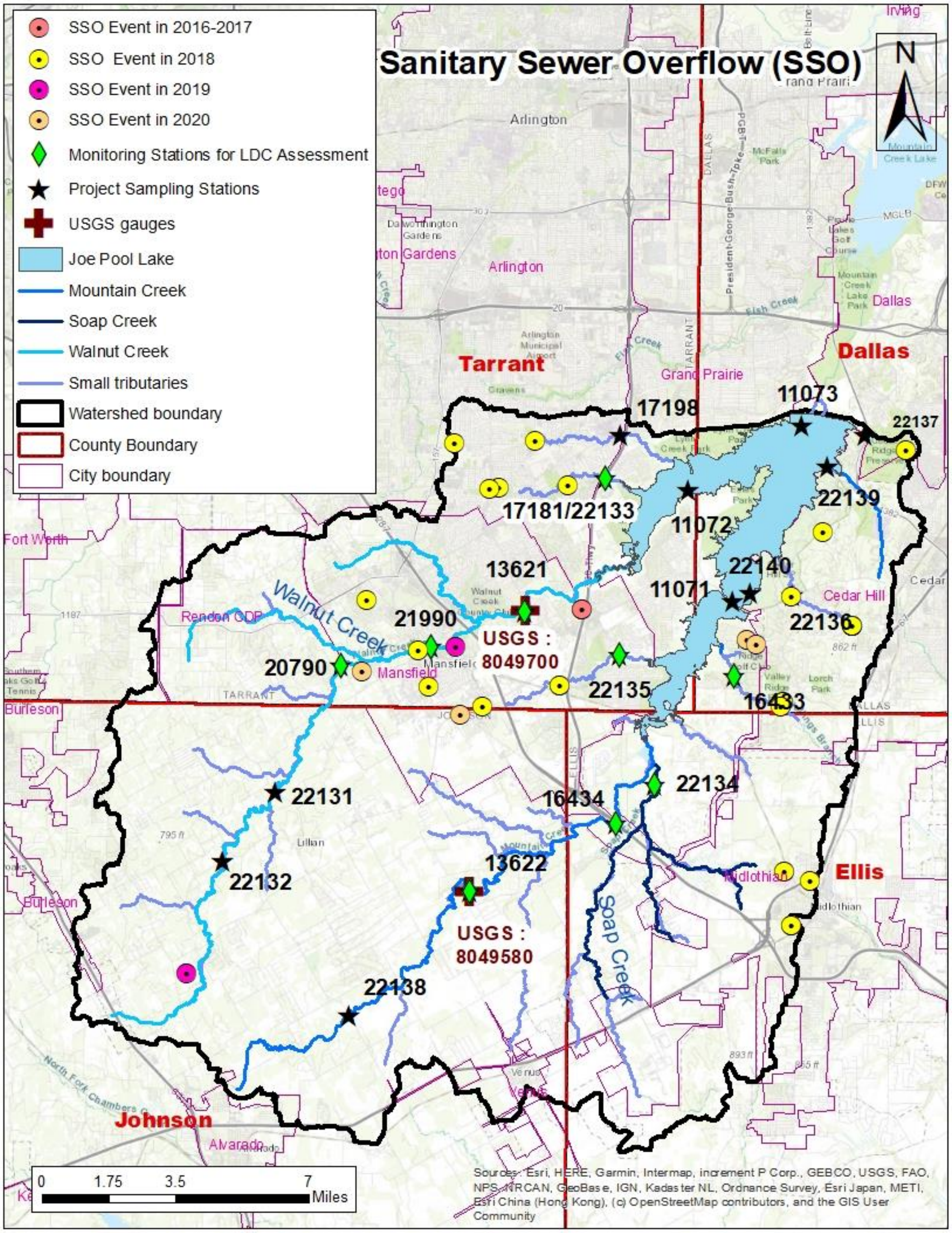
Table 4-2 Compliance history for active WWTFs in the JPL watershed

TPDES Permit	NPDES Permit	Facility Name	Receiving Water body	Flow (daily average, MGD)		*E. coli* (daily average, MPN/100 mL)		Number of Exceedances[4]			
				Permitted	Reported[1]	Permitted	Reported[2]	*E. coli*	Ammonia	BOD_5	TSS
WQ0002427000	TX0083437	Ash Grove Texas LP	Bedford Branch	0.3	0.1865	126	N/A	0	0	0	0
WQ0002427000	TX0083437	Ash Grove Texas LP	Bedford Branch	0.006	0.00138	126	1.19	0	0	0	12
WQ0014101001	TX0119229	Alvarado ISD	Unnamed Trib to King Branch to Walnut Creek	0.035	0.00139	126	4.596 [3]	0	0	1	1
WQ0013769001	TX0113573	Country Vista WWTP	Unnamed Trib to Valley Branch to Walnut Creek	0.042	0.0255	126	4.265[3]	0	0	3	8
WQ0013352002	TX0133388	Mansfield ISD	Unnamed Trib to Valley Branch to Walnut Creek	0.02	0.0116	126	2.888 [3]	0	0	14	16
WQ0010348001	TX0025011	Mountain Creek Regional WWTF	Unnamed Trib to Soap Creek	3	2.371	126	4.93	2	0	0	2
WQ0013868001	TX0118770	Walnut Creek MHP	Walnut Creek	0.0225	0.0139	126	66.93 [3]	2	0	26	33

(1) 4-year average based on daily measurements from EPA data, 03/01/2017 - 06/01/2021.
(2) 4-year geomean based on daily measurements from EPA data, 03/01/2017-06/01/2021.
(3) Reported quarterly rather than monthly.
(4) EPA data, 03/01/2017-06/01/2021.

4.2.2 Sanitary Sewer Overflows

Being components of the wastewater conveyance system, many of the same issues encountered at WWTFs are caused by issues with the pipes and other infrastructure carrying wastewater from homes and businesses. SSOs occur when pipes are blocked, broken, or when deteriorating pipes and connections allow stormwater or groundwater infiltration into the wastewater system. These I/I issues often result in combined stormwater/ wastewater volumes that exceed the design capacity of the pipes, causing backups that will eventually find a relief point, often a manhole cover or other surface access. From this relief point, untreated sewage can potentially reach streams and lakes if not contained properly or in a timely manner. For this reason, proximity of the SSO site to a water body must be accounted for when analyzing potential impacts. Older neighborhoods tend to be more prone to SSOs, as they tend to be serviced by older infrastructure that may be subject to the deterioration or design capacity issues mentioned previously (Figure 4-3). In addition, continued development over the years can outgrow the design capacity making these older systems more prone to SSOs. In general, SSOs are combined with pet waste nonpoint sources and used as surrogates for urban runoff when calculating pollutant loads from urban sources. The compendium of past reports of SSO occurrences was used to illustrate locations, overflow amount, cause of SSOs, and potentially determine impacts of SSOs on the day of occurrence. The North Central Texas Council of Governments (NCTCOG) acquired SSO data from TCEQ for the region for the period 2016-2020 across the 25 subwatersheds. For each subwatershed, the number of SSOs and the total gallons discharged were used. However, the amount of SSOs in the JPL watershed were too few to expand on in analysis and determine a daily discharge, as these are sporadic overflows. It is possible to calculate if there is a chronic overflow. BMPs for SSOs require infrastructure assessments and proper maintenance that are usually built into a municipal separate storm sewer system (MS4) program as well as part of operations for any community with infrastructure.



Basemap: ESRI World Street Map; Stream data source: NHD; station data: TCEQ

Figure 4-3 Reported SSO events in the JPL watershed, 2016-2020

4.2.3 Other Point Sources

Stakeholders also expressed interest in identifying threats to groundwater quality throughout the watershed. While important, these additional sources are not specifically tied to *E. coli* concerns, and as such cannot be estimated as part of this analysis due to the technical limitations of the analytical tool used for this project.

Water Wells

Chemical or pollutant spills that occur in or near any water well can provide a direct route for pollutants to reach aquifers, bypassing the soil and rock substrata that usually provide some measure of remediation in natural systems. Plugged or destroyed wells, along with abandoned or otherwise unmaintained wells, are of particular interest. These wells are usually not closely monitored and potential contamination may go unnoticed for long periods of time. A total of 28 unused and 4 plugged or destroyed wells are present in the watershed (Figure 2-5). Well construction standards, along with regulation of abandoned or deteriorated water wells, are under the jurisdiction of the Texas Department of Licensing and Regulation. Complaints for such wells can be reported to the Texas Department of Licensing and Regulation through their website.

Underground Storage Tanks

Underground storage tanks are often used to store petroleum products and other hazardous liquids, most notably at gas stations. Most underground storage tanks are made of common steel, and thus are subject to oxidation and rust over time. Excessive corrosion may lead to cracks or holes in the tank, which can result in groundwater contamination. TCEQ is the regulatory entity and current custodian of records related to leaking underground storage tanks in Texas.

Oil & Gas Exploration

Although several traditional oil and gas wells exist in the watershed, continued development of the Barnett Shale natural gas field has resulted in expansion of hydraulic fracturing activities, sometimes near the lake. As such, development of additional pad sites and associated pipelines and process water injection wells is anticipated to continue (Malcolm Pirnie & Arcadis US, 2011). Along with groundwater concerns, pad site construction may require a deforestation or other clearing of vegetation that can lead to increased runoff, in terms of both volume and frequency. If these pad sites are located near riparian buffer zones, the increased runoff may deliver higher pollutant loads to nearby waterways. The most recent EPA report on hydraulic fracturing (EPA, 2016) recommended that stakeholders focus on several activities that are more likely than others to result in water supply impacts, including but not limited to:

- Water withdrawals in area where groundwater is already scarce;
- Surface spills of chemicals or process water that may reach groundwater sources;
- Fluid injection into inadequately designed wells that allow for leakage into groundwater;
- Discharge of inadequately treated process water into surface water; or
- Disposal or storage of process water in unlined or improperly lined pits, allowing for groundwater contamination.

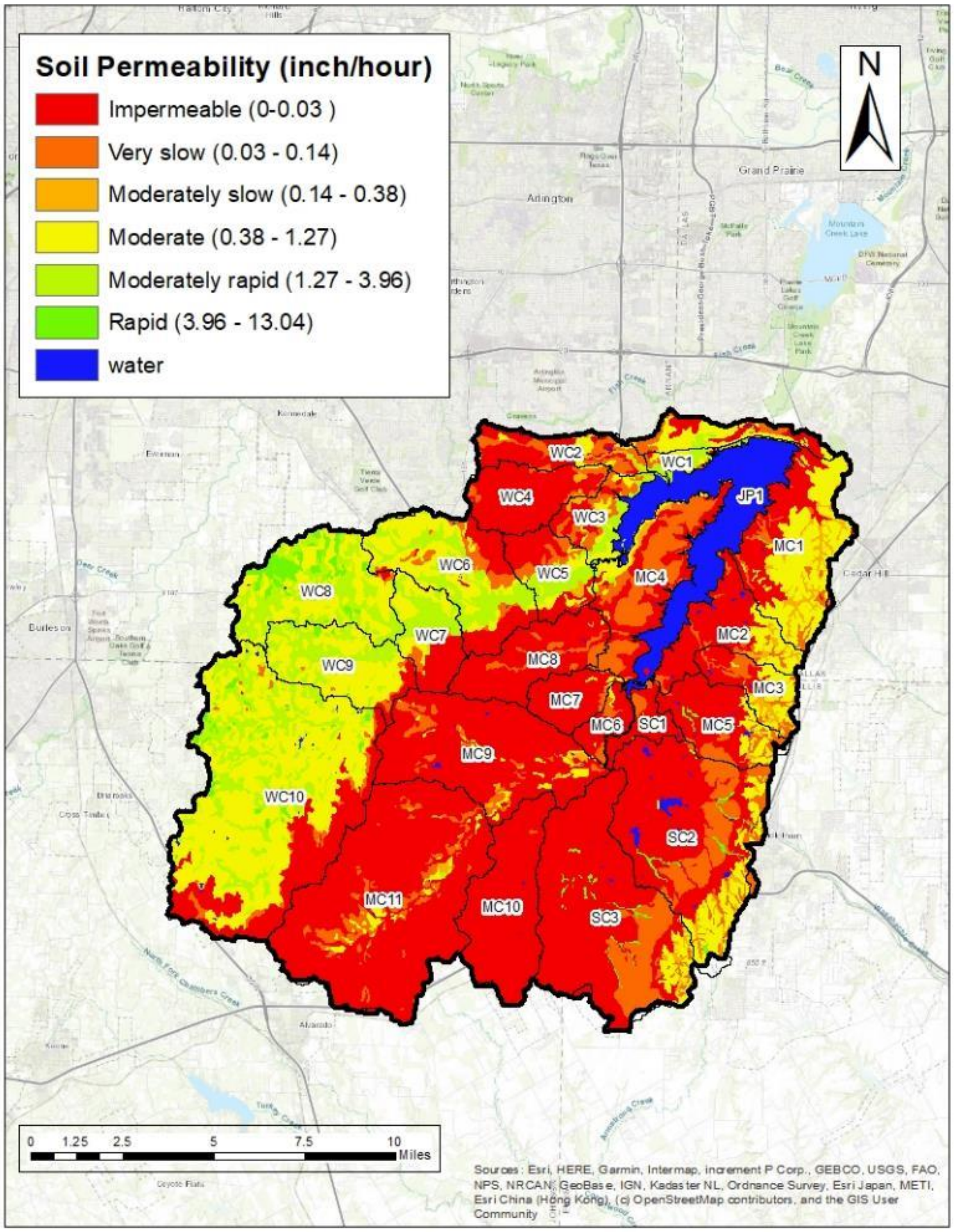
TCEQ is the entity responsible for regulation and operation of oil and gas wells in Texas.

4.3 Nonpoint Source Pollution

Unless explicitly stated for each source, the contribution weights for the riparian buffer (90% contribution) and upland areas (50% contribution) mentioned previously are applied to the nonpoint sources analyzed for this project.

4.3.1 On-Site Sewage Facilities

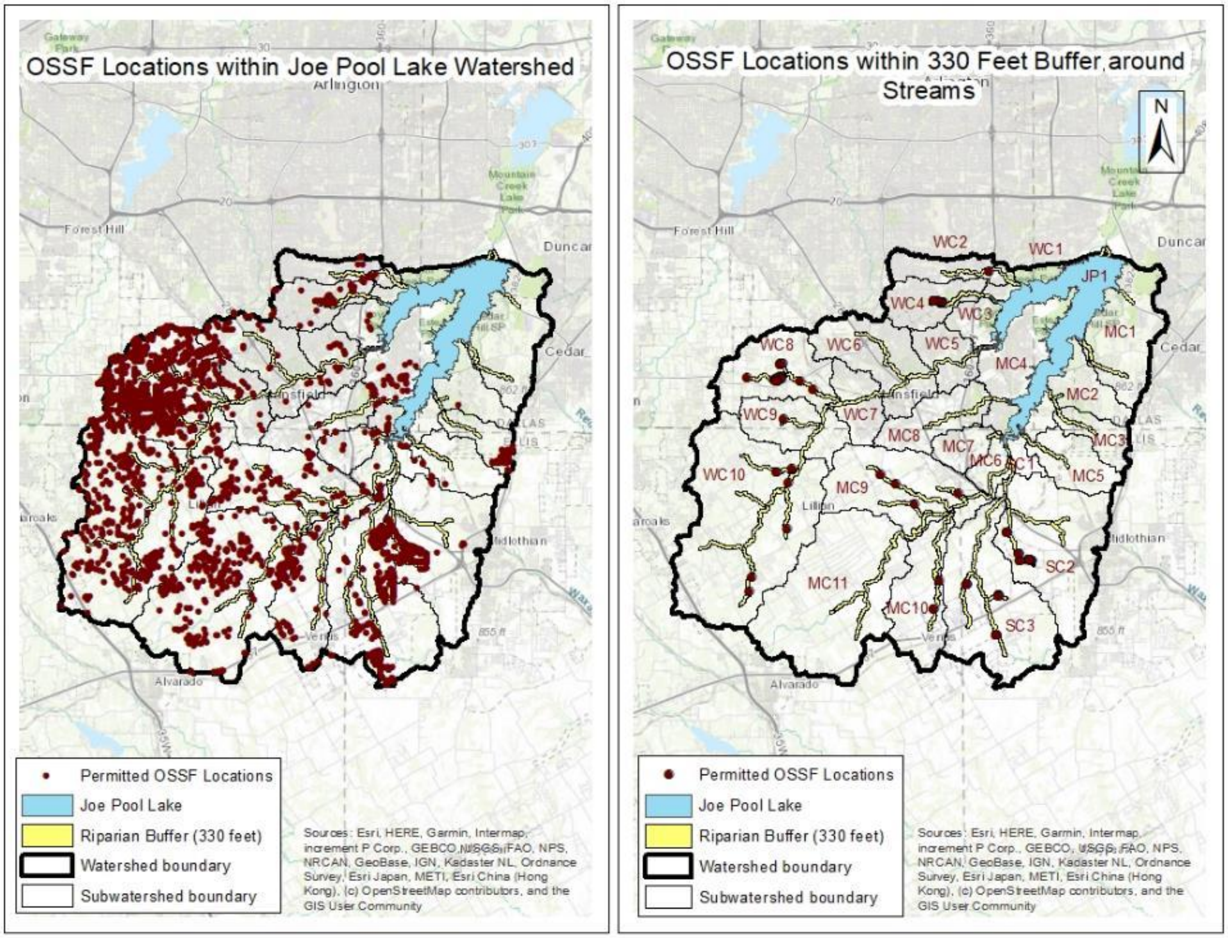
There are several unincorporated and rural areas in the watershed where on-site sewage facilities (OSSFs) are used by residents for wastewater treatment. When not functioning properly, OSSFs can become sources of pollution for *E. coli*, nutrients, and solids, both in groundwater and surface water bodies. A variety of causes can be to blame for reduced performance or malfunctions, including improper use, design/installation, lack of maintenance, unsuitable soil types (Figure 4-4), age of the system, and proximity to other systems.



Basemap: ESRI World Street Map; Soil data: NRCS-SSURGO

Figure 4-4 Permeability of soils in the JPL watershed

Since 1989, counties with agreed orders with TCEQ are responsible for maintaining records of permitted OSSFs, which must be inspected to ensure compliance with state regulations. Many of the systems in the watershed installed prior to 1989 are not tied to a current permit, indicating that they have not been recently inspected, and thus have a higher likelihood for failure. Since many of these systems were constructed before stricter permitting requirements were put in place, it is possible that many were either designed or installed improperly, especially in areas where soils are less suitable and unable to treat and absorb effluent loads. These “non-permitted” systems present a greater contamination risk to water quality and are weighted accordingly for analysis. However, it is expected that even some permitted systems are currently in a state of failure, usually due to neglect or lack of homeowner knowledge regarding OSSF operation. Designated Representatives for counties in the watershed, as well as other stakeholders, agreed with statewide estimates of failure rates for 50% failure rate for “non-permitted” and 12% failure rate for permitted systems used in several other WPP efforts in Texas (Reed et al., 2002).



Basemap: ESRI World Street Map; OSSF data: Ellis, Johnson, and Tarrant County and the cities of Grand Prairie and Arlington

Figure 4-5 Permitted OSSFs in Ellis, Johnson, and Tarrant County

Proximity to a water body is also a major factor in contamination. OSSFs within the stakeholder-recognized buffer distance (330 ft) are expected to have the greatest impact (Figure 4-5). For this reason, stakeholders chose to focus management efforts specifically on those OSSFs within the buffer for this project, agreeing to a 90% contribution weight from OSSFs within the riparian buffer. OSSFs contributions from upland areas were limited to 10% to account for some additional remediation provided by the soil before reaching the surface. Of the total 14,268 OSSFs estimated to exist in the watershed, only 4,756 have existing permits. Considering only those OSSFs inside the riparian buffer, 115 have associated permits and 230 do not. Proximity to other systems can negatively affect OSSF performance, particularly in areas where systems are densely spaced. In these situations, multiple failures are possible if one drain field exceeds its capacity and impacts adjacent fields, increasing the likelihood for drain field contaminants reaching waterbodies.

4.3.2 Pet waste

Feces from pets may also be a source of *E. coli* and nutrient loading to waterbodies via stormwater runoff. This may include dogs as well as cats that defecate outdoors, such as feral and barn cats. As with any nonpoint source, the severity of the contamination from an area is heavily influenced by the presence of impermeable soils (Figure 4-4) and increasing amounts of impervious cover (e.g., buildings, parking lots, Figure 2-4) associated with ongoing development in the watershed. These measurements are derived from human population data, so while there will be some contributions from rural areas, it is expected that urban areas will show the largest contributions. Thus, loading from pet sources will serve to approximate *E. coli* and nutrient contributions from urban runoff, in concert with other yard waste runoff and contributions from SSOs. Additionally, if excessive pet waste is left in yards to accumulate, this increases the chances of gastrointestinal parasite or other disease transmission to other pets or potentially to other species.

Estimates for pets (Table 4-3) were made by extrapolating census data from the watershed and applying nationwide estimates for the number of dogs and cats per household. According to the American Veterinary Medical Association (AVMA), approximately 36.5% of U.S. households have dogs, and 30.4% own cats, and it is estimated that there are 1.6 dogs per householdhousehold with dogs, an average of 0.614 dogs per household overall, 1.8 cats per householdhousehold with cats, and an average of 0.457 cats per household overall (AVMA, 2018). That number is slightly higher for cats, but stakeholders recommended using the dog estimate to account for the outdoor cats that do not use litter boxes. This estimate is supported by information from several animal welfare groups, which estimate 350,000 stray cats in the DFW metroplex, with the majority in the southern extent (Rajwani and Tsiaperas, 2016). Stakeholders recommended using the AVMA estimates for dogs and cats.

4.3.3 Agricultural Activities

Livestock that roam freely to graze can also be a contributor to nonpoint source *E. coli* loads, especially if they have direct access to waterbodies where they can defecate directly into or near a water body. However, poor land management practices can also affect the amount of manure *E. coli* that reaches waterbodies from upland areas by stormwater flows. If pastures are overgrazed, improperly tilled, or otherwise mismanaged for runoff potential, runoff will increase, which can deliver larger loads of *E. coli*, nutrients, and pesticides/herbicides to waterbodies.

Initially, populations for cattle, sheep/goats, and horses (Table 4-3), were estimated using data from the 2017 National Agricultural Statistics Survey ((NASS),TPWD, or Texas A&M University (TAMU) data (USDA, 2017). Holding with values used in other WPPs across the state, all livestock animal classes were originally applied to 100% of grassland and 90% of pastureland classes in the watershed. Populations were applied to pasture at a lower percentage on the assumption that some portion will be used for seed or hay crops and not grazed by livestock. These stocking percentages were approved by the Steering Committee. Cattle population estimates were compared to United States Department of Agriculture (USDA) stocking rate recommendations, and stakeholders eventually recommended moving forward with the NASS estimate. However, stakeholders felt the NASS numbers for horses were too low. This assumption was made given the watershed's location along the metropolitan/rural fringe of the DFW metroplex, where many small-acreage "hobby farms" and youth 4-H/FFA animal projects that do not receive the NASS mail-outs are expected to inflate numbers beyond the NASS estimates. To account for this, stakeholders recommended increasing the population estimates for horses. For this source classes, the applicable land use was expanded to include 5% of low-density developed areas to account for some of the hobby farms/animal projects that exist in the urban/rural mosaic that is typical in the watershed.

Table 4-3 Estimated animal populations in the JPL watershed.

Source		Population	Additional Information
Pets	Dogs	38,558	Estimate from U.S. Census and AVMA data
	Cats	28,698	Estimate from U.S. Census and AVMA data
Livestock	Cattle	11,165	USDA-NASS estimate
	Sheep/Goats	1,991	USDA-NASS estimate
	Horses	1,207	Stakeholder adjustment from NASS estimate of 1,077
Wild Animals	Deer	902	TPWD annual median density estimate for DMU #20,21,22
	Avian	158	TPWD eBird survey estimate
	Feral Hogs	593	TAMU estimate

In addition to *E. coli* and nutrient inputs from grazing livestock, production agriculture may also contribute other types of nonpoint source pollution to waterways, including nutrients from fertilizers, herbicides, and pesticides.

4.3.4 Wildlife and Feral Hogs

Although some areas of denser forest exist in the watershed, it is expected that the majority of wildlife in the watershed inhabit the forested riparian buffers that exist throughout the watershed. Wild animals tend to spend much of their life moving through riparian areas, so stakeholders felt it was important to account for them as a pollutant source. Stakeholders agreed that accounting for native wildlife specifically (e.g., not including feral hogs) would be a source of “background” or “baseline” *E. coli* loading rather than a significant opportunity for *E. coli* load management. For this project, wild animal populations were estimated using data for deer, feral hogs, and avian species as no data exists for other species.

For deer populations, stakeholders agreed to use the most recent annual median density estimate of one deer per 126.55 acres in deer management unit (DMU) 20 (126.55 acres/deer), 143.1 acres in DMU 21 (143.1 acres/deer), and 61.28 acres in DMU 22 (61.28 acres/deer) recommended by the TPWD analysis for the DMU in which the watershed exists (unpublished TPWD data). According to TPWD, this density is spread across all land uses except heavy development and open water. Avian species, specifically ducks and geese, were estimated based on TPWD surveys around JPL and the stakeholders recommended using the TPWD data. Feral hogs, by contrast, were applied only to riparian zones and upland forested areas. Data from several studies done by TAMU were cited for the estimate. Using the TAMU population estimate (Table 4-3), this amounted to approximately 50.4 acres/hog.

4.3.5 Other Nonpoint Sources

There are several other pollutant sources that stakeholders deemed important, but for which we could not account for numerically in the pollutant analysis due to lack of data. Some of the sources include 1) direct depositions of *E. coli* from bridge-nesting birds, 2) *E. coli* contributions from rural “yard birds” and small backyard poultry operations in both rural and urban areas, 3) stormwater runoff from exercise areas for dog kennels/animal shelters if feces are not properly disposed of, as well as washout areas for these facilities where collected feces travels with wash water into nearby waterways, 4) illegal dumping at bridges/secluded areas, 5) exotic animal operations (ranches, sanctuaries, hunting outfitters, etc.), and 6) residential yard waste that is improperly handled, allowing yard clippings, fertilizer, pesticides, herbicides, excess sediments, and other pollutants to reach storm drains and nearby waterbodies.

Other sources of urban runoff were also considered, including stormwater runoff from large industrial/commercial pads, roads, and parking lots. These areas can be sources of polyaromatic hydrocarbons, automotive fluids, and other synthetic compounds used by humans (detergents, degreasers, colorants, etc.) (Malcolm Pirnie & Arcadis US, 2011). Many of these areas may be subject to regulation under their own stormwater pollution prevention plans.

Sediment is a pollutant source concern as well as an impact to the water supply and flood control capacity of JPL.JPL Future growth, expansion and development can lead to decreased riparian buffers and in turn speed up runoff velocities that will increase erosion. Sedimentation in the streams and the lake will increase and thus impact aquatic life, harbor bacteria, and potentially impact the water supply capacity in JPL. A sedimentation study is planned for 2022 and will be funded by TRA customer cities.

In addition, flooding concerns were also noted as a concern by stakeholders. Flood management is outside the scope of this WPP, but when flow regimes change or flooding increases due to future growth, expansion and development, the impact of pollutant sources in the watershed can be altered. Flooding concerns are being included in this WPP based on their potential water quality impact and the need for consideration when future development and flood mitigation projects that may modify the waterways are planned for the system.

Stakeholders agreed that addressing illegal dumping and yard waste were important pollutant sources that should be prioritized. Throughout the monitoring effort, staff observed numerous construction/landscaping waste and household items/furniture near/under bridges and along roadsides near riparian zones, particularly in secluded areas. These remains can contribute directly to *E. coli* loads and nutrient loads in a waterway, especially in places where disposal is recurrent and removal or cleanup is infrequent or non-existent. If improperly managed, organic waste and chemical residues from managed green spaces (e.g., residential lawns, public parks, sports fields, golf courses, etc.), can also be a major contributor of pollutants to waterbodies, even in the absence of pets and their waste. Over-application can lead to an excessive build-up of nutrient fertilizers, pesticides, and herbicides in managed green spaces. Stormwater runoff (or similarly, lawn irrigation) will carry these pollutants to the nearest water body, usually via storm drain. In addition to the concerns associated with the herbicides and pesticides, excessive nutrient fertilizer runoff from multiple residential lawns will accumulate in the water body, encouraging growth of excessive algae. Extensive algal populations can cause diurnal swings in DO in the water, potentially placing aquatic organisms at risk. Once the algae have exhausted the excess nutrient supply, they will eventually die and begin to decay, removing additional DO, which is a major cause of fish kills (Figure 4-6). Some algal species also produce toxins that can kill fish and other gill-breathing organisms, especially when in high abundance. If nutrient enrichment is also accompanied by leaf litter and grass clippings being blown into storm drains after mowing, the decay from this plant matter will further exacerbate DO swings and impair water quality even further.

Figure 4-6 Fish kills due to excessive algal growth (credit: TPWD)

5.0 Pollutant Source Assessment

No one method of analysis is sufficiently accurate to provide a clear picture of the water quality impacts in a watershed on its own. To ensure that a thorough characterization of the watershed's status was achieved, pollutant loadings were assessed using a variety of methods utilizing both empirical data and estimations based on literature values from multiple sources. The methods used in this study included routine and flow-biased water quality data analysis, the Load Estimation program (LOADEST) Load Duration Curve (LDC) analysis based on collected data for multiple pollutants, Flow Duration Curves (FDCs), spatial analysis of potential *E. coli* sources using the SELECT analysis, and hydrological modeling using the Soil and Water Assessment Tool (SWAT).

SWAT has been the most widely used watershed-scale hydrology/water quality model in the world for over 20 years. The standard version of SWAT requires detailed inputs related to weather, climate, topography, soils, land use, water infrastructure, and point-sources of pollution. As a result, it can be difficult to build and calibrate SWAT models for specific watersheds and river basins. To overcome this problem, over the last several years, the TAMU Spatial Sciences Laboratory has worked closely with the EPA to develop the Hydrologic and Water Quality System (HAWQS).

HAWQS is a free, open-source, internet-based, SWAT-based platform using a point-and-click interface and powerful output visualization tools. HAWQS provides all input data (soils, weather, land use, topography, water bodies, point-sources of pollution, etc.) and graphical input/output interfaces for the contiguous 48 states. It requires no specialized software, hardware, or training in statistics or geographic information systems (GIS). As a result, HAWQS reduces by 90% the time and effort required to conduct calibrated SWAT-based watershed-scale environmental assessments. In addition, the HAWQS platform allows users to customize SWAT inputs to create scenarios based on BMPs by modifying agricultural management, operations management, and conservation practices. The parameters and operations can be modified within the HAWQS user interface or they can be directly uploaded into HAWQS. For this project, HAWQS was used to calibrate and calculate the daily stream flow for LOADEST where streamflow was not available for LDCs.

Teague et al. (2009) developed SELECT to identify and estimate potential pathogen loads resulting from various fecal sources in watersheds. This tool can be used to determine the actual contaminant loads resulting in streams using pollutant connectivity algorithms (Riebschleager et al., 2012) or in conjunction with a fate and transport watershed model (Thilakarathne et al., 2018). For JPL, Texas specific databases were used based on stakeholder input. While the methodology used was from SELECT, this is now referred to as SELECT-TX. This tool can simulate potential pathogen loading in a watershed for various management scenarios based on user defined inputs. Inputs that can be modified based on BMPs include pet density, livestock and wildlife stocking rates, sources of OSSF numbers and amount of wastewater, daily *E. coli* and discharge values for WWTFs, and fecal coliform production rates and conversion to *E. coli* factors. Additional information about these analyses is provided in Appendix D: and Appendix E: respectively.

Figure 5-1 TRA staff conducting stream flow measurement on Bowman Branch in the JPL watershed

5.1 Water Quality Monitoring

Additional sampling proposed for this project was intended to further characterize the sources of the nutrient screening level concerns in the lake and the *E. coli* impairment in Walnut Creek. This supplemental sampling began in June 2019 and concluded in April 2020. Five distinct sampling regimes were conducted as part of this effort:

- Regime #1 - routine sampling at nine stream stations (herein after called routine monitoring). The routine monitoring consisted of bi-monthly *E. coli*, NO_2, NO_3, TKN, TP, and OP samples, as well as field and flow parameters. These routine samples were consistently taken near the beginning of the two-month cycle, regardless of flow conditions. This routine data may be used for biennial integrated water quality assessments conducted by TCEQ.
- Regime #2 - bi-monthly flow-biased monitoring at the same nine stream stations (herein after called flow-targeted monitoring) and for the same parameters described for the routine monitoring. The flows represented by these sample events were selected to capture a wide range of flows needed for building functional LDCs. The goal of the flow-targeted monitoring was to ensure that, to the furthest extent possible, the full range of flows were represented in the resultant data set. Therefore, sampling for targeted flows was based on data gaps that developed in the routine monitoring. For example, if routine monitoring did not include high flow events, then higher flows were targeted for monitoring. Conversely, if routine monitoring tended to occur during normal and higher flow events, then low flow events were targeted. The needed flows and timing of flow-targeted monitoring were evaluated on a continuous basis during the course of sampling to ensure that any flow-targeted samples were spread out as evenly as possible. Use of data from these samples has been restricted to load calculation, and thus does not qualify for inclusion in future biennial integrated reports composed by TCEQ.

- Regime #3 - a supplement of the first and second regime, focused on the high flow events that may have occurred during routine sampling or among those events selected for the flow-targeted monitoring. Three sampling events were completed with an additional six sites sampled. These stations are located within ephemeral portions of main tributaries near their headwaters, or within smaller, typically ephemeral tributaries surrounding the lake. The intent of using this regime was to characterize the periodic loading to the lake from channels or portions of channels that are typically dry, but where accumulated pollutants may contribute significantly to pollutant loads during periods of significant overland runoff. As there were only three samples per station collected in this regime, they will not be directly used to calculate LDCs or FDCs. Rather, they will act to inform downstream measurements, providing additional information about potential pollutant sources and periodic contribution to the overall load delivered to the lake.
- Regime #4 - monitoring at five lake stations in JPL, with samples collected during both the routine and flow-targeted regimes described above. All parameters described in those regimes were collected at lake sites, except for flow parameters. Despite this lack of flow data, the flow-targeted samples will still provide important information about any changes in the condition of the lake during flow-targeted events, specifically during low-flow or drought periods, as well as high flow or flood conditions. Given the pooled conditions at these sites, assessment of conditions will not be based on the calculation of FDCs/LDCs, but rather on the pollutant concentrations at each site. Profile samples were collected for relevant field parameters (water temperature, pH, DO, specific conductance) at lake sites following the TCEQ Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods, (RG-415) (Chapter 3, pg. 4):
    - ***Reservoirs, inland streams, bays, and barge channels with depths 1.5 to < 3.0 meters.*** *In reservoirs, inland streams, bays, and barge channels (for example, the Intracoastal Waterway) which are 1.5 to < 3.0 meters deep, record measurements at 0.30 meters below the surface, at mid-depth, and at 0.3 meters above the bottom.*
    - ***Reservoirs, inland streams, and bays with depths ≥ 3.0 meters.*** *In reservoirs, inland streams, and bays which are 3.0 meters or greater in depth, record measurements at 0.30 meters below the surface and then at 1.0 meter and each subsequent 1.0 meter interval. For the final measurement, take a reading 0.30 meters above the bottom, if possible. If the remaining distance is less than 0.3 meters, a final measurement is not required. The intervals may be extended to 3.0 meters in reservoirs if the total depth exceeds 18 meters. All of the intervals, however, must be equal—1, 2, or 3 meters—and consistent with intervals used in earlier and subsequent field events. This helps determine compliance with water quality standards.*
- Regime #5 - optical brightener (OB) testing at various stations in the watershed including, but not necessarily limited to, the 9 sites at which routine and flow-targeted monitoring were conducted. This testing consisted of deployment of natural untreated cotton sampling medium for a short period of time while field staff were on site collecting samples. The sampling medium was placed in a rigid flow-through sample container and fixed in the stream. After deployment, the sample medium was collected and checked for fluorescence due to the detectable presence of OBs. These compounds are found in many laundry detergents and can indicate the presence of sewage leaks or failing septic systems in the upstream watershed. This testing did not generate numeric data but may help identify the potential sources of *E. coli* in the watersheds and provide information for the development of the WPP. In addition, this testing may help in the selection of BMPs for some areas of the JPL watershed. The OB testing was completed, but the results were largely inconclusive.

Additional information such as land use, soil types, locations of septic systems (also known as on-site sewage facilities or OSSFs), etc., were obtained and published in the *Analysis of Historical Data for the Joe Pool Lake Watershed Characterization document* (TRA, 2019). This information will be supplemented from other sources (e.g., stakeholders) as needed to fill data gaps for SELECT, SWAT, and LDC calculations. A variety of sites were selected to encompass different land uses and flow regimes (Figure 3-1). Figure 5-2 shows the landcover distribution upland of surface water quality monitoring stations across the JPL watershed.

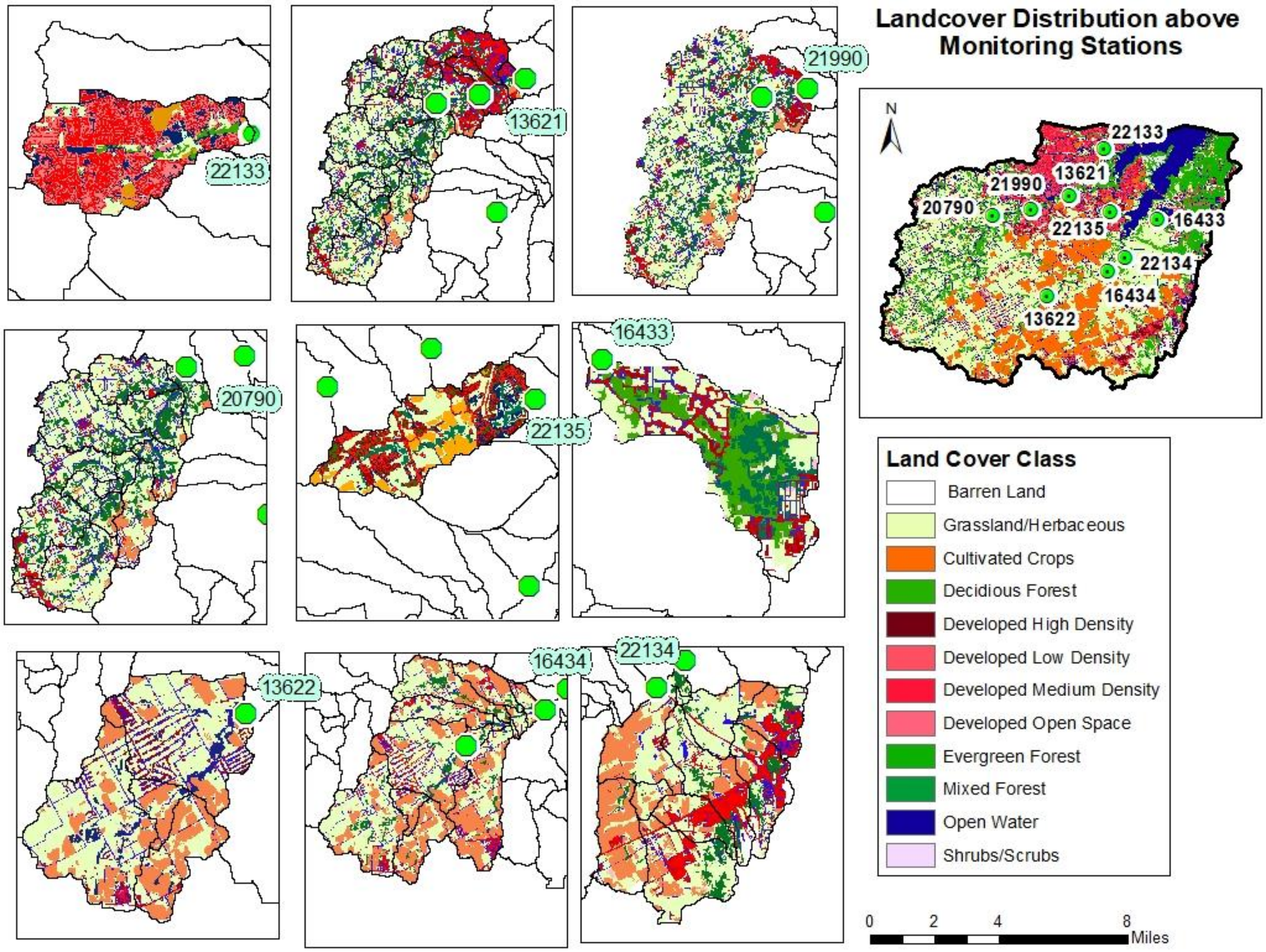


Figure 5-2 Land Cover Distribution upland of surface water quality monitoring stations across the JPL watershed

Station 22133, Bowman Branch at South SH 360, is characterized as 64% urban and 18% rangeland/pastureland and agriculture. Stations 20790, 21990, and 1362 are located on the Walnut Creek tributary, while station 22133 enters directly into the Walnut Creek arm of the lake. Station 13621, Walnut Creek at Matlock Rd, location of one USGS gage, is characterized as 52% rangeland/pastureland and agriculture and 16% urban, a suburban-rural mosaic. Station 21990, Walnut Creek at Katherine Rose Bridge, is characterized as 58% rangeland/pastureland and agriculture, 10% urban, and 20% forest. Station 20790, Walnut Creek at Retta Rd, is characterized as 62% rangeland/pastureland and agriculture, 21% forest, and 6% urban. Station 22135 and 16433 enters directly into the Mountain Creek arm of the lake. Station 22135, Low branch at South Holland Dr, is characterized as 40% rangeland/pastureland and agriculture and 41% urban, another suburban-rural mosaic landscape. Station 16433, Hollings Branch at Tangle Ridge Rd, is characterized as 49% forest, 34% rangeland/pastureland, and 11% urban. Stations 13622 and 16434 are located on Mountain Creek tributary. Station 13622, Mountain Creek at FM 157 north of Venus, is characterized as 81% rangeland/pastureland and agriculture and 6% urban. Station 16434, Mountain Creek at US287 is characterized as 81% rangeland/pastureland and agriculture and 7% urban. Station 22134, Soap Creek upstream of Mountain Creek is characterized as 71% rangeland/pastureland and agriculture with 14% urban landscape. Table 5-1 provides a summary of percent land cover upland of each surface water quality monitoring station. Figure 5-3 is a supplementary breakdown of land use classes within the watershed.

Table 5-1 Percent of land cover upstream of each surface water quality monitoring station across JPL watershed

Surface Water Quality Monitoring Station	Forest	Rangeland	Urban	Agriculture	Water
16433	49%	34%	11%	0%	6%
22135	7%	35%	41%	5%	12%
22134	9%	45%	14%	26%	6%
16434	5%	52%	7%	29%	7%
13622	5%	54%	6%	27%	8%
22133	3%	6%	64%	12%	15%
13621	19%	49%	16%	3%	13%
21990	20%	55%	10%	3%	12%
20790	21%	58%	6%	4%	11%

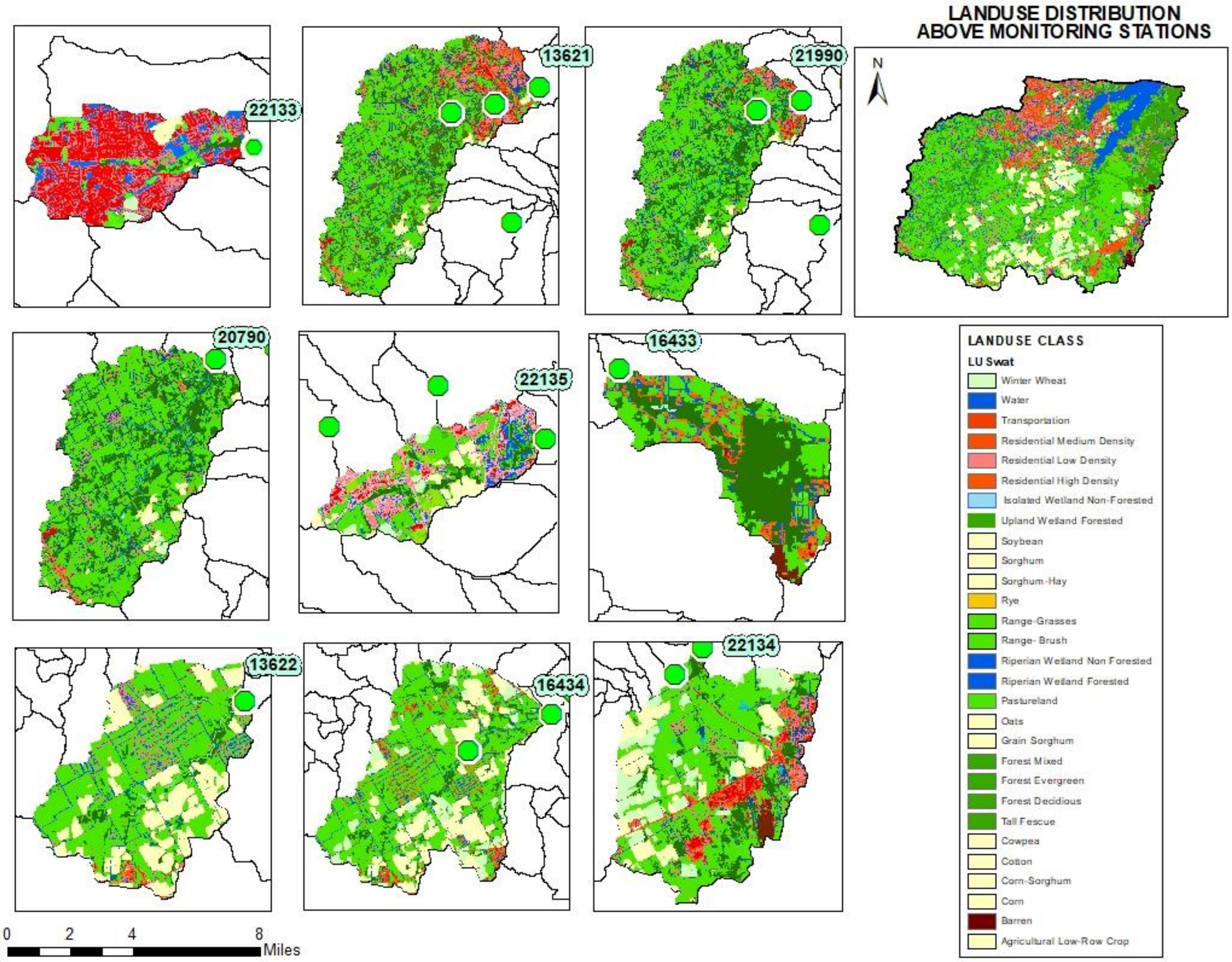


Figure 5-3 Land Use Distribution upland of surface water quality monitoring stations across JPL watershed

5.1.1 *E. coli*

The additional monitoring conducted by TRA in 2019-2020 indicates that contact recreational use is not supported in Walnut Creek due to elevated *E. coli* levels. Contact recreational use is supported in Mountain Creek albeit at one site, Soap Creek MC-C/22134. Contact recreational use is supported in JPL. Often, evaluations of supported uses employ a 10% margin of safety (MOS) to account for one or several sources of uncertainty related to data collection and analysis, including field collection and laboratory errors. When applied in water quality, the MOS is often observed to provided additional confidence that the noted water quality action level is being met. A boxplot analysis of all surface water quality monitoring stations (Figure 5-4) reveals that JPL and Mountain Creek stations maintained a geomean concentration below the water quality standard (126 MPN/100 mL) with the exception of Station 22134 (MC-C/Soap Creek) that had a geomean concentration of 147 MPN/100mL. All Walnut Creek stations exceeded the water quality standard with geomeans ranging from 268 MPN/100mL (WC-D/Walnut Creek at Matlock) to 614 MPN/100mL (WC-C/Walnut Creek at Katherine Rose Park). As indicated earlier, it is worth reiterating that flow-targeted sampling methods were a component of this data collection effort, and several high- and flood-flow events represented in the boxplot were intentionally sought so that a variety of flows would be available to conduct a thorough LDC analysis and load estimations. As such, only a portion of this data will be represented in future biennial integrated reports.

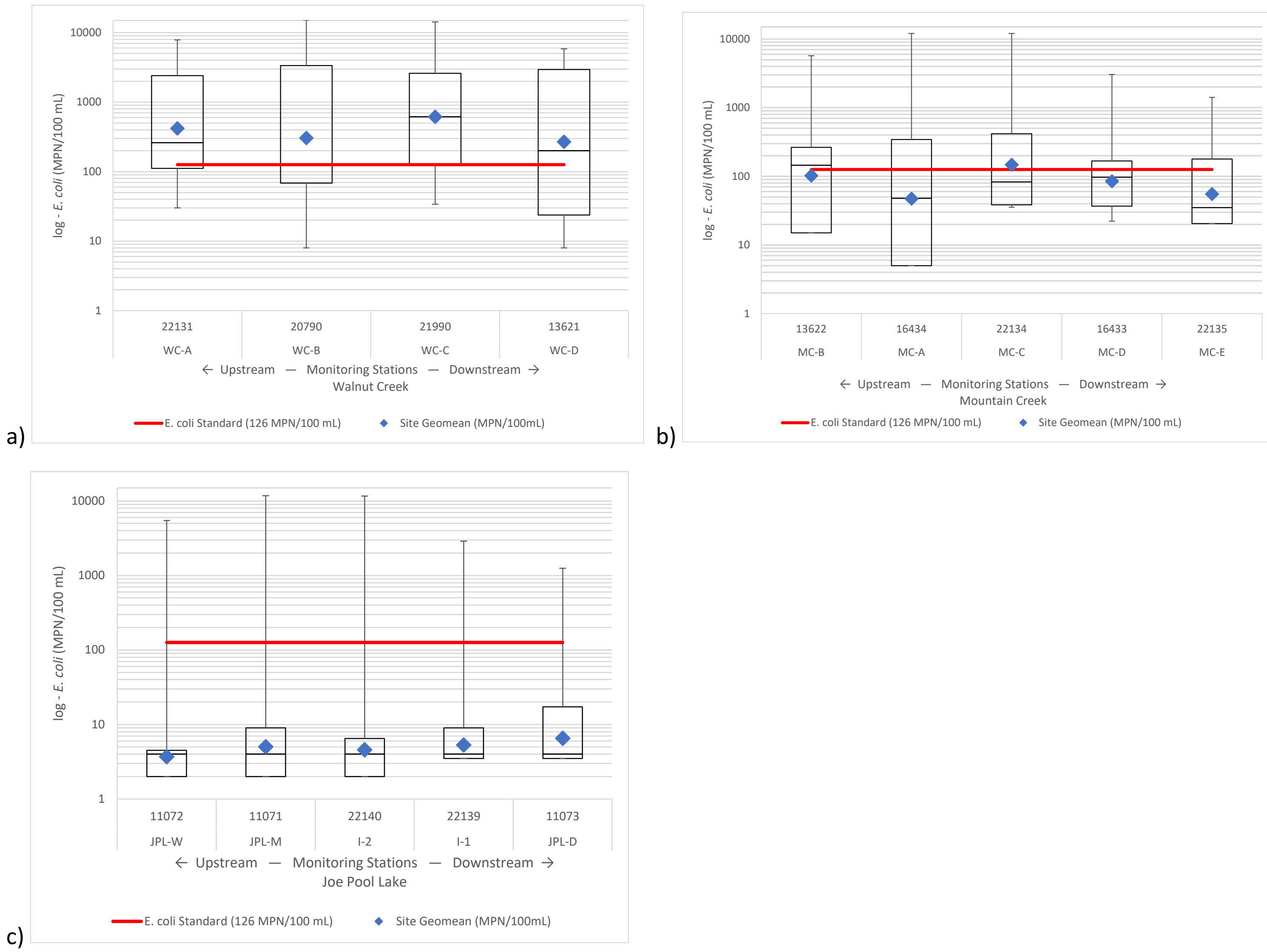


Figure 5-4 Boxplots and geomeans for *E. coli* samples collected June 2019 - April 2020; a) Walnut Creek, b) Mountain Creek, c) JPL

For most of the Stations in the JPL watershed, *E. coli* concentrations appeared to be closely related to precipitation events and thus higher flows, indicating that nonpoint sources and/or resuspension of existing sediment bacterial colonies are likely to be the significant contributors of *E. coli*. Figure 5-5 provides an example of the flow-concentration relationship typical of these surface water quality monitoring stations. Flow is represented by black horizontal bars. *E. coli* is represented by the vertical bars. The red dotted line represents the water quality criteria for *E. coli* (126 MPN/100 mL), which is technically only appropriate for geomean measurements, but is shown here simply for comparison. Additional station summaries for *E. coli* and streamflow can be found in Appendix E:.

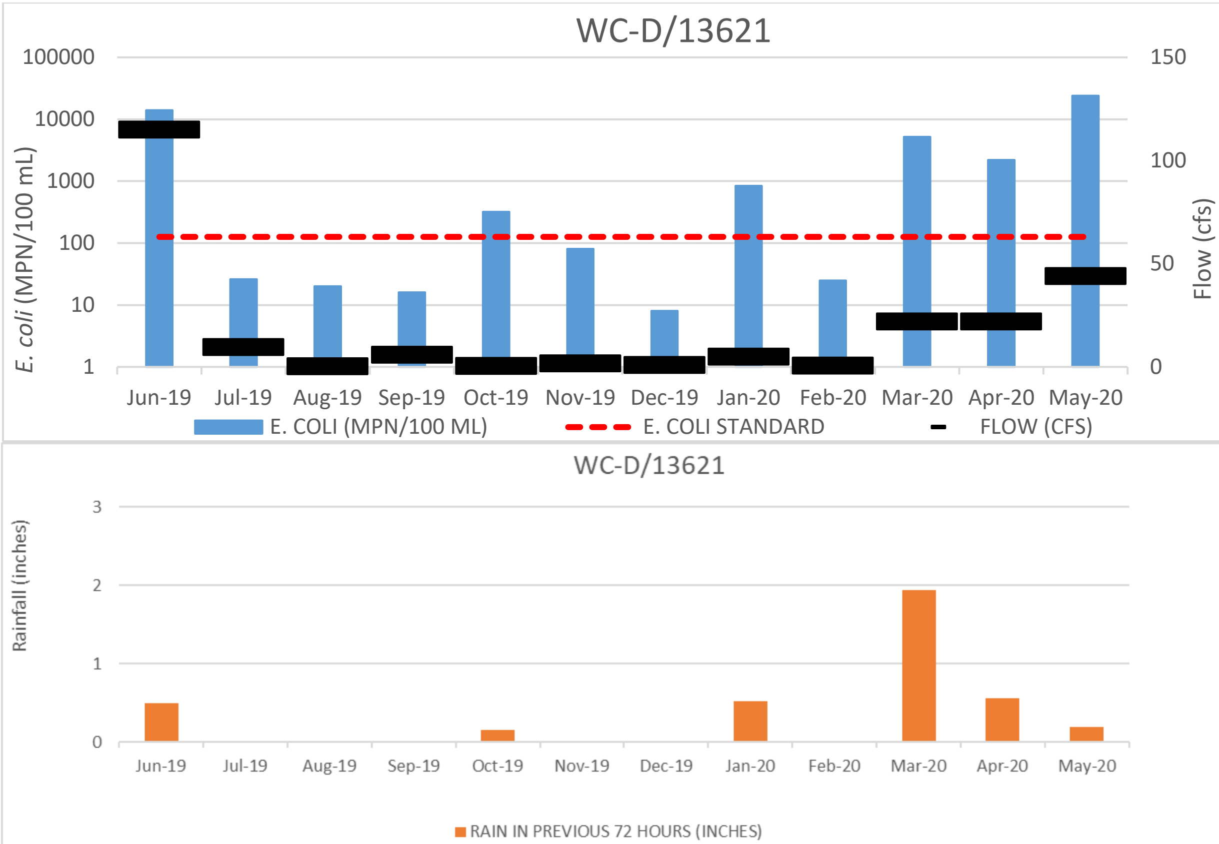


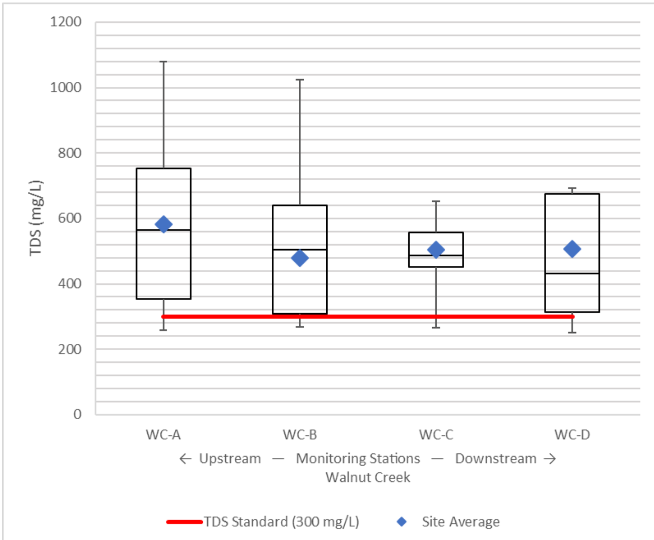
Figure 5-5 Hydrology and *E. coli* parameters, Walnut Creek at Matlock Road (13621)

Rainfall data for each station was estimated using area-interpolated daily precipitation values from the National Weather Service's Advanced Hydrologic Prediction Service (https://water.weather.gov/precip/). This provides a more accurate estimate of recent rainfall compared with using precipitation values from the nearest weather station.

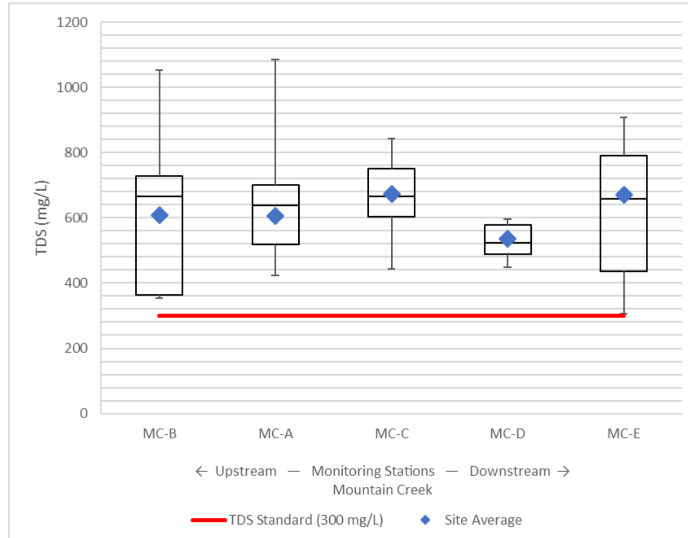
5.1.2 Solids

Typically, discussions of solids, and TDS in particular, are not major components of watershed plans. Most of the BMPs aimed at curbing TDS are applicable to reducing *E. coli* and nutrient inflows, so they can easily be grouped in with those contaminants for simplicity. Viewed in tandem with the *E. coli* boxplots, the TDS data also support a case for point source wastewater influence within JPL watershed, since high TDS values are often associated with raw human sewage. However, inflows from lawn irrigation leaving one of the many residential properties that drain to the watershed may just as easily be the cause. Frequent, low-duration irrigation cycles can cause solids to build up in lawns due to evapotranspiration. In the event an irrigation cycle does produce runoff, it can carry these accumulated solids, along with *E. coli* from any pet feces currently left in the yard, to the stream. Another explanation may lie in the groundwater composition of the watershed. Groundwater may contribute high TDS. A constant inflow of groundwater could be a factor both the elevated TDS and consistent flow but would not explain why *E. coli* values remain elevated.

