TMDLS FOR
TURBIDITY IN ABLES AND OVERFLOW CREEKS
AND
CHLORIDE IN OVERFLOW CREEK

Chloride and Turbidity TMDLs for Overflow Creek
Assessment Unit AR_08040205_908

Turbidity TMDL for Ables Creek
Assessment Unit AR_08040205_911

September 25, 2023

TMDLs for Turbidity in Ables and Overflow Creeks and Chloride in Overflow Creek

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies not meeting water quality standards and develop total maximum daily loads (TMDLs) for pollutants causing impairments in those waterbodies. A TMDL is the amount of pollutant a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the waterbody. This report presents TMDLs that have been developed for Ables Creek and Overflow Creek within the Bayou Bartholomew watershed, Arkansas.

Bayou Bartholomew originates near Pine Bluff and flows generally southward through southeastern Arkansas and into northeastern Louisiana. The drainage area of Bayou Bartholomew at the Arkansas/Louisiana state line is 1,180 square miles (USGS 2016a), including 115 square miles in the Ables Creek watershed (USGS 2016a) and 90.89 square miles in the portion of the Overflow Creek watershed within Arkansas (ESRI 2017). Bayou Bartholomew watershed is in the Gulf Coastal Plain ecoregion and is in Arkansas Department of Energy and Environment, Division of Environmental Quality (DEQ) Planning Segment 2B.

Ables Creek and Overflow Creek assessment units (AU) addressed in this TMDL report were listed as impaired on the 2018 Arkansas 303(d) list (DEQ 2018). Listings are summarized in Table ES.1.

Table ES.1: 2018 listing information for impairments addressed by TMDLs in this report.

Assessment Unit	Stream Name	Impaired Use	Suspected Causes of Impairment	Suspected Sources of Impairment	Priority
AR_08040205_911	Ables Creek	Aquatic Life	Siltation / turbidity	Surface Erosion	Low
AR_08040205_908	Overflow Creek	Aquatic Life	Siltation / turbidity; Chloride	Surface Erosion; Unknown	Low

Historic DEQ water quality data collected at three locations (two sites on Ables Creek and one on Overflow Creek) were analyzed with basic statistics for seasonal patterns and relationships between concentration and stream flow (Section 3). There were no consistent seasonal patterns or significant relationships between water quality and stream flow rate.

Load duration curve (LDC) method was used to develop all five TMDLs (one chloride, and four turbidity) in this report (Tables ES. 2 and ES. 3). This method illustrates allowable loading at a wide range of flow conditions and allows for examination of actual load data plotted along a flow continuum. The general steps for applying this methodology for the TMDLs in this report were: develop a flow duration curve for each waterbody; convert the flow duration curves to load duration curves for each parameter within each waterbody; plot observed loads with load duration curves; and calculate the overall TMDL, margin of safety (MOS), and future growth (FG); and calculate loads from permitted and non-permitted sources.

A flow duration curve was developed for each impaired AU and parameter using available long term daily flow data published by the United States Geological Survey (USGS). Flow duration curves were converted to load duration curves by multiplying the flow values by an allowable concentration and a unit conversion factor. For TMDLs in this report, an explicit MOS was established by setting aside 10% of the total TMDL. Additionally, 10% of the total TMDL was set aside as FG to accommodate new or expanded loading sources.

For turbidity TMDLs, allowable concentrations and loads were expressed using total suspended solids (TSS) as a surrogate for turbidity. Regressions with DEQ routine monitoring data were used to develop relationships between turbidity and TSS. These relationships were then used to develop water quality targets for TMDL development. For chloride, the site specific criterion of 20 mg/L for Overflow Creek was used as the water quality target.

No continuous point sources of turbidity were identified in either the Ables Creek or Overflow Creek watersheds. No continuous point sources of chloride were identified in the Overflow Creek watershed. Three NPDES permitted stormwater sources were identified within Ables Creek watershed; none were identified within the Overflow Creek watershed. For turbidity/TSS in Ables Creek, loads from regulated stormwater sources were assigned an aggregate stormwater wasteload allocation (∑swWLA) and the remaining diffuse loading was assigned to the load allocation (LA) (after MOS and FG were accounted for). TMDL calculations are summarized in Tables ES.2 and ES.3.

Table ES.2. Summary of Chloride TMDL.

Assessment Unit	Loads of Chloride (lbs/day)					
	WLA for Continuous Point Sources	swWLA for NPDES Regulated Stormwater	LA for non-Regulated Diffuse Sources	MOS	Future Growth	TMDL
Overflow Creek AR_08040205_908	N/A[A]	N/A[A]	104.10	13.01	13.01	130.12

A. There are currently no permitted dischargers to these AUs.

Table ES.3. Summary of Turbidity TMDLs.

Assessment Unit	Season	Loads of TSS (lbs/day)					
		WLA for Continuous Point Sources	swWLA for NPDES Regulated Stormwater	LA for Non-Regulated Diffuse Sources	MOS	Future Growth	TMDL
Overflow Creek AR_08040205_908	Base	N/A[A]	N/A[A]	164.08	20.51	20.51	205.09
	Storm	N/A[A]	N/A[A]	1701.74	212.72	212.72	2127.17
Ables Creek AR_08040205_911	Base	N/A[A]	1.77	531.98	66.72	66.72	667.19
	Storm	N/A[A]	9.58	2874.15	360.47	360.47	3604.66

A. There are currently no permitted dischargers to these Aus.

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LIST OF ABBREVIATIONS

ANRC	Arkansas Natural Resources Commission
APC&EC	Arkansas Pollution Control and Ecology Commission
AU	Assessment Unit
BBA	Bayou Bartholomew Alliance
BMPs	Best Management Practices
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPP	Continuing Planning Process
DEQ	Division of Environmental Quality
EPA	United States Environmental Protection Agency
FG	Future Growth
FTN	FTN Associates, Ltd.
HMF	Harmonic Mean Flow
ICIS	Integrated Compliance Information System
LA	Load Allocation
LDC	Load Duration Curve
MGD	Million Gallons per Day
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
SWAT	Soil and Water Assessment Tool
SWPPP	Stormwater Pollution Prevention Plan
TSS	Total Suspended Solids
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQBEL	Water Quality Based Effluent Limitation
WQMP	Water Quality Management Plan
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

This report presents TMDLs for chloride and turbidity for two assessment units (AU) within the Bayou Bartholomew watershed (Table 1.1). “Assessment unit” is synonymous with “stream reach” used in previous Arkansas TMDLs. These AUs were initially listed as impaired on the 2006 303(d) list and have remained listed through the 2018 303(d) list for Arkansas (DEQ 2006 and 2018). Table 1 presents information concerning these impairments from the final 2018 303(d) list and Integrated Water Quality Monitoring and Assessment Report (DEQ 2018). The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and United States Environmental Protection Agency (EPA) regulations at Title 40 Code of Federal Regulations (C.F.R.) Part 130.7.

Table 1: Impairments addressed by TMDLs in this report as described by the 2018 303(d) list for Arkansas.

Assessment Unit	Stream Name	Impaired Use	Suspected Causes of Impairment	Suspected Sources of Impairment	Priority
AR_08040205_911	Ables Creek	Aquatic Life	Siltation / turbidity	Unknown	Low
AR_08040205_908	Overflow Creek	Aquatic Life	Siltation / turbidity; Chloride	Surface Erosion; Unknown	Low

The purpose of a TMDL is to determine the pollutant loading a water body can assimilate without exceeding the water quality standard for that pollutant. A TMDL is the sum of waste load allocations (WLA), load allocations (LA), and a margin of safety (MOS). Future growth (FG) is an optional loading component calculated for TMDLs in this report. The WLA is the load allocated to regulated point and nonpoint sources. The LA is the load allocated to non-regulated, typically nonpoint, sources. The MOS is a percentage of the TMDL that takes into account uncertainty concerning the relationship between pollutant loadings and water quality. Future growth is set aside to accommodate new or increased loading sources that contribute the pollutant of concern into the waterbody.

2.0 BACKGROUND INFORMATION

2.1 General Information

The study area for this report consists of watersheds for the two AUs listed in Table 1: Ables Creek and Overflow Creek. Ables Creek watershed is 115 square miles, measured using StreamStats (USGS 2016a), at the confluence of Ables Creek and Bayou Bartholomew. Overflow Creek watershed is 90.89 square miles, measured using Arc GIS (ESRI 2017) as the total area of the three 12-digit hydrologic unit codes (HUC) that make up the Overflow Creek watershed. Both watersheds are contained within DEQ Planning Segment 2B.

These AUs are located within the Bayou Bartholomew watershed in southeastern Arkansas as shown on Figure A.1 in Appendix A. All AUs and their watersheds included in this TMDL report are fully contained within the Gulf Coastal Plains ecoregion as identified on map plates within Arkansas Pollution Control and Ecology Commission (APC&EC) Rule 2 (formerly Regulation No. 2) (APC&EC 2020).

Ables Creek watershed spans parts of Lincoln, Drew, and Desha counties. Overflow Creek watershed is contained within Ashley County in Arkansas with a small portion in Morehouse Parish, Louisiana.

2.2 Land Use Land Cover (LULC)

LULC data used for this TMDL report are published by the United States Geological Survey (USGS) (Dewitz 2019) and accessed using ArcGIS 10.5.1. Spatial distribution of land uses is shown on Figure A.2 and Figure A.3 (Appendix A) and approximate LULC percentages per watershed are shown in Table 2.

The upper portion of Ables Creek watershed is dominated by forest while the lower portion is dominated by cultivated crops (Figure A.2). Overflow Creek watershed is dominated by cultivated crops on the eastern side and wetlands and forest on the western side (Figure A.3).

Table 2: LULC percentages for Ables Creek and Overflow Creek watersheds (Dewitz 2019).

Land Use Category	Ables Creek Watershed	Overflow Creek Watershed
Open water	0%	1%
Developed area	2%	2%
Forest	32%	13%
Scrub/Shrub	6%	7%
Grassland/ Pasture	8%	3%
Cultivated crops	32%	27%
Wetlands	20%	45%
Barren Land	0%	2%
TOTAL	**100%**	**100%**

2.3 Stream Flow Data

TMDLs in this report were developed using USGS stream flow data from two gaging stations (USGS 2016b and 2016c). Gage information is summarized in Table 3. The location of the Bayou Bartholomew gage is shown on Figure A.4 in Appendix A. These flow gaging stations were selected based on having either a direct relation to a study reach (Ables Creek) or being in the nearest watershed with a high similarity to a study reach (Overflow Creek), and having current continuous daily data records maintained by USGS. Flow for TMDL development was based on a ratio of watershed area at gage to watershed area of each AU.

Table 3: Information for USGS stream flow gaging stations.

Gage Number	Gage Name	Descriptive Location	Stream Used For	Period of Record	Drainage Area
07364133	Bayou Bartholomew at Garrett Bridge, AR	Downstream side of bridge on State Highway 54	Ables Creek	Jan 1991 – May 2021	380 sq mi
07366200	Little Corney Bayou near Lillie, LA	Left bank on downstream side of bridge on State Highway 15	Overflow Creek	Jan 1991 – May 2021	208 sq mi

2.4 Water Quality Standards

Water quality standards (WQS) for Arkansas are described in Rule 2 (formerly Regulation No. 2) (APC&EC 2020). WQS consist of designated uses, narrative and/or numeric criteria, and an antidegradation policy. Components relevant to these TMDLs are discussed below in each pollutant's section.

2.4.1 Designated Uses

Designated uses for the AUs addressed in this report are primary contact recreation; secondary contact recreation; domestic, industrial, and agricultural water supply; and aquatic life. Aquatic life designated use is applicable to the TMDLs discussed in this report.

2.4.2 Chloride Criteria

Section 2.511 of Rule 2 provides both a narrative criterion and numeric criteria for dissolved minerals (chlorides). The narrative criterion is: "Mineral quality shall not be altered by municipal, industrial, other waste discharges or instream activities so as to interfere with designated uses." Rule 2.511(a) lists numeric criteria for dissolved minerals for specific waterbodies. Site specific numeric chloride criterion for Overflow Creek is 20 mg/L. Critical flow for dissolved minerals, such as chloride, is defined in Section 2.106 of Rule 2. For site-specific dissolved minerals criteria listed without an asterisk in Rule 2.511(a) (Overflow Creek), critical flow is harmonic mean flow (HMF).

2.4.3 Turbidity Criteria

Section 2.503 of Rule 2 provides both a narrative criterion and numeric criteria that apply to turbidity. The narrative criterion is: "There shall be no distinctly visible increase in turbidity of receiving waters attributable to discharges or instream activities." Numeric turbidity criteria for Ables Creek and Overflow Creek are based on Gulf Coastal ecoregion criteria of 21 NTU for base flows season (June 1 – October 31) and 32 NTU for storm flows season (year round). Section 2.106 of Rule 2 defines the critical flow for conventional pollutants (including turbidity) as 7Q10.

2.4.4 Antidegradation

As specified in 40 C.F.R. §130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas's antidegradation policy is listed in Chapter 2 of Rule 2. These sections impose the following requirements:

- Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected;
- Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development, although water quality must still be adequate to fully protect existing uses; and
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.

2.5 Non-regulated Loading Sources

Non-regulated loading sources include nonpoint sources such as overland runoff. The 2018 Integrated Report specifies sources of chloride in Overflow Creek as unknown. Sources of turbidity in Ables Creek are listed as unknown, while sources of turbidity in Overflow Creek are listed as surface erosion (DEQ 2018).

2.6 Regulated Loading Sources

Regulated loading sources are those with an active National Pollutant Discharge Elimination System (NPDES) permit. Regulated sources can be either continuous point source permitted facilities or nonpoint source permitted areas such as Municipal Separate Storm Sewer Systems (MS4) or facilities with stormwater permits. Information for regulated source discharges in the study area was obtained by searching DEQ’s NPDES permits database. The search yielded three (3) facilities with regulated stormwater source discharges in Ables Creek watershed that discharged TSS (Figure A.4 in Appendix A). No regulated dischargers were located within the Overflow Creek watershed that discharged either TSS or chloride. A full list of regulated loading sources is provided in Table A.1 in Appendix A.

2.7 Previous Water Quality Studies

Following is a list of previous water quality studies that were identified for the Bayou Bartholomew watershed:

1. "Short and Long Term Strategies for Protecting and Enhancing Natural Resources in the Bayou Bartholomew Watershed" (Bayou Bartholomew Alliance (BBA) 1996), prepared by the BBA Technical Support Group. This document identifies environmental problems for Bayou Bartholomew and presents short-term and long-term action items to address the problems.
2. "Watershed Restoration Action Strategy for the Bayou Bartholomew Watershed" (Arkansas Natural Resources Commission (ANRC) 1999). This discusses existing conditions within the watershed, expected future uses and needs, and strategies for restoration actions within the watershed.
3. "Physical, Chemical and Biological Assessment of the Bayou Bartholomew Watershed" (DEQ 2001). This report documents physical, water quality, and biological data collected by DEQ in the Bayou Bartholomew watershed during 1998 – 2000. It also presents various watershed information as well as conclusions from the collection and analysis of the field data.
4. "Bayou Bartholomew Wetland Planning Area Report" (Layher and Phillips 2002). This report includes discussion of physical and biological watershed characteristics, historical land use and wetlands protection, characteristics of wetland ecosystems in the Bayou Bartholomew Wetland Planning Area, and the potential for wetlands losses and gain in the area.
5. "TMDLs for Segments Listed for Mercury in Fish Tissue for the Ouachita River Basin and Bayou Bartholomew, Arkansas" (FTN 2002a). This report provides analyses of fish tissue data and calculations of existing and allowable loads of mercury to two reaches of Bayou Bartholomew and one reach of Cutoff Creek plus other streams in the Ouachita River basin in Arkansas and Louisiana.
6. "TMDLs for Turbidity for Bayou Bartholomew, AR" (FTN 2002b). This report presents background information about the Bayou Bartholomew watershed, a summary of DEQ water quality data, and calculations of existing and allowable loads of total suspended solids (TSS).
7. "Bayou Bartholomew Watershed Nine Element Plan" (BBA 2005). This report provides a description of watershed characteristics, a summary of environmental problems that have been identified and actions that have been taken to address the problems, and a discussion of future actions that are needed.
8. "Bayou Bartholomew Watershed Plan 2009 Update" This report provides a description of watershed characteristics, a summary of environmental problems that have been identified and actions that can be taken to address the problems. (Can be accessed through the Arkansaswater.org website: https://www.arkansaswater.org/29-watershed/116-bayou-bartholomew-8040205)
9. "Changes in fish community structure in the Bayou Bartholomew of southeast Arkansas as a result of watershed improvements made through 319 grant initiatives" (Layher 2005). This study assessed changes in fish communities at

thirteen sites on Bayou Bartholomew after a series of nonpoint source reduction and stream restoration projects.

10. SWAT modeling of Arkansas priority watersheds. Bayou Bartholomew is one of 10 priority watersheds in Arkansas targeted for reduction of nonpoint source pollution. The University of Arkansas Division of Agriculture, Department of Biological and Agricultural Engineering, Little Rock, Arkansas, has prepared and calibrated a SWAT model of the Bayou Bartholomew watershed to develop estimates of the relative contribution of Bayou Bartholomew sub-watersheds to sediment and nutrient concentrations in the bayou.

3.0 EXISTING WATER QUALITY

Tables and figures referenced in Section 3.0 are organized in the appendices of this report as follows:

Appendix A:	Maps and NPDES loading sources		
Appendix B:	Overflow Creek	Chloride	AR_08040205_908
Appendix C:	Overflow Creek	TSS	AR_08040205_908
Appendix D:	Ables Creek	TSS	AR_08040205_911

3.1 General Description of Water Quality Data

Routine monitoring data for chloride, turbidity, and TSS used in this report were collected at DEQ monitoring stations located on Ables Creek (OUA00153 and OUA00158) and Overflow Creek (OUA0012A). Locations of the sampling sites are shown on Figures A.1 – A.4 in Appendix A. Data relevant to TMDLs are summarized in Table 4, including comparisons with the current criteria in the water quality standards. Tables B.1, C.1, and D.1 (Appendices B, C, and D) include tabular listings of data for Overflow Creek chloride, Overflow Creek TSS/turbidity, and Ables Creek TSS/turbidity, respectively. Data from OUA153 and OUA0158 were combined and used as an aggregate data set for calculations and TMDL development for Ables Creek.

3.2 Water Quality Trends

Time series plots of each pollutant are included in Appendices B, C, and D (Figures B.1, C.1, C.2, D.1 and D.2). Limited datasets and data gaps prevent a detailed analysis of long term trends. In general, these plots do not demonstrate noticeable trends over time.

3.3 Seasonal Patterns

Seasonal plots of each pollutant are shown in Appendices B, C, and D (Figures B.2, C.3, C.4, D.3, and D.4). Turbidity and TSS tended to be higher from January through June than the remainder of the year.

3.4 Relationships between Concentration and Flow

Plots of each pollutant versus stream flow were developed to examine correlations between concentration and flow. Graphs are shown in Appendices B, C, and D (Figures B.3, C.5, C.6, D.5, and D.6). Generally, relationships between each pollutant and flow showed extremely weak correlations. R squared (R^2) values are summarized in Table 5.

Table 4: Summary of water quality data for Ables Creek and Overflow Creek.

