TMDLS FOR TURBIDITY IN THE STRAWBERRY RIVER BASIN, AR

FINAL January 5, 2006

Revised July 9, 2025

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standards for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the waterbody.

The study area for this project is located in the Strawberry River watershed in northern Arkansas. The study area is part of the Arkansas Department of Environmental Quality (ADEQ) Planning Segment 4G and is located within the Ozark Highlands ecoregion. Land use in the study area is about 55% pasture and 43% forest.

Seven reaches in the Strawberry River watershed are included on the draft 2004 Arkansas 303(d) list as not supporting the aquatic life use due to exceedences of numeric criteria for turbidity. The applicable numeric criteria for turbidity for these reaches are 10 NTU ("primary" value) and 17 NTU ("storm-flow" value).

ADEQ historical water quality data were analyzed for four locations along the impaired reaches of the Strawberry River. These data were analyzed for long term trends, seasonal patterns, relationships between concentration and stream flow, and relationships between turbidity and total suspended solids (TSS). These analyses showed no significant seasonal pattern or relationship between that concentration and stream flow, but higher turbidity levels tended to correspond with higher TSS values.

These TMDLs were expressed using TSS as a surrogate for turbidity because turbidity cannot be expressed as a mass load. The ADEQ data from all four sampling stations were combined to developed two regressions between TSS and turbidity (a base flow regression and a storm-flow regression). Using the base flow regression equation with the turbidity criterion values, the target TSS concentration of 14 mg/L (corresponding to the primary turbidity criterion of 10 NTU) was identified. Using the storm-flow regression equation with the turbidity criterion

values, the target TSS concentration of 22 mg/L (corresponding to the storm-flow turbidity criterion of 17 NTU) was identified.

The TMDLs in this report were developed using the load duration curve methodology. This method illustrates allowable loading at a wide range of stream flow conditions. The steps for applying this methodology for the TMDLs in this report were:

1. Developing a flow duration curve,
2. Converting the flow duration curve to a load duration curve,
3. Plotting observed loads with the load duration curve,
4. Calculating the TMDL components, and
5. Calculating percent reductions.

The load duration curve was developed using multiple target TSS concentrations because Arkansas has different turbidity criteria for different flow conditions. The target TSS concentration corresponding to the primary turbidity criterion was applied between the 100% exceedance of stream flow and the 60% exceedance of stream flow. The target TSS concentration corresponding to the storm-flow turbidity criterion was applied between the 60% exceedance of stream flow and the 0% exceedance of stream flow.

The wasteload allocations (WLAs) for point source contributions were set to not applicable (NA) ~~zero~~ because TSS in these TMDLs was considered to represent inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). The suspended solids discharged by point sources (such as domestic wastewater) in the study area are assumed to consist primarily of organic solids rather than inorganic solids. Discharges of organic suspended solids from point sources are already addressed by ADEQ through their permitting of point sources to maintain water quality standards for dissolved oxygen. The WLAs to support these TMDLs will not require any changes to the permits concerning inorganic suspended solids. Therefore, future growth for these permits or new permits would not be restricted by these turbidity TMDLs.

An implicit margin of safety (MOS) was incorporated through the use of conservative assumptions. The primary conservative assumption was calculating the TMDLs assuming that TSS is a conservative parameter and does not settle out of the water column. The TMDLs and percent reductions needed are summarized in Table ES.1.

Table ES.1. Summary of TMDLs and percent reductions.

Reach ID	Stream Name	Flow Category	Loads (tons/day of TSS)				Percent Reduction Needed
			WLA	LA	MOS	TMDL	
11010012-004	Strawberry River	Base flow	~~0~~NA	3.97	~~0~~ Implicit	3.97	0%
		Storm-flow	~~0~~NA	31.1	~~0~~ Implicit	31.1	50%
11010012-005	Strawberry River	Base flow	~~0~~NA	3.75	~~0~~ Implicit	3.75	0%
		Storm-flow	~~0~~NA	29.1	~~0~~ Implicit	29.1	50%
11010012-006	Strawberry River	Base flow	~~0~~NA	3.52	~~0~~ Implicit	3.52	0%
		Storm-flow	~~0~~NA	27.4	~~0~~ Implicit	27.4	50%
11010012-008	Strawberry River	Base flow	~~0~~NA	2.63	~~0~~ Implicit	2.63	0%
		Storm-flow	~~0~~NA	20.7	~~0~~ Implicit	20.7	53%
11010012-009	Strawberry River	Base flow	~~0~~NA	2.00	~~0~~ Implicit	2.00	0%
		Storm-flow	~~0~~NA	15.5	~~0~~ Implicit	15.5	53%
11010012-010	Little Strawberry River	Base flow	~~0~~NA	0.233	~~0~~ Implicit	0.233	0%
		Storm-flow	~~0~~NA	1.83	~~0~~ Implicit	1.83	0%
11010012-011	Strawberry River	Base flow	~~0~~NA	0.488	~~0~~ Implicit	0.488	0%
		Storm-flow	~~0~~NA	3.81	~~0~~ Implicit	3.81	58%

The percent reductions shown in Table ES.1 were calculated using methodology that is slightly different than the assessment criteria used by ADEQ to develop the 2004 draft 303(d) list. These differences caused the assessment for the 2004 draft 303(d) list to indicate that seven stream reaches in the Strawberry River watershed are impaired and the TMDL analysis to indicate that one of those reaches (Little Strawberry River) is not impaired. The 2004 draft 303(d) list is still being reviewed by EPA and has not been finalized yet.

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for siltation/turbidity for 7 stream reaches in the Strawberry River basin in northern Arkansas. These stream reaches were included on the Arkansas Department of Environmental Quality (ADEQ) draft 2004 Section 303(d) list (ADEQ 2005a) as not supporting their designated use of aquatic life. The sources of contamination and causes of impairment from the 303(d) listing are shown below in Table 1.1. The TMDLs in this report address the impairments due to siltation/turbidity, but not other causes of impairment (pathogens). The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and the Environmental Protection Agency's (EPA) regulations in 40 CFR 130.7.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources (NPS), including natural background. The MOS is a percentage of the TMDL that takes into account any lack of knowledge concerning the relationship between pollutant loadings and water quality.

Table 1.1. 303(d) listing for stream reaches in this task order.

Reach No.	Stream Name	Sources	Causes	Category	Priority
11010012-004	Strawberry River	Surface erosion	Siltation/turbidity	5a	High
11010012-005	Strawberry River	Surface erosion	Siltation/turbidity	5a	High
11010012-006	Strawberry River	Surface erosion	Siltation/turbidity	5a	High
11010012-008	Strawberry River	Surface erosion, Agriculture	Siltation/turbidity, pathogens	5a	High
11010012-009	Strawberry River	Surface erosion, Agriculture	Siltation/turbidity, pathogens	5a	High
11010012-010	Little Strawberry River	Surface erosion, Agriculture	Siltation/turbidity, pathogens	5a	High
11010012-011	Strawberry River	Surface erosion, Agriculture	Siltation/turbidity, pathogens	5a	High

2.0 BACKGROUND INFORMATION

2.1 General Information

The study area for this project is located in the Strawberry River basin in northern Arkansas (see Figure A.1 in Appendix A). The portion of the Strawberry River basin that is included in the study area is within the Ozark Highlands ecoregion. The Strawberry River basin is in United States Geological Survey (USGS) Hydrologic Unit 11010012 and is part of ADEQ Planning Segment 4G. The study area covers 681 square miles and includes parts of Lawrence, Izard, Fulton, and Sharp Counties.

2.2 Soils and Topography

The soils and topography information was obtained from soil surveys for Fulton, Izard, Sharp, and Lawrence Counties (USDA 1984a, USDA 1984b, USDA 1978). The soils in the study area range from deep stony soils to shallow clay and loamy soils. The topography of the study area is characterized by rolling hills, steep valleys, and ridges.

2.3 Land Use

Land use data for the study area were obtained from the GEOSTOR database, which is maintained by the Center for Advanced Spatial Technology (CAST) at the University of Arkansas in Fayetteville. These data were based on satellite imagery from 1999. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that forest and pasture are the predominant land uses.

Table 2.1. Land use percentages for the study area.

Land use	Percentage of Study Area
Urban	1.2%
Barren	0.1%
Water	0.5%
Forest (all types)	55.4%
Soybeans	0.2%
Pasture	42.6%
Total	100.0%

2.4 Description of Hydrology

Average precipitation for the study area is about 44-46 inches per year (USGS 1985). There was one USGS flow gage in the study area: Strawberry River at Poughkeepsie (USGS 07074000). Flow data were not published for this gage for October 1994 through September 2001. Strawberry River flows during that period were estimated by taking observed flows for the North Sylamore Creek (USGS 07060710) and multiplying them by the average ratio of Strawberry River flows to North Sylamore Creek flows during the years when both gages were active (1966 to 1993). Information for these flow gages is summarized in Table 2.2.

Table 2.2. Information for stream flow gaging station (USGS 2005).

Gage Name:	North Sylamore Creek near Fifty-Six, AR	Strawberry River near Poughkeepsie
Gage number:	07060710	07074000
Descriptive location:	On Ozark National Forest Service road, 2.7 miles north of Fifty-Six	On State Hwy 58, 2.5 miles northeast of Poughkeepsie
Period of record:	Dec 1965 to Sep 2004	Feb 1963 - Sep 1994, Oct 2001 to Sep 2004
Drainage area:	58.1 square miles	473 square miles
Mean daily flow:	46.7 cfs	497 cfs
Median daily flow:		

2.5 Water Quality Standards

Water quality standards for Arkansas waterbodies are listed by ecoregion in Regulation No. 2 (APCEC 2004a). Designated uses for the Strawberry River include primary and secondary contact recreation; public, industrial, and agricultural water supply; and perennial Ozark

Highland fishery (where the drainage area is 10 square miles or more). Special designations for streams in the Strawberry River basin include the following:

- Natural and Scenic Waterway – Strawberry River from its headwaters to the Sharp-Izard County line (all of reach 11010012-011 and part of reach 11010012-009);
- Extraordinary Resource Water – All of the Strawberry River and Little Strawberry River (all seven reaches in Table 1.1); and
- Ecologically Sensitive Waterbody – Little Strawberry River and Strawberry River where the Strawberry River darter is found (all of reaches 11010012-011, -010, -009, and –008, and part of reach 11010012-006).

Section 2.503 of Regulation No. 2 provides both a narrative criterion and numeric criteria that apply to siltation/turbidity. The general narrative criterion is: "There shall be no distinctly visible increase in turbidity of receiving waters attributable to municipal, industrial, agricultural, other waste discharges or instream activities." The numeric turbidity criteria for streams in the Ozark Highlands ecoregion are 10 NTU for "primary" values and 17 NTU for "stormwater" values streams. The regulation also states that "the non-point source runoff shall not result in the exceedance of the in stream storm-flow values in more than 20% of the ADEQ ambient monitoring network samples taken in not less than 24 monthly samples."

As specified in EPA's regulations at 40 CFR 130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is listed in Sections 2.201-2.204 of Regulation No. 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.
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.

- For potential water quality impairments associated with a thermal discharge, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act.

2.6 Nonpoint Sources

Nonpoint sources of pollution in the study area are discussed in the 2002 305(b) report (ADEQ 2002), which states "Trend data from the monitoring station on the Strawberry River demonstrates these excessive turbidity levels occurring routinely over the last 5 to 10 years. Concurrently, the total suspended solids (TSS) and the total phosphorus levels show peaking values much above normal. This is most likely from agriculture activities probably associated with pasturing and animal grazing to the edge of the stream bank." Recommendations from a multi-year assessment of the Strawberry River basin (ADEQ 2003) indicated that runoff from county roads, pasture runoff, silviculture activities, construction activities, and eroding stream banks are also sources of turbidity.

2.7 Point Sources

Information for point source discharges in the study area was obtained by searching the Permit Compliance System on the EPA web site (PCS 2005). The search yielded five facilities with point source discharges. Search results, including flow rate and permit limits for TSS, are included in Table 2.3. Locations of the permitted facilities are shown on Figure A.3 in Appendix A.

Table 2.3. Inventory of point source dischargers.

NPDES Permit Number	Facility Name	Flow Rate (MGD)	Receiving Stream	Average TSS Limits (mg/L)
AR0035254	City of Horshoe Bend, White Oak WWTP	0.20	Unnamed Tributary, Little Strawberry River, Strawberry River	30
AR0038326	Allegheny Wastewater Association	0.05	Worthington Creek, North Big Creek, Strawberry River	20
AR0039608	City of Horshoe Bend, Hubble Creek WWTP	0.06	Hubble Creek, Little Strawberry River, Strawberry River	30
AR0041742	City of Ash Flat WWTP	0.15	North Big Creek, Strawberry River, Black River	15
AR0049701	City of Oxford WWTP	0.09	Sandy Creek, Strawberry River, Black River	20

2.8 Previous Study

ADEQ recently conducted a multi-year assessment of the Strawberry River basin (ADEQ 2003). This study included collection of turbidity, TSS, and other water quality data on 16 occasions at 20 locations throughout the Strawberry River basin. Turbidity values exceeded ADEQ's assessment criteria for designated use attainment at five locations in the Strawberry River and Little Strawberry River. Turbidity values at seven other locations in various parts of the Strawberry River basin had several exceedances of significant magnitude to warrant concern. The study also noted that there was a distinct decrease in magnitude and frequency of high turbidity values in the tributaries from the headwaters to the mouth, but turbidity values in the main stem of the Strawberry River increased in a downstream direction.