A boxplot analysis of all surface water quality monitoring stations (Figure 5-6) reveals that all stations within Walnut Creek and Mountain Creek exceeded the water quality standard (300 mg/L streams and 500 mg/L lakes). Mountain Creek average concentrations ranged from 535 mg/L to 674 mg/L. Walnut Creek average concentrations ranged from 480 mg/L to 583 mg/L. JPL stations did not exceed the water quality standard.



a)



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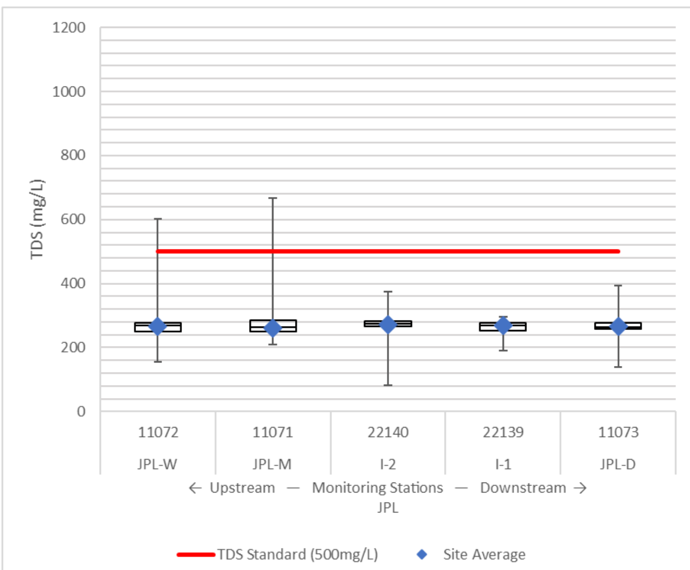


c)

Figure 5-6 Boxplots and geomeans for TDS samples collected June 2019-April 2020; a) Walnut Creek, b) Mountain Creek, c) JPL

5.1.3 Nutrients

Nutrients are transient in a flowing system such as a creek or river, but once those nutrients are delivered to a dammed water body like a lake or reservoir, flow rates decrease significantly, and will likely even be difficult to accurately measure during reservoir releases at the dam. This increased residence time leads to accumulation of nutrients, sediment, and other solids. Nutrients will continue to accumulate in both the water column and bed sediments, until they are used by organisms, removed by human means (typically through dredging), or resuspended and flushed downstream over the dam. If excessive nutrients begin to accumulate in a lake, this reduces the growth limitations on algae, and algal blooms will often result. This phenomenon is commonly referred to as lake eutrophication. In many cases, eutrophication is a natural process in lakes, but can be intensified with the proliferation of urban environments. These environments and their associated increase in impervious surfaces decrease groundwater infiltration rates. This increases stormwater runoff and elevates the potential for pollutants (including excess nutrients) being delivered to waterways. In addition to the potentially harmful environmental effects, algal blooms may also cause taste and odor problems in municipal water taken from the lake and may impact recreational opportunities. Boxplot analysis of all surface water quality monitoring stations are available for nitrate (Figure 5-7), TKN (Figure 5-8), TP (Figure 5-9), orthophosphate (Figure 5-10), and chlorophyll-*a* (Figure 5-11).

In summary, TP and orthophosphate do not exceed nutrient screening level concerns, nitrate exceeds the screening level concern at Station 22134 (MC-C/Soap Creek), TKN exceeds the EPA reference water quality screening level for all streams with the exception of Station 16433 (MC-D/Hollings Branch) and Station 22135 (MC-E/Low Branch), and chlorophyll-*a* exceeds the screening level concern at Station 22134 (MC-C/Soap Creek).

5.1.4 Nitrate

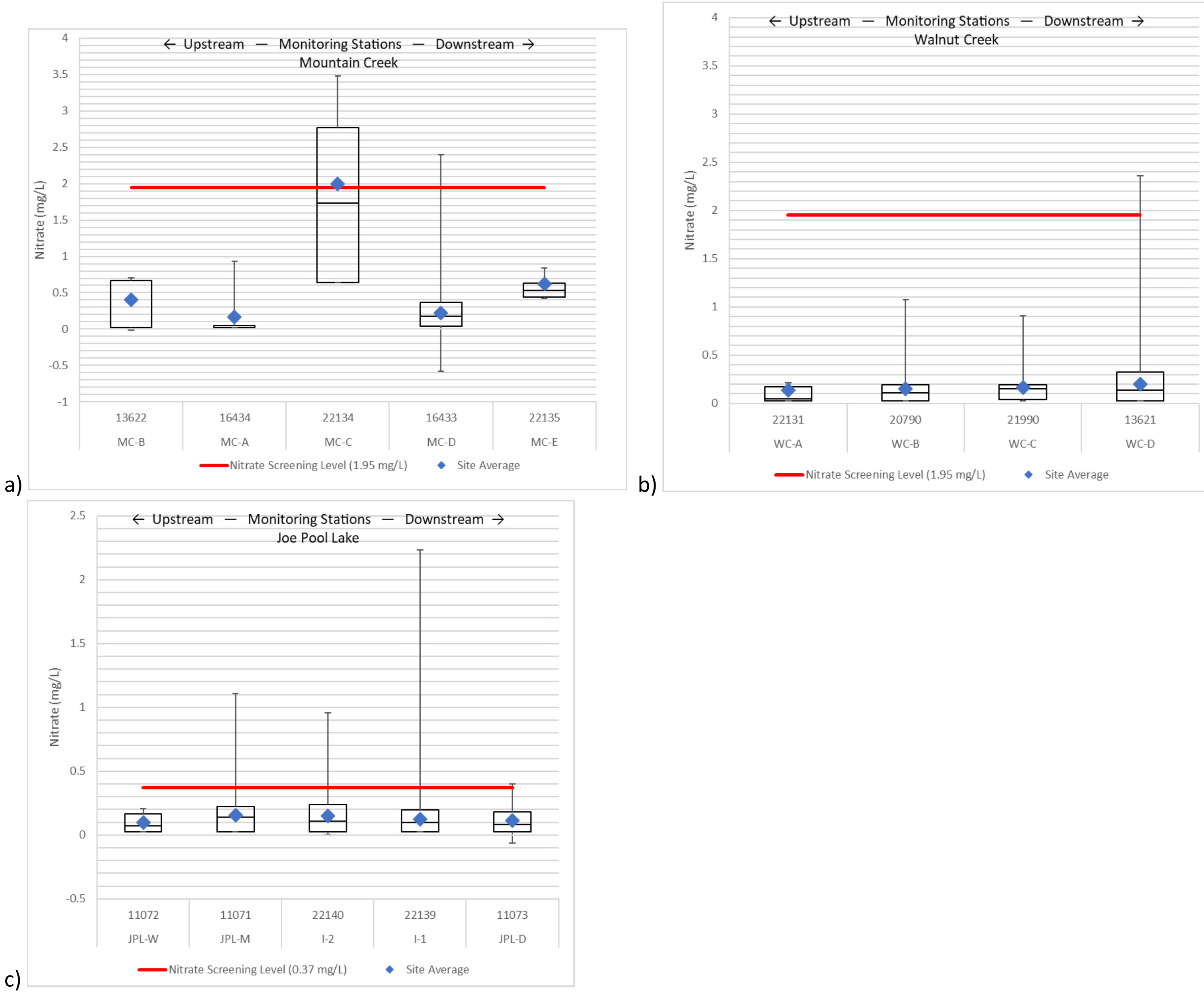


Figure 5-7 Boxplots and geomeans for nitrate in samples collected June 2019-April 2020; a) Mountain Creek, b) Walnut Creek, c) JPL

A boxplot analysis of all stations revealed that JPL, Walnut Creek, and Mountain Creek stations maintained an average concentration below the TCEQ water quality screening level (1.95 mg/L streams and 0.37 mg/L lakes) with the exception of Station 22134 (MC-C/Soap Creek) that had an average concentration of 2.00 mg/L.

5.1.5 Total Kjeldahl Nitrogen

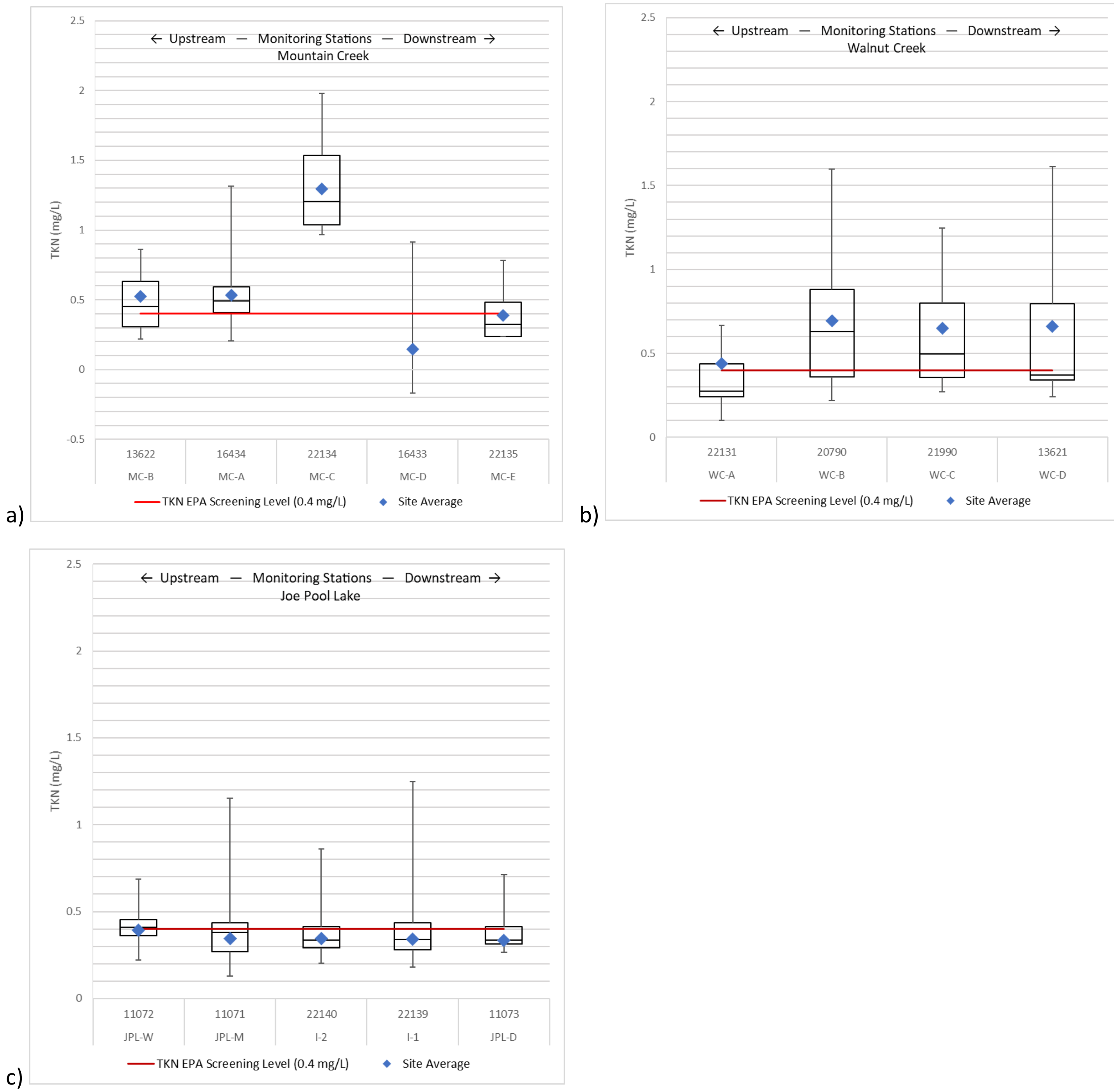
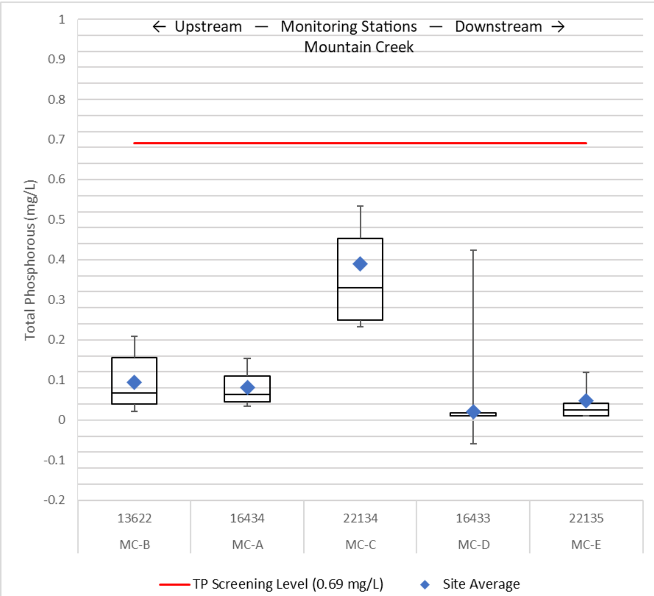


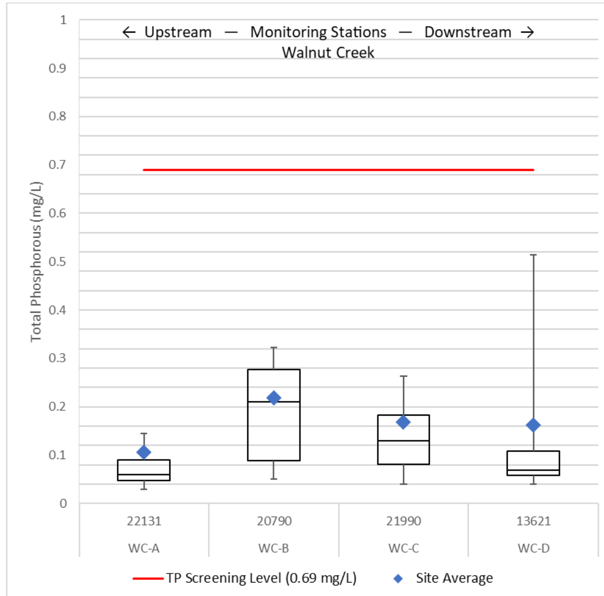
Figure 5-8 Boxplots and geomeans for TKN in samples collected June 2019-April 2020; a) Mountain Creek, b) Walnut Creek, c) JPL

A boxplot analysis of all surface water quality monitoring stations revealed that all stations within Walnut Creek and majority of Mountain Creek stations exceeded the EPA reference water quality screening level (0.4 mg/L streams and 0.41 mg/L lakes) with the exception of Station 16433 (MC-D/Hollings Branch) that had an average concentration of 0.15 mg/L and Station 22135 (MC-E/Low Branch) that had an average concentration of 0.39 mg/L. Walnut Creek stations ranged from 0.44 mg/L to 0.69 mg/L. JPL stations did not exceed the EPA reference water quality screening level.

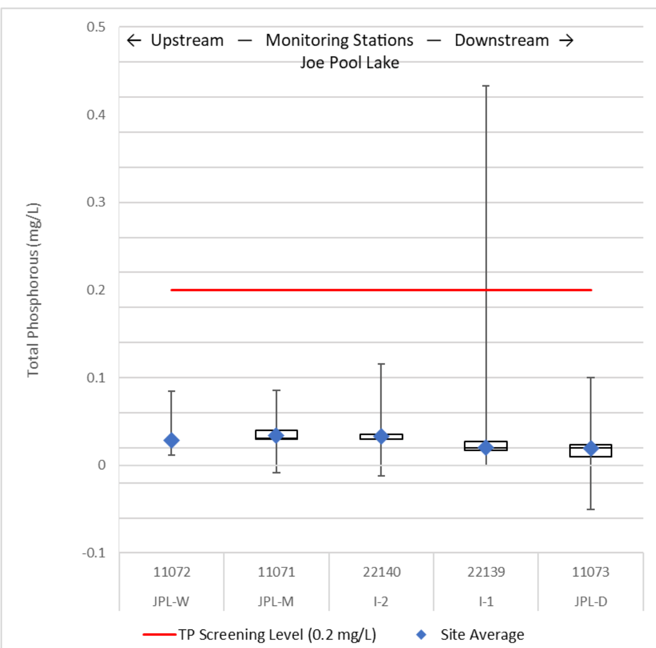
5.1.6 Total Phosphorus



a)



b)



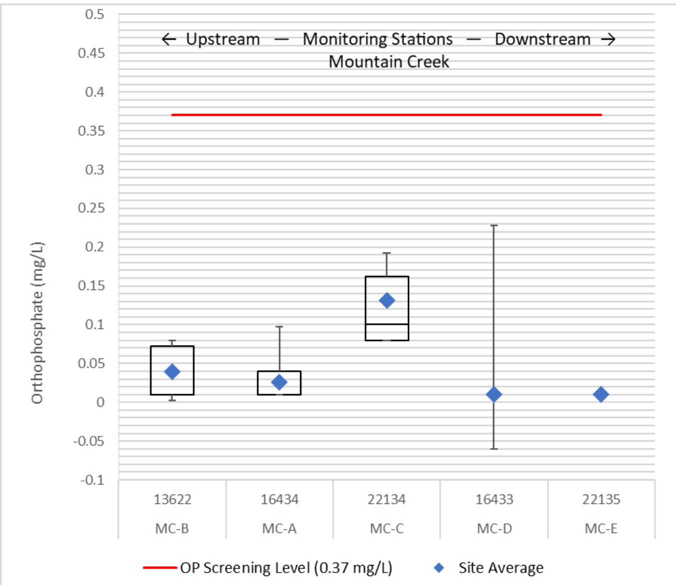
c)

Figure 5-9 Boxplots and geomeans for total phosphorus in samples collected June 2019-April 2020; a) Mountain Creek, b) Walnut Creek, c) JPL

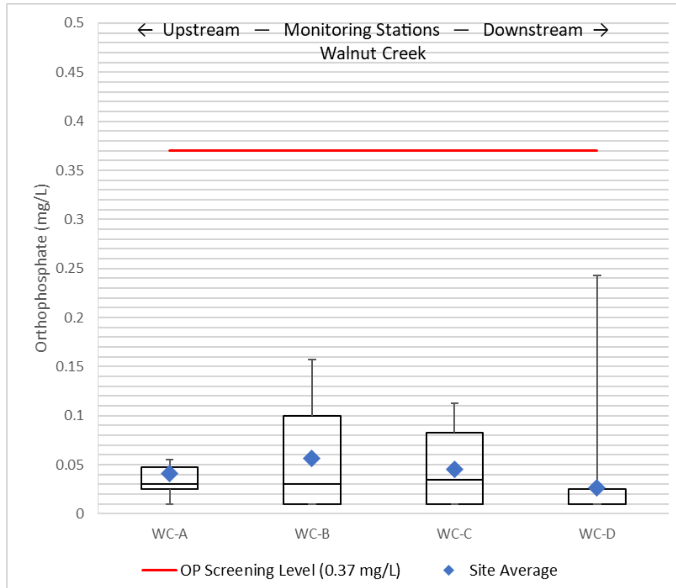
A boxplot analysis of all surface water quality monitoring stations revealed that all stations within JPL watershed maintained an average concentration below the TCEQ total phosphorus water quality screening level (0.69 mg/L streams and 0.20 mg/L lakes).

5.1.7 Orthophosphate

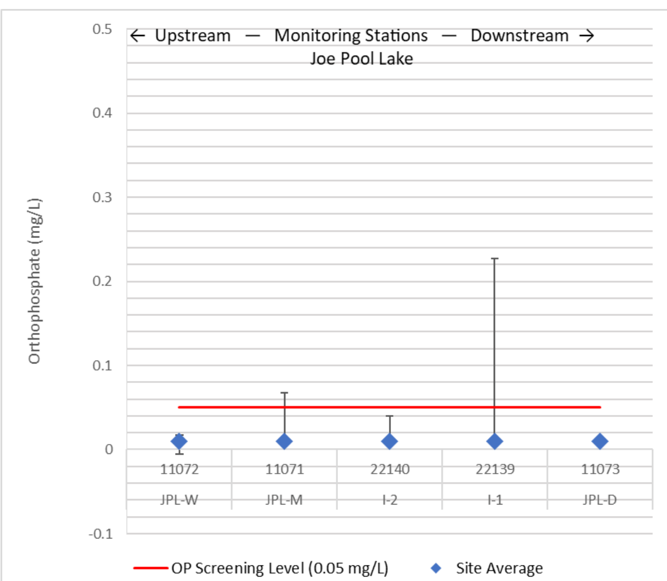
Orthophosphate is no longer used for TCEQ screening purposes as of the 2014 Texas Integrated report.



a)



b)

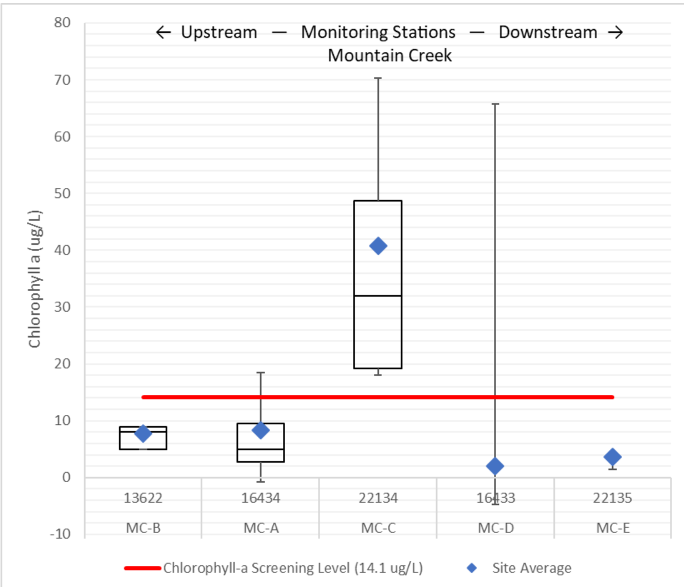


c)

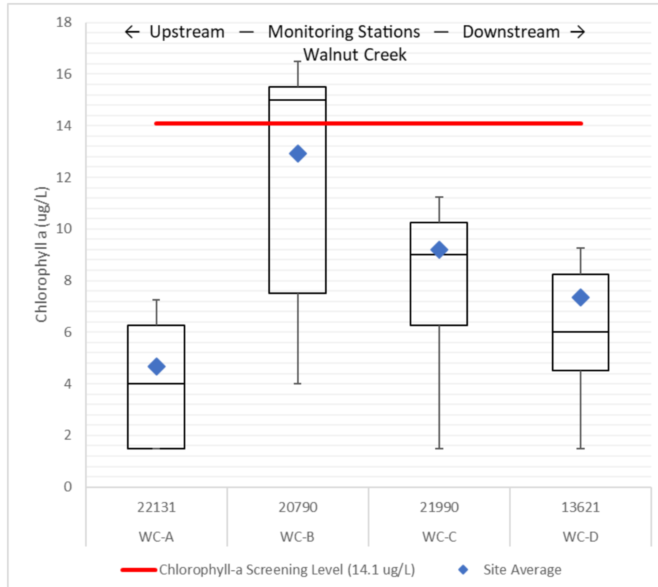
Figure 5-10 Boxplots and geomeans for orthophosphate in samples collected June 2019-April 2020; a) Mountain Creek, b) Walnut Creek, c) JPL

A boxplot analysis of all surface water quality monitoring stations revealed that all stations within JPL watershed maintained an average concentration below the TCEQ orthophosphate water quality screening level (0.37 mg/L streams and 0.05 mg/L lakes).

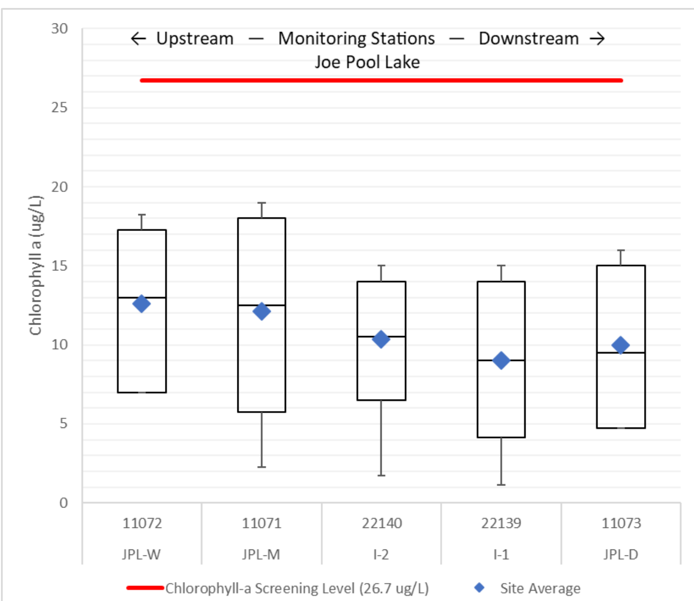
5.1.8 Chlorophyll-*a*



a)



b)



c)

Figure 5-11 Boxplots and geomeans for chlorophyll-*a* in samples collected June 2019-April 2020; a) Mountain Creek, b) Walnut Creek, c) JPL

A boxplot analysis of all surface water quality monitoring stations revealed that the majority of stations within the JPL watershed do not exceed the water quality screening level (14.1 µg/L streams and 26.7 µg/L lakes) with the exception of Station 22134 (MC-C/Soap Creek) that had an average concentration of 40.83 µg/L.

5.2 Load Duration Curve Analysis

In watersheds where nonpoint sources are the likely primary source of pollutant loading, LDCs are useful tools for illustrating the relationship between stream flow, pollutant concentration, and the resulting pollutant loads. The pollutant loads during each monitoring event can be compared to the maximum allowable load at that particular flow rate; this data can then be used to calculate the reduction needed to meet the water quality goal for each pollutant. Although LDCs cannot be used to differentiate between specific sources (e.g., livestock, pets, OSSFs), they can be used to determine whether point sources or nonpoint sources are the primary concern by identifying whether exceedances occur within a specific flow regime. If exceedances are only observed during periods of high flow or moist conditions associated with storm events, then nonpoint sources are the likely contributor. However, if allowable load exceedances are also present during dry conditions or periods of low flow, then it is likely that point sources are also contributing to the overall load, becoming more prominent as flows decrease (Figure 5-12). Both stakeholders and regulatory entities recognize that exceedances at high flows are usually attributed to flooding, and thus inherently unmanageable. Therefore, stakeholders agreed that reductions demonstrated in the mid-range conditions flow regime would be most appropriate for representing the water quality reduction goal at each site. Additional information regarding LDC development is provided in Appendix B:.

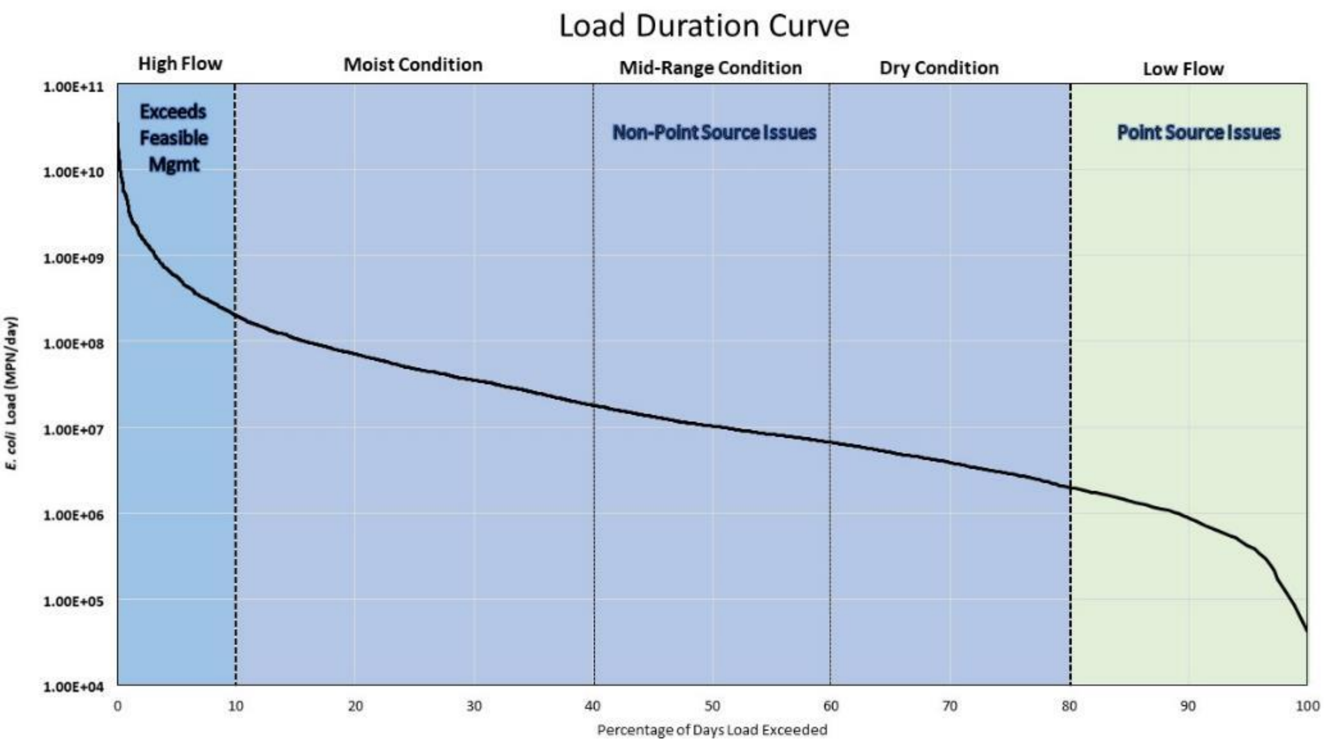


Figure 5-12 Flow categories and regions of likely pollutant sources in an example LDC

A minimum of 12 paired stream flow-pollutant concentration data points are required to properly execute the LDC analysis tool. During the monitoring effort, nine paired samples were successfully collected from the 20 monitoring stations (Figure 5-13). LDCs were developed at each of the nine surface water quality monitoring stations for five key constituents, *E. coli*, TP, OP, TKN, and NO_X (NO_3 + NO_2) so that any trends between stations could be analyzed. Although the LDCs for all stations were instrumental in developing an understanding of pollutant load dynamics throughout the watershed, this project focused on only a few stations to determine several short-term and long-term water quality goals.

For planning purposes, surface water quality monitoring station22134 (Soap Creek upstream of Mountain Creek confluence), station 13621 (Walnut Creek at Matlock Rd), station 16434 (Mountain Creek at U.S. 287), station 16433 (Hollings Branch at Tangle Ridge Rd), station 22135 (Low Branch at South Holland Rd) and station 22133 (Bowman Branch at South SH 360) were selected for establishing water quality goals for pollutant reductions. These stations represent distinct catchment or containment areas within the JPL watershed and loadings will be combined in order to establish a watershed wide water quality improvement goal.

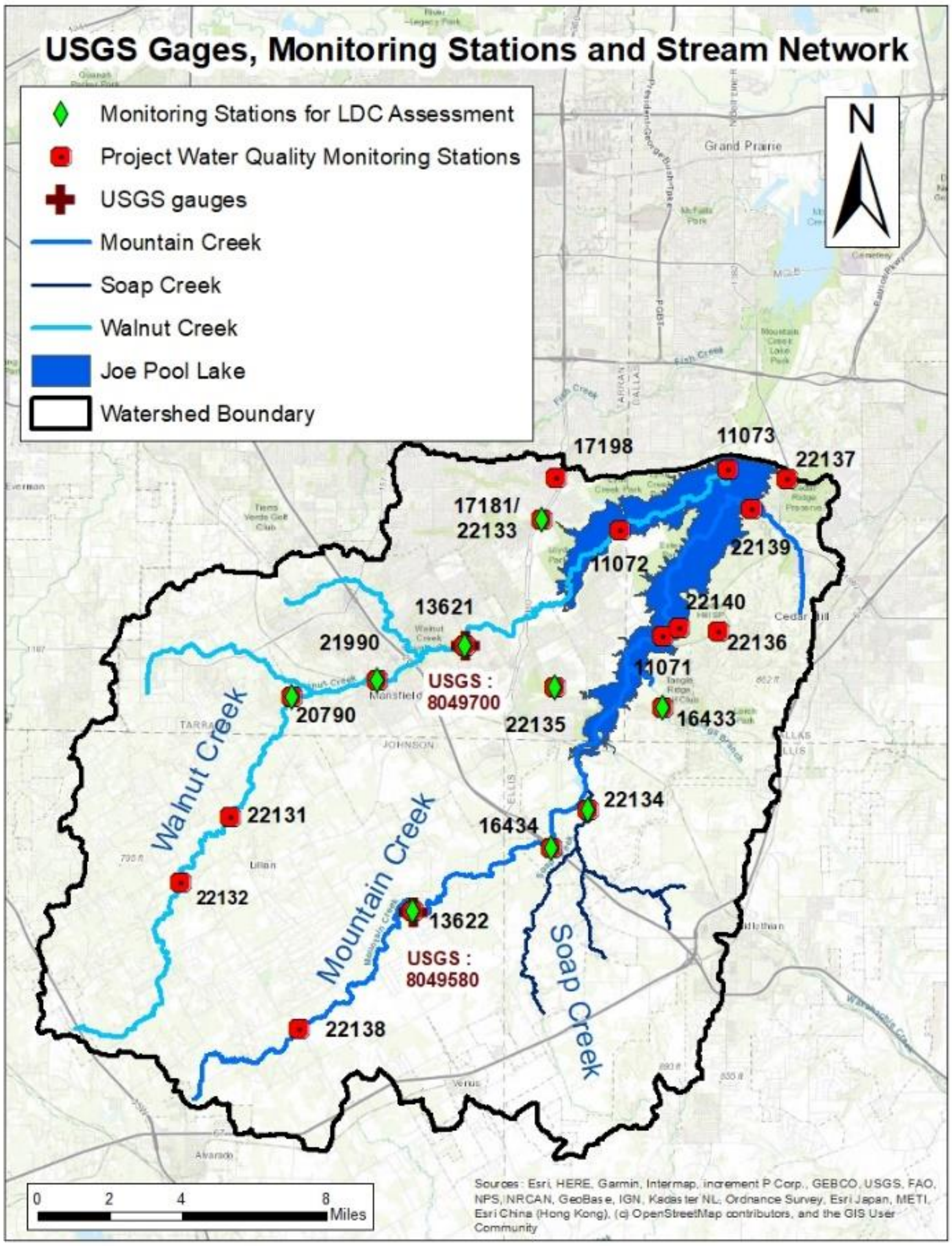


Figure 5-13 Surface water quality monitoring stations for LDC assessment

Through scientific analysis, researchers supporting the Partnership determined how much bacteria and nutrient levels in JPL watershed should be reduced in each monitored region of the watershed (Table 5-2). The Soap Creek region contains parts of Midlothian, Venus, and Grand Prairie along with unincorporated areas of Ellis and Johnson County. The Walnut Creek region contains Mansfield, parts of Grand Prairie, and unincorporated areas of Tarrant and Johnson County. The Mountain Creek region contains Mansfield, parts of Grand Prairie, Venus, and unincorporated parts of Johnson County. Bowman Branch contains Arlington and Grand Prairie. Low Branch contains Mansfield. Hollings Branch region contains Midlothian, Cedar Hill, and Grand Prairie. Water quality improvement activities will be watershed wide. The *E. coli* load reduction goal for JPL watershed is 2.42E+15 MPN/yr and the nutrient water quality improvement goal for JPL watershed is 17.5 ton/yr.

Table 5-2 *E. coli*, TKN, and NO_x load reduction goals

Parameter		Soap Creek (22134)	Walnut Creek (13621)	Mountain Creek (16434)	Hollings Branch (16433)	Low Branch (22135)	Bowman Branch (22133)	Total Load Reduction Goal
E.coli	Mid-Range Flow Conditions	91%	99%	93%	87%	96%	99%	
	MPN/yr	7.70E+14	5.37E+14	9.88E+14	5.72E+13	4.80E+13	1.60E+13	**2.42E+15**
TKN	Mid-Range Flow Conditions	74%	42%	31%	35%	16%	4%	
	Ton/yr	*	6.16E-01	1.2634	1.63E-01	1.39E-02	1.56E-03	**2.1**
NOx	Mid-Range Flow Conditions	53%	—	—	—	—	—	
	Ton/yr	1.54E+01	—	—	—	—	—	**15.4**
Nutrients ($TKN+NO_x$)*	Ton/yr							**17.5**

** Soap Creek TKN loading of 7.82E+00 ton/yr is not included in the reduction calculation. Stakeholders agreed that since NO_x (NO_2+NO_3) loading is greater than TKN loading in Soap Creek, BMPs implemented targeted for NO_x loading would also mitigate TKN loading specifically in Soap Creek.*

5.2.2 *E. coli*

The LDC analysis indicates that elevated *E. coli* concentrations are associated with all flow conditions. However some sites are primarily associated with high flow, moist conditions, and mid-range conditions flow categories, indicating that nonpoint source inputs and instream resuspension of *E. coli* from bed sediments are primarily responsible for the exceedances (Figure 5-14 through Figure 5-19). However, point sources may also need to be addressed. The geometric means of *E. coli* concentration were found to exceed the standard of 126 MPN/100mL at all nine surface water quality monitoring stations at all flow conditions with the exception of one station (16433) at low flow. Table 5-3 through Table 5-8 break down each flow regime, annual reduction needed and highlights the water quality improvement goal selected for that catchment area.

To ensure the water quality goals are achieved, an annual reduction of 2.42E+15 MPN/yr during mid-range conditions is needed watershed wide. The complete list of geometric means of allowable loading, estimated loading, and reduction of nutrient loading needed for *E. coli* at all surface water quality monitoring stations can be found in Appendix F:.

Table 5-3 Average allowable loading, estimated loading, and load reduction of *E. coli* loading for surface water quality monitoring station 13621 (Walnut Creek)

Flow Condition at station 13621	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Load Reduction Needed	Annual Loading (MPN/yr)	Annual Reduction Needed (MPN/yr)
High Flow	0-10%	7.11E+11	2.37E+14	100%	8.64E+16	862E+14
Moist Conditions	10-40%	5.19E+10	1.48E+13	100%	5.40E+15	53.8E+14
Mid-Range Conditions	40-60%	1.05E+10	1.48E+12	99%	5.41E+14	5.37E+14
Dry Conditions	60-80%	3.80E+09	2.69E+11	99%	9.83E+13	0.97E+14
Low Flow	80-100%	5.25E+08	3.33E+09	84%	1.21E+12	0.10E+14

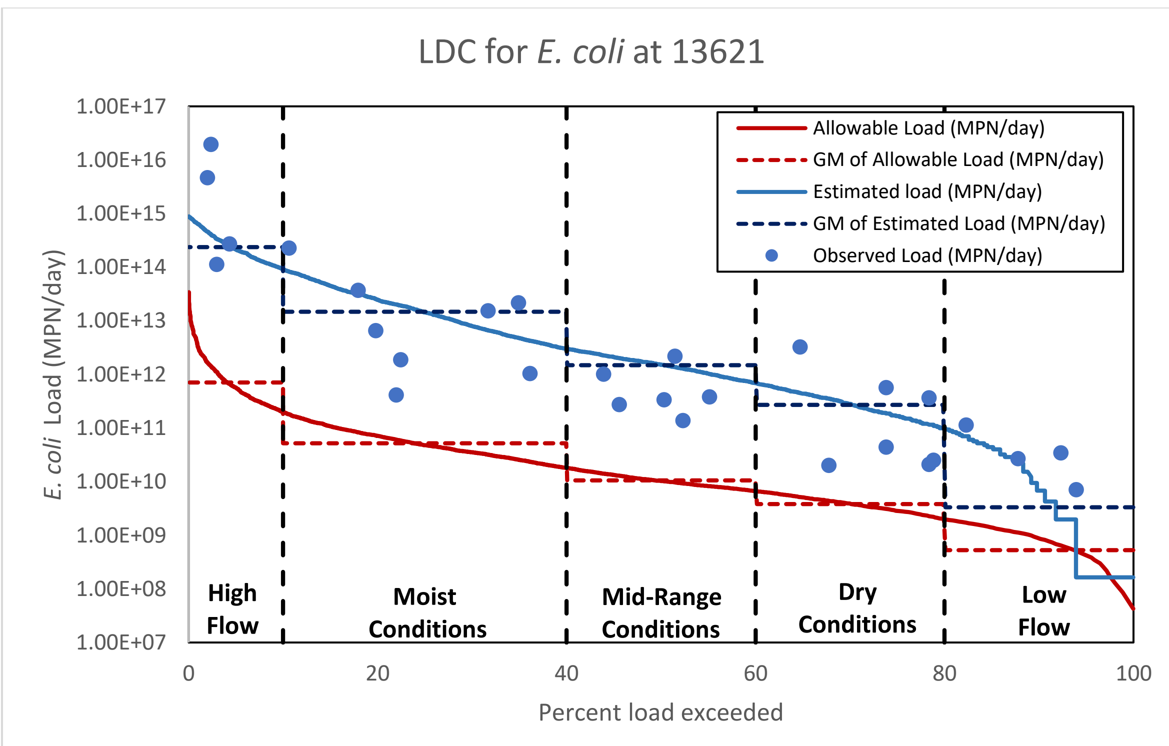


Figure 5-14 LDC for *E. coli* at surface water quality monitoring station 13621 (Walnut Creek)

Table 5-4 Average allowable loading, estimated loading, and load reduction of *E. coli* loading for surface water quality monitoring station 16434 (Mountain Creek)

Flow Condition at station 16434	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Load Reduction Needed	Annual Loading (MPN/yr)	Annual Reduction Needed (MPN/yr)
High Flow	0-10%	2.88E+12	8.79E+14	100%	3.21E+17	3208E+14
Moist Conditions	10-40%	4.06E+11	1.81E+13	98%	6.61E+15	64.6E+14
Mid-Range Conditions	40-60%	2.19E+11	2.93E+12	93%	1.07E+15	9.88E+14
Dry Conditions	60-80%	1.61E+11	1.03E+12	84%	3.78E+14	3.19E+14
Low Flow	80-100%	1.32E+11	4.97E+11	74%	1.82E+14	1.33E+14

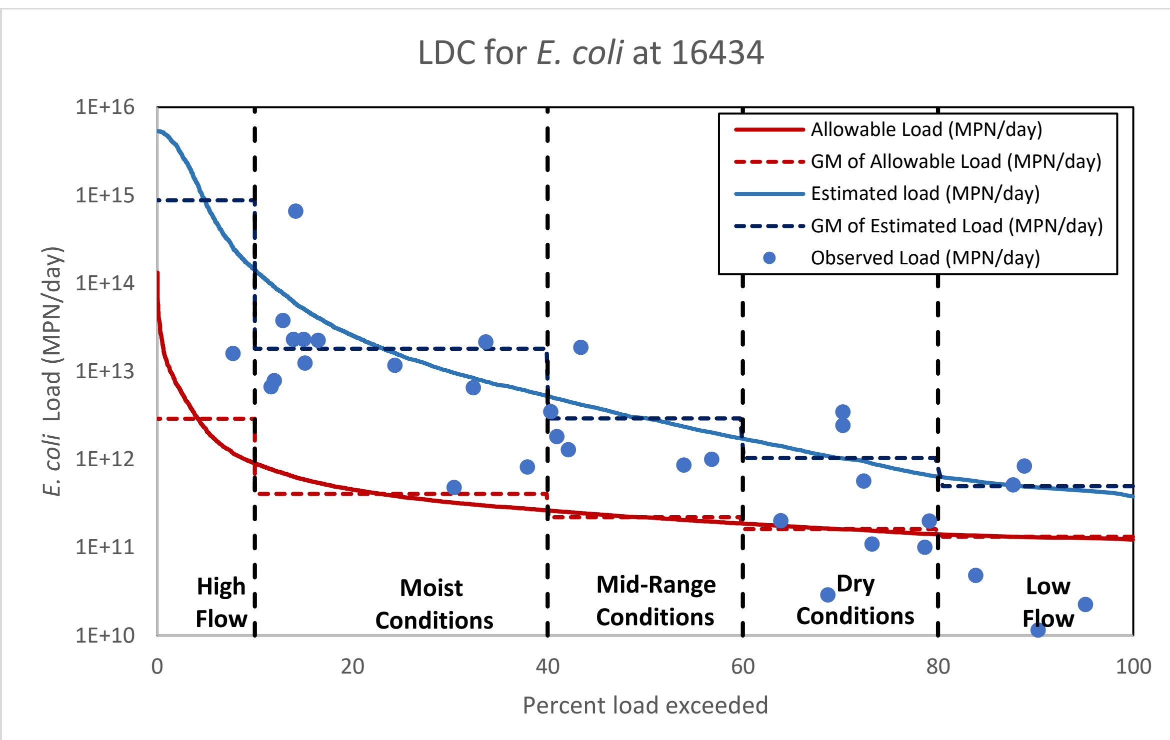


Figure 5-15 LDC for *E. coli* at surface water quality monitoring station 16434 (Mountain Creek)

Table 5-5 Average allowable loading, estimated loading, and load reduction of *E. coli* loading for surface water quality monitoring station 22134 (Soap Creek)

Flow Condition at station 22134	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Load Reduction Needed	Annual Loading (MPN/yr)	Annual Reduction Needed (MPN/yr)
High Flow	0-10%	2.88E+12	4.29E+14	99%	1.57E+17	1550E+14
Moist Conditions	10-40%	4.07E+11	7.93E+12	95%	2.90E+15	27.5E+14
Mid-Range Conditions	40-60%	2.20E+11	2.33E+12	91%	8.50E+14	7.70E+14
Dry Conditions	60-80%	1.62E+11	1.49E+12	89%	5.45E+14	4.86E+14
Low Flow	80-100%	1.31E+11	7.20E+11	82%	2.63E+14	2.15E+14

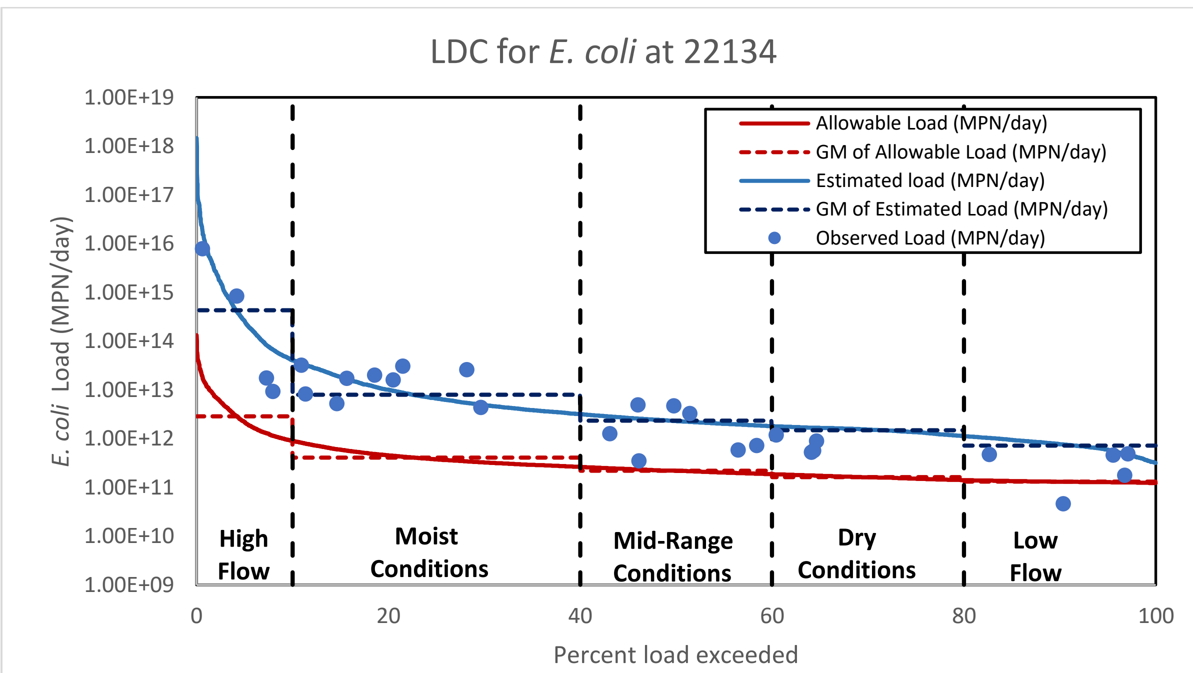


Figure 5-16 LDC for *E. coli* at surface water quality monitoring station 22134 (Soap Creek)

Table 5-6 Average allowable loading, estimated loading, and load reduction of *E. coli* loading for surface water quality monitoring station 16433 (Hollings Branch)

Flow Condition at station 16433	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Load Reduction Needed	Annual Loading (MPN/yr)	Annual Reduction Needed (MPN/yr)
High Flow	0-10%	2.74E+11	1.04E+13	97%	3.79E+15	369E+13
Moist Conditions	10-40%	5.88E+10	8.88E+11	93%	3.24E+14	30.2E+13
Mid-Range Conditions	40-60%	2.36E+10	1.80E+11	87%	6.58E+13	5.72E+13
Dry Conditions	60-80%	8.19E+9	3.22E+10	75%	1.17E+13	0.877E+13
Low Flow	80-100%	6.14E+08	4.09E+08	0%	1.49E+11	0

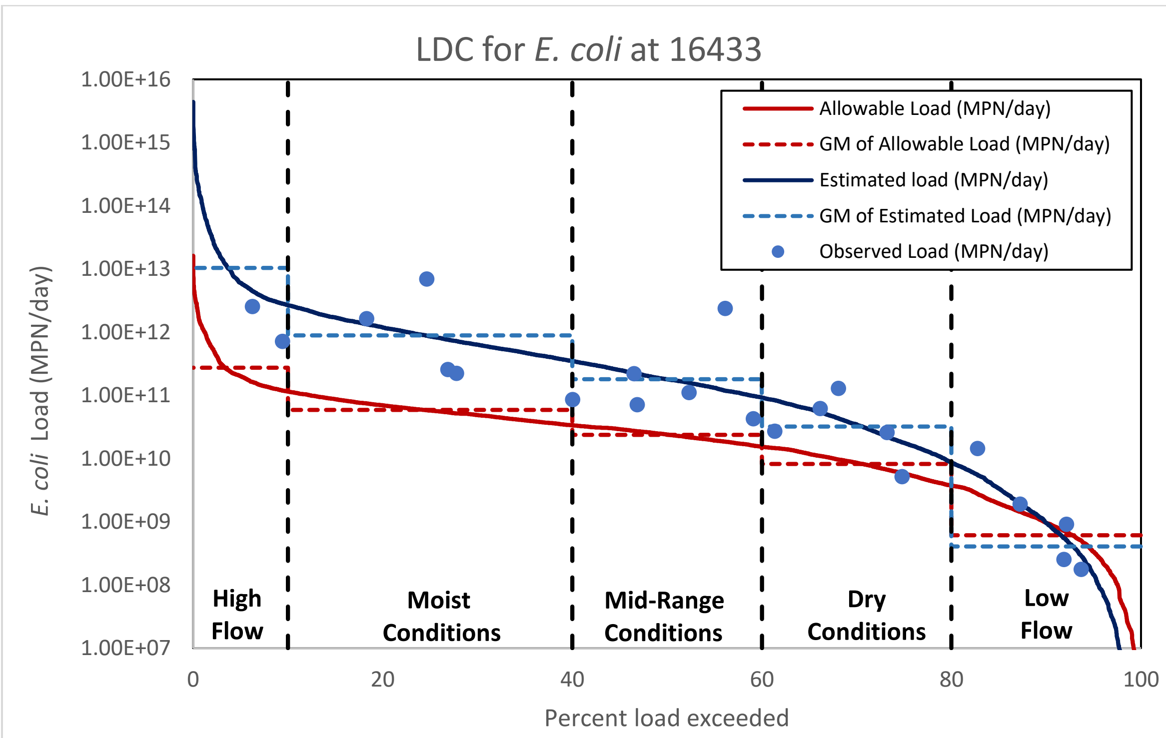


Figure 5-17 LDC for *E. coli* at surface water quality monitoring station 16433 (Hollings Branch)

Table 5-7 Average allowable loading, estimated loading, and load reduction of *E. coli* loading for surface water quality monitoring station 22135 (Low Branch)

Flow Condition at station 22135	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Load Reduction Needed	Annual Loading (MPN/yr)	Annual Reduction Needed (MPN/yr)
High Flow	0-10%	6.77E+11	2.66E+14	100%	9.72E+16	9700E+13
Moist Conditions	10-40%	2.97E+10	1.84E+12	98%	6.71E+14	66.0E+13
Mid-Range Conditions	40-60%	5.91E+09	1.37E+11	96%	5.02E+13	4.80E+13
Dry Conditions	60-80%	1.64E+09	1.73E+10	91%	6.33E+12	0.57E+13
Low Flow	80-100%	7.48E+07	1.11E+08	33%	4.05E+10	0.001E+13

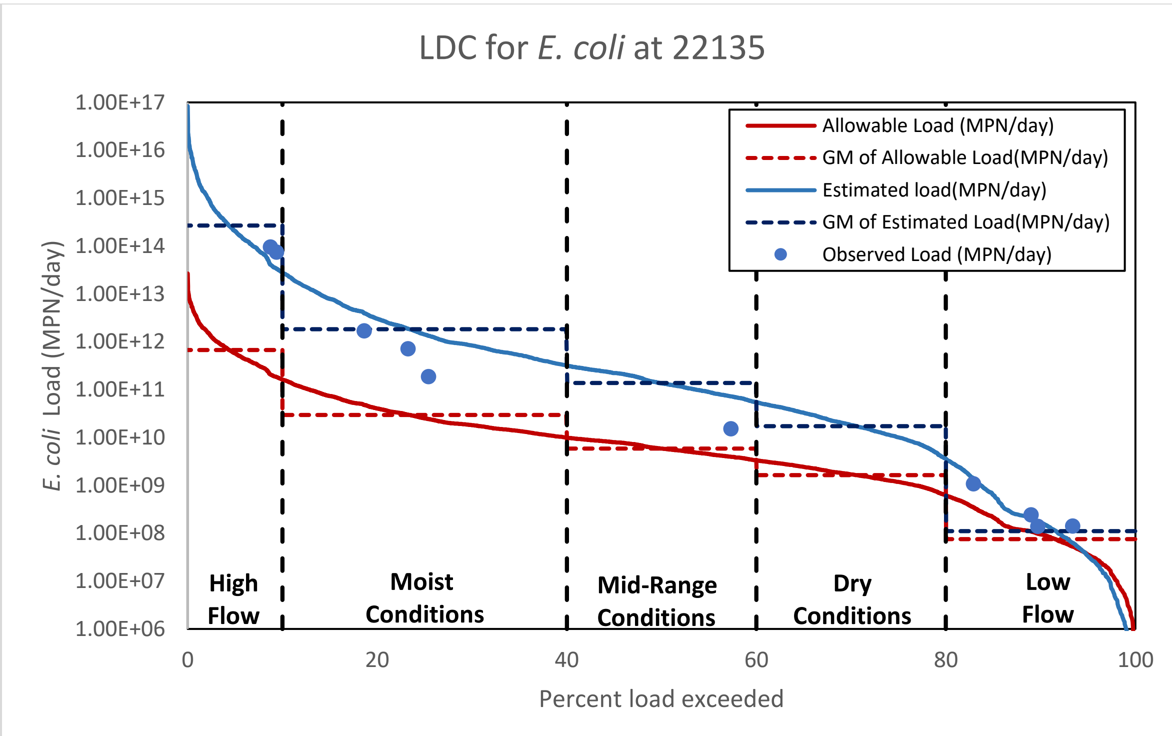


Figure 5-18 LDC for *E. coli* at surface water quality monitoring station 22135 (Low Branch)

Table 5-8 Average allowable loading, estimated loading, and load reduction of *E. coli* loading for surface water quality monitoring station 22133 (Bowman Branch)

Flow Condition at station 22133	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Load Reduction Needed	Annual Loading (MPN/yr)	Annual Reduction Needed (MPN/yr)
High Flow	0-10%	7.87E+10	1.33E+14	100%	4.84E+16	4840E+13
Moist Conditions	10-40%	2.41E+09	5.81E+11	100%	2.12E+14	21.1E+13
Mid-Range Conditions	40-60%	5.03E+08	4.42E+10	99%	1.61E+13	1.60E+13
Dry Conditions	60-80%	1.49E+08	6.36E+09	98%	2.32E+12	0.227E+13
Low Flow	80-100%	2.78E+07	4.40E+08	94%	1.61E+11	0.015E+13

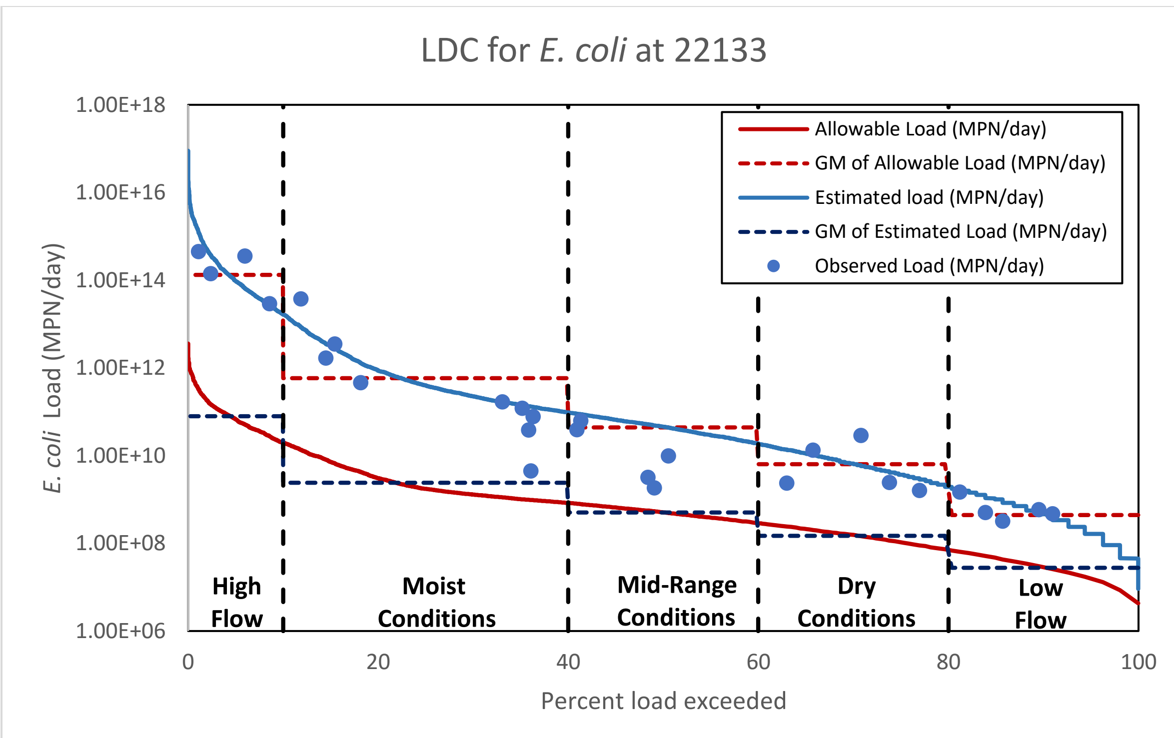


Figure 5-19 LDC for *E. coli* at surface water quality monitoring station 22133 (Bowman Branch)

5.2.3 Nutrients

Soap Creek converges with Mountain Creek upstream of the confluence with JPL. The surface water quality monitoring station 22134 on Soap Creek receives most of the runoff from forest and rangelands. The upstream portion of the surface water quality monitoring station is covered by 9% of forest land, 14% urban, 26% agriculture and 45% of rangelands (Table 5-1). The majority is rangeland/pastureland and agriculture, but there is some urban land that can be contributing to the nonpoint source runoff of nutrients. Figure 5-20 displays the computation of load duration of NO_X in ton/day spanning high flows to low flows from 2013 to 2020. The LDC was compared to the maximum allowable load which accounts for a 10% MOS and the allowable load (TCEQ water quality standard) in order to determine the amount of reduction needed to meet the allowable load. The LDC depicted in Figure 5-20 exceeded the allowable NO_X level thus load reduction is required. The percentage of reduction of daily NO_x loading needed at station 22134 is between 40-56% for wetter flow conditions and 1% for low flow conditions. Table 5-9 provides the allowable and estimated geometric mean daily load along with annual reduction values needed at station 22134.