Monitoring Station	OUA0153 and OUA0158	OUA0012A
Site Description	Ables Creek southwest of Tyro, AR and Ables Creek north of Selma, AR, respectively	Overflow Creek near Bonita, LA
Assessment Unit	AR_08040205_911	AR_08040205_908
Period of Record	1/12/99 – 6/5/2000 and 11/09/98 – 3/15/11, respectively	11/09/98 – 3/14/11
	TSS	
Number of Values	34	26
Minimum (mg/L)	<1	< 1
Maximum (mg/L)	464	61
Median (mg/L)	13.25	4.25
	Turbidity	
Number of Values	34	26
Minimum (NTU)	1.4	2.2
Maximum (NTU)	520	74
Median (NTU)	38	14.6
Number of Values > 21 NTU (base flow season only	7	0
Percent of Values > 21 NTU (base flow season only)	64%	0%
Number of Values > 32 NTU	18	4
Percent of Values > 32 NTU	51%	15.4%
	Chloride	
Number of Values	n/a	26
Minimum (mg/L)	n/a	1.7
Maximum (mg/L)	n/a	43.2
Median (mg/L)	n/a	17.3
Number of Values > 20 mg/L	n/a	12
Percent of Values > 20 mg/L	n/a	46.2%

Table 5: Summary of correlations between parameters and flow.

Stream Name	Parameter	R^2 Value
Ables Creek	Turbidity	0.045
	TSS	0.026
Overflow Creek	Turbidity	0.007
	TSS	0.006
	Chloride	0.139

3.5 Relationships between Turbidity and TSS

Plots of TSS versus turbidity for the water quality stations in Ables Creek and Overflow Creek (Appendices C and D; Figures C.7 and D.7) showed a moderately high correlation (R^2 = 0.56 for Ables Creek and 0.64 for Overflow Creek), with higher turbidity values tending to correspond with higher TSS concentrations. Regressions were performed on the logarithms of turbidity and TSS values from these water quality stations. The results of these regressions are summarized in Table 6.

Regressions were performed using the logarithms of the data (rather than the raw data values) because turbidity and TSS usually fit a lognormal distribution better than a normal distribution. Regressions were performed using all turbidity and TSS data from each DEQ monitoring station on the impaired reach (1998–2011; n = 34 for Ables Creek and 26 for Overflow Creek). Separate regressions for base flows season and storm flows season were not developed due to the limited number of data points available.

Table 6: Summary of results of turbidity and TSS regressions for Ables Creek and Overflow Creek.

Sampling Station	Regression Equation	Number of Data Points	Coefficient of Determination (R^2)
OUA0153 and OUA0158 Ables Cr.	Turbidity = 6.5576 × $(TSS)^{0.649}$	34	0.56
OUA0012A Overflow Cr.	Turbidity = 4.4669 × $(TSS)^{0.66587}$	26	0.64

The strength of the linear relationship is measured by the coefficient of determination (R^2) calculated during the regression analysis (Zar 1996). The R^2 value is the percentage of the total variation in the logarithm of turbidity that is explained or accounted for by the fitted regression (logarithm TSS). The unexplained portion is attributed to factors other than TSS.

The statistical significance for each regression was evaluated by computing the “P value” for the slope for each regression. The P value is the probability that the slope of the regression line is really zero. A low P value indicates that a non-zero slope calculated from the regression analysis is statistically significant. The P values for these regressions were less than 0.01, which is statistically significant.

4.0 TMDL DEVELOPMENT

Tables and figures referenced in Section 4.0 are organized in the appendices of this report as follows:

Appendix A:	Maps and NPDES loading sources		
Appendix B:	Overflow Creek	Chloride	AR_08040205_908
Appendix C:	Overflow Creek	TSS	AR_08040205_908
Appendix D:	Ables Creek	TSS	AR_08040205_911

4.1 Methodology for TMDL Development

Load duration curve (LDC) methodology was used to develop TMDLs for this report. This methodology is described in an EPA guidance document titled “An Approach for Using Load Duration Curves in the Development of TMDLs” (EPA 2007).

Because loading capacity varies as a function of flow, TMDLs developed with LDC methodology illustrate a continuum of allowable loads over all flow conditions, rather than a fixed load for one flow condition. Stream flow variability is an important factor when non-point source loading is important (Cleland 2002). While LDC methodology allows for investigation of pollutant loading across flow regimes, it does not take other factors into account like more complicated modeling. For example, LDC methodology does not consider fate and transport mechanisms (EPA 2007); nor does it provide information regarding the magnitude of pollutant sources. These limitations can be mitigated depending on pollutant type, number of loading sources, and types of loading sources.

The steps for application of LDC methodology for the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve (Section 4.2),
2. Convert the flow duration curve to load duration curve (Section 4.4),
3. Plot observed loads with the load duration curves (Section 4.5),
4. Calculate the TMDL (Section 4.7.1),
5. Calculate the MOS (Section 4.7.2),
6. Calculate the loads reserved for future growth (Section 4.7.3),
7. Calculate existing and allowable loads for continuous point sources (Section 4.7.4), and
8. Calculate existing and allowable loads from diffuse sources (Section 4.7.5).

Loading curves created with this method help illustrate TMDL targets, magnitude of water quality standards, measured loads, and allowable loads (NDEP 2003). Easily understood graphics are important for conveying scientifically technical information to stakeholders and citizens.

4.2 Flow Duration Curves

A flow duration curve was developed for Ables Creek and Overflow Creek using the long-term flow gage data discussed in Section 2.3. Daily stream flow measurements from each gage were sorted in increasing order and the percentile ranking of each flow was calculated. Flows at the downstream end of each reach were estimated from the flow at the gage based on the ratio of drainage area for the reach and for the gage. Each flow duration curve was then plotted as daily flow (cfs) on the Y axis versus percent exceedance on the X axis. Percent exceedance is when the flow is equal to or exceeded x% of time. At 50% flow exceedance, for example, stream flow is at this flow or higher 50% of the time.

4.3 Water Quality Targets

Water quality targets are established for each pollutant pair (AU and pollutant) in order to convert the flow duration curve to a load duration curve. For the Overflow Creek chloride TMDL the water quality target was set at the site specific numeric criterion of 20 mg/L as discussed in Section 2.4.2. Chloride can be expressed as mass, so there was no need to use a surrogate parameter.

Turbidity is an expression of the optical properties in water that cause light to be scattered or absorbed. This may be caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, plankton, and other microscopic organisms (Standard Methods 1999). Turbidity cannot be expressed as mass as is preferred for TMDL development, if possible. To achieve a load-based (mass) value, turbidity is often correlated with a surrogate parameter such as TSS that can be expressed as a load. In general, activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (EPA 1991 Relyea et al. (2000) states, “increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrophs to substrate surfaces.”

The relationships between turbidity and TSS presented in Table 6 were used to develop water quality target TSS concentrations for the TSS TMDLs (Table 7.)

Table 7: Summary of target TSS concentrations.

Stream Name	Sampling Station	Season	Turbidity Criterion (NTU)	TSS Target (mg/L)
Ables Creek	OUA0158	Base flows season	21	6.01
		Storm flows season	32	11.5
Overflow Creek	OUA0012A	Base flows season	21	10.2
		Storm flows season	32	19.2

4.4 Load Duration Curves

For each TMDL, flow values from flow duration curves were multiplied by the appropriate target concentration of chloride, or TSS, (from Section 4.3) to make a duration curve of allowable loads. Each load duration curve is a plot of pounds per day of chloride or TSS versus the percent exceedances from the flow duration curve.

Load duration curves show loads at a wide range of flows rather than at a single critical flow. The official TMDL number may be reported as one or more discrete numbers, but the curve is provided to demonstrate the value of the acceptable load at other flows. This will allow analysis of load cases in the future for different flow regimes. Load duration curves and relevant calculations for load duration curves for each pollutant pair (AU and pollutant) are shown in the appendices of this report.

4.5 Observed Loads

Load duration curve plots show observed pollutant loads on sampling days. Observed loads were calculated by multiplying each observed concentration of chloride, or TSS, by the estimate of flow at the downstream end of the reach on the sampling day. These observed loads were then plotted versus the percent exceedances of the flow on the sampling day and placed on the plot with the corresponding load duration curve. These plots with the load duration curves and observed loads are shown in the appendices of this report.

These plots provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads plotted above the load duration curve represent conditions where observed loads exceed the loads corresponding to the numeric criterion from the water quality standards (i.e., violating water quality standards). Observed loads below the load duration curve represent conditions where observed loads were less than loads corresponding to the numeric criterion (i.e., not violating water quality standards).

The load duration curve is beneficial when analyzing monitoring data with its corresponding flow information plotted as a load. This allows monitoring data to be plotted in relation to its place in the flow continuum.

4.6 Seasonality and Critical Conditions

Section 303(d) of the Clean Water Act and 40 C.F.R. §130.7 require TMDLs to consider seasonal variations for meeting water quality standards. 40 C.F.R. §130.7 requires TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, historical data and analyses discussed in Section 3.0 were used to evaluate whether there were flow conditions or certain periods of the year that could be used to characterize critical conditions.

The chloride TMDL in this report was not developed for individual seasons because water quality data do not show strong, consistent seasonal patterns and the assimilative capacity for this parameter does not vary with seasonal temperature changes (unlike parameters such as dissolved oxygen). TSS TMDLs were developed for base season and stormflow season, as defined by Rule 2.503.

Critical flow conditions were addressed by using the LDC methodology to develop these TMDLs. LDCs relate flow values to the percent of time those values have been met or exceeded (EPA 2007). This methodology allows for loading to be considered for a wide range of flows. The chloride TMDL for Overflow Creek was set at HMF, which is the critical flow for minerals as described in Rule 2.106. HMF was calculated using Excel. The TSS TMDLs for both Overflow Creek and Ables Creek were set at 50% flow exceedance (load at which flows are met or exceeded 50% of the time) because actual loads exceeded the load duration curve across the entire flow spectrum.

4.7 TMDL Calculations

TMDLs in this report consist of WLAs for regulated sources, LAs for non-regulated sources, MOS, and FG. TMDLs for Overflow Creek and Ables Creek are summarized in Tables 8 and 9.

4.7.1 TMDLs

The TMDL for chloride in Overflow Creek was developed using harmonic mean critical flow conditions (82.8%). Turbidity TMDLs for both Ables Creek and Overflow Creek were developed at 50% flow because observed load exceedances were found across the flow spectrum for both AUs across all seasons (base and storm).

Table 8: Summary of chloride TMDL for Overflow Creek.

	Loads of Chloride (lbs/day)					
	WLA for Continuous Point Sources	swWLA for NPDES Regulated Stormwater	LA for non-Regulated Diffuse Sources	MOS	Future Growth	TMDL
Overflow Creek AR_08040205_908	N/A[A]	N/A[A]	104.10	13.01	13.01	130.12

A. There are currently no permitted dischargers to these AUs.

Table 9: Summary of turbidity TMDLs for Ables Creek and Overflow Creek.

		Loads of TSS (lbs/day)					
Assessment Unit	Season	WLA for Continuous Point Sources	swWLA for NPDES Regulated Stormwater	LA for Non-Regulated Diffuse Sources	MOS	Future Growth	TMDL
Overflow Creek AR_08040205_908	Base	N/A[A]	N/A[A]	164.08	20.51	20.51	205.09
	Storm	N/A[A]	N/A[A]	1701.74	212.72	212.72	2127.17
Ables Creek AR_08040205_911	Base	N/A[A]	1.77	531.98	66.72	66.72	667.19
	Storm	N/A[A]	9.58	2874.15	360.47	360.47	3604.66

A. There are currently no permitted dischargers to these AUs.

4.7.2 MOS

Section 303(d) of the Clean Water Act and regulations in 40 C.F.R. §130.7 require TMDLs to include an MOS to account for any uncertainty concerning the relationship between pollutant loading and water quality. There are no guidelines for estimating MOS, although it may be expressed explicitly as unallocated assimilative capacity or implicitly through conservative assumptions used in establishing the TMDL. TMDLs in this report were assigned an explicit MOS of 10% of estimated load capacity. Nunoo et al. (2020) reported that 10% of estimated load capacity is the most used value for explicit MOS in all of the United States and territories and that 84% of explicit MOS values selected for TMDL development were not based on uncertainty estimation methods. Load for existing or future sources should never be taken from the MOS.

4.7.3 Future Growth

An explicit loading allowance of 10% was set aside for future growth for each TSS and chloride TMDL. This reserve load will accommodate growth of existing facilities or influx of new facilities that have the pollutant of concern in their effluent.

4.7.4 Continuous Point Source Discharges

There are no NPDES continuous point sources that discharge inorganic TSS or chloride within the Ables Creek or Overflow Creek watersheds at the time this report was written; therefore, the WLA is recorded as “N/A” or not applicable. If continuous point sources that necessitate a WLA are developed within either watershed, load will be taken from future growth allowance. This reallocation does not require EPA approval and can be handled within the water quality management plan (WQMP) maintained by the DEQ NPDES Permitting program. Reallocation would also be documented as an amendment to the TMDL by the DEQ TMDL program and updated on the DEQ TMDL website.

4.7.5 Loads from Diffuse Sources

Loads from diffuse sources consist of 1) nonpoint runoff or base flow from areas that are not regulated by NPDES permits, and 2) industrial or municipal stormwater regulated by NPDES permits.

Loading from non-regulated sources, such as overland runoff, are assigned loading as the LA. For LDC method TMDL development, this is the remaining load after MOS, FG, and WLA from continuous point sources are calculated. LAs for TMDLs in this report are summarized in Table 8 and 9.

Turbidity sources of non-regulated diffuse loading in Overflow and Ables Creek watersheds include cultivated crop land use (27% and 32%, respectively), gravel roads, stream bank erosion, and other sources. Chloride sources of non-regulated diffuse loading in Overflow Creek watershed are unknown. The Bayou Bartholomew watershed is located within the Mississippi Alluvial Plain. Groundwater in the area comes from the Quaternary Mississippi River Valley Alluvial (MRVA) aquifer. The MRVA aquifer and the streams within the Bayou Bartholomew watershed are hydrologically connected (Broom and Reed 1973). Larsen et al. (2020) reported groundwater from the MRVA aquifer in southeastern Arkansas (where the Bayou Bartholomew watershed is located) has higher salinity than MRVA groundwater in other areas. Although Overflow Creek is not specifically mentioned within the cited literature, it cannot be ruled out that groundwater-surface water interactions could be a source of chloride loading in Overflow Creek.

Loading from regulated diffuse sources is calculated and subtracted from the LA and reassigned as stormwater WLA (swWLA).

No relevant NPDES regulated facilities were found in Overflow Creek watershed. Three NPDES permitted facilities were identified in the Ables Creek watershed with TSS as a constituent of concern in their effluent. All three facilities are covered under the Stormwater Industrial General Permit (ARR00). Loading for these facilities is presented as an aggregate stormwater WLA (∑swWLA). This was accomplished by delineating the area of each facility, summing those values, and comparing the total to the Ables Creek watershed area (115 sq. miles).

Cumulative area for the three facilities was measured as 245.19 acres or 0.3822 square miles, which equates to 0.3% of the total Ables Creek watershed area. To calculate the ∑swWLA for these facilities 0.3% of the LA was converted to ∑swWLA.

Table 10: Stormwater NPDES permit facility areas.

Facility Name	Permit Number	Facility Area (acres)	Facility Area (sq mi)
Select Concrete Co., LLC	ARR000568	199	0.31
Golden Lane Gravel	ARR001105	6.19	0.0097
Selma Hardwood Flooring	ARR00B592	40	0.0625
Total Area		**245.19**	**0.3822**

Area for Golden Lane Gravel was identified on a map within the stormwater pollution prevention plan (SWPPP) submitted to DEQ. Area for Select Concrete Co., LLC and Selma Hardwood Flooring was not identified within the SWPPP or other permit-related information. Area for these facilities was delineated using the Google Earth measuring tool. Facility boundaries were estimated using visual clues such as fences, tree lines, and other land use boundaries.

4.8 Implementation

For permitted loading sources, implementation of these TMDLs will occur by DEQ through NPDES permits. For non-permitted sources, implementation occurs through voluntary efforts by watershed groups, best management practices, and other non-regulatory means.

5.0 PUBLIC PARTICIPATION

Federal regulation 40 C.F.R. §130.7(c)(1)(ii) specifies that TMDLs shall be subject to public review as defined in the state's continuing planning process (CPP) (DEQ 2000). This report was previously public noticed in 2012; however, it has undergone extensive modification and will be public noticed again in accordance with the above-mentioned CPP.

DEQ public noticed these TMDLs in the Arkansas Democrat-Gazette, a state wide newspaper, on Sunday, and on the DEQ website, August 20, 2023. The public comment period ended September 19, 2023. No comments were received.

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APPENDIX A: WATERSHED MAPS AND LOADING SOURCE INFORMATION

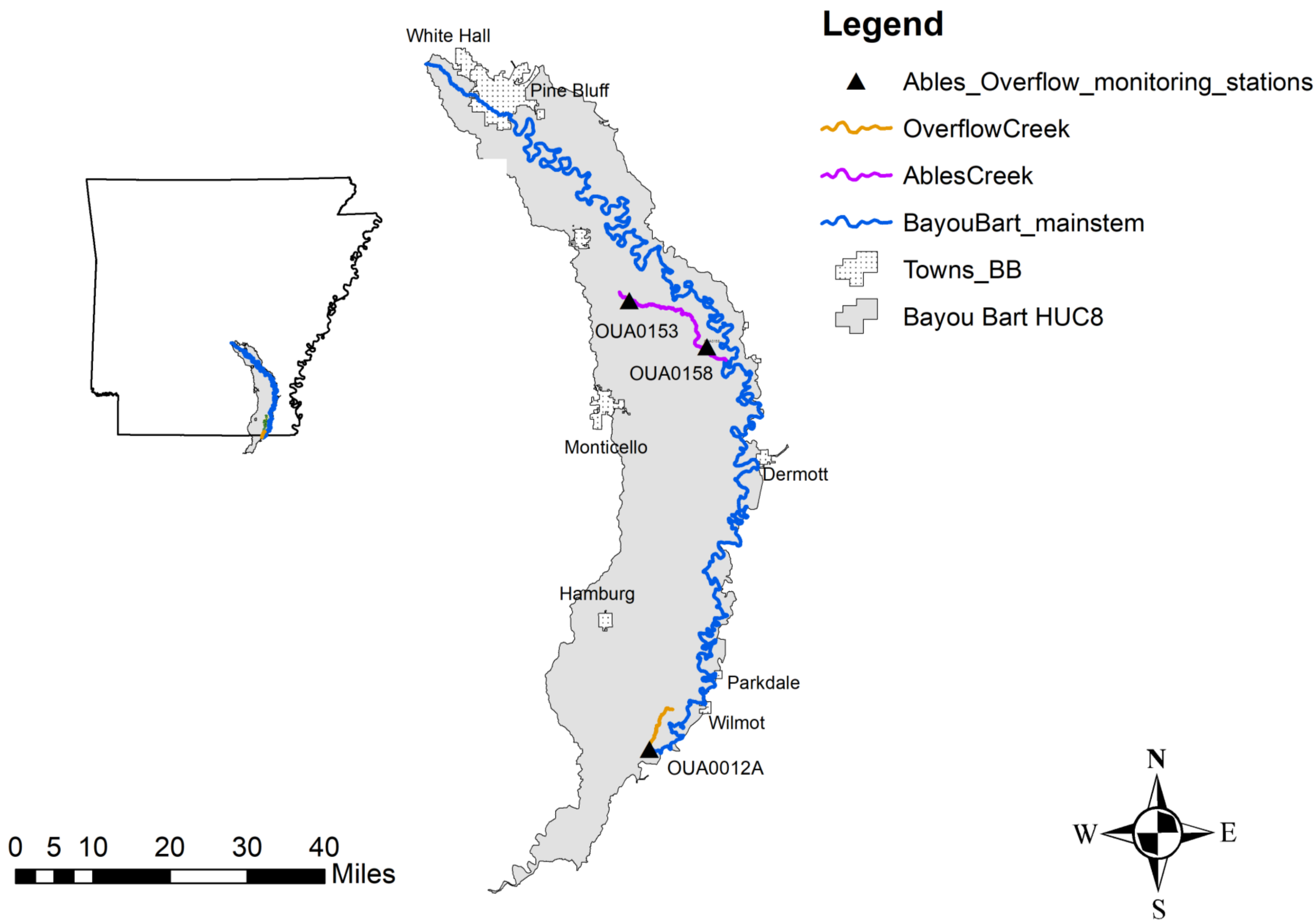


Figure A.1: Bayou Bartholomew watershed.