3.0 EXISTING WATER QUALITY FOR TURBIDITY AND TSS

3.1 General Description of Data

Turbidity and TSS data from four ADEQ sites in the study area were analyzed. These four sampling sites were specified in the draft 2004 Section 303(d) list (ADEQ 2005a) as indicating impairments for siltation/turbidity. The location of these sampling sites are shown on Figure A.3 (located in Appendix A). TSS data are discussed here because TSS is needed as a surrogate parameter for expressing the siltation/turbidity TMDLs. These turbidity and TSS data were obtained from the ADEQ web site (ADEQ 2005b) and are summarized in Table 3.1. The individual data are listed in Tables B.1-B.4 and shown graphically as time series plots on Figures B.1-B.8 (located in Appendix B). The data for the first two sampling stations in Table 3.1 are stored in the ADEQ database with "UWSBR01" and "UWSBR02" as the station names, but these stations are referred to by their more common descriptors, "SBR0001" and "SBR0002" throughout this report.

Table 3.1 Summary of ADEQ data for turbidity and TSS.

Station	Description	Parameter	Count	Min.	Median	Average	Max
SBR0001	Strawberry River near Wiseman, AR	Turbidity	22	2.4	5.8	20.8	104
		TSS	21	1.0	4.7	27.8	225
SBR0002	Strawberry River at Evening Shade, AR	Turbidity	24	1.3	3.2	23.4	360
		TSS	19	1.7	4.5	39.1	442
WHI0143H	Little Strawberry River	Turbidity	16	1.3	3.5	12.9	64
		TSS	16	1.0	3.5	11.2	68
WHI0024	Strawberry River near Smithville, AR	Turbidity	187	1.4	6.7	17.6	230
		TSS	182	1.0	11.0	30.5	610

Tables B.1-B.4 include comparisons between the observed turbidity data and the numeric water quality criteria. These comparisons required the observed data to be separated into base flow data (to be compared with the "primary" criterion) and storm-flow data (to be compared with the "storm-flow" criterion). It was assumed here that the lowest 40% of stream flow values represent flow conditions without significant influence from storm runoff and that stream flow values above the 40th percentile would have some influence from storm runoff. The turbidity

data were considered to be base flow data when the flow on the sampling day at the USGS gage on the Strawberry River near Poughkeepsie was 133 cfs or less (the 40th percentile flow, or the flow that was exceeded 60% of the time). The turbidity data were considered to be storm-flow data when the flow on the sampling day at the USGS gage on the Strawberry River near Poughkeepsie was 134 cfs or more. Table 3.2 summarizes the percentages of observed values that exceeded the applicable criteria over the period of record for each water quality station (from Tables B.1 – B.4).

Table 3.2.Percentages of observed data exceeding primary and storm-flow criteria.

Sampling Station	Period of Record	Percent Exceeding Base Flow Criterion	Percent Exceeding Storm-Flow Criterion
SBR0001	1994-2003	22%	46%
SBR0002	1994-2003	0%	25%
WHI0143H	2001-2003	0%	40%
WHI0024	1990-2005	13%	33%

3.2 Seasonal Patterns

Seasonal plots of turbidity and TSS are shown on Figures C.1-C.8 (located in Appendix C). These plots show no seasonal pattern.

3.3 Relationships Between Turbidity and Flow

Plots of turbidity and TSS versus stream flow were also developed to examine any correlation between these two parameters and flow (Figures D.1-D.8, located in Appendix D). These plots showed no noticeable relationship between concentration and flow.

3.4 Relationships Between TSS and Turbidity

Plots and regression analyses were used to examine relationships between TSS and turbidity. The regressions were performed using the natural logarithms of the data (rather than the raw data values) because most data such as turbidity and TSS fit a lognormal distribution better than a normal distribution.

Separate plots and regression analyses were developed for base flow conditions and storm-flow conditions to be consistent with the numeric criteria for turbidity. The plots and linear regressions for base flow conditions (Figures E.1, E.3, E.5, E.7, and E.9) use only the base flow data. The plots and linear regressions for storm-flow conditions (Figures E.2, E.4, E.6, E.8, and E.10) use all of the data regardless of flow on the sampling day. The data collected under base flow conditions were included in the storm-flow regression in order to maximize the accuracy of the lower end of the regression line that corresponds to turbidity values near the numeric criteria.

Most of the plots showed noticeable correlations, with higher turbidity levels tending to correspond with higher TSS concentrations. Because most of the regressions were similar (i.e., they yielded similar TSS values for a given turbidity), the data from all four stations were combined and base flow and storm-flow regressions were then conducted on the combined data set. The results of the linear regression analyses for the individual stations and for the combined data set are summarized in Table 3.3.

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 ln TSS that is explained or accounted for by the fitted regression (ln turbidity). For the base flow regression for station SBR0001, 74% of the variation in TSS is accounted for by turbidity and the remaining 26% of variation in TSS is unexplained. The unexplained portion is attributed to factors other than the measured value of turbidity.

Table 3.3. Results of regressions between TSS and turbidity

Sampling station	Category	Regression equation	Number of Data	R^2	Significance Level (P value)
SBR0001	Base Flow	ln TSS = 1.092 * ln Turbidity - 0.100	8	0.74	6.4×10^{-3}
	Storm-Flow	ln TSS = 1.128 * ln Turbidity - 0.508	21	0.83	7.4×10^{-9}
SBR0002	Base Flow	ln TSS = -0.037 * ln Turbidity + 4.144	7	0.007	0.97
	Storm-Flow	ln TSS = 1.010 * ln Turbidity + 0.184	19	0.87	6.6×10^{-9}
WHI0143H	Base Flow	ln TSS = 0.476 * ln Turbidity + 0.683	6	0.18	0.40
	Storm-Flow	ln TSS = 0.971 * ln Turbidity - 0.239	16	0.78	1.9×10^{-5}
WHI0024	Base Flow	ln TSS = 0.949 * ln Turbidity + 0.497	72	0.75	7.4×10^{-23}
	Storm-Flow	ln TSS = 0.990 * ln Turbidity + 0.402	180	0.75	8.1×10^{-56}
Combined	Base Flow	ln TSS = 0.996 * ln Turbidity + 0.341	94	0.74	7.3×10^{-29}
	Storm-Flow	ln TSS = 1.007 * ln Turbidity + 0.259	236	0.76	2.6×10^{-74}

These regressions show a majority of the measurement of the turbidity (NTU) is explained by the measured concentration of TSS. The perfect explanation of the measurement of turbidity to the measurement of TSS would require collecting and analyzing a large amount of data. A number of the items effecting this perfect explanation of the relationship would need to be known. A partial list of the items effecting the relationship follows:

- Velocity of the water at the time of sampling;
- Carbonaceous biochemical oxygen demand (CBOD) concentration;
- Ammonia concentration;
- Nitrate concentration;
- Phosphorus concentration;
- Algal mass in the water column;
- Bacteria mass in the water;
- Measured color of the water;
- Mass of the organic component of the TSS;
- Mass of the material passing through the filter during the TSS analysis;
- Grain size distribution of the inorganic portion of the TSS;
- Specific gravity of the different sizes of inorganic solids particles;
- Hydrograph for the stream;
- Position on the hydrograph (i.e., rising limb, falling limb) at the time of sampling;
- Number of overlapping rainfall events represented by this sample day;
- Magnitude of each of the rainfall events represented by this sample day; and
- Lags of the overlapping rainfall events represented by this sample day.

The collection of the above data would not change the fact that inorganic particles represented in the TSS measurements is the major contributor to the turbidity reading and is the major constituent reduced when sediment BMPs are applied to nonpoint sources. The BMPs used on nonpoint sources for sediment also reduce the load of many of the unexplained contributors in the regression. The effort to have a perfect explanation of turbidity may not result in a better selection of BMPs. The regressions presented above between TSS and turbidity are adequate for the preparation of this TMDL. A stakeholder group of knowledgeable persons from the watershed may need additional information to set a plan of action for this TMDL.

Except for the base flow regressions for SBR0002 and WHI0143H, the correlations between turbidity and TSS for the Strawberry River basin were considered to be good. The R^2 values for most of these regressions were higher than or similar to R^2 values for correlations between turbidity and TSS from other approved TMDLs in Arkansas (FTN 2001, FTN 2003, FTN 2005).

The statistical significance of each regression was evaluated by computing the "P value" for the slope for each regression. The P value is essentially the probability that the slope of the regression line is really zero. Thus, a low P value indicates that a non-zero slope calculated from the regression analysis is statistically significant. Except for the base flow regressions for SBR0002 and WHI0143H, the P values are quite small and are considered good.

4.0 TMDL DEVELOPMENT

4.1 Seasonality and Critical Conditions

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. The historical data and analysis in Section 3.0 showed little or no correlation between turbidity levels and either season of the year or streamflow. Therefore, there is not a critical season or a single critical flow for these TMDLs. The methodology used to develop these TMDLs (load duration curve) addresses allowable loading for a wide range of flow conditions.

4.2 Water Quality Targets

Turbidity is an expression of the optical properties in a water sample that cause light to be scattered or absorbed and may be caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms (Standard Methods 1999). Turbidity cannot be expressed as a load as preferred for TMDLs. To achieve a load based value, turbidity is often correlated with a surrogate parameter such as TSS that may be expressed as a load. In general, activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (EPA 1991). Research by 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."

For the turbidity TMDLs in this report, the relationships between turbidity and TSS for the combined data set presented in Table 3.3 were used to develop target TSS concentrations (i.e., numeric endpoints for the TMDLs). The two target TSS concentrations developed for these TMDLs were 14 mg/L (using the base flow regression and the primary turbidity criterion of 10 NTU) and 22 mg/L (using the storm-flow regression and the stormflow turbidity criterion of 17 NTU). The discussion in Section 3.1 associating the primary turbidity criterion with the base

flow portion of the duration curve is the basis for using the descriptor "base flow" in this document for the conditions when the primary turbidity criterion should apply.

4.3 Methodology for TMDL Calculations

The methodology used for the TMDLs in the report is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represent a continuum of desired loads over all flow conditions, rather than fixed at a single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment web site (KDHE 2005). This method was used to illustrate allowable loading at a wide range of flows. The steps for how this methodology was applied for the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve (Section 4.4);
2. Convert the flow duration curve to load duration curves (Section 4.5);
3. Plot observed loads with load duration curves (Section 4.6);
4. Calculate TMDL, MOS, WLA, and LA (Section 4.7); and
5. Calculate percent reductions required to meet assessment criteria (Section 4.8).

4.4 Flow Duration Curve

A flow per unit area duration curve was developed for the whole study area (see Table F.1 in Appendix F for details). Daily streamflow measurements for the Strawberry River near Poughkeepsie (USGS Gage No. 07074000) were sorted in increasing order and the percent exceedance of each flow was calculated. The flow was divided by the drainage area of the gage to get a flow per square mile. The flow per unit area duration curve is shown on Figure F.1 in Appendix F.

4.5 Load Duration Curves

Each flow per unit area from the flow duration curve was multiplied by the appropriate TSS target concentration to develop plots of allowable load versus flow exceedance (load duration curves). The water quality standards for Arkansas (Arkansas Pollution Control and Ecology Commission (APCEC) 2004a) do not specify a range of flows or flow exceedances for

which each of the turbidity criteria (primary and storm-flow) is applicable. As discussed in Section 3.1, it was assumed here that the lowest 40% of stream flow values represent flow conditions without significant influence from storm runoff and that stream flow values above the 40th percentile would have some influence from storm runoff. Therefore, the TSS target corresponding to the primary turbidity criterion was applied to the lowest 40% of flows (from 100% exceedence of stream flow to 60% exceedence of stream flow) and the TSS target corresponding to the storm-flow turbidity criterion was applied from 60% exceedence of stream flow to 0% exceedence of stream flow. The load duration curves for storm-flow conditions and base flow conditions are shown on Figures F.2 – F.9 (in Appendix F).

4.6 Observed Loads

The observed loads per unit of drainage area for the three Strawberry River and the Little Strawberry River water quality stations were calculated for each sampling day. Each observed load per unit of drainage area was calculated by simply multiplying the observed TSS concentration times the flow per unit of drainage area on the sampling day (with a conversion factor incorporated).

The load duration plots (Figures F.2 – F.9) provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions where observed water quality concentrations exceed the target concentrations. Observed loads below the load duration curve represent conditions where observed water quality concentrations were less than target concentrations (i.e., not exceeding water quality criteria).

4.7 TMDL and MOS

The allowable load per unit area for storm-flow conditions was calculated as the TSS target for storm-flow conditions (22 mg/L) multiplied times the flow per unit area at the 30% flow exceedance. The 30% flow exceedance was used because it is considered to represent a typical flow value for storm-flow conditions (it is the midpoint along the flow duration curve between 0% and 60%). The allowable load per unit area for base flow conditions was calculated

as the TSS target for base flow conditions (14 mg/L) multiplied times the flow per unit area at the 80% flow exceedance. The 80% flow exceedance was used because it is considered to represent a typical flow value for base flow conditions (it is the midpoint along the flow duration curve between 60% and 100%). The TMDL was calculated as the allowable load per unit area multiplied times the total drainage area at the downstream end of the reach. These calculations are shown at the bottom of Tables F.1 – F.4.