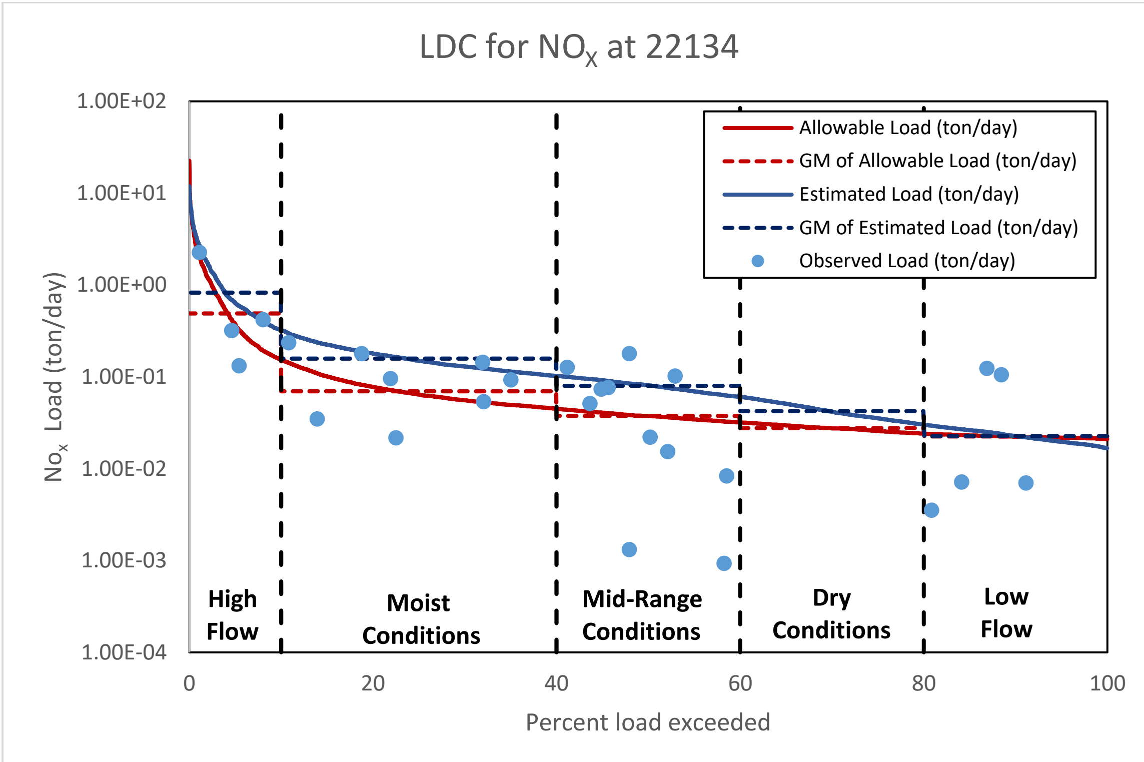


Figure 5-20 LDC for NO_x at surface water quality monitoring station 22134 (Soap Creek)

The NO_x loading at this surface water quality monitoring station may be due to waste from livestock like cattle, sheep, goat, and horses from upstream rangelands (Table 5-9). Better management of livestock grazing in the surrounding area could be a viable way to reduce the amount of NO_x loading at this surface water quality monitoring station.

Table 5-9 Average allowable loading, estimated loading, and load reduction of NO_x for surface water quality monitoring station 22134 (Soap Creek)

Flow Condition at station 22134	% of Time Flow Exceeds	Allowable Loading (ton/day)	Daily Loading (ton/day)	% Daily Load Reduction Needed	Annual Loading (ton/yr)	Annual Reduction Needed (ton/yr)
High Flow	0-10%	4.92E-01	8.25E-01	40%	3.01E+02	122
Moist Conditions	10-40%	6.94E-02	1.58E-01	56%	5.77E+01	32.4
Mid-Range Conditions	40-60%	3.75E-02	7.97E-02	53%	2.91E+01	15.40
Dry Conditions	60-80%	2.76E-02	4.23E-02	35%	1.54E+01	5.35
Low Flow	80-100%	2.24E-02	2.27E-02	1%	8.30E+00	0.108

In the case of TKN, no management trigger levels exist, although reference concentrations do (EPA, 2001a). The screening level criteria of TKN was exceeded at all nine surface water quality monitoring stations for at least one flow condition. The three stations located on the Mountain Creek arm exceeded the screening level criteria at all flow conditions resulting in larger reduction values further downstream. Station 22134, the furthest downstream station in the mountain creek watershed, resulted in reduction values of 74% for most of the flow conditions with high flow needing an annual reduction of about 105 ton/yr. Table 5-10 provides all screening criteria and load reduction values for station 22134. The LDC for station 22134 is shown in Figure 5-21 which shows almost all observed loadings exceed the allowable screening level criteria across all flow conditions.

A similar scenario was found on Walnut Creek; all three surface water quality monitoring stations indicate TKN reduction is needed which was compounded downstream. The furthest station downstream, 13621, resulted in a load reduction of 69% for high flow conditions which is an annual reduction of about 130 ton/yr (Appendix F:). The stations located on the smaller streams also exceeded the screening level criteria but not for all flow conditions. Table 5-11 summarizes the screening level criteria of TKN for all surface water quality monitoring stations.

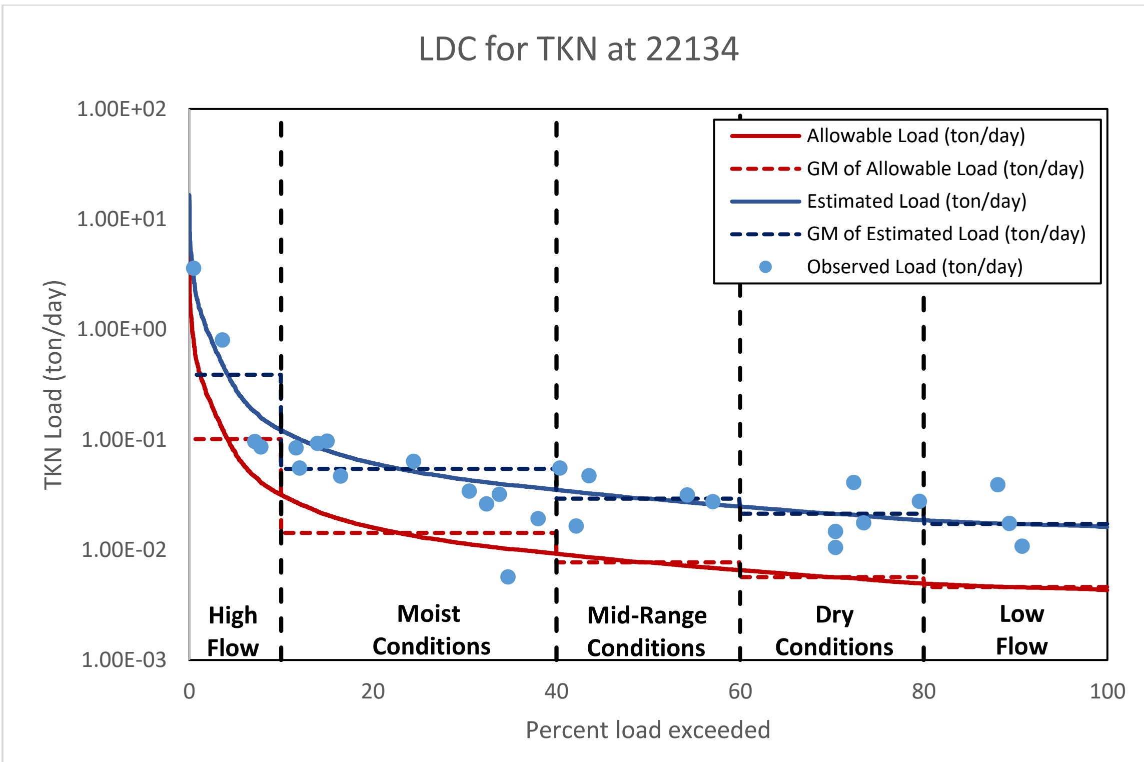


Figure 5-21 LDC for TKN at surface water quality monitoring station 22134 (Soap Creek)

Table 5-10 Average allowable loading, estimated loading, and load reduction of TKN for surface water quality monitoring station 22134 (Soap Creek)

Flow Condition at station 22134	% of Time Flow Exceeds	Allowable Loading (ton/day)	Daily Loading (ton/day)	% Daily Load Reduction Needed	Annual Loading (ton/yr)	Annual Reduction Needed (ton/yr)
High Flow	0-10%	1.01E-01	3.88E-01	74%	142	105
Moist Conditions	10-40%	1.42E-02	5.44E-02	74%	19.9	14.71
Mid-Range Conditions	40-60%	7.69E-03	2.91E-02	74%	10.6	7.82
Dry Conditions	60-80%	5.66E-03	2.13E-02	73%	7.78	5.71
Low Flow	80-100%	4.60E-03	1.72E-02	73%	6.29	4.61

The TKN component of total nitrogen is the sum of organic nitrogen and ammonia which comes mainly from animal manure. The TKN loading exceedance at surface water quality monitoring station 16433 during high flow conditions was high due to the runoff containing manure from feral hogs and deer from upstream forests (Table 5-1) while the high loading at surface water quality monitoring stations 22134 and 13622 were caused by waste from livestock grazing on rangelands and pasturelands upstream of these monitoring stations (Table 5-1). Additionally, the TKN loading exceedance at low flow conditions may be due to OSSFs and WWTFs. Similarly, the high concentration of TKN at high flow conditions for the Walnut Creek monitoring stations (20790, 21990, and 13621) may be caused by the runoff received from the surrounding grasslands (Table 5-1) containing waste from livestock. TKN at low flow conditions at these monitoring stations may be related to SSO, OSSF, and WWTFs in the area.

Table 5-11 Summary of EPA reference screening level exceedance at different flow conditions for TKN

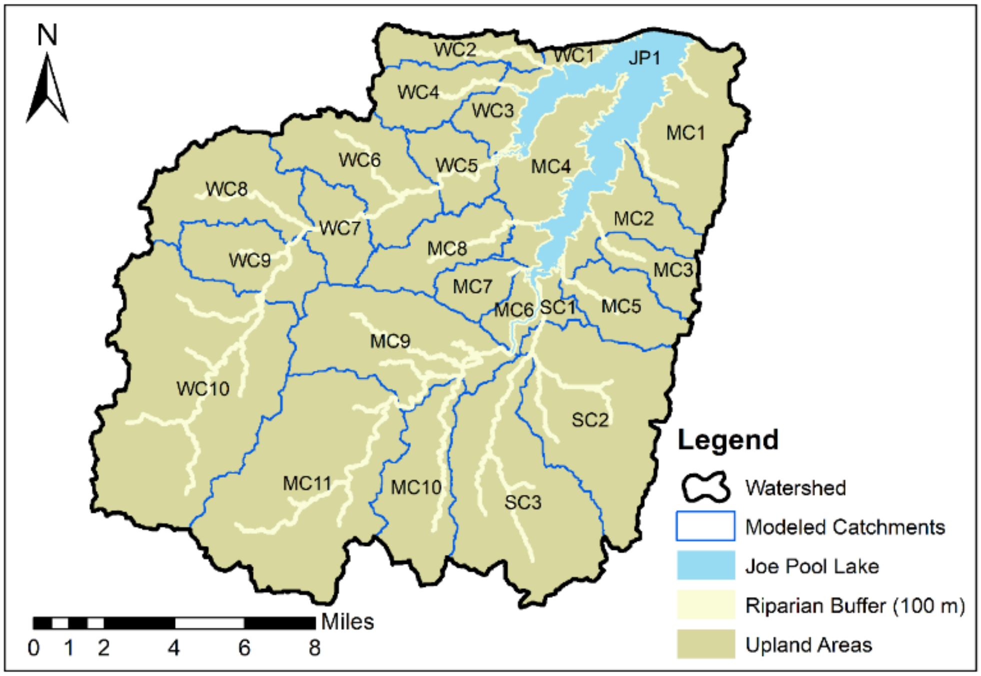
Monitoring Stations	Low Flow	Dry Conditions	Mid-Range Conditions	Moist Conditions	High Flow
16433	×	×	×	×	×
22135	✓	×	×	×	×
22134	×	×	×	×	×
16434	×	×	×	×	×
13622	×	×	×	×	×
22133	×	✓	×	×	×
13621	×	×	×	×	×
21990	✓	×	×	×	×
20790	✓	✓	×	×	×

Symbol × indicates exceedance and symbol ✓ indicates no exceedance

To ensure the water quality improvement goals are achieved for nutrients, an annual reduction of 1.86E+01 ton/yr during mid-range conditions are needed watershed wide. The complete list of geometric means of allowable loading, estimated loading, and reduction of nutrient loading needed at all surface water quality monitoring stations are presented Appendix F: and the corresponding LDCs are presented in Appendix G:.

5.3 Spatial Analysis of *E. coli* Sources Using SELECT

Watershed prioritization and BMP recommendations were further refined with the use of the SELECT analysis, which distributes potential *E. coli* loads into 25 modeled catchments, or subwatersheds (Figure 5-22), based on likely *E. coli* sources as identified by watershed stakeholders. Using a combination of GIS and spreadsheet tools, estimated populations of various warm-blooded animal species (humans, pets, livestock, wildlife) were distributed spatially throughout the watershed based on each population's applicability to different LULC characteristics. Once distributed, species-specific *E. coli* load production values published in scientific literature were applied to each population (Table 5-12), producing the *E. coli* loads that may eventually find their way to waterways (Figure 5-23, Figure 5-24, Figure 5-25). To account for the variety in the sizes of the subwatersheds, these loads were then normalized to a per-acre basis to ensure that contributions from larger subwatersheds did not overshadow those from several smaller ones. Finally, the separate, normalized sources were then aggregated to produce an overall normalized *E. coli* load for each subwatershed. It should be noted that SELECT was designed specifically for calculating loads from *E. coli* sources, and thus cannot be used to calculate loads from other pollutants of interest to stakeholders, despite their relative importance.



Stream data source: NHD; watershed source: TCEQ, subwatershed source: TNRIS LiDAR 30m DEM

Figure 5-22 JPL subwatersheds and stream network used in SELECT analysis

Table 5-12 *E. coli* loading factors for calculating *E. coli* loads from various sources

Source	*E. coli* Loading Factor	Literature Source
Cattle	2.70E+9 MPN/AU-day	Metcalf & Eddy, 1991
Sheep/Goats	9.00E+9 MPN/AU-day	Metcalf & Eddy, 1991
Horses	2.10E+8 MPN/AU-day	Hahn et al., 1998
Deer	1.75E+8 MPN/AU-day	Teague et al., 2009
Feral Hogs	4.45E+9 MPN/AU-day	Metcalf & Eddy, 1991
Dogs/Cats	2.50E+9 MPN/AU-day	Horsley &Witten, 1996
Ducks	5.50E+9 MPN/AU-day	Metcalf & Eddy, 1991
Geese	2.45E+10 MPN/AU-day	LIRPB, 1978
OSSFs	1.33E+9 MPN/person-day	Teague et al., 2009
SSOs	1.89E+7 MPN/gal; daily volume varies based on reported release volumes (gal) from database	EPA, 2001b
WWTFs	4.78E+9 MPN/MGD; daily volume varies based on self-reported release volumes (MGD) from facility	Teague et al., 2009

Proper distribution of populations is of paramount importance in the analysis, and stakeholders took care to ensure that distributions accurately reflected conditions experienced in watersheds existing along urban-rural fringes outside of major metropolitan areas like DFW. For example, it is unlikely that you would find a large cow/calf operation in the middle of a dense urban area, so no portion of the watershed's cattle population was distributed to urban land uses, instead they were placed in range and pasture lands. Conversely, while it is likely that the majority of the watershed's horse population will also be found in range and pastureland use classes, it is also likely that some portion may be found in low-density urban areas, on what are commonly known as small-acreage or "hobby" farms, typically five acres or less. Therefore, the stakeholder group elected to account for these "pocket populations" by distributing very small portions (5%) of applicable species populations to these low-density urban areas so that a more accurate characterization of the watershed conditions could be achieved.

Raw SELECT output is often seen as a "worst case scenario" for estimating *E. coli* loads, as the tool does not contain any built-in functionality that automatically adjusts for *E. coli* die-off, predation, soil entrainment, or other forms of mitigation between the time of deposition up to its introduction to a waterway. However, these processes can be partially accounted for by applying weights to the loads based on their distance to a waterway. For example, manure deposition within riparian buffer areas (< 100-m (330-ft) from a stream), carry more weight than would deposition in an upland area further away (Figure 5-22). Use of this tactic will allow for further refinement of critical areas for BMP implementation.

E. coli loads were similar for all livestock species (cattle, sheep, goats, and horses), being generally more prevalent in the southern region of the JPL watershed, with minimal impacts in the urban areas east and west of JPL. In particular, per-acre loads were most concentrated in subwatersheds MC9, MC11, WC10, and SC1 (Figure 5-23).

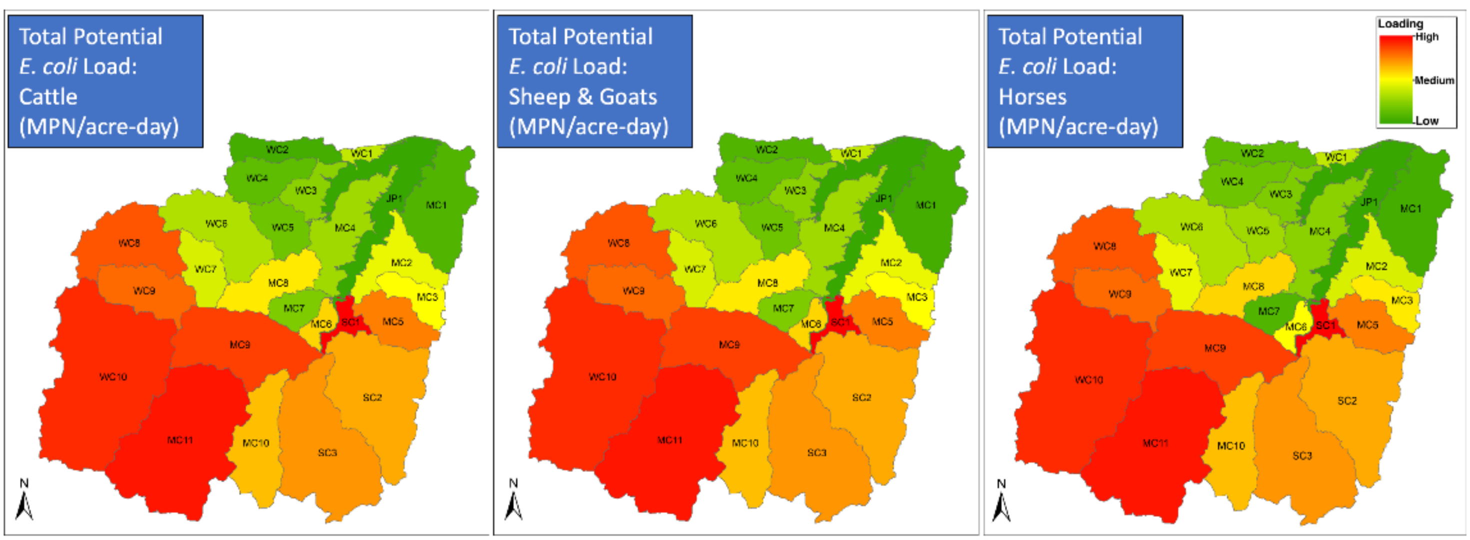


Figure 5-23 Relative severity of *E. coli* loads from cattle, sheep & goats, and horses, by subwatershed

The largest impacts from deer *E. coli* loads were found in the western side of the watershed (WC8, WC9, and WC10) with moderate loads in the forested area in the northeast. The highest *E. coli* loads for feral hogs were exhibited in subwatersheds MC1 and WC1 located adjacent to northern JPL. Subwatersheds MC2 and MC3 located on the eastern side of JPL also had slightly higher loads. In contrast, *E. coli* loads from dogs and cats tended to be highest in urban dominated subwatersheds, with the highest loads encountered in subwatersheds WC2 and WC4. Slightly higher and moderate loads were found closer on the western rim of the lake (Figure 5-24).

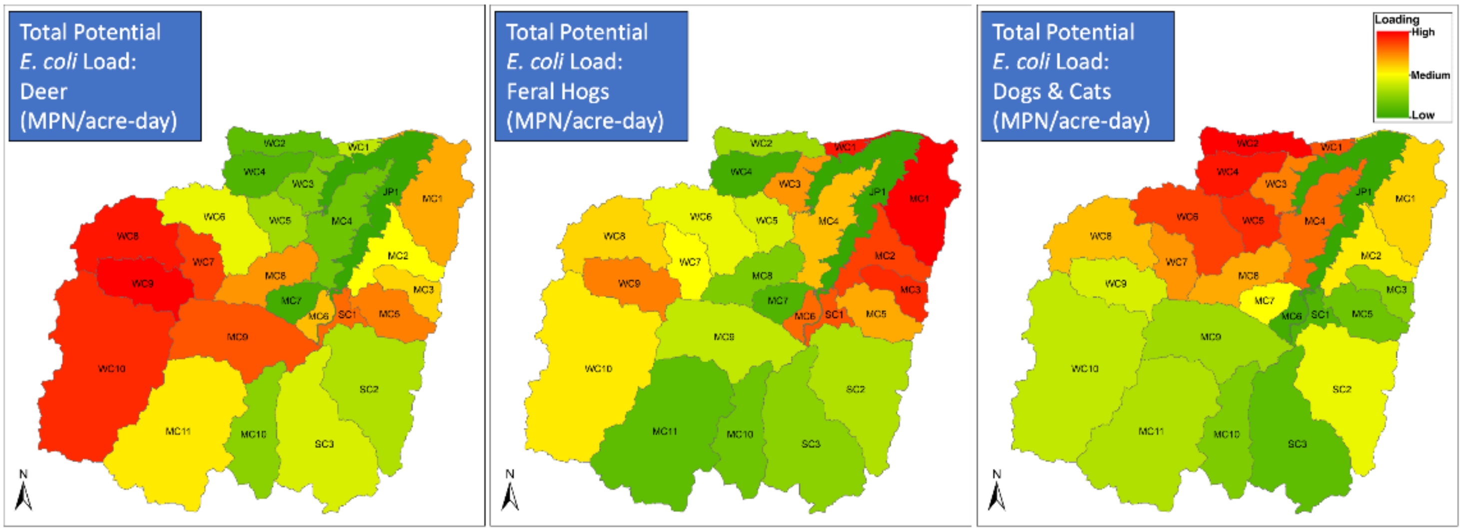


Figure 5-24 Relative severity of *E. coli* loads from deer, feral hogs, and dogs & cats, by subwatershed

As expected, *E. coli* loads from OSSFs were most significant in the rural areas to the west, with highest loads coming from subwatersheds WC8 and WC9. For WWTFs, the three subwatersheds containing active facilities WC10, MC11, and SC2, were the only ones with measurable loads with the highest loads found in SC2 where Midlothian is located (Figure 5-25).

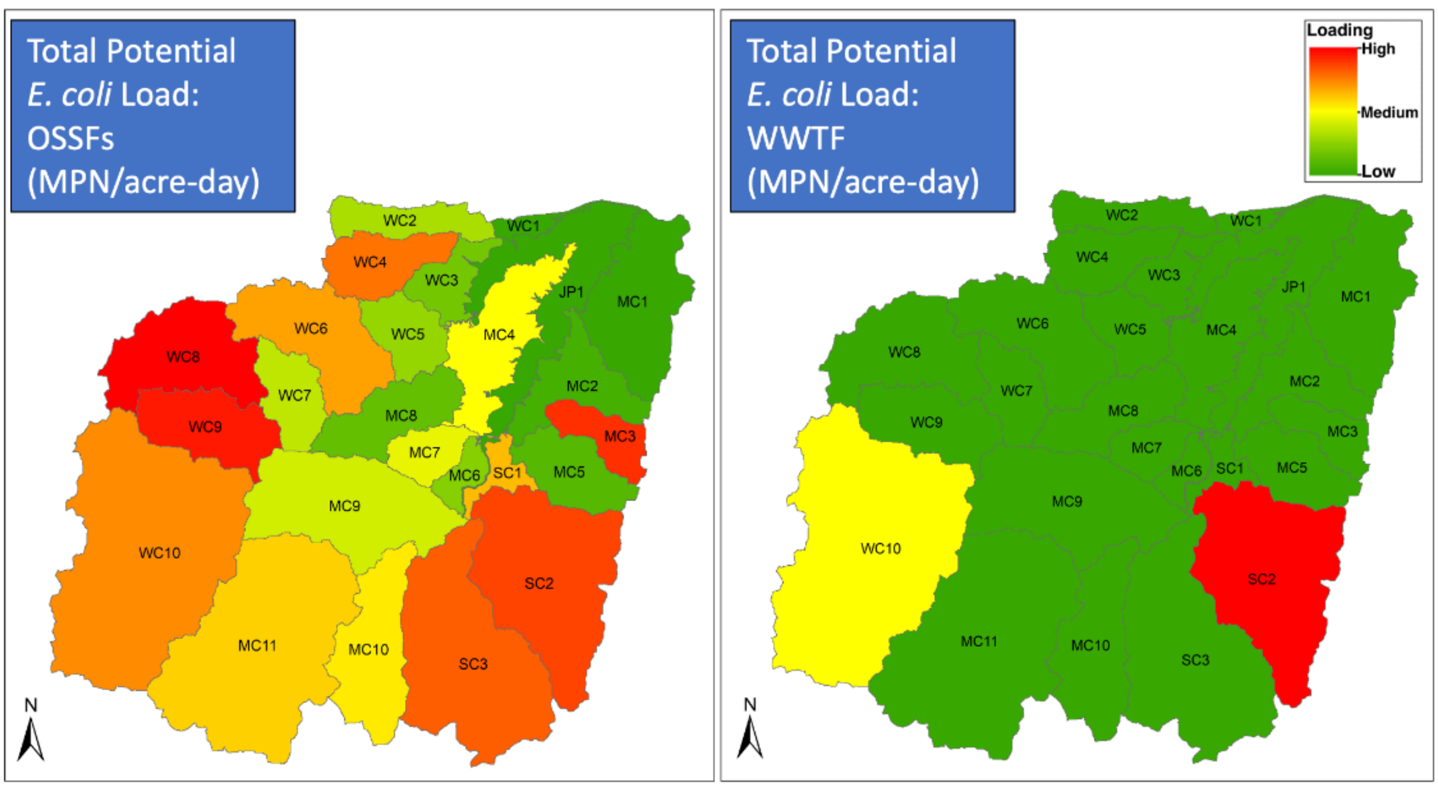


Figure 5-25 Relative severity of *E. coli* loads from human waste sources, by subwatershed

As with any spatial analysis, aberrations can occur, and unexpected results should be discussed with stakeholders. For example, after the initial stakeholder meeting, it was requested that horses from “hobby farms” be included. To account for this, 5% of all low density urban land use (9% of the watershed) was used. This was the agreeable amount of viable land within low density urban area. The total low density land use is about 13,000 acres, therefore 650 acres (or 5% of the total) was used for this analysis. One horse was added for every five acres of viable land resulting in an increase of 130 horses across the watershed.

Overall, impacts from all combined *E. coli* sources appeared to be most prevalent in the smaller subwatersheds surrounding the lake (Figure 5-26). These watersheds are comprised of urban areas with the predominant *E. coli* loading attributed to pet waste. Although the western subwatersheds on Walnut Creek had high loadings from deer and livestock, the values of high loading were well below the 126 MPN/acre-day allowable loading and therefore did not have a large contribution to the total loading from all sources. OSSFs also supplied high to moderate loads in the south, and WWTFs contributed to the overall *E. coli* loading only in regions where they were located. Table 5-13 provides a summary of highest priority subwatershed based on potential sources load. Figure 5-27 provides a visual comparison of the minimum and maximum loading values for all evaluated *E. coli* sources for the watershed, while Table 5-14 provides an in-depth analysis of all evaluated sources in all 25 subwatersheds. Please note that Figure 5-27 uses units of MPN/acre-day for comparison between pollutant source classes, while Table 5-14 uses units of MPN/day to establish the scope of the reductions needed to meet water quality goals.

As noted previously, there exist several potential *E. coli* sources that could not be included reliably, but the stakeholders still recognize them as viable pollutant management opportunities. These excluded sources as listed in Section 4.3.5, will also be considered in the overall management strategy covered in future chapters.

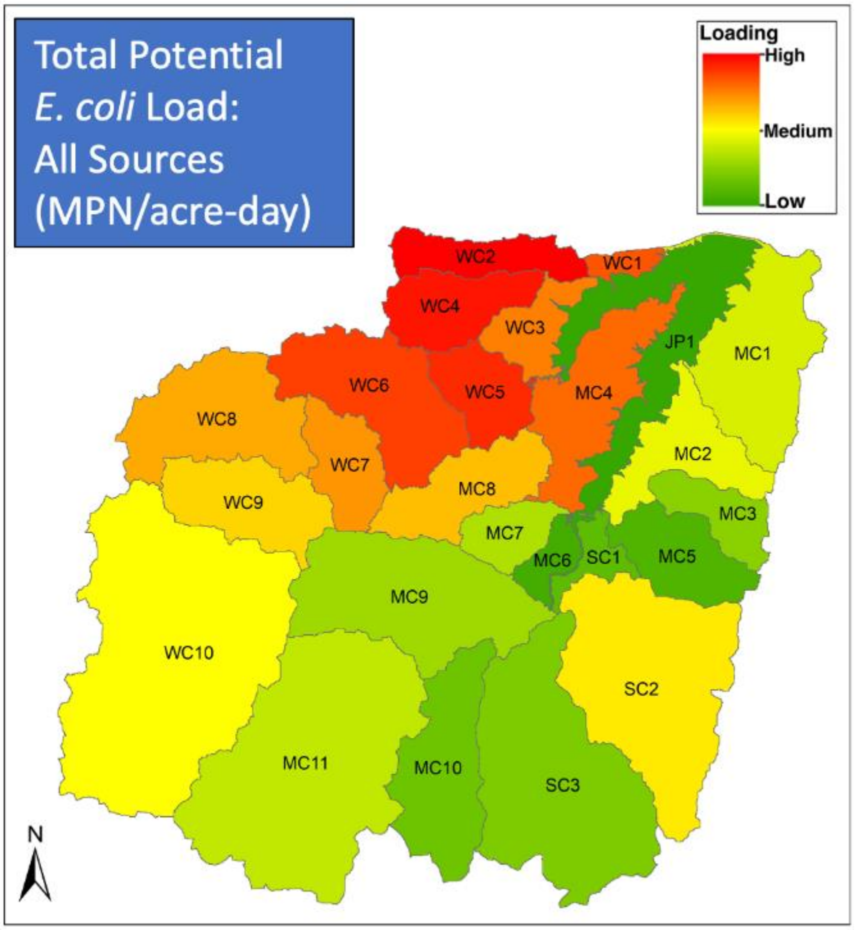


Figure 5-26 Relative severity of *E. coli* loads from all sources by subwatershed

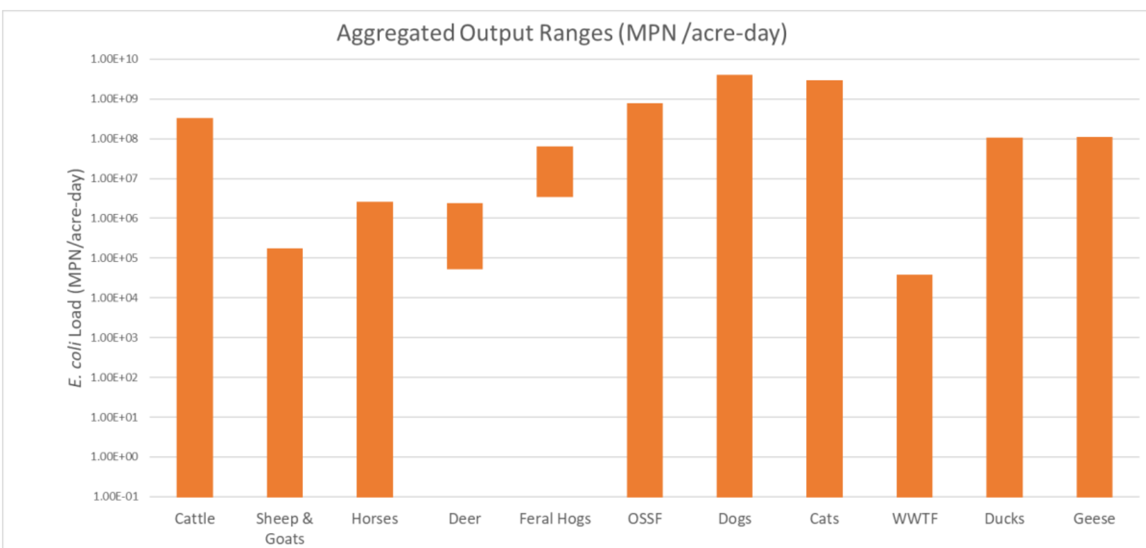


Figure 5-27 Daily potential *E. coli* load ranges by source categories. All values are area-normalized

Table 5-13 Highest Priority subwatersheds based on potential *E. coli* load (MPN/yr)

Source	JPL Watershed	
	Potential Load (MPN/yr)	Highest Priority Watersheds
Pets	614E+14	WC2, WC4, WC5, WC6, WC1, MC4, WC3
Cattle (Livestock)	176E+14	MC11, MC9, WC10, WC9, WC8, SC1
OSSFs	77.7E+14	WC8, WC9, MC3, SC2, SC3, WC4
Feral Hogs	9.64E+14	MC1, MC2, MC3, WC1, SC1, MC6
Wildlife (Deer, Avian)	5.83E+14	WC10, WC9, WC8, C7, MC9, SC1, MC8, MC5, MC1, JP1
WWTF/SSOs	0.00175E+14	SC2, WC10

Table 5-14 Potential *E. coli* loads for all subwatershed and evaluated sources (MPN/day)

Subwatershed	Cattle	Sheep	Goats	Horses	Deer	Feral Hogs	OSSF	Dogs	Cats	WWTF	Ducks	Geese	Total *E. coli*
JP1	—	—	—	—	3.50E+08	2.23E+10	—	—	—	—	7.04E+11	7.35E+11	**1.46E+12**
MC1	3.67E+11	8.10E+10	1.35E+11	3.99E+09	6.83E+09	4.54E+11	—	3.58E+12	2.66E+12	—	—	—	**7.28E+12**
MC2	6.18E+11	1.35E+11	2.34E+11	5.46E+09	3.50E+09	1.51E+11	3.79E+09	1.79E+12	1.34E+12	—	—	—	**4.28E+12**
MC3	3.78E+11	8.10E+10	1.44E+11	3.57E+09	2.10E+09	8.90E+10	6.31E+11	4.20E+11	3.13E+11	—	—	—	**2.06E+12**
MC4	5.16E+11	1.17E+11	1.89E+11	5.88E+09	2.80E+09	1.25E+11	4.21E+11	8.45E+12	6.29E+12	—	—	—	**16.1E+12**
MC5	9.48E+11	2.07E+11	3.51E+11	7.35E+09	3.50E+09	8.46E+10	2.99E+10	4.23E+11	3.15E+11	—	—	—	**2.37E+12**
MC6	2.21E+11	4.50E+10	8.10E+10	1.68E+09	1.05E+09	3.12E+10	1.55E+10	3.00E+10	2.25E+10	—	—	—	**4.49E+11**
MC7	1.65E+11	3.60E+10	6.30E+10	1.47E+09	7.00E+08	1.34E+10	1.42E+11	8.28E+11	6.15E+11	—	—	—	**1.86E+12**
MC8	7.32E+11	1.62E+11	2.70E+11	6.93E+09	4.03E+09	4.01E+10	4.16E+10	4.06E+12	3.03E+12	—	—	—	**8.34E+12**
MC9	2.68E+12	5.94E+11	1.01E+12	2.10E+10	1.12E+10	1.20E+11	5.97E+11	2.02E+12	1.51E+12	—	—	—	**8.56E+12**
MC10	1.35E+12	2.97E+11	5.04E+11	1.09E+10	4.03E+09	4.90E+10	4.73E+11	8.70E+11	6.48E+11	—	—	—	**4.21E+12**
MC11	4.91E+12	1.08E+12	1.84E+12	3.86E+10	1.49E+10	1.29E+11	1.47E+12	4.06E+12	3.02E+12	—	—	—	**16.5E+12**
SC1	3.78E+11	8.10E+10	1.44E+11	2.94E+09	1.40E+09	3.56E+10	1.08E+11	3.50E+10	2.75E+10	—	—	—	**0.81E+12**
SC2	2.85E+12	6.30E+11	1.07E+12	2.33E+10	9.10E+09	1.51E+11	3.04E+12	3.84E+12	2.86E+12	4.39E+08	—	—	**14.5E+12**
SC3	3.16E+12	6.93E+11	1.19E+12	2.50E+10	9.80E+09	1.34E+11	3.12E+12	1.07E+12	7.95E+11	—	—	—	**10.2E+12**
WC1	8.91E+10	1.80E+10	3.60E+10	8.40E+08	5.25E+08	3.56E+10	—	1.31E+12	9.70E+11	—	—	—	**2.46E+12**
WC2	1.35E+11	2.70E+10	5.40E+10	2.52E+09	1.23E+09	3.12E+10	8.61E+10	1.06E+13	7.86E+12	—	—	—	**18.8E+12**
WC3	1.94E+11	4.50E+10	7.20E+10	2.31E+09	1.40E+09	5.79E+10	2.49E+10	3.32E+12	2.47E+12	—	—	—	**6.19E+12**
WC4	1.86E+11	4.50E+10	7.20E+10	3.36E+09	1.40E+09	2.23E+10	5.96E+11	1.19E+13	8.86E+12	—	—	—	**21.7E+12**
WC5	1.84E+11	3.60E+10	7.20E+10	3.15E+09	2.10E+09	4.01E+10	8.84E+10	7.25E+12	5.40E+12	—	—	—	**13.1E+12**
WC6	6.32E+11	1.35E+11	2.34E+11	8.19E+09	5.78E+09	9.35E+10	6.12E+11	1.50E+13	1.12E+13	—	—	—	**28.0E+12**
WC7	4.16E+11	9.00E+10	1.53E+11	4.20E+09	3.85E+09	4.90E+10	1.53E+11	3.75E+12	2.79E+12	—	—	—	**7.41E+12**
WC8	1.77E+12	3.87E+11	6.66E+11	1.41E+10	1.42E+10	1.42E+11	5.07E+12	4.00E+12	2.98E+12	—	—	—	**15.0E+12**
WC9	1.23E+12	2.70E+11	4.59E+11	9.66E+09	1.07E+10	1.20E+11	2.50E+12	1.50E+12	1.12E+12	—	—	—	**7.21E+12**
WC10	6.04E+12	1.33E+12	2.26E+12	4.70E+10	4.15E+10	4.18E+11	2.07E+12	6.30E+12	4.69E+12	4.06E+07	—	—	**23.2E+12**
Totals													
Daily Load	3.01E+13	6.62E+12	1.13E+13	2.53E+11	1.58E+11	2.64E+12	2.13E+13	9.64E+13	7.17E+13	4.79E+08	7.04E+11	7.35E+11	**2.42E+14**
Annual Load	*1.10E+16*	*2.42E+15*	*4.12E+15*	*9.23E+13*	*5.77E+13*	*9.64E+14*	*7.77E+15*	*3.52E+16*	*2.62E+16*	*1.75E+11*	*2.57E+14*	*2.68E+14*	***8.83E+16***

5.4 Documentation of Illegal Dumping Using Photograph Repository

Significant quantities of refuse and potentially hazardous materials were found in and near tributaries by TRA field scientists at many of the sampling locations. Therefore, further reconnaissance in the watershed was conducted at rural/urban bridge crossings and cul-de-sacs with known or expected uses as illegal dumping sites. Examples of these findings are shown in Figure 5-28.

Prior to conducting the reconnaissance, sites were selected using aerial imagery, based on roadway access and proximity to JPL. A standard field data sheet was created that included parameters such as waste type, streambank erosion, homeless occupation, stream flow, and waste quantity. These parameters were further broken down into sub-categories with assigned point values based on potential water quality impacts. Hazardous waste was assigned the highest value of 5, whereas common litter items (cans, cups, fast food containers, bags, bottles, etc.), were assigned the lowest value of 1. Each site's cumulative point value was multiplied by a factor of 1-2 if the refuse was purposely dumped and then multiplied by 1-2 again based on the quantity. This created a standard grading rubric for each site where higher severity scores indicated more severe potential negative impacts on water quality. During the survey, field scientists completed data sheets, recorded Global Positioning System (GPS) points, and took photographs to support their findings. Field data were entered into a spreadsheet and used to create a mapping geodatabase. Using the total severity score, sites were distributed into four categories: 1) *minimal impact*, 2) *some impact, 3) significant impact,* and 4) *critical impact.* Of the 61 surveys, zero were classified as *critical impact*, seven were *significant impact*, nine had *some impact*, and 45 had *minimal impact* on water quality.

Example of a site with minimal impacts from illegal dumping.

Example of a site with some impacts from illegal dumping.

Example of a site with significant impacts from illegal dumping.

Example of a site with significant impacts from illegal dumping.

Figure 5-28 Examples of illegal dumping in JPL watershed

5.5 Conclusions

Based on these analyses, nonpoint source pollution is the main driver of water quality impairments in the JPL tributaries. It is clear that there are several significant sources of *E. coli*, nutrients, and other contaminants distributed throughout the watershed, and that focusing on one particular land use or location will not provide a viable solution. In many cases, wildlife tend to be the primary contributor of *E. coli* in Texas watersheds. Stakeholders have few management options in these cases, and stakeholders in the JPL watershed even expressed interest in avoiding management of wildlife contributions altogether, instead preferring to account for wildlife E. coli loads as background or baseline contributions. However, due to the significant amount of urbanized area in the JPL watershed, several sources that are inherently more manageable outranked wildlife sources. For this reason, *E. coli* contributions from dogs and cats are likely the primary source of pollution in the watershed, followed closely by agricultural livestock. These sources prove to be advantageous for *E. coli* management in the watershed, as several well-known and proven management strategies exist for both source categories, whether it be for *E. coli* or nutrients. Additional BMPs put in place for several of the other source categories will provide additional flexibility for achieving the watershed wide loading reduction of $2.42*10^{15}$ MPN/yr *E. coli* and 17.5 ton/yr nutrients (TKN and NO_x) during mid-range flow range conditions.

It is expected that some form of routine monitoring regime resembling that which was used to characterize the watershed will continue into the future. That prospect, if supported by both funding availability and stakeholder willingness, will supply researchers and decision-makers in the watershed with the data and knowledge required to continue application of one or several of the analyses detailed in this report to track progress for the improvement and protection of water quality in the JPL watershed.

Appropriate BMPs must be implemented to reduce TKN, NO_x, and *E. coli* loadings where estimated concentrations exceeded the screening criteria or the water quality standard concentration. In urban regions management of pet waste and in rangelands management of grazing activities can reduce both the nutrient and bacteria load. BMPs for SSO events would consist of proper maintenance and prevention measures as the impacts from such episodic events are difficult to simulate or predict.

6.0 Management Strategies and Associated Load Reductions

The WPP planning process operates on a continuum, beginning with the identification of the watershed's issues and recognition of the data gaps that need to be addressed before decisions can be made to remedy those issues. Several analyses are then conducted to spatially and quantitatively characterize the pollutant loads. This information can then be used by stakeholders to make informed decisions about the management methods most appropriate for remedying the issues with the highest stakeholder priorities.

6.1 Meeting Water Quality Goals

The primary water quality reduction goals for the watershed, as defined in Section 5.2, are specifically for *E. coli* loads, in terms of MPN/yr, and nutrient loads, TKN + NO_x in terms of ton/yr. However, these loads are expected to fluctuate, with reductions from BMP implementation offset by increases from LULC changes with continued development. To meet this challenge, load reduction goals will always refer back to the PCR 1 water quality standard for *E. coli* of 126 MPN/100 mL, which is measured as a concentration rather than a load. A 10% MOS on the water quality standard will be observed for load calculation, so the water quality target for the waterbodies of interest will effectively be 113 MPN/100 mL for calculating the *E. coli* loads. The nutrient load reduction goals will always refer back to the TCEQ screening level of concern for NO_x of 1.95 mg/L and the EPA screening level of concern for TKN of 0.4 mg/L. A 10% MOS of the water quality standard will be observed for load calculation, so the water quality target for the waterbodies of interest will effectively be 1.76 mg/L for calculating the NO_x loads and 0.36 mg/L for TKN loads.

Typically, only one index site is chosen for establishing water quality goals in a WPP. However, as described in Section 5.2, the watershed is a suburban rural mosaic thus stakeholders have recommended that the water quality improvement goals for the individual catchment areas be grouped into one watershed wide goal. Stakeholders selected the mid-range conditions flow regime as the basis for calculating the load reductions needed to reach the water quality goal. With reductions already in excess of 90% for *E. coli* and 50% for nutrients within this regime, stakeholders sought to set a realistic goal for water quality improvement that could be revisited in the future if merited. An annual watershed wide reduction during mid-range flow conditions of *E. coli* is $2.42*10^{15}$ MPN/yr and 17.5 ton/yr nutrients is needed to achieve water quality goals.

Although the *E. coli* reductions are the primary regulatory goal for the WPP, stakeholders agreed that bacteria issues were not necessarily the primary concern in the watershed. Concerns related to the amount of nutrients reaching the lake and their relationship to eutrophication, and more specifically algal growth, were of primary interest due in part to the lake's uses as a popular recreational area and as a drinking water supply for residents in Midlothian, Venus, Rockett, Mountain Peak, Sardis, and parts of Southern Grand Prairie. LDC analysis revealed a TCEQ nutrient screening level exceedance of NO_x and an EPA reference criteria exceedance of TKN. NO_x loading needs to be reduced in Soap Creek during mid-range conditions as well as TKN watershed wide during mid-range conditions. Nutrient reductions will be tied to management recommendations for *E. coli*, since many bacteria BMPs, (specifically those for water retention/detention and treatment) are also expected to curb both nutrient and sediment loads as well. Stakeholders also expressed interest in addressing more visible forms of pollution, including floatable trash, illegal dumping, and yard residues. Due to the sporadic and often transient nature of these sources, no quantitative reduction goals were recommended. However, stakeholders did recommend goals related to improving homeowner education and communication between various field investigators and regulatory entities (municipalities) to improve response time and cleanup.

With many examples of active oil and gas production around the lake and throughout the watershed, it is also possible that contamination from petroleum products or production by-products may endanger the lake or its tributaries. Due again to the sporadic and transient nature of these occurrences (similar to SSOs), no explicit load reduction goals were identified within the scope of the WPP towards these areas specifically; they will instead be considered within the overall scope of loads considered for greenspaces and open areas in general. There is also the possibility that stakeholders may choose to re-evaluate the need to address these areas separately in the future.

6.2 The Whole Watershed Approach

Stakeholders understand that focusing all of the group's efforts on a single source will likely result in diminishing returns in the form of load reductions with successive incremental funding increases. Instead, stakeholders have chosen to offset these diminishing returns by selecting appropriate BMPs for a variety of pollutant source categories. While the overall loads from each source were certainly taken into account, the stakeholder BMP recommendation process also incorporated elements of feasibility, cost-effectiveness, and community visibility. It is for this reason that several un-modeled sources (e.g., illegal dumping, yard waste) received a higher stakeholder priority rating than did more significant *E. coli* sources (e.g., livestock, OSSFs), as illustrated in Table 4-1. Conversely, these selection criteria also serve as justification for why stakeholders chose not to prioritize BMPs for native wildlife *E. coli* contributions, even recommending to avoid them outright to avoid creating perceived attractive nuisance issues near alternative watering facilities. This approach has been used in other WPPs, as management of wildlife in any capacity (for *E. coli* deposition or otherwise) is impractical, costly, and thus unlikely to yield meaningful load reductions within the watershed.

Prioritization by source was then followed by spatial prioritization. Stakeholders agreed that while placement of physical/environmental BMPs should follow the results of the SELECT analysis, education-based BMPs should be focused on areas that impose the most direct impacts to JPL and expand outward and upstream as appropriate. It is anticipated that these priority areas will fluctuate in size, shape, and location as needs arise or are resolved. These adjustments will rely heavily on stakeholder input, and only those BMP recommendations approved by stakeholders (at present or in the future) will be considered. Stakeholders themselves are responsible for implementing these voluntary recommendations, and their willingness to do so will ultimately define the speed and efficacy with which water quality goals are achieved.

Stakeholder communities may also have MS4 permits and implement measures to comply with their permit. Working cooperatively to implement similar BMPs outlined in this WPP through the watershed is more likely to achieve success. Section 319 funds will not be used to fund any measures in the MS4 permits but can potentially be used to fund stormwater management activities that go above and beyond permit requirements (TCEQ, 2011).

6.3 Animal Sources

6.3.1 Pet Waste

Although certainly more of a concern in higher-density urban areas, pet waste was determined to not only be the largest potential *E. coli* source throughout the entire watershed, but also the most pervasive, with no subwatersheds (exception of the lake itself (JP1) exhibiting “zero loads” for pet waste (Table 5-14)). Stakeholders also recognized that many of the public areas frequented by residents and their dogs occur in or near riparian areas and flood zones (greenbelt parks, dog parks), where the potential for contamination is greater. Efforts will begin with a focus on the critical areas described in the SELECT analysis, which include the subwatersheds adjacent to the lake and those in more urbanized areas. As human populations in the watershed rise, so will those for dogs and cats. BMPs selected for reduction of *E. coli* loads from pet waste will primarily focus on dogs, as it is assumed that most domestic cats use litter boxes and have their waste deposited in the landfill. However, it is expected that some portions of domestic felines are indoor/outdoor cats, barn cats, or other feral cats that do defecate outdoors. It is also likely that some cat owners continue to dump soiled cat litter into the environment after cleaning.

Management practices recommended to reduce pet waste *E. coli* loads seek to remove pet waste from known pathways by either a) confining the waste to a landfill, or b) treating the waste on-site in the ground through infiltration. This includes capitalizing on several educational opportunities that are already being promoted through various entities in the DFW metropolitan area, in addition to new resources currently being developed as part of this WPP effort and several others in the North Central Texas area. This includes relevant print media (utility bill inserts, info pamphlets, public signage) as well as mass media campaigns (websites, videos). This also includes promotion of both proven waste management methods and pilot projects. By providing additional opportunities for pet waste pickup and removal, such as supplementary pet waste stations for public areas that are currently lacking or have stations in need of repair. Installation of newer yet potentially even more effective pet waste treatments called in-ground pet waste digesters is also planned (Figure 6-1). A summary of stakeholder recommendations and the associated load reductions for pet waste are provided in Table 6-1.

Above: Installation of DIY pet waste digester (Zach Ogilvie, www.instructables.com).
Below: Installation of prefabricated pet waste digester near Lake Arlington.

Figure 6-1 Pet waste digester (credit: Zach Ogilvie)

Table 6-1 Recommended BMPs for pet waste

<table>
<tr><th colspan="4">Pollutant Source: Pet Waste</th></tr>
<tr><td colspan="4">Concerns: (1) Improper disposal of pet waste, (2) lack of education on impacts and proper disposal, (3) disease transmission and public safety</td></tr>
<tr><td colspan="4">Potential Impacts: (1) Indirect E. coli loading to waterbody from yards, public greenspaces, kennels, and shelters; (2) spread of disease amongst/between species</td></tr>
<tr><td colspan="4">Critical Areas: (1) Subwatersheds adjacent to the lake, (2) urbanized areas</td></tr>
<tr><td colspan="4">Goal: Reduce the E. coli load from pet waste delivered to waterbodies through stormwater and irrigation runoff through management of E. coli loads representing 20% of the present pet population (13,451 pets).</td></tr>
<tr><td colspan="4">Objectives: (1) Increase education and outreach efforts pertaining to proper disposal of pet waste, (2) Provide opportunities for proper waste disposal/abatement</td></tr>
<tr><th colspan="4">Recommendations</th></tr>
<tr><th>Focus Group</th><th>Management Practice</th><th>Timeframe</th><th>Costs</th></tr>
<tr><td>Cities, counties, NCTCOG, regional entities</td><td>Expand delivery of existing pet waste education resources, develop/implement new educational resources (e.g., utility bill inserts, websites, info pamphlets, videos, signage in public greenspaces/trails)</td><td>2023-2032</td><td>$170,000</td></tr>
<tr><td rowspan="3">Cities, counties, HOAs, NAs</td><td>Development and adoption of model pet waste pickup/disposal ordinances for municipalities and by-laws for HOAs/NAs</td><td>2023</td><td>N/A</td></tr>
<tr><td>Reconaissance of critical areas for pet waste station placement in municipal or community greenspaces</td><td>2023</td><td>$3,000</td></tr>
<tr><td>Install 34 new pet waste stations (@$300/station) and fund supplies (collection bags, wastebin bags) for 9 years (@ $85/yr)</td><td>2023-2032</td><td>$40,000</td></tr>
<tr><td>Residents</td><td>Install 5 pet waste digesters (@ $1000/install) per year on residential properties</td><td>2023-2032</td><td>$50,000</td></tr>
<tr><th colspan="4">Estimated Load Reductions</th></tr>
<tr><td colspan="4">BMPs recommended for pet waste seek to a) confine the waste to a landfill, or b) treat waste on-site in the ground. In doing so, the amount of E. coli from pet waste sources entering waterways via runoff from rainfall or irrigation will be reduced. It is reasonable to assume that not all of the deposited waste can be removed via bagging/burial, so a 75% removal efficiency will be applied to the load reduction. Similarly, it is expected that the recommendations will likely only capture loads from only 20% of the present pet population (13,451 pets). With the 75% removal efficiency, a 15% reduction is expected. The expectation that only 25% of the E. coli deposited by pets actually reaches the stream is then generally applied as an attenuation factor to realistically estimate the actual reduction. This results in a reasonable estimate of the total annual pet waste reduction of 2.3E+15 MPN/yr for the managed pet population.</td></tr>
<tr><td>Effectiveness</td><td colspan="3">With several dense population centers in the watershed, pet populations are estimated to be similarly dense. Treatment in this case is by direct removal of the pollutant source and internment elsewhere, exhibiting a high removal efficiency. Therefore, noticeable reductions are likely even by managing a limited population.</td></tr>
<tr><td>Certainty</td><td colspan="3">Improving opportunities for proper pet waste disposal for those aware of the contamination concern will provide most of the reductions.It is assumed that those who have other reasons for not properly disposing of waste will be difficult to convince to modify their behavior.</td></tr>
<tr><td>Commitment</td><td colspan="3">Most greenspaces already have some level of pet waste stations on-site, although bag stocking and bin cleanout could be improved. Signage for ordinances/by-laws are less visible, and enforcement thereof is limited or non-existent. Many homeowners are interested in installing pet waste digesters due to the low cost and convenience, but may be uncomfortable with the amount of digging required for proper function in north Texas soils.</td></tr>
<tr><td>Needs</td><td colspan="3">Funds for increasing the number and continued maintenance of pet waste stations, enactment of pet waste disposal ordinances/by-laws or enforcement of those existing, willing homeowners for expansion of pet waste digester installation program, with funding support.</td></tr>
</table>

6.3.2 Livestock

Production Agriculture

Livestock species (cattle, horses, sheep, and goats) ranked 2nd with respect to daily potential *E. coli* loading according to the SELECT analysis. However, stakeholders placed livestock inputs lower within the list of priorities for several reasons. It is understood that while the livestock *E. coli* load is large when compared to other modeled sources, there are several other threats to overall water quality in closer proximity to the lake that could also prove to be more cost-effective for long-term management. It is also understood that while Walnut Creek's listing for *E. coli* impairment only began in 2006, production agriculture within the watershed has been steady, and in some areas has decreased, with the growth of urban areas in Dallas, Ellis, Johnson, and Tarrant Counties (Walnut Creek was subsequently delisted in the 2018 Texas Integrated Report).

As a source, waste from livestock may sometimes be deposited directly into a water body if the animals are allowed access for drinking or wading to cool off during hotter seasons. In addition to direct water quality impacts from *E. coli*, direct access may significantly impact bank stability and increase sedimentation near the access area. However, livestock waste is typically deposited in upland areas and washed into waterways via stormwater runoff. As such, a significant amount of the *E. coli* deposited by livestock as waste dies before it can reach a stream or lake (Wagner et al., 2013).

In production agriculture, BMPs for water quality improvement typically involve strategic placement and utilization of resources to manage population density/distribution, thereby improving vegetative cover, and in turn reducing *E. coli* in runoff. Using exclusionary fencing is a simple method for reducing/eliminating livestock access to streams, but requires the construction of alternative watering facilities and shade to accommodate livestock needs. Exclusionary fencing, however, continues to be somewhat unpopular among producers. Even if fencing is not used, additional water troughs conveniently placed closer to animal grazing areas can still reduce traffic to streams. Typically, these additional water sources are supplied with a well, but can be fed by municipal supply if well drilling is not feasible. To reduce stormwater runoff of *E. coli* in upland areas, BMPs focused on improving soil infiltration and reducing runoff velocity are most effective. Prescribed grazing, when combined with herbaceous weed control, brush management, and strategic plantings of forage species will improve the vegetative cover quality of grazing areas. Responsible pest and nutrient management will further improve forage health and reduce the potential for excess additives being washed into waterbodies.

These practices are most effective when applied simultaneously across an entire property using a comprehensive management plan. To assist producers, technical and financial assistance is available through Natural Resources Conservation Service (NRCS) as conservation plans (CPs) and the Texas State Soil & Water Conservation Board (TSSWCB) as water quality management plans (WQMPs). These plans, usually administered through local soil and water conservation districts (SWCDs) are developed with input from district-level technicians familiar with the management methods best suited for the local area. A summary of priority project areas, stakeholder recommendations and the associated load reductions for livestock are provided in Table 6-2.

Small-acreage Farms

As noted earlier, a number of small-acreage hobby farms exist within the watershed, which stakeholders recognized as a potentially significant contributor to growing water quality concerns. In contrast to area trends in production agriculture, there is significant anecdotal evidence that the number of hobby farms is increasing. It is likely that many of these hobby farm operators are new to agriculture, and more likely to be uneducated about proper land management practices. This, combined with a tendency for higher stocking rates on the smaller plots, increase the likelihood for *E. coli* contamination to nearby waterbodies in comparison to full-scale production agriculture operations.

However, educational opportunities are still planned for hobby farm owners looking to improve their knowledge about land management and how their decisions can impact local water quality for themselves and their neighbors.