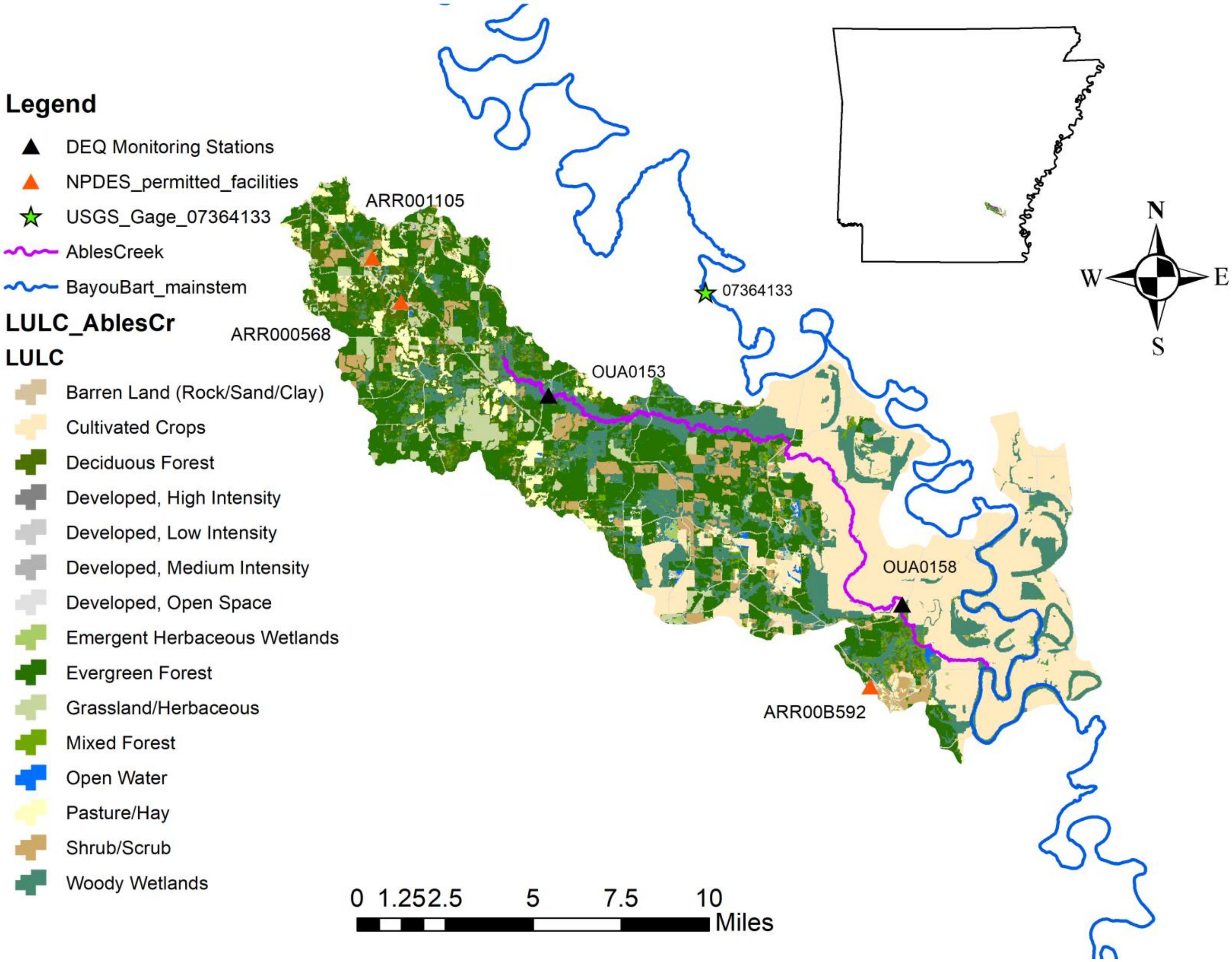


Figure A.2: Ables Creek LULC map.

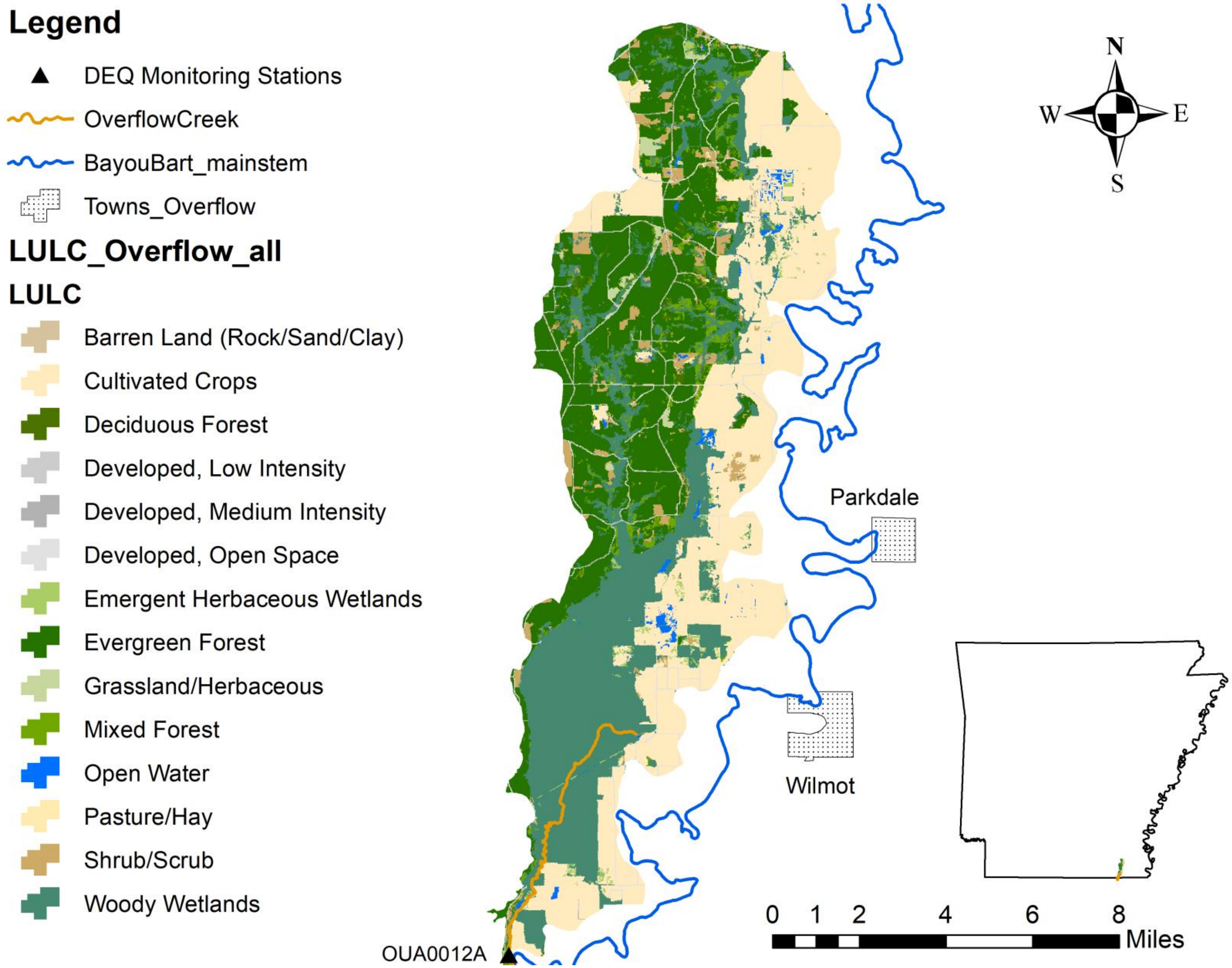


Figure A.3: Overflow Creek LULC map.

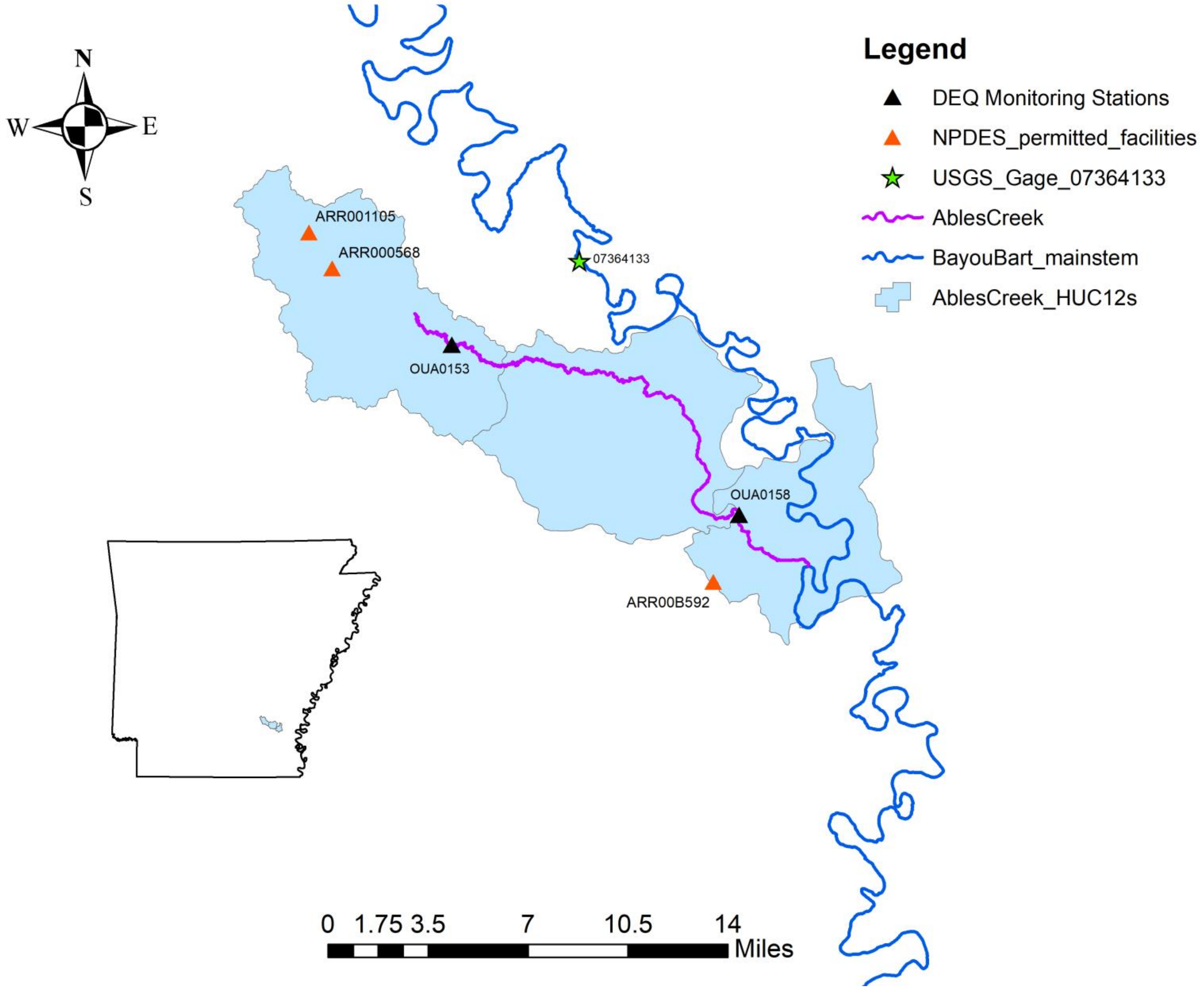
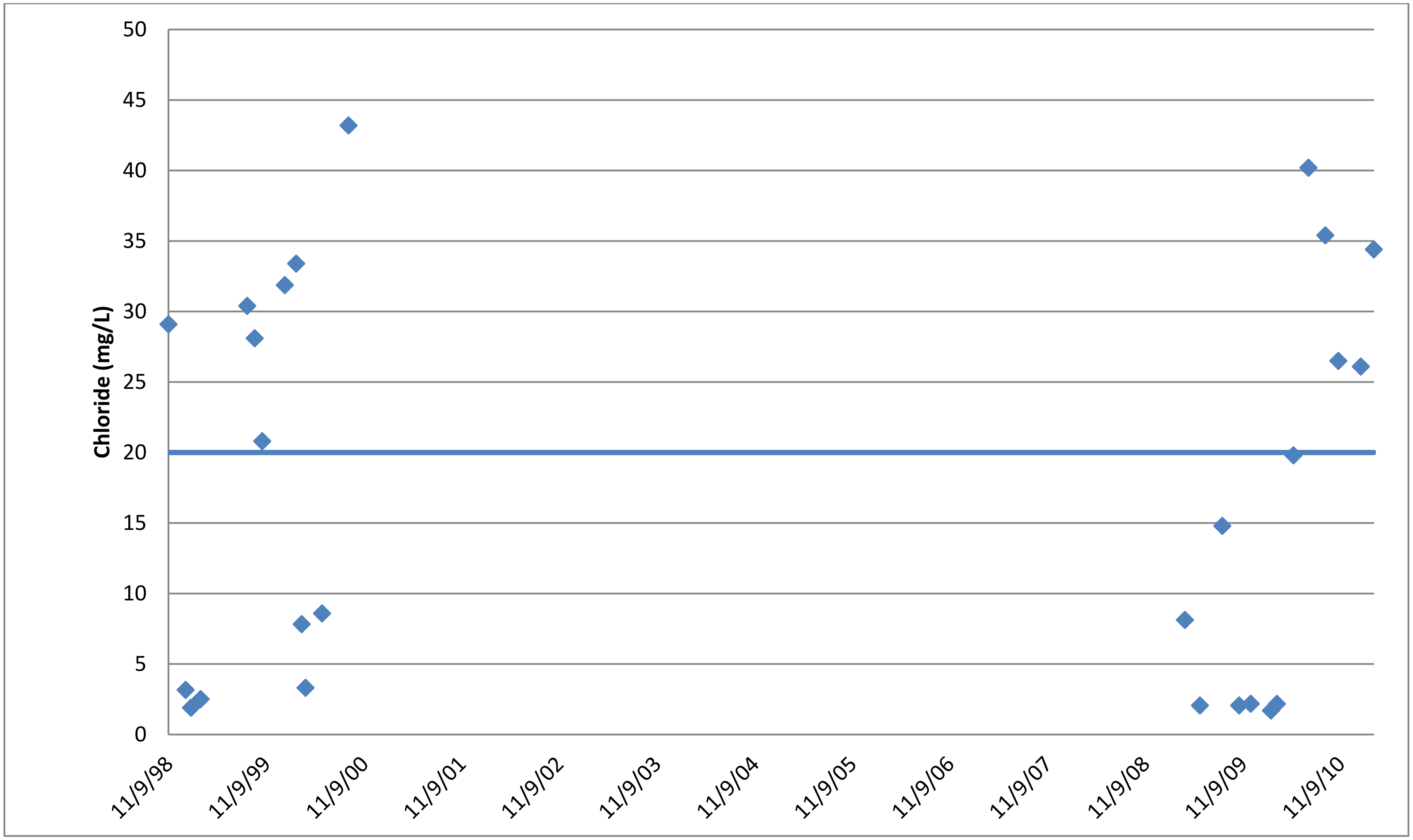


Figure A.4: NPDES permitted turbidity loading sources in the Ables Creek watershed.

Table A.1: NPDES regulated loading sources for TSS in the Ables Creek and Overflow Creek watersheds.

Permit Number	Facility Name	Type of Discharge	Flow Rate (MGD)	Receiving Waterbody	Permit Expiration Date	Industrial Sector (SW permits)	Does permit have limits for AU parameter	Should permitted facility be assigned WLA
Ables Creek AU AR-08040205_911 TMDL Parameter Siltation/Turbidity								
ARR000568	Select Concrete Co., LLC	Storm water	n/a	Unnamed Tributary, Chance Creek, Ables Creek	6/30/2019	E2 Concrete	Yes	Yes
ARR001105	Golden Lane Gravel	Storm water	n/a	Ables Creek	6/30/2024	J1Sand and gravel	Yes	Yes
ARR00B592	Selma Hardwood Flooring	Storm water	n/a	Unnamed Tributary, Ables Creek	6/30/2024	A1 Sawmill	Yes	Yes
Overflow Creek AU AR_08040205_908 TMDL Parameter Siltation/Turbidity and Chloride								
There are no permitted facilities within this watershed.								

APPENDIX B: OVERFLOW CREEK CHLORIDE TMDL INFORMATION

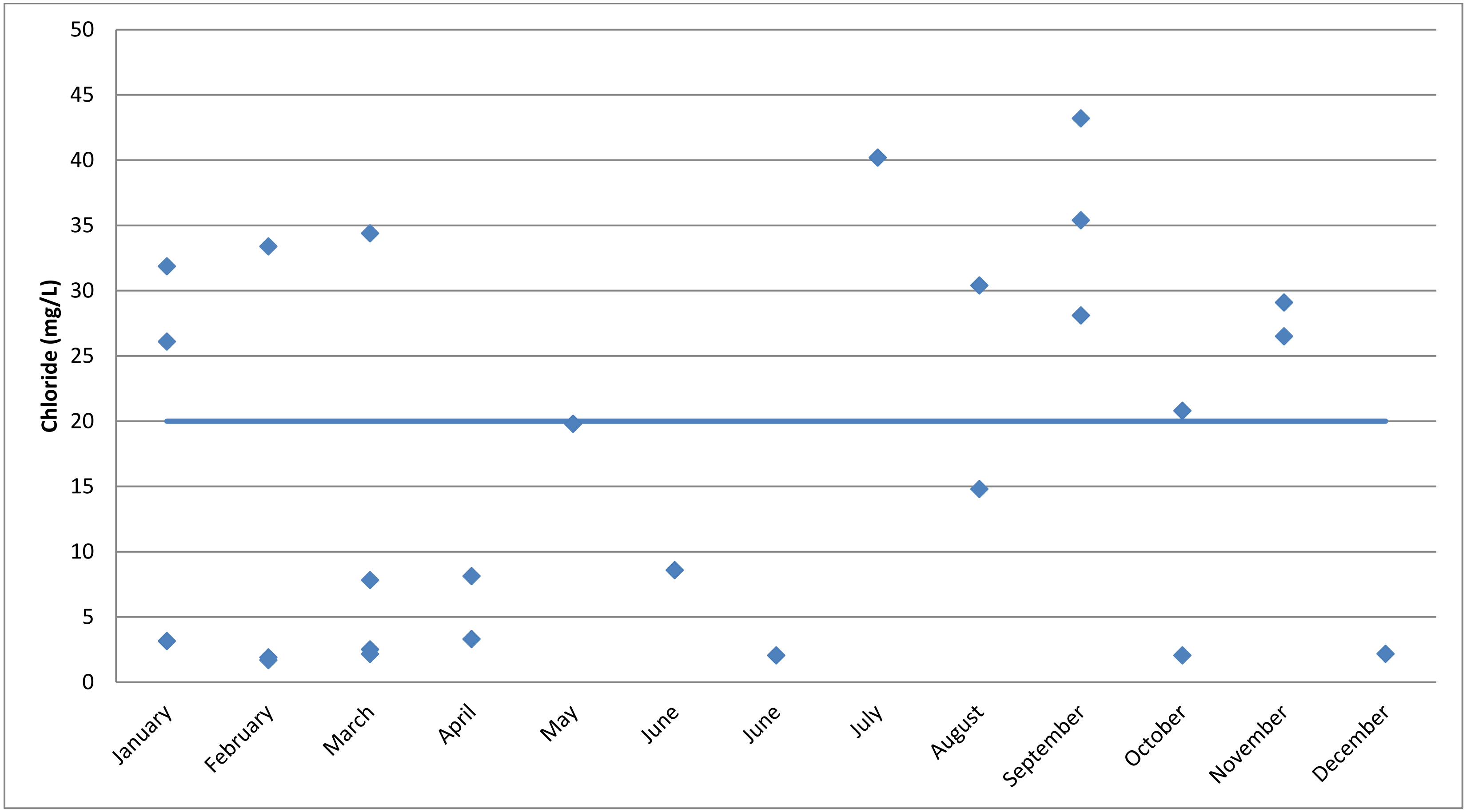


The line at 20 mg/L represents the site specific criteria for chloride in Overflow Creek.