Both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to include a MOS to account for uncertainty in available data or in the actual effect that controls will have on the loading reductions and receiving water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly through conservative assumptions used in establishing the TMDL. For these turbidity TMDLs, an implicit MOS was incorporated through the use of conservative assumptions. The primary conservative assumption was calculating the turbidity TMDLs assuming that TSS is a conservative parameter and does not settle out of the water column.

4.8 Point Source Loads

The WLAs for the point sources were set to NA ~~zero~~ because the surrogate being used for turbidity (TSS) is considered to represent inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). The suspended solids discharged by point sources in the Strawberry River basin are assumed to consist primarily of organic solids rather than inorganic solids. Discharges of organic suspended solids from point sources are already addressed by ADEQ through their permitting of point sources to maintain water quality standards for DO. The WLAs to support this TMDL will not require any changes to the permits concerning inorganic suspended solids. Therefore, future growth for these permits or new permits would not be restricted by these turbidity TMDLs.

4.9 Nonpoint Source Loads

The LAs for nonpoint sources, including natural background, result in being equal to the TMDLs because the WLAs were NA ~~zero~~ and the MOS was implicit.

4.10 Percent Reductions

In addition to calculating allowable loads, estimates were made for percent reductions of nonpoint source loads that are needed. For each observed TSS load that exceeded the allowable load at that flow (i.e., each observed TSS load above the allowable load curve in Figures F.2 – F.9), a uniform percent reduction was applied until the number of TSS loads exceeding the allowable loads was less than or equal to an acceptable number. For storm-flow conditions, the acceptable number of exceedances was 20% of the number of storm-flow data. This percentage (20%) was based on the Arkansas water quality standards, which state that "the non-point source runoff shall not result in the exceedance of the in stream storm-flow values in more than 20% of the ADEQ ambient monitoring network samples taken in not less than 24 monthly samples." (APCEC 2004a). For base flow conditions, the acceptable number of exceedances was 25% of the number of base flow data. This percentage (25%) was based on the ADEQ assessment criteria for turbidity (ADEQ 2002, ADEQ 2005a). For both storm-flow and base flow conditions, whenever the appropriate percentage multiplied by the number of observed values yielded a fractional number (e.g., 25% x 38 = 9.5), the allowable number of exceedances was rounded up to the next whole number (e.g., 9.5 rounded up to 10) in accordance with the ADEQ assessment criteria (ADEQ 2002, ADEQ 2005a). The calculations for percent reductions are shown in Tables F.5 - F.12.

For the impaired reaches without water quality monitoring data, percent reductions were calculated using existing nonpoint source loads per unit of drainage area that were calculated for the nearest reach with observed water quality data. These percent reductions and the results of the TMDL calculations are summarized in Table 4.1.

The percent reductions in Table 4.1 were calculated using methodology that is slightly different than the assessment criteria used by ADEQ to develop the 2004 303(d) list. The ADEQ assessment was performed using turbidity data that were categorized as either base flow or storm-flow values based on the month of the year in which the values were measured. The percent reductions in Table 4.1 were calculated using TSS data that were categorized as either base flow or storm-flow values based on streamflow data on each sampling day. These differences caused the assessment for the 2004 draft 303(d) list to indicate seven stream reaches

in the Strawberry River watershed are impaired and the TMDL analysis to indicate that one of those reaches (Little Strawberry River) is not impaired. The 2004 draft 303(d) list is still being reviewed by EPA and has not been finalized yet.

Table 4.1. Summary of turbidity TMDLs.

Reach ID	Stream Name	Flow Category	Loads (tons/day of TSS)				Percent Reduction Needed
			WLA	LA	MOS	TMDL	
11010012-004	Strawberry River	Base flow	~~0~~NA	3.97	~~0~~Implicit	3.97	0%
		Storm-flow	~~0~~NA	31.1	~~0~~ Implicit	31.1	50%
11010012-005	Strawberry River	Base flow	~~0~~NA	3.75	~~0~~ Implicit	3.75	0%
		Storm-flow	~~0~~NA	29.1	~~0~~ Implicit	29.1	50%
11010012-006	Strawberry River	Base flow	~~0~~NA	3.52	~~0~~ Implicit	3.52	0%
		Storm-flow	~~0~~NA	27.4	~~0~~ Implicit	27.4	50%
11010012-008	Strawberry River	Base flow	~~0~~NA	2.63	~~0~~ Implicit	2.63	0%
		Storm-flow	~~0~~NA	20.7	~~0~~ Implicit	20.7	53%
11010012-009	Strawberry River	Base flow	~~0~~NA	2.00	~~0~~ Implicit	2.00	0%
		Storm-flow	~~0~~NA	15.5	~~0~~ Implicit	15.5	53%
11010012-010	Little Strawberry River	Base flow	~~0~~NA	0.233	~~0~~ Implicit	0.233	0%
		Storm-flow	~~0~~NA	1.83	~~0~~ Implicit	1.83	0%
11010012-011	Strawberry River	Base flow	~~0~~NA	0.488	~~0~~ Implicit	0.488	0%
		Storm-flow	~~0~~NA	3.81	~~0~~ Implicit	3.81	58%

4.11 Future Growth

As mentioned in Section 4.8, future growth of existing or new point source discharges would not be restricted by these TMDLs.

5.0 OTHER RELEVANT INFORMATION

In accordance with Section 106 of the federal Clean Water Act and under its own authority, ADEQ has established a comprehensive program for monitoring the quality of the State's surface waters. ADEQ collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for long term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (*Water Quality Inventory*) and the 303(d) list of impaired waters, which are issued as a single document titled Arkansas Integrated Water Quality Monitoring and Assessment Report.

6.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, federal regulations require EPA to publicly notice and seek comment concerning the TMDL. Pursuant to a May 2000 consent decree, these TMDLs were prepared under contract to EPA. After development of the draft version of these TMDLs, EPA prepared a notice seeking comments, information, and data from the general public and affected public. No comments, data, or information were submitted during the public comment period. EPA has transmitted the final TMDLs to ADEQ for implementation and for incorporation into ADEQ's current water quality management plan

7.0 REFERENCES

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APPENDIX A

Maps

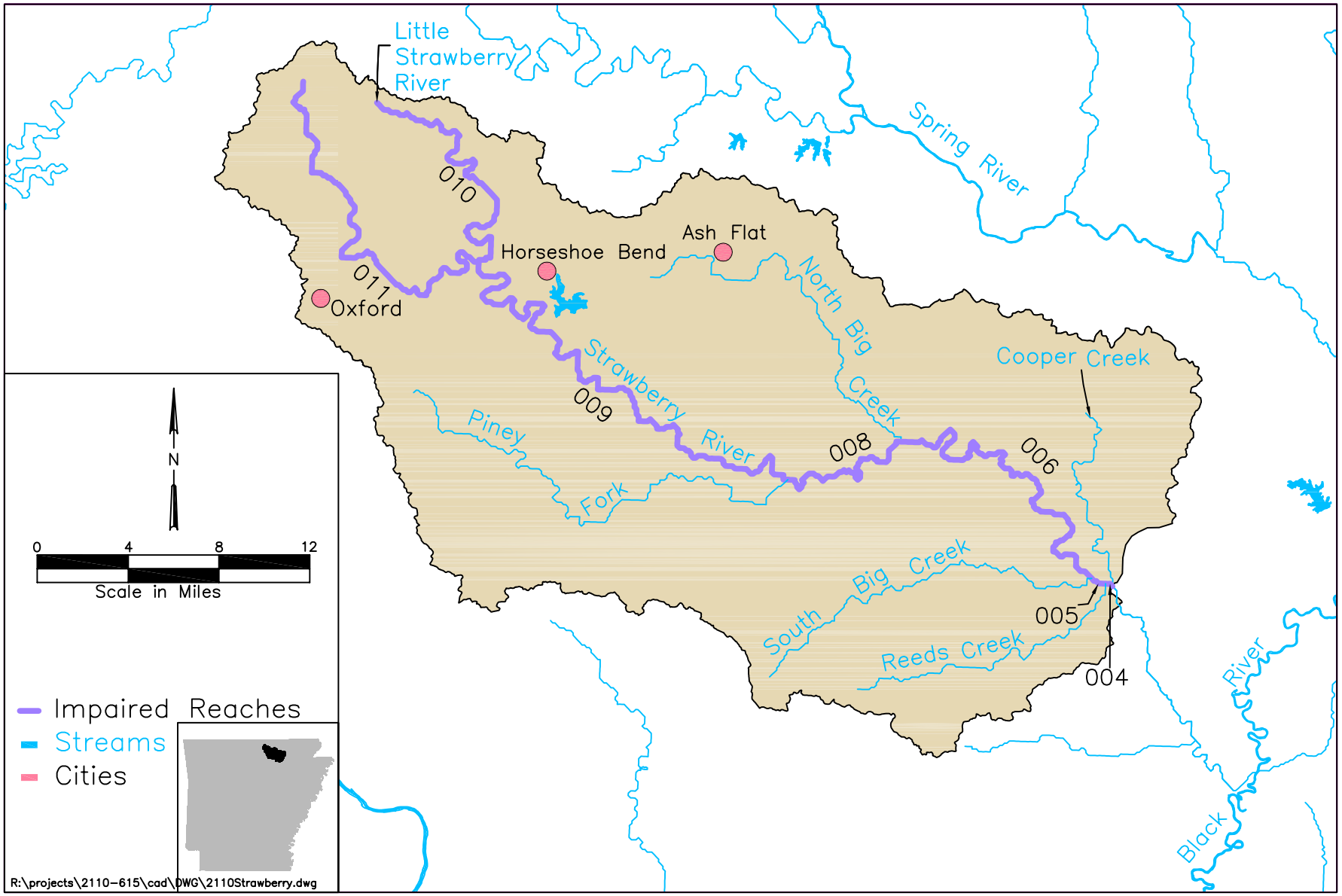

Figure A.1. Map of study area

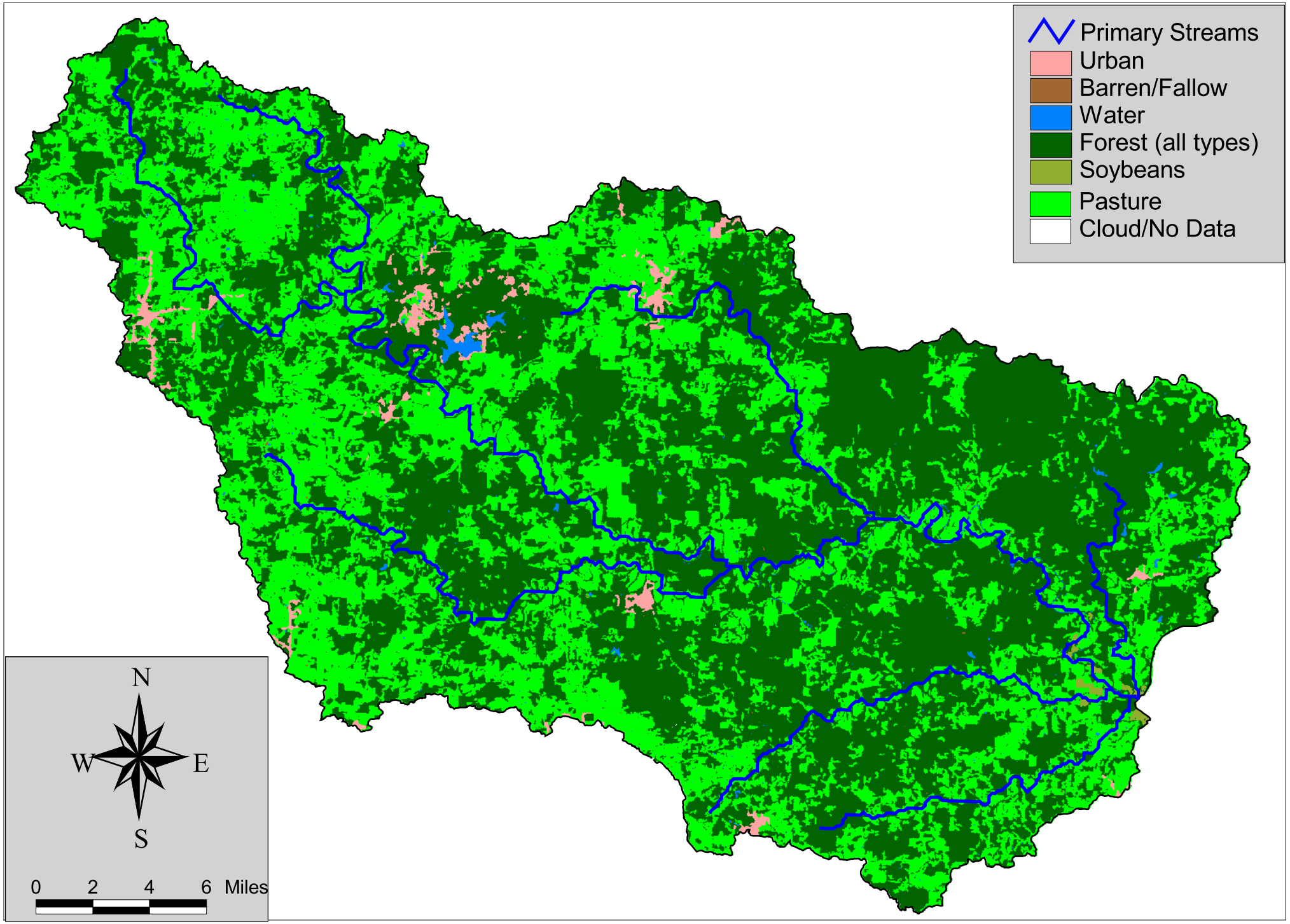

Figure A.2. Land use in Strawberry River watershed.