Table 6-2 Recommended BMPs for livestock

Pollutant Source: Livestock			
Concerns: Overstocking of animals that results in overgrazing/feed and forage imbalance, degradation of riparian buffers and terrestrial habitat for wildlife and invertebrates, stream bank destabilization/bank erosion, nutrients transported to surface water and disturbance of aquatic habitat for fish and other organisms. (List not exhaustive, refer to NRCS National Resource Concern List and Planning Criteria).			
Potential Impacts: (1) Indirect *E. coli* loading to waterbody from rangeland, ag fields, and small acreage operations (hobby farms), (2) threats to aquatic life health/diversity, (3) property damage from stream bank failures			
Critical Areas: Production agriculture operations and hobby farms near riparian zones			
Goal: Reduce *E. coli* loading from livestock through education and by encouraging participation in WQMP/CP programs, with projects focused on minimizing the amount of time animals spend in riparian zones by improving resources across the property			
Objectives: (1) Promote use of WQMPs/CPs in the watershed, with emphasis on operations near riparian zones, (2) provide educational opportunities for hobby farm owners to improve management of their property			
Recommendations			
Focus Group	**Management Practice**	**Timeframe**	**Costs**
Production agriculture	Development and implementation of WQMPs and CPs for 30 properties (@$15K/plan) *Based on land use changes projected by NRCS and TSSWCB*	2023-2032	$450,000
Hobby farm operators	Provide educational opportunities and informational resources focused on new small acreage landowners who plan to stock animals on-site	2023-2032	$10,000
Estimated Load Reductions			
Adherence to prescribed whole-farm management plans like WQMPs and CPs is expected to reduce *E. coli* loading to streams through indirect (fecal contamination in stormwater runoff) and direct (direct fecal deposition in streams) inputs. Improving landcover management and limiting the time spent by animals in riparian zones are expected to provide a total annual *E. coli* load reduction of 1.08E+15 MPN/yr, in addition to reductions to both nutrient and sediment loads. For simplicity, this calculation was made using only the cattle population, as they were by far the most numerous livestock species (78% of the total estimated livestock population). The standard 25% attenuation factor was again applied to realistically characterize the reduction (for rotational grazing and exclusionary fencing only). Additional detail regarding this estimate is provided in Appendix G.			
Effectiveness	Reducing the time spent by livestock within riparian zones, coupled with proper management of vegetative cover in upland areas, are expected to provide significant direct and indirect reductions to *E. coli* loads, reaching waterbodies, with those used directly within riparian zones being the most effective.		
Certainty	Locating willing landowners may be difficult without the assistance of local natural resource representatives, and there is no guarantee that future owners will continue to utilize the BMPs identified in the site plans if the property changes ownership.		
Commitment	Agricultural landowners are typically willing to engage in land conservation practices once they're made aware of the benefits, especially if those pratices relate to cost savings in the form of reduced erosion and more efficient use of pesticides, herbicides, and fertilizers. However, initial costs may limit adoption of such practices.		
Needs	Significant financial support, as directed through the WQMP and CP programs, is essential for the success of this component, which is capable of providing significant load reductions if utilized across all ag species. Therefore, education pertaining to participation and benefits of these programs is also imperative, as is funding for education targeted to new small-acreage landowners.		

6.3.3 Feral Hogs

The potential *E. coli* load from feral hogs ranked 4th overall, but feral hog control as a means of load reduction was given a much lower priority ranking by stakeholders. It was understood that feral hogs are indeed a persistent and growing threat to water quality that needs to be addressed, even in metropolitan areas (Figure 6-2). However, in contrast to domesticated livestock, population management with feral hogs is difficult, due in no small part to the species' prolific reproductive capacity. Feral hogs also prefer dense habitat, are opportunistic feeders, and can quickly adapt to trapping tactics and pass this knowledge on to their offspring if care is not taken to capture entire groups at one time.

Despite these obstacles, stakeholders still recognize that feral hogs' preference for riparian habitat places them at the epicenter of water quality impacts and proposed several BMPs aimed at either continuation/expansion of current educational/outreach activities, or encouragement of low-cost voluntary measures that can be employed by landowners impacted by feral hog activity. TRA, along with several other local and regional entities, will continue development and delivery of feral hog education catered to a variety of stakeholder groups across the watershed. To complement these education and outreach activities, stakeholders also expressed interest in establishing a framework making information available to the public for local hog trappers, trap wholesalers/distributors, trapping programs, and other feral hog related resources in a centralized location.

Although education/outreach activities can be practical, low-cost approaches to control, stakeholders understand that support of control methods intent on physical removal of feral hogs remain the most effective method that will lead to water quality improvements. TRA and its partners will continue to promote several voluntary activities for private landowners targeted to either removal of hogs or associated attractive nuisances, like 1) constructing exclusionary fencing around deer feeders and other food sources to prevent feral hog use, and 2) trapping and/or shooting all hogs on-site, cooperating with their managers and lessees to do the same. Stakeholders also indicated their support for a "trap share" program, where 2-3 state-of-the-art, wirelessly operated traps would be purchased by a regional entity, to be loaned out to municipalities or the counties for use in public greenspaces currently besieged by feral hogs. A summary of priority project areas, stakeholder recommendations, and the associated load reductions for feral hog control are provided in Table 6-3.

Figure 6-2 Evidence of feral hog damage in urban areas (credit: City of Fort Worth)

Table 6-3 Recommended BMPs for feral hog control.

Pollutant Source: Feral Hogs			
Concerns: Uncontrolled proliferation of feral hogs in watershed			
Potential Impacts: (1) Direct/indirect E. coli loading in riparian zones, (2) destruction of riparian buffers, crops, pastures, (3) resource competition with and predation of native species			
Critical Areas: Riparian buffer zones throughout entire watershed			
Goal: Reduce the feral hog population by 5% in the watershed (30 hogs) and prevent further population increases			
Objectives: (1) Increase education and outreach efforts pertaining to feral hog control, (2) reduce and maintain population through direct removal of hogs and removal of/exclusion of hogs from attractive nuisances			
Recommendations			
Focus Group	**Management Practice**	**Timeframe**	**Costs**
Cities, counties, NCTCOG, regional entities	Fund and field a "trap share" program that will allow for three corral traps to be shared amongst cooperating entities for placement in public greenspaces (@$15K per system, +$5000 for support/maintenance for 10 yrs)	2023-2032	$50,000
Landowners, land managers	Voluntarily construct exclusionary fencing around deer feeders and other food sources to prevent feral hog use	2023-2032	N/A
	Voluntarily shoot all hogs on-site, cooperating with managers and lessees to do the same	2023-2032	N/A
	Provide framework to landowners for easy access to trappers, trap wholesalers, trapping programs, and feral hog-related other resources, in cooperation w/NCTCOG	2023-2032	$5,000
All stakeholders	Continue development and delivery of general/specific feral hog educational workshops (yearly, @$7500/event)	2023-2032	$75,000
Estimated Load Reductions			
Due to their physiological need to live in close proximity to water sources, removal of feral hogs can provide significant reductions to *E. coli* loads, with reductions through both direct fecal deposition and via stormwater runoff from riparian zones, many of which may have been already disturbed by hog use. Through the removal of 5% of the population (30 hogs) and prevention of further increases, a reduction of 1.20E+13 MPN/yr is expected, after applying the 25% standard attentuation factor.			
Effectiveness	Provided the rural/urban mosaic land use of the watershed, it is expected that some feral hog control will take place on agricultural lands, but the most effective control will occur within the riparian corridors hogs use to travel between known food supplies. Population control will decrease loading primarily through direct fecal deposition, but also through stormwater runoff contributions.		
Certainty	Feral hogs are an adaptable and mobile species, and even minimal population reductions may be difficult to obtain and even more difficult to maintain, especially if large groups (sounders) become wary of tactics employed as recommended BMPs.		
Commitment	Although most landowners affected by feral hogs are willing to implement population control tactics, the effectiveness and certainty of success depend heavily on the diligence and commitment of landowners to not deviate from the recommended methods of hog removal, as well as the		
Needs	Funds to support education/outreach activities are needed, as well as continued technical assistance for improving the effectiveness of hog removal tactics.		

6.4 Human Activities

6.3.4 Illegal Dumping and Litter Accumulation

As previously indicated, no reliable data currently exists with which to estimate *E. coli* loads that may arise from both illegally dumped materials and passively accumulated floatable litter in waterways. *E. coli* loads comprise only a fraction of the potentially hazardous substances that may arise from illegal dumpsites, which commonly occur in easily accessible areas, constituting a public health hazard (Figure 6-3). Many also voiced concerns related to the prevalence of the dumping activity in such close proximity to JPL, which provides drinking water to residents. For these reasons, stakeholders consider illegal dumping to be a 3rd -tier priority for water quality improvement.

Above: Dumping in Mountain Creek.
Left Below: Dumping near Venus in Mountain Creek watershed.
Right Below: Floatable litter accumulation in Walnut Creek.

Figure 6-3 Illegal dumping and refuse accumulation (credit: TRA)

Several regional campaigns for littering currently exist, which can be administered in the watershed. This was reiterated for any existing illegal dumping-related content if such programs currently exist. Expansion of the JPL cleanup events further into Walnut Creek and Mountain Creek was also identified as a viable method of both direct removal of garbage and illegal dumpsite discovery. Stakeholders also had an interest in the proliferation of home hazardous waste pickup/drop off events into rural/unincorporated areas, as those efforts are currently only available to residents of participating cities.

Finally, stakeholders expressed interest in continued development of the proposed illegal dumping/refuse accumulation surveys, both by frequently revisiting established sites and adding new sites as more impacted areas become apparent through watershed reconnaissance and receipt of information from other watershed stakeholders. This also includes significant efforts to improve and promote interdepartmental communication at the municipal level to ensure that valuable information about potential illegal dumping sites discovered by any other municipal employee reaches code enforcement staff. Likewise, communication between neighboring cities, local agency staff, residents, and the appropriate city staff will also help to ensure the success of this effort. Continued monitoring of illegal dumping sites may also reveal the need for long-term surveillance and/or posting of relevant signage to improve the efficacy of enforcement efforts. A summary of priority project areas, stakeholder recommendations and associated load reductions for illegal dumping and litter accumulation are provided in Table 6-4.

Table 6-4 Recommended BMPs for illegal dumping and litter accumulation

<table>
<tr><th colspan="4">Pollutant Source: Illegal Dumping and Litter Accumulation</th></tr>
<tr><td colspan="4">Concerns: (1) Multiple pollutants from illegally dumped materials leaching into local water resources, (2) large dumped items restricting/redirecting flow in waterways</td></tr>
<tr><td colspan="4">Potential Impacts: (1) Direct/indirect contamination of waterbodies from E. coli, nutrients, and hazardous materials, (2) localized human health hazards, (3) Flow obstruction/alteration resulting in impoundment or erosion</td></tr>
<tr><td colspan="4">Critical Areas: (1) Small urban tributaries around the lake, (2) riparian buffers</td></tr>
<tr><td colspan="4">Goal: Reduce waste to a degree resulting in 15% of the total baseline survey sites shifting to lower-impact categories</td></tr>
<tr><td colspan="4">Objectives: (1) Work with municipalities to monitor sites and provide evidence for enforcement actions, (2) Increase education and outreach efforts pertaining to litter and illegal dumping through existing mass media campaigns, (3) Coordinate with other stakeholder entities to set up creek cleanup events in their vicinity</td></tr>
<tr><th colspan="4">Recommendations</th></tr>
<tr><th>Focus Group</th><th>Management Practice</th><th>Timeframe</th><th>Costs</th></tr>
<tr><td>Cities, counties, HOAs, NAs</td><td>Continuation and expansion of survey to identify illegal dumping/refuse accumulation "hot spots" throughout watershed for 10 years (@$5800/yr); Use results of survey to coordinate with other entities to provided evidence for enforcement actions and to identify critical areas for signage/surveillance in urban and rural areas</td><td>2023-2032</td><td>$58,000</td></tr>
<tr><td>Counties, CDPs</td><td>Work with county representatives and local leaders in unincoroporated areas to institute hazardous waste pickup days for 10 years (2/yr @$10k/yr)</td><td>2023-2032</td><td>$100,000</td></tr>
<tr><td rowspan="2">Cities, counties, HOAs, NAs, nonprofits, regional entities, resource agencies</td><td>Coordinate w/ other watershed entities on public outreach/education opportunities via existing litter/illegal dumping mass media campaigns</td><td>2023-2032</td><td>N/A</td></tr>
<tr><td>Work w/ other watershed entities (Keep "____" Beautiful groups) to coordinate cleanups on Joe Pool Lake or its tributaries for 10 years (1/yr @ $3500/event)</td><td>2023-2032</td><td>$35,000</td></tr>
<tr><th colspan="4">Estimated Load Reductions</th></tr>
<tr><td colspan="4">BMPs recommended for illegal dumping and litter accumulation are not tied to a specific E. coli reduction, but it is likely that reductions in the incidence of E. coli will occur to some degree, as dumping of whole animal carcasses and hunting remains are commonly found at site survey locations, occasionally deposited directly in the waterbody. Although this group of BMPs may not necessarily be tied to a load reduction, its visual nature will allow for documentation of progress as individual management measures are put into place.</td></tr>
<tr><td>Effectiveness</td><td colspan="3">The "patchwork" urban/rural landscape indicative of the watershed provides prime opportunities for illegal dumping activity, and several chronically affected sites appear to be well-known and frequently used by nearby residents/businesses. Treatment in this case is by direct removal of the pollutant source and internment elsewhere, exhibiting a high removal efficiency. Due to the highly visible nature of the pollutant source, identification takes minimal effort.</td></tr>
<tr><td>Certainty</td><td colspan="3">Improving opportunities for proper waste disposal for those aware of the contamination concern is expected to yield little, if any, improvement, as illegal dumping typically takes place as a matter of convenience for perpetrators, and thus it will be difficult to convince them to modify their behavior. Therefore, it is assumed that the bulk of illegal dumping concerns will be addressed through enforcement of city ordinances and criminal investigations, which can be improved through the use of proposed photo/video surveillance techniques.</td></tr>
<tr><td>Commitment</td><td colspan="3">Several municipalities have code enforcement staff currently available to handle illegal dumping activities, but lack the staff to actively patrol for violations. Providing these staff with the evidence they need will improve their efficiency and response time.</td></tr>
<tr><td>Needs</td><td colspan="3">Fund support of HHW pickup/dropoff and creek cleanup events; fund routine watershed reconnaisance to identify/characterize dump sites and track site recovery or movement; enforcement of existing illegal dumping codes once evidence has been provided.</td></tr>
</table>

6.3.5 Lawn Residue and Waste

Stakeholders evaluated concerns related to residue and waste from managed green spaces in a manner similar to that previously used for illegal dumping and litter accumulation concerns. This came from the understanding that both sets of concerns arose from direct human influence on the landscape, either from ignorance of the environmental impacts, lack of proper education/training, or potentially from willful disregard of existing laws and ordinances. Similarly, a lack of solid information required to make pollutant load estimates was recognized here as well, meaning that lawn residue and waste could not be quantitatively compared to other pollutant sources. Despite this lack of information, stakeholders saw the benefits of emphasizing BMPs for this widespread water quality concern, identifying it as a 1^{st} –tier priority to be addressed, due chiefly to its importance for managing eutrophication and overall water quality in JPL.

As is the case with many other pollutant sources, education and outreach initiatives are a vital first step. In this case, that entails ensuring that both staff and citizens have the knowledge to recognize behaviors that produce nutrient and DO concerns, which can consequently lead to fish kills, taste/odor problems in drinking water, or other impacts from eutrophication. Stakeholders have also proposed the use of illicit discharge studies for municipal stormwater infrastructure, chiefly to identify violations, but to also provide information to complement other pollutant site tracking efforts mentioned elsewhere within this WPP framework (see Section 0). EPA defines an illicit discharge as "...any discharge to an MS4 that is not composed entirely of stormwater..." with few notable exceptions like water from emergency response events (water from firefighters) or discharges specifically allowed through the National Pollutant Discharge Elimination System (NPDES) permitting (EPA, 2005). Put simply, this means anything other than "rain down the storm drain" is considered an illicit discharge, whether put there willfully, accidentally, or while unaware of the environmental consequences. Successful identification of these illicit discharges involves a survey of either all or a subset of a municipalities' storm drain inlets, looking for evidence of everything from hazardous wastes like automotive fluids or other liquids poured directly into drain inlets to yard waste forced in with a leaf blower. Encouraging neighboring municipalities to enforce existing or adopt new model lawn waste handling/disposal ordinances to manage these activities is a high priority for stakeholders.

Move organic debris back onto lawns or into compost piles to avoid storm drain clogs and impacts to aquatic health in local streams (credit: www.mygreenmontgomery.com).

Figure 6-4 Example of nutrient BMP (credit: www.mygreenmontgomery.com)

Based on 2016 National Land Cover Database (NLCD), there are approximately 8,991.24 acres (391,658,414 sq. ft) of developed land (open space, low density, medium density, and high density) across the watershed (Figure 3). The impervious surfaces in developed and urbanized areas increase the amount of rainfall that becomes runoff. This increased overland flow has the potential to pick up and carry pollutants to nearby water bodies, even during small rainfall events. The variables are too numerous to model with certainty (urban fertilizer and pesticide use, construction sites, urban avian and terrestrial wildlife, trash and other waste, and many other nonpoint sources); however, any reduction in runoff will result in a reduction of pollutants reaching surface waterbodies. Various stormwater/green infrastructure BMPs are available to reduce the volume of stormwater that runs off developed sites, potentially decreasing the amount of pollutants entering the stream. Based on one study in Texas, implementing rainwater harvesting, permeable pavers and rain gardens in 20%-34% of properties with roofs and 31% to 47% of properties with parking lots, an estimated reduction in surface runoff varies from 14% to 29% and reduction in nitrate runoff varies between 24% and 30% (Seo et al., 2017). In another study, stormwater quality improvements were seen through installation of pervious pavement, raingardens, bioswales, and bioretention ponds that reduced pollutant loads by 25-100% (Clary et al., 2017). A summary of priority project areas, stakeholder recommendations, and associated load reductions for lawn residue/waste are provided in Table 6-5.

Table 6-5 Recommended BMPs for lawn residue and waste.

Pollutant Source: Lawn Residue and Waste			
Concerns: (1) Improper disposal of organic lawn waste, (2) excessive fertilizer, herbicide, pesticide, or other chemical application on lawns and other open areas			
Potential Impacts: (1) Direct/indirect contamination of waterbody from *E. coli*, nutrients, and hazardous materials; (2) impacts to aquatic wildlife			
Critical Areas: (1) Lake-adjacent subwatersheds, (2) managed open spaces (sports fields, golf courses, oil/gas pad sites)			
Goal: Reduction of nutrients sufficient to reduce TKN and NOx loading in the Joe Pool Lake Watershed.			
Objectives: (1) Increase education and outreach efforts pertaining to proper handling of organic yard waste, (2) Promote use of residential/commercial lawn management, (3) conduct illicit discharge surveys, (4) identify and install green infrastructure in coordination with cities, counties, and property owners (list not exhaustive)			
Recommendations			
Focus Group	**Management Practice**	**Timeframe**	**Costs**
Cities, counties, NCTCOG, regional entities	Expand delivery of existing lawn waste education resources, develop/implement new educational resources (e.g., utility bill inserts, websites, info pamphlets, videos, signage in public greenspaces/trails)	2023-2032	$170,000
Cities, counties	Conduct illicit discharge surveys	2023-2032	N/A
Schools, HOAs/NAs, golf courses, oil & gas pad operators, airports, real estate	Connect landowners w/ existing resources for proper land management, green infrastructure, irrigation, soil testing/fertilization, herbicide/pesticide application	2023-2032	N/A
	Development and adoption of model lawn waste pickup/disposal ordinances for municipalities and by-laws for HOAs/NAs	2023	N/A
Cities, property owners, contractors	Identify and install green infrastructure BMPs as funding becomes available	2023-2032	$6 - $45/per sq. ft or $261,000 - $1,949,746/per acre (estimate)
Residents, landscape companies	Deliver "water wise" education program for proper lawn care, landscaping, and stormwater management, w/ soil nutrient testing opportunity (3 events @$3500/event)	2023, 2027, 2030	$10,500

Continued from previous page

Estimated Load Reductions	
BMPs recommended for lawn residue/waste seek to reduce the amount of organic matter, nutrients, and chemicals reaching waterbodies via stormwater runoff and irrigation. LDC analysis revealed that load reductions for TKN were needed within the monitored tributaries. It is expected that several of the BMPs recommended for *E. coli* reductions will also reduce nutrient loading, by either a) confining the organic matter to a landfill, b) on-site retention and composting, or c) more efficent applications of lawn additives. In doing so, the amount of organic matter, nutrients, and other chemicals from lawn waste and residue entering waterways via runoff from rainfall or irrigation will be reduced at values proportional to those of *E. coli*. Installation of green infrastructure will vary in potential load reduction because of location, type, and size or projects installed. The load reduction needed is 1.86E+01 ton/yr of nutrients (includes TKN watershed wide and NOx specific to Soap Creek), approximately 53% watershide wide. Research has shown that reductions can be met between 25-100% depending on location with various types and maintenance.	
Effectiveness	Effectiveness varies depending on the BMP of interest, with direct removal/reductions possible with respect to design, site selection and maintenance of green infrastructure BMP, proper lawn waste management, but less direct benefits from lawn chemical application training/management. Again, given the dense population centers in the watershed, noticeable reductions are likely even if participation is limited.
Certainty	Installion of green infrastructure BMPs requires sustained commitment from city officials or property owners. Education on properly managing lawn waste is a low-cost solution that most individuals can adopt easily. Enforcement of current lawn waste ordinances within municipalities is typically limited, with few cities having enough to properly address the issue. Unclear if on-site soil testing made available at workshops will improve participation.
Commitment	Homeowner adherence to lawn waste management protocols can be fleeting, dependent on perceptions of convenience, aesthetics, and understanding of negative impacts. City staff devoted to code enforcement will be as committed as their funding and schedules permit. Most homeowners understand the impacts of over-application of lawn additives, but may be uncomfortable with customizing their lawn care regimens even after receiving training to do so. Green infrastructure may not be a high priority for local municipalities; financial or other incentives will be needed to encourage and secure long-term commitment.
Needs	Funding for development and delivery of educational resources, development and/or enforcement of lawn waste ordinances with funding for staff. As well as financial assistance for green infrastructure design, site selection and maintenance.

6.4 Wastewater

6.4.1 Centralized Wastewater

For incorporated areas where onsite wastewater treatment is unfeasible due to higher population densities, centralized systems are the most common method of wastewater treatment. These systems use a network of pipelines connecting several homes and businesses to a centralized processing facility where it is treated before being released into a nearby waterway. It was determined that WWTFs within the JPL watershed generally function as intended, with few instances of effluent violations.

In contrast, several vulnerabilities within the conveyance system, which includes above ground and underground pipelines, pump stations, and manholes, were identified. These include both I/I issues that cause the majority of wet-weather SSOs, as well as blockages and physical damage that tend to result in dry-weather SSOs (Figure 6-5). Of these, I/I issues tend to cause the majority of large-volume SSOs most likely to reach waterbodies before being contained. Dry-weather SSOs tend to be the result of human activity, specifically improper disposal of non-flushable items in toilets. Stakeholders agreed that with violations at area WWTFs being infrequent, it was best to focus efforts on identifying and correcting SSOs. While SSOs were not assessed for potential volume as an *E. coli* loading source in the watershed, stakeholders recognized that the instance of many large-volume SSOs near the lake and on Walnut Creek were indeed in need of attention and proposed that SSOs constitute a 4th-tier priority for water quality improvement.

Above: Active SSO with flow from sewer access (credit: City of Arlington).
Middle: Evidence of recent wet-weather SSO – note debris around rim (credit: City of Fort Worth).
Below: Underground SSO, emerging at a culvert (credit: City of Fort Worth).

Figure 6-5 Examples of SSOs (credit: City of Arlington and City of Fort Worth)

Education and outreach efforts will tend to focus on preventing blockages and damage by educating citizens about the consequences of indiscriminately using toilets as means of waste disposal, and how it costs them more in the long run to do so. SSOs from I/I issues will focus on training and education for municipal staff and other wastewater infrastructure operators, with emphasis on establishing and/or improving interdepartmental and inter-entity communication to ensure that I/I issues are quickly identified and addressed, including use of citizen reporting for improved coverage and function. Some funding was identified to assist municipalities with additional stormwater infrastructure assessments used to locate infrastructure in need of redesign or refurbishment, but the majority of construction for SSO-related water quality improvement rests with municipal capital improvement program (CIP) funding, as infrastructure projects are typically outside of the purview of CWA 319(h) funding mechanisms. A summary of priority project areas, stakeholder recommendations and the associated load reductions for centralized wastewater are provided in Table 6-6.

Table 6-6 Recommended BMPs for SSOs

Pollutant Source: SSOs			
Concerns: (1) Overloaded wastewater infrastructure from inflow/infiltration, illicit discharges, or conveyance blockages from improperly disposed waste items, (2) failure of deteriorated, aging, or undersized wastewater infrastructure			
Potential Impacts: Direct/indirect loading to waterbodies from failing infrastructure/overloaded systems, (2) localized human health hazards			
Critical Areas: (1) Subwatersheds adjacent to the lake, (2) older neighborhoods w/ aging infrastructure			
Goal: Reduce the E. coli load from human sewage delivered to waterbodies through failing or overloaded wastewater conveyance infrastructure by reducing the instance of SSOs by 10%			
Objectives: (1) Identify high-priority SSOs, their causes, and available remedies, (2) Increase public education and outreach efforts pertaining to protection of wastewater infrastructure			
Recommendations			
Focus Group	**Management Practice**	**Timeframe**	**Costs**
Wastewater infrastructure operators	Use interdepartmental communication mechanisms to identify recurring/high-volume SSOs to target for rehab/ replacement through capital improvement programs	2023-2032	N/A
Cities	Conduct stormwater infrastructure assessments for identification of illegal wastewater connections, proper placement and abundance of storm drains, other opportunities to improve conveyance/reduce pollution	2023-2032	$12,000
Residents	Coordinate with other entities on established public outreach campaigns related to wastewater infrastructure protection/SSO prevention	2023-2032	N/A

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Estimated Load Reductions	
Effects from SSOs are highly localized and acute in nature, and in many cases, discharges are contained before reaching a waterway. Therefore, making accurate predictions for load reductions based on these BMPs may be difficult. Much of the wastewater produced within the watershed is conveyed to WWTFs elsewhere, and *E. coli* violiations at WWTFs in the watershed are extremely rare. Therefore, reducing the instance of SSOs on a numeric basis was deemed as the appropriate metric for tracking progress. Recommended BMPs are expected to provide a decrease in the instance of SSOs over a 6-year period by 10% (4 events), using the 2016-2020 estimate (39 events) as the basis.	
Effectiveness	Identification and correction of SSOs will provide a direct reduction to *E. coli* loads reaching waterbodies. Reductions in the amount of improperly flushed items will significantly reduce the instance of pipeline blockages that lead to many of the smaller, dry-weather SSOs.
Certainty	SSOs can usually be identified easily by both trained staff and concerned citizens, but an entity's ability to address SSO issues is often limited by available funding, with many entities opting for 5-10 year capital improvement plans (CIPs). Improving awareness of what is safe to flush among uninformed individuals may produce some benefit , but it is assumed that those who do so out of convenience will be difficult to convince to modify their behavior.
Commitment	Most cities already employ some level of interdepartmental communication for alerts about stormwater/sewer issues. Regular messaging through education/outreach may be necessary to ensure that the public remains aware of how their actions affect wastewater infrastructure.
Needs	Significant funding is needed to correct even the smallest SSO issue, and many municipalities lack sufficient funding to address them all in a timely fashion. Identifying supplemental funds for CIP projects will be of utmost importance. Existing outreach campaigns like "Defend Your Drains" and "Cease the Grease" are well-known and are low-cost message delivery mechanisms for public messaging.

6.4.2 OSSFs

OSSFs are still prevalent in the JPL watershed, which use onsite treatment of human waste into a soil drain field as opposed to routing waste to a centralized WWTF. With normal maintenance, these systems are an effective method of sequestering and mitigating various pollutants within the soil, away from human and animal contact that could result in disease transmission. Should the system fail due to neglect or use beyond its capacity, pathogens, nutrients, and other BOD-related substances could reach the surface, endangering human health and contaminating local surface water sources (Figure 6-6). In general, many of the OSSFs in the watershed exist in the more rural areas further upstream from JPL.JPL As a source, contamination from OSSFs ranked 3rd overall in terms of load volume, but stakeholders recognize that addressing OSSF issues are costly, and there are several other more immediate threats to water quality closer to the lake that present opportunities to impact water quality with significantly fewer capital costs. With that understanding, BMPs related to OSSF contamination concerns were given a 3rd-tier priority. Given the low volume of the potential releases, proximity is a key consideration for BMP selection. Stakeholders agreed that emphasis again be placed on those OSSFs that exist within the riparian buffer, as these are the most likely to be pollutant sources.

OSSF malfunctions can occur due to lack of maintenance, improper construction in unsuitable soils, or overloading the drain field, resulting in overflows at the surface (City of Arlington).

Figure 6-6 Example of OSSF malfunction (credit: City of Arlington)

It is understood that repair or replacement of failing OSSFs is the most straightforward method of contaminant reduction, but that funding such activities would be cost-prohibitive and quickly exhaust available grant funding. It would appear that the majority of both known and supposed OSSF locations in the watershed exist in areas with suitable soil types (Figure 4-4, Figure 4-5), so it is expected that most failures are due to design and maintenance issues. For that reason, it was recommended to consider providing incentives to landowners by offsetting the cost of both inspection and pump out. Along with the requisite homeowner focused OSSF maintenance training, it was also brought to attention that training for real estate professionals would also be beneficial. Many stakeholders noted that either during the purchase of their new homes or through the experience of acquaintances, it was clear that OSSF maintenance was clearly an afterthought in most transactions. Many new rural homeowners are likely unaware that they even have an OSSF on their property, a scenario that can quickly lead to system failure. Providing this training, along with providing support to counties and municipalities to draft and enforce ordinances requiring OSSFs to be inspected (and potentially even pumped out) before the property even changes hands would be the preference of the stakeholder group. Support for municipal “septic to sewer” programs, designed to bring older properties within municipal jurisdictions that still use OSSFs onto the centralized WWTF, will also be considered, along with encouraging homeowner associations to coordinate w/ private OSSF contractors to develop neighborhood-wide inspection/pumpout events in an attempt to reduce costs for residents. A summary of priority project areas, stakeholder recommendations and the associated load reductions for OSSFs are provided in

Table 6-7.

Table 6-7 Recommended BMPs for OSSFs

Pollutant Source: OSSFs			
Concerns: (1) Direct/indirect pollutant loading from failing/non-existent OSSFs, (2) disease transmission/public safety			
Potential Impacts: (1) Indirect E. coli loading to waterbody from failing/non-existent OSSFs, (2) spread of disease amongst/between species			
Critical Areas: Riparian buffer zones in rural/unincorporated areas			
Goal: Reduce the *E. coli* load from OSSFs delivered to waterbodies directly or indirectly through education, outreach, and incentivized inspections to yield a 15% reduction in the number of deficient systems.			
Objectives: (1) Increase education and outreach efforts pertaining to proper maintenance of OSSFs, (2) Provide access to affordable inspections/pumpouts for at-risk OSSFs in the watershed			
Recommendations			
Focus Group	**Management Practice**	**Timeframe**	**Costs**
Residents, HOAs, NAs	Provide homeowner-focused OSSF care/maintenance training (yearly, @$7500/event)	2023-2032	$75,000
	Incentivize OSSF inspections (with pumpout) for property owners with at-risks systems that have not been recently inspected (½ cost for 50 inspections/yr @$325/event, 10 yrs), with priority for OSSFs within riparian buffer zones	2023-2032	$162,500
	Encourage HOAs/NAs to coordinate w/ private contractors to develop neighborhood-wide inspection/pumpout days to cut costs to residents	2023-2032	N/A
Real estate agents, OSSF professionals	Provide practice-focused OSSF training for awareness of pollution potential, local ordinances, and importance of routine maintenance/cleanouts (yearly, @$7500/event)	2023-2032	$75,000
Cities, Counties	Work with municipalities to create/expand “septic to sewer” programs to transition properties with OSSFs within municipal sewer service boundaries over to the centralized wastewater collection system	2023-2032	N/A
	Draft and enforce ordinances that require OSSFs to be inspected before property changes hands	2023-2032	N/A

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Estimated Load Reductions	
Efforts involve BMPs focused on OSSF owner education and incentivized inspections targeting at-risk OSSFs, with priority given to those located in riparian buffer zones. By applying these recommended BMPs, a 10% decrease in the reduction of failing systems is expected, resulting in an *E. coli* load reduction 4.71E+12 MPN/yr, applying the same 25% attenuation factor used in other reduction calculations to realistically represent the expected load reduction. Reductions for nutrients are also expected, with ranges of 10-40% for nitrogen, and 85-95% for phosphorus species (USEPA 2002).	
Effectiveness	Incompatible soils are a common cause of OSSF malfunction, with many such soils identified in the western half of the watershed. Thankfully, subwatersheds with the highest OSSF densities fall outside of these areas. Lack of awareness and proper maintenance are therefore inferred to be the main causes of malfunction; these are more easily corrected than geologic factors. Repair or replacement of faulty OSSFs will provide direct reductions to *E. coli* loading to nearby waterways.
Certainty	Workshops targeted to residents/homeowners are subject to wide ranges of variance in attendance, but those targeted to trade professionals are usually well-attended, especially for those with education requirements. If a malfunction is identified during an inspection, most authorized agencies require reporting and remedy to the OSSF. This may motivate some owners to not be proactive and eschew the inspection incentives.
Commitment	It is unclear if homeowners will put what they learn into practice, but professionals are likely to adopt curriculum into their long-term business practices. It is also unclear whether OSSF owners will continue with proactive inspections after receiving initial incentives.
Needs	Significant funding is required for the incentivized inspection/pumpout program, along with identification of several local private contractors willing to conduct the work in cooperation with authorized agencies. Funding for administering training programs will also be necessary.

6.5 Other Nonpoint Concerns

6.5.1 Sediment and Flooding

No specific modeling or analysis was conducted for other stakeholder concerns such as flooding and sediment. However, stakeholders expressed interest in developing recommendations due to future growth, expansion and development expected in the area. Therefore, BMPs related to sediment and flooding were given 4^{th} – tier priority. Increased development can lead to decreased riparian buffers, decrease in filtration capacity, and an increase in erosion due to runoff velocities. Excess and suspended sediment in waterbodies can harbor bacteria and nutrients, decrease die-off of bacteria, impact DO levels, alter flow regimes, and decrease water supply and flood control capacity in JPL. Flood management is outside the scope of this WPP, but when flow regimes change or flooding increases due to development, water quality can be impacted. Sediment and flooding concerns should be considered when future development and flood mitigation project that may modify the waterways are planned for the system. Management measures are identified based on feasibility. Coordination with other partner efforts and programs that overlap with these concerns is recommended as part of the BMPs. BMPs It should be noted that many of the management measures for bacteria and nutrients also function to provide erosion control and sediment capture. A summary of priority project areas and stakeholder recommendations for sediment and flooding are provided in Table 6-8.

Table 6-8 Recommended BMPs for Sediment and Flooding.

Pollutant Source: Sediment and Flooding			
Concerns: (1) Sediment loading and increased risk in flooding in developing areas, (2) loss of natural areas/green spaces			
Potential Impacts: (1)Impact to aquatic life (2) impact to water supply and flood supply capacity in JPL, (3)Direct/indirect nutrient and bacteria loading to waterbodies from runoff and erosion events, (4) public health and safety (5) erosion, (6) infrastructure damage			
Critical Areas: Watershed wide			
Goal: Mitigate sediment loading and flooding			
Objectives: (1) Work with partners and agencies tasked with flood assessment to incorporate water quality concerns in future development and planned flood mitigation projects (2) identify and install green infrastructure in coordination with cities, counties, and property owners (list not exhaustive) (3) develop and organize a BMP education and outreach program to address concerns(4) monitor the effectiveness of BMPs			
Recommendations			
Focus Group	**Management Practice**	**Timeframe**	**Costs**
Cities, property owners, contractors, agencies, partners	Identify and install green infrastructure as funding becomes available	2023-2032	$6 - $45/per sq. ft or $261,000 - $1,949,746/per acre (estimate)
Cities, Counties	Conduct stormwater infrastructure assessments for identification of illicit discharges, proper placement and abundance of storm drains, other opportunities to improve conveyance/reduce pollution, and identify erosion and prevent erosion	2023-2032	$5,000 per year; cost is dependant on scale of effort
USACE, Cities, Counties, Local, State partners	Riparian, Wetland, and/or Stream Restoration Projects	2023-2032	$500,000 estimate per project
Cities, counties, NCTCOG, regional entities	Expand delivery of existing sediment, flooding, and BMP education resources, develop/implement new educational resources (e.g., utility bill inserts, websites, info pamphlets, videos, signage in public greenspaces/trails)	2023-2032	$170,000
Residents	Coordinate with other entities on established public outreach campaigns related to sedimentation, flood mitigation, and green infrastructure	2023-2032	costs associated with distribution of materials

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Estimated Load Reductions	
BMPs recommended for mitigation of sediment loading and flooding are not tied to a specific *E.coli* or nutrient reduction, but it is likely that reductions in the incidence of *E.coli* and nutrients will occur to some degree as nutrients can be bound to soil and sediments and sediment can harbor *E.coli* and reduce die-off. Potential load reductions were not calculated because the location, type, and size of projects installed will dictate the potential load reductions; however, they have not been identified yet.	
Effectiveness	The effectiveness of BMPs at reducing sediment loadings and mitigating flooding is dependent on the design, site selection and maintenance of the BMP
Certainty	Installation of BMPs requires sustained commitment from city officials or property owners.
Commitment	Green infrastructure may not be a high priority for local municipalities; financial or other incentives will be needed to encourage and secure long-term commitment.
Needs	Significant funding is needed to identify, install, maintain and monitor green infrastructure BMPs.

6.6 Summary of Expected Load Reductions

While reductions to watershed-wide *E. coli* loads are the primary goal of this WPP, stakeholders also chose to incorporate other water quality-related goals for the watershed, along with some potentially unconventional methods of measuring success. In many recent WPPs, education and outreach have become prominent components. While these can be effective means of achieving pollutant reductions, they are difficult to quantitatively measuredue to the reticent response time inherent to many BMPs that rely on behavioral change. The use of before/after surveys for these activities can be used to test knowledge gained, but cannot predict what attendees will actually put into practice. Furthermore, any water quality improvements from education/outreach initiatives often run parallel to other recommended BMPs, particularly those targeted to reducing animal waste volumes through population control, which provide direct, and often the most significant, reductions to *E. coli* loads. Less prominent activities targeted to correction/removal of SSOs, as well as malfunctioning OSSFs, will provide some additional relief for systems stressed by excessive *E. coli* loads. A summary of all anticipated *E. coli* load reductions is provided in Table 6-9**.** The overall anticipated load reduction provided by the management measures is 3.40E+15 MPN/yr, which exceeds the needed reductions of 2.42E+15 MPN/yr for JPL watershed.

There is an expectation that steps taken to physically reduce *E. coli* loads would inherently reduce both nutrient and sediment loads as well. Additionally, measures related to illegal dumping and lawn waste and residues will help provide reductions such that the existing water quality concerns for nitrate are not only removed, but water quality overall is improved through reductions in other pollutants as well. As indicated earlier, reductions of these nature are dependent on the level of participation, which cannot always be predicted or differentiated from the load reduction as a whole. The anticipated nutrient load reduction provided by the management measures is 1.86E+01 ton/yr.

Table 6-9 Summary of recommended management measures and water quality goals.

Management Measures[1]	Anticipated *E. coli* Load Reduction	Other Management Goals
Pet Waste		
Pet waste disposal ordinances	2.30E+15 MPN/yr	-
Supplemental pet waste stations		
Bioswale/raingarden projects		
Backyard pet waste digesters		
Lawn Residue and Waste		
Illicit discharge surveys	*1.86E+01 Ton/yr (Nutrients)*	Nutrient reduction to remove existing concerns
Lawn waste management ordinances		
Permeable paver sidewalks/driveways, rain barrels, low-water plantings, bioswale/rain garden projects, bio retention ponds		
Livestock		
WQMPs and CPs	1.08E+15 MPN/yr	-
OSSFs		
Incentivized OSSF inspections/pumpouts	4.71E+12 MPN/yr	-
HOA/NA coordinated OSSF cleanout events		
Practice-focused OSSF training		
Septic-to-sewer initiatives		
OSSF inspection ordinances for property transfers		
Illegal Dumping and Litter Accumulation		
Illegal dumping surveys	-	15% of sites shift to lower impact category
Rural home hazardous waste pickup/dropoff days		
JPL cleanup events		
SSOs		
Support for interdepartmental reporting network for SSO locations	-	Reduce instance of SSOs in watershed by 10%
Stormwater infrastructure assessments		
Permeable paver parking lots		
Sediment and Flooding		
Riparian, wetland and/or stream restoration projects	-	-
Stormwater infrastructure assessments		
Identify and install green infrastructure		
Feral Hogs		
Trap share program	1.20E+13 MPN/yr	-
Establish regional feral hog resource and support network		
Feral hog removal and/or exclusion from attractive nuisances		
Riparian buffer restoration/extension		
Total Anticipated *E.coli* Load Reductions	3.40E+15 MPN/yr	
Anticipated Nutrient Load Reductions	1.86E+01 Ton/yr	

(1) Note that all management measures categories include education and outreach components.

7.0 Plan Implementation

The management recommendations described in previous chapters are likely to involve multiple entities actively participating in several overlapping efforts at any given time over a structured period for implementation. This complex structure requires a flexible schedule, employing the use of interim milestones to track progress and make changes as necessary. While it is likely that project costs will ultimately fluctuate from now until they are actually implemented, it is still important to provide estimated costs during the planning stage to provide a gross overall estimate as a guide during the early stages of development.

Access to variety of technical and financial resources will be necessary to fully implement the broad scope of projects recommended by stakeholders for this WPP. Matching these resources to each project's needs will be critical during both the development and implementation of this WPP. As time progresses and needs change, the list of available resources may also need to be updated to ensure that stakeholders are made aware of both new assistance sources as well as those that are no longer accessible. The amount and type of resources required for successful implementation will inevitably depend on the size, scope, location, and complexity of each project. Assistance needs will also vary depending on the pollutant source categories the project is intended to manage.

7.1 Schedule, Interim Milestones, and Estimated Costs

Implementation of the JPL WPP is intended to occur within a 10-year timeframe. However, it is expected that several challenges will be encountered during this period and will need to be addressed through adaptive management. Some situations that may be encountered include staff turnover within stakeholder entities, lack of funds for project implementation or delayed access to those funds, or even delayed project initiation. As these challenges are encountered, modifications to the schedule and/or list of feasible BMPs may be necessary. Whenever possible, interim milestones should be used by stakeholders to help them make informed judgments about necessary adjustments to the implementation schedule. An initial list of recommended management strategies is provided in Table 7-1, which includes each BMP's intended focus group, expected implementation timeframe with milestones, and anticipated costs, as applicable. Information about the funding sources referenced in the last column in Table 7-1 is provided later in Section 7.5.

Early emphasis for implementation will be on projects that have lower management needs, favorable cost-to-benefit ratios, and the ability to yield significant reductions to loadings for *E. coli* and other contaminants. These "low-hanging fruit" are often projects that have been widely utilized across the state or nation with documented and significant positive influence on water quality and recreational potential. If further reductions are required after implementation and exhaustion of these projects, stakeholders may choose to proceed with incrementally less favorable, more cumbersome, or more costly methods of load reduction as the need arises.

7.2 Synergies with Existing and Ongoing Water Quality Initiatives

It is expected that implementation efforts within the JPL watershed will experience overlap with several ongoing water quality and environmental initiatives led by other entities within the watershed. Participants in the JPL WPP should do their best to identify these other entities and become educated about their programming, in an effort to reduce duplication of efforts, avoid division of resources, or to potentially even uncover opportunities for collaboration. Stakeholders should also be aware of the MS4-related activities currently being required of all the Phase I and Phase II entities in the watershed. This should be done to ensure that no grant funding is being used to conduct activities already required by an entity's MS4 permit. Section 319 funds cannot be used to fund any measures in the MS4 permits but can potentially be used to fund stormwater management activities that go above and beyond permit requirements (TCEQ, 2011). Instead, stakeholders should focus on projects that supplement MS4 activities or expand efforts beyond their current scope.

Table 7-1 Summary of BMP recommendations, implementation schedule, and associated costs

Management Measure	Responsible Party	Unit Cost	Units Implemented (by year)										Total Cost	Funding Source
			1	2	3	4	5	6	7	8	9	10		
Pet Waste														
Pet waste disposal ordinances/bylaws	Cities, counties, HOAs, NAs	N/A	As early as feasible										N/A	L, F3
Supplemental pet waste station recon		$3,000	1										$3,000	F6,S5,S7,N1,N3
Supplemental pet waste station install		$300		34									$10,200	
Pet waste station maintenance/supplies		$85		34	34	34	34	34	34	34	34	34	$26,010	
Bioswales and rain gardens		$12,500		1		1		1		1			$50,000	F6,S5,S7,N1,N2,N3
Backyard pet waste digesters	Residents	$1,000	5	5	5	5	5	5	5	5	5	5	$50,000	F6,S7,N1,N3
Education & outreach - direct marketing	Cities, counties, regional entities	$17,000		1	1	1	1	1	1	1	1	1	$153,000	F8,N1,N3
Education & outreach - general		$17,000	Assistance/input as needed										$17,000	
Livestock														
WQMPs and CPs	Production agriculture	$15,000		3	3	3	3	3	3	4	4	4	$450,000	F1,F4,F5,F7,S1, S4,S10,S11,N2,N4
WQMP Technician (1/2 time)		$40,000		1	1	1	1	1	1	1	1	1	$360,000	
Education & outreach	Hobby farmers	$1,000	1	1	1	1	1	1	1	1	1	1	$10,000	F8,N1,N2,N3
Feral Hogs														
Trap share program - trap purchase	Cities, counties, regional entities	$15,000	3										$45,000	F6,S7
Trap share program - maintenance		$500	1	1	1	1	1	1	1	1	1	1	$5,000	
Establish regional feral hog resource and support network	Any public/private landowners, land managers	$500	1	1	1	1	1	1	1	1	1	1	$5,000	F6,F8
Feral hog removal		N/A	As many as possible										N/A	Unknown
Hog exclusion from attractive nuisances		N/A	As many as possible										N/A	Unknown
Riparian buffer restoration/extension		N/A	Assistance/input as needed										N/A	F6,S5,S7,N1,N2,N3
Education & outreach	All stakeholders	$7,500	1	1	1	1	1	1	1	1	1	1	$75,000	F8
Illegal Dumping and Litter Accumulation														
Illegal dumping surveys	Cities, counties, HOAs, NAs	$5,800	1	1	1	1	1	1	1	1	1	1	$58,000	F6,S7,S8,N1,N3
Rural home hazardous waste pickup/dropoff days	Counties, CDPs	$5,000	2	2	2	2	2	2	2	2	2	2	$100,000	F6,S7,N1,N3
JPL cleanup events	All stakeholders	$3,500	1	1	1	1	1	1	1	1	1	1	$35,000	F6,S7,N1,N3
Education & outreach		N/A	Assistance/input as needed										N/A	Unknown
Lawn Residue and Waste														
Illicit discharge surveys	Cities, counties	N/A	As needed										N/A	F6,S2,S7,S8,N1,N3
Permeable paver driveways, rain barrels	Residents, businesses, cities, counties	$5,500	1	1	1	1	1	1	1	1	1	1	$55,000	F6,S5,S7,N1,N2,N3
Low-water use plantings in greenspaces		N/A	Assistance/input as needed										N/A	F6,S5,S7,N1,N2,N3
Lawn waste management ordinances/bylaws	Cities, counties, HOAs, NAs	N/A	As early as feasible										N/A	L, F3
"Water Wise" lawn care training	Residents, landscapers	$3,500		1			1			1			$10,500	F8,N1,N3
Education & outreach - direct marketing	Cities, counties, regional entities	$17,000		1	1	1	1	1	1	1	1	1	$153,000	F8,N1,N3
Education & outreach - general		$17,000	Assistance/input as needed										$17,000	F8,N1,N3

SSOs														
Support for interdepartmental reporting network for SSO locations	Wastewater infrastructure operators	N/A	As needed										N/A	L, F3, S12
Stormwater infrastructure assessments	Cities	$800	1	1	2	2	2	2	2	1	1	1	$12,000	F6,S2,S7,S8,N1,N3
Permeable pavers for parking lots	Lot owners/operators	$37,500		1		1		1		1			$150,000	F6,S5,S7,S12, N1,N2,N3
Education & outreach	Residents	N/A	Assistance/input as needed										N/A	N/A
OSSFs														
Incentivized OSSF inspections/pumpouts	Residents, HOAs, NAs	$325	50	50	50	50	50	50	50	50	50	50	$162,500	F9,S2,S7
Replace failing systems		$10,000			1	1	1	2	2	2	1		$100,000	F6,S5,S7,N1,N2,N3
HOA/NA coordinated OSSF cleanout events		N/A	Assistance/input as needed										N/A	S7
Homeowner OSSF training		$7,500	1	1	1	1	1	1	1	1	1	1	$75,000	F8
Practice-focused OSSF training	Real estate agents, OSSF professionals	$7,500	1	1	1	1	1	1	1	1	1	1	$75,000	F8
OSSF inventory, septic-to-sewer initiatives	Cities, counties	N/A	Assistance/input as needed										N/A	F9,S2,S6,S8
OSSF inspection ordinances for property transfers		N/A	As early as feasible										N/A	L
Sediment and Flooding														
Education & outreach - direct marketing	Cities, counties, regional entities	$17,000		1	1	1	1	1	1	1	1	1	$153,000	F8,N1,N3
Education & outreach - general		$17,000	Assistance/input as needed										$17,000	F8,N1,N3
Identify and install GI BMP projects	Cities, contractors, property owners, Counties	$6 - $45/per sq. ft	As many as possible										Varies	F3, F6,F10, F11, S5,S7,N1,N2,N3
Riparian, wetland and/or stream restoration	Cities, Counties, USACE, Local and State partners	$500,000 per project	As needed										Varies	F3, F10, F11
Stormwater infrastructure assessments	Cities, Counties	$800	7	7	7	7	7	7	7	7	7	7	$56,000	F6,S2,S7,S8,N1,N3
Monitoring Projects														
JPL Long-term Monitoring (bimonthly)	TRA	$72,000	1			1			1			1	$288,000	F3,S9

7.3 Education and Public Outreach

The implementation efforts of WPPs rely heavily on education and outreach activities to increase the knowledge and acceptance of the physical BMPs used to mitigate pollutant loads in a watershed. For meaningful success to be achieved in a watershed, it is critical that stakeholders be provided information and training that is ongoing, clearly organized, and relevant to the watershed and its specific challenges. Using the resources and connections within multiple entities, educational programs will pull from local entity staff, known topical experts, and practiced industry specialists to provide meaningful content in a variety of subject areas. Many existing programs relevant to pollutant source categories identified in this WPP can be utilized. In cases where present regional programming was found to be lacking, additional funding was identified to develop new programs. It is likely that additional programming needs will arise in the future. In these cases, several options will be considered before seeking supplementary funding to develop and administer new content. Due to the nature of the grant and its primary goal of eliminating the water quality impairment, education and outreach programming will primarily focus on affecting behaviors to drive *E. coli* reductions. However, it is expected that topics such as nutrient reductions, eutrophication, industrial/petrochemical contamination, illegal dumping, floatable trash, green infrastructure, and water conservation will also be discussed. Details about general and specific education and outreach efforts identified for this WPP are provided in Table 7-1.

7.4 Technical Assistance

Some of the management measures recommended for this WPP will require specialized technical expertise to adequately and safely navigate the planning, design, and implementation phases on a project-specific basis. Identifying and securing such expertise will be initiated as soon as is feasible for individual projects. For those projects where focused, long-term expertise is needed to guided implementation, creation of and funding for either full-time or split-time positions for watershed projects may be necessary to adequately address the watershed's needs.

7.4.1 Pet Waste Management

Many municipalities already have considerable experience dealing with pet waste concerns as part of their MS4 permitting requirements. This expertise also exists at the regional level, with staff at (NCTCOG) and regional water entities (TRA, TRWD) already engaged in delivery of education/outreach programming focused on pet waste as a pollutant source. Although no structural projects are proposed, installation of prefabricated pet waste stations is recommended, which will require some reconnaissance beforehand by either/or TRA and municipal personnel. For pet waste digesters, basic knowledge of soil types is useful, which is readily accessible to homeowners. Before digging occurs, homeowners will also be encouraged to call the statewide 8-1-1 number to ensure that their proposed dig zone is safe to install the pet waste digester.

7.4.2 Livestock Management

Several agencies across the state have significant and documented expertise in the development and implementation of BMPs related to managing livestock and farmland. Agents and technicians from the TSSWCB, NRCS, local SWCDs, and local Texas AgriLife Extension staff are all conveniently officed in the DFW metroplex and are familiar with the specific needs of the area. A wealth of technical assistance is available to both large-scale agricultural producers and hobby farm operators operating locally. While many whole-property management programs currently exist only for production agriculture, these agencies see the need to develop similar programs for hobby farms and other smaller-scale operations as their exposure has increased, along with their perceived water quality impacts.

Due to its proximity to several urban centers, it is likely that the JPL watershed possesses a lower percentage of eligible agricultural operations eligible for WQMPs and CPs. Therefore, it is likely that any dedicated technicians hired to develop WQMPs/CPs for the watershed will likely need to be split-time with another watershed, project, or encompass a larger area beyond that of the JPL watershed. This technician would need to work with knowledgeable personnel from NRCS, TSSWCB, or Texas AgriLife Extension to begin the process of identifying and engaging potential plan candidates.

7.4.3 Feral Hog Management

Although feral hog control as a pollutant load control measure is expected to be a lower priority, several forms of technical assistance will still be made available, primarily through the proposed development of a feral hog control assistance framework. This is intended to provide landowners with information related to various aspects of feral hog control. This framework will be developed with input from Texas Wildlife Services, Texas AgriLife Extension, and TPWD staff, who provide the bulk of the educational programming currently available to Texas landowners contending with feral hog impacts.

7.4.4 Illegal Dumping and Litter Accumulation

As is the case with pet waste, many municipalities and county officials already have considerable experience with illegal dumping and litter accumulation as part of their MS4 permitting requirements, which is again reflected at the regional level. Their assistance will be vital as TRA expands its illegal dumping survey efforts, providing both historical accounts of any prevalent dumping/accumulation sites and available remedies at their entity's disposal for site cleanup and/or prevention of future dumping activities. The expertise of non-profit organizations, particularly those focused on community beautification and public health, may also prove to be a valuable asset during the development and execution of volunteer watershed cleanup efforts.

7.4.5 Lawn Residue and Waste

Being primarily a stormwater-related issue, there will be considerable reliance on municipal, county, and regional entity personnel who may already be contending with illicit discharge issues as part of their MS4 permits. Their expertise will prove beneficial during the development of the recommended model lawn waste pickup/disposal ordinances. Additional assistance from industry professionals and other outside sources may also be needed to successfully administer the education and outreach initiatives planned for this WPP.

7.4.6 SSOs

Technical assistance for issues tied to SSOs will also rely heavily on municipal and regional entity staff, particularly those in departments related to the management of wastewater infrastructure owned or operated by that entity. Since the majority of the funding identified to address SSOs will come from CIPs initiated by these wastewater infrastructure entities, the expertise of these staff will be instrumental in determining how reconnaissance and interdepartmental communication initiatives identified in the WPP can best be implemented to better inform CIP efforts.

7.4.7 OSSFs

Any efforts to counteract the negative impacts of failing OSSFs are likely to benefit from the continued support and input from county designated representatives tasked with OSSF initiatives. These individuals will be instrumental in identifying staff from municipalities that are currently engaged in septic-to-sewer initiatives and will be a crucial resource to those elsewhere wishing to implement their own similar efforts as part of the program outlined in the WPP. It is likely that some of these same staff will also be involved with the drafting and enforcement of model ordinances requiring OSSF inspections when real estate property changes hands. Others will be instrumental in coordinating both the incentivized OSSF inspection/pumpout program and the neighborhood-wide pumpout days. Designated representatives will be the lead on any OSSF inventories conducted in the watershed to locate properties with OSSFs most in need of these programs. Input from experienced OSSF inspectors, as well as from real estate professionals who have dealt with rural properties using OSSFs, will also be sought when planning for their respective practice-focused training opportunities which were identified as needs by stakeholders.

7.4.8 Sediment and Flooding

Sediment load control and flooding mitigation as a BMPBMP is expected to be a lower priority due to future development. Technical assistance will rely heavily on municipal, regional, special district, higher education, AgriLife, state and federal staff to support investigation, identification, design, installation, operations, maintenance, and monitoring of green infrastructure.

7.5 Financial Assistance

While some of the BMPs recommended by stakeholders may be able to take advantage of programs covered through existing funding sources, it is expected that the majority will require financial support in some capacity. In other cases, grant funding may be used for initial reconnaissance or other preliminary assessments, with funding for construction, reconstruction, or retrofitting coming mainly from other sources (e.g., illegal dumping reconnaissance, illicit discharge surveys). Whenever possible, existing programs in the watershed will be leveraged with new funding to expand scope and/or frequency to further improve the chances of implementation success. For the WPP to be truly successful, it is imperative to identify funding opportunities from a variety of sources that could potentially be used to support one or several projects. Several of the identified sources are frequently utilized by water quality-related projects such as WPPs, and therefore can be easily navigated. In cases where these traditional sources aren't applicable or are otherwise unsuited for a project, it may become necessary to either seek out new sources or creatively apply known resources in fresh new ways to achieve results. The funding sources described below are referenced in the last column in Table 7-1 using the letter/number system accompanying each description. It should be noted that CWA § 319(h) funding (F3 below) could be used to fund some portion of each of the recommended management measures. However, identifying other sources of funding provides additional means of achieving success for the WPP's goals to improve and protect water quality.

7.5.1 Federal Funding Sources

Agricultural Water Enhancement Program

F1 Designed to promote water enhancement projects on agricultural land, this program provides both financial and technical assistance to agricultural producers and rural landowners interested in developing resource conservation plans to protect the quality of the surface and groundwater on their property. This is a voluntary conservation initiative overseen by NRCS, which aims to improve water quality through the implementation of ideas.

Clean Water Act § 106 – State Water Pollution Control Grants

F2 States, eligible tribes, and interstate agencies can use § 106 grants to establish, expand, and implement long-term, large-scale water quality monitoring programs. These include statewide water quality monitoring and assessment programs, TMDL development, creation of water quality standards, point source permitting, and training.

Clean Water Act § 319(h) – Nonpoint Source Grant Program

F3 In Texas, the EPA distributes these grant funds evenly between the TSSWCB and TCEQ to implement nonpoint source pollution projects. TSSWCB projects typically focus on nonpoint source pollution from predominantly agricultural and silvicultural watersheds, while TCEQ projects tend to concentrate more on urban sources and other forms of pollution. To be eligible for 319(h) funding, applicants must have a written plan that satisfies the nine key elements of successful watershed-based plans (Appendix A:).:). Applicants may apply for multiple projects and are usually encouraged to cater their application to either agency based on project goals: projects funding WQMP/CP projects, feral hog control, or stock pond management would therefore be directed to TSSWCB, whereas urban stormwater assessments, illicit discharge surveys, and illegal dumping reconnaissance would be better suited for TCEQ funding. Some projects, such as overall BMP effectiveness monitoring, OSSF-related projects, or pet waste management, could be sought from either agency.

Conservation Reserve Program

F4 Agricultural producers participating in this program are eligible to receive annual rental payments for land where they voluntarily establish vegetative/woody plant cover in environmentally sensitive areas. The NRCS-Farm Service Agency can offset up to 50% of the costs associated with establishing these approved conservation practices, with the ultimate goal of the program being to protect lakes, rivers, streams, and ponds by reducing runoff and therefore sedimentation that can reduce storage capacity and introduce nonpoint source pollutants.