Figure B.1: Time series plot of chloride data in Overflow Creek at DEQ monitoring station OUA0012A.

Table B.1: Chloride data (mg/L) in Overflow Creek from DEQ monitoring station OUA0012A. Site specific criterion for Overflow Creek is 20 mg/L chloride.

Date Sampled	Chloride (mg/L)
11/9/1998	29.1
1/12/1999	3.16
2/1/1999	1.9
3/9/1999	2.51
8/30/1999	30.4
9/27/1999	28.1
10/25/1999	20.8
1/18/2000	31.87
2/29/2000	33.4
3/21/2000	7.83
4/4/2000	3.31
6/5/2000	8.59
9/12/2000	43.2
4/6/2009	8.13
6/1/2009	2.06
8/24/2009	14.8
10/26/2009	2.06
12/8/2009	2.18
2/22/2010	1.7
3/16/2010	2.17
5/17/2010	19.8
7/12/2010	40.2
9/13/2010	35.4
11/1/2010	26.5
1/24/2011	26.1
3/14/2011	34.4
n	**26**
MIN	**1.7**
MAX	**43.2**
MED	**17.3**
n > 20	**12**
% > 20	**46**



The line at 20 mg/L represents the site specific criteria for chloride in Overflow Creek.

Figure B.2: Seasonal plot of chloride data in Overflow Creek at DEQ monitoring station OUA0012A.

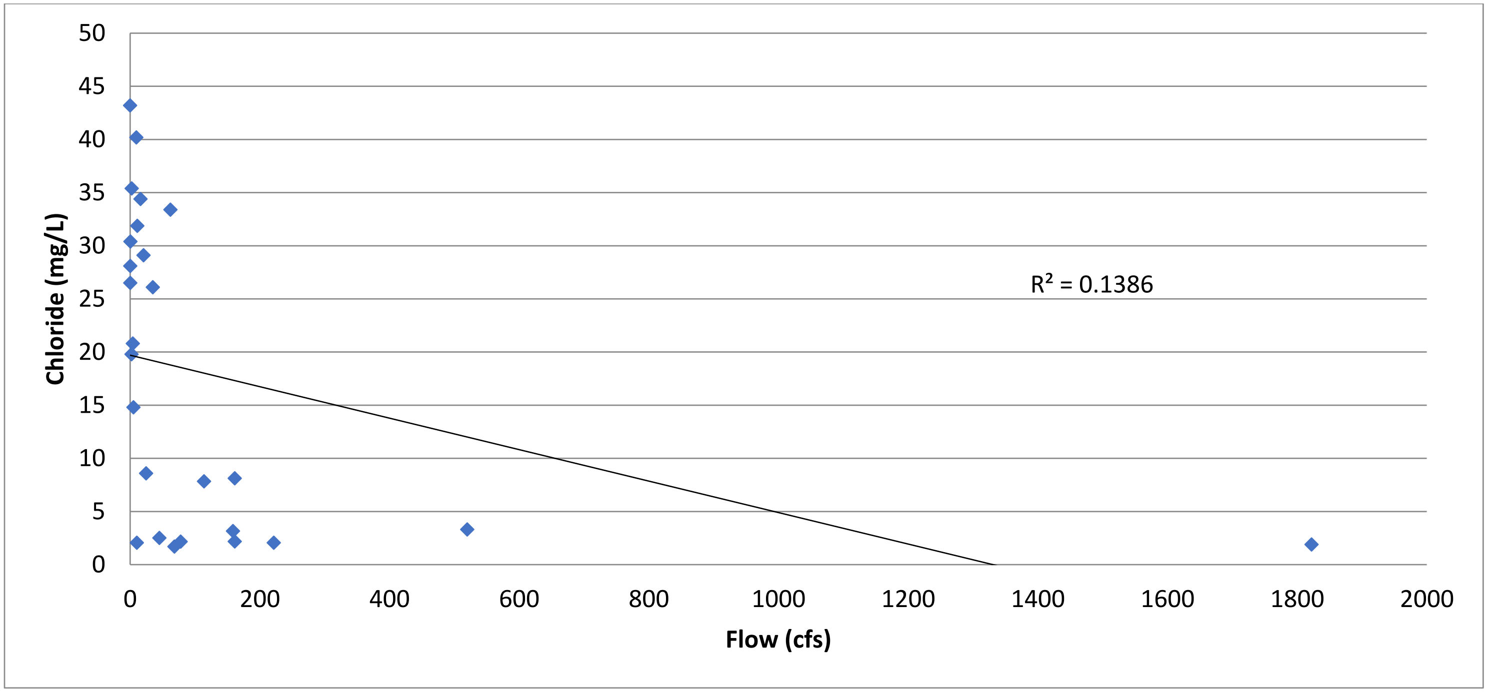


Figure B3: Chloride concentration versus flow in Overflow Creek at DEQ monitoring station OUA0012A. Flow is proportional at OUA0012A to the watershed with the USGS gage flow data.

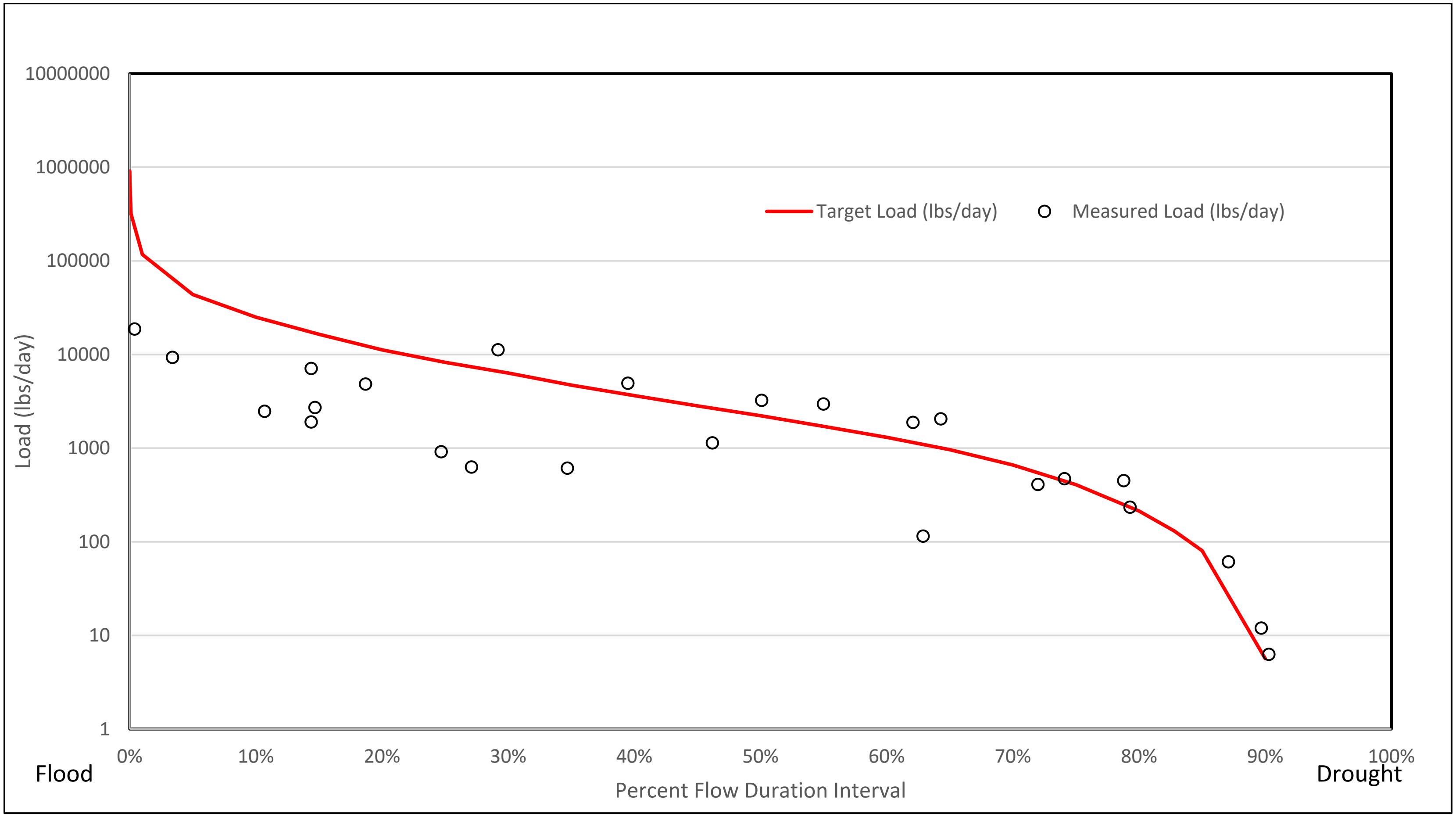


Figure B.4: Load duration curve for chloride in Overflow Creek. Chloride data are from DEQ monitoring station OUA0012A. Flow data are from USGS gage 07366200.

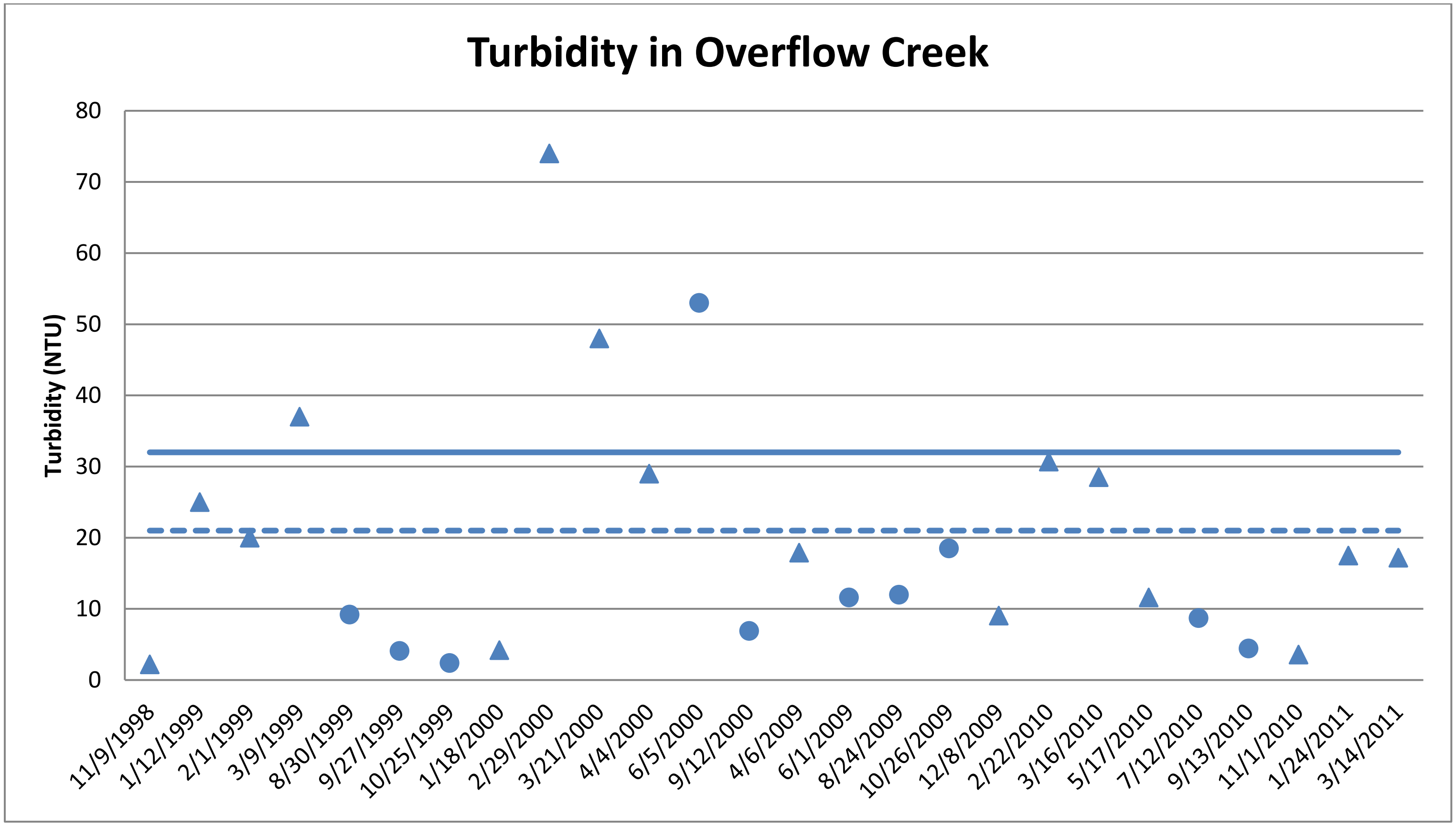
Table B.2: Target loads for chloride in Overflow Creek. Flow presented is a ratio of USGS gage 07366200 watershed (208 sq. mi.) to Overflow Creek watershed (90.89 sq. mi.). The TMDL for chloride in Overflow Creek was developed at harmonic mean flow of 82.8%.

Calculated Target Load		
Percent	Flow (cfs)	Target Load (lbs/day)
100%	0	0.00E+00
99%	0	0.00E+00
95%	0	0.00E+00
90%	0.05	5.66E+00
85%	0.75	8.05E+01
82.8%	1.21	1.30E+02
80%	1.97	2.13E+02
75%	3.77	4.07E+02
70%	6.12	6.60E+02
65%	8.93	9.63E+02
60%	12.10	1.31E+03
55%	15.82	1.71E+03
50%	20.54	2.22E+03
45%	26.17	2.82E+03
40%	33.69	3.63E+03
35%	43.70	4.71E+03
30%	58.82	6.35E+03
25%	76.25	8.23E+03
20%	104.00	1.12E+04
15%	152.63	1.65E+04
10%	232.03	2.50E+04
5%	404.20	4.36E+04
1%	1083.16	1.17E+05
0%	2952.72	3.19E+05
0%	6385.79	6.89E+05
0%	8433.54	9.10E+05

Table B.3: Chloride data (mg/L) from DEQ monitoring station OUA0012A calculated into load. Flow presented is a ratio of USGS gage 07366200 watershed (208 sq. mi.) to Overflow Creek watershed (90.89 sq. mi.).

Date	Chloride (mg/L)	Sample Date Flow (cfs)	Flow Percentile	Measured Load (lbs/day)
9/12/2000	43.20	0.00	100%	0.00E+00
11/1/2010	26.50	0.04	90%	6.25E+00
9/27/1999	28.10	0.08	90%	1.19E+01
8/30/1999	30.40	0.37	87%	6.09E+01
5/17/2010	19.80	2.18	79%	2.33E+02
9/13/2010	35.40	2.34	79%	4.47E+02
10/25/1999	20.80	4.19	74%	4.71E+02
8/24/2009	14.80	5.11	72%	4.08E+02
7/12/2010	40.20	9.44	64%	2.05E+03
6/1/2009	2.06	10.31	63%	1.15E+02
1/18/2000	31.87	10.92	62%	1.88E+03
3/14/2011	34.40	15.91	55%	2.95E+03
11/9/1998	29.10	20.54	50%	3.22E+03
6/5/2000	8.59	24.47	46%	1.13E+03
1/24/2011	26.10	34.87	40%	4.91E+03
3/9/1999	2.51	45.01	35%	6.09E+02
2/29/2000	33.40	62.05	29%	1.12E+04
2/22/2010	1.70	68.17	27%	6.25E+02
3/16/2010	2.17	77.78	25%	9.11E+02
3/21/2000	7.83	114.05	19%	4.82E+03
1/12/1999	3.16	158.62	15%	2.70E+03
4/6/2009	8.13	161.24	14%	7.07E+03
12/8/2009	2.18	161.24	14%	1.90E+03
10/26/2009	2.06	221.54	11%	2.46E+03
4/4/2000	3.31	520.00	3%	9.28E+03
2/1/1999	1.90	1822.17	0%	1.87E+04

APPENDIX C: OVERFLOW CREEK TSS TMDL INFORMATION



Solid line at 32 NTU is Gulf Coastal Ecoregion storm flows season turbidity criterion.
Dotted line at 21 NTU is the Gulf Coastal Ecoregion base flows season turbidity criterion.

Figure C.1: Time series plot of turbidity data in Overflow Creek at DEQ monitoring station OUA0012A. Base flow season data are represented by triangles and data not collected in base flow season is represented by dots.