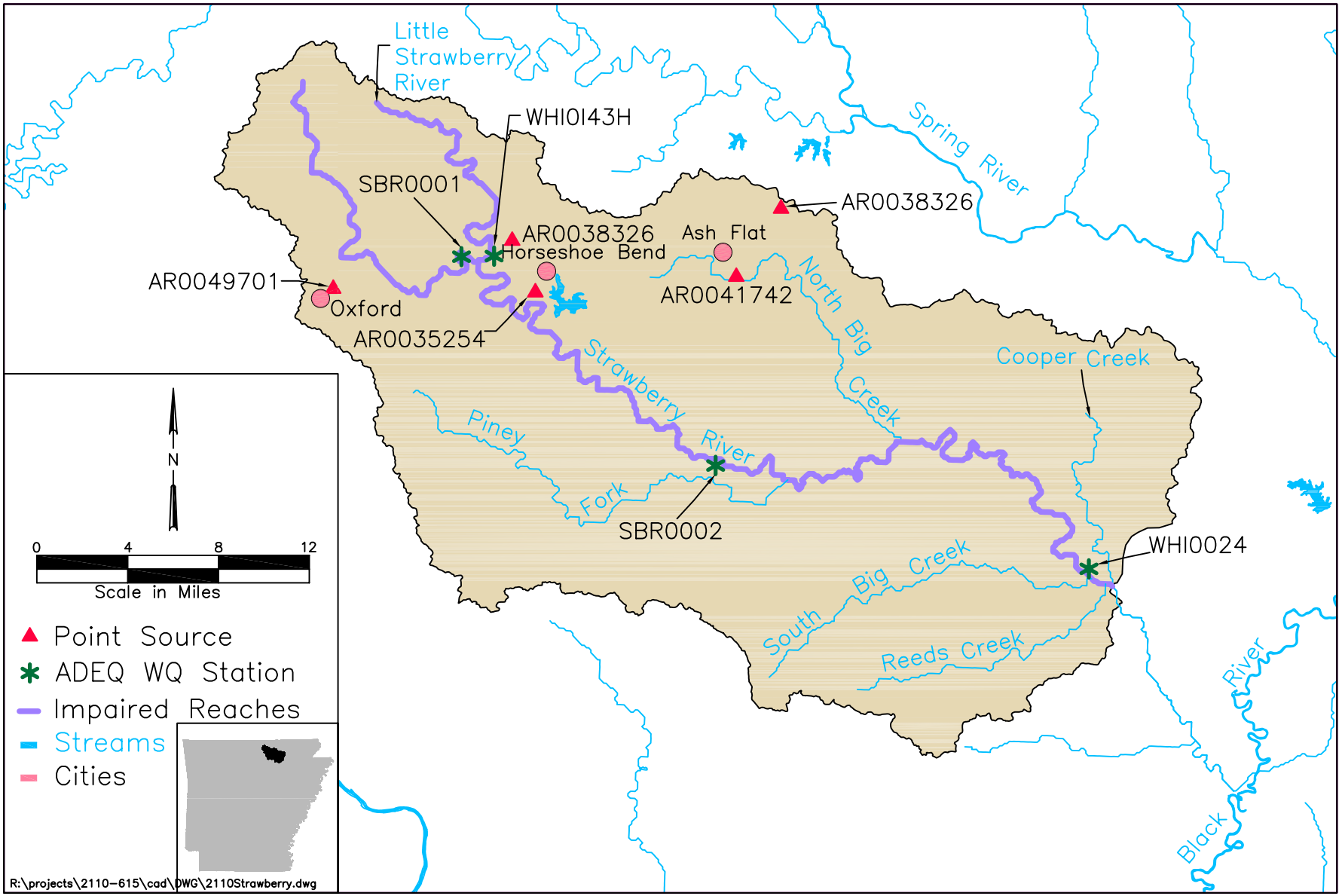

Figure A.3. Map of water quality stations and point sources in the study area

APPENDIX B

Long Term Plots of Turbidity and TSS

Table B.1. Observed Turbidity and TSS Data for Strawberry River at SBR0001.

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
8/27/2001	12	16	24	0.05	4.31E+00	99.69%	Base flow	10	No	
9/12/1994	4.2	5	61	0.13	3.48E+00	87.17%	Base flow	10	Yes	
12/3/2002	2.46	<1	62	0.13	7.07E-01	86.43%	Base flow	10	Yes	
7/18/1995	15	15	68	0.14	1.16E+01	83.28%	Base flow	10	No	
10/8/1996	2.6	1.5	70	0.15	1.19E+00	82.14%	Base flow	10	Yes	
5/1/2001	2.4	4.7	76	0.16	4.07E+00	78.84%	Base flow	10	Yes	
11/6/2001	3.4	2.5	79	0.17	2.25E+00	76.96%	Base flow	10	Yes	
8/27/2002	5.2	3.5	79	0.17	3.15E+00	76.96%	Base flow	10	Yes	
2/20/1996	6.2	10.5	103	0.22	1.23E+01	67.53%	Base flow	10	Yes	
6/13/1994	4.1	4	165	0.35	7.52E+00	52.33%	Storm-flow	17		Yes
6/18/2003	5.37	3	171	0.36	5.85E+00	51.25%	Storm-flow	17		Yes
6/17/2002	3.8	2.7	182	0.38	5.60E+00	49.31%	Storm-flow	17		Yes
3/19/2001	3.5	1.3	185	0.39	2.74E+00	48.81%	Storm-flow	17		Yes
3/19/2003	12.9	4.7	232	0.49	1.24E+01	42.09%	Storm-flow	17		Yes
4/29/2002	3	2.75	385	0.81	1.21E+01	28.47%	Storm-flow	17		Yes
10/3/1995	46	25.5	390	0.82	1.13E+02	28.10%	Storm-flow	17		No
5/6/1996	58	51.5	400	0.85	2.35E+02	27.42%	Storm-flow	17		No
1/17/1995	6.7	1	565	1.19	6.44E+00	18.97%	Storm-flow	17		Yes
2/24/2003	20	10.8	1270	2.68	1.56E+02	6.70%	Storm-flow	17		No
4/8/2002	104	225.5	1470	3.11	3.78E+03	5.44%	Storm-flow	17		No
3/12/2002	63	70.8	3820	8.08	3.08E+03	1.68%	Storm-flow	17		No
4/11/1995	74	122	5533	11.70	7.70E+03	0.99%	Storm-flow	17		No
							Number exceeding applicable water quality standard for turbidity =		2	6
							Total number of observations in each category =		9	13
							Percent exceeding applicable water quality standard for turbidity =		22%	46%

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Table B.2. Observed Turbidity and TSS Data for Strawberry River at SBR0002.

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
8/27/2001	4.2	3	24	0.05	8.08E-01	99.70%	Base flow	10	Yes	
9/12/1994	2.7	3	61	0.13	2.09E+00	87.18%	Base flow	10	Yes	
12/3/2002	1.91	<1	62	0.13		86.44%	Base flow	10	Yes	
7/18/1995	4.1	6.5	68	0.14	5.02E+00	83.29%	Base flow	10	Yes	
10/8/1996	3.4	3.5	70	0.15	2.79E+00	82.15%	Base flow	10	Yes	
5/1/2001	2.1	6.5	76	0.16	5.63E+00	78.85%	Base flow	10	Yes	
6/19/2001			77	0.16		78.35%	Base flow	10		
11/6/2001	1.3	<1	79	0.17		76.97%	Base flow	10	Yes	
8/27/2002	2.4	3.2	79	0.17	2.88E+00	76.97%	Base flow	10	Yes	
2/20/1996	3	2.5	103	0.22	2.93E+00	67.54%	Base flow	10	Yes	
1/22/2002	2.2	<1	161	0.34		53.21%	Storm flow	17		Yes
6/13/1994	4.6	6.5	165	0.35	1.22E+01	52.35%	Storm flow	17		Yes
6/18/2003	2.94	3.2	171	0.36	6.24E+00	51.27%	Storm flow	17		Yes
6/17/2002	2.5	1.7	182	0.38	3.53E+00	49.33%	Storm flow	17		Yes
3/19/2001	1.8	<1	185	0.39		48.82%	Storm flow	17		Yes
3/19/2003	3.28	<1	232	0.49		42.11%	Storm flow	17		Yes
4/29/2002	1.5	3.25	385	0.81	1.43E+01	28.49%	Storm flow	17		Yes
10/3/1995	3.2	4.5	390	0.82	2.00E+01	28.12%	Storm flow	17		Yes
5/6/1996	4.4	4.5	400	0.85	2.05E+01	27.44%	Storm flow	17		Yes
1/17/1995	6.8	3	565	1.19	1.93E+01	19.00%	Storm flow	17		Yes
2/24/2003	26.2	12.8	1270	2.68	1.85E+02	6.73%	Storm flow	17		No
4/8/2002	31	81.5	1470	3.11	1.37E+03	5.46%	Storm flow	17		No
3/12/2002	70	105	3820	8.08	4.57E+03	1.71%	Storm flow	17		No
1/24/2002	360	442	5030	10.63	2.53E+04	1.18%	Storm flow	17		No
4/11/1995	15	46	5533	11.70	2.90E+03	1.02%	Storm flow	17		Yes
							Number exceeding applicable water quality standard for turbidity =		0	4
							Total number of observations in each category =		9	15
							Percent exceeding applicable water quality standard for turbidity =		0%	27%

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Table B.3. Observed Turbidity and TSS Data for Strawberry River at WHI0024

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
9/19/2000	4.1	8.5	15	0.03	1.49E+00	99.94%	Base flow	10	Yes	
8/22/2000	4.5	7.5	17	0.04	1.49E+00	99.89%	Base flow	10	Yes	
9/28/2004	7.79	5.5	20	0.04	1.22E+00	99.85%	Base flow	10	Yes	
8/28/2001	7.6	13.5	24	0.05	3.63E+00	99.69%	Base flow	10	Yes	
8/28/2001	8.2	12.8	24	0.05	3.45E+00	99.69%	Base flow	10	Yes	
10/21/1997	3.9	7	28	0.06	2.21E+00	99.46%	Base flow	10	Yes	
7/24/2001	6.2	9.8	31	0.07	3.44E+00	99.27%	Base flow	10	Yes	
1/25/2000	2.9	2	32	0.07	7.26E-01	99.18%	Base flow	10	Yes	
10/17/2000	2.2	6	38	0.08	2.60E+00	98.61%	Base flow	10	Yes	
7/20/1999	7.5	11	39	0.08	4.89E+00	98.45%	Base flow	10	Yes	
8/20/1996	6.6	12.5	41	0.09	5.85E+00	98.06%	Base flow	10	Yes	
8/22/1995	8.6	16.5	42	0.09	7.92E+00	97.78%	Base flow	10	Yes	
9/21/1999	4.4	14	43	0.09	6.88E+00	97.47%	Base flow	10	Yes	
10/10/1995	3.8	6.5	45	0.10	3.35E+00	96.47%	Base flow	10	Yes	
11/16/1999	2.2	4.5	45	0.10	2.32E+00	96.47%	Base flow	10	Yes	
10/11/1994	3.1	3.5	46	0.10	1.84E+00	95.96%	Base flow	10	Yes	
6/26/2001	7.9	12.3	46	0.10	6.48E+00	95.96%	Base flow	10	Yes	
7/29/1997	6.2	13.5	47	0.10	7.27E+00	95.63%	Base flow	10	Yes	
6/29/2004	12.3	14	47	0.10	7.54E+00	95.63%	Base flow	10	No	
6/25/1996	7.2	12.5	49	0.10	7.02E+00	94.78%	Base flow	10	Yes	
10/7/2003	4.65	4.8	51	0.11	2.81E+00	93.78%	Base flow	10	Yes	
10/1/1991	3	5	52	0.11	2.96E+00	93.40%	Base flow	10	Yes	
11/4/2003	6.19	7.2	53	0.11	4.38E+00	92.21%	Base flow	10	Yes	
10/8/2002	7.5	6.75	55	0.12	4.23E+00	91.13%	Base flow	10	Yes	
9/23/1997	11	17	56	0.12	1.09E+01	90.27%	Base flow	10	No	
9/22/1998	5.6	12.5	56	0.12	8.05E+00	90.27%	Base flow	10	Yes	
10/30/2001	3	3.2	58	0.12	2.12E+00	89.26%	Base flow	10	Yes	
4/18/2000	4.4		59	0.12		88.85%	Base flow	10	Yes	
8/13/1991	8.6	20	59	0.12	1.35E+01	88.57%	Base flow	10	Yes	
8/24/1993	8.4	14	59	0.12	9.42E+00	88.57%	Base flow	10	Yes	
7/7/1998	5.4	11	60	0.13	7.47E+00	88.30%	Base flow	10	Yes	