Conservation Stewardship Program

F5 This is another USDA program, administered through NRCS, which encourages producers to implement conservation activities on private cropland, grassland, prairies, improved pasture, and rangeland in a comprehensive manner. Producers are encouraged to combine several practices like prescribed grazing, precision nutrient application and budgeting, manure application, and integrated pest management.

Cooperative Watershed Management Program

F6 The U.S. Bureau of Reclamation provides funding through this two-phased program to 1) develop watershed stakeholder groups (Phase I), and 2) implement watershed management projects. Like the 319(h) grant program, these funds can be used for nonpoint source pollution control and watershed monitoring, modeling, and mapping, but may also be used to fund other watershed restoration activities.

Environmental Quality Incentives Program

F7 This is another USDA-NRCS program that promotes agricultural production and environmental quality as compatible goals that can operate simultaneously on agricultural lands. These are typically 10-year contracts with voluntary participation from agricultural producers seeking to address natural resource concerns on their property through the use of a variety of structural controls and management practices. Plans must be developed in concert with NRCS technicians, who will design the plan for local conditions using NRCS technical standards. Applicants must be engaged in production agriculture to be eligible for technical and financial assistance, and these plans must be approved by local SWCDs before being implemented.

Environmental Education Grants

F8 The EPA's Environmental Education Division, Office of Children's Health Protection and Environmental Education sponsors grants for environmental education intended to promote public awareness, knowledge, and skills to help citizens recognize how their behaviors impact the environment around them. Available funding is dependent on Congressional appropriations but grant requests that are accepted are typically funded for $15,000 to $25,000.

Rural Development Program – Water & Environmental

F9 USDA's Rural Development Programs offers grants and low-interest loans to rural communities seeking funding to develop water supply and wastewater infrastructure through repair, rehabilitation, or new construction projects.

Rural Repair and Rehabilitation Loans or Grants - Funding is intended to improve/repair low-income housing, or remove health and safety hazards.

Technical Assistance and Training Grants for Rural Waste Systems - Offers grants to non-profit organizations which focus on training and technical assistance relevant to rural water delivery and waste disposal.

Water and Waste Disposal Direct Loans and Grants - This program assists rural communities with populations of less than 10,000 individuals with development of water and waste disposal systems.

Water Resources Development Act – Environmental Restoration Program

F10 Through § 1135 of the Water Resources Development Act, the U.S. Army Corps of Engineers is authorized to plan, design, and construct modifications to existing Corps projects that restore aquatic habitats for fish and wildlife use. This also applies to areas that are subsequently affected by the construction of a Corps project. Funding for individual projects is limited to $10 million in total Federal costs, which can be further leveraged with non-federal funds.

United States Army Corps of Engineers

F11 *Floodplain Management Services Program Technical Assistance* - Through Section 206 Flood Act 1960, Section 321 Water Resources Development Act 1990, Section 202 Water Resources Development Act 1999, and 33 U.S. Code 709a, USACE is authorized to provide planning and technical assistance for anything related to flooding - example Hydraulic and hydrologic modeling. Approximately $100,000100,000/study; Approximately $15 million15 million/year nationwide. 100% Federally funded

Planning Assistance to States- Through S42 U.S. Code 1962d-16, Section 2013 of the Water Resources Development Act 2007 and Section 3015 of the Water Resources Reform and Development Act 2014, USACE is authorized to provide planning and technical assistance for all things water. Approximately $10-13 million13 million/yr. 50% non-federal match required.

Watershed Studies (Sec 729) - Through Section 7001 of Water Resources Reform and Development Act 2014, USACE is authorized to provide planning to identify water resources needs and actions that could be taken by multiple entities within the watershed. Cost-shared 75%Fed/25%Non-Fed; Based on Congressional Appropriations.

Individually Authorized Feasibility Studies and Projects - Annual eligibility via Water Resources Development Act authorization and/or via the Sec 7001 proposal process; selection based on annual appropriations by Congress; Limited to large water resource projects in USACE mission areas (navigation, flood risk management, ecosystem restoration) and must be cost-shared by a non-Federal entity. USACE is authorized to perform Planning and Design, Construction, Operations and Maintenance (some cost-shared), and Monitoring and Adaptive Management.

7.5.2 State Funding Sources

Agricultural Water Conservation Program

S1 TWDB assists political subdivisions and private individuals by providing grants and low-interest loans for agricultural water conservation/improvement projects.

Clean Water State Revolving Fund

S2 TWDB also assists political subdivisions and private individuals with authority to own and operate WWTFs by providing grants and loans below market rates for the planning, design, and construction of wastewater, stormwater, reuse, and other pollution control projects. Funds can be used for construction of facilities, collection systems, stormwater/nonpoint source pollution control project, or may even be used to acquire and retrofit existing systems. Loans through the fund have flexible terms and qualifying parties may be eligible for principal forgiveness.

Economically Distressed Area Program

S3 This is another TWDB program that provides grants and loans to communities in economically distressed areas where existing facilities do not adequately meet the minimum needs of residents. Representatives from these areas may request funding for projects to improve their wastewater infrastructure. Although the likelihood is low that funding from this program could be utilized in the watershed, there may be smaller communities or subdivisions in both the rural and urban areas that potentially qualify for assistance based on economic criteria.

Landowner Incentive Program

S4 This program, administered through TPWD, encourages private landowners to implement conservation practices that create, restore, protect, and enhance aquatic and/or terrestrial habitat for at-risk or rare species. A list of eligible species is provided in the Texas State Wildlife Action Plan and Landowner Incentive Plan Priority Plant Species List. The program is somewhat unique in its approach, in that landowners are required to actively contribute through labor, materials, or other means to be eligible for financial assistance.

Outdoor Recreation Grants

S5 Another TPWD program, designed to assist communities of less than 500,000 acquire and develop park land or renovate existing public recreational areas. Grants provide up to 50% matching funds, with a maximum award of $500,000, with two funding cycles per year. Available applicants include municipalities, counties, municipal utility districts, river authorities, and other special districts.

Regional Water Supply and Wastewater Facility Planning Program

S6 This TWDB grant program is designed to help various entities plan for future regional water supply and wastewater facility needs in their region. Funding can be used to determine the most feasible alternatives for facility size/locations needed to meet regional needs under different population scenarios, as well as for identifying functional institutional arrangements to provide adequate services throughout the region.

Supplemental Environmental Projects Program

S7 This TCEQ program redirects the fines, fees, and penalties collected from environmental violations into funding for environmental pollution reduction projects. Instead of contributing to the Texas General Revenue fund, entities subject to enforcement may choose to direct their penalty dollars to other environmental improvement activities like wildlife habitat improvement, pollutant clean-ups, and OSSF repair initiatives. Common project types include illegal dumping site cleanups and household hazardous waste collection events.

Texas Capital Fund

S8 Texas Department of Agriculture administers this fund as part of its Community Development Block Grant, which is a competitive process providing funding to eligible municipalities and counties in rural areas to construct new or replace old failing public infrastructure. Funds can be used for water supply and wastewater lines, as well as stormwater drainage improvements. Typical grant awards range from $100,000 to $1.5 million per project.

Texas Clean Rivers Program

S9 The Texas Clean Rivers Program (CRP) is a state-fee funded program principally providing water quality monitoring throughout the state. Funds are allocated to 15 partner agencies, typically river authorities, to fund routine monitoring, special projects, and public outreach, with funding allocated on a biannual basis. The TRA is the designated CRP partner for the JPL watershed, which applies the bulk of the allocated funds to water quality monitoring and development of annual water quality assessments. Based on data for the 2018-2019 term, funding identified for special projects was approximately $25,000. A portion of these funds may be available to stakeholders if they are able to identify a monitoring need in the watershed that aligns with the intent of CRP's special projects program. An additional $15,000 is allotted for education and outreach activities, which fund existing programs that could be utilized within the watershed.

Texas Farm & Ranch Lands Conservation Program

S10 This TPWD program provides grants to landowners for the sale of conservation easements on high-value working lands to protect fish, wildlife, water quality, and agricultural production from the threats of land fragmentation, impervious cover encroachment, and loss of agricultural production. The intent of the program is to educate landowners about the importance of natural resource stewardship by providing a voluntary, free-market alternative for landowners averse to selling and fragmenting their land for development.

Water Quality Management Plans

S11 The WQMP program, administered through the TSSWCB, is another voluntary mechanism for agricultural and silvicultural producers that combines components of several other conservation-based BMPs on a "whole farm" scale to effectively reduce nonpoint source pollution. Utilizing technical guidance from local SWCDs, these plans are developed with the goals of both the producer and the state in mind and provide several financial incentives for participants once the plans are adopted.

Sewer Overflow and Stormwater Reuse Municipal Grants Program

S12 Contact EPA Region 6 for state administrative contact. Available for municipalities and non-profits to address overflow or stormwater concerns through planning, design, and construction. State entities may use funds to plan, design, or construct projects that correct combined sewer overflows, SSOs, stormwater needs, or subsurface drainage needs. Projects may include but are not limited to: installation of separate sanitary and storm sewers; infiltration/inflow correction; stormwater collection systems; Green Infrastructure; or other capital projects that mitigate sewer overflows or stormwater concerns. $67 million is available nationally. There is a formula for grants to aid in distribution to states.

7.5.3 Local Funding Sources

L Most grants require some form of matching funds to be eligible for application. In many cases, existing expenses for personnel time, equipment used, ongoing environmental programs, or from other sources are sufficient to offset match funding requirements, but at times other sources of funding may be required. Many municipalities across the state are beginning to embrace creative new ways of funding their environmental projects, including the use of stormwater or environmental services fees as part of their utility billing outlays. Many municipalities in the JPL watershed already employ the use of such fees. As the watershed becomes increasingly more developed, the need for other entities to implement their own supplemental fee systems may become an increasingly viable option for offsetting the costs of protecting water quality as both runoff and nonpoint source pollution increase along with the amount of impervious cover throughout the watershed.

7.5.4 Other Sources

Non-profit organizations, private foundations, land trusts, and even individual donors may also prove to be useful funding sources.

Cynthia and George Mitchell Foundation

N1 Grants are offered for several programs, including land conservation, water, and sustainability education, with a focus on maintaining sustainability and providing protection and conservation of the state's land and water resources.

Dixon Water Foundation

N2 Grants are provided to non-profit organizations for projects related to improving or maintaining watershed health through the use of proper land management techniques. Emphasis is on production agriculture, grazing management, and long-term research to monitor the environmental responses to various land conservation and stewardship practices.

Meadows Foundation

N3 Grants are provided to agencies, research universities, and non-profit organizations, with initiatives in several areas, including environmental stewardship. Potential projects for funding include those for water quality, land and habitat conservation, and public education and advocacy.

Texas Agricultural Land Trust

N4 Funding is provided with the intention of preserving Texas' heritage by protecting farmlands, wildlife habitat, and other natural resources. This is accomplished through the use of conservation easements to curtail land fragmentation and maintain large tracts of land that will remain economically sustainable.

8.0 Measuring Success

The JPL watershed protection effort and the subsequent WPP document that was produced are the products of over three years of coordination between dedicated watershed stakeholders from all walks of life that have come together to protect the water quality and recreational capacity of Walnut Creek, Mountain Creek, and JPL.JPL Continued stakeholder support and input is vital for effective implementation of this WPP. The current core stakeholder group has demonstrated their knowledge of the watershed and passion for protecting the environmental, recreational, and aesthetic aspects of the watershed. However, efforts required for successfully implementing the WPP will far exceed the limitations of a single stakeholder. Therefore, it is imperative that the planning process incorporate several long-term support mechanics for planning implementation timelines, organizing projects, and securing funding for those projects. Additional support will also be needed to track progress, both through demonstration of project completion and through effectiveness monitoring.

8.1 Implementation Oversight

Due to the intensive needs for long-term implementation oversight, a full-time watershed coordinator position will likely be needed for full WPP implementation support. The watershed coordinator will be responsible for shepherding various implementation projects through from inception to completion, beginning with solicitation of project ideas from engaged stakeholders. Along with further project development, funding opportunities must also be identified and approval paperwork must be filed to progress projects. Planning and promotion of educational programming and materials, along with tracking all forms of implementation progress, will also fall to the watershed coordinator to organize. To fully support this position, $110,000 for annual salary, benefits, travel, and other necessities would be required to perform their duties.

8.2 Effectiveness Monitoring

From the onset of the WPP planning process, stakeholders made it clear that they had aspirations well beyond addressing the existing water quality impairments and concerns in JPL watershed. To that end, a variety of techniques is expected to be utilized to monitor overall WPP effectiveness as projects are implemented. These techniques are intended to be quantitative in nature whenever feasible but may involve qualitative elements when appropriate. These techniques will also incorporate appropriate interim milestones so that stakeholders can evaluate progress and adapt as necessary to meet the needs of the watershed (see 'Units implemented, Table 7-1).

Continued long-term and project-specific monitoring will be vital for recording changes in water quality and documenting project success

Figure 8-1 Example of Effectiveness Monitoring

8.2.1 Water Quality Monitoring

Some form of long-term water quality monitoring is a mainstay of most WPP implementation programs to support ongoing efforts and gauge overall program effectiveness. Typically, these monitoring regimes closely resemble the monitoring site distribution, monitoring frequency, and parameters of interest used during the watershed characterization phase. Stakeholders may choose to employ the use of one or several targeted water quality sampling efforts to supplement an ongoing, low-intensity routine effort, adapting to needs as project demands fluctuate.

Routine Water Quality Monitoring

The routine monitoring regime used for characterization of this watershed is covered in detail in Section 5.1, and will be applied as described there, with allowances for flexibility based on funding availability. At a minimum, parameters for *E. coli*, the nutrients of interest, dissolved solids, and sonde measurements (as described in Section 5.1) will be collected at sites 22134, 13621, 16434, 16433, 22135, and 22133 with quarterly frequency. Site 13621 is a priority due to its concurrent use as both a TRA/CRP and USGS site before watershed characterization began for the WPP. Other TRA/CRP sites used before watershed characterization began for WPP include stations 22134, 16434, 16433, and 22133. Most of the data used in previous biennial assessments (as described in the Texas Integrated Report) comes from these sites, highlighting their use as a long-term benchmark for denoting water quality improvements in the watershed from a historical perspective. Station 22135 is also identified as a priority, due to its preference for use in modeling and monitoring as the most downstream site outside of significant lake influence and within its own catchment. Dedicated monitoring at this site only began in 2019, as part of the watershed characterization project. This may limit its uses as a benchmark in comparison to the other sites, but data from this site will be useful not only for water quality monitoring, but also for estimating watershed pollutant loads, as an endpoint for any future water quality, hydraulic, or hydrologic modeling projects, or for a number of other potential projects expecting to use a site that best represents the JPL watershed's inputs to the lake. Ongoing quarterly water quality monitoring at several lake stations (11073, 11072, and 11071) will also be instrumental in monitoring progress with respect to the nutrient concerns in the lake.

Targeted Water Quality Monitoring

Although useful for tracking overall water quality progress, the regime identified for long-term monitoring at sites 22134, 13621, 16434, 16433, 22135, and 22133 will likely be insufficient in both spatial distribution and frequency to adequately describe loadings from specific subwatersheds, or at certain times of the day or year. This inadequacy also precludes efforts to pinpoint the effectiveness of specific BMPs. To meet these needs, it will be necessary to supplement the routine water quality monitoring regime with one or several targeted monitoring regimes, specific to a particular management practice, pollutant source, location, or set of conditions.

The monitoring approach chosen will vary depending on a project's needs. When funding allows, there will be a preference for all routine parameters to be collected, but the suite of parameters chosen will likely be based on a specific project's goals, for efficiency considerations. Given the nature of the impairments and concerns in the watershed priority will be given to flow, *E. coli*, and nutrient parameters, so that implementation progress can be tracked, but additional parameters may be added as appropriate.

Non-numerical Monitoring

In some cases, demonstrating progress through numerical methods (e.g., water quality sampling) may not be feasible, either due to a lack of data or potentially due to the pollutant's existence as both a qualitative and quantitative entity. This will necessitate the use of other metrics to indicate progress. One such example is that of illegal dumping, where the qualitative aspect of large illegal dumpsites in clear public view may constitute public health concerns or unfavorably reflect on the aesthetic conditions of a location.

In other cases, while the source in question may have direct, measurable impacts to water quality, there may still be other considerations associated with the source that require improvements beyond that of an *E. coli* load reduction. One such case is that of SSOs, where there is a higher possibility of human contact with raw sewage, constituting a public health hazard. To illustrate this, goals for this source group are tied to a reduction in the incidence of SSO events and not just to the overall *E. coli* reduction.

Periodic reconnaissance of storm drain inlets and likely illegal dumping sites are other examples of non-numerical monitoring.

Figure 8-2 Example of Non-Numerical Monitoring

8.2.2 Progress Indicators

By definition, adaptive management is the ability to use information as it is collected to modify management approaches and reduce uncertainty over time. To assist stakeholders during the initial 10-year implementation period the JPL Watershed Protection Partnership will convene, at a frequency and manner that is agreed upon by the Partnership, with an annual meeting at a minimum, and assess several indicator criteria that have been developed to check overall progress (Section 6.0, Table 7-1). When working with a decade-long timeframe, the likelihood of unforeseen circumstances appearing to delay implementation progress is high, highlighting the need for continuous application of adaptive management techniques. Lapses in funding, lack of stakeholder support, and social/political resistance are examples of such situations that may delay implementation. In these situations, stakeholders will use the progress indicators built into each recommended management activity to determine whether delays are significant enough to warrant adjustments to the implementation schedule. A WPP update report that identifies and summarizes major accomplishments and/or delays will be provided in year 5 as funding allows.

In addition to project-specific progress indicators (see 'Units implemented,' Table 7-1), continued load reductions in pursuit of water quality goals will be used to gauge overall implementation progress. These include attainment of the 126 MPN/100 mL geometric mean goal for *E. coli* and attainment of nutrient reductions (for nitrate, 1.95 mg/L and TKN 0.4 mg/L, as geometric means). Teague et al. (2009) developed SELECT to identify and estimate potential pathogen loads resulting from various fecal sources in watersheds. This tool can be used to determine the actual contaminant loads resulting in streams using pollutant connectivity algorithms (Riebschleager et al., 2012) or in conjunction with a fate and transport watershed model (Thilakarathne et al., 2018). SELECT for-TX "HAWQS" can simulate potential pathogen loading in a watershed for various management scenarios based on user defined inputs. Inputs that can be modified based on BMPs include pet density, livestock and wildlife stocking rates, sources of OSSF numbers and amount of wastewater, daily *E. coli* and discharge values for WWTFs, and fecal coliform production rates and conversion to *E. coli* factors. HAWQS can also be used as a platform to gauge overall implementation progress and potential strategies. HAWQS is a free, open-source, internet-based, SWAT-based platform using a point-and-click interface and powerful output visualization tools. It allows users to customize SWAT inputs to create scenarios based on BMPs by modifying agricultural management, operations management, and conservation practices. The parameters and operations can be modified within the HAWQS user interface, or they can be directly uploaded into HAWQS..

By extension, a biannual, iterative application of the *E. coli* standard and nutrient screening criteria within the Texas Integrated Report will also be used to monitoring implementation effectiveness. This will become more important as more and more data taken within the implementation period falls within the seven-year moving window utilized for report analysis. If implementation begins on schedule in 2023, the first Integrated Report that will use post-implementation data will be 2031. This biennial review, while useful as the statewide benchmark for measuring implementation success, may not be a feasible means of measuring project- specific water quality improvements due to its coarse nature, especially in the short-term. Instead, targeted or project-specific monitoring should be used as the primary indicators for individual BMP success, with the primary indicator of program-wide success measured through periodic review of long-term monitoring results. In this regard, Texas Integrated Report results will be used as a helpful secondary indicator of progress.

It is widely understood that load reductions in pursuit of both *E. coli* and nutrient goals will be a long-term endeavor. Changes in water quality are a compound response to a diffuse and complex collection of factors, with positive influences on water quality afforded by implementation efforts often taking months or years to become obvious and measurable. Here again, stakeholders must use their best judgment when considering the need to apply adaptive management techniques is warranted. As the 10-year implementation window draws to a conclusion, progress towards the WPP's goals will again be evaluated using the performance metrics described throughout Chapters 7 and 8. Stakeholders will need to use adaptive management techniques to evaluate whether the water quality goals have been achieved, or if additional or expanded efforts are necessary for success.

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Appendix A: Key Elements of Successful WPPs

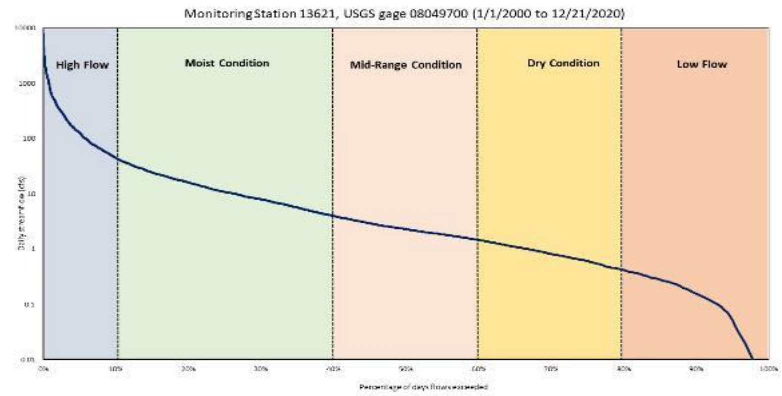
EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA, 2008) describes the 'Element of Successful Watershed Plans' that must be sufficiently included in the WPP for it to be eligible for implementation funding through the CWA Section 319(h) grant funding program.

Element	Report Section(s)
Element A: Identification of Causes and Sources	
1. Sources identified, described, and mapped	4.0 and 5.0, Appendix E:
2. Subwatershed sources	4.0 and 5.0, Appendix E:
3. Data Sources are accurate and verifiable	4.0 and 5.0
4. Data gaps	4.0 and 5.0
Element B: Expected Load Reductions	
1. Load reductions achieve environmental goal	5.0 and 6.0, Appendix D:
2. Load reductions linked to sources	6.0, Appendix D:
3. Model complexity appropriate	5.0, Appendix B:, Appendix C:
4. Basis of effectiveness estimates explained	6.0 Appendix D:
5. Methods and data cited and verifiable	Appendix B:, Appendix C:, Appendix D:
Element C: Management Measures Identified	
1. Specific management measures are identified	6.0 and 7.0
2. Priority areas	6.0
3. Measure selection rationale documented	6.0
4. Technically sound	7.0
Element D: Technical and Financial Assistance	
1. Estimate of technical assistance	7.0
2.Estimate of financial assistance	7.0
Element E: Education/Outreach	
1. Public education/information	7.0
2. All relevant stakeholders are identified in outreach process	1.0, 6.0, 7.0
3. Stakeholder outreach	6.0 and 7.0
4. Public participation in plan development	1.0, 4.0, 0, 6.0 and 7.0
5. Emphasis on achieving water quality standards	3.0, 5.0, 6.1 6.0 , 8.2.2 Appendix B:, Appendix E:
6. Operation & maintenance of BMPs	6.0 and 7.0
Element F: Implementation Schedule	
1. Includes completion dates	7.0
2. Schedule is appropriate	7.0
Element G: Milestones	
1. Milestones are measurable and attainable	7.0
2. Milestones include completion dates	7.0
3. Progress evaluation and course correction	7.0 and 8.2.2
4. Milestones linked to schedule	7.0
Element H: Load Reduction Criteria	
1. Criteria are measurable and quantifiable	8.2.2
2. Criteria measure progress toward load reduction goal	8.2.2
3. Data and models identified	5.00, Appendix B:, Appendix C:
4. Target achievement dates for reduction	8.2.2
5. Review of progress toward goals	8.2
6. Criteria for revision	8.2.2
7. Adaptive management	8.2.2

Element	Report Section(s)
Element I: Monitoring	
1. Description of how monitoring used to evaluate implementation	8.2
2. Monitoring measures evaluation criteria	8.2
3. Routine reporting of progress and methods	8.2
4. Parameters are appropriate	5.0, 8.2
5. Number of sites is adequate	5.0, 8.2
6. Frequency of sampling is adequate	5.0, 8.2
7. Monitoring tied to Quality Assurance Project Plan	5.0, 8.2
8. Can link implementation to improved water quality	8.2

Appendix B: Load Duration Curve Explanation

LDCs allow for a visual interpretation of load exceedances in comparison to the allowable load at specific flow conditions. Using flow and *E. coli* data collected from a specific monitoring campaign, FDCs and LDCs can be built to further evaluate the contaminant sources. First, all flow values are aggregated and ranked from lowest to highest. This data is then graphically depicted to show the general flow regime, complete with the percentage of time that the water body is expected to be dry, as well as its response to storm flows (Figure B-1).

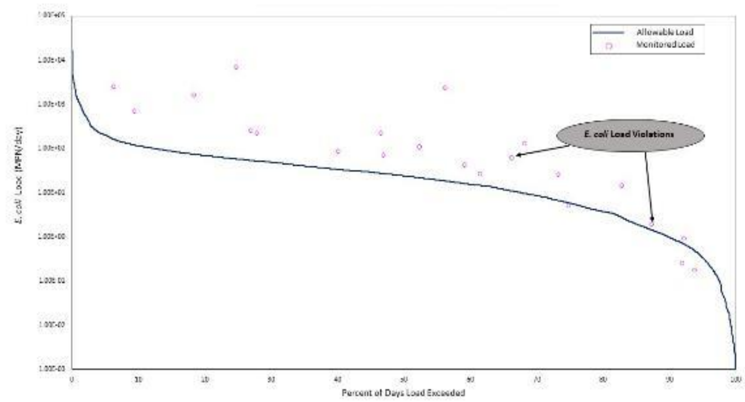


Source: FDC for streamflow conditions at monitoring station 13621 on Walnut Creek, near Mansfield, TX.

Figure B-1 FDC example from JPL watershed (log scale Y-axis)

The FDC can then be used to develop a LDC for a specific pollutant of interest, given that there is pollutant concentration data that complements the flow data. Figure B-2 depicts an example LDC based on the FDC shown in Figure B-1. The first step in the process is to apply the pollutant's allowable limit concentration to all available flow values to produce the allowable load limit curve. In the case of bacteria, this value is 126 MPN/100 mL (solid line in **Error! Reference source not found.**). Then, the baseline monitoring data values for *E. coli* (also in MPN/100 mL) are also multiplied by their associated flow values to get loads for each data point (pink squares in Figure B-2). This can be developed further by performing regression analysis on the monitored data points, as depicted in **Error! Reference source not found.** Here, the allowable load limit is depicted in red, while the regression line for the data points is depicted in blue. Regression analysis can be completed using one of many techniques. In this case, a USGS program known as Load Estimator (LOADEST) is utilized. A load reduction estimate can be calculated for each of the different flow regimes (High, Moist , Mid-range, Dry, Low). Achieving these reductions will become the one of the primary targets once the WPP moves into the implementation stage.

LOAD DURATION CURVE FOR *E. COLI* AT MONITORING STATION 16433



Source: LDC at monitoring station 16433 on Hollings branch, near JPL.

Figure B-2 LDC example from JPL watershed (log scale Y-axis)

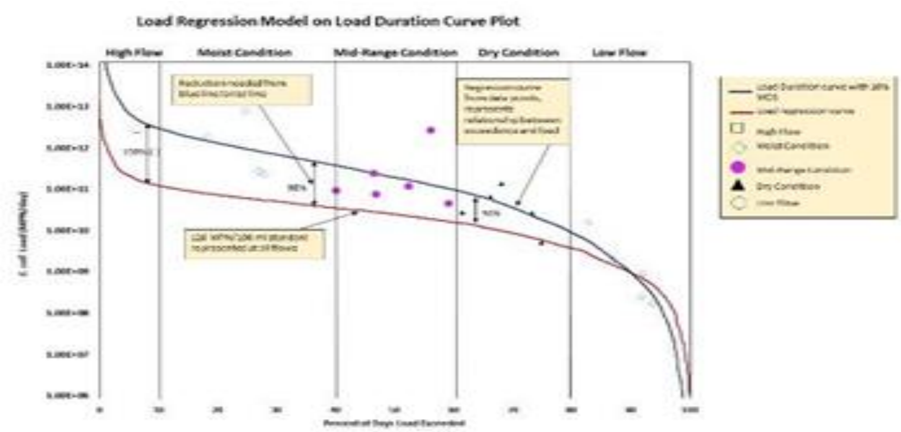


Figure B-1 LDC example for *E. coli*, with flow condition breakdowns and load reduction estimates (log scale Y-axis)

However, it is worth noting that some of these reductions, specifically those within the “High Flows” range, may not be achievable due to feasibility of applying management measures to storm flows that fall within the extreme range. It is therefore customary to focus efforts on the load reductions identified at the lower flow conditions, where it becomes easier to separate potential point source contributors from nonpoint source contributors. In most cases, if a water body exhibits high pollutant loads on the extreme right of the graph where low flows are represented (Figure B-4), it is highly likely that this may be attributable to a point source, such as a malfunctioning WWTF or leaking/failing wastewater infrastructure somewhere in the watershed. These types of contributions can typically be easily addressed and are worth investigating early in the process. Conversely, if pollutant loads tend towards the middle of the graph, it is likely that they are attributed to stormwater runoff during periods of normal or moderate rainfall. While typically not as easily addressed as point sources, these areas may also be targeted for watershed pollutant load reductions through BMP recommendations.

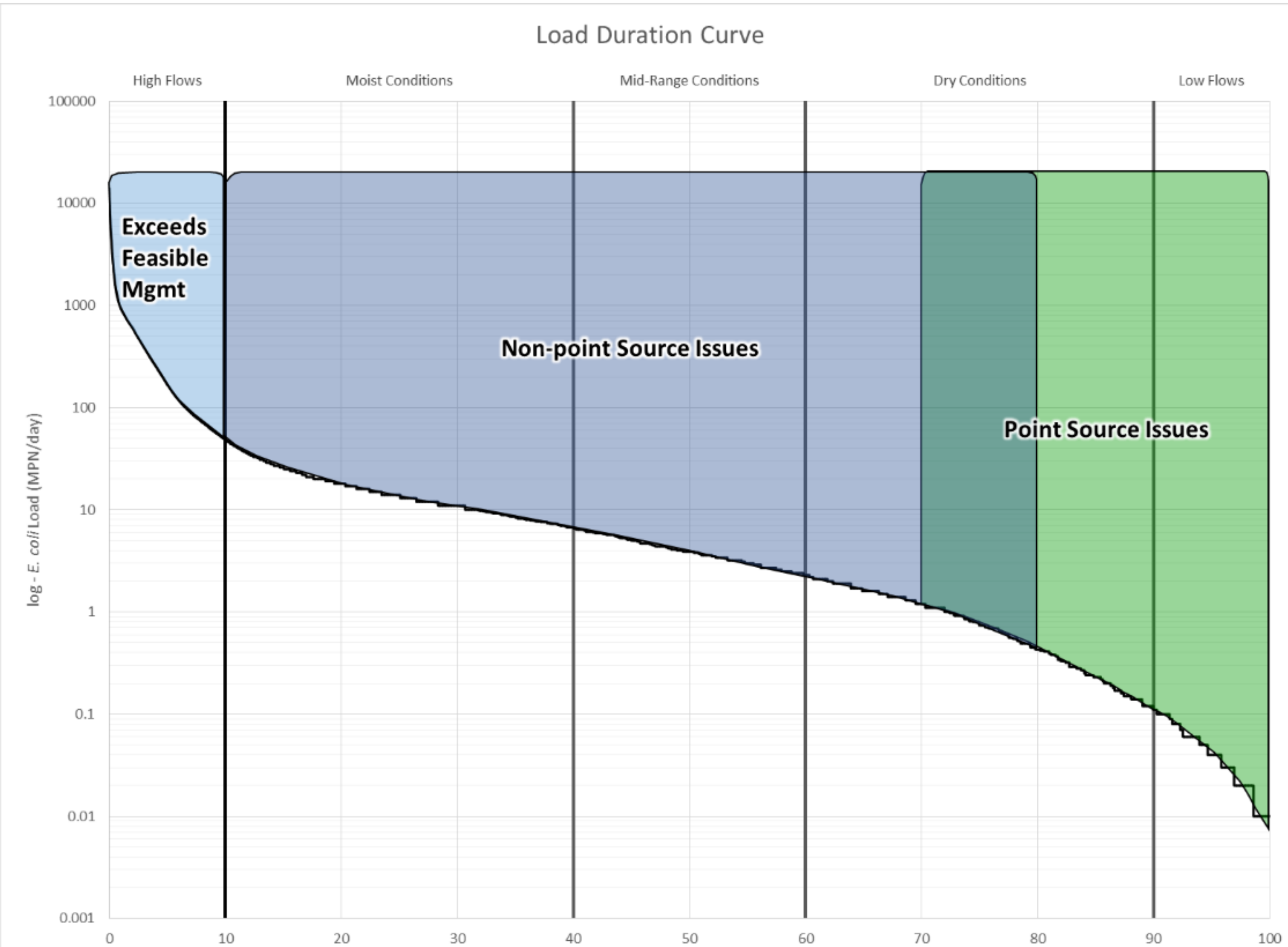


Figure B-2 Flow categories and regions of likely pollutant sources along an example load duration curve

Appendix C: SELECT Analysis Explanation

General Approach

To further identify the extent of a certain source type's likely contribution to the bacteria load in a specific subwatershed, the SELECT analysis can be conducted for any number of potential bacteria source types, including urban/municipal runoff, agricultural runoff, failing septic systems, wildlife, and even invasive species.

The SELECT approach first uses spatial data for LULC data to determine where representatives from a particular contributing source might be located, and then uses watershed boundaries, topography, and stream network information to further determine suitability and range. Then, an estimated population density is applied to these suitable areas. Population density data can come in the form of census estimates for humans, literature values from published resource agency materials, or in some cases, anecdotal evidence from watershed stakeholders.

Finally, published literature values for *E. coli* production from these sources are applied to the estimated population so that a potential *E. coli* load can be calculated for each subwatershed in the analysis. This yields visual output that can be color-coded to show the severity of the load's potential contribution to the watershed, which can be used to pinpoint areas where management measures would provide the most cost-to-benefit ratio. Details about the process for calculating each source category's load estimate are provided below.

WWTFs

The following procedures were used to prepare data from the national Enforcement and Compliance History Online (ECHO) database provided through EPA for spatial analysis within SELECT.

Outfall data was obtained from the Discharge Monitoring Report (DMR) database via EPA's ECHO website. Used discharge data reported for calendar years 2017-2021 at six active WWTFs currently treating human sewage in the watershed. There are six permitted and active WWTFs within the JPL watershed. Details about the six active WWTFs and any associated permit limit exceedances for water quality parameters are provided in Table 4-2. The WWTFs do not exceed the maximum allowable average daily discharge. WWTFs are not a significant source of *E. coli* for the JPL watershed as it contributes only about 0.002% of the load.

Load Calculation

The equation to calculate the *E. coli* (EC) for WWTFs (Teague, 2009) is given as:

$$\mathrm{EC} = \mathrm{Average\ flow\ (MGD)} \cdot \frac{\mathrm{Reported}\ E.coli\ \mathrm{geomeanMPN}}{100\ \mathrm{mL}} \cdot \frac{10^6\mathrm{gal}}{\mathrm{MG}} \cdot \frac{3785.41\ \mathrm{mL}}{\mathrm{gal}}$$

Total *E. coli* calculations for each subwatershed (in MPN/day) are normalized across the watershed by dividing by the subwatershed's area (MPN/acre-day).

SSOs

In general, SSOs are combined with pet waste nonpoint sources and used as surrogates for urban runoff when calculating pollutant loads from urban sources. The compendium of past reports of SSO occurrences was used to illustrate locations, overflow amount, cause of SSOs, and potentially determine impacts of SSOs on the day of occurrence. NCTCOG acquired SSO data from TCEQ for the region for the period 2016-2020 across the 25 subwatersheds. For each subwatershed, the number of SSOs and the total gallons discharged were used. However, the amount of SSOs in the JPL watershed were too few to expand on in analysis and determine a daily discharge, as these are sporadic overflows. It is possible to calculate if there is a chronic overflow. BMPs for SSOs require infrastructure assessments and proper maintenance that are usually built into a MS4 program.

Load Calculation

Although it was not possible to calculate load calculations for SSOs, the equation to calculate the EC for SSOs is provided below. EC is obtained from combined sewer overflow and septic equations in EPA's Protocol for Developing Pathogen TMDLs (EPA, 2001), and given as:

$$\mathrm{EC} = \frac{\text{Avg discharge in gal}}{\text{day}} \cdot \frac{5 \cdot 10^3\ \text{MPN}}{\text{mL}} \cdot \frac{3785.41\ \text{mL}}{\text{gal}}$$

The *E. coli* load assigned to raw sewage is $5*10^3$ MPN/mL (EPA, 2001). Total *E. coli* calculations for each subwatershed (in MPN/day) are then normalized across the watershed by dividing by the sub watershed's area (MPN/acre-day). According to the SSO data from NCTCOG spanning 2016-2020, there were 39 incidents of overflow in the JPL watershed.

Dogs & Cats

Households Analysis

The population and household estimates were obtained from the North Central Texas 2045 Demographic Forecast dataset provided by NCTCOG (NCTCOG, 2011). This dataset includes household population for 2045 aggregated to 2010 census block groups as delineated by the U.S. Census Bureau. Data is further aggregated by traffic survey zones (TSZ). If the TSZ was completely within a subwatershed, its entire population was used. If the TSZ was partially in the subwatershed, the population in the subwatershed was estimated by multiplying the block group population to the proportion of its area in the subwatershed. The area of JPL subwatershed was removed from the TSZ shapefile before applying the population and household over the block group area to avoid applying population projections to the lake area. The resulting values were used to determine the number of households in the JPL watershed.

Approximately 36.5% of U.S. households have dogs, with 30.4% owning cats. It is estimated that there is an average fraction of 0.614 dogs per every household and an average fraction of 0.457 cats per every household (AVMA, 2018).

Load Calculation

The equation to calculate the EC for dogs and separately for cats is given as:

$$\mathrm{EC} = \text{Number of households} * \frac{\text{fraction of pets}}{\text{household}} * 2.5 * 10^9\ \text{MPN d}^{-1}\ \text{head}^{-1}$$

The EC loading of 2.5 E+9 MPN/day-head comes from fecal coliform estimate of 5.0E+9 MPN/day-head (Horsley and Witten, 1996) with the 50% fecal coliform to *E. coli* conversion applied. This 50% conversion is a rule of thumb that estimates that 50% of fecal coliform are *E. coli* (Doyle and Erikson, 2006). A 90% contribution was assumed to reach waterways within the 330-ft (100-m) riparian buffers, with a presumed 50% contribution from upland areas. Total EC calculations for each subwatershed (in MPN/day) are then normalized across the watershed by dividing by the subwatersheds area (MPN/acre-day).

Livestock, Deer, Horse Feral Hogs

Estimating Population Density

Similar steps were taken when developing the EC loads for larger mammals, such as domestic livestock, deer, and feral hogs. First, land use categories were considered for their suitability as habitat for the species of interest. Total watershed acreage of land uses relevant to large mammal populations were calculated based on the NCLD 2016 database (Table C-2). County-wide NASS population estimates were then extrapolated to the watershed using a percent-area basis (Table C-3). Animal populations were originally based on proportioned NASS, TPWD, or TAMU data. These were then modified based on Steering Committee recommendations (

Table C-4). If a particular land use was only partially utilized as habitat by a species, population density adjustments were made to that land use category (Table C-5). Population densities for each species were then calculated using the stakeholder-recommended populations and the land use-based density adjustments (Table C-6, Table C-7).

Load Calculation

The adjusted animal population densities were used to calculate the *E. coli* loads for various livestock, deer, and feral hogs with the equations as shown in Table C-1 (Teague, 2009).

Table C-1 Equations to calculate the *E. coli* loads for various livestock, deer, feral hogs, and avian wildlife

Source	Calculation
Cattle	$EC = \#cattle * 2.7 * 10^9 MPNd^{-1}head^{-1}$
Horses	$EC = \#horses * 2.1 * 10^8 MPNd^{-1}head^{-1}$
Sheep and goats	$EC = \#sheep * 9 * 10^9 MPNd^{-1}head^{-1}$
Deer	$EC = \#deer * 1.75 * 10^8 MPNd^{-1}head^{-1}$
Feral Hogs	$EC = \#hogs * 4.45 * 10^9 MPNd^{-1}head^{-1}$
Ducks	$EC = \#ducks * 5.5 * 10^9 MPNd^{-1}head^{-1}$
Geese	$EC = \#geese * 2.45 * 10^{10} MPNd^{-1}head^{-1}$

Total *E. coli* calculations for each subwatershed (in MPN/day) are then normalized across the watershed by dividing by the subwatersheds area (MPN/acre-day).

Table C-2 Total land cover acreages for relevant land uses in JPL watershed

Land Cover	Acres
Grassland	45,670
Pasture/Hay	12,943
Deciduous Forest	19,622
Evergreen Forest	4,252
Mixed forest	370
Developed	35,965

Table C-3 Percentage of area of different counties falling within the boundary of JPL watershed from NLCD 2016

County	Total Acres	Acres in Watershed	% of County	% of Watershed
Johnson	469,950	55,998	11.92	39.13
Ellis	609,282	30,550	5.01	21.35
Tarrant	577,376	38,508	6.67	26.91
Dallas	581,676	18,036	3.10	12.61
Total	2,238,284	143,091	N/A	100

Table C-4 Assumed populations of various large mammals in the watershed based on Steering Committee recommendations

Steering Committee Recommendations		
Large Mammals	Number	Notes
Cattle	11,165	Original estimates based on USDA-NASS data
Equine	1,207	Original estimates based on USDA-NASS data, added 130 across low density urban land
Sheep	736	Original estimates based on USDA-NASS data
Goats	1,255	Original estimates based on USDA-NASS data
Deer	902	Original estimates based on TPWD annual median density estimate for DMU #20,21,22
Feral Hogs	593	Original estimates based on TAMU
Cats	28,698	Original estimates based on AVMA data
Dogs	38,558	Original estimates based on AVMA data

Table C-5 Proposed population density adjustments based on % of each land use type used by each animal classification across watershed

Density Adjustments	Grassland	Pasture/Hay	Shrub/Scrub	Low Density Urban
Cattle	1	1	1	
Equine	1	1	1	1
Sheep	1	1	1	
Goat	1	1	1	

Table C-6 Estimated animal densities, animals/acres and acres/animal basis

Species	animal/acres	acres/animal	Notes
Cattle	0.19	5.39	100% pasture, 100% grassland, 100% shrub/scrub
Equine	0.02	56.03	100% pasture, 100% grassland, 100% shrub/scrub
Equine	0.2	5	5% low density urban
Sheep	0.01	81.7	100% pasture, 100% grassland, 100% shrub/scrub
Goat	0.02	48	100% pasture, 100% grassland, 100% shrub/scrub
Deer	0.02	53.7	whole watershed except developed (all), open water
Feral Hogs	0.02	50.4	100 % riparian zones, 100 % forest land uses

Table C-7 Acreages used in calculation of feral hog population (in green)

LULC Category	Acres	
	Riparian	Upland
Open Water	1,772	5,373
Developed, Open Space	550	10,708
Developed, Low Density	355	12,561
Developed, Med Density	158	9,256
Developed, High Density	41	2,335
Barren land (Rock/Sand/Clay)	10	698
Deciduous Forest	4,944	14,678
Evergreen Forest	86	4,166
Mixed Forest	52	318
Shrub/Scrub	149	1,530
Grassland/Herbaceous	3,030	42,640
Pasture/Hay	754	12,190
Cultivated Crops	180	13,988
Woody Wetlands	104	58
Emergent Herbaceous Wetlands	291	117
Total Suitable Acreage	10,704	19,162
Total Composite Acreage		29,866

OSSFs

Permitted OSSF information was obtained for Johnson, Ellis, and Tarrant counties, and for the cities of Grand Prairie and Arlington. Only the last seven years of permits were available from Johnson County therefore the number of total permitted OSSFs could be higher across the JPL watershed in this county. Based on the available data for permitted OSSFs, a total of 4,756 were located within the JPL watershed (Figure 4-5). Since 1989, counties are responsible for maintaining records of permitted OSSFs, which must be inspected to ensure compliance with state regulations. Many of the known existing systems in the watershed installed prior to 1989 are not tied to a current permit, indicating that they have not been recently inspected, and thus have a much higher likelihood for failure. Since many of these systems were constructed before stricter permitting requirements were put in place, it is possible that many were either designed or installed improperly, especially in areas where soils are less suitable and unable to treat and absorb effluent loads. These “non-permitted” systems present a greater contamination risk to water quality. However, it is expected that even some permitted systems are currently in a state of failure, usually due to neglect or lack of homeowner knowledge regarding OSSF operation. Designated representatives for counties in the watershed, as well as other stakeholders, agreed with statewide estimates of 50% failure rate for “non-permitted” and 12% for permitted systems used in several other WPP efforts in Texas (Reed et al., 2002). No information was available for the actual number of “non-permitted” OSSFs across the JPL watershed. Stakeholders indicated there are about two “non-permitted” OSSFs present for every permitted OSSF across the watershed. Using this ratio, a total of 9,512 “non-permitted” OSSFs were designated for the SELECT analysis.

Load Calculation

The equation to calculate EC for OSSFs is:

$$\mathrm{EC} = \#\text{failing systems} \cdot \frac{5 \cdot 10^5\ \mathrm{MPN}}{\mathrm{mL}} \cdot \frac{2.65 \cdot 10^5\ \mathrm{mL}}{\text{person} \cdot \text{day}} \cdot \frac{\text{Avg}\ \#\text{persons}}{\text{household}}$$

The *E. coli* load assigned to OSSFs: $5*10^5$ MPN/100 mL, with the average per-person water use estimated at 70gal/person-day ($2.65*10^5$ mL) to be delivered to the OSSF (Teague, 2009).

Appendix D: Load Reduction Calculations

When calculating *E. coli* load reductions, it is imperative that planners understand that there are many factors at work in the watershed that reduce BMP efficiency, whether they be physical limitations of the BMP itself, barriers to information flow that prohibit full proliferation and use of the BMP amongst all stakeholders, or societal/fiscal limitations that prevent full proliferation of BMP application even when benefits of the BMP are well-known. If planners are not careful in accounting for these factors that limit BMP efficiency, they run the risk of over-estimating load reductions, inflating expectations, and producing erroneous results that could potentially delay and significantly side-track implementation effectiveness. All efforts have been made to account for reduced BMP efficiency when calculating load reductions for this project.

Dogs & Cats

When considering *E. coli* loads for pet waste, it can be assumed that not all people pick up after their pets, and even with a modest improvement in awareness and BMP use, stakeholders were only comfortable assuming 20% of the pet waste load would be managed. With an estimated 67,256 dogs and feral, outdoor, or barn cats in the watershed, the managed population of 20% amounts to 13,451 animals. This population is then multiplied by the per-animal load factor (2.50E+09 MPN/AU-day) and the 75% removal effectiveness factor associated with picking up and bagging pet waste to get a total daily load reduction. This is then extrapolated over a year to arrive at a daily load, and then multiplied by a 25% attenuation factor to account for environmental processes that may deactivate or otherwise remove *E. coli* before it has a chance to reach a water body. As mentioned previously, this attenuation factor is yet another attempt to make load reduction calculations realistic, and not account for load reductions that are not associated with the BMP in question. After attenuation, a realistic estimate of 2.30E+15 MPN/yr can be expected from the application of pet-waste related BMPs.

Table D-1 Attenuated *E. coli* load reduction for Pet Waste Management

Load Reduction Calculation - Dogs & Cats	
Total Number of Dogs & Cats in Watershed	67,256.00
20% of Population to be Managed	13,451.20
E. coli load for Dogs & Cats (MPN/AU-day)	2.50E+09
Bagged waste Removal Effectiveness Factor	0.75
Total Annual Load Reduction (MPN/100mL)	9.21E+15
with 25% Attenuation Factor (MPN/100mL)	2.30E+15

Livestock

When considering load reductions for animal agriculture, it is important to note that multiple species, BMPs, and operation sizes may complicate matters. For the purposes of this study, analysis will be limited to reductions for cattle, as they represent 78% of the watershed's total livestock population. There is an estimated 11,165 cattle in the watershed, however based on land use changes projected by NRCS and TSSWCB, stakeholders were only comfortable with the assumption that 20% of the cattle waste load could be managed. This amounts to 2,233 animals. For each of the three agriculture BMPs discussed in this appendix, several barriers to progress will be discussed. All of the agricultural BMPs suggested here fall under the umbrella of WQMPs, so progress with each may be able to be tracked concurrently. When comparing between BMPs, accounting for that BMP's specific mean effectiveness (Table D-2) is also necessary. From there, the process is similar to others from this chapter, where the per-animal *E. coli* production (2.70E+09 MPN/AU-day) is multiplied by 20% of the population and then reduced using the BMP effectiveness factor associated with each BMP. Once the loads for each BMP have been calculated and aggregated to the annual time scale, they will be added together as one overall load reduction, but not before application of the flat, 25% attenuation factor used in other BMP analyses throughout this chapter. Once attenuated, this overall *E. coli* reduction will total 1.08E+15 MPN/yr (Table D-3). In order to determine the number of properties to develop and implement WQMPs and CPs, NASS estimates were used for each county. The average farm size was determined to be 140.75 acres, along with an average number of animal units onsite based on the size of the operation (43.5 AUs). The result was 52 properties. However, based on land use changes projected by NRCS and TSSWCB, 52 properties are not realistic and they proposed a maximum of 30 properties be targeted for management.

Table D-2 *E. coli* removal efficiencies for selected livestock BMPs

BMP	Removal Efficiency*
Rotational grazing[1]	69%
Exclusionary fencing[2]	42%
Alternative water sources[3]	85%

***median E. coli removal efficiency, based on survey of multiple studies.**

[1] Tate et. al 2004, UESPA 2010

[2] Brenner 1996, Cook 1998, Hagedorn et al. 1999, Line 2002, Line 2003, Lombardo et al. 2000, Meals 2001, Meals 2004, Peterson 2011

[3] Byers et al. 2005, Hagedorn et al. 1999, Sheffield et al. 1997

Table D-3 Attenuated *E. coli* load reduction for Livestock BMPs

Rotational grazing	
Total Number of Cattle in Watershed	11165
20% of Population to be Managed	2233
BMP effectiveness (mean, from table)	0.69
E. coli production (cattle, MPN/Au-day)	2.70E+09
Total daily load reduction from prescribed grazing	4.16E+12
Total annual reduction from prescribed grazing (MPN/yr)	1.52E+15
With 25% attenutation (MPN/yr)	**3.80E+14**
Exclusionary Fencing	
Total Number of Cattle in Watershed	11165
20% of Population to be Managed	2233
BMP effectiveness (mean, from table)	0.42
E. coli production (cattle, MPN/Au-day)	2.70E+09
Total daily load reduction from prescribed grazing	2.53E+12
Total annual reduction from prescribed grazing (MPN/yr)	9.24E+14
With 25% attenutation (MPN/yr)	**2.31E+14**
Alternative Water Sources	
Total Number of Cattle in Watershed	11165
20% of Population to be Managed	2233
BMP effectiveness (mean, from table)	0.85
E. coli production (cattle, MPN/Au-day)	2.70E+09
Total daily load reduction from prescribed grazing	5.12E+12
Total annual reduction from prescribed grazing (MPN/yr)	1.87E+15
With 25% attenutation (MPN/yr)	**4.68E+14**
Total overall reduction from all BMPs	**1.08E+15**

Feral Hogs

Arguably one of the most direct methods of *E. coli* load reductions due the primary focus on removal by exclusion, capture and transport, or lethal means, feral hog control is particularly effective due to feral hogs' preference for riparian habitat, meaning that there are fewer inefficiencies to account for. Given an initial estimated watershed population of 593 hogs, a goal of 5% removal was chosen, equaling 30 hogs. When the per-animal *E. coli* loading factor of 4.45E+09 MPN/AU-day is applied and then aggregated over the year, the total load reduction afforded by feral hog population control totals to 4.82E+13 MPN/yr. For consistency, the 25% attenuation factor was again applied, bringing the total attenuated reduction to 1.20E+13 MPN/yr.

Table D-4 Attenuated *E. coli* load reduction for Feral Hog Population Control

Feral Hogs	
Total estimated # hogs in watershed	593
5% of population that will be removed	29.65
E. coli production (hogs, MPN/AU-day)	4.45E+09
Total reduction from population control (MPN/yr	4.816E+13
with 25% attenuation (MPN/yr)	1.204E+13

SSOs

Due to the high volume, sporadic nature of SSOs, implementation success for the SSO source group will be reflected as the number of SSOs reduced instead of as a load reduction.

OSSFs

An estimated 129 failing OSSFs exist in the watershed. If approximately 11% of those systems are repaired, retrofitted, or replaced, this would yield a total daily reduction of 5.17E+10 MPN/100 mL. When aggregated for the year with the standard 25% attenuation factor applied, the attenuated annual reduction in *E. coli* is expected to be 4.71E+12 MPN/100 mL.

Table D-5 Attenuated *E. coli* load reduction for OSSF Management

Load Reduction Calculation	# of Failing Systems	
	Permitted	No Permit
Number of OSSFs in Riparian Buffer	115	230
Total Number of Failing Systems	13.8	115
10% of Failing Systems Repaired	2	12
Daily Load to be Removed (MPN/100 mL)	7.38E+09	4.43E+10
Total Daily Reduction (MPN/100 mL)	5.17E+10	
Total Annual Reduction (MPN/100 mL)	1.89E+13	
with 25% Attenuation Factor (MPN/100 mL)	4.71E+12	

WWTFs

No reductions necessary or proposed by stakeholders.

Appendix E: Site Summaries for *E. coli* and Streamflow

Figure E-1 through Figure E-8 correlate flow and *E. coli* measurements to rainfall events. Flow is represented by black horizontal bars and *E. coli* is represented by the horizontal bars. The red dotted line represents the water quality criteria for *E. coli* (126 MPN/100 mL), which is technically only appropriate for geomean measurements, but is shown here for a rough comparison.