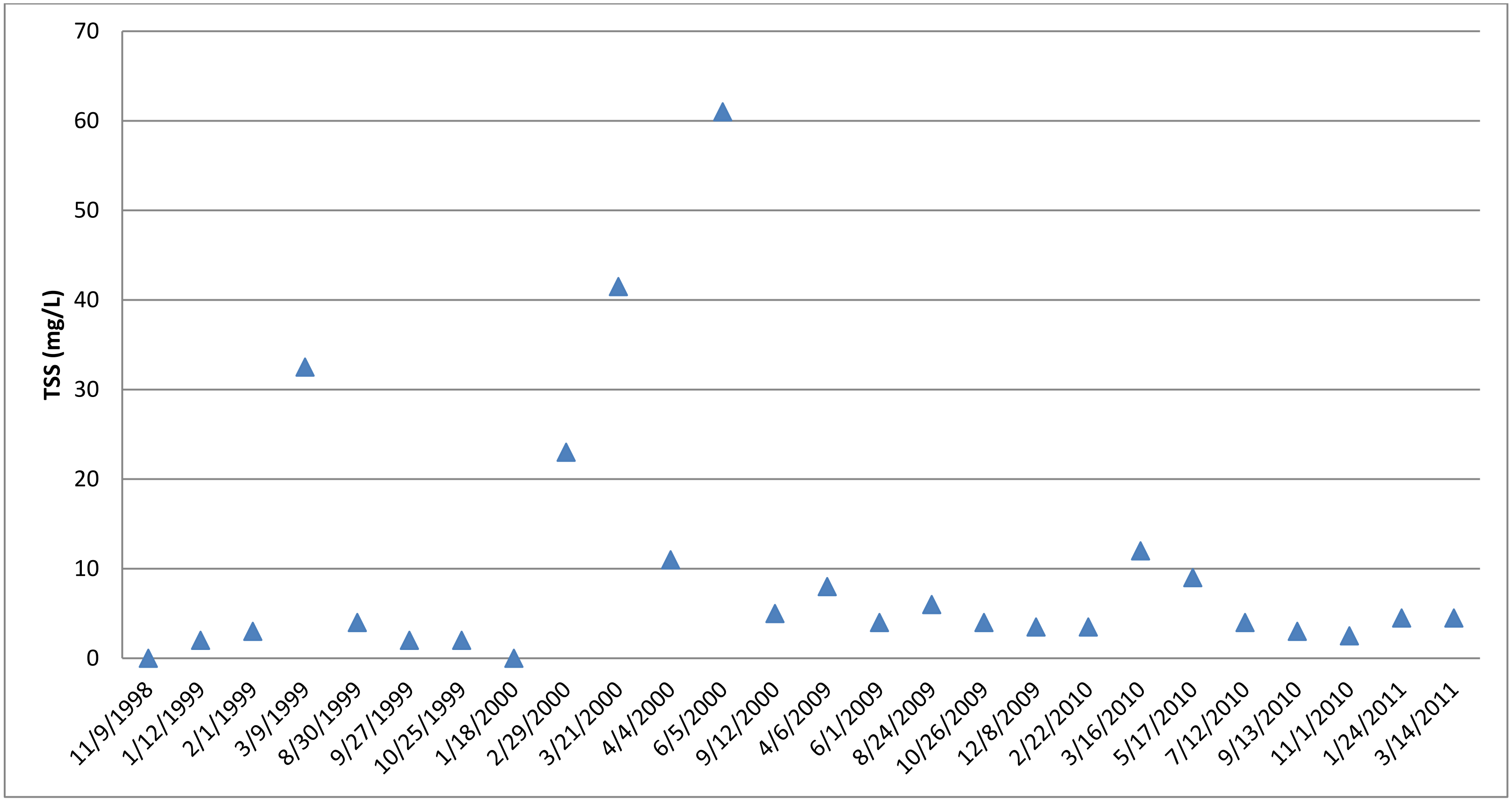
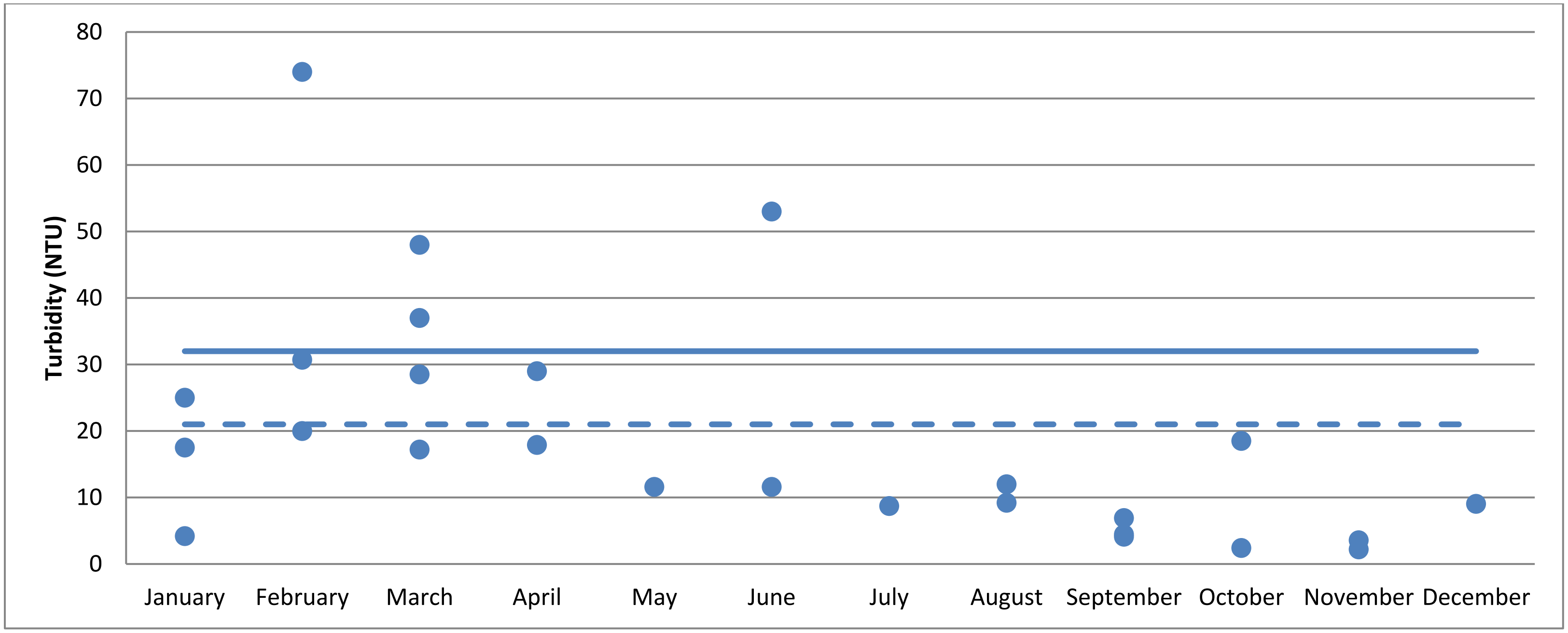


Figure C.2: Time series plot of TSS data in Overflow Creek at DEQ monitoring station OUA0012A.

Table C.1: TSS (mg/L) and turbidity (NTU) data in Overflow Creek at DEQ monitoring station OUA0012A.

Date Sampled	Total suspended solids (mg/L)	Turbidity (NTU)
11/9/1998	<1	2.2
1/12/1999	2	25
2/1/1999	3	20
3/9/1999	32.5	37
8/30/1999	4	9.2
9/27/1999	2	4.1
10/25/1999	2	2.4
1/18/2000	<1	4.2
2/29/2000	23	74
3/21/2000	41.5	48
4/4/2000	11	29
6/5/2000	61	53
9/12/2000	5	6.9
4/6/2009	8	17.9
6/1/2009	4	11.6
8/24/2009	6	12
10/26/2009	4	18.5
12/8/2009	3.5	9.05
2/22/2010	3.5	30.7
3/16/2010	12	28.5
5/17/2010	9	11.6
7/12/2010	4	8.71
9/13/2010	3	4.44
11/1/2010	2.5	3.57
1/24/2011	4.5	17.5
3/14/2011	4.5	17.2
n	**26**	**26**
MIN	**<1**	**2.2**
MAX	**61**	**74**
MED	**4.25**	**14.6**
n> 21 NTU	**n/a**	**8**
% > 21 NTU	**n/a**	**30.8**
n> 32 NTU	**n/a**	**4**
% > 32 NTU	**n/a**	**15.4**



Solid line at 32 NTU is Gulf Coastal Ecoregion storm flows season turbidity criterion.
Dotted line at 21 NTU is the Gulf Coastal Ecoregion base flows season turbidity criterion.

Figure C.3: Seasonal plot of turbidity data in Overflow Creek at DEQ monitoring station OUA0012A.

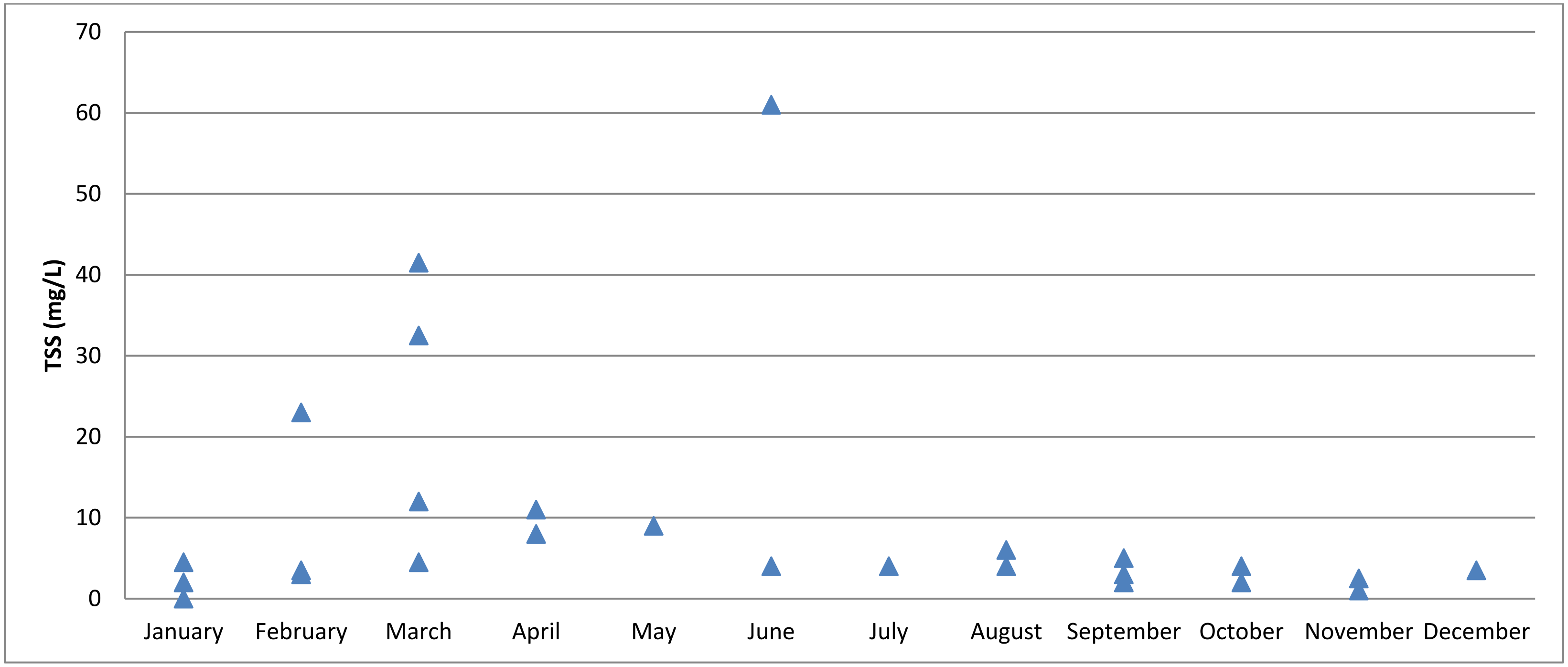


Figure C.4: Seasonal plot of TSS data in Overflow Creek at DEQ monitoring station OUA0012A.

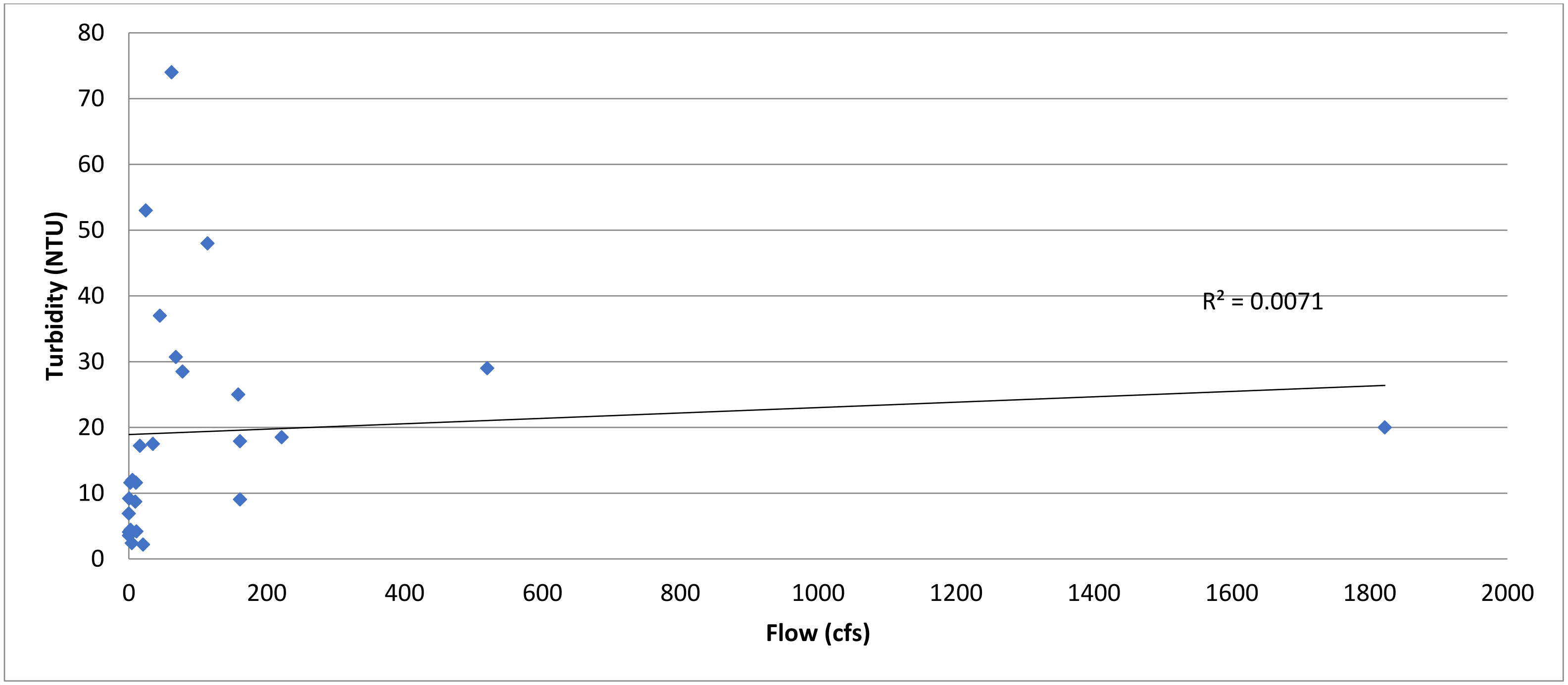


Figure C.5: Turbidity versus flow in Overflow Creek at DEQ monitoring station OUA0012A. Flow is proportional at OUA0012A to the watershed with the USGS gage flow data.

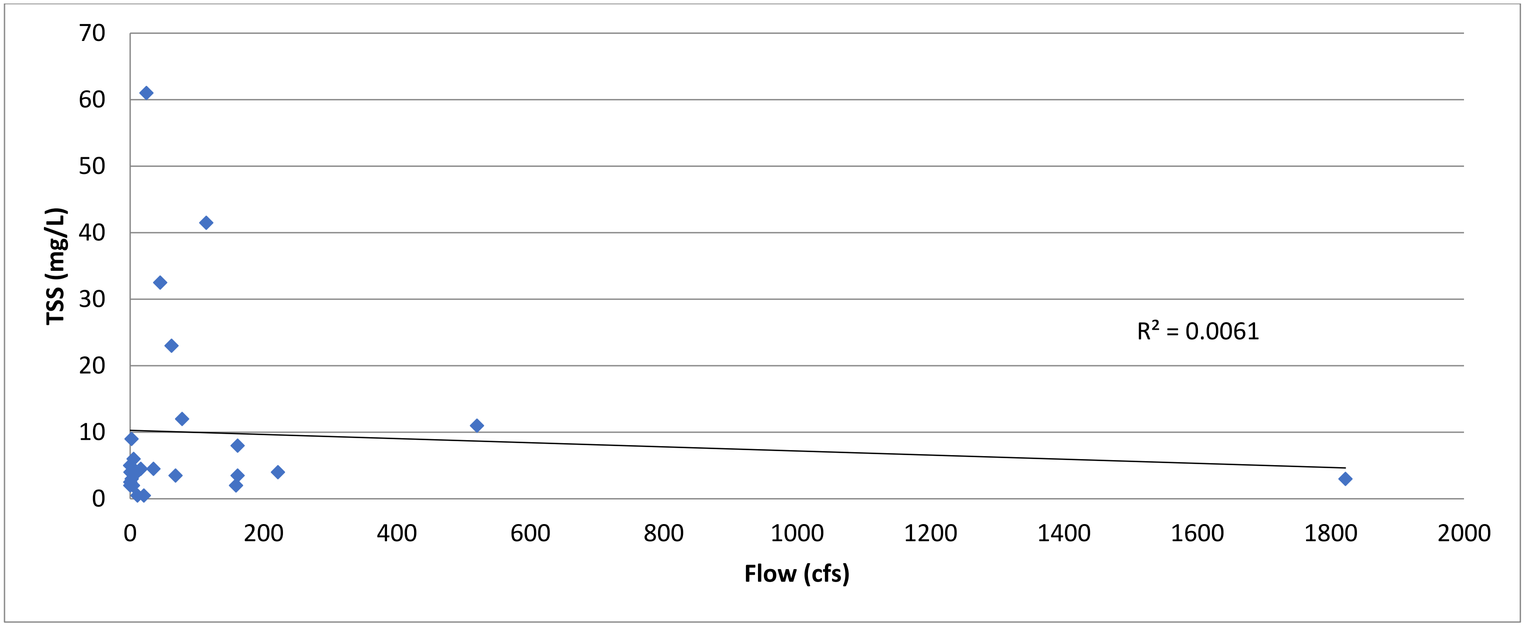


Figure C.6: TSS concentration versus flow in Overflow Creek at DEQ monitoring station OUA0012A. Flow is proportional at OUA0012A to the watershed with the USGS gage flow data.

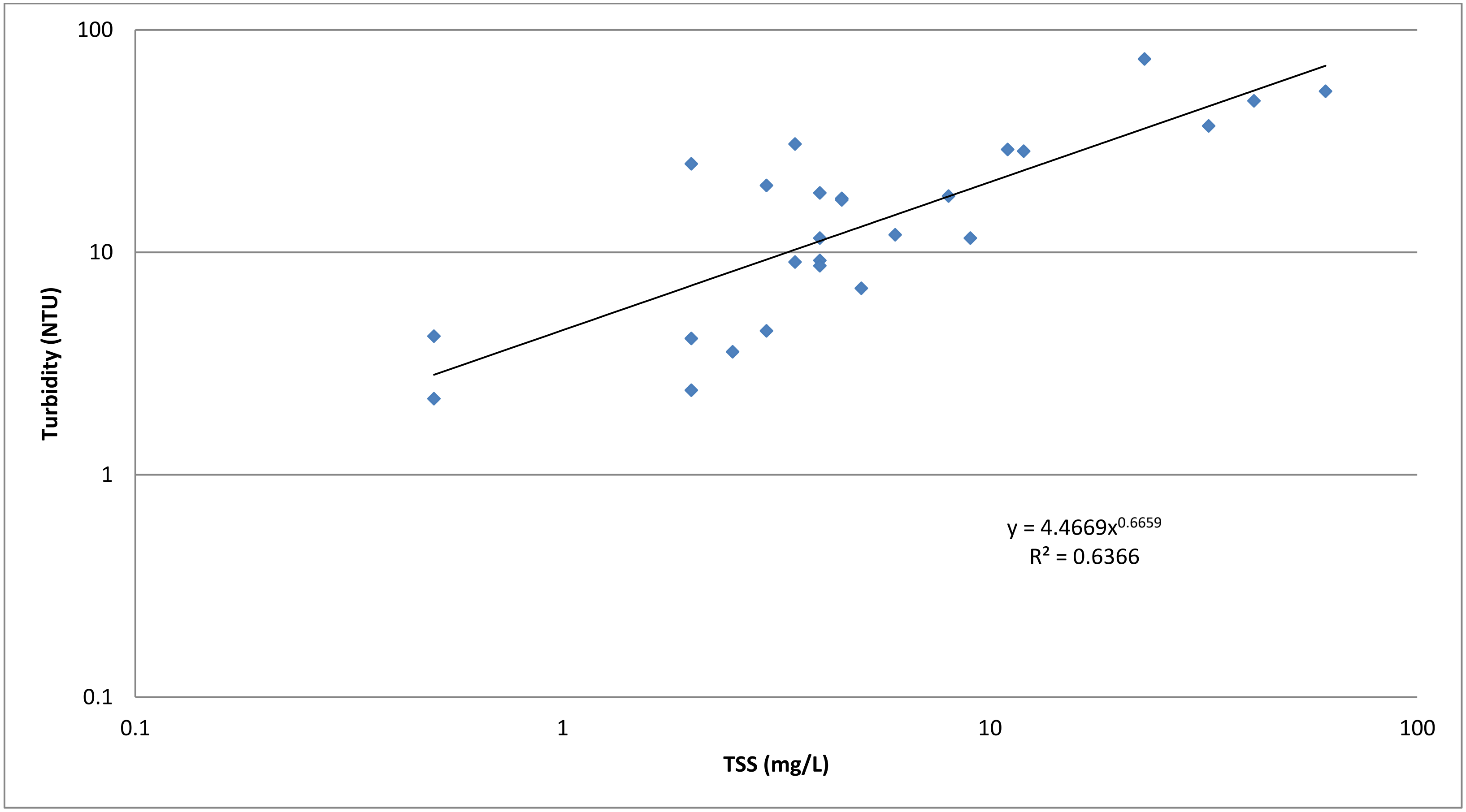


Figure C.7: TSS versus Turbidity in Overflow Creek at DEQ monitoring station OUA00012A.