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
9/7/1993	9.4	12	61	0.13	8.35E+00	87.17%	Base flow	10	Yes	
9/27/1994	4.4	5.5	61	0.13	3.83E+00	87.17%	Base flow	10	Yes	
8/18/1998	4.6	14	62	0.13	9.83E+00	86.79%	Base flow	10	Yes	
10/12/1999	6.1	9	62	0.13	6.32E+00	86.79%	Base flow	10	Yes	
9/10/2002	5.3	7	62	0.13	4.95E+00	86.43%	Base flow	10	Yes	
12/3/2002	2.36	<1	62	0.13	7.07E-01	86.43%	Base flow	10	Yes	
11/13/2001	3.4	2.5	63	0.13	1.80E+00	85.81%	Base flow	10	Yes	
5/28/1996		12.5	65	0.14	9.22E+00	85.03%	Base flow	10		
11/12/2002	3.45	3	65	0.14	2.22E+00	84.71%	Base flow	10	Yes	
11/18/1997	1.5	<1	66	0.14	7.49E-01	84.39%	Base flow	10	Yes	
6/15/1999	34	36.5	66	0.14	2.73E+01	84.39%	Base flow	10	No	
2/23/1999	2.8	6.5	68	0.14	5.02E+00	83.28%	Base flow	10	Yes	
8/24/1999	12	21.5	68	0.14	1.66E+01	83.28%	Base flow	10	No	
9/11/1990	16	24	71	0.15	1.94E+01	81.30%	Base flow	10	No	
6/16/1998	5.4	12	73	0.15	9.97E+00	80.51%	Base flow	10	Yes	
8/19/1997	9.4	18	75	0.16	1.54E+01	79.33%	Base flow	10	Yes	
5/1/2001	4.2	11.2	76	0.16	9.70E+00	78.84%	Base flow	10	Yes	
10/27/1992	5.2	8	76	0.16	6.93E+00	78.59%	Base flow	10	Yes	
6/19/2001	7.8	17.25	77	0.16	1.51E+01	78.34%	Base flow	10	Yes	
9/10/1991	4	14	78	0.16	1.25E+01	77.47%	Base flow	10	Yes	
7/30/1996	230	240	78	0.16	2.13E+02	77.18%	Base flow	10	No	
11/6/2001	3	3.8	79	0.17	3.42E+00	76.96%	Base flow	10	Yes	
6/24/1997	5	10.5	79	0.17	9.46E+00	76.73%	Base flow	10	Yes	
8/26/2002	7.2	8.8	81	0.17	8.13E+00	75.97%	Base flow	10	Yes	
7/9/2002	5.1	15.5	82	0.17	1.45E+01	75.52%	Base flow	10	Yes	
8/13/2002	8.8	11.5	88	0.19	1.15E+01	72.91%	Base flow	10	Yes	
2/14/1995	1.6	1.5	91	0.19	1.56E+00	71.55%	Base flow	10	Yes	
7/9/1991	8.8	13	92	0.19	1.36E+01	71.37%	Base flow	10	Yes	
9/1/1992	7.8	16	95	0.20	1.73E+01	70.30%	Base flow	10	Yes	
8/9/1994	6.2	10.5	95	0.20	1.14E+01	70.30%	Base flow	10	Yes	
8/16/2004	13.6	13.3	99	0.21	1.49E+01	68.98%	Base flow	10	No	
7/27/2004	16.9	17	100	0.21	1.93E+01	68.72%	Base flow	10	No	
2/13/1996	2.5	2	102	0.21	2.32E+00	68.00%	Base flow	10	Yes	

Table B.3.
Turbidity and TSS data WHI0024

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
5/11/1999	4.2	11	102	0.21	1.27E+01	68.00%	Base flow	10	Yes	
8/1/2000	6.6	13	103	0.22	1.52E+01	67.53%	Base flow	10	Yes	
3/16/2004	11.2	6.2	103	0.22	7.26E+00	67.53%	Base flow	10	No	
12/17/2002	2.98	3.3	110	0.23	4.14E+00	65.40%	Base flow	10	Yes	
7/6/1993	6.7	13	111	0.23	1.65E+01	65.09%	Base flow	10	Yes	
12/30/1997	2.1	1.5	113	0.24	1.93E+00	64.59%	Base flow	10	Yes	
3/21/2000	4.3	7	113	0.24	9.01E+00	64.59%	Base flow	10	Yes	
4/17/2001	3.6	8	113	0.24	1.03E+01	64.59%	Base flow	10	Yes	
9/22/1992	115	153	122	0.26	2.13E+02	62.07%	Base flow	10	No	
1/19/1999	4.8	6	123	0.26	8.43E+00	61.59%	Base flow	10	Yes	
12/18/2000	4.9	2	123	0.26	2.81E+00	61.59%	Base flow	10	Yes	
5/22/2001	10	18	123	0.26	2.53E+01	61.59%	Base flow	10	Yes	
11/6/1990	3.7		133	0.28		59.46%	Storm flow	17		Yes
11/20/1995	2.2	1	133	0.28	1.52E+00	59.20%	Storm flow	17		Yes
9/24/1996	6.1	7	133	0.28	1.07E+01	59.20%	Storm flow	17		Yes
10/19/2004	26	25.8	133	0.28	3.93E+01	59.20%	Storm flow	17		No
1/28/2003	4.46	1.3	137	0.29	2.03E+00	58.31%	Storm flow	17		Yes
7/25/1995	17	37	144	0.30	6.06E+01	56.97%	Storm flow	17		Yes
4/22/2003	10	11	148	0.31	1.86E+01	55.97%	Storm flow	17		Yes
10/12/1993	2.6	2	149	0.32	3.40E+00	55.76%	Storm flow	17		Yes
6/14/1994	5.8	10.5	152	0.32	1.82E+01	55.26%	Storm flow	17		Yes
12/6/1994	3.3	5	154	0.33	8.78E+00	54.83%	Storm flow	17		Yes
9/19/1995	11	19	154	0.33	3.34E+01	54.83%	Storm flow	17		Yes
6/11/1991	6.4	11	154	0.33	1.93E+01	54.60%	Storm flow	17		Yes
1/22/2002	1.7	1.8	161	0.34	3.30E+00	53.20%	Storm flow	17		Yes
1/21/1997	2.8	3	164	0.35	5.62E+00	52.49%	Storm flow	17		Yes
6/18/2002	7.1	9.5	168	0.36	1.82E+01	51.81%	Storm flow	17		Yes
6/27/2000	10	22.5	175	0.37	4.48E+01	50.71%	Storm flow	17		Yes
3/20/2001	3.3	3.8	175	0.37	7.56E+00	50.71%	Storm flow	17		Yes
5/18/2004	26.3	6	175	0.37	1.19E+01	50.71%	Storm flow	17		No
6/30/2003	6.66	4	178	0.38	8.12E+00	49.96%	Storm flow	17		Yes
6/17/2002	7.2	10.5	182	0.38	2.18E+01	49.31%	Storm flow	17		Yes
11/9/1998	4.3	6	185	0.39	1.26E+01	48.81%	Storm flow	17		Yes

Table B.3.
Turbidity and TSS data WHI0024

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
3/19/2001	2.6	3.3	185	0.39	6.95E+00	48.81%	Storm flow	17		Yes
5/24/1994	3.8	6.5	185	0.39	1.37E+01	48.68%	Storm flow	17		Yes
4/1/2003	5	3	192	0.41	6.57E+00	47.79%	Storm flow	17		Yes
7/26/1994	7.2	14	193	0.41	3.08E+01	47.67%	Storm flow	17		Yes
3/28/1995	2.2	3	195	0.41	6.67E+00	47.31%	Storm flow	17		Yes
11/2/1993	2.4	2	196	0.41	4.47E+00	47.17%	Storm flow	17		Yes
3/12/1991	2.8	2	202	0.43	4.61E+00	46.14%	Storm flow	17		Yes
12/9/2003	16	11	205	0.43	2.57E+01	45.67%	Storm flow	17		Yes
12/14/2004	12.8	5.8	205	0.43	1.36E+01	45.67%	Storm flow	17		Yes
4/29/1997	2.1	3	216	0.46	7.37E+00	44.33%	Storm flow	17		Yes
3/19/2003	7.83	7.7	232	0.49	2.04E+01	42.09%	Storm flow	17		Yes
5/12/1992	2	6	239	0.51	1.63E+01	41.29%	Storm flow	17		Yes
6/9/1992	9.4	22	240	0.51	6.02E+01	41.19%	Storm flow	17		Yes
1/30/1996	6.8	6	246	0.52	1.69E+01	40.32%	Storm flow	17		Yes
7/7/1992	46	64	250	0.53	1.82E+02	39.84%	Storm flow	17		No
2/12/1991	3.6	5	253	0.53	1.44E+01	39.55%	Storm flow	17		Yes
9/25/2001	6.6	5.7	257	0.54	1.67E+01	39.19%	Storm flow	17		Yes
10/29/1996	7.6	12	267	0.56	3.65E+01	38.11%	Storm flow	17		Yes
10/20/1998	1.5	15	267	0.56	4.56E+01	38.11%	Storm flow	17		Yes
1/25/2005	11.2	4.5	267	0.56	1.37E+01	38.11%	Storm flow	17		Yes
3/8/2005	7.29	6	267	0.56	1.83E+01	38.11%	Storm flow	17		Yes
1/2/2002	4.4	5	270	0.57	1.54E+01	37.76%	Storm flow	17		Yes
8/5/2003	41.8	46.2	296	0.63	1.56E+02	35.35%	Storm flow	17		No
5/27/1997	61	173	298	0.63	5.87E+02	35.14%	Storm flow	17		No
6/1/1993	6.1	12	305	0.64	4.17E+01	34.51%	Storm flow	17		Yes
3/23/1999	5.5	8	308	0.65	2.81E+01	34.29%	Storm flow	17		Yes
1/16/2001	4.2	7	308	0.65	2.46E+01	34.29%	Storm flow	17		Yes
2/17/2004	10.6	2.5	318	0.67	9.07E+00	33.37%	Storm flow	17		Yes
9/9/2003	23.1	28.2	322	0.68	1.04E+02	33.09%	Storm flow	17		No
3/17/1992	1.8	3	323	0.68	1.10E+01	33.00%	Storm flow	17		Yes
12/11/2001	13	14.3	355	0.75	5.79E+01	30.63%	Storm flow	17		Yes
5/27/2003	15.9	21.5	359	0.76	8.80E+01	30.38%	Storm flow	17		Yes
11/7/2000	5.7	8.5	370	0.78	3.58E+01	29.52%	Storm flow	17		Yes

Table B.3.
Turbidity and TSS data WHI0024

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
4/29/2002	12	41.25	385	0.81	1.81E+02	28.47%	Storm flow	17		Yes
4/26/1994	1.8	5	390	0.82	2.22E+01	28.18%	Storm flow	17		Yes
5/16/1995	5.5	15	390	0.82	6.67E+01	28.10%	Storm flow	17		Yes
7/22/2003	69.6	73.2	396	0.84	3.30E+02	27.70%	Storm flow	17		No
3/16/1993	2.2	4	398	0.84	1.82E+01	27.57%	Storm flow	17		Yes
12/15/1998	1.4	5	411	0.87	2.34E+01	26.79%	Storm flow	17		Yes
1/20/2004	21.5	7.5	431	0.91	3.69E+01	25.57%	Storm flow	17		No
4/13/1993	3.3	7	464	0.98	3.70E+01	23.62%	Storm flow	17		Yes
3/25/1997	4.3	10.5	472	1.00	5.65E+01	23.19%	Storm flow	17		Yes
3/4/2003	5.32	4	476	1.01	2.17E+01	22.95%	Storm flow	17		Yes
2/25/1992	3.1	3	481	1.02	1.65E+01	22.64%	Storm flow	17		Yes
2/12/2002	7.5	11	482	1.02	6.05E+01	22.59%	Storm flow	17		Yes
11/5/1991	16	20	493	1.04	1.12E+02	22.14%	Storm flow	17		Yes
11/19/1996	13	17.5	513	1.09	1.02E+02	21.22%	Storm flow	17		Yes
8/4/1992	10	12	523	1.11	7.16E+01	20.74%	Storm flow	17		Yes
1/21/1992	2.2	4	533	1.13	2.43E+01	20.33%	Storm flow	17		Yes
1/27/1998	3.1	4.5	534	1.13	2.74E+01	20.31%	Storm flow	17		Yes
5/12/1998	35	64.5	534	1.13	3.93E+02	20.31%	Storm flow	17		No
1/17/1995	11	9	565	1.19	5.79E+01	18.97%	Storm flow	17		Yes
5/7/1991	6.6	9	617	1.30	6.33E+01	17.00%	Storm flow	17		Yes
2/29/2000	34	52	657	1.39	3.89E+02	15.80%	Storm flow	17		No
3/22/1994	4.6	9.5	676	1.43	7.32E+01	15.23%	Storm flow	17		Yes
12/17/1996	20	30	698	1.48	2.39E+02	14.63%	Storm flow	17		No
12/14/1999		56	698	1.48	4.46E+02	14.63%	Storm flow	17		
5/21/2002	12	28.5	702	1.48	2.28E+02	14.49%	Storm flow	17		Yes
1/26/1993	9.4	13	740	1.56	1.10E+02	13.57%	Storm flow	17		Yes
2/18/1997	3.5	10.5	780	1.65	9.34E+01	12.83%	Storm flow	17		Yes
4/9/1991	18	30	797	1.68	2.73E+02	12.51%	Storm flow	17		No
4/2/1996	22		821	1.74		12.00%	Storm flow	17		No
6/13/1995	30	31.5	862	1.82	3.10E+02	11.14%	Storm flow	17		No
4/7/1998	5.4	10.5	862	1.82	1.03E+02	11.14%	Storm flow	17		Yes
2/15/2005	39.7	37.8	903	1.91	3.89E+02	10.47%	Storm flow	17		No
3/5/1996	3.2	3	955	2.02	3.27E+01	9.73%	Storm flow	17		Yes