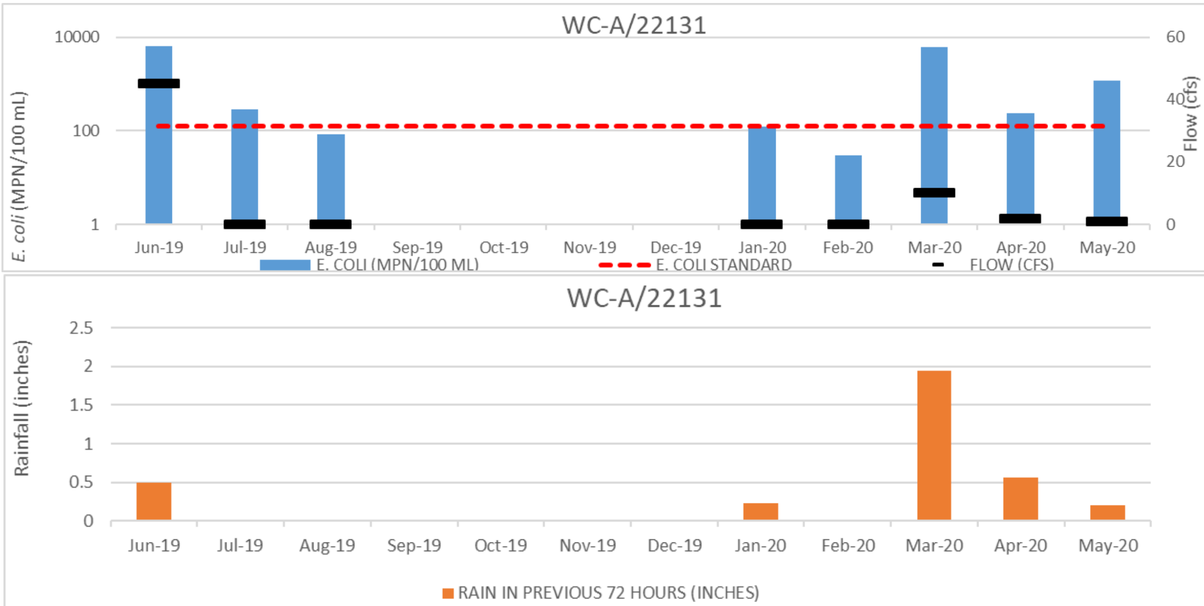


Figure E-1 Hydrology and *E. coli* parameters, Walnut Creek at FM 2738 (22131)

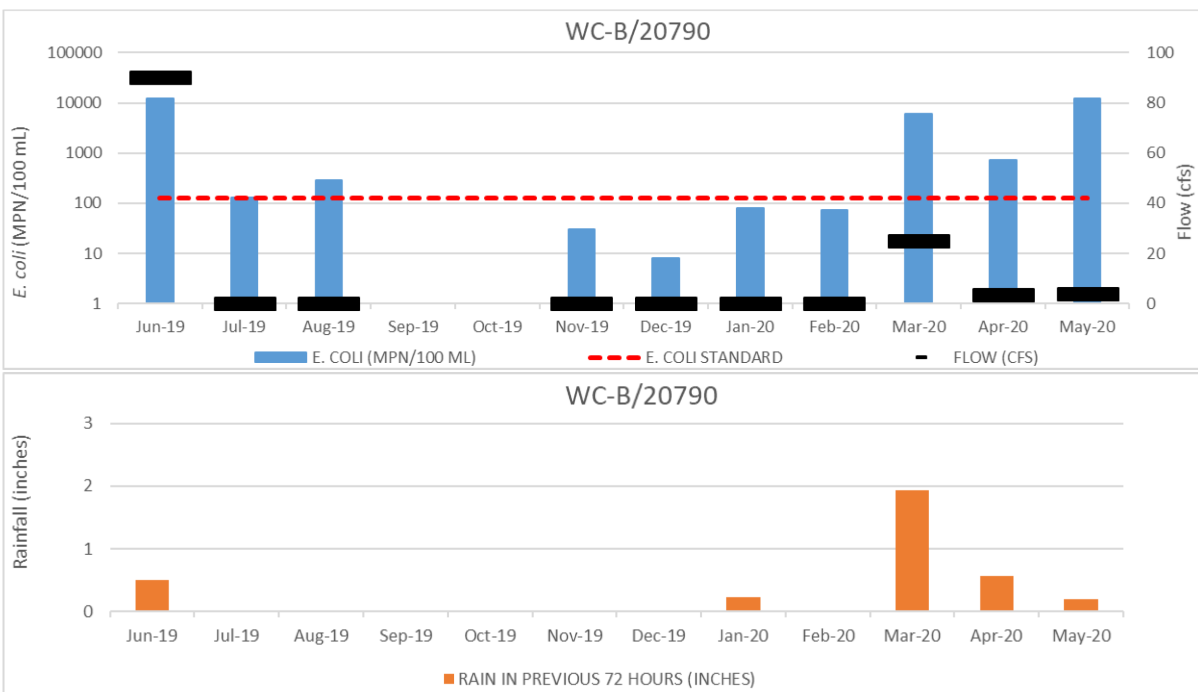


Figure E-2 Hydrology and *E. coli* parameters, Walnut Creek at Retta Road (20790)

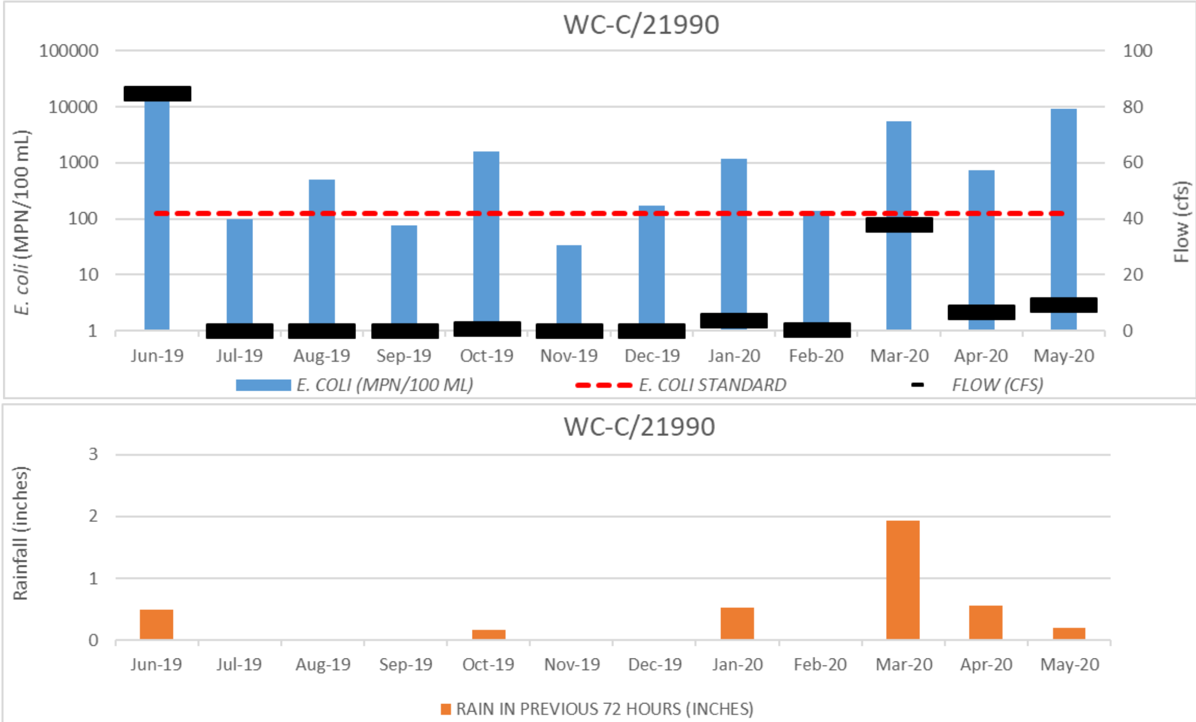


Figure E-3 Hydrology and *E. coli* parameters, Walnut Creek at Katherine Rose Park (21990)

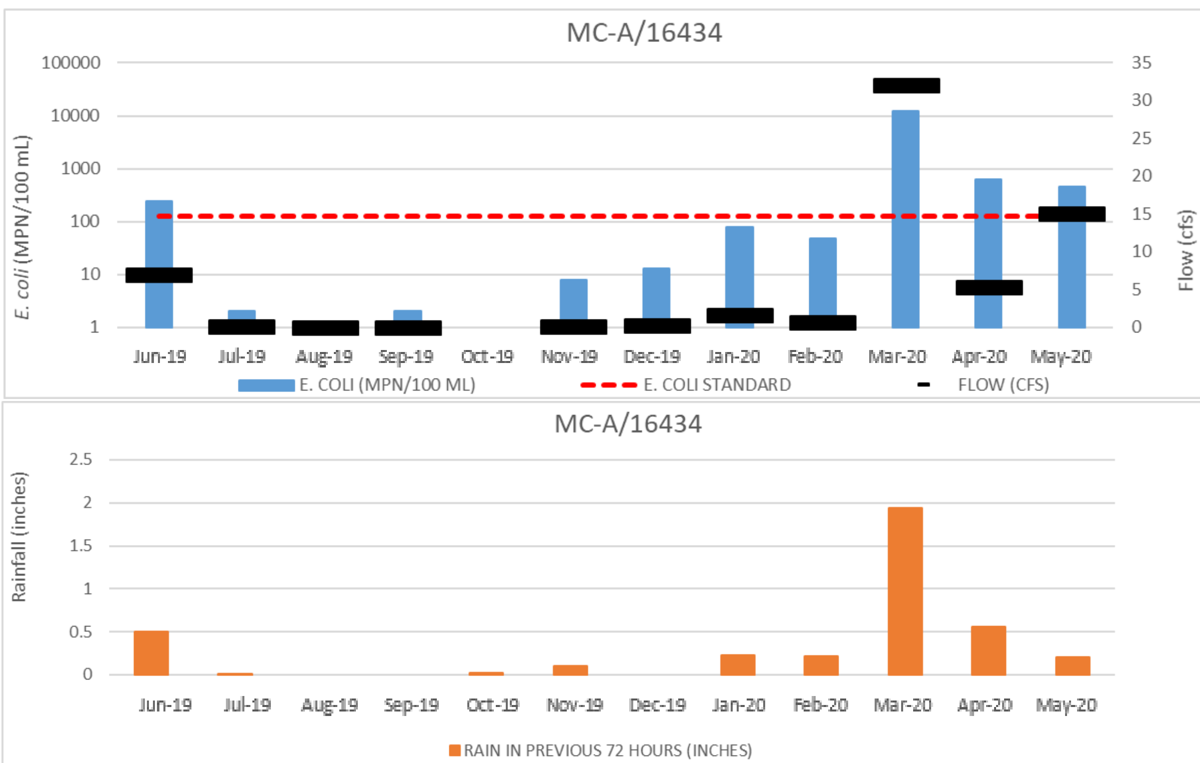


Figure E-4 Hydrology and *E. coli* Parameters, Mountain Creek at UU.S. 287 (16434)

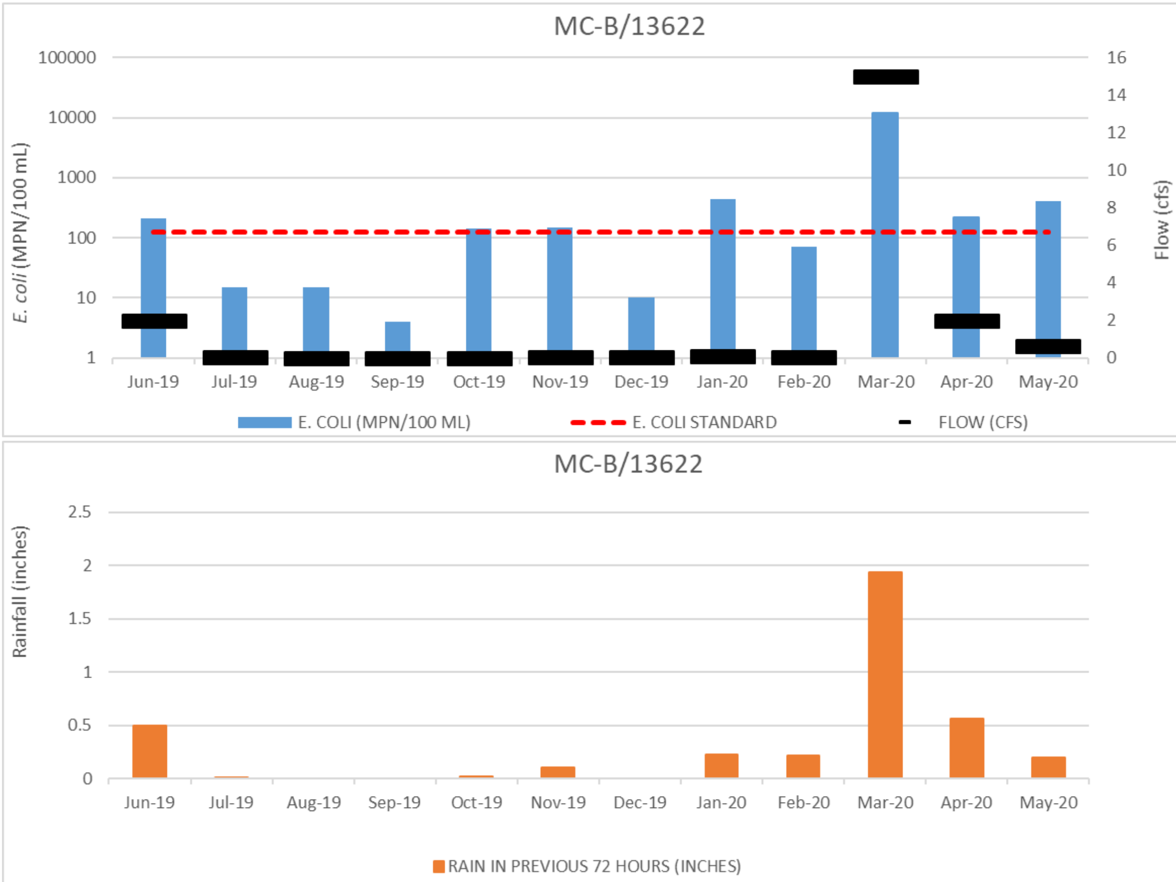


Figure E-5 Hydrology and *E. coli* Parameters, Mountain Creek at FM 157 (13622)

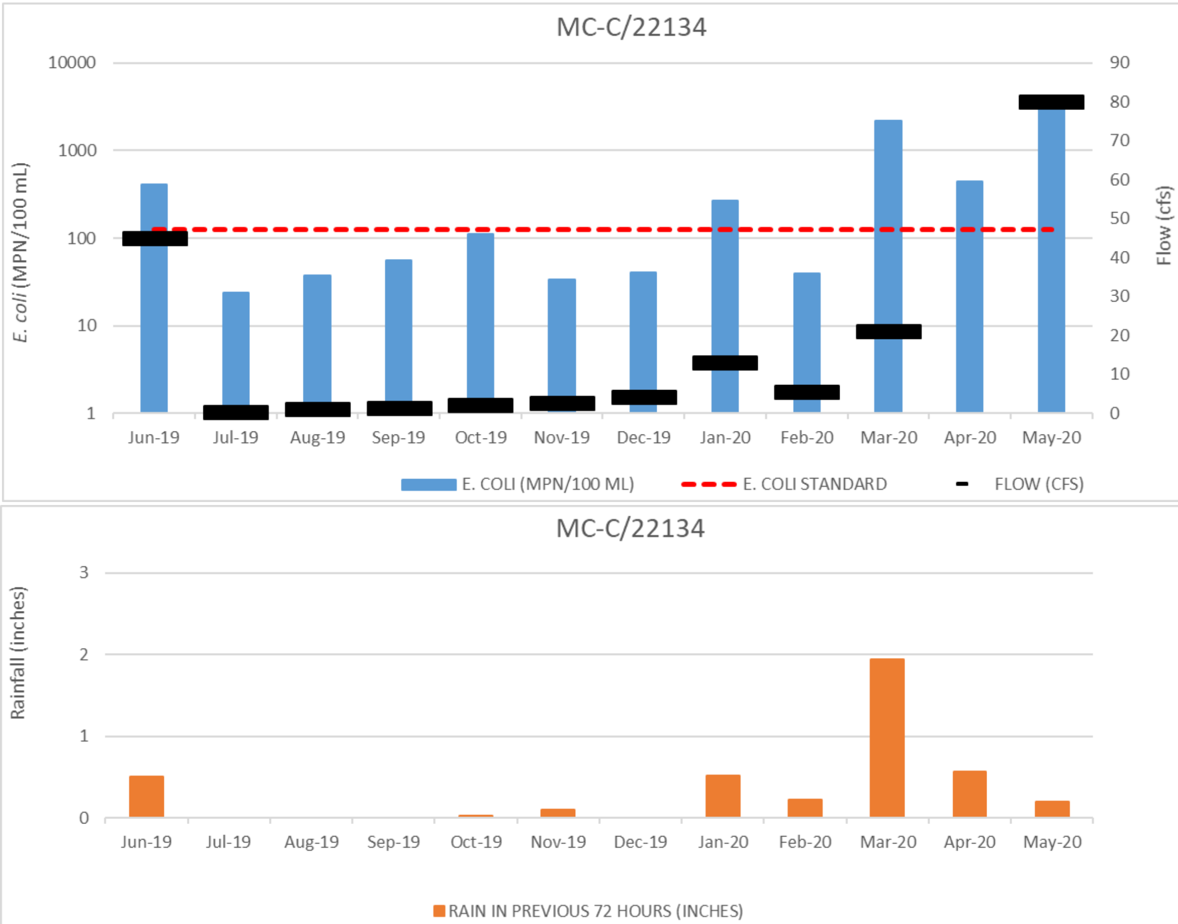


Figure E-6 Hydrology and *E. coli* parameters, Soap Creek 1.1 km upstream of Mountain Creek (22134)

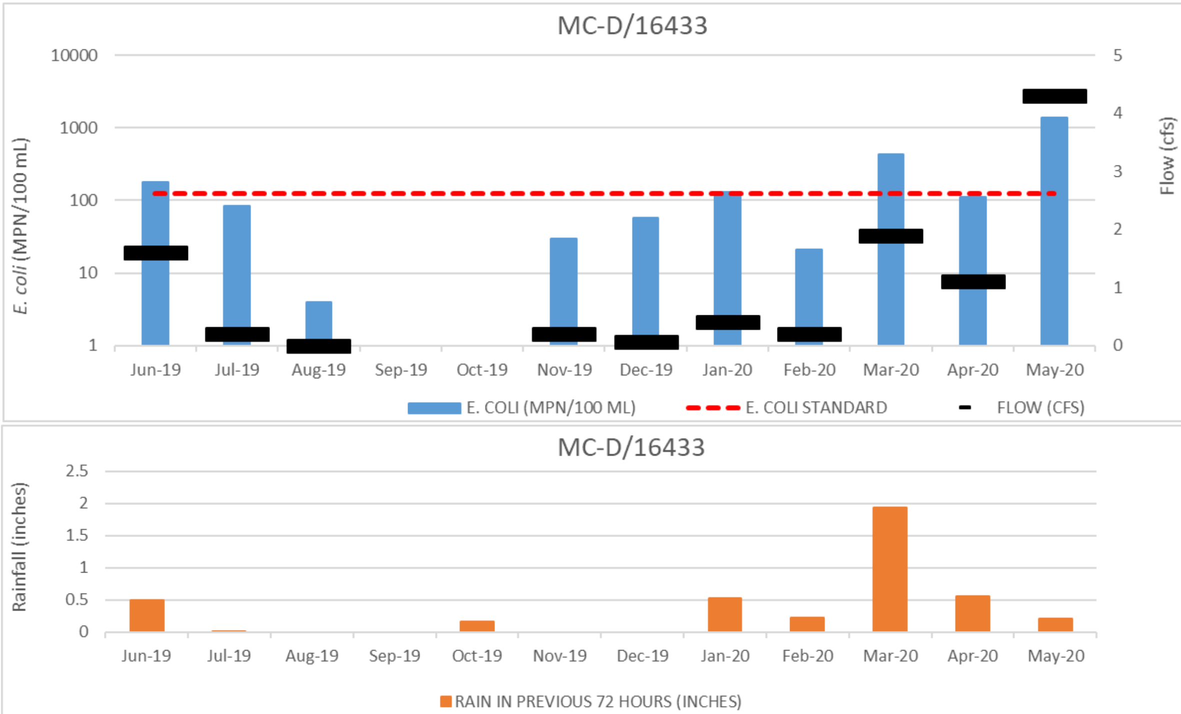


Figure E-7 Hydrology and *E. coli* parameters, Hollings Branch at Tangle Ridge Road (16433)

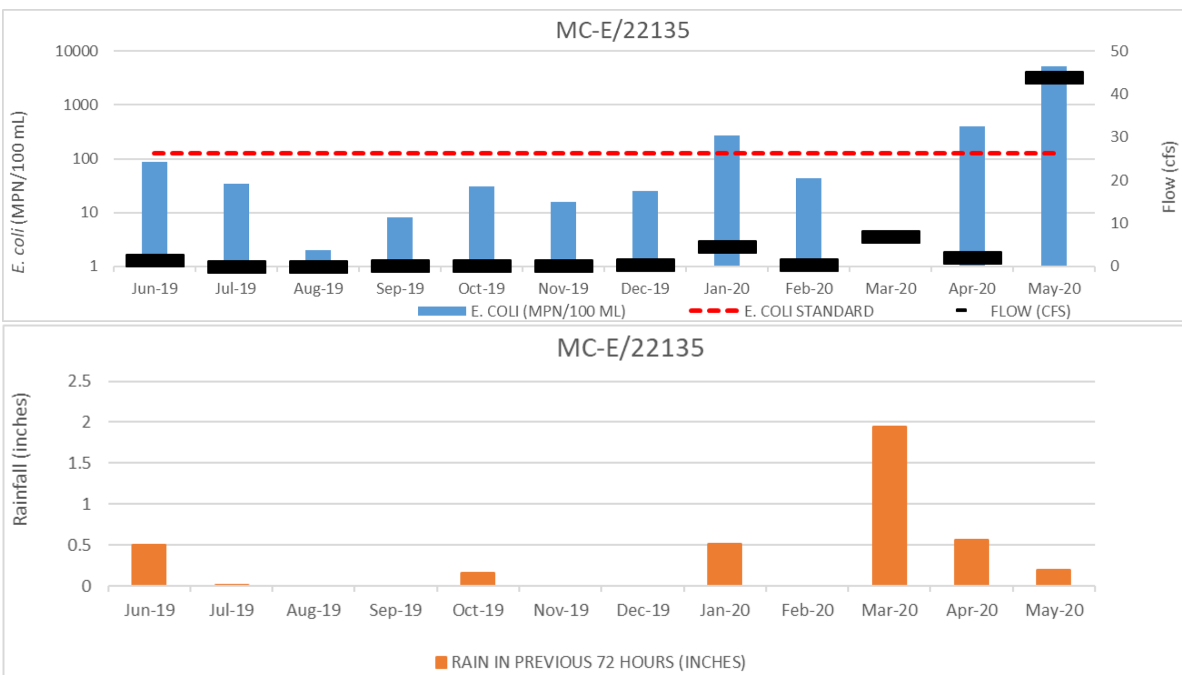


Figure E-8 Hydrology and *E. coli* parameters, Low Branch at South Holland Rd (22135)

Appendix F: Geometric mean of Nutrient and Bacteria Load

Table F-1 Geometric mean of Allowable and Estimated nitrate and nitrite ($NO_3 + NO_2$) Load at each surface water quality monitoring station across the JPL at different flow conditions

Station Number	Flow Condition	% of Time Flow Exceeds	Allowable Loading (ton/day)	Daily Loading (ton/day)	% Daily Reduction Needed	Annual Loading (ton/yr)	Annual reduction needed (ton/yr)
16433	High Flow	0-10%	4.92E-01	6.98E-02	-	2.55E+01	-
	Moist Conditions	10-40%	6.93E-02	6.28E-03	-	2.29E+00	-
	Mid-Range Conditions	40-60%	3.74E-02	2.71E-03	-	9.88E-01	-
	Dry Conditions	60-80%	2.75E-02	1.75E-03	-	6.40E-01	-
	Low Flow	80-100%	2.25E-02	1.31E-03	-	4.78E-01	-
22135	High Flow	0-10%	1.15E-01	1.68E-02	-	6.12E+00	-
	Moist Conditions	10-40%	5.06E-03	1.23E-03	-	4.48E-01	-
	Mid-Range Conditions	40-60%	1.01E-03	3.03E-04	-	1.10E-01	-
	Dry Conditions	60-80%	2.80E-04	9.35E-05	-	3.41E-02	-
	Low Flow	80-100%	1.28E-05	5.12E-06	-	1.87E-03	-
22134	High Flow	0-10%	4.92E-01	8.25E-01	40%	3.01E+02	1.22E+02
	Moist Conditions	10-40%	6.94E-02	1.58E-01	56%	5.77E+01	3.24E+01
	Mid-Range Conditions	40-60%	3.75E-02	7.97E-02	53%	2.91E+01	1.54E+01
	Dry Conditions	60-80%	2.76E-02	4.23E-02	35%	1.54E+01	5.35E+00
	Low Flow	80-100%	2.24E-02	2.27E-02	1%	8.30E+00	1.08E-01
16434	High Flow	0-10%	4.92E-01	6.98E-02	-	2.55E+01	-
	Moist Conditions	10-40%	6.93E-02	6.28E-03	-	2.29E+00	-
	Mid-Range Conditions	40-60%	3.74E-02	2.71E-03	-	9.88E-01	-
	Dry Conditions	60-80%	2.75E-02	1.75E-03	-	6.40E-01	-
	Low Flow	80-100%	2.25E-02	1.31E-03	-	4.78E-01	-
13622	High Flow	0-10%	6.30E-01	2.74E-01	-	1.00E+02	-
	Moist Conditions	10-40%	2.76E-02	9.70E-03	-	3.54E+00	-
	Mid-Range Conditions	40-60%	7.43E-03	2.29E-03	-	8.37E-01	-
	Dry Conditions	60-80%	3.51E-03	9.92E-04	-	3.62E-01	-
	Low Flow	80-100%	1.51E-03	3.82E-04	-	1.40E-01	-
22133	High Flow	0-10%	8.68E-02	5.81E-02	-	2.12E+01	-
	Moist Conditions	10-40%	2.65E-03	8.74E-04	-	3.19E-01	-
	Mid-Range Conditions	40-60%	5.54E-04	1.15E-04	-	4.21E-02	-
	Dry Conditions	60-80%	1.64E-04	2.45E-05	-	8.96E-03	-
	Low Flow	80-100%	3.07E-05	2.62E-06	-	9.55E-04	-
13621	High Flow	0-10%	7.84E-01	1.51E+00	48%	5.51E+02	2.65E+02
	Moist Conditions	10-40%	5.69E-02	2.87E-02	-	1.05E+01	-
	Mid-Range Conditions	40-60%	1.16E-02	2.73E-03	-	9.96E-01	-
	Dry Conditions	60-80%	4.19E-03	5.51E-04	-	2.01E-01	-
	Low Flow	80-100%	5.79E-04	2.82E-05	-	1.03E-02	-
21990	High Flow	0-10%	5.86E-01	1.19E-01	-	4.35E+01	-
	Moist Conditions	10-40%	5.04E-02	4.82E-03	-	1.76E+00	-
	Mid-Range Conditions	40-60%	1.23E-02	7.51E-04	-	2.74E-01	-
	Dry Conditions	60-80%	6.08E-03	2.94E-04	-	1.07E-01	-
	Low Flow	80-100%	1.79E-03	5.76E-05	-	2.10E-02	-
20790	High Flow	0-10%	5.18E-01	1.45E-01	-	5.28E+01	-
	Moist Conditions	10-40%	3.29E-02	3.21E-03	-	1.17E+00	-
	Mid-Range Conditions	40-60%	7.72E-03	4.01E-04	-	1.46E-01	-
	Dry Conditions	60-80%	3.89E-03	1.49E-04	-	5.45E-02	-
	Low Flow	80-100%	1.07E-03	2.27E-05	-	8.28E-03	-

Table F-2 Geometric mean of Allowable and Estimated TKN Load at each surface water quality monitoring station across the JPL watershed at different flow conditions

Station Number	Flow Condition	% of Time Flow Exceeds	Allowable Loading (ton/day)	Daily Loading (ton/day)	% Daily Reduction Needed	Annual Loading (ton/yr)	Annual reduction needed (ton/yr)
16433	High Flow	0-10%	9.61E-03	2.18E-02	56%	7.94E+00	4.44E+00
	Moist Conditions	10-40%	2.06E-03	3.81E-03	46%	1.39E+00	6.38E-01
	Mid-Range Conditions	40-60%	8.26E-04	1.27E-03	35%	4.64E-01	1.63E-01
	Dry Conditions	60-80%	2.87E-04	3.97E-04	28%	1.45E-01	4.02E-02
	Low Flow	80-100%	2.15E-05	2.66E-05	19%	9.69E-03	1.86E-03
22135	High Flow	0-10%	2.37E-02	4.75E-02	50%	1.73E+01	8.69E+00
	Moist Conditions	10-40%	1.04E-03	1.48E-03	30%	5.40E-01	1.61E-01
	Mid-Range Conditions	40-60%	2.07E-04	2.45E-04	16%	8.94E-02	1.39E-02
	Dry Conditions	60-80%	5.75E-05	5.85E-05	2%	2.14E-02	3.80E-04
	Low Flow	80-100%	2.62E-06	1.82E-06	-	6.63E-04	-
22134	High Flow	0-10%	1.01E-01	3.88E-01	74%	1.42E+02	1.05E+02
	Moist Conditions	10-40%	1.42E-02	5.44E-02	74%	1.99E+01	1.47E+01
	Mid-Range Conditions	40-60%	7.69E-03	2.91E-02	74%	1.06E+01	7.82E+00
	Dry Conditions	60-80%	5.66E-03	2.13E-02	73%	7.78E+00	5.71E+00
	Low Flow	80-100%	4.60E-03	1.72E-02	73%	6.29E+00	4.61E+00
16434	High Flow	0-10%	1.01E-01	1.48E-01	32%	5.39E+01	1.71E+01
	Moist Conditions	10-40%	1.42E-02	2.46E-02	42%	8.98E+00	3.79E+00
	Mid-Range Conditions	40-60%	7.68E-03	1.11E-02	31%	4.07E+00	1.26E+00
	Dry Conditions	60-80%	5.65E-03	7.20E-03	22%	2.63E+00	5.68E-01
	Low Flow	80-100%	4.61E-03	5.33E-03	14%	1.94E+00	2.63E-01
13622	High Flow	0-10%	1.29E-01	1.96E-01	34%	7.16E+01	2.44E+01
	Moist Conditions	10-40%	5.65E-03	1.12E-02	50%	4.10E+00	2.04E+00
	Mid-Range Conditions	40-60%	1.52E-03	2.92E-03	48%	1.07E+00	5.11E-01
	Dry Conditions	60-80%	7.20E-04	1.32E-03	45%	4.80E-01	2.18E-01
	Low Flow	80-100%	3.09E-04	5.27E-04	41%	1.92E-01	7.95E-02
22133	High Flow	0-10%	1.78E-02	5.05E-02	65%	1.84E+01	1.19E+01
	Moist Conditions	10-40%	5.45E-04	6.81E-04	20%	2.49E-01	5.00E-02
	Mid-Range Conditions	40-60%	1.14E-04	1.18E-04	4%	4.31E-02	1.56E-03
	Dry Conditions	60-80%	3.37E-05	3.35E-05	-	1.22E-02	-
	Low Flow	80-100%	6.30E-06	6.63E-06	5%	2.42E-03	1.21E-04
13621	High Flow	0-10%	1.61E-01	5.17E-01	69%	1.89E+02	1.30E+02
	Moist Conditions	10-40%	1.17E-02	2.39E-02	51%	8.73E+00	4.48E+00
	Mid-Range Conditions	40-60%	2.37E-03	4.06E-03	42%	1.48E+00	6.16E-01
	Dry Conditions	60-80%	8.59E-04	1.37E-03	37%	5.00E-01	1.87E-01
	Low Flow	80-100%	1.19E-04	1.85E-04	36%	6.74E-02	2.40E-02
21990	High Flow	0-10%	1.20E-01	3.52E-01	66%	1.29E+02	8.47E+01
	Moist Conditions	10-40%	1.03E-02	1.93E-02	46%	7.05E+00	3.27E+00
	Mid-Range Conditions	40-60%	2.53E-03	3.60E-03	30%	1.32E+00	3.93E-01
	Dry Conditions	60-80%	1.25E-03	1.55E-03	19%	5.64E-01	1.09E-01
	Low Flow	80-100%	3.68E-04	3.56E-04	-	1.30E-01	-
20790	High Flow	0-10%	9.08E-02	5.25E-01	83%	1.92E+02	1.59E+02
	Moist Conditions	10-40%	6.75E-03	1.48E-02	54%	5.40E+00	2.93E+00
	Mid-Range Conditions	40-60%	1.58E-03	2.19E-03	28%	7.99E-01	2.21E-01
	Dry Conditions	60-80%	7.99E-04	7.85E-04	-	2.87E-01	-
	Low Flow	80-100%	2.58E-04	1.54E-04	-	5.62E-02	-

Table F-3 Geometric mean of Allowable and Estimated Orthophosphate (OP) Load at each surface water quality monitoring station across the JPL Watershed at different flow conditions

Station Number	Flow Condition	% of Time Flow Exceeds	Allowable Loading (ton/day)	Daily Loading (ton/day)	% Daily Reduction Needed	Annual Loading (ton/yr)	Annual reduction needed (ton/yr)
16433	High Flow	0-10%	8.89E-03	2.03E-01	96%	7.42E+01	7.10E+01
	Moist Conditions	10-40%	1.91E-03	1.81E-03	-	6.59E-01	-
	Mid-Range Conditions	40-60%	7.64E-04	1.28E-04	-	4.67E-02	-
	Dry Conditions	60-80%	2.65E-04	1.75E-05	-	6.40E-03	-
	Low Flow	80-100%	2.54E-05	-	-	-	-
22135	High Flow	0-10%	2.19E-02	1.06E-03	-	3.88E-01	-
	Moist Conditions	10-40%	9.60E-04	3.16E-05	-	1.15E-02	-
	Mid-Range Conditions	40-60%	1.91E-04	5.57E-06	-	2.03E-03	-
	Dry Conditions	60-80%	5.32E-05	1.48E-06	-	5.42E-04	-
	Low Flow	80-100%	2.42E-06	7.36E-08	-	2.69E-05	-
22134	High Flow	0-10%	9.33E-02	2.10E-02	-	7.66E+00	-
	Moist Conditions	10-40%	1.32E-02	7.17E-03	-	2.62E+00	-
	Mid-Range Conditions	40-60%	7.11E-03	5.93E-03	-	2.16E+00	-
	Dry Conditions	60-80%	5.24E-03	5.48E-03	4%	2.00E+00	8.85E-02
	Low Flow	80-100%	4.26E-03	5.20E-03	18%	1.90E+00	3.44E-01
16434	High Flow	0-10%	9.34E-02	6.22E-03	-	2.27E+00	-
	Moist Conditions	10-40%	1.32E-02	1.08E-03	-	3.95E-01	-
	Mid-Range Conditions	40-60%	7.10E-03	5.86E-04	-	2.14E-01	-
	Dry Conditions	60-80%	5.22E-03	4.26E-04	-	1.55E-01	-
	Low Flow	80-100%	4.26E-03	3.44E-04	-	1.26E-01	-
13622	High Flow	0-10%	1.19E-01	2.12E-02	-	7.73E+00	-
	Moist Conditions	10-40%	5.23E-03	7.82E-04	-	2.85E-01	-
	Mid-Range Conditions	40-60%	1.41E-03	1.92E-04	-	7.00E-02	-
	Dry Conditions	60-80%	6.66E-04	8.53E-05	-	3.11E-02	-
	Low Flow	80-100%	2.86E-04	3.40E-05	-	1.24E-02	-
22133	High Flow	0-10%	1.65E-02	1.90E-03	-	6.92E-01	-
	Moist Conditions	10-40%	5.04E-04	3.62E-05	-	1.32E-02	-
	Mid-Range Conditions	40-60%	1.05E-04	6.73E-06	-	2.46E-03	-
	Dry Conditions	60-80%	3.12E-05	1.93E-06	-	7.03E-04	-
	Low Flow	80-100%	5.82E-06	3.65E-07	-	1.33E-04	-
13621	High Flow	0-10%	1.49E-01	4.28E-02	-	1.56E+01	-
	Moist Conditions	10-40%	1.08E-02	1.75E-03	-	6.38E-01	-
	Mid-Range Conditions	40-60%	2.19E-03	2.81E-04	-	1.03E-01	-
	Dry Conditions	60-80%	7.94E-04	8.85E-05	-	3.23E-02	-
	Low Flow	80-100%	1.10E-04	1.07E-05	-	3.91E-03	-
21990	High Flow	0-10%	1.11E-01	1.42E-02	-	5.17E+00	-
	Moist Conditions	10-40%	9.56E-03	1.38E-03	-	5.02E-01	-
	Mid-Range Conditions	40-60%	2.34E-03	3.42E-04	-	1.25E-01	-
	Dry Conditions	60-80%	1.15E-03	1.67E-04	-	6.11E-02	-
	Low Flow	80-100%	3.40E-04	4.70E-05	-	1.72E-02	-
20790	High Flow	0-10%	9.82E-02	3.06E-02	-	1.12E+01	-
	Moist Conditions	10-40%	6.24E-03	1.22E-03	-	4.46E-01	-
	Mid-Range Conditions	40-60%	1.46E-03	2.01E-04	-	7.35E-02	-
	Dry Conditions	60-80%	7.39E-04	8.36E-05	-	3.05E-02	-
	Low Flow	80-100%	2.03E-04	1.48E-05	-	5.41E-03	-

Table F-4 Geometric mean of Allowable and Estimated total phosphorus (TP) Load at each surface water quality monitoring station across the JPL watershed at different flow conditions

Station Number	Flow Condition	% of Time Flow Exceeds	Allowable Loading (ton/day)	Daily Loading (ton/day)	% Daily Reduction Needed	Annual Loading (ton/yr)	Annual reduction needed (ton/yr)
16433	High Flow	0-10%	1.74E-01	4.64E-02	-	1.69E+01	-
	Moist Conditions	10-40%	2.45E-02	5.62E-03	-	2.05E+00	-
	Mid-Range Conditions	40-60%	1.32E-02	1.40E-03	-	5.11E-01	-
	Dry Conditions	60-80%	9.74E-03	6.39E-04	-	2.33E-01	-
	Low Flow	80-100%	7.95E-03	2.11E-04	-	7.71E-02	-
22135	High Flow	0-10%	4.09E-02	1.90E-02	-	6.95E+00	-
	Moist Conditions	10-40%	1.79E-03	1.43E-04	-	5.22E-02	-
	Mid-Range Conditions	40-60%	3.57E-04	1.44E-05	-	5.24E-03	-
	Dry Conditions	60-80%	9.92E-05	2.82E-06	-	1.03E-03	-
	Low Flow	80-100%	4.51E-06	1.09E-07	-	3.98E-05	-
22134	High Flow	0-10%	1.74E-01	1.17E-01	-	4.27E+01	-
	Moist Conditions	10-40%	2.46E-02	2.00E-02	-	7.29E+00	-
	Mid-Range Conditions	40-60%	1.33E-02	1.13E-02	-	4.11E+00	-
	Dry Conditions	60-80%	9.77E-03	8.44E-03	-	3.08E+00	-
	Low Flow	80-100%	7.94E-03	6.94E-03	-	2.53E+00	-
16434	High Flow	0-10%	1.74E-01	4.64E-02	-	1.69E+01	-
	Moist Conditions	10-40%	2.45E-02	5.62E-03	-	2.05E+00	-
	Mid-Range Conditions	40-60%	1.32E-02	1.40E-03	-	5.11E-01	-
	Dry Conditions	60-80%	9.74E-03	6.39E-04	-	2.33E-01	-
	Low Flow	80-100%	7.95E-03	2.11E-04	-	7.71E-02	-
13622	High Flow	0-10%	2.23E-01	4.94E-02	-	1.80E+01	-
	Moist Conditions	10-40%	9.75E-03	1.85E-03	-	6.76E-01	-
	Mid-Range Conditions	40-60%	2.63E-03	4.63E-04	-	1.69E-01	-
	Dry Conditions	60-80%	1.24E-03	2.09E-04	-	7.61E-02	-
	Low Flow	80-100%	5.33E-04	8.47E-05	-	3.09E-02	-
22133	High Flow	0-10%	3.07E-02	9.09E-03	-	3.32E+00	-
	Moist Conditions	10-40%	9.39E-04	8.65E-05	-	3.16E-02	-
	Mid-Range Conditions	40-60%	1.96E-04	1.28E-05	-	4.68E-03	-
	Dry Conditions	60-80%	5.82E-05	3.25E-06	-	1.19E-03	-
	Low Flow	80-100%	1.09E-05	5.46E-07	-	1.99E-04	-
13621	High Flow	0-10%	2.77E-01	1.57E-01	-	5.73E+01	-
	Moist Conditions	10-40%	2.01E-02	3.52E-03	-	1.28E+00	-
	Mid-Range Conditions	40-60%	4.09E-03	4.41E-04	-	1.61E-01	-
	Dry Conditions	60-80%	1.48E-03	1.36E-04	-	4.96E-02	-
	Low Flow	80-100%	2.05E-04	1.71E-05	-	6.25E-03	-
21990	High Flow	0-10%	2.07E-01	8.06E-02	-	2.94E+01	-
	Moist Conditions	10-40%	1.78E-02	4.97E-03	-	1.81E+00	-
	Mid-Range Conditions	40-60%	4.36E-03	9.78E-04	-	3.57E-01	-
	Dry Conditions	60-80%	2.15E-03	4.29E-04	-	1.57E-01	-
	Low Flow	80-100%	6.34E-04	1.02E-04	-	3.71E-02	-
20790	High Flow	0-10%	9.82E-02	3.06E-02	-	1.12E+01	-
	Moist Conditions	10-40%	6.24E-03	1.22E-03	-	4.46E-01	-
	Mid-Range Conditions	40-60%	1.46E-03	2.01E-04	-	7.35E-02	-
	Dry Conditions	60-80%	7.39E-04	8.36E-05	-	3.05E-02	-
	Low Flow	80-100%	2.03E-04	1.48E-05	-	5.41E-03	-

Table F-5 Geometric mean of Allowable and Estimated *E. coli* Load at each surface water quality monitoring station across the JPL watershed at different flow conditions in MPN/day

Station Number	Flow Condition	% of Time Flow Exceeds	Allowable Loading (MPN/day)	Daily Loading (MPN/day)	% Daily Reduction Needed	Annual Loading (MPN/yr)	Annual reduction needed (MPN/yr)
16433	High Flow	0-10%	2.74E+11	1.04E+13	97%	3.79E+15	3.69E+15
	Moist Conditions	10-40%	5.88E+10	8.88E+11	93%	3.24E+14	3.02E+14
	Mid-Range Conditions	40-60%	2.36E+10	1.80E+11	87%	6.58E+13	5.72E+13
	Dry Conditions	60-80%	8.19E+9	3.22E+10	75%	1.17E+13	8.77E+12
	Low Flow	80-100%	6.14E+08	4.09E+08	-	1.49E+11	-
22135	High Flow	0-10%	6.77E+11	2.66E+14	100%	9.72E+16	9.70E+16
	Moist Conditions	10-40%	2.97E+10	1.84E+12	98%	6.71E+14	6.60E+14
	Mid-Range Conditions	40-60%	5.91E+09	1.37E+11	96%	5.02E+13	4.80E+13
	Dry Conditions	60-80%	1.64E+09	1.73E+10	91%	6.33E+12	5.73E+12
	Low Flow	80-100%	7.48E+07	1.11E+08	33%	4.05E+10	1.32E+10
22134	High Flow	0-10%	2.88E+12	4.29E+14	99%	1.57E+17	1.55E+17
	Moist Conditions	10-40%	4.07E+11	7.93E+12	95%	2.90E+15	2.75E+15
	Mid-Range Conditions	40-60%	2.20E+11	2.33E+12	91%	8.50E+14	7.70E+14
	Dry Conditions	60-80%	1.62E+11	1.49E+12	89%	5.45E+14	4.86E+14
	Low Flow	80-100%	1.31E+11	7.20E+11	82%	2.63E+14	2.15E+14
16434	High Flow	0-10%	2.88E+12	8.79E+14	100%	3.21E+17	3.20E+17
	Moist Conditions	10-40%	4.06E+11	1.81E+13	98%	6.61E+15	6.46E+15
	Mid-Range Conditions	40-60%	2.19E+11	2.93E+12	93%	1.07E+15	9.88E+14
	Dry Conditions	60-80%	1.61E+11	1.03E+12	84%	3.78E+14	3.19E+14
	Low Flow	80-100%	1.32E+11	4.97E+11	74%	1.82E+14	1.33E+14
13622	High Flow	0-10%	3.69E+13	1.38E+15	97%	5.04E+17	4.90E+17
	Moist Conditions	10-40%	1.61E+12	1.74E+13	91%	6.35E+15	5.76E+15
	Mid-Range Conditions	40-60%	4.35E+11	2.67E+12	84%	9.76E+14	8.17E+14
	Dry Conditions	60-80%	2.06E+11	9.04E+11	77%	3.30E+14	2.55E+14
	Low Flow	80-100%	8.83E+10	2.64E+11	67%	9.63E+13	6.40E+13
22133	High Flow	0-10%	7.87E+10	1.33E+14	100%	4.84E+16	4.84E+16
	Moist Conditions	10-40%	2.41E+09	5.81E+11	100%	2.12E+14	2.11E+14
	Mid-Range Conditions	40-60%	5.03E+08	4.42E+10	99%	1.61E+13	1.60E+13
	Dry Conditions	60-80%	1.49E+08	6.36E+09	98%	2.32E+12	2.27E+12
	Low Flow	80-100%	2.78E+07	4.40E+08	94%	1.61E+11	1.50E+11
13621	High Flow	0-10%	7.11E+11	2.37E+14	100%	8.64E+16	8.62E+16
	Moist Conditions	10-40%	5.19E+10	1.48E+13	100%	5.40E+15	5.38E+15
	Mid-Range Conditions	40-60%	1.05E+10	1.48E+12	99%	5.41E+14	5.37E+14
	Dry Conditions	60-80%	3.80E+09	2.69E+11	99%	9.83E+13	9.69E+13
	Low Flow	80-100%	5.25E+08	3.33E+09	84%	1.21E+12	1.02E+12
21990	High Flow	0-10%	5.31E+11	3.04E+15	100%	1.11E+18	1.11E+18
	Moist Conditions	10-40%	4.57E+10	5.29E+13	100%	1.93E+16	1.93E+16
	Mid-Range Conditions	40-60%	1.12E+10	4.71E+12	100%	1.72E+15	1.72E+15
	Dry Conditions	60-80%	5.51E+09	1.36E+12	100%	4.97E+14	4.95E+14
	Low Flow	80-100%	1.63E+09	1.51E+11	99%	5.53E+13	5.47E+13
20790	High Flow	0-10%	4.70E+11	1.05E+16	100%	3.84E+18	3.84E+18
	Moist Conditions	10-40%	2.98E+10	3.17E+13	100%	1.16E+16	1.16E+16
	Mid-Range Conditions	40-60%	7.00E+09	1.21E+12	99%	4.41E+14	4.38E+14
	Dry Conditions	60-80%	3.53E+09	2.44E+11	99%	8.91E+13	8.78E+13
	Low Flow	80-100%	9.69E+08	1.04E+10	91%	3.80E+12	3.44E+12