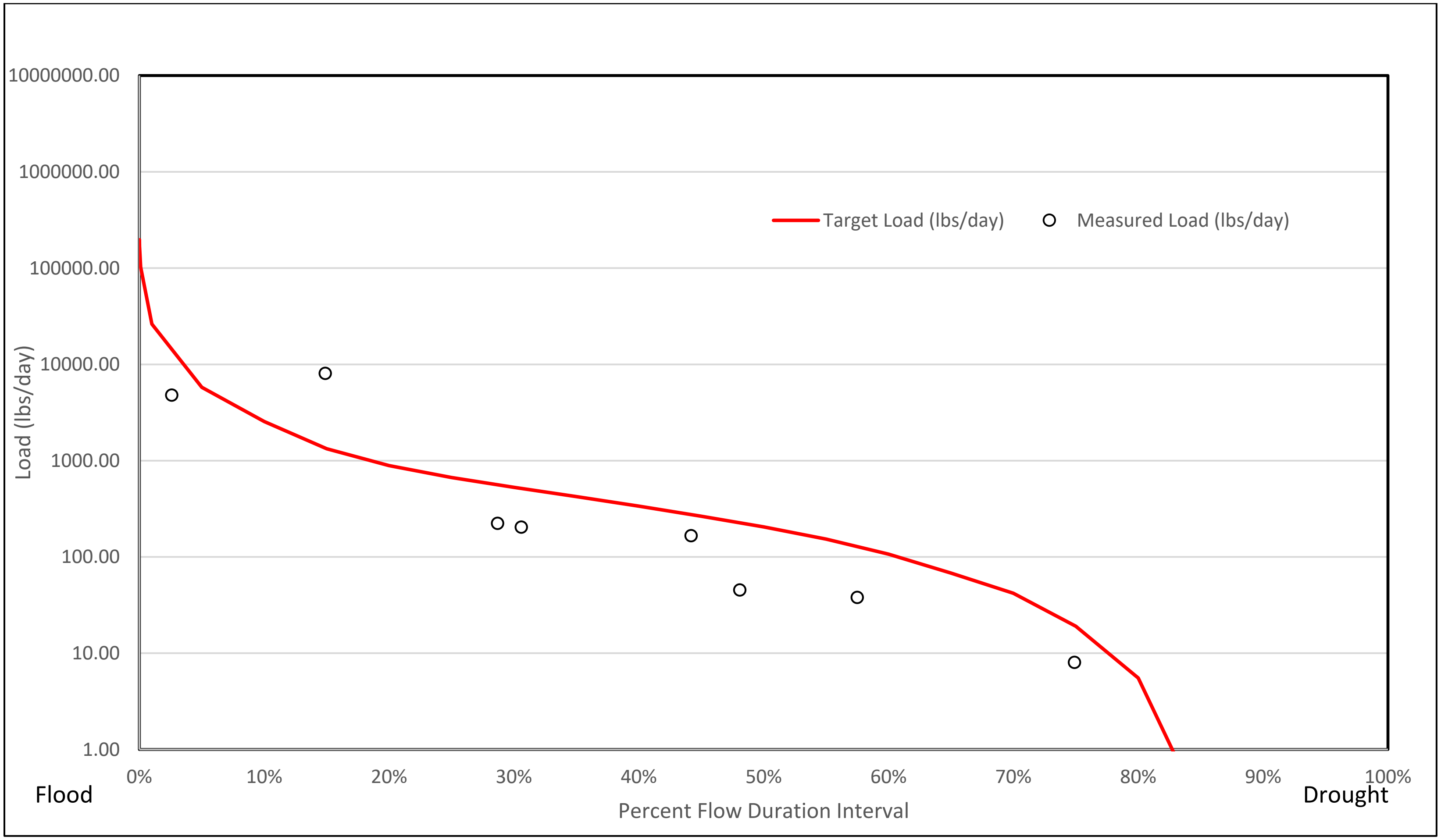


Figure C.8: Load duration curve for TSS in Overflow Creek – Base flows season. TSS load data are from DEQ monitoring station OUA0012A. Flow data are from USGS gage 07366200.

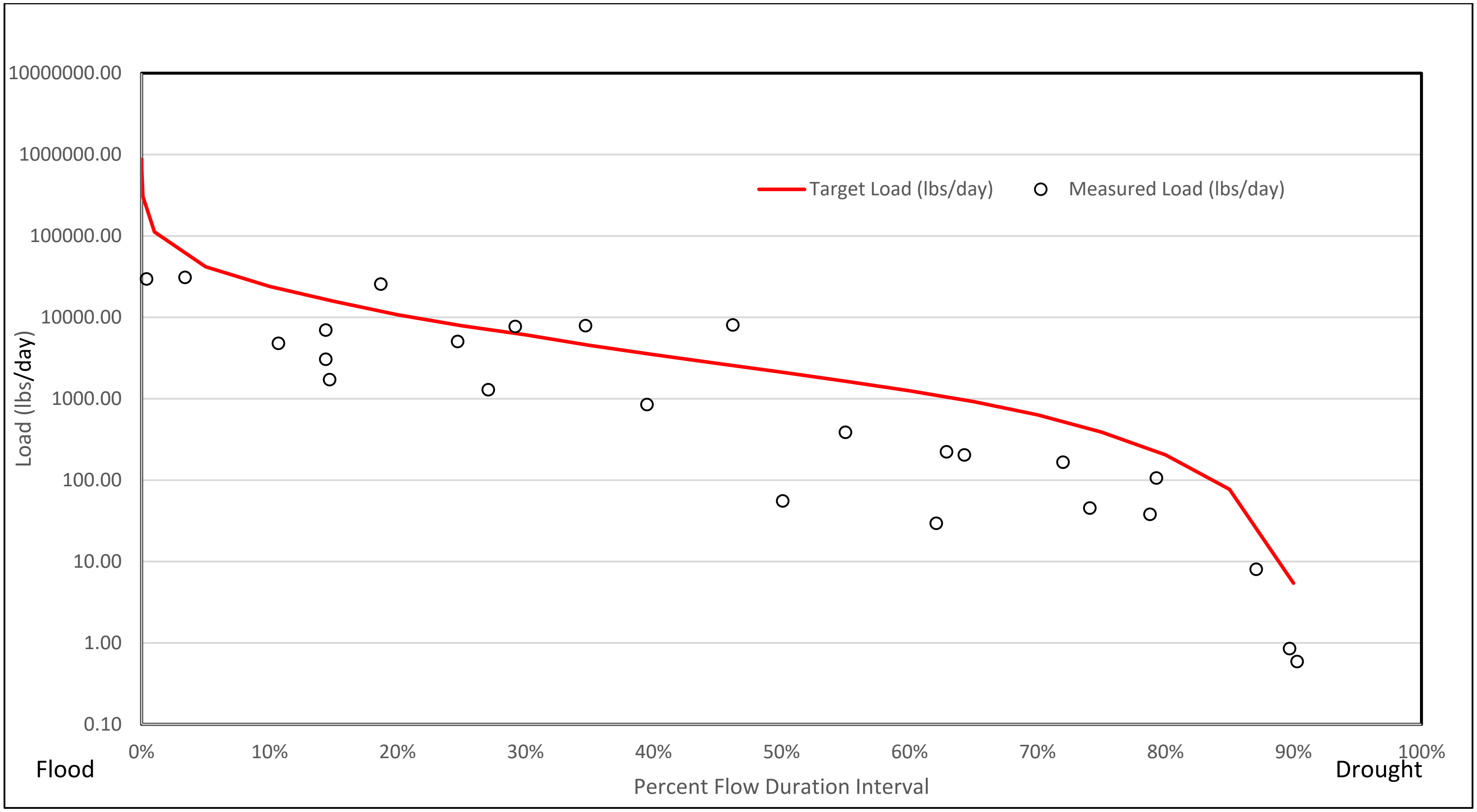


Figure C.9: Load duration curve for TSS in Overflow Creek – Storm flows season. TSS load data are from DEQ monitoring station OUA0012A. Flow data are from USGS gage 07366200.

Table C.2: Target loads for TSS in Overflow Creek for base flows season. Flow presented is a ratio of USGS gage 07366200 watershed (208 sq. mi.) to Overflow Creek watershed (90.89 sq. mi.). The base flows season TMDL for TSS in Overflow Creek was developed at 50% flow (in bold).

Percent	Flow (cfs)	Target Load (lbs/day)
100%	0.00	0.00E+00
99%	0.00	0.00E+00
95%	0.00	0.00E+00
90%	0.00	0.00E+00
85%	0.00	2.40E-01
80%	0.10	5.53E+00
75%	0.35	1.91E+01
70%	0.76	4.20E+01
65%	1.23	6.79E+01
60%	1.94	1.07E+02
55%	2.78	1.53E+02
50%	**3.73**	**2.05E+02**
45%	4.81	2.64E+02
40%	6.12	3.37E+02
35%	7.69	4.23E+02
30%	9.61	5.29E+02
25%	12.15	6.68E+02
20%	16.17	8.90E+02
15%	24.19	1.33E+03
10%	46.36	2.55E+03
5%	104.92	5.77E+03
1%	476.78	2.62E+04
0%	1868.86	1.03E+05
0%	3075.47	1.69E+05
0%	3578.79	1.97E+05

Table C.3: Base flows season TSS data (mg/L) from DEQ monitoring station OUA0012A calculated into load. Flow presented is a ratio of USGS gage 07366200 watershed (208 sq. mi.) to Overflow Creek watershed (90.89 sq. mi.).

Sample Date	TSS (mg/L)	Sample Date Flow (cfs)	Flow Percent Exceedance	Measured Load (lbs/day)
9/12/2000	5	0.00	100%	0.00
9/27/1999	2	0.08	81%	0.85
8/30/1999	4	0.37	75%	8.01
9/13/2010	3	2.34	58%	37.90
10/25/1999	2	4.19	48%	45.26
8/24/2009	6	5.11	44%	165.48
7/12/2010	4	9.44	31%	203.67
6/1/2009	4	10.31	29%	222.52
6/5/2000	61	24.47	15%	8052.33
10/26/2009	4	221.54	3%	4780.48

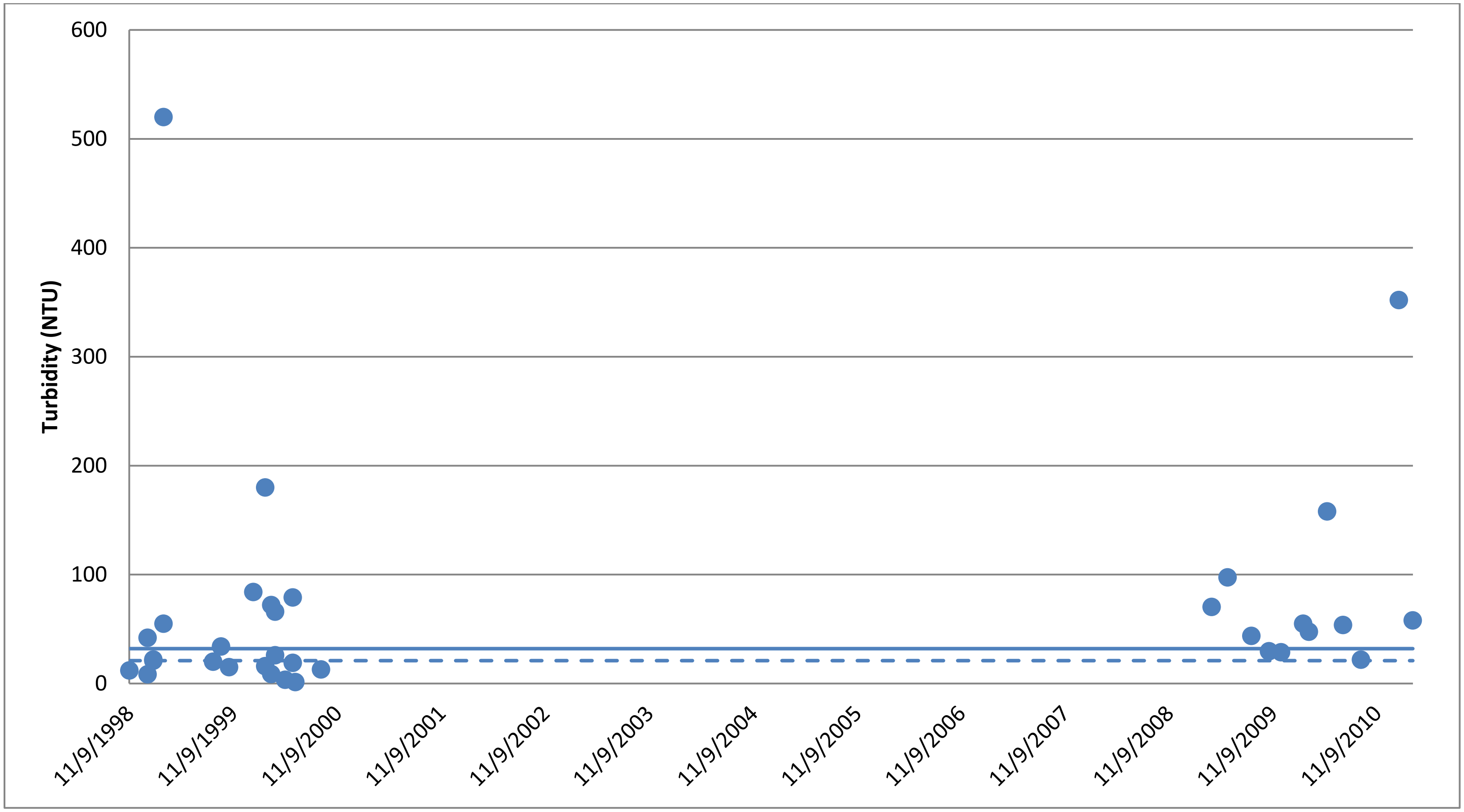
Table C.4: Target loads for TSS in Overflow Creek for storm flows season. Flow presented is a ratio of USGS gage 07366200 watershed (208 sq. mi.) to Overflow Creek watershed (90.89 sq. mi.). The storm flows season TMDL for TSS in Overflow Creek was developed at 50% flow.

Percent	Flow (cfs)	Target Load (lbs/day)
100%	0.00	0.00E+00
99%	0.00	0.00E+00
95%	0.00	0.00E+00
90%	0.05	5.43E+00
85%	0.75	7.73E+01
80%	1.97	2.04E+02
75%	3.77	3.90E+02
70%	6.12	6.34E+02
65%	8.93	9.25E+02
60%	12.10	1.25E+03
55%	15.82	1.64E+03
50%	20.54	2.13E+03
45%	26.17	2.71E+03
40%	33.69	3.49E+03
35%	43.70	4.53E+03
30%	58.82	6.09E+03
25%	76.25	7.90E+03
20%	104.00	1.08E+04
15%	152.63	1.58E+04
10%	232.03	2.40E+04
5%	404.20	4.19E+04
1%	1083.16	1.12E+05
0%	2952.72	3.06E+05
0%	6385.79	6.61E+05
0%	8433.54	8.73E+05

Table C.5: Storm flows season TSS data (mg/L) from DEQ monitoring station OUA0012A calculated into load. Flow presented is a ratio of USGS gage 07366200 watershed (208 sq. mi.) to Overflow Creek watershed (90.89 sq. mi.).

Sample Date	TSS (mg/L)	Sample Date Flow (cfs)	Flow Percent Exceedance	Measured Load (lbs/day)
9/12/2000	5	0.00	100%	0.00
11/1/2010	2.5	0.04	90%	0.59
9/27/1999	2	0.08	90%	0.85
8/30/1999	4	0.37	87%	8.01
5/17/2010	9	2.18	79%	105.86
9/13/2010	3	2.34	79%	37.90
10/25/1999	2	4.19	74%	45.26
8/24/2009	6	5.11	72%	165.48
7/12/2010	4	9.44	64%	203.67
6/1/2009	4	10.31	63%	222.52
1/18/2000	0.5	10.92	62%	29.47
3/14/2011	4.5	15.91	55%	386.12
11/9/1998	0.5	20.54	50%	55.40
6/5/2000	61	24.47	46%	8052.33
1/24/2011	4.5	34.87	40%	846.49
3/9/1999	32.5	45.01	35%	7890.86
2/29/2000	23	62.05	29%	7698.75
2/22/2010	3.5	68.17	27%	1287.05
3/16/2010	12	77.78	25%	5035.07
3/21/2000	41.5	114.05	19%	25532.45
1/12/1999	2	158.62	15%	1711.36
4/6/2009	8	161.24	14%	6958.58
12/8/2009	3.5	161.24	14%	3044.38
10/26/2009	4	221.54	11%	4780.48
4/4/2000	11	520.00	3%	30856.28
2/1/1999	3	1822.17	0%	29489.08

APPENDIX D: ABLES CREEK TSS TMDL INFORMATION



Solid line at 32 NTU is Gulf Coastal Ecoregion storm flows season turbidity criterion.
Dotted line at 21 NTU is the Gulf Coastal Ecoregion base flows season turbidity criterion.

Figure D.1: Time series plot of turbidity data in Ables Creek at DEQ monitoring stations OUA0153 and OUA0158.