Table B.3.
Turbidity and TSS data WHI0024

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
10/9/1990	74	188	1030	2.18	2.21E+03	8.83%	Storm flow	17		No
2/13/2001	5.3	8.2	1037	2.19	9.69E+01	8.77%	Storm flow	17		Yes
2/23/1993	30	32	1050	2.22	3.83E+02	8.59%	Storm flow	17		No
1/15/1991	13	24	1110	2.35	3.04E+02	7.96%	Storm flow	17		Yes
5/30/2000	45	106.5	1170	2.47	1.42E+03	7.41%	Storm flow	17		No
2/24/2003	50.4	54.5	1270	2.68	7.89E+02	6.70%	Storm flow	17		No
4/16/2002	19	39	1280	2.71	5.69E+02	6.62%	Storm flow	17		No
11/15/1994	18	19	1283	2.71	2.78E+02	6.57%	Storm flow	17		No
5/11/1993	26		1380	2.92		5.91%	Storm flow	17		No
12/18/1990	27	44	1400	2.96	7.02E+02	5.79%	Storm flow	17		No
4/8/2002	10	20.8	1470	3.11	3.49E+02	5.44%	Storm flow	17		Yes
12/14/1993	26	40	1500	3.17	6.84E+02	5.31%	Storm flow	17		No
3/10/1998	55	107.5	1591	3.36	1.95E+03	4.98%	Storm flow	17		No
2/17/1998	46	92	1848	3.91	1.94E+03	4.10%	Storm flow	17		No
11/23/1992	200	334	1870	3.95	7.12E+03	4.02%	Storm flow	17		No
12/3/1991			2400	5.07		2.99%	Storm flow	17		
1/25/1994	6.2	196	2670	5.64	5.97E+03	2.57%	Storm flow	17		Yes
4/30/1991	180		3270	6.91		2.03%	Storm flow	17		No
4/6/1999	78	223	3357	7.10	8.53E+03	1.95%	Storm flow	17		No
12/19/1995	81	102	3541	7.49	4.12E+03	1.84%	Storm flow	17		No
2/22/1994	110	209	3560	7.53	8.48E+03	1.82%	Storm flow	17		No
3/19/2002	57	158.3	3620	7.65	6.53E+03	1.79%	Storm flow	17		No
3/12/2002	76	155.5	3820	8.08	6.77E+03	1.68%	Storm flow	17		No
11/30/2004	103	102	4209	8.90	4.89E+03	1.55%	Storm flow	17		No
4/21/1992	115	137	5030	10.63	7.86E+03	1.16%	Storm flow	17		No
1/24/2002	33	610	5030	10.63	3.50E+04	1.16%	Storm flow	17		No
4/11/1995	18	43	5533	11.70	2.71E+03	0.99%	Storm flow	17		No
							Number exceeding applicable water quality standard for turbidity =		10	37
							Total number of observations in each category =		75	112
							Percent exceeding applicable water quality standard for turbidity =		13%	33%

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Table B.3.
Turbidity and TSS data WHI0024

Table B.4. Observed Turbidity and TSS Data for Strawberry River at WHI143h.

Date	Observed turbidity (NTU)	Observed TSS (mg/L)	Flow at USGS gage (cfs)	Flow per unit area (cfs/mi2)	Load per unit area (lbs/day/mi2)	Percent of days flow exceeded	Applicable category	Applicable water quality standard (NTU)	Turbidity meeting base flow standard?	Turbidity meeting storm-flow standard?
8/27/2001	4.8	4.7	24	0.05	1.27E+00	99.70	Base flow	10	Yes	
12/3/2002	3.9	2.5	62	0.13	1.77E+00	86.44	Base flow	10	Yes	
5/1/2001	2	3.8	76	0.16	3.29E+00	78.85	Base flow	10	Yes	
6/19/2001	3.6	5.5	77	0.16	4.83E+00	78.35	Base flow	10	Yes	
11/6/2001	2.2	2	79	0.17	1.80E+00	76.97	Base flow	10	Yes	
8/26/2002	3.2	3.2	81	0.17	2.96E+00	75.98	Base flow	10	Yes	
1/22/2002	1.5	1.3	161	0.34	2.39E+00	53.21	Storm-flow	17		Yes
6/18/2003	3.4	2.5	171	0.36	4.87E+00	51.27	Storm-flow	17		Yes
6/17/2002	2.7	1	182	0.38	2.08E+00	49.33	Storm-flow	17		Yes
3/19/2001	1.3	<1	185	0.39	2.11E+00	48.82	Storm-flow	17		Yes
3/19/2003	5.6	1	232	0.49	2.65E+00	42.11	Storm-flow	17		Yes
4/29/2002	1.9	4.25	385	0.81	1.87E+01	28.49	Storm-flow	17		Yes
2/24/2003	17.8	16	1270	2.68	2.32E+02	6.73	Storm-flow	17		No
4/8/2002	55	68	1470	3.11	1.14E+03	5.46	Storm-flow	17		No
3/12/2002	33	13	3820	8.08	5.66E+02	1.71	Storm-flow	17		No
1/24/2002	64	49	5030	10.63	2.81E+03	1.18	Storm-flow	17		No
							Number exceeding applicable water quality standard for turbidity =		0	4
							Total number of observations in each category =		6	10
							Percent exceeding applicable water quality standard for turbidity =		0%	40%

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Figure B.1. Observed Long Term TSS for Strawberry River near Wiseman, AR (SBR0001)

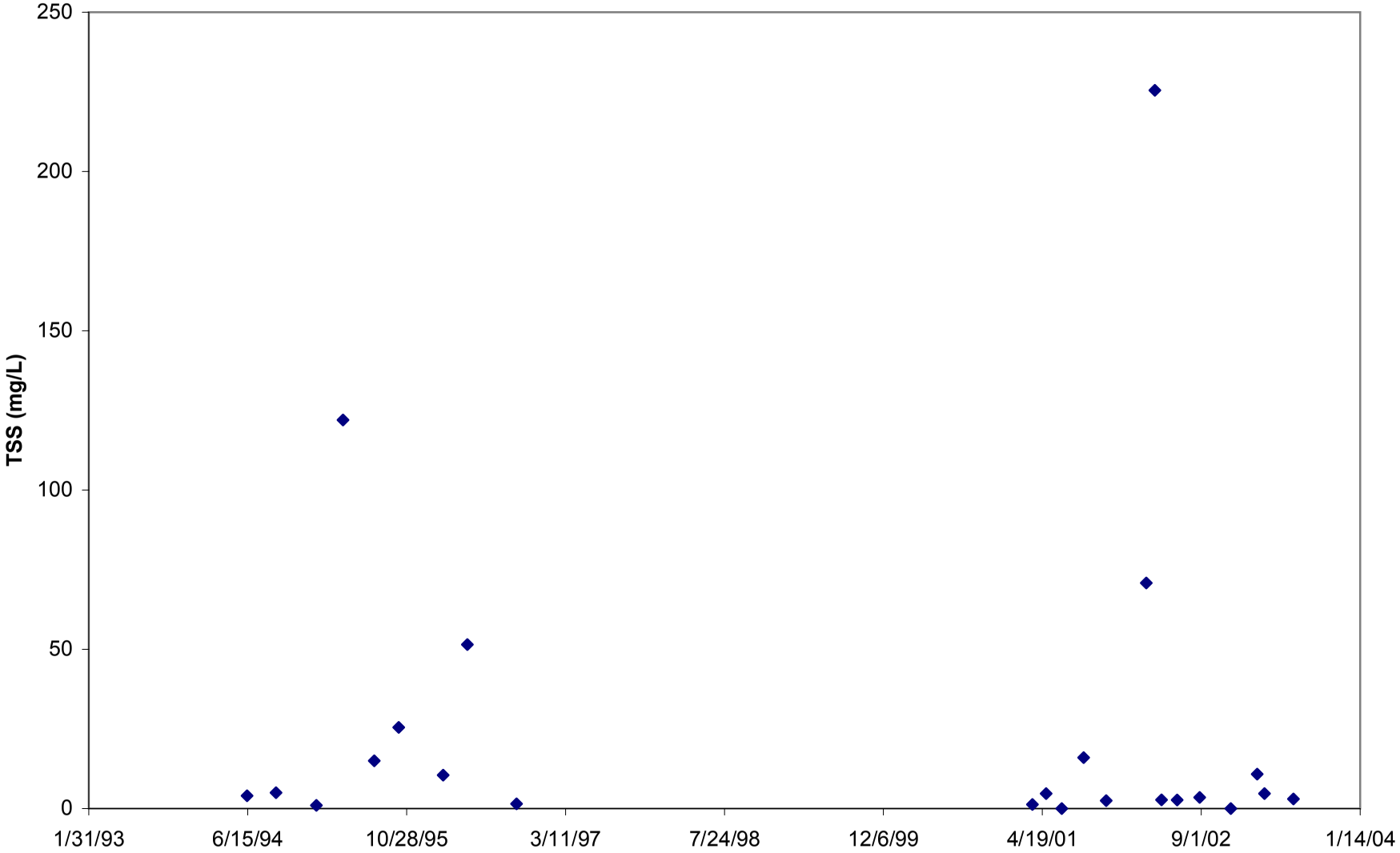


Figure B.2. Observed Long Term Turbidity for Strawberry River near Wiseman, AR (SBR0001)

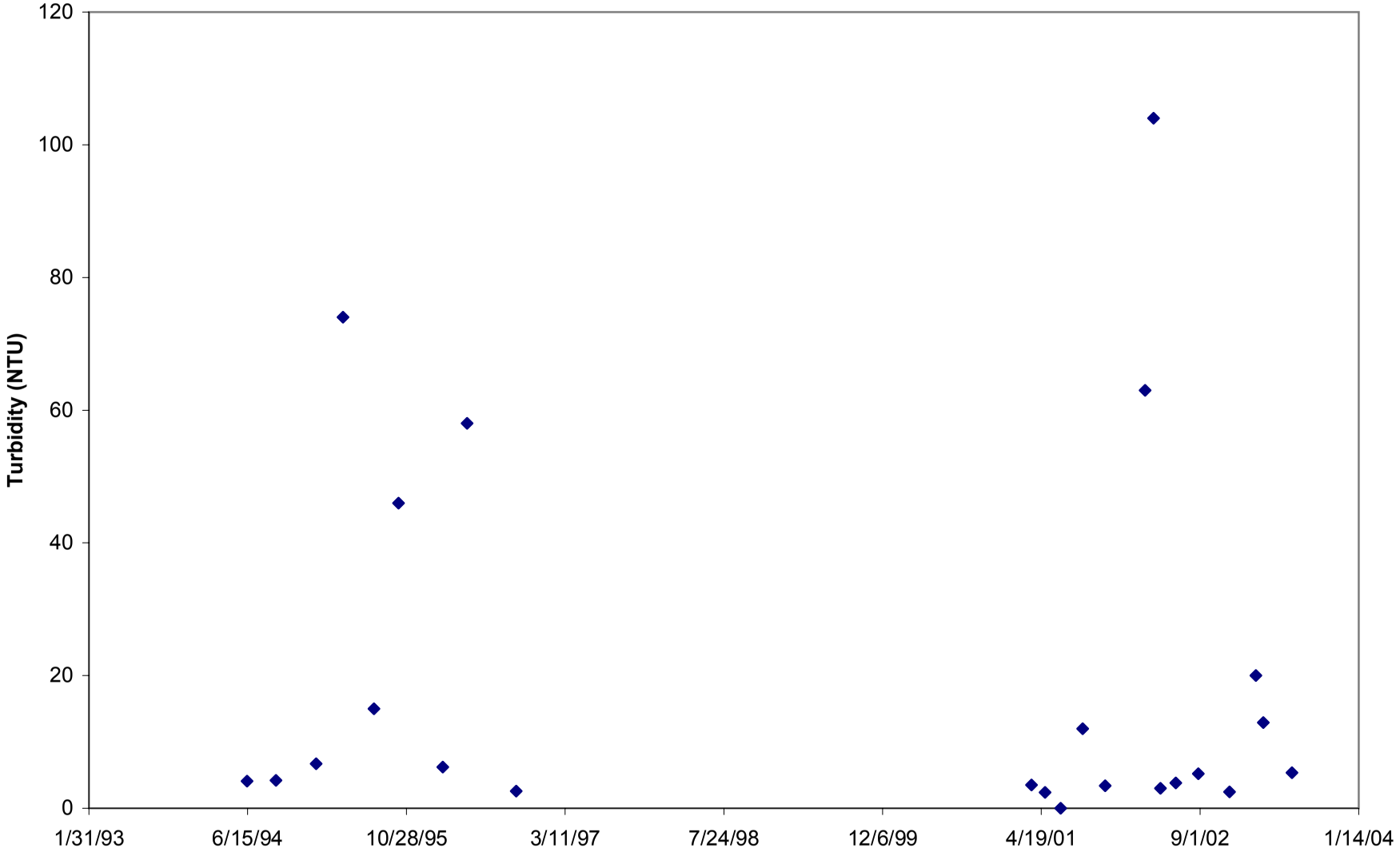


Figure B.3. Observed long Term TSS for Strawberry River at Hwy 167 (SBR0002)