Appendix G: Load Duration Curve Results

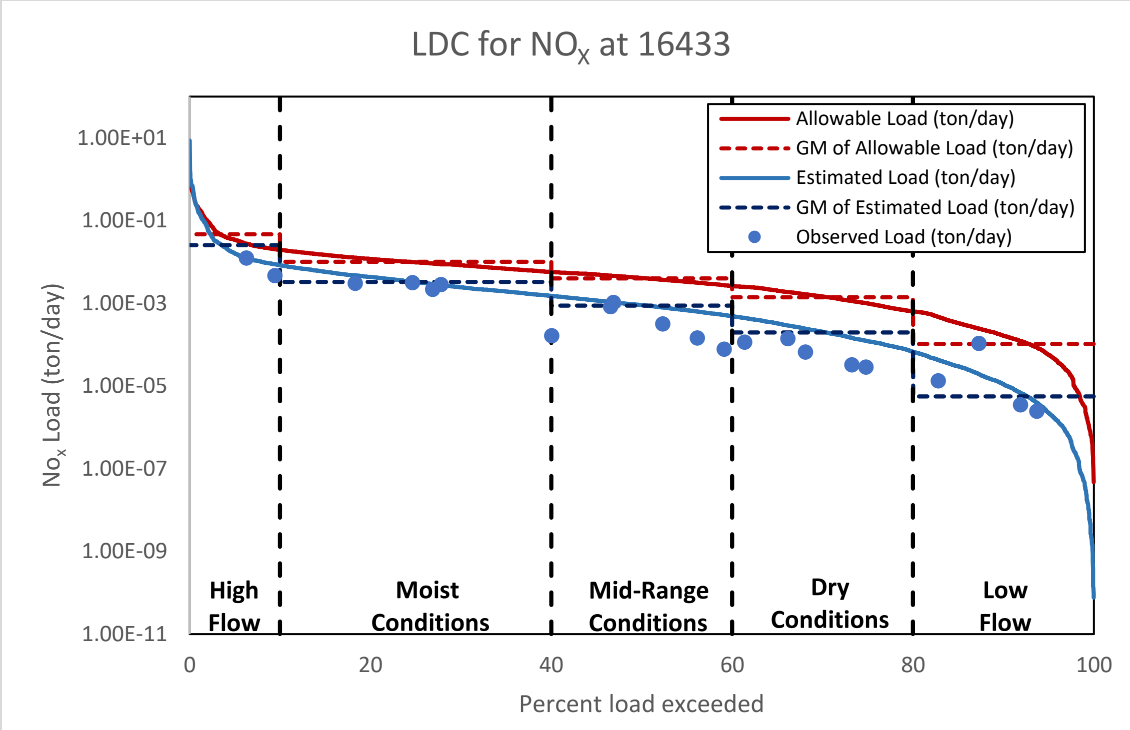


Figure G-1 LDC for NOx at surface water quality monitoring station 16433

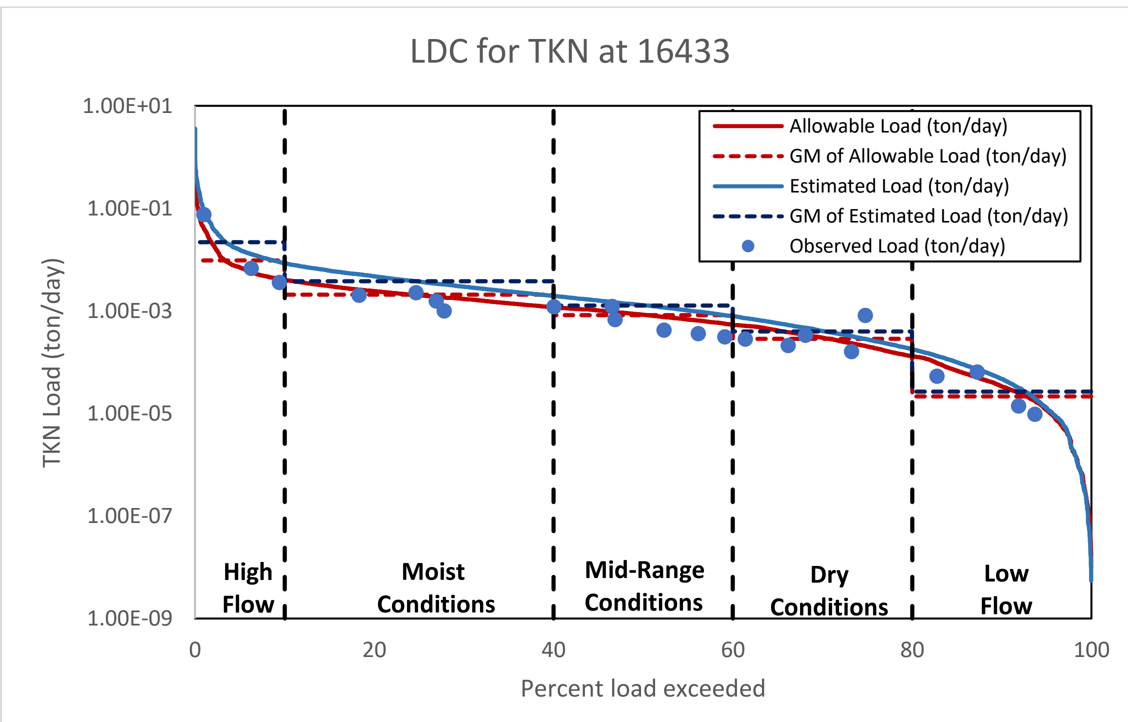


Figure G-2 LDC for TKN at surface water quality monitoring station 16433

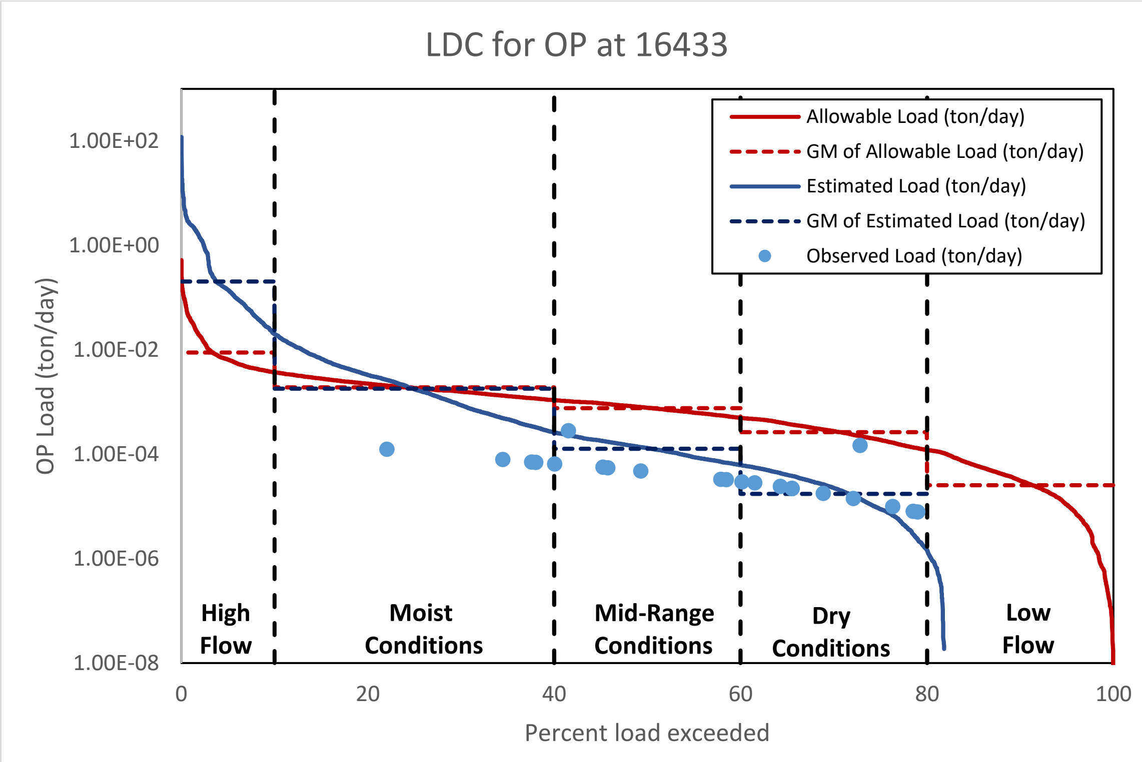


Figure G-3 LDC for OP at surface water quality monitoring station 16433

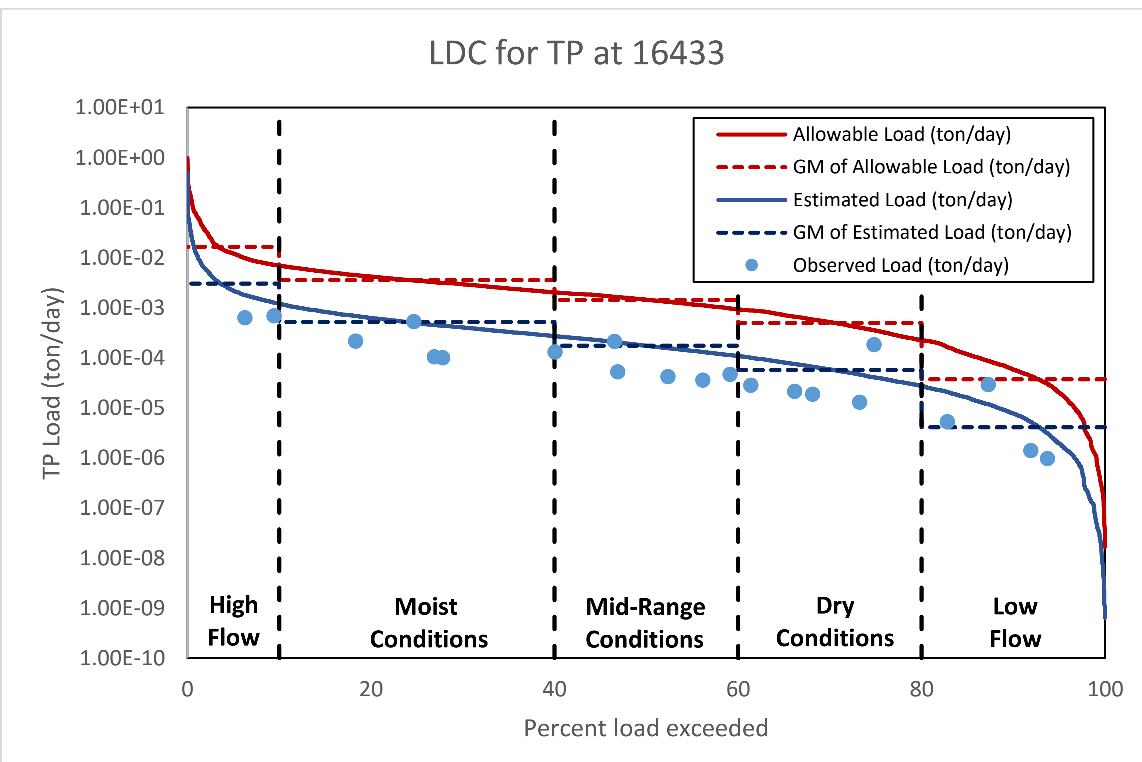


Figure G-4 LDC for TP at surface water quality monitoring station 16433

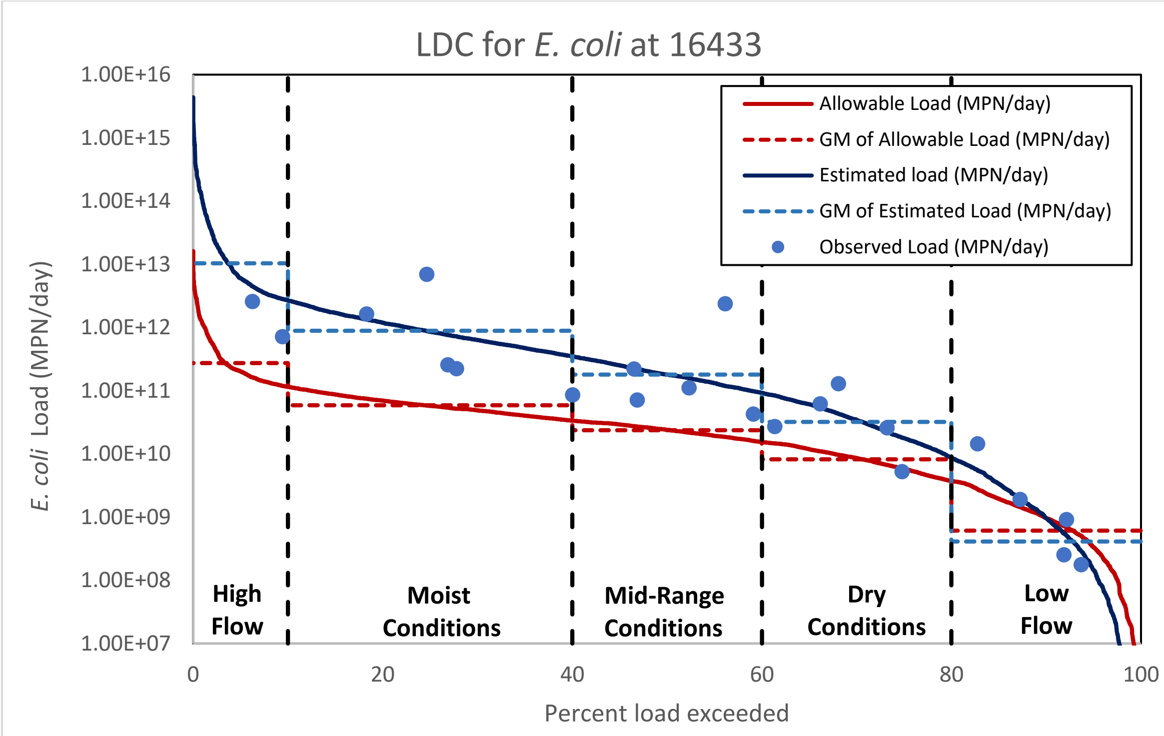


Figure G-5 LDC for *E. coli* at surface water quality monitoring station 16433

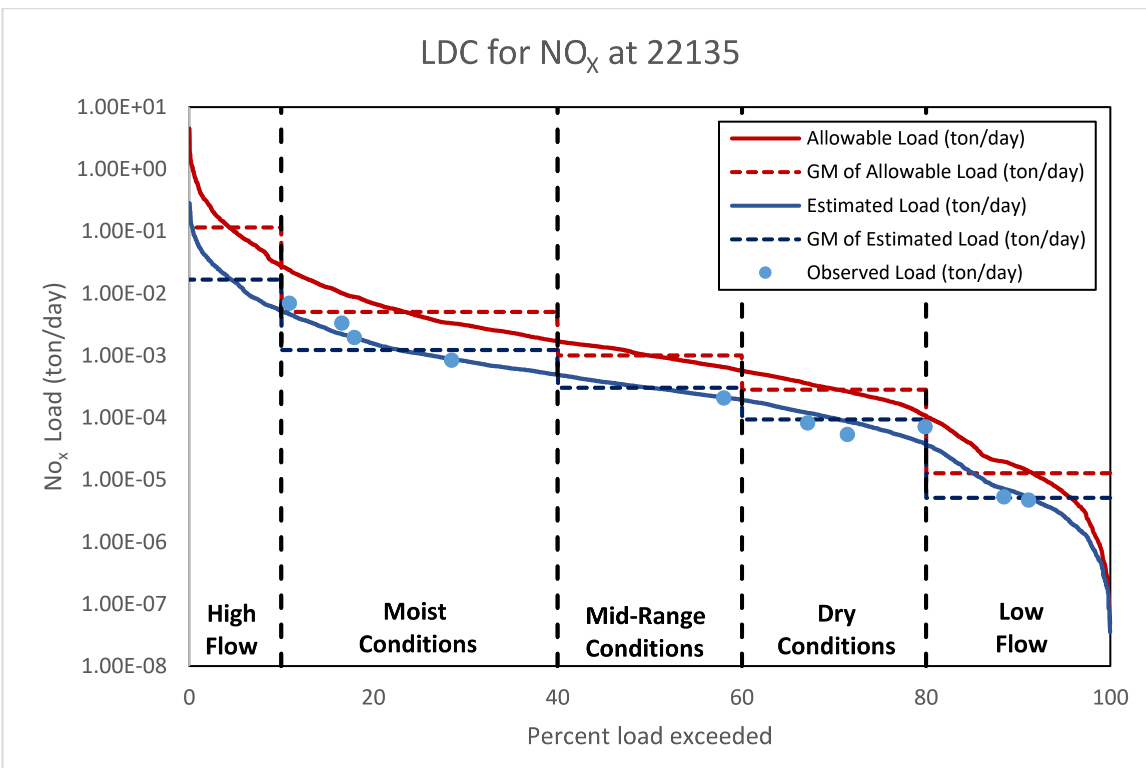


Figure G-6 LDC for NOx at surface water quality monitoring station 22135

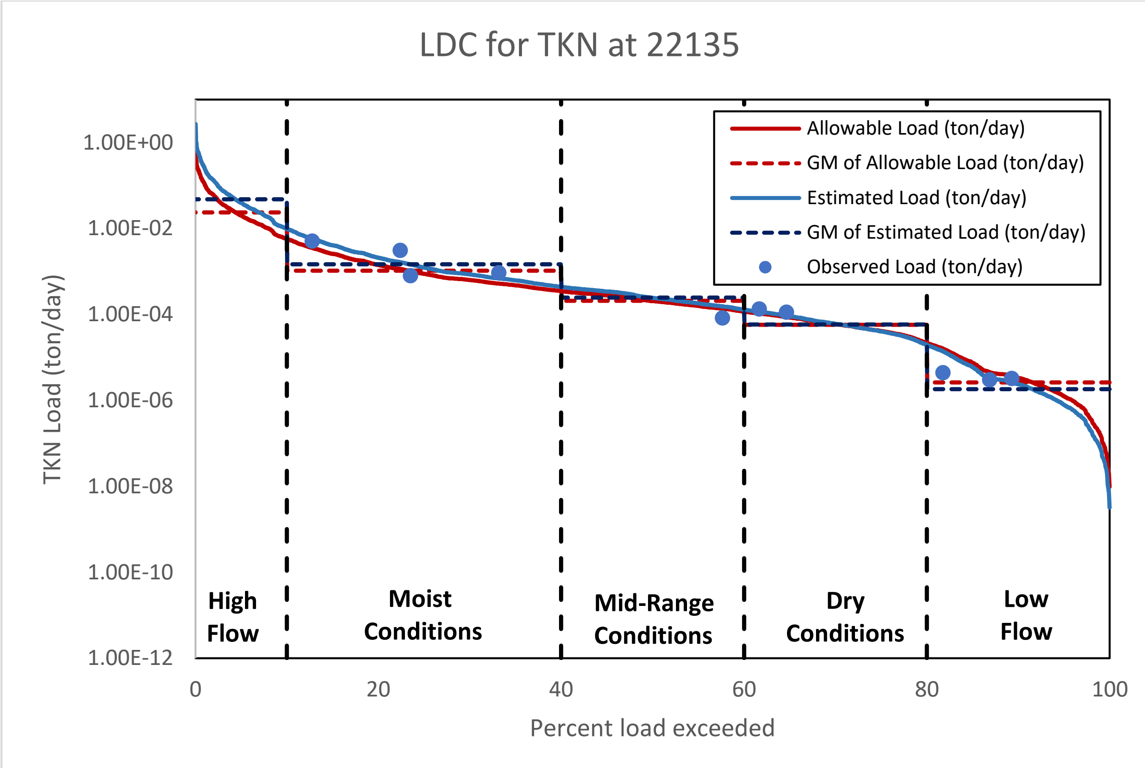


Figure G-7 LDC for TKN at surface water quality monitoring station 22135

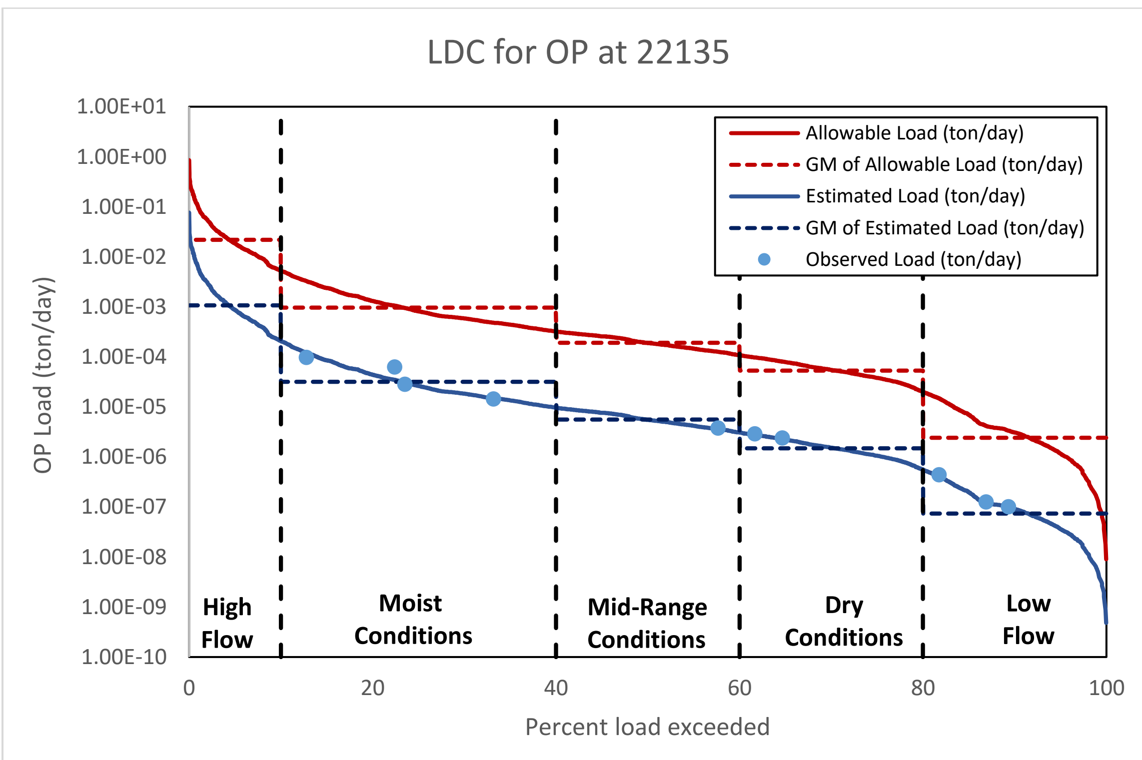


Figure G-8 LDC for OP at surface water quality monitoring station 22135

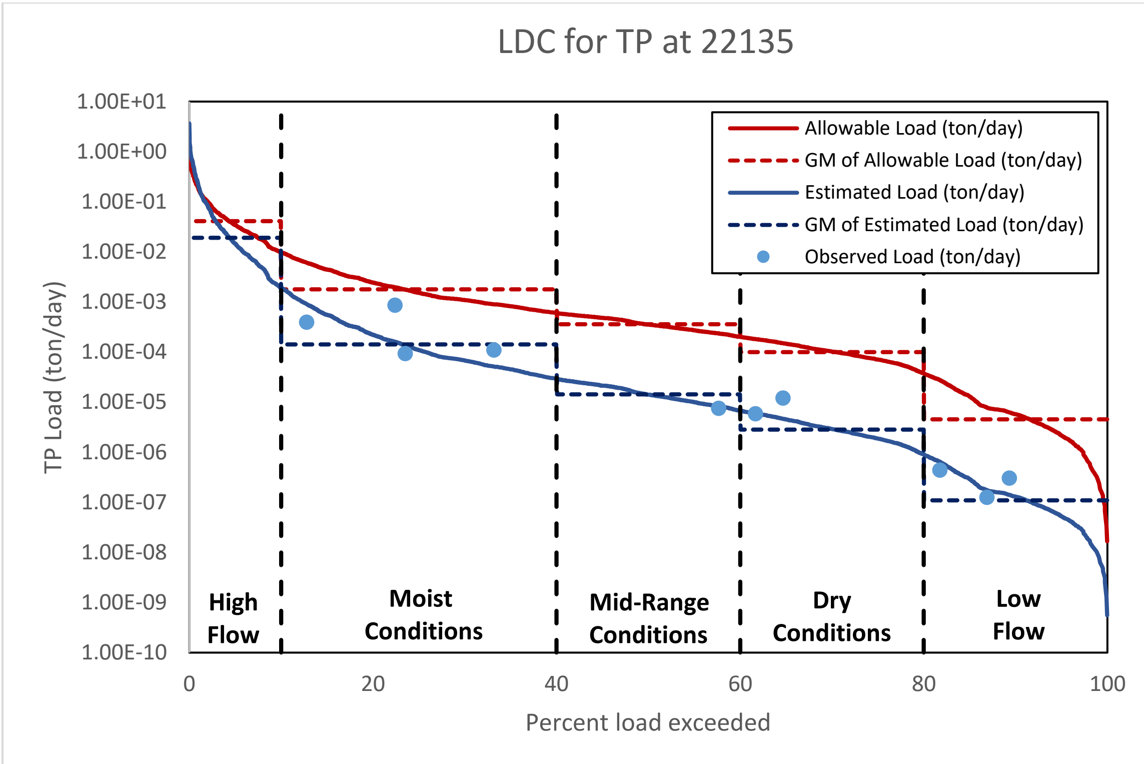


Figure G-9 LDC for TP at surface water quality monitoring station 22135

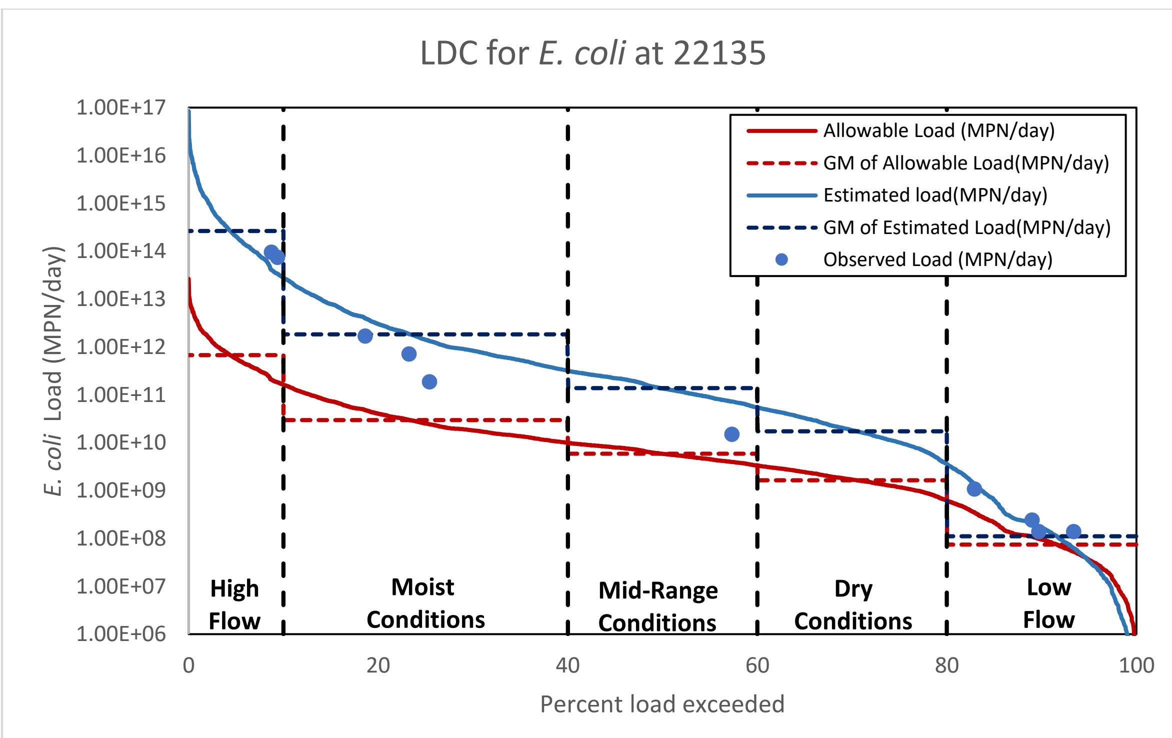


Figure G-10 LDC for *E. coli* at surface water quality monitoring station 22135

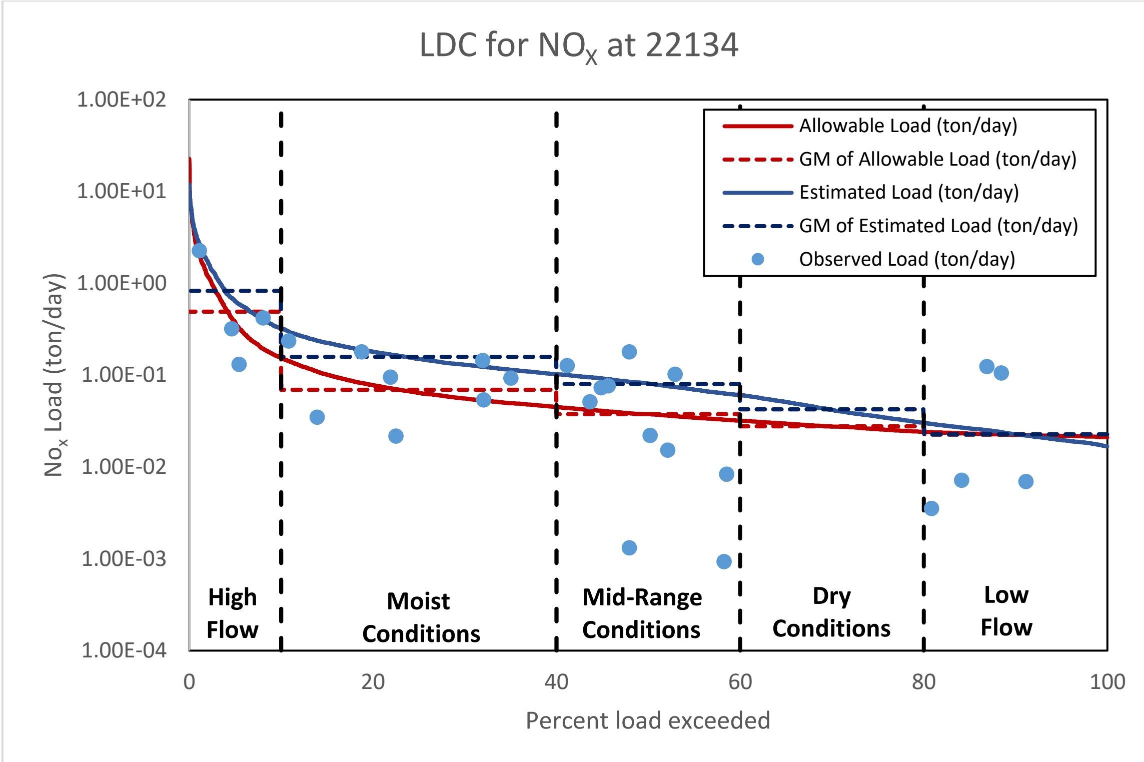


Figure G-11 LDC for NOx at surface water quality monitoring station 22134

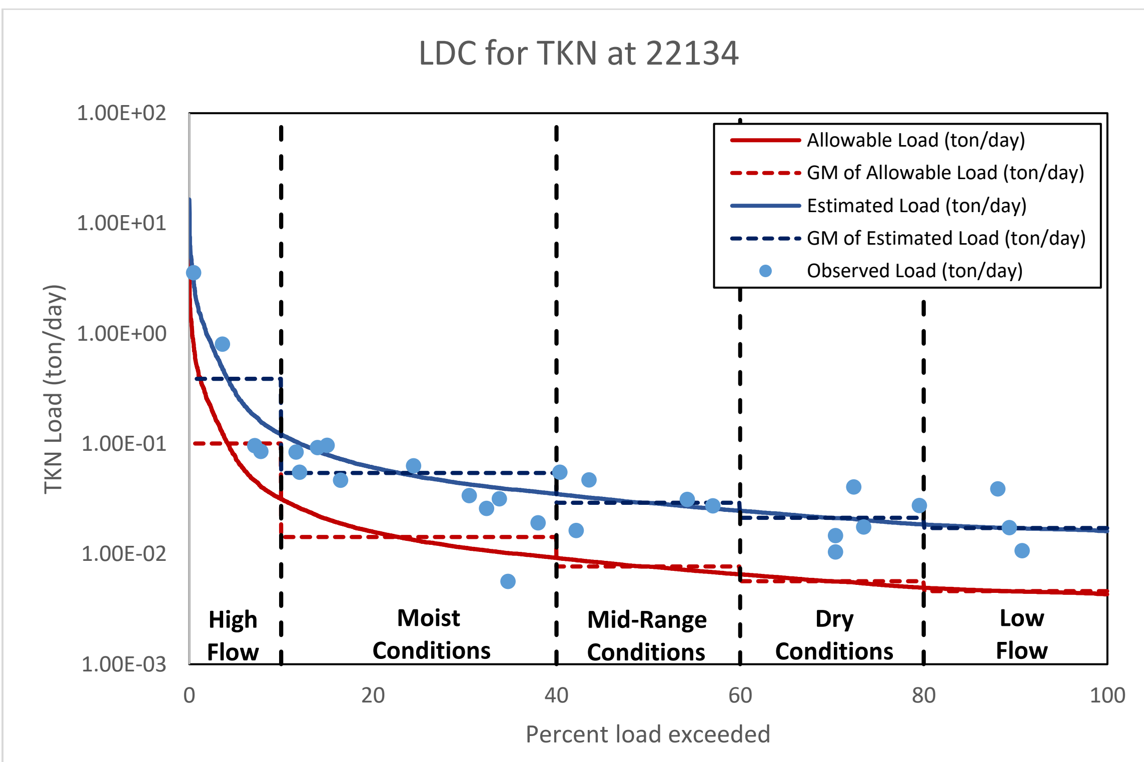


Figure G-12 LDC for TKN at surface water quality monitoring station 22134

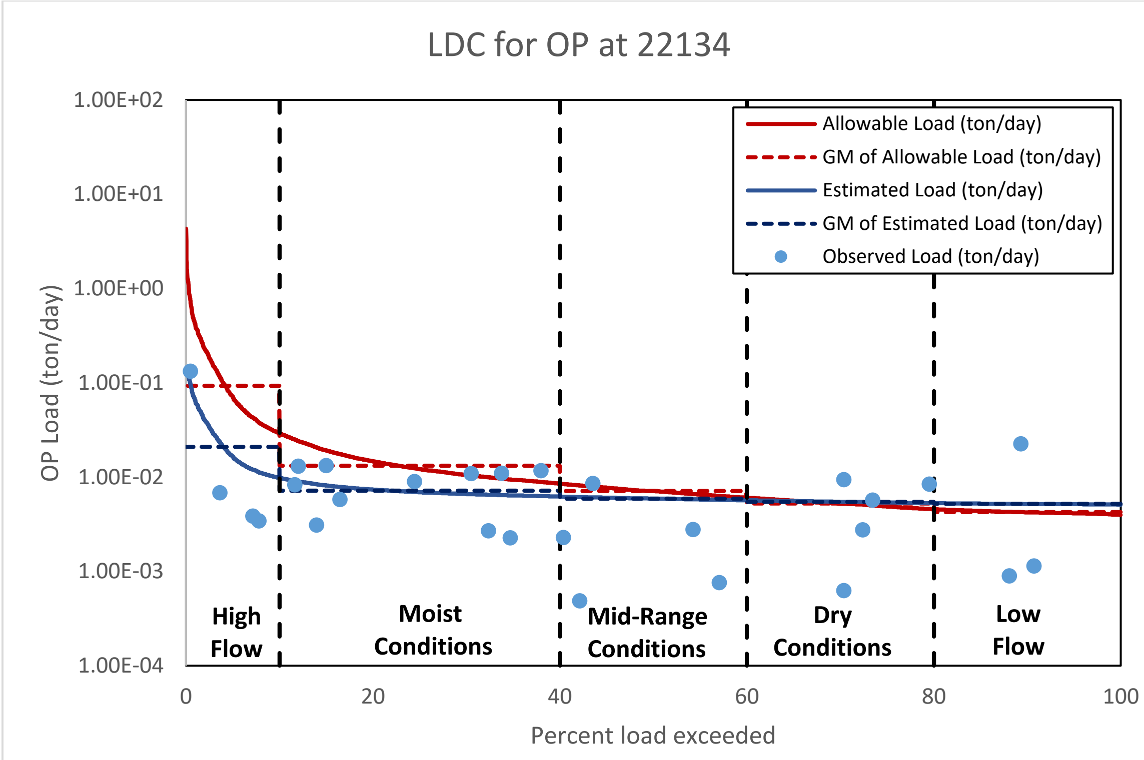


Figure G-13 LDC for OP at surface water quality monitoring station 22134

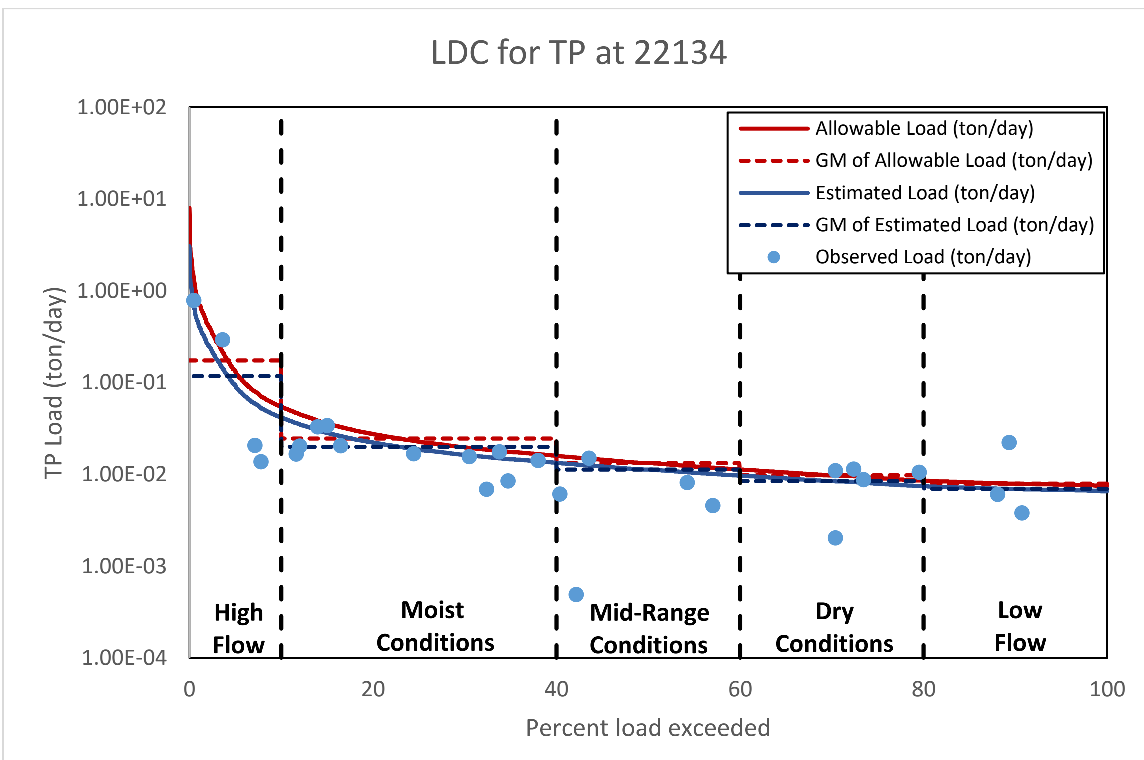


Figure G-14 LDC for TP at surface water quality monitoring station 22134

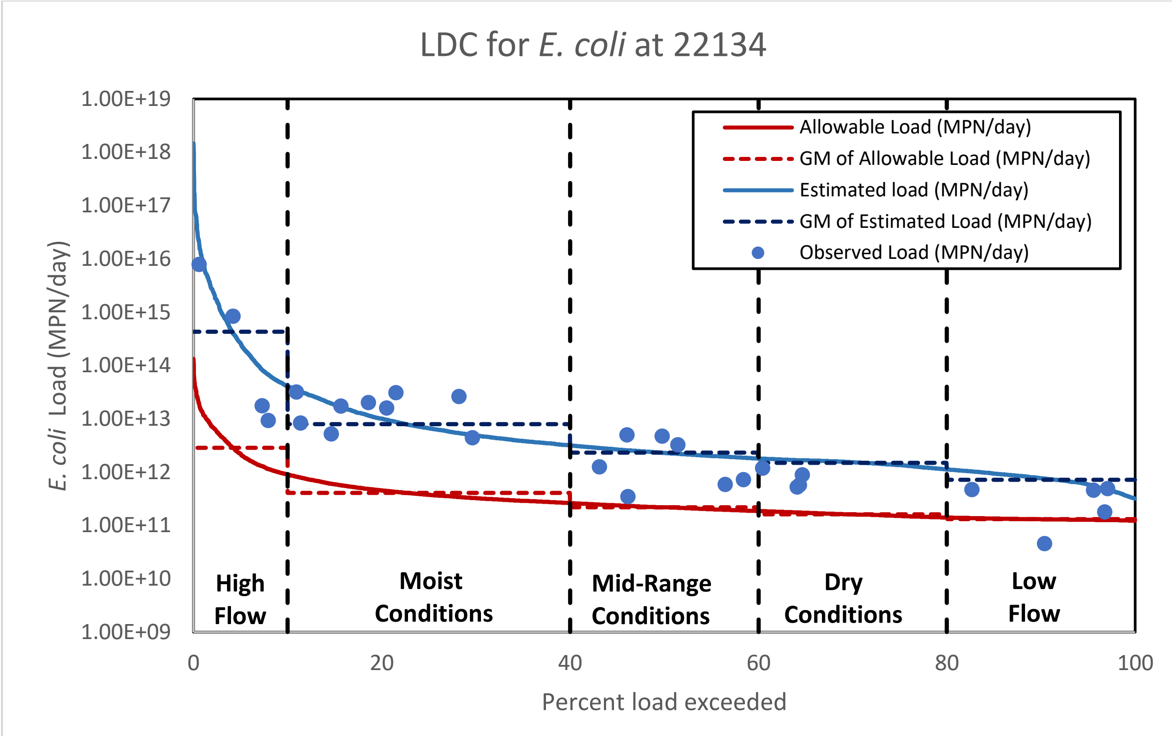


Figure G-15 LDC for *E. coli* at surface water quality monitoring station 22134

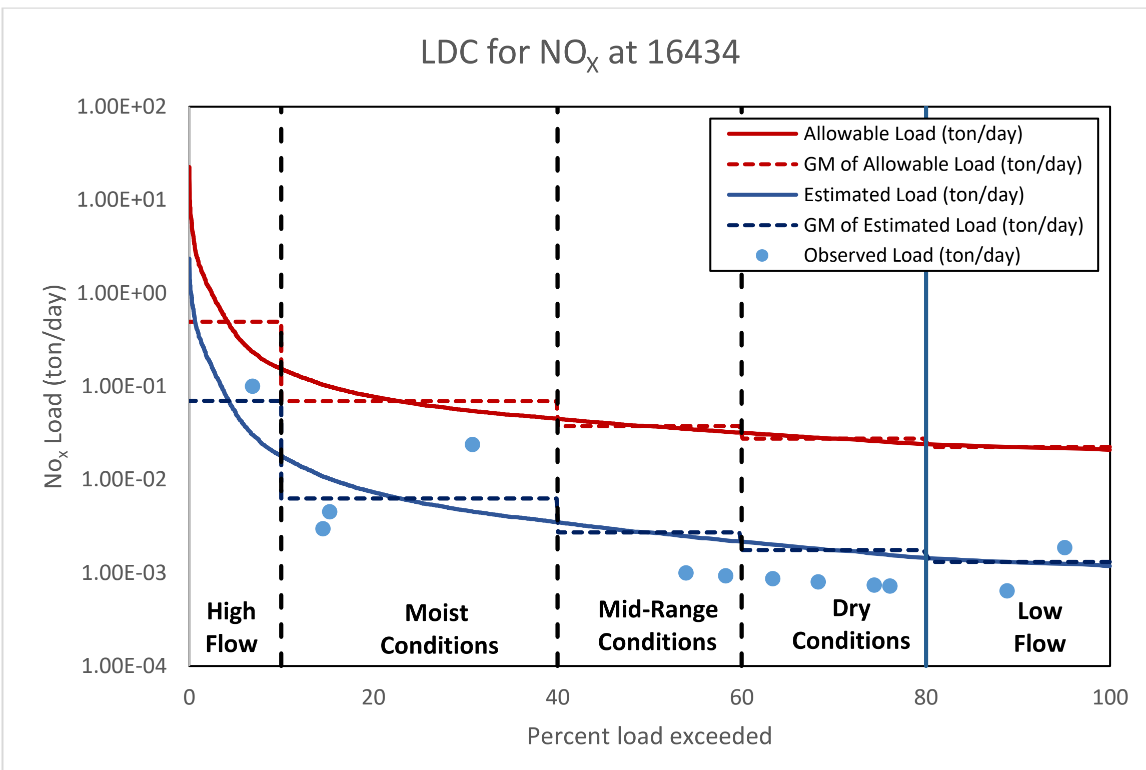


Figure G-16 LDC for NOx at surface water quality monitoring station 16434

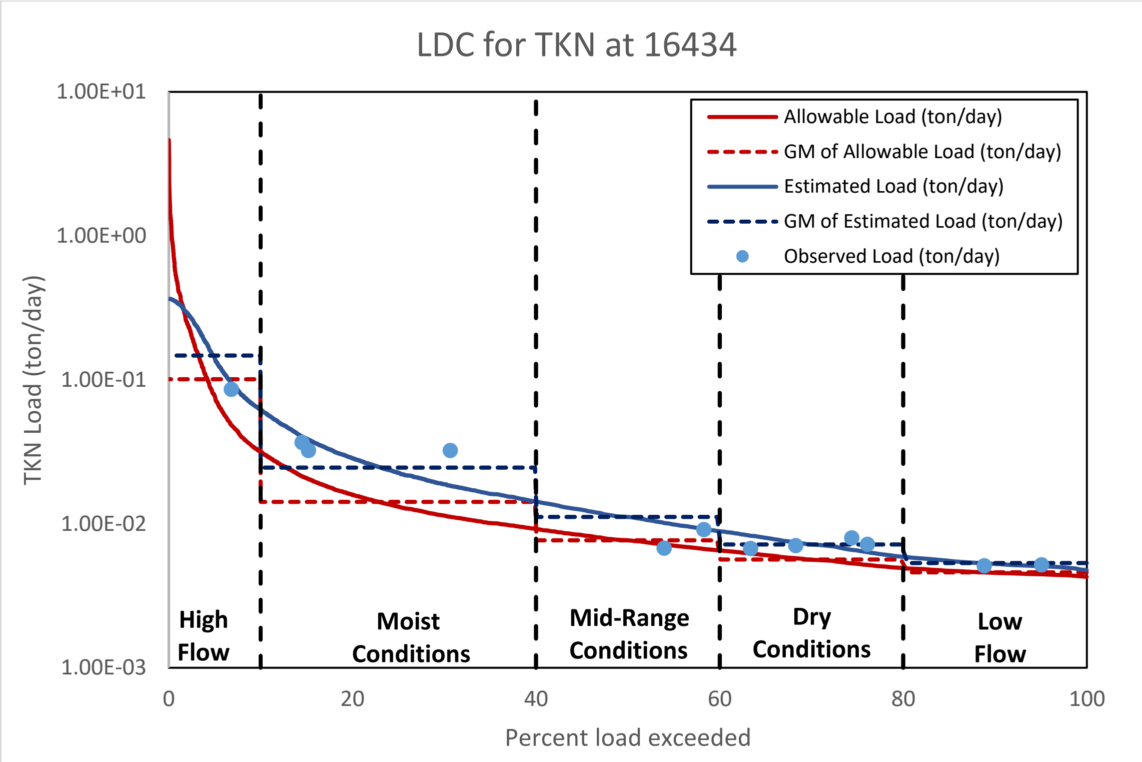


Figure G-17 LDC for TKN at surface water quality monitoring station 16434

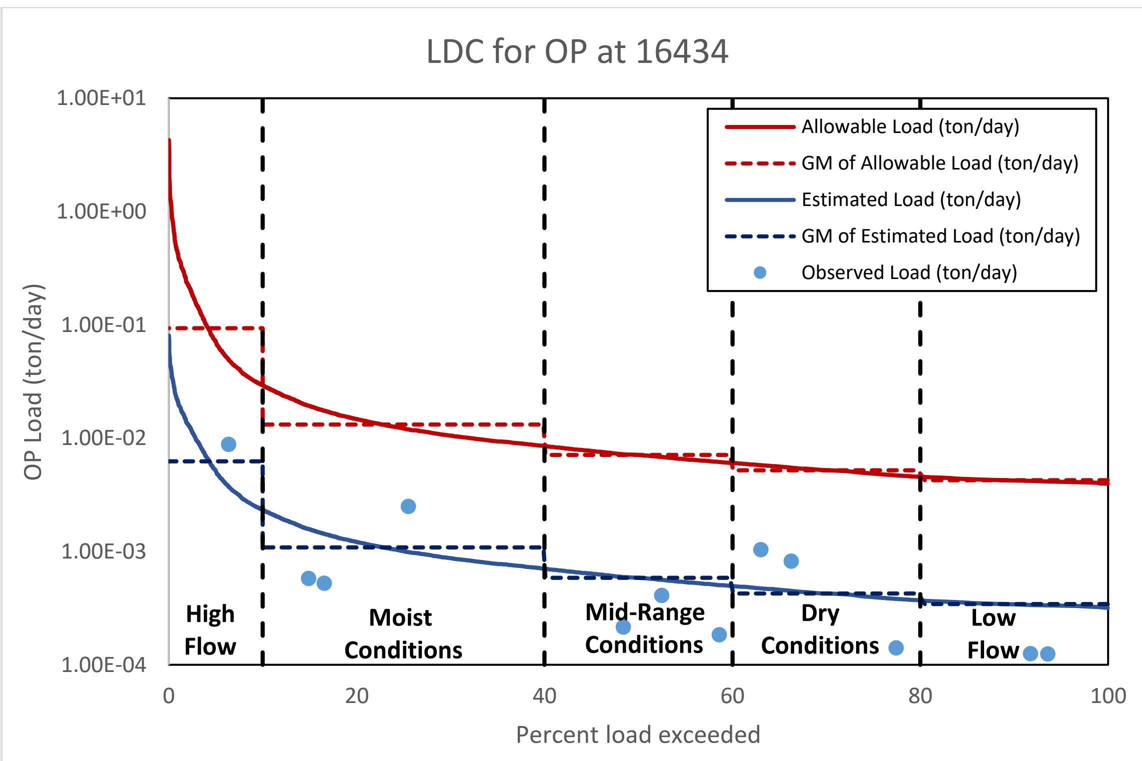


Figure G-18 LDC for OP at surface water quality monitoring station 16434

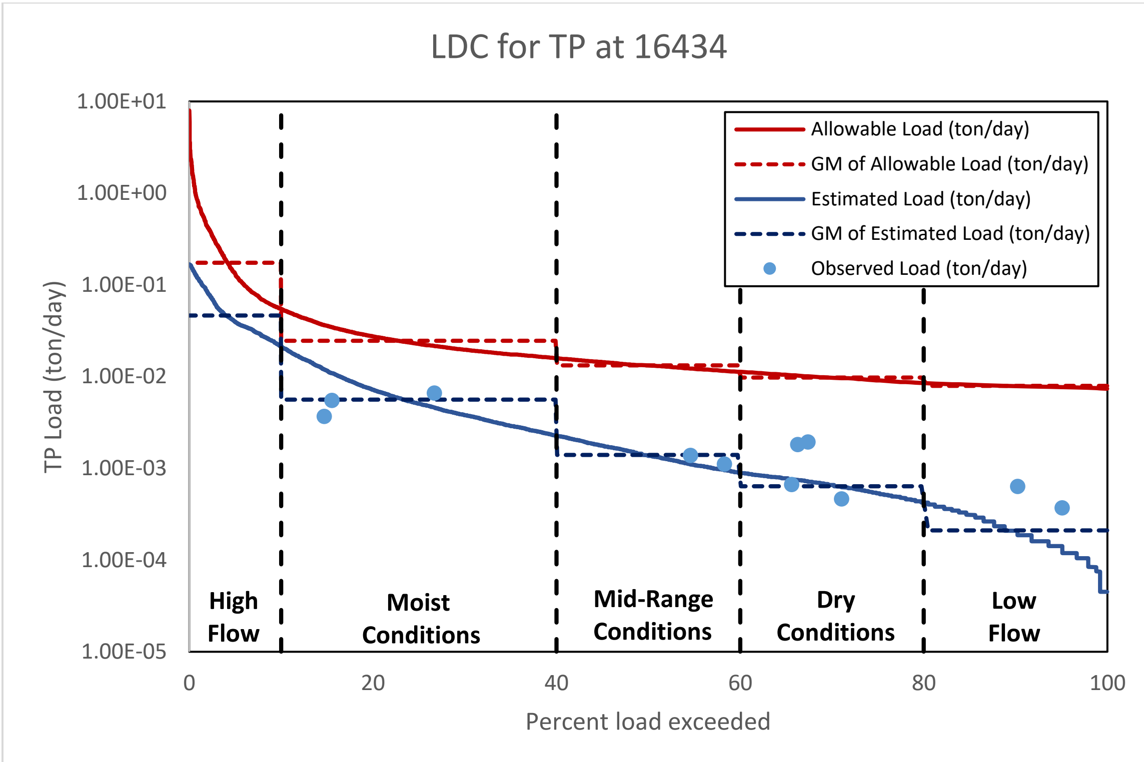


Figure G-19 LDC for TP at surface water quality monitoring station 16434

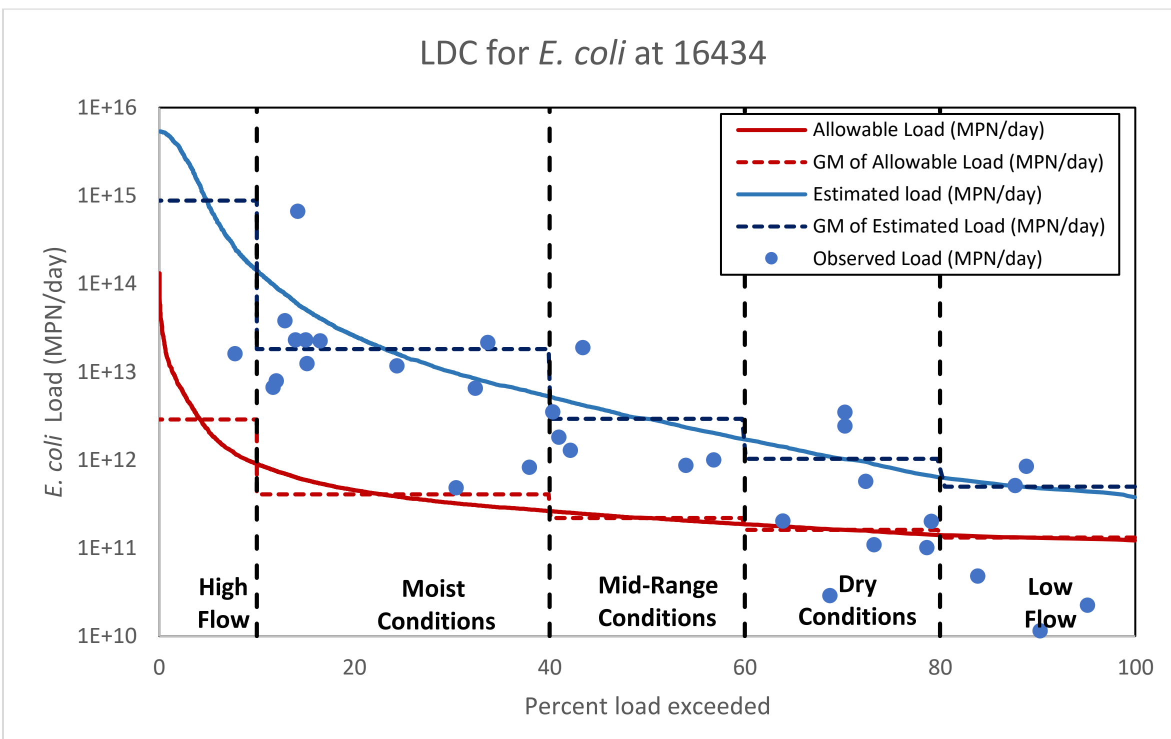


Figure G-20 LDC for *E. coli* at surface water quality monitoring station 16434

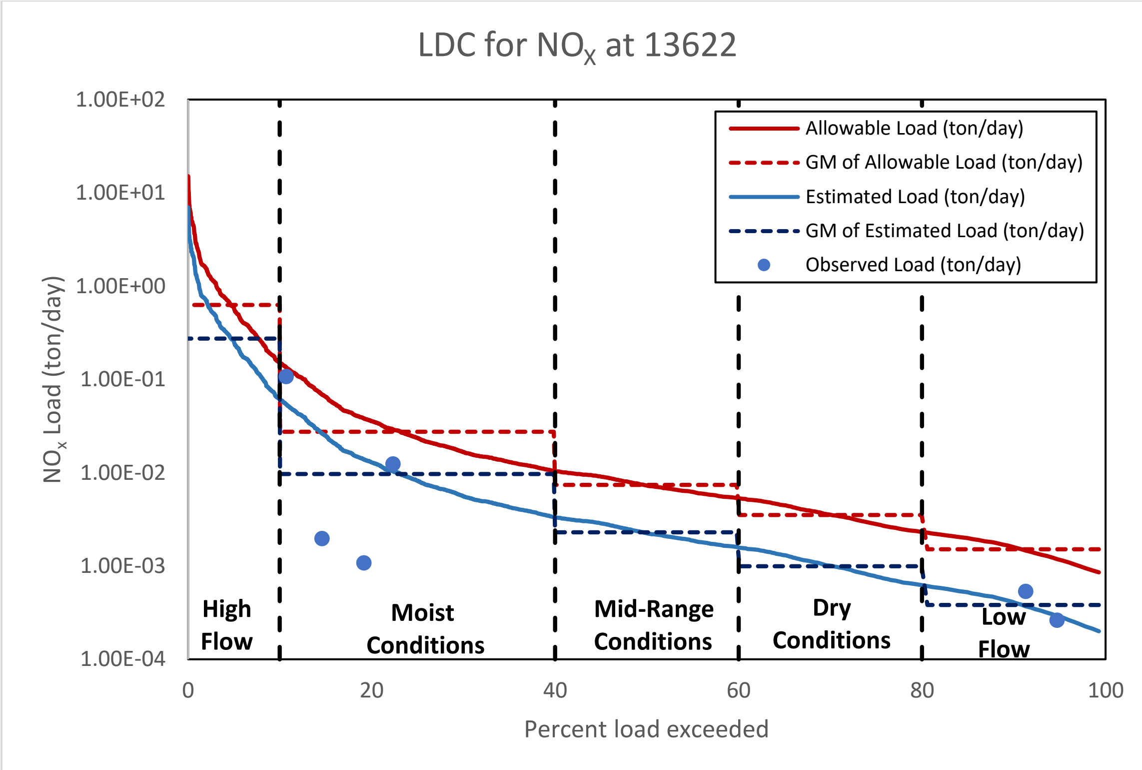


Figure G-21 LDC for NOx at surface water quality monitoring station 13622

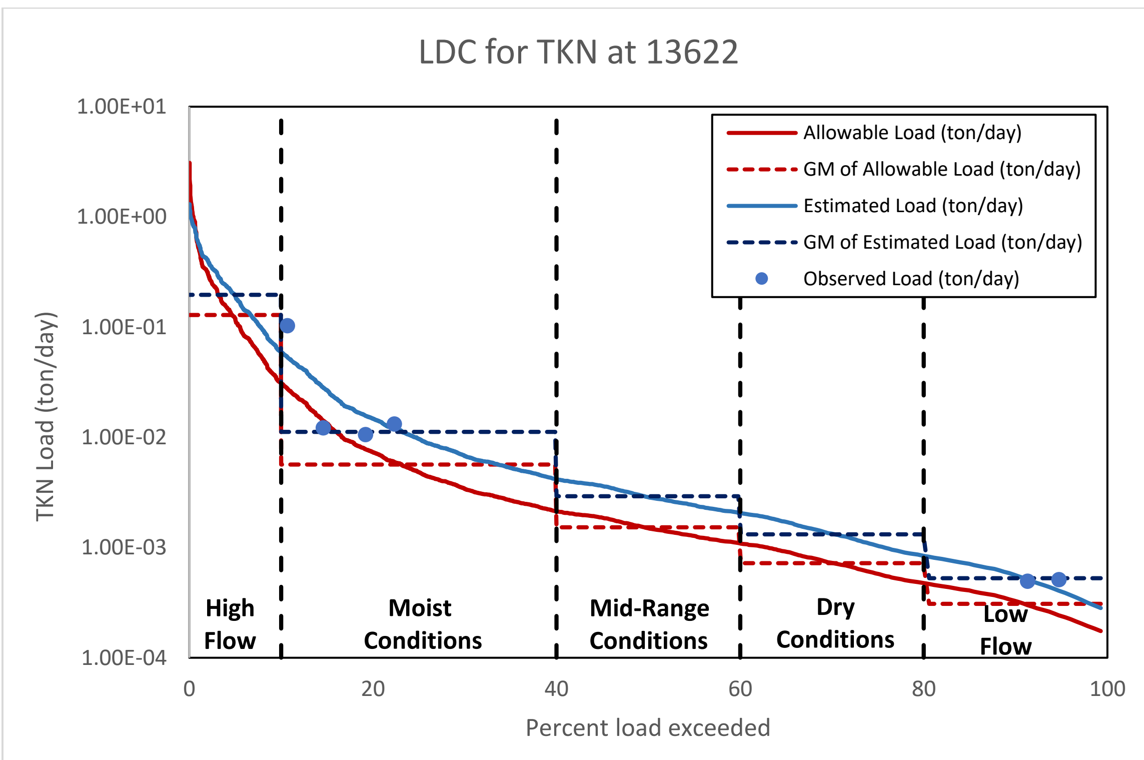


Figure G-22 LDC for TKN at surface water quality monitoring station 13622

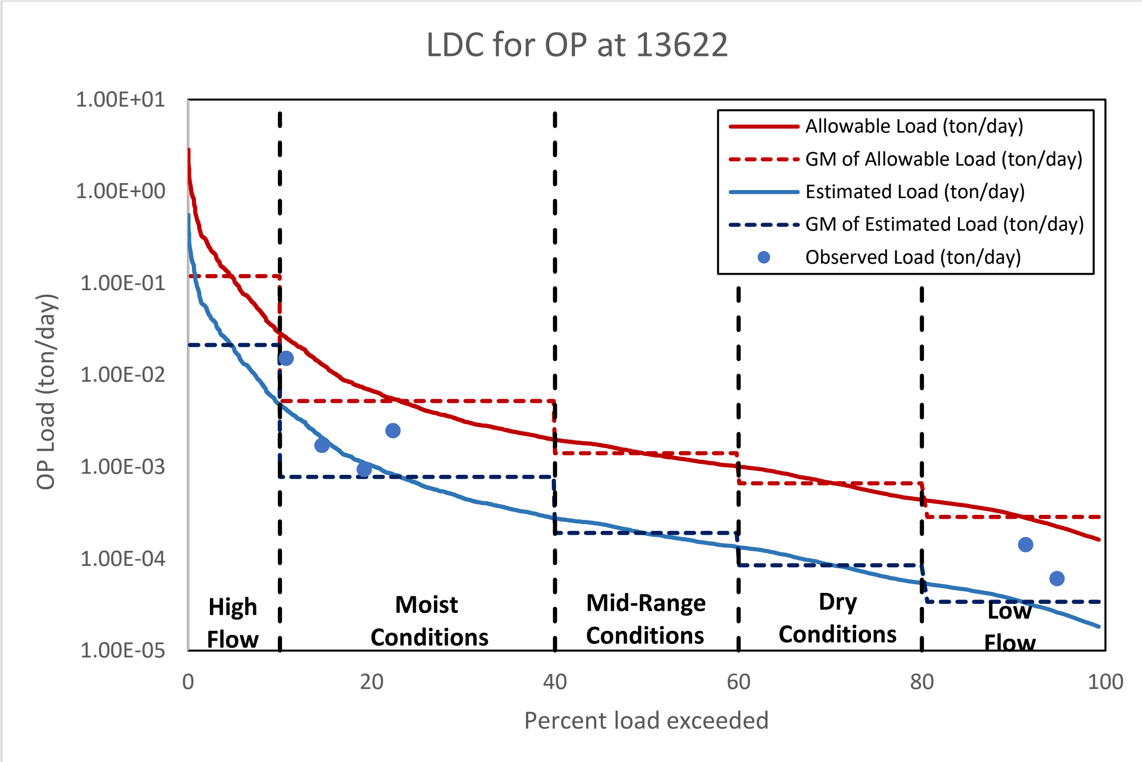


Figure G-23 LDC for OP at surface water quality monitoring station 13622

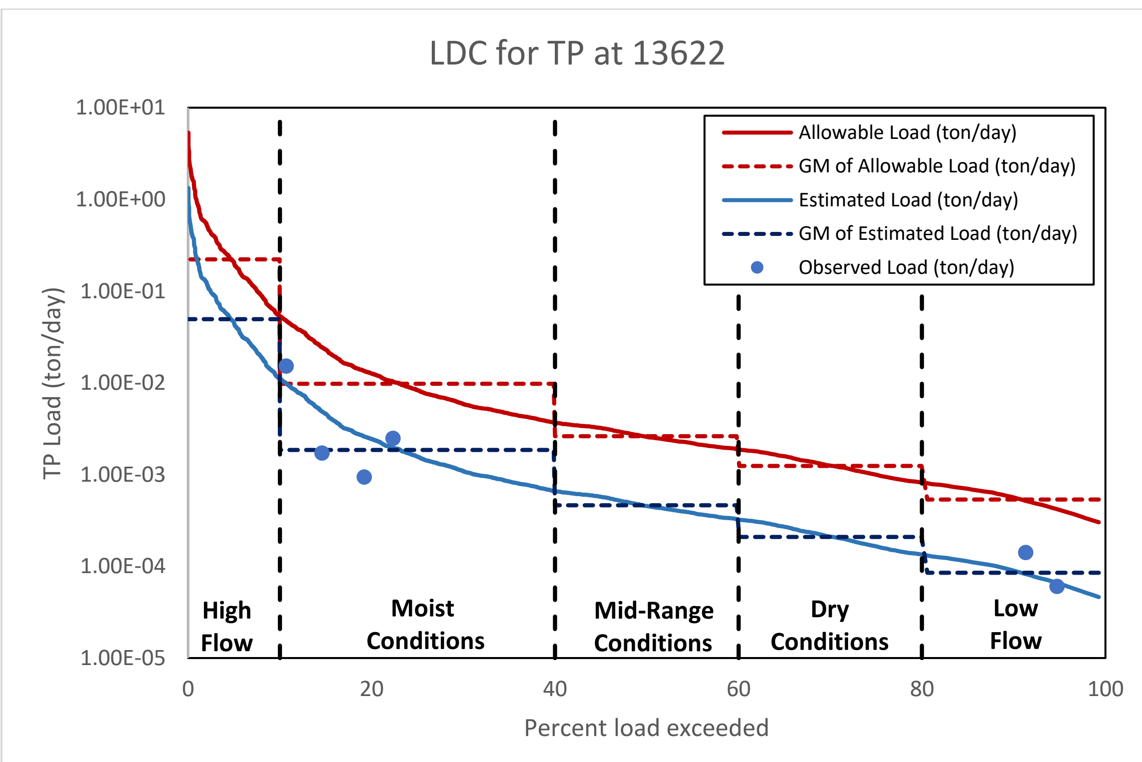


Figure G-24 LDC for TP at surface water quality monitoring station 13622

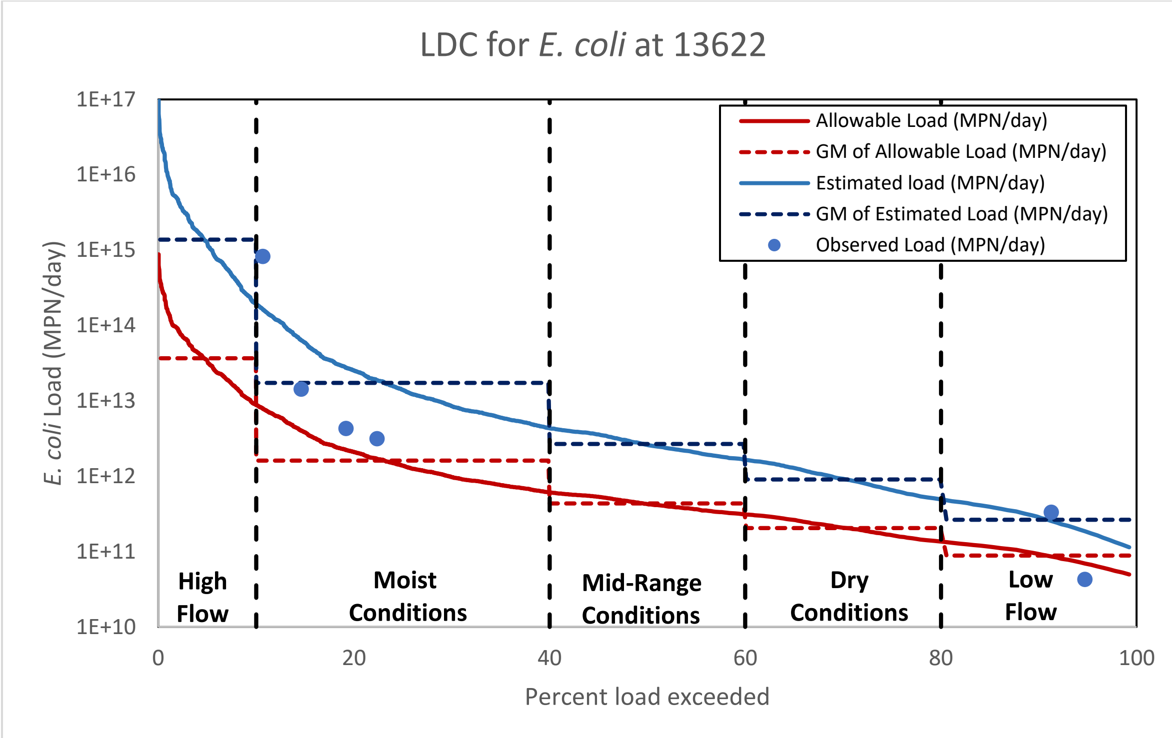


Figure G-25 LDC for *E. coli* at surface water quality monitoring station 13622

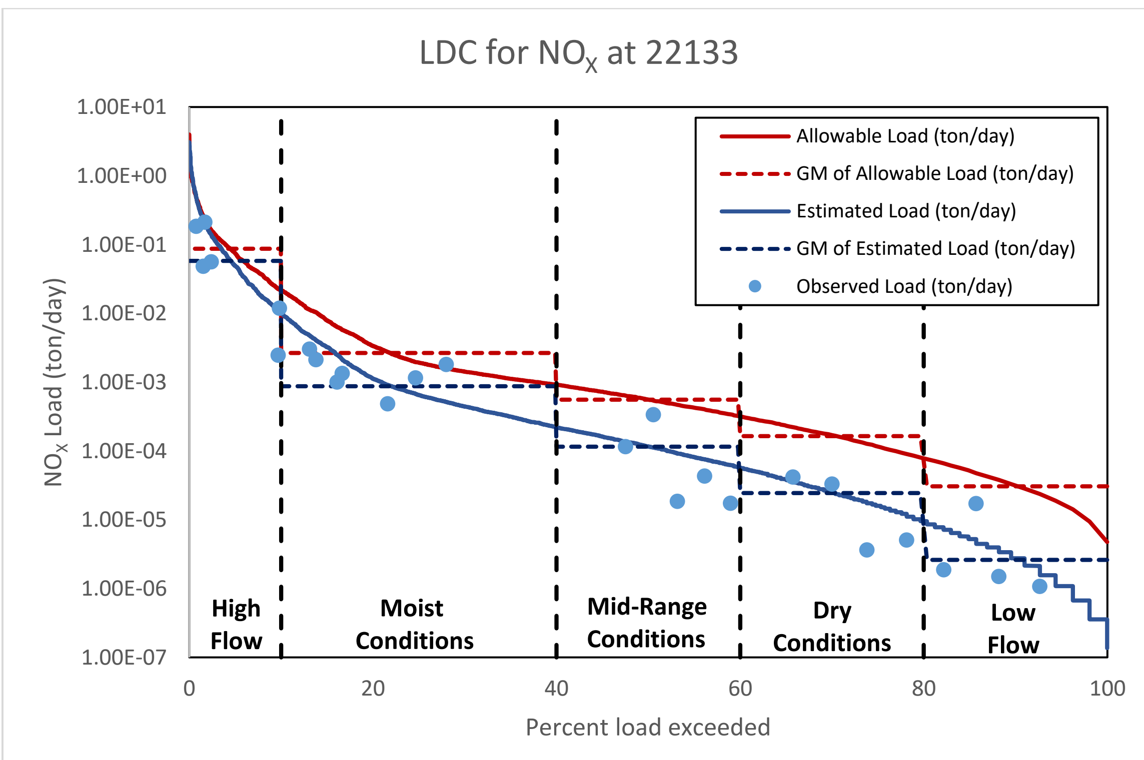


Figure G-26 LDC for NOx at surface water quality monitoring station 22133

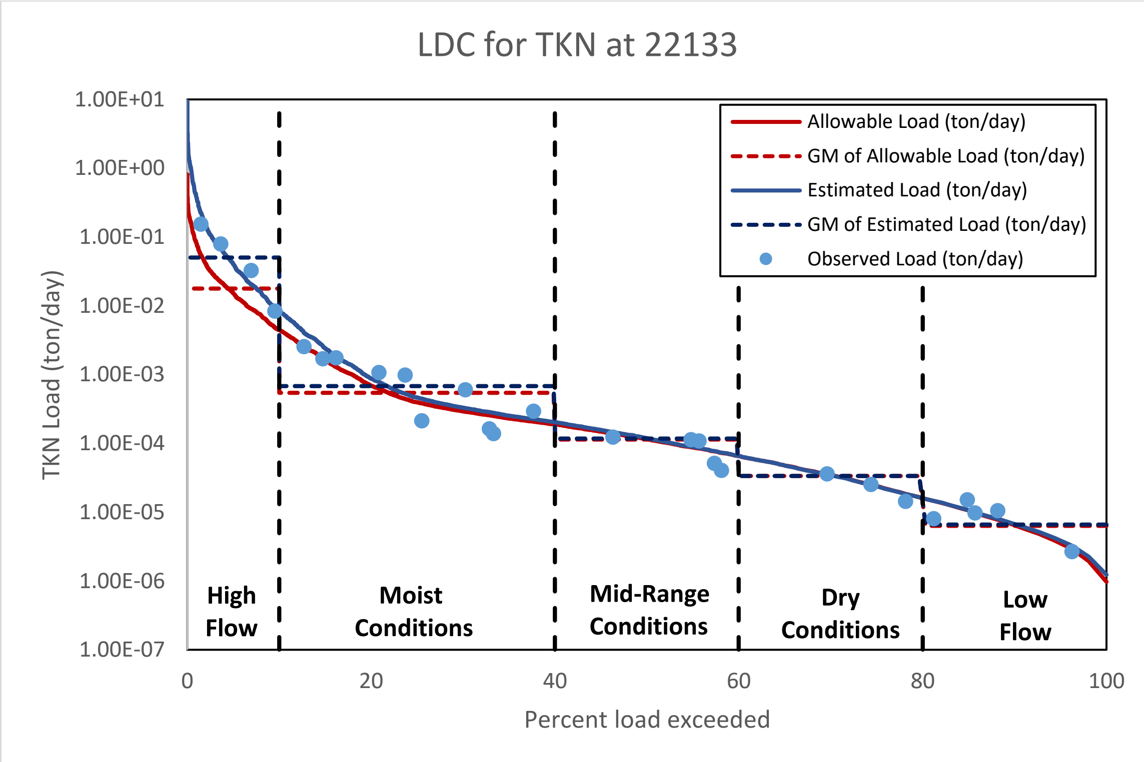


Figure G-27 LDC for TKN at surface water quality monitoring station 22133

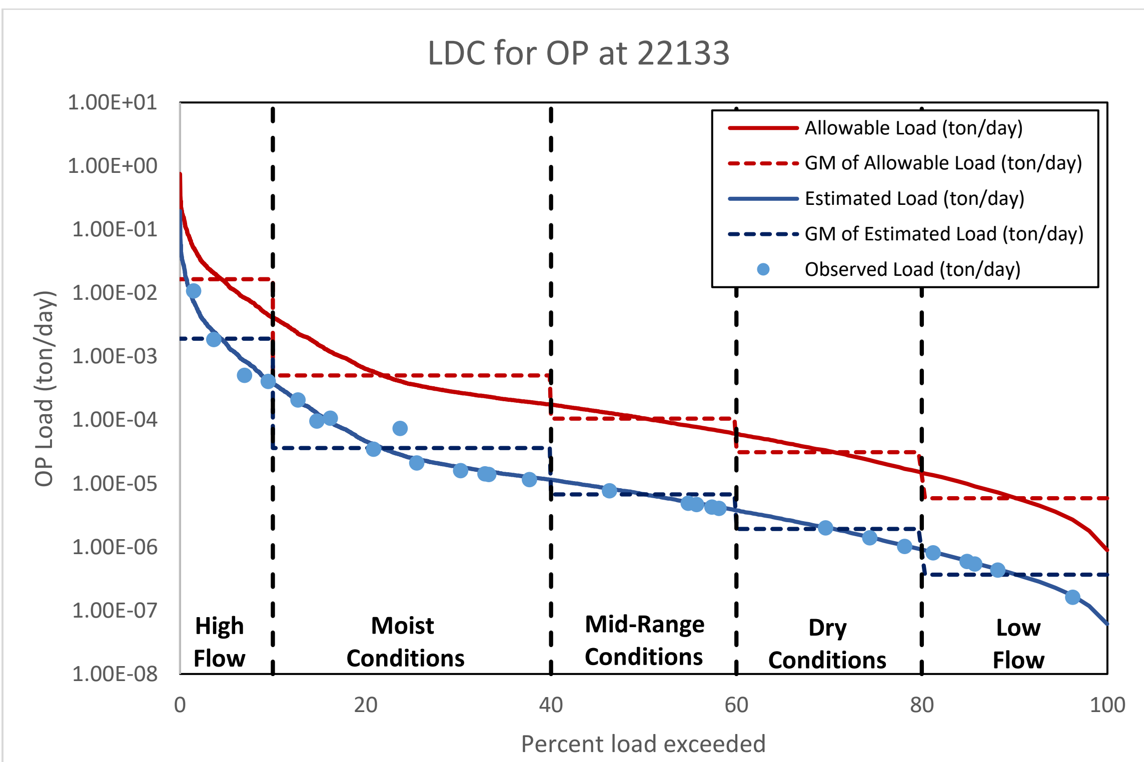


Figure G-28 LDC for OP at surface water quality monitoring station 22133

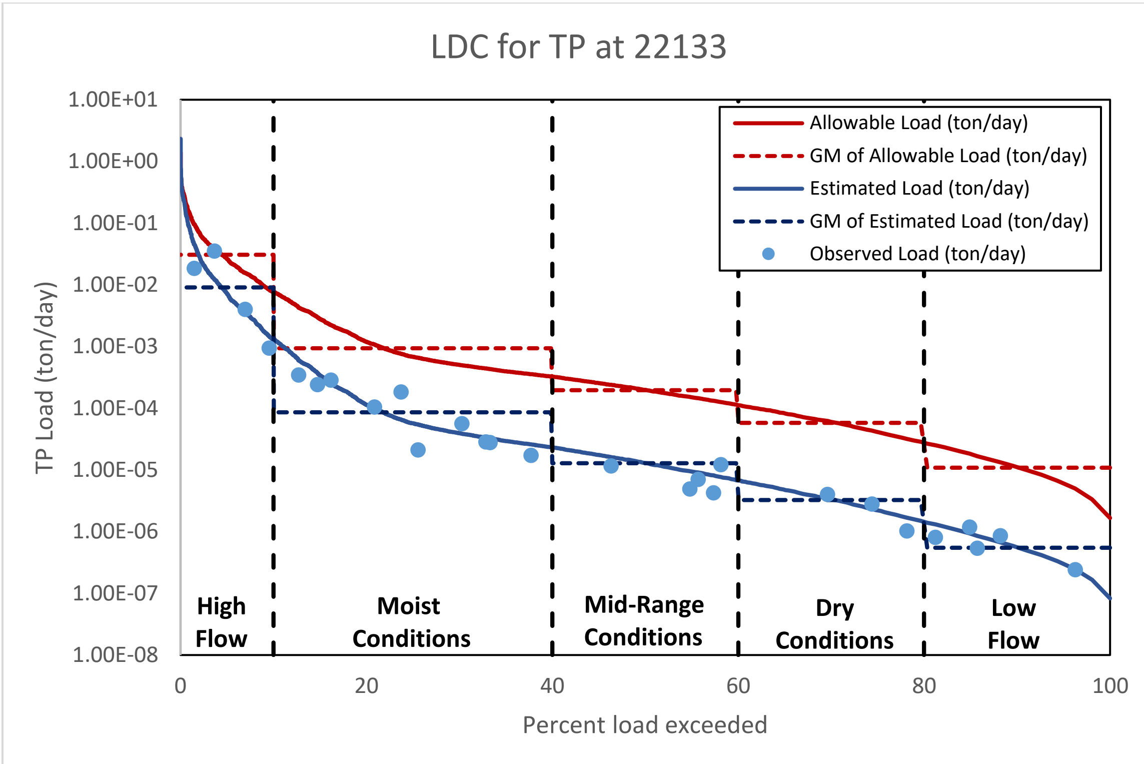


Figure G-29 LDC for TP at surface water quality monitoring station 22133

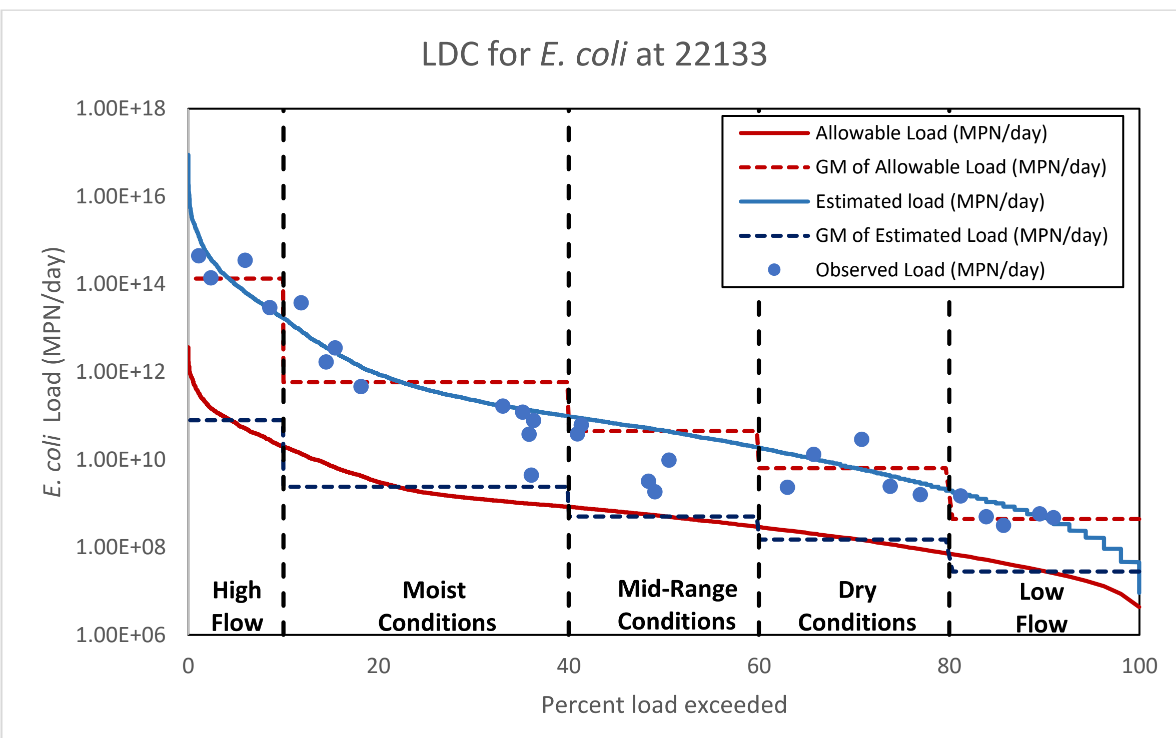


Figure G-30 LDC for *E. coli* at surface water quality monitoring station 22133

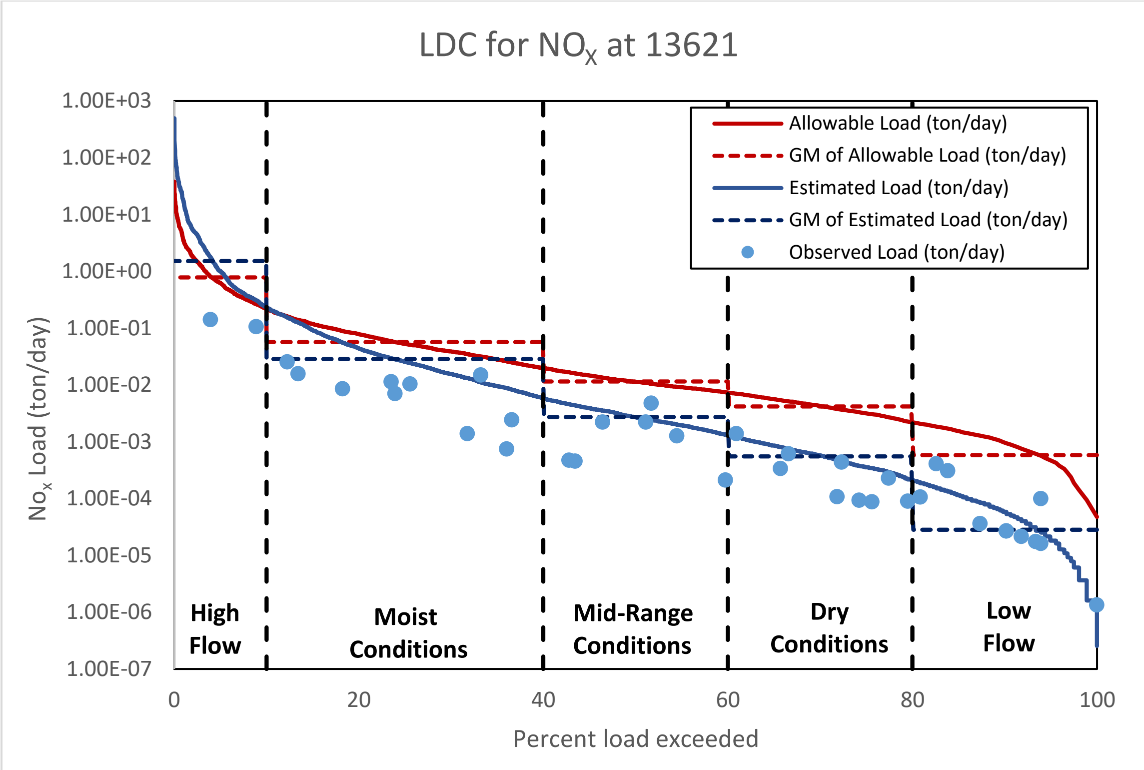


Figure G-31 LDC for NOx at surface water quality monitoring station 13621

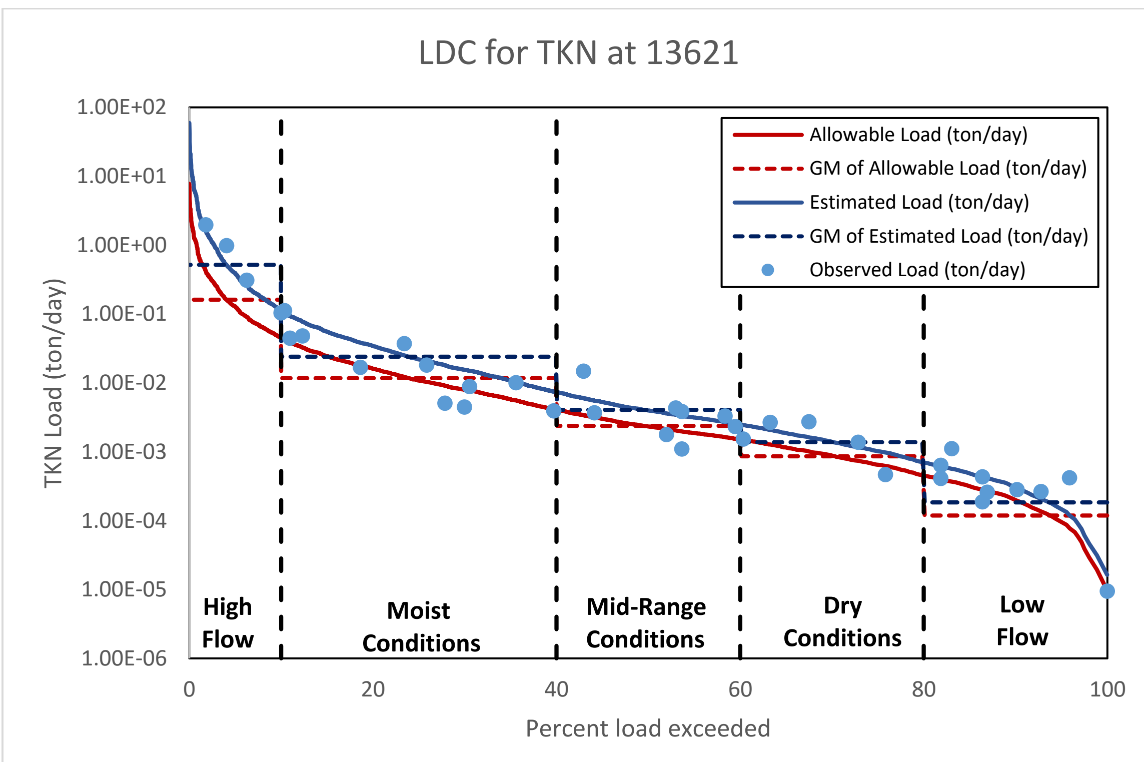


Figure G-32 LDC for TKN at surface water quality monitoring station 13621

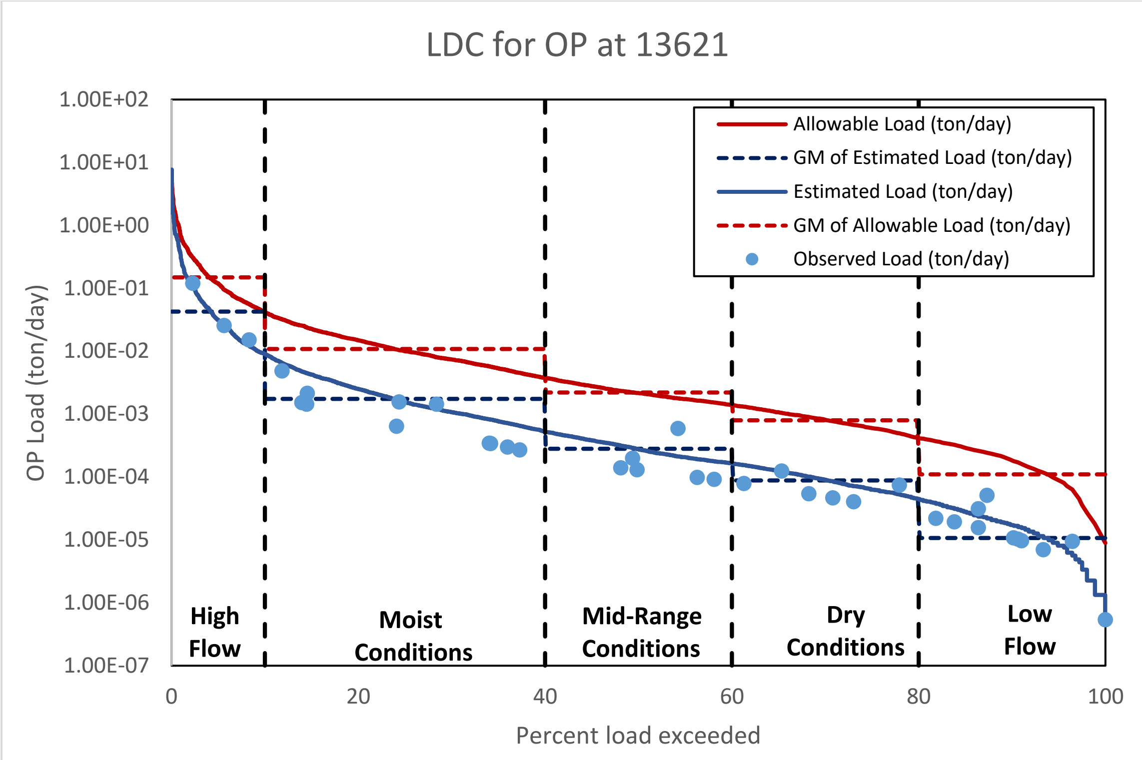


Figure G-33 LDC for OP at surface water quality monitoring station 13621

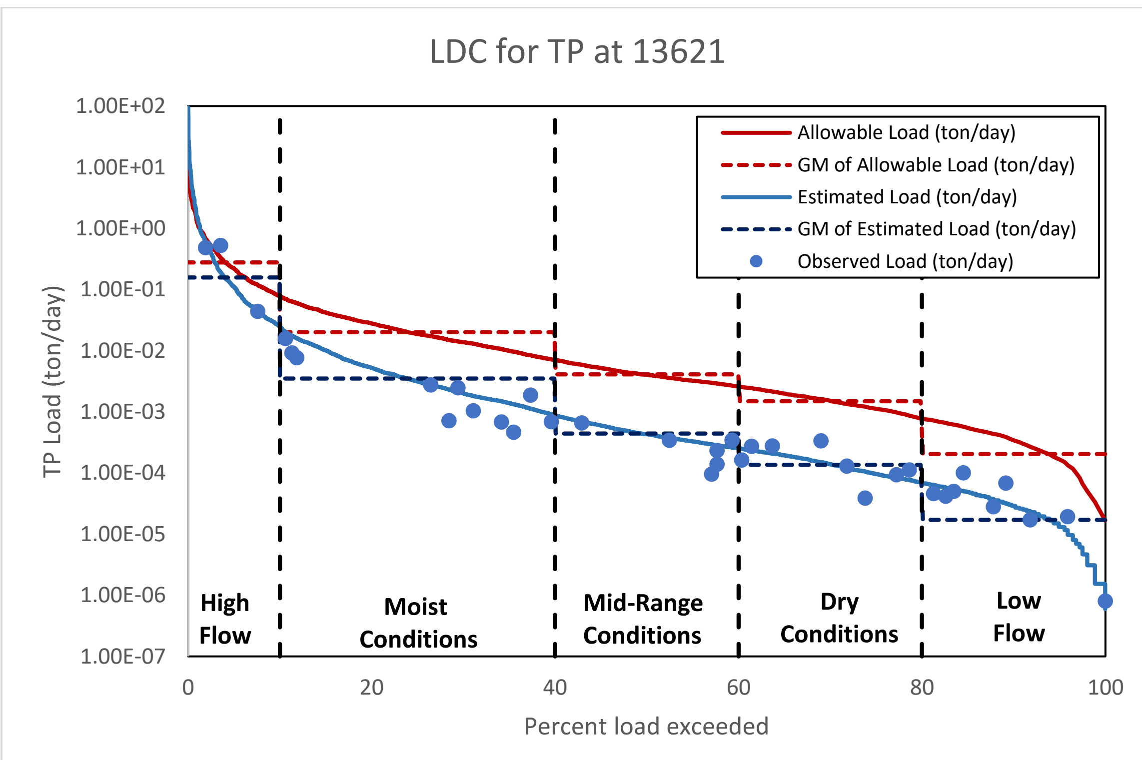


Figure G-34 LDC for TP at surface water quality monitoring station 13621

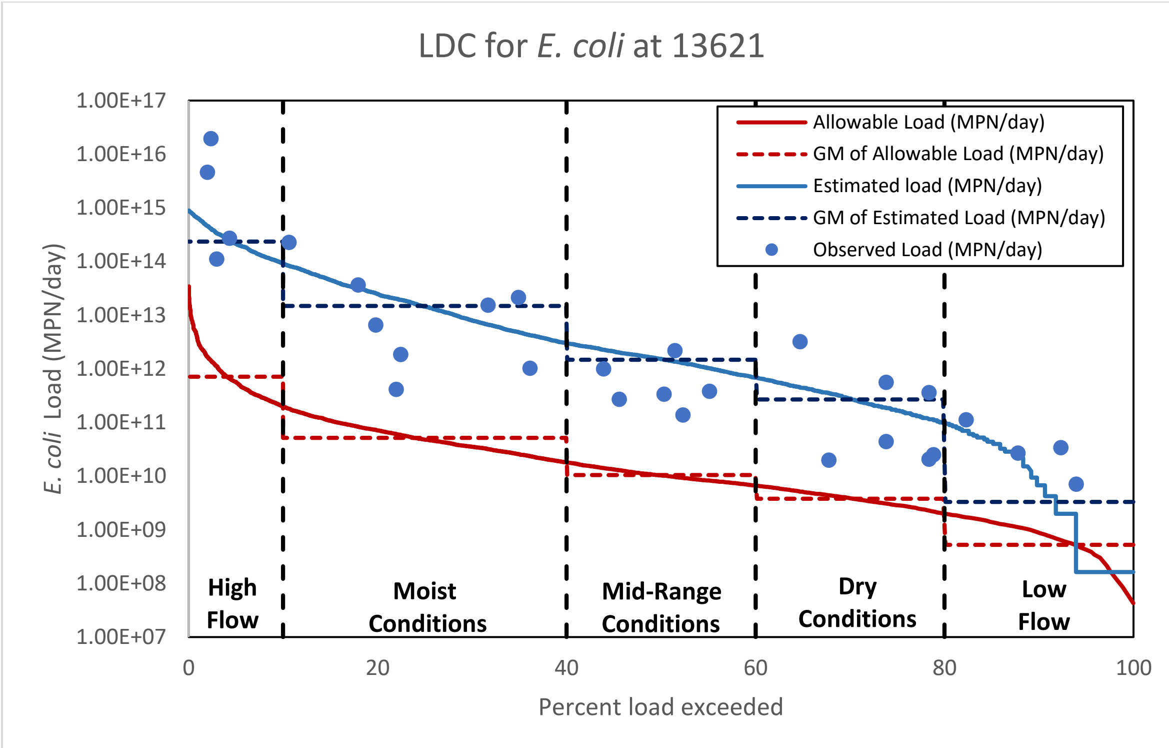


Figure G-35 LDC for *E. coli* at surface water quality monitoring station 13621

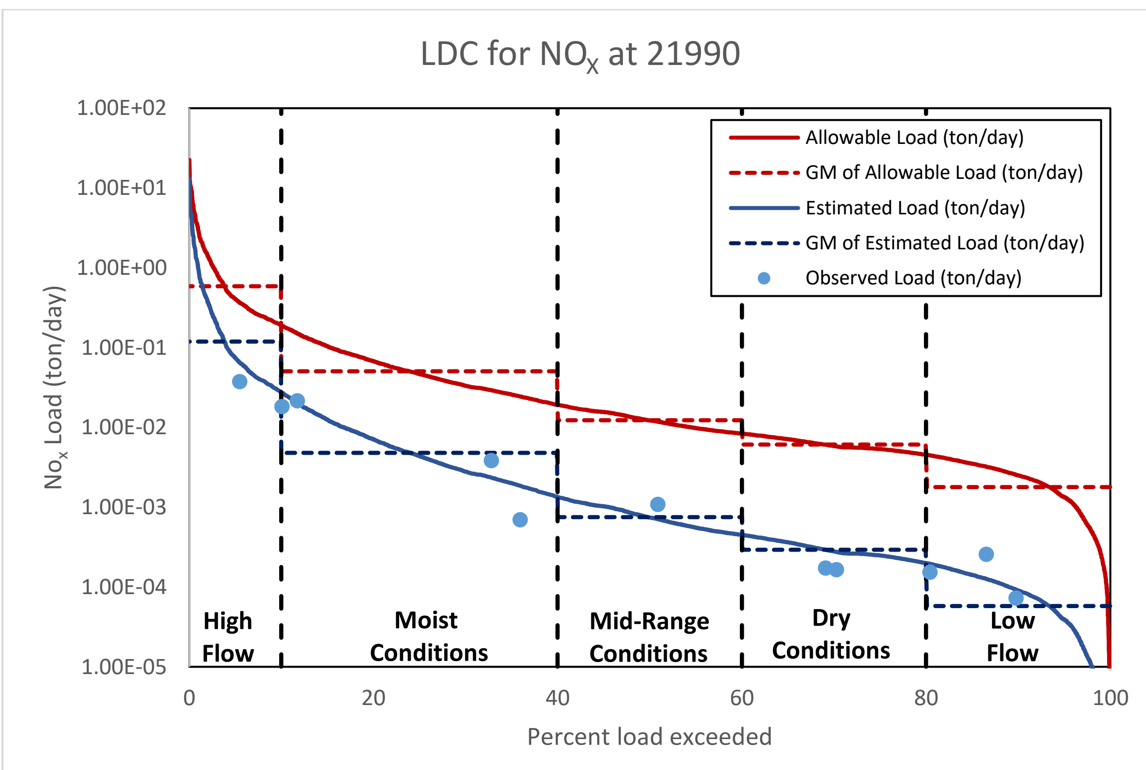


Figure G-36 LDC for NOx at surface water quality monitoring station 21990

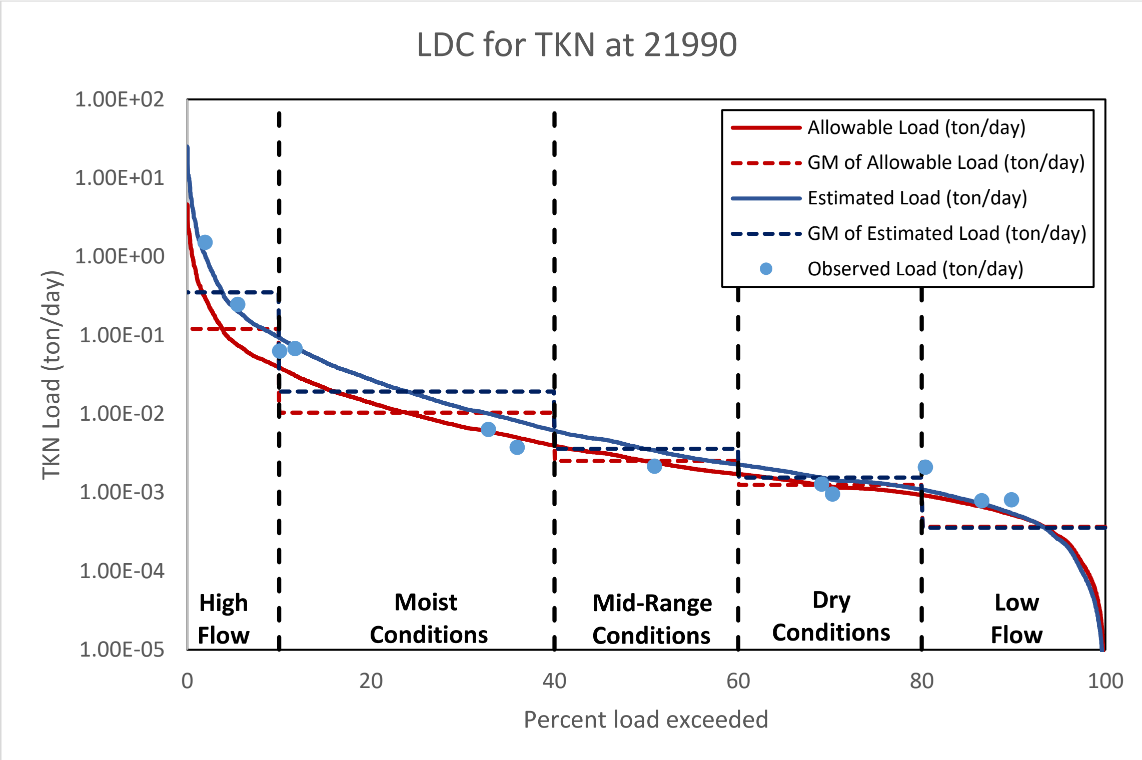


Figure G-37 LDC for TKN at surface water quality monitoring station 21990

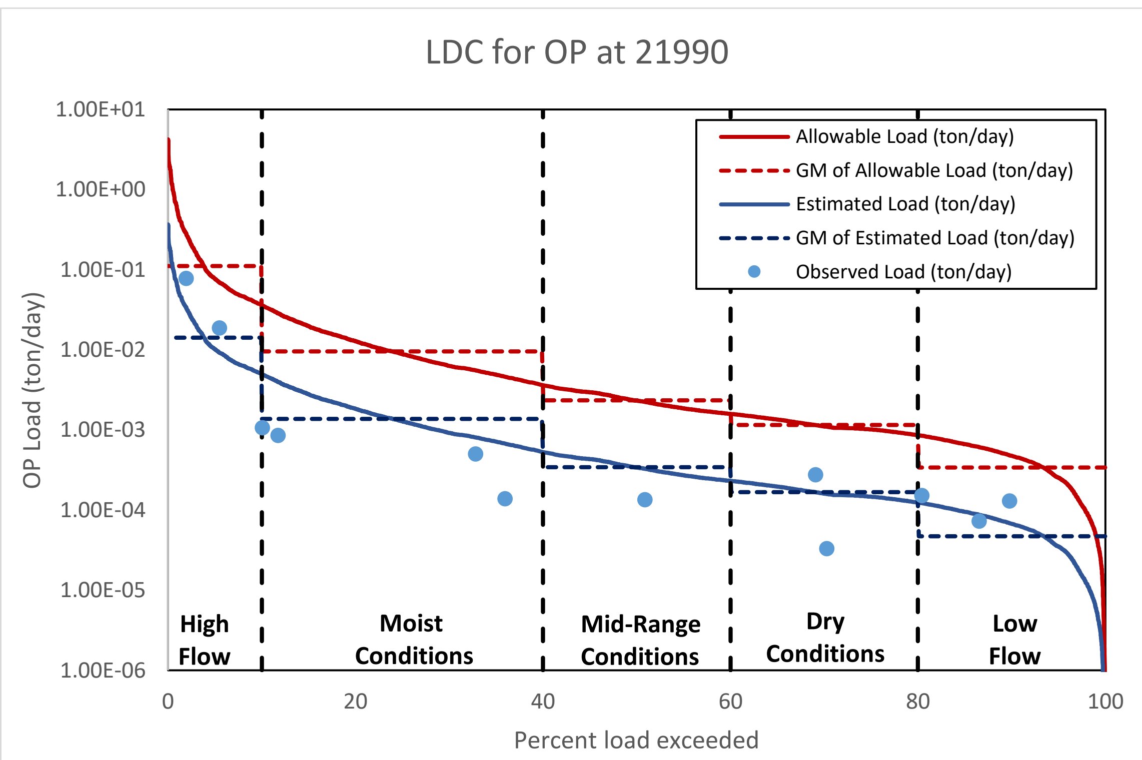


Figure G-38 LDC for OP at surface water quality monitoring station 21990

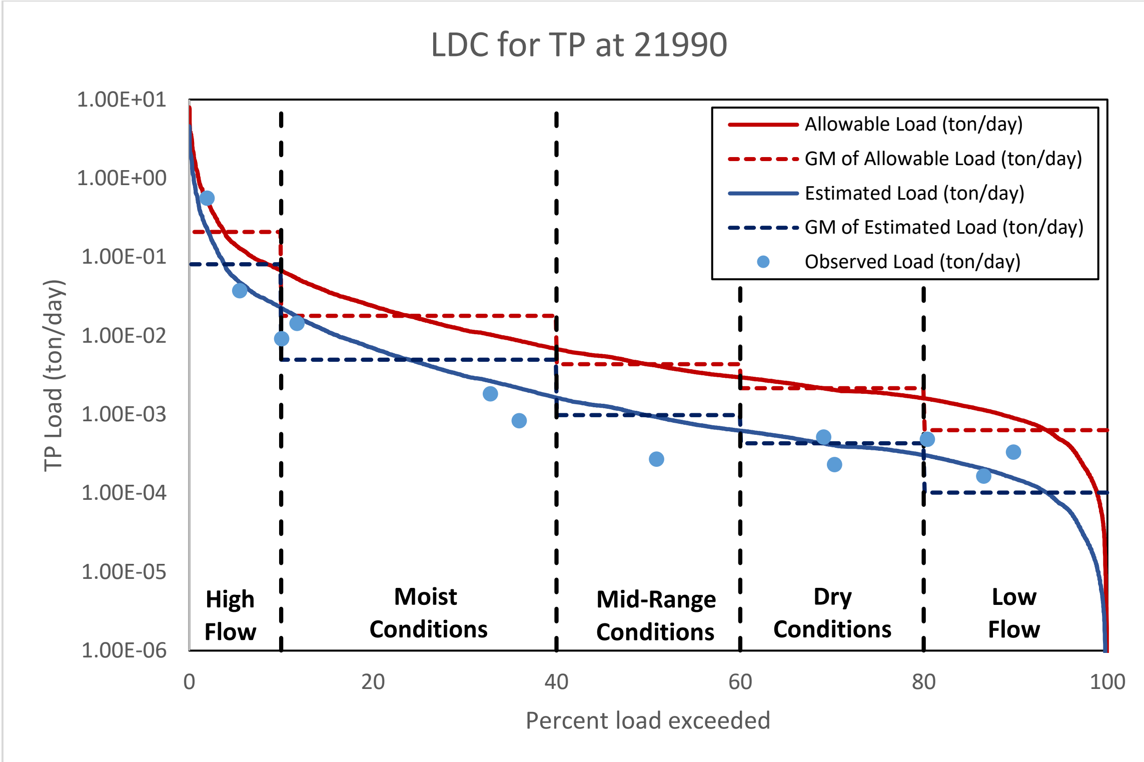


Figure G-39 LDC for TP at surface water quality monitoring station 21990

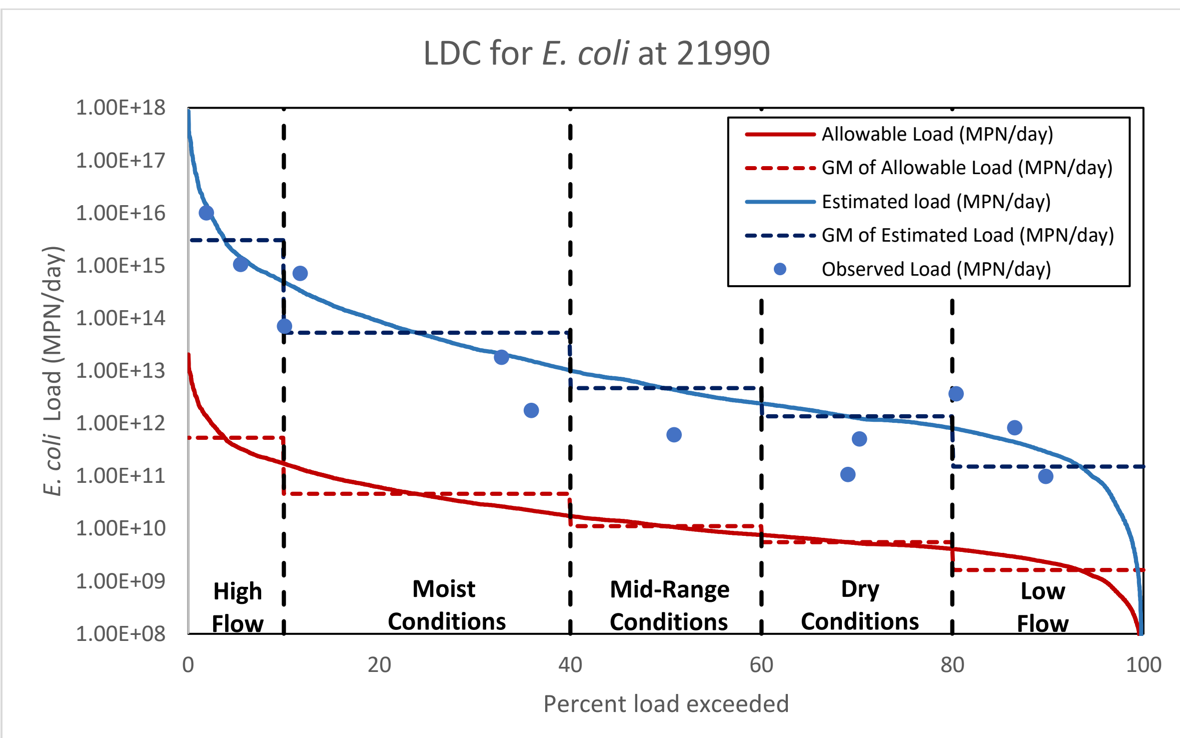


Figure G-40 LDC for *E. coli* at surface water quality monitoring station 21990

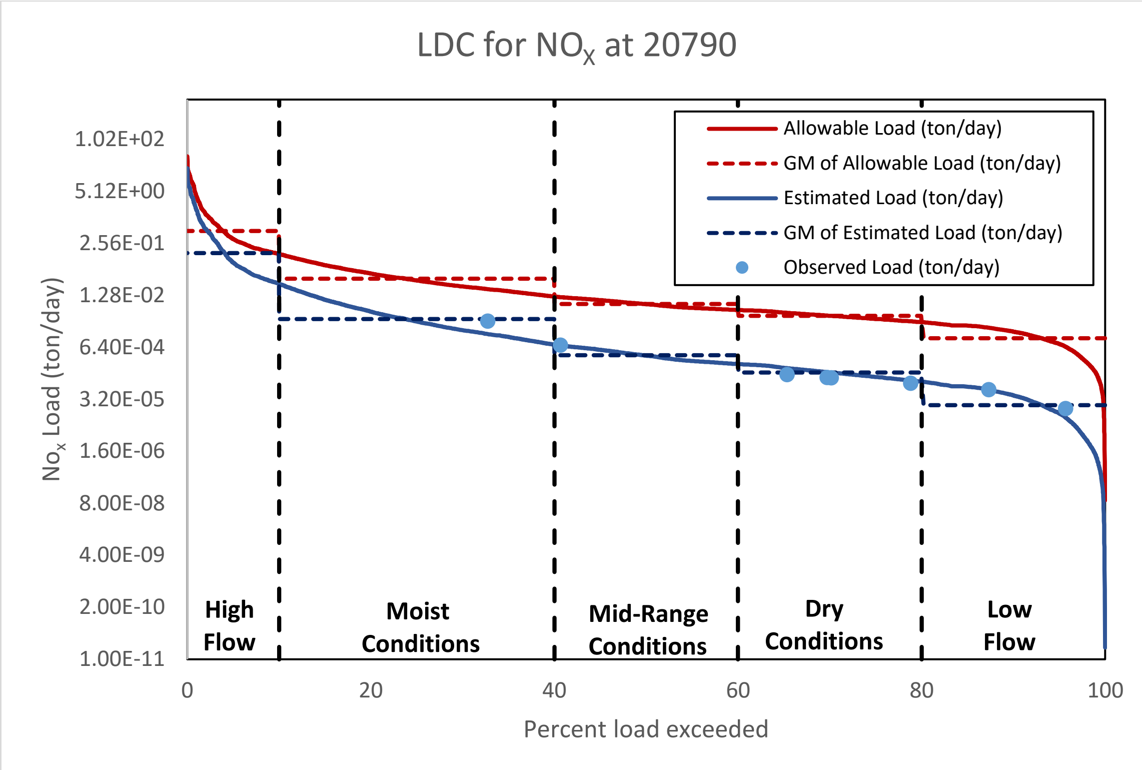


Figure G-41 LDC for NOx at surface water quality monitoring station 20790

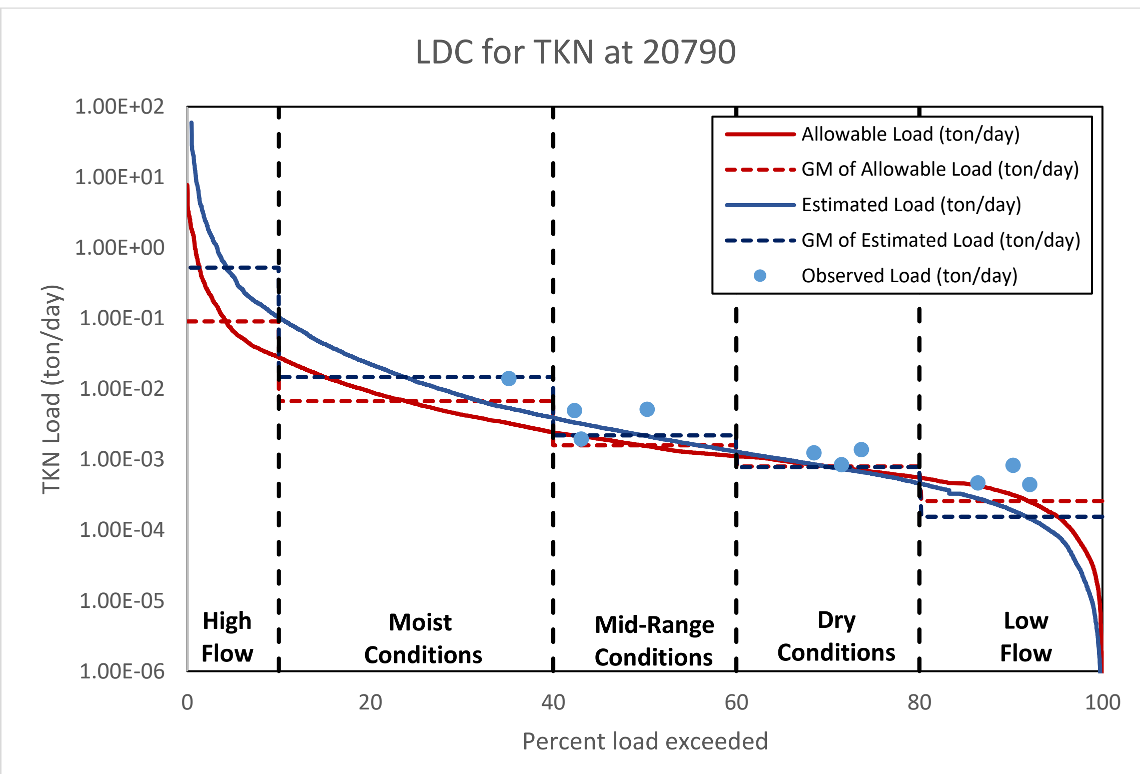


Figure G-42 LDC for TKN at surface water quality monitoring station 20790

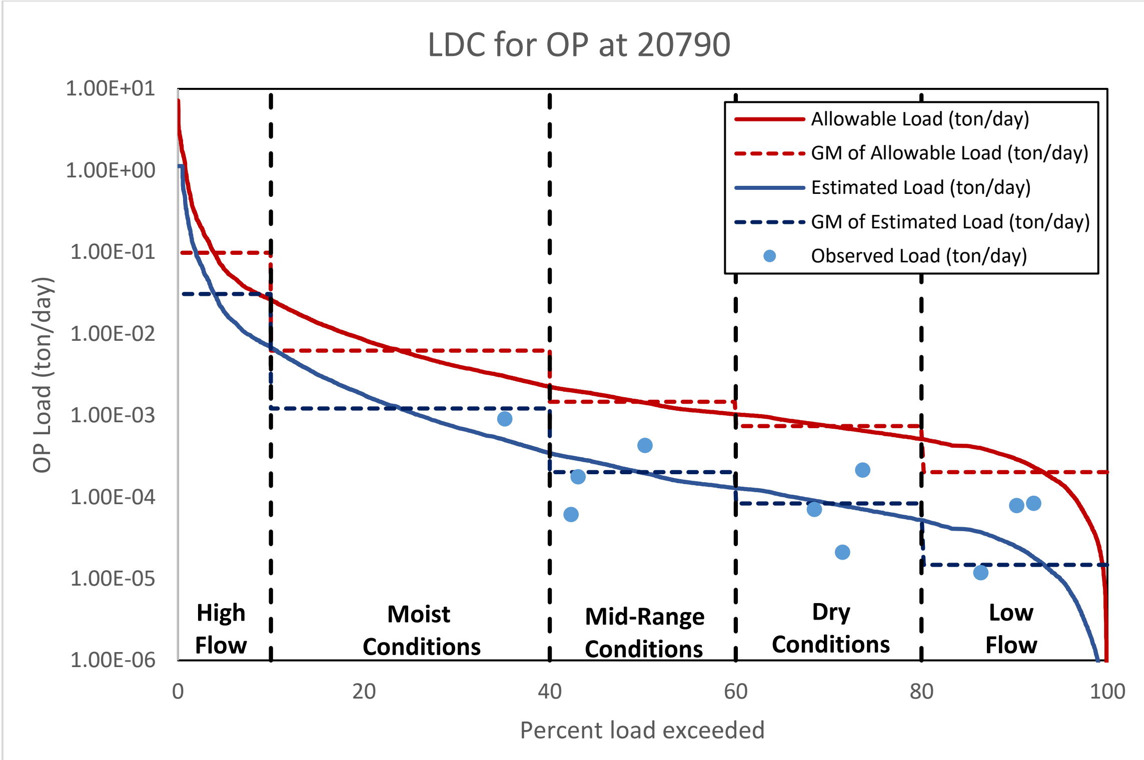


Figure G-43 LDC for OP at surface water quality monitoring station 20790

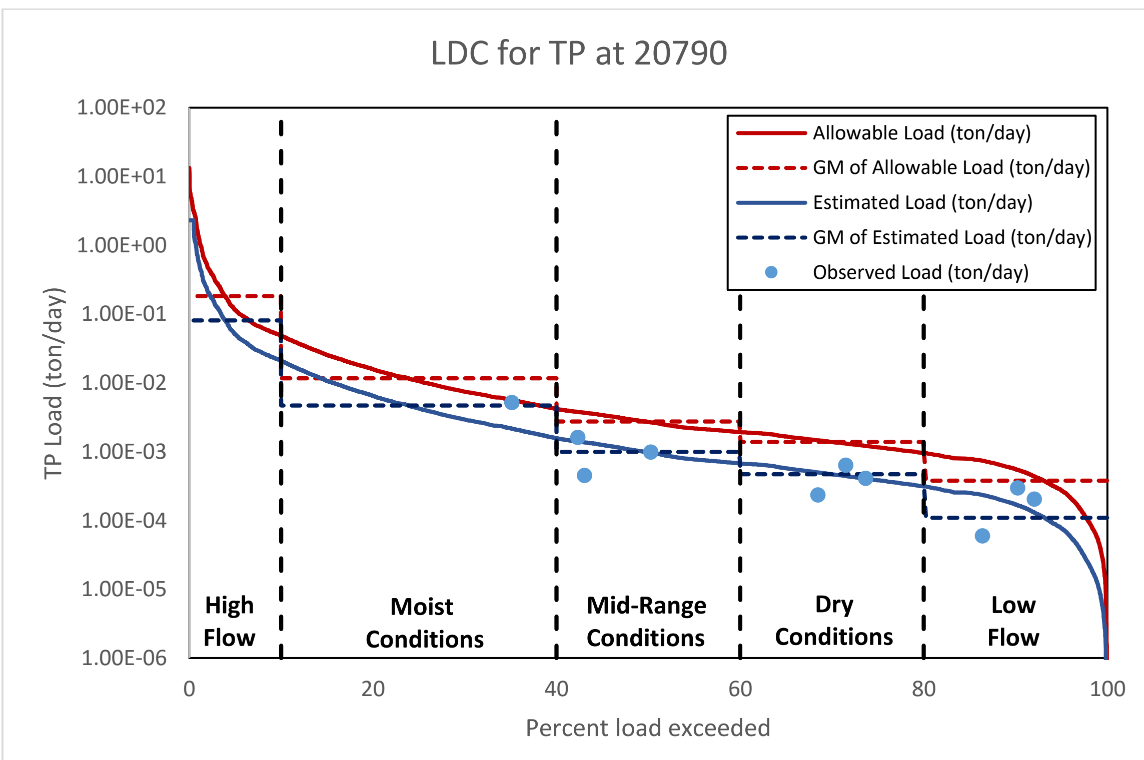


Figure G-44 LDC for TP at surface water quality monitoring station 20790

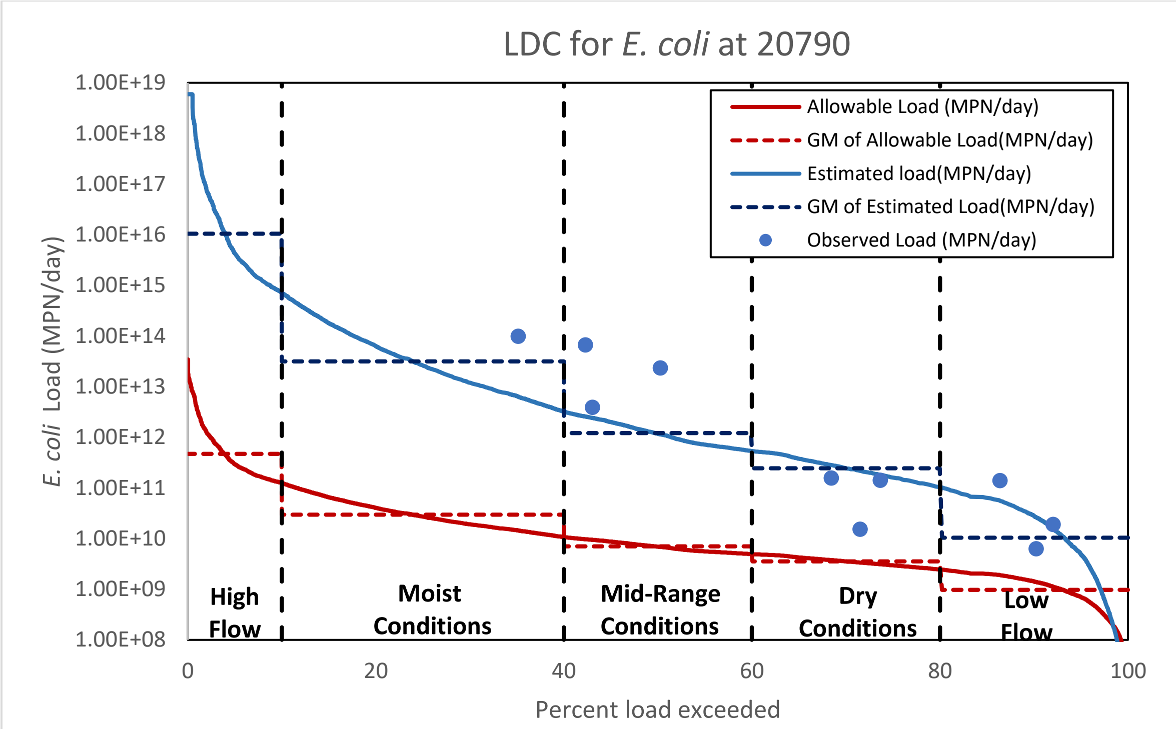


Figure G-45 LDC for *E. coli* at surface water quality monitoring station 20790

Appendix H: Parks, Trails, Public Spaces

Table H- 1 is current as of December 2021 and is subject to change as the watershed develops.

Location	Activity	Address	Responsible Party	Website
Bowman Branch Linear Park	Hiking, Natural Area	201 E. Lonesome Dove Trail, Arlington, TX 76002	City of Arlington	https://arlingtontx.gov/cms/One.aspx?portalId=14481146&pageId=16336237
Britton Park	Boating, Paddling, Fishing	829 E. Seeton Rd., Mansfield, TX 76063	City of Grand Prairie	https://grandfungp.com/britton-park/
Calabria Nature Preserve	Undeveloped	750 West FM 1382, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2562/Calabria-Nature-Preserve
Cedar Hill State Park	Swimming, Boating, Paddling, Fishing	1570 West FM 1382, Cedar Hill, TX 75104	Texas Parks and Wildlife Department	https://tpwd.texas.gov/state-parks/cedar-hill
Cedar Mountain Preserve	Hiking	1300 West FM 1382, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2696/Cedar-Mountain-Preserve; https://www.dallascounty.org/departments/plandev/openspaces/locations/18-cedar-mountain.php
Cedar Ridge Preserve	Hiking	7171 Mountain Creek Parkway, Dallas, TX 75249	Audubon Dallas	https://audubondallas.org/cedar-ridge-preserve/; https://www.dallascounty.org/departments/plandev/openspaces/locations/19-escarpment.php
Clayton W Chandler Park	Fishing, Nature Walking Trail	1530 N Walnut Creek Dr, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1113/Clayton-W-Chandler-Park
Community Center Park	Hiking	1740 Mansfield Rd, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2566/Community-Center-Park
Dogwood Canyon Audubon Center	Hiking	1206 West FM 1382, Cedar Hill, TX 75104	National Audubon Society	https://dogwood.audubon.org/
Don Misenhimer Park	Hiking	201 E Lonesome Dove Trail, Arlington, TX 76002	City of Arlington	https://www.arlingtontx.gov/city_hall/departments/parks_recreation/facilities/aquatics/splashpads/don_misenhimer

Donald R. Barg Park	Fishing, Nature Walking Trail	1435 Whispering Water Ln, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1091/Donald-R-Barg-Park