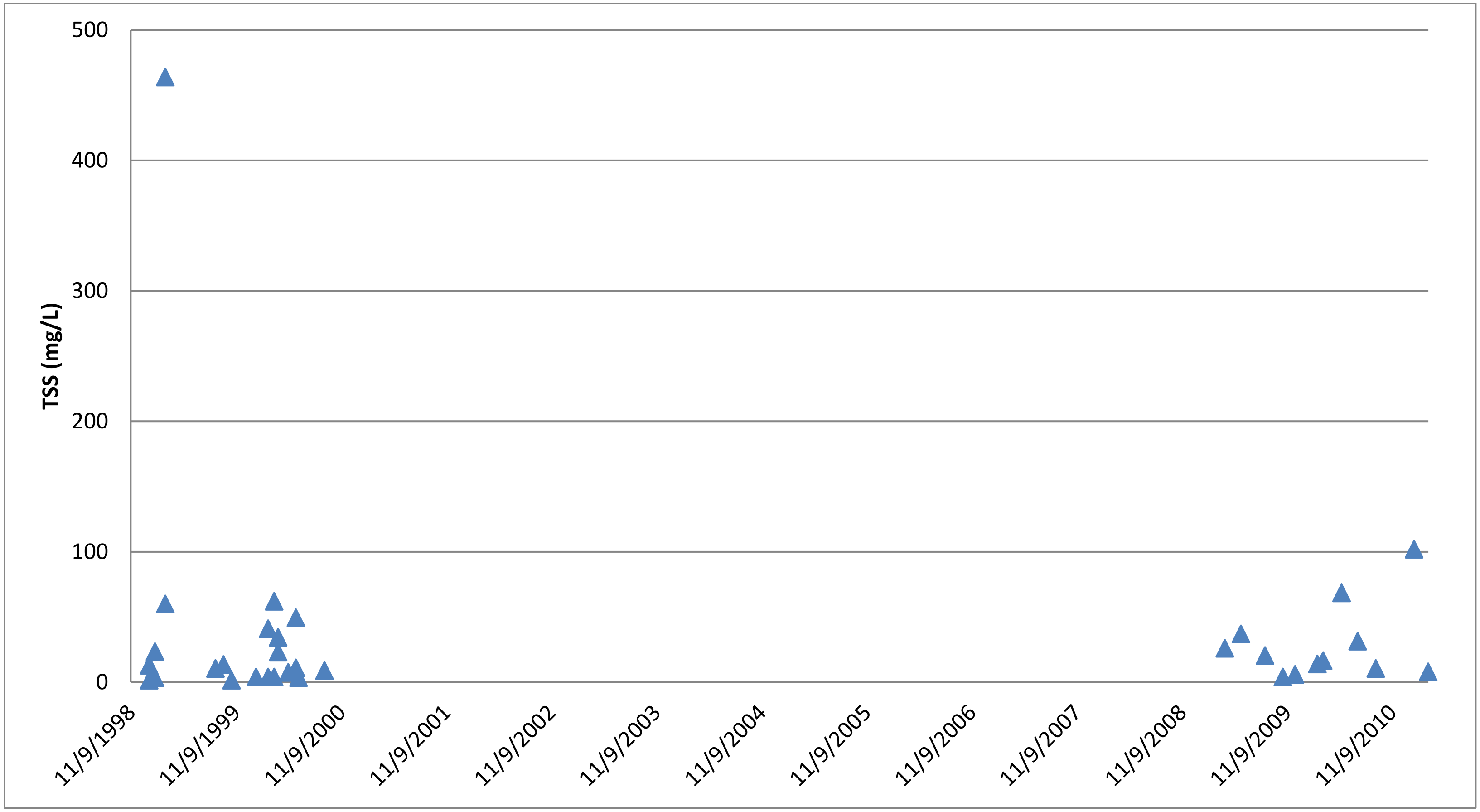
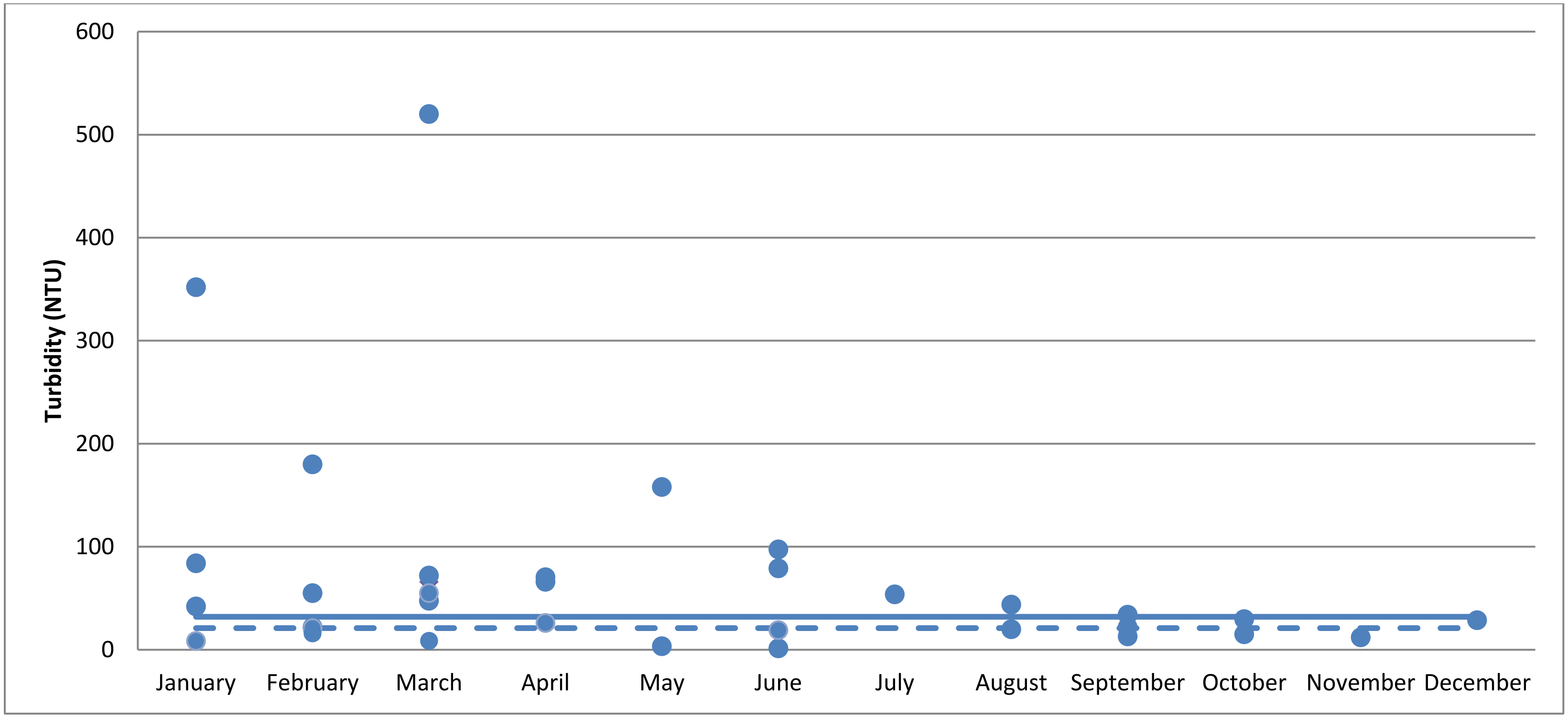


Figure D.2: Time series of TSS data in Ables Creek at DEQ monitoring stations OUA0153 and OUA0158.

Table D.1: Monitoring data for TSS and turbidity in Ables Creek at DEQ monitoring stations OUA0153 and OUA0158.

Monitoring Station	Date Sampled	Total suspended solids (mg/L)	Turbidity (NTU)
OUA0158	11/9/1998	0.5	12
OUA0153	1/12/1999	1.5	8.5
OUA0158	1/12/1999	13	42
OUA0153	2/1/1999	23.5	21
OUA0158	2/1/1999	3.5	22
OUA0153	3/9/1999	60	55
OUA0158	3/9/1999	464	520
OUA0158	8/30/1999	10.5	20
OUA0158	9/27/1999	13.5	34
OUA0158	10/25/1999	1.5	15
OUA0158	1/18/2000	4	84
OUA0153	2/29/2000	4	16
OUA0158	2/29/2000	41	180
OUA0153	3/21/2000	4	8.7
OUA0158	3/21/2000	62	72
OUA0153	4/4/2000	34.5	26
OUA0158	4/4/2000	23	66
OUA0158	5/9/2000	7.5	3.5
OUA0153	6/5/2000	11	19
OUA0158	6/5/2000	49.5	79
OUA0158	6/14/2000	3.5	1.4
OUA0158	9/12/2000	9	13
OUA0158	4/7/2009	26	70.4
OUA0158	6/2/2009	37	97.5
OUA0158	8/25/2009	20.5	43.8
OUA0158	10/26/2009	4	29.7
OUA0158	12/7/2009	6	28.7
OUA0158	2/23/2010	14	55
OUA0158	3/15/2010	16.5	47.6
OUA0158	5/18/2010	68.5	158
OUA0158	7/13/2010	31.5	53.8
OUA0158	9/14/2010	10.5	21.9
OUA0158	1/25/2011	102	352
OUA0158	3/15/2011	8	57.9

Data summary		
	TSS	Turb.
n	34	34
min	0.5	1.4
max	464	520
median	13.25	38
n > 21 NTU	na	23
% > 21 NTU	na	66%
n > 32 NTU	na	18
% > 32 NTU	na	51%



Solid line at 32 NTU is Gulf Coastal Ecoregion storm flows season turbidity criterion.
Dotted line at 21 NTU is the Gulf Coastal Ecoregion base flows season turbidity criterion.

Figure D.3: Seasonal plot of turbidity data in Ables Creek from DEQ monitoring stations OUA0153 and OUA0158.

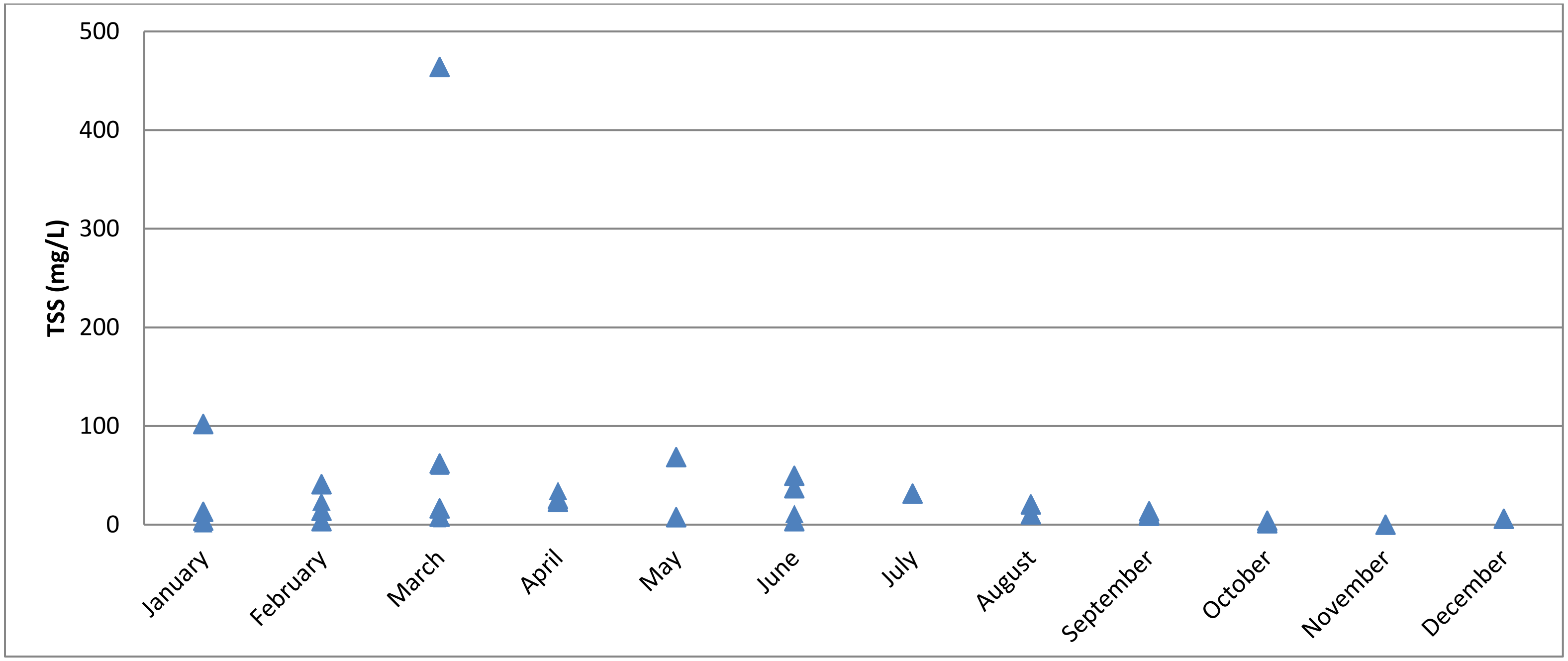


Figure D.4: Seasonal plot of TSS data in Ables Creek from DEQ monitoring stations OUA0153 and OUA0158.

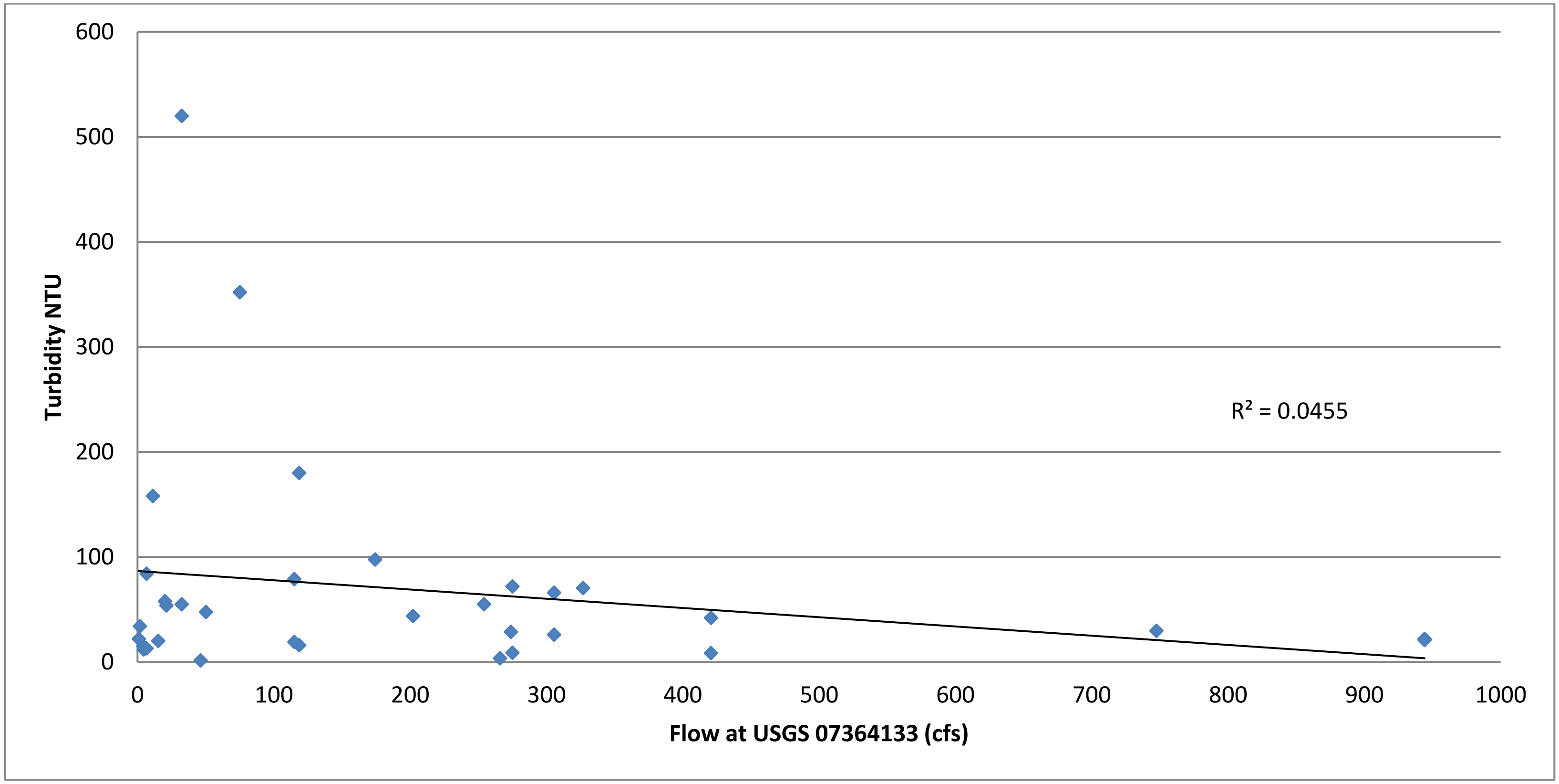


Figure D.5: Turbidity at DEQ monitoring stations OUA0153 and OUA0158 versus flow in Ables Creek. Flow is proportional at OUA0158 to the watershed with the USGS gage flow data.

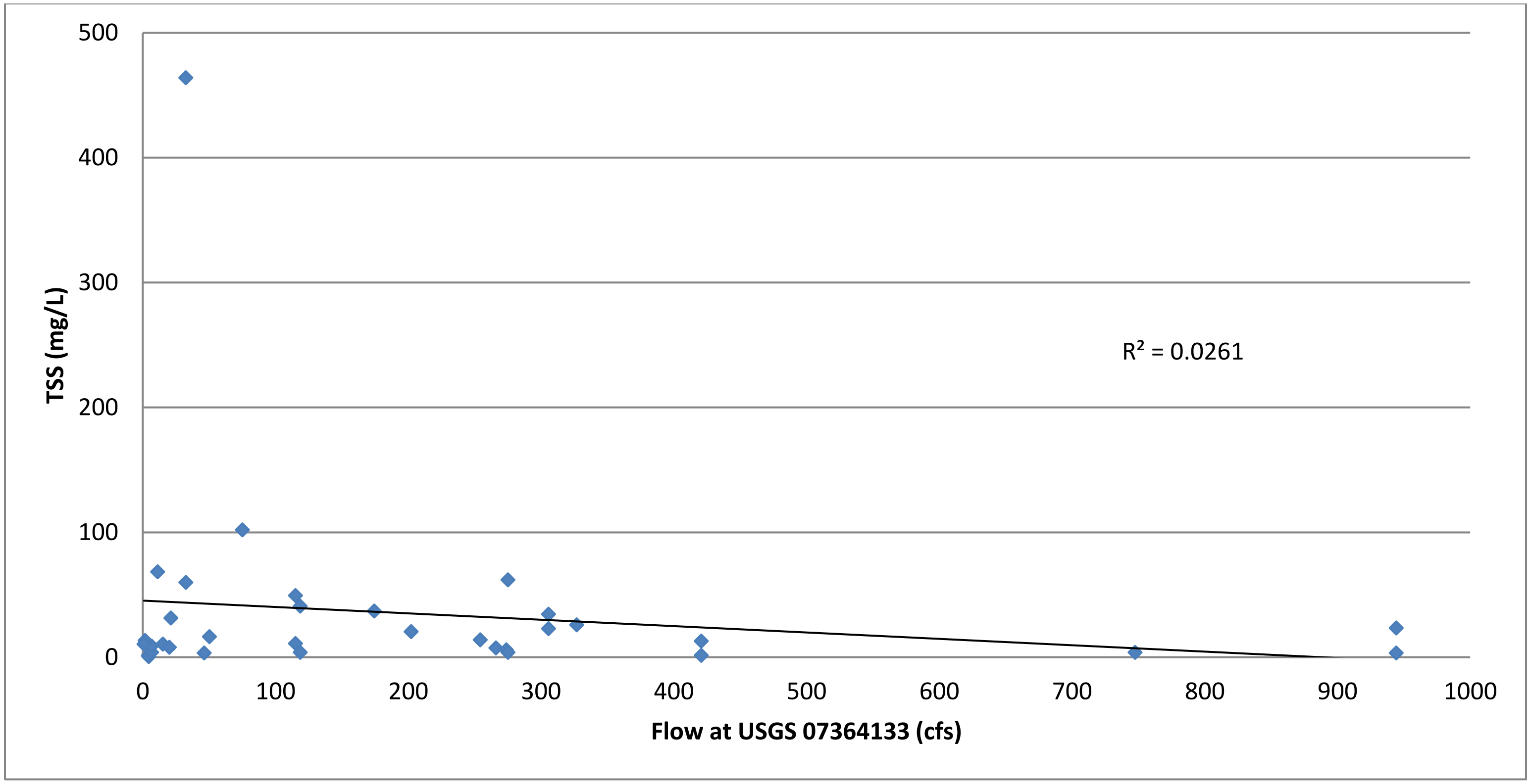


Figure D.6: TSS concentration at DEQ monitoring stations OUA0153 and OUA0158 versus flow in Ables Creek. Flow is proportional at OUA0158 to the watershed with the USGS gage flow data.