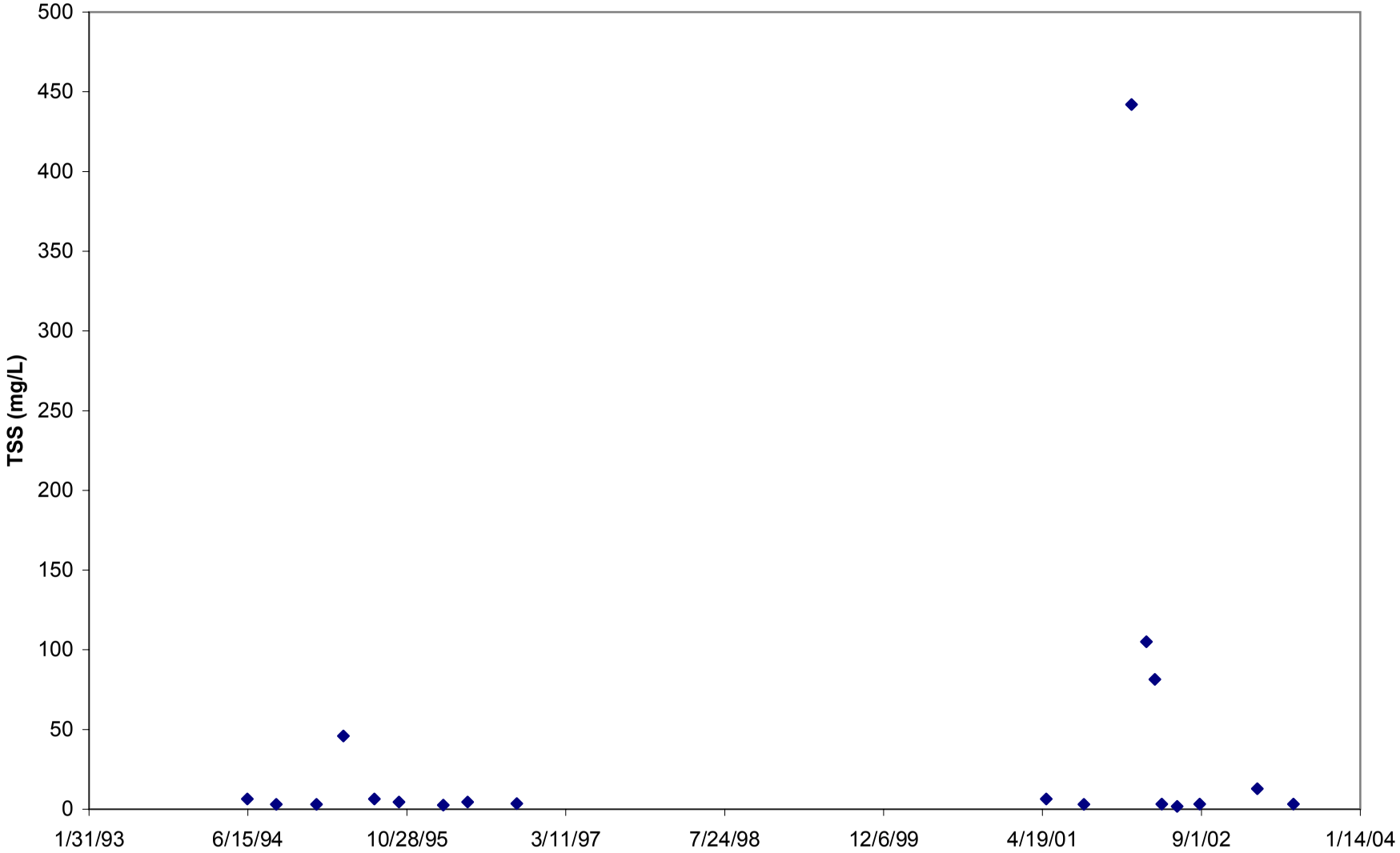


Figure B.4. Observed long Term Turbidity for Strawberry River at Hwy 167 (SBR0002)

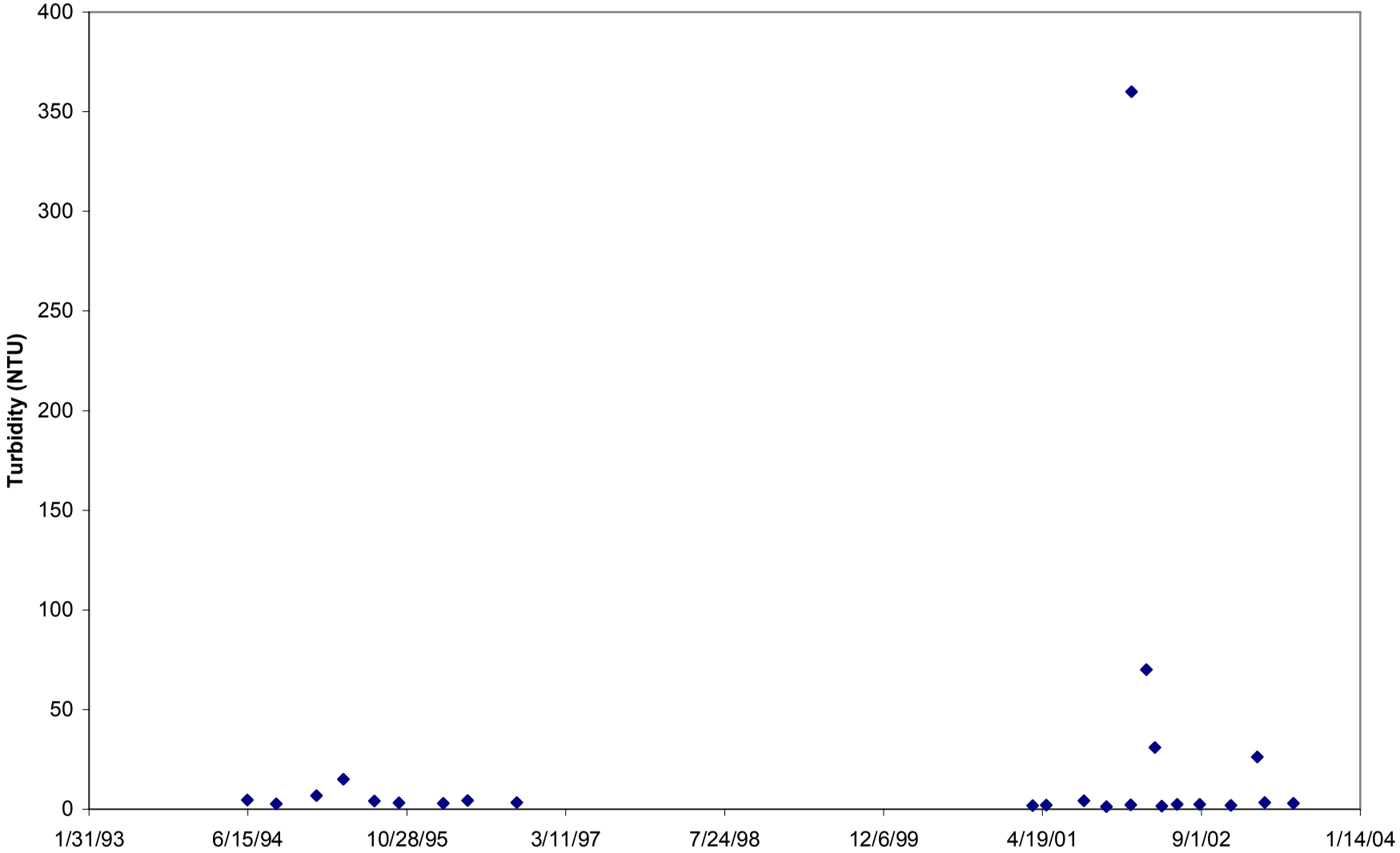


Figure F.5. Base Flow Load Duration Curve For Strawberry River SBR0002

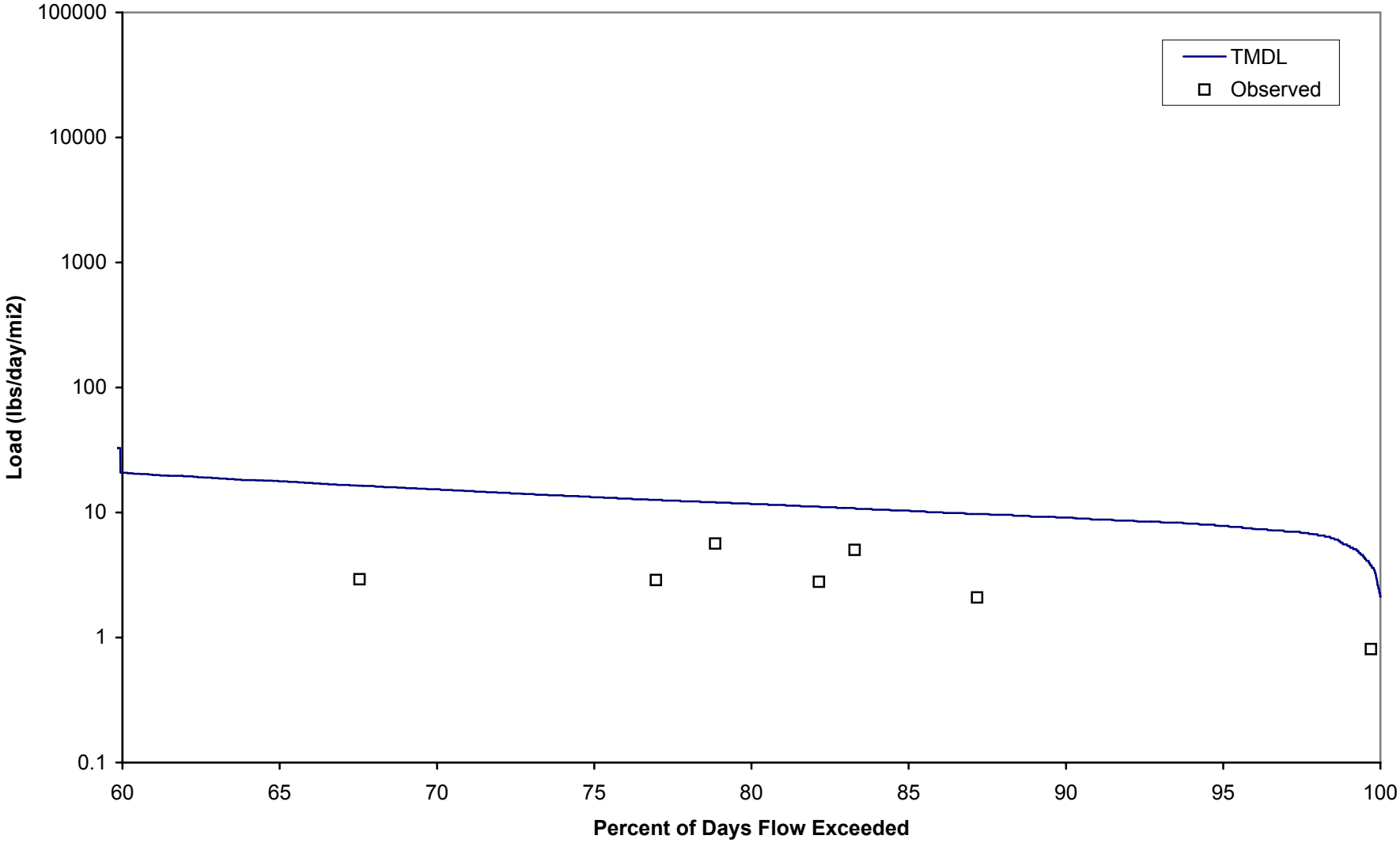


Figure B.6. Observed Long Term Turbidity for Strawberry River near Smithville, AR (WHI0024)

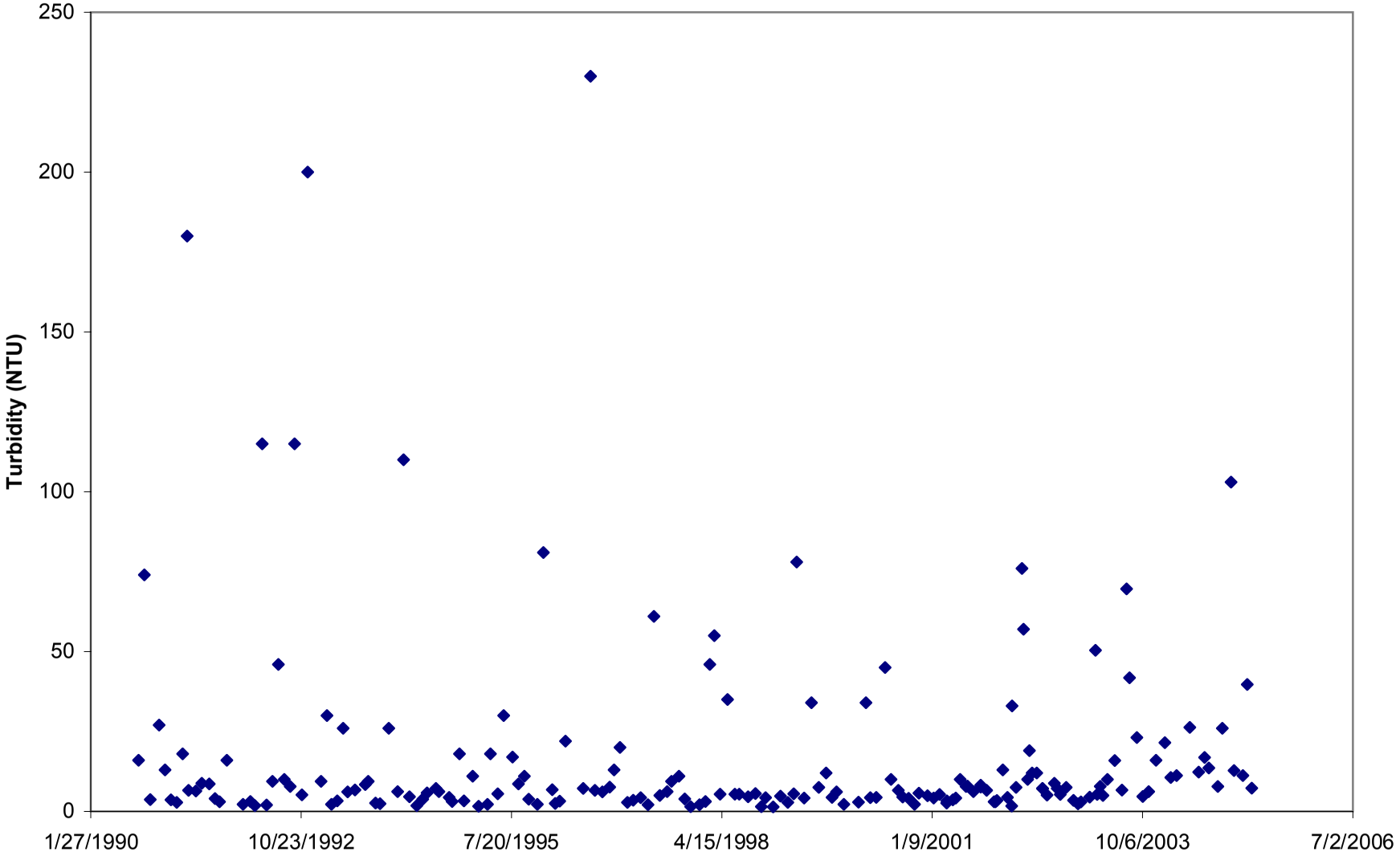


Figure B.7. Observed Long Term TSS for Strawberry River (WHI143)