Eden Road Park	Hiking, Natural Area	1860 Mansfield Webb Rd, Arlington, TX 76002	City of Arlington	https://arlingtontx.gov/cms/One.aspx?portalId=14481146&pageId=16345720
Elmer W. Oliver Nature Park	Hiking	1650 Matlock Road, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/865/Oliver-Nature-Park-ONP
Estes Park	Undeveloped	Grand Prairie, TX 75054		Currently no public access
Fielder Park	Walking	204 6th St, Venus, TX 76084	City of Venus	https://www.cityofvenus.org/parks-recreation/pages/fielder-park
Harold M. Bell Park	Nature Walking Trail	1703 S Matlock Rd, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1222/Harold-M-Bell-Park
Heritage Park	Walking	234 N 8th St, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
James McKnight Park East	Nature Walking Trail	700 U.S. 287 Frontage Rd, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1092/James-McKnight-Park-East
James McKnight Park West	Nature Walking Trail	302 N Wisteria St, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1093/James-McKnight-Park-West
Jaycee Park	Walking	1711 Meadow Ln, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
JPL & Walnut Creek Paddling Trail	Paddling	Loyd Park 3401 Ragland Rd., Grand Prairie, TX 75052	City of Grand Prairie	https://tpwd.texas.gov/fishboat/boat/paddlingtrails/inland/grandprairie_walnutcreek/
Julian Feild Park	Nature Walking Trail	1531 E Broad St, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1094/Julian-Feild-Park---Serenity-Gardens
Katherine Rose Memorial Park	Nature Walking Trail	303 N Walnut Creek Dr, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1095/Katherine-Rose-Memorial-Park

Killian Park at Woodland Estates	Fishing	901 Killian Dr, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1096/Killian-Park-at-Woodland-Estates
Kimmel Park	Walking	124 N 1st St, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
Kingswood Park	Hiking	1528 Sharon Dr, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2573/Kingswood-Park
Lester Lorch Nature Preserve	Hiking, Fishing	1823 Texas Plume Rd. Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2586/Lester-Lorch-Nature-Preserve; https://www.dallascounty.org/departments/plandev/openspaces/locations/17-lester-lorch.php
Lloyd Park	Swimming, Boating, Paddling, Fishing	3401 Ragland Rd., Grand Prairie, TX 75052	City of Grand Prairie	https://loydpark.com/
Lucretia & Gary Mills Park	Walking	5112 Crestwater Dr, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1097/Lucretia-and-Gary-Mills-Park
Lynn Creek Linear Park	Hiking, Natural Area	6501 Matlock Rd, Arlington, TX 76002	City of Arlington	https://arlingtontx.gov/cms/One.aspx?portalId=14481146&pageId=16354156
Lynn Creek Park	Swimming, Boating, Paddling, Fishing	5610 Lake Ridge Pkwy., Grand Prairie, TX 75052	City of Grand Prairie	https://grandfungp.com/lynn-creek-park/
Margie Webb Park	Walking	200 W Railway Ave, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
McClendon Park East	Walking	740 W Kimball St, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/Facilities/Facility/Details/McClendon-Park-East-28
McClendon Park West	Walking	799 W Broad St, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1099/McClendon-Park-West
Midlothian Dog Park	Walking	1111 Walter Stephenson Rd, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
Pleasant Valley Park	Undeveloped	Nature Ct, Cedar Hill, TX 75104		Currently no public access

Pond Branch Linear Park	Nature Walking Trail	199 E Broad St, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1089/Pond-Branch-Linear-Park
Prairie View Park	Walking	2600 Prairie View Blvd, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2591/Prairie-View-Park
Ridge View Park		1150 Lake Ridge Pkwy, Cedar Hill, TX 75104		Currently no public access
Ridgeview Park	Walking	750 Walter Stephenson Rd, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
Town Park	Nature Walking Trail	500 N Main St, Mansfield, TX 76063	City of Mansfield	https://www.mansfieldtexas.gov/1105/Town-Park
Triangle Park	Walking	200 E Avenue G, Midlothian, TX 76065	City of Midlothian	https://www.midlothian.tx.us/121/City-Parks-Facilities
Valley Ridge Park	Walking, Fishing	2850 Park Ridge Dr, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2595/Valley-Ridge-Park
Webb Community Park	Fishing, Hiking, Natural Area	1100 Mansfield Webb Rd, Arlington, TX 76002	City of Arlington	https://arlingtontx.gov/cms/One.aspx?portalId=14481146&pageId=16371479
Wildwood Park	Walking	2415 S Lakeview Dr, Cedar Hill, TX 75104	City of Cedar Hill	http://cedarhilltx.com/2599/Wildwood-Park

Table H- 1 Parks, Trails, Public Spaces

Appendix I: EPA Acceptance Letter

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1201 ELM STREET, SUITE 500
DALLAS, TEXAS 75270

October 25, 2022

Mrs. Faith Hambleton
NPS Program Manager
Texas Commission on Environmental Quality
TCEQ, P.O. Box 13087
Austin, TX 78711-3087

Dear Faith,

USEPA Region 6 Nonpoint Source staff have completed their review of the final draft of the Joe Pool Lake (JPL) Watershed Protection Plan (WPP), which was received on August 29, 2022. We are pleased to inform you that EPA R6 found that the plan has met all nine elements in EPA NPS guidance, and is hereby accepted as complete.

This WPP was developed by The Joe Pool Lake Watershed Protection Partnership with local stakeholder input and was submitted as a draft for EPA review. All EPA comments have been addressed.

Walnut Creek, one of JPL's two main tributaries, was first listed for a recreational use impairment due to excessive levels of Escherichia coli (E. coli) in the 2006 Texas Commission on Environmental Quality Water Quality and 303(d) List (TCEQ, 2007). The stakeholder impetus for this WPP is based on the 2014 Texas Integrated Report, which indicated the Walnut Creek geometric mean for E. coli was 195.60 colony forming units (cfu)/100 milliliters (mL), greater than the state standard of 126 cfu/100mL for water bodies designated for primary contact recreation 1 use (PCR1). In the 2018 Texas Integrated Report, Walnut Creek had a geometric mean of 94.75 MPN/100mL for E. coli and was delisted as an impaired water body. Limited data precluded the full assessment of Walnut Creek in the 2022 Integrated Report, and it was listed as a concern for bacteria.

The second motive for the development of the WPP was the 2010 Texas Integrated Report listing of concern for nitrate screening level in the Mountain Creek arm of JPL (TCEQ, 2010). The nitrate mean exceedance reported in the 2014 Texas Integrated Report was 0.74 milligram per liter (mg/L) which is greater than the state screening level of 0.37 mg/L for lakes (TCEQ, 2015a). We anticipate Best Management Practices (BMPs) will be selected and implemented to address these and other concerns throughout this watershed as well as any mid-course corrections if a decline in water quality results in listing on the impaired waters list.

We also acknowledge and appreciate the strong collaborative relationships TCEQ have fostered with the The Joe Pool Lake Watershed Protection Partnership in pursuit of the State's water quality restoration goals.

Based on our acceptance of the WPP, the Texas Commission on Environmental Quality is now eligible for CWA Section 319 funding for watershed implementation projects consistent with this WPP and the Texas Nonpoint Source Management Program. If you or your staff have any questions regarding our review, please contact me at 214-665-8365, or Jim Drake of my staff at 214-665-7367.

Sincerely,

Karen McCormick, Supervisor, MPA
Marine, Coastal and Nonpoint Source Section