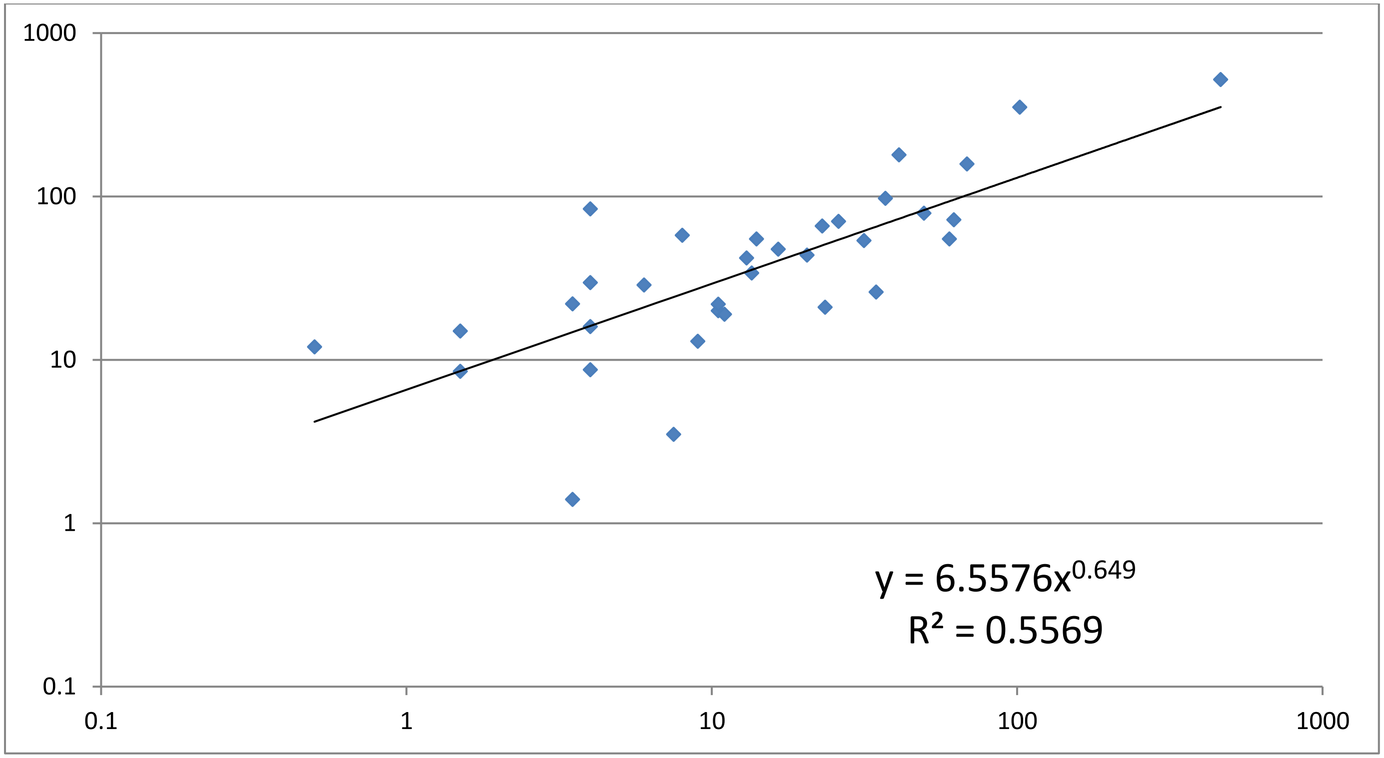


Figure D.7: TSS versus turbidity in Ables Creek at DEQ monitoring stations OUA0153 and OUA0158.

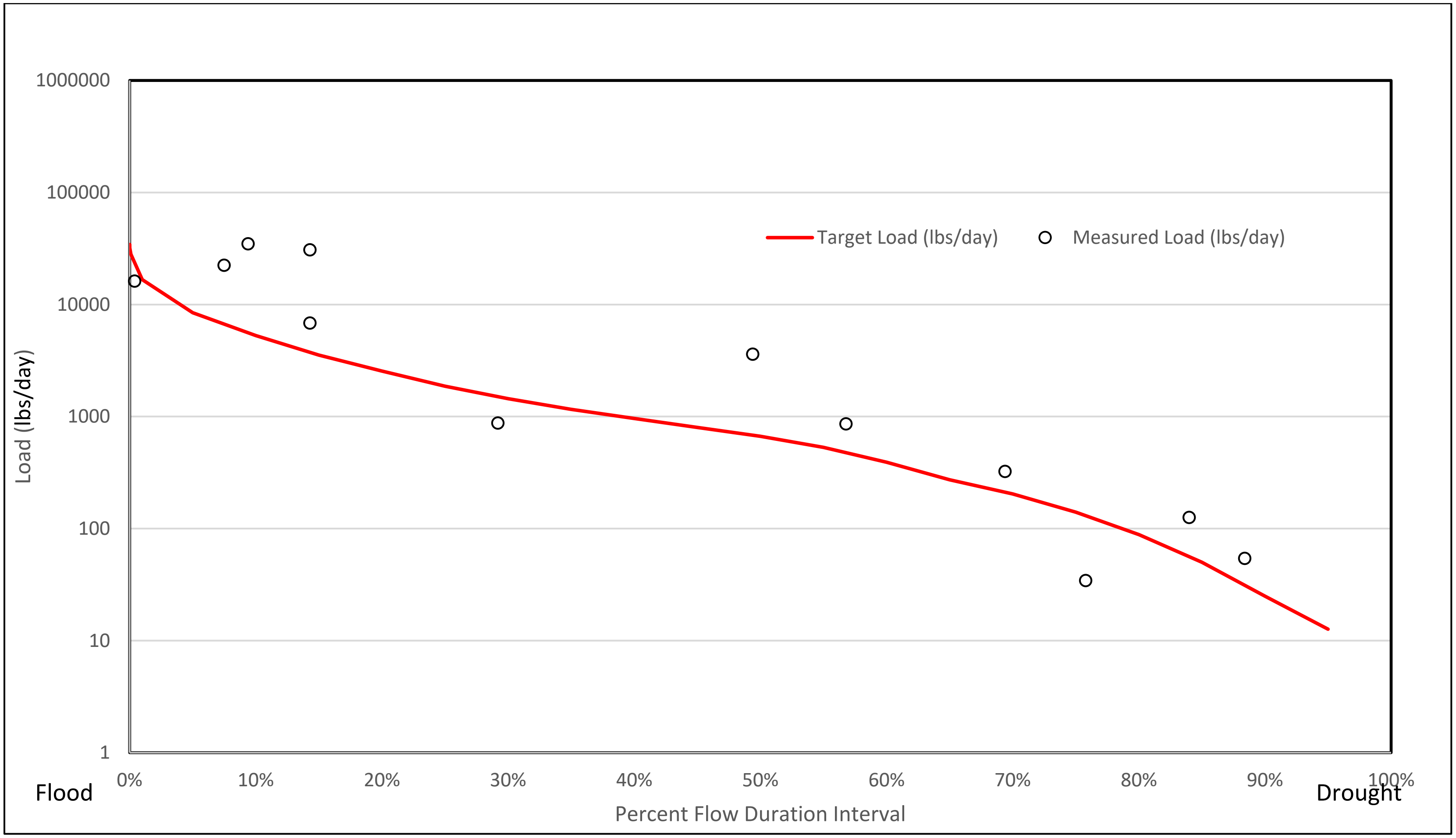


Figure D.8: Load duration curve for TSS in Ables Creek - Base flows season. TSS data are from DEQ monitoring stations OUA0153 and OUA0158. Flow data from USGS gage 07364133.

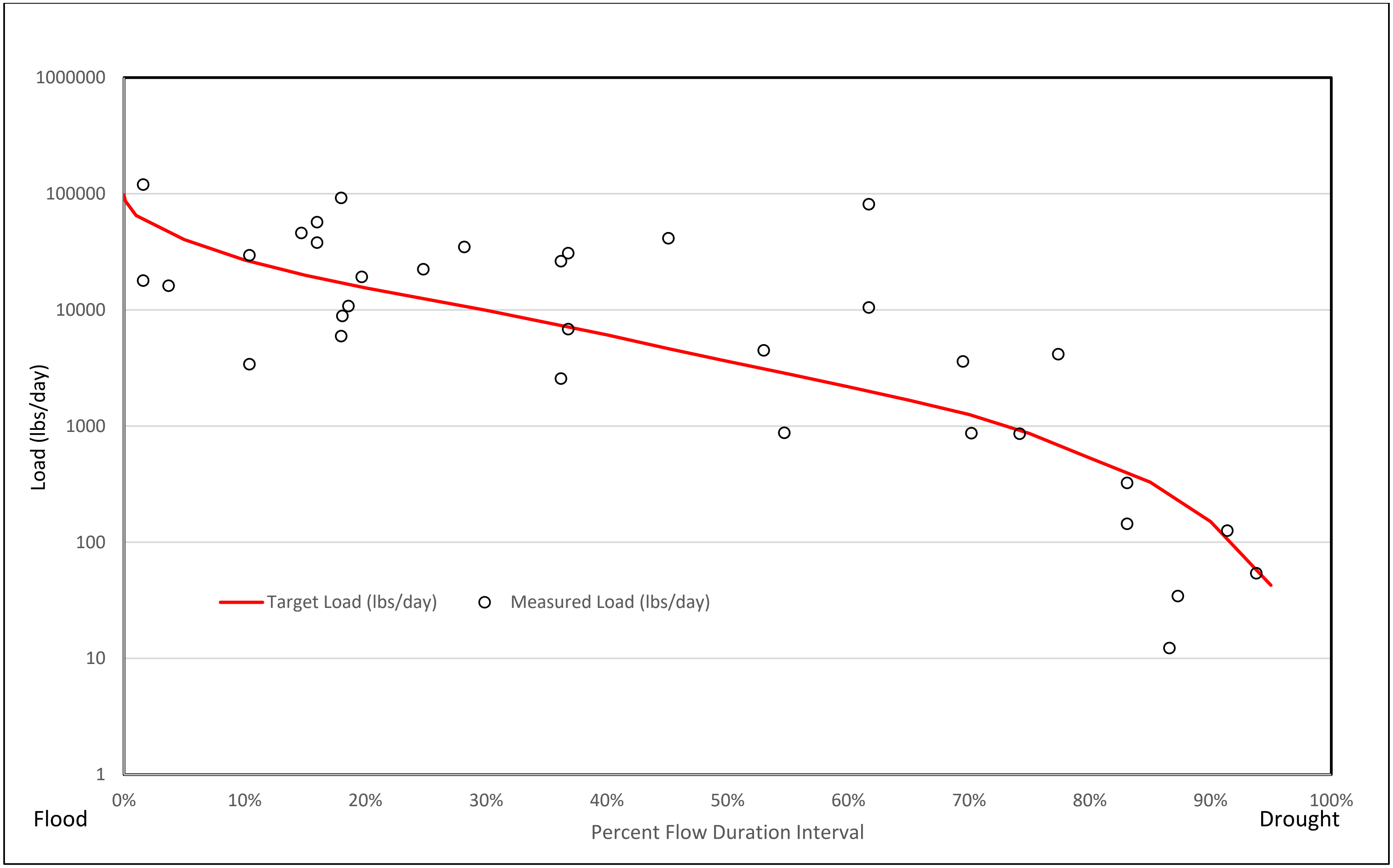


Figure D.9: Load duration curve for TSS in Ables Creek - Storm flows season. TSS data are from DEQ monitoring stations OUA0153 and OUA0158. Flow data from USGS gage 07364133.

Table D.2: Target loads for TSS in Ables Creek during base flows season. Flow presented is a ratio of USGS gage 07364133 watershed (380 sq. mi.) to Ables Creek watershed (115 sq. mi.). The base flow TMDL for TSS in Ables Creek was developed at 50% flow (in bold).

Percent	Flow (cfs)	Target Load (lbs/day)
0.004%	1059.21	3.43E+04
0.010%	987.01	3.20E+04
0.100%	867.67	2.81E+04
1.00%	514.84	1.67E+04
5.00%	260.75	8.45E+03
10.00%	163.00	5.28E+03
15.00%	109.25	3.54E+03
20.00%	78.68	2.55E+03
25.00%	57.50	1.86E+03
30.00%	44.49	1.44E+03
35.00%	35.77	1.16E+03
40.00%	29.63	9.61E+02
45.00%	24.65	7.99E+02
50.00%	**20.58**	**6.67E+02**
55.00%	16.39	5.31E+02
60.00%	12.08	3.92E+02
65.00%	8.41	2.73E+02
70.00%	6.29	2.04E+02
75.00%	4.33	1.40E+02
80.00%	2.72	8.83E+01
85.00%	1.54	5.00E+01
90.00%	0.77	2.50E+01
95.00%	0.39	1.27E+01
99.00%	0	0
100.00%	0	0

Table D.3: Actual base flows season loading for Ables Creek. TSS data (mg/L) from DEQ monitoring stations OUA0153 and OUA0158. Flow presented is a ratio of USGS gage 07366200 watershed (380 sq. mi.) to Ables Creek watershed (115 sq. mi.) on the date corresponding to the date of the result data.

Site	Date	TSS Result mg/L	Flow (cfs)	Flow Percentile	Measured Load (lbs/day)
OUA0158	8/30/1999	10.5	15.13	57%	8.57E+02
OUA0158	9/27/1999	13.5	1.73	84%	1.26E+02
OUA0158	10/25/1999	1.5	4.24	76%	3.43E+01
OUA0158	6/5/2000	49.5	115.00	14%	3.07E+04
OUA0158	6/14/2000	3.5	46.30	29%	8.74E+02
OUA0158	9/12/2000	9	6.66	69%	3.23E+02
OUA0158	6/2/2009	37	174.32	9%	3.48E+04
OUA0158	8/25/2009	20.5	202.16	8%	2.24E+04
OUA0158	10/26/2009	4	747.50	0%	1.61E+04
OUA0158	7/13/2010	31.5	21.15	49%	3.59E+03
OUA0158	9/14/2010	10.5	0.95	88%	5.40E+01
OUA0153	6/5/2000	11	115.00	14%	6.82E+03

Table D.4: Target loads for TSS in Ables Creek for storm flows season. Flow presented is a ratio of USGS gage 07364133 watershed (380 sq. mi.) to Ables Creek watershed (115 sq. mi.). The storm flows season TMDL for TSS in Ables Creek was developed at 50% flow.

Percent	Flow (cfs)	Target Load (lbs/day)
0.004%	1576.71	9.78E+04
0.010%	1566.36	9.72E+04
0.100%	1400.88	8.69E+04
1.00%	1047.11	6.50E+04
5.00%	649.14	4.03E+04
10.00%	432.76	2.68E+04
15.00%	320.79	1.99E+04
20.00%	249.67	1.55E+04
25.00%	199.74	1.24E+04
30.00%	159.79	9.91E+03
35.00%	125.44	7.78E+03
40.00%	98.36	6.10E+03
45.00%	75.05	4.66E+03
50.00%	**58.11**	**3.60E+03**
55.00%	45.39	2.82E+03
60.00%	35.11	2.18E+03
65.00%	26.96	1.67E+03
70.00%	20.28	1.26E+03
75.00%	13.92	8.64E+02
80.00%	8.56	5.31E+02
85.00%	5.30	3.29E+02
90.00%	2.43	1.51E+02
95.00%	0.69	4.26E+01
99.00%	0.00	0
100.00%	0.00	0

Table D.5: Storm flows season TSS data (mg/L) from DEQ monitoring station OUA0158 calculated into load. Flow presented is a ratio of USGS gage 07366200 watershed (380 sq. mi.) to Ables Creek watershed (115 sq. mi.) on the date corresponding to the date of the result data.

Site	Date	TSS (mg/L)	Flow (cfs)	Flow Percentile	Measured Load (lbs/day)
OUA0158	11/9/1998	0.5	4.54	87%	1.22E+01
OUA0158	1/12/1999	13	420.66	10%	2.95E+04
OUA0153	1/12/1999	1.5	420.66	10%	3.40E+03
OUA0158	2/1/1999	3.5	944.21	2%	1.78E+04
OUA0153	2/1/1999	23.5	944.21	2%	1.20E+05
OUA0158	3/9/1999	464	32.38	62%	8.11E+04
OUA0153	3/9/1999	60	32.38	62%	1.05E+04
OUA0158	8/30/1999	10.5	15.13	74%	8.57E+02
OUA0158	9/27/1999	13.5	1.73	91%	1.26E+02
OUA0158	10/25/1999	1.5	4.24	87%	3.43E+01
OUA0158	1/18/2000	4	6.66	83%	1.44E+02
OUA0158	2/29/2000	41	118.63	36%	2.62E+04
OUA0153	2/29/2000	4	118.63	36%	2.56E+03
OUA0158	3/21/2000	62	275.09	18%	9.20E+04
OUA0153	3/21/2000	4	275.09	18%	5.94E+03
OUA0158	4/4/2000	23	305.66	16%	3.79E+04
OUA0153	4/4/2000	34.5	305.66	16%	5.69E+04
OUA0158	5/9/2000	7.5	266.01	19%	1.08E+04
OUA0158	6/5/2000	49.5	115.00	37%	3.07E+04
OUA0153	6/5/2000	11	115.00	37%	6.82E+03
OUA0158	6/14/2000	3.5	46.30	55%	8.74E+02
OUA0158	9/12/2000	9	6.66	83%	3.23E+02
OUA0158	4/7/2009	26	326.84	15%	4.58E+04
OUA0158	6/2/2009	37	174.32	28%	3.48E+04
OUA0158	8/25/2009	20.5	202.16	25%	2.24E+04
OUA0158	10/26/2009	4	747.50	4%	1.61E+04
OUA0158	12/7/2009	6	273.88	18%	8.86E+03
OUA0158	2/23/2010	14	254.21	20%	1.92E+04
OUA0158	3/15/2010	16.5	50.24	53%	4.47E+03
OUA0158	5/18/2010	68.5	11.23	77%	4.15E+03
OUA0158	7/13/2010	31.5	21.15	70%	3.59E+03
OUA0158	9/14/2010	10.5	0.95	94%	5.40E+01
OUA0158	1/25/2011	102	75.05	45%	4.13E+04
OUA0158	3/15/2011	8	20.06	70%	8.66E+02