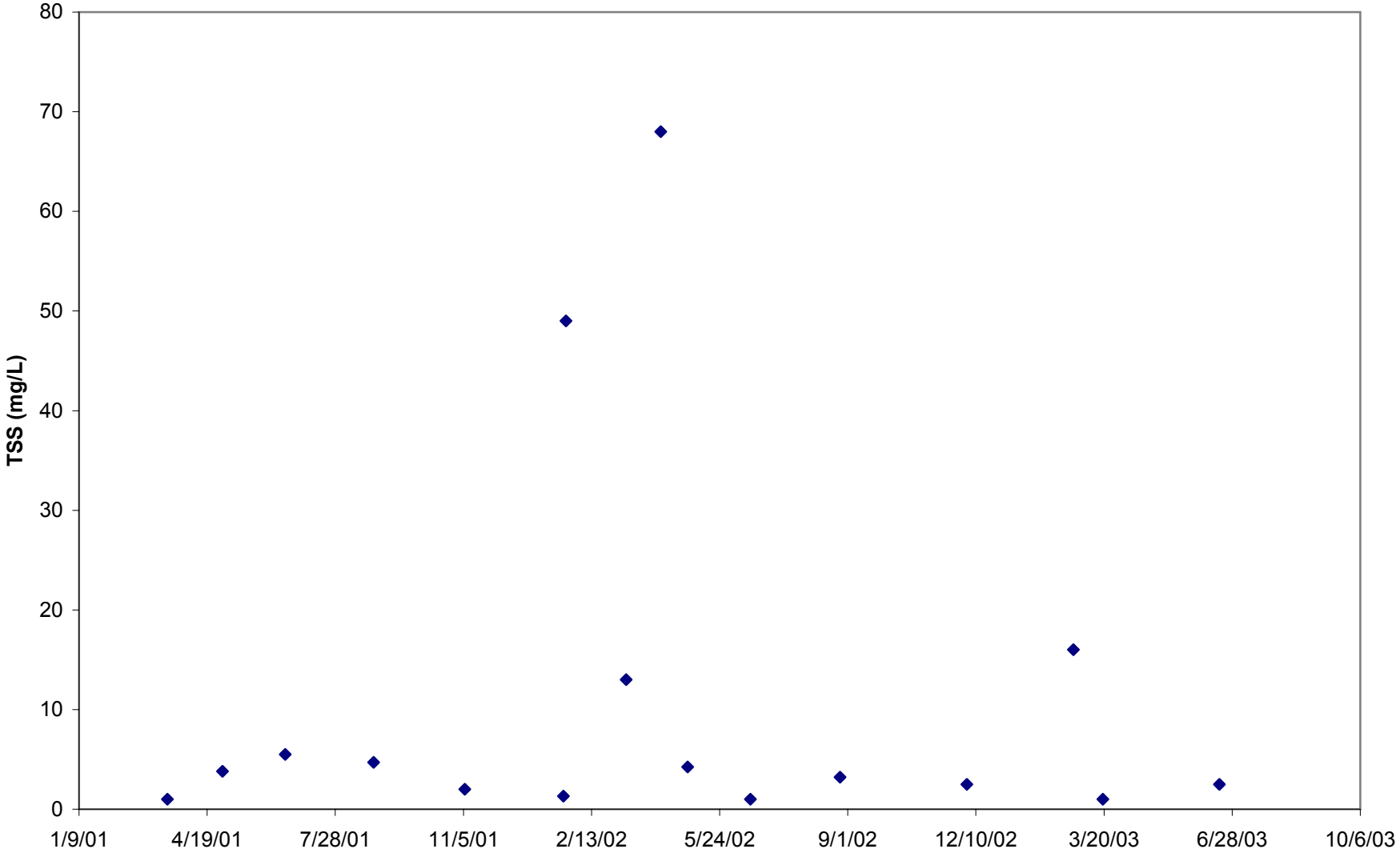
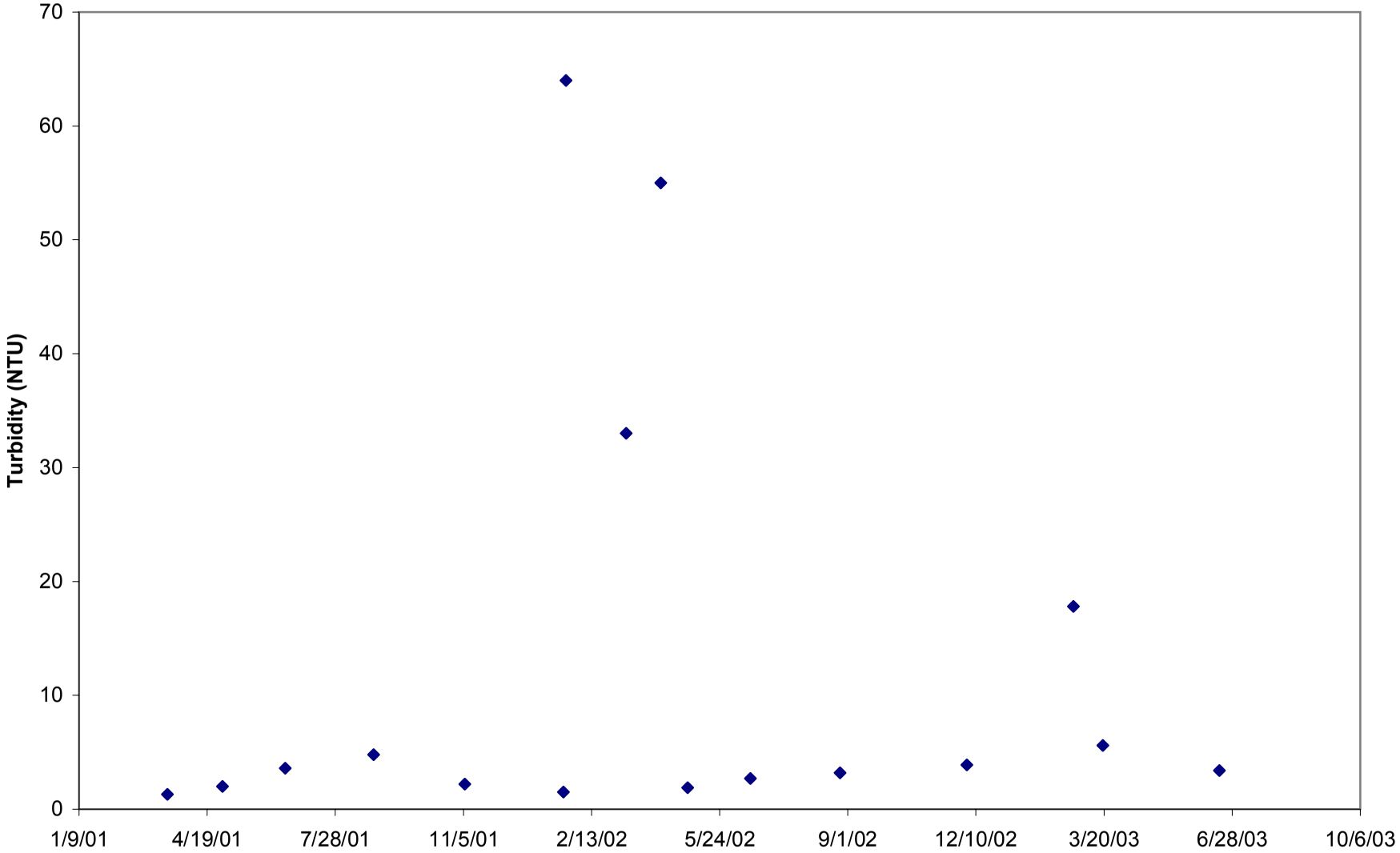


Figure B.8.Observed Long Term Turbidity for Strawberry River (WHI143h)



APPENDIX C

Seasonal Plots of Turbidity and TSS>

Figure C.1. Seasonal TSS for Strawberry River near Wiseman, AR (SBR0001)

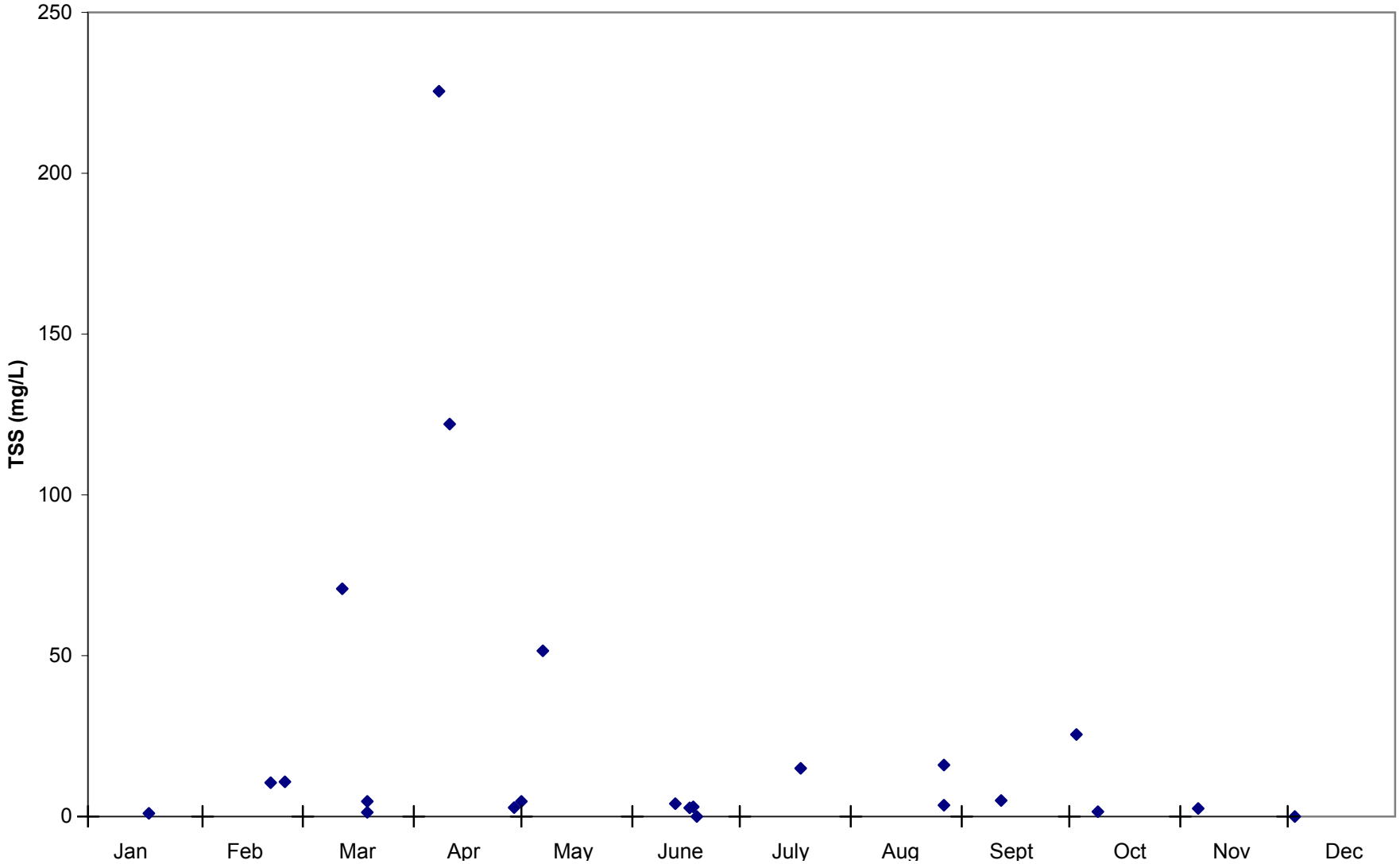


Figure C.2. Seasonal Turbidity for Strawberry River near Wiseman, AR (SBR0001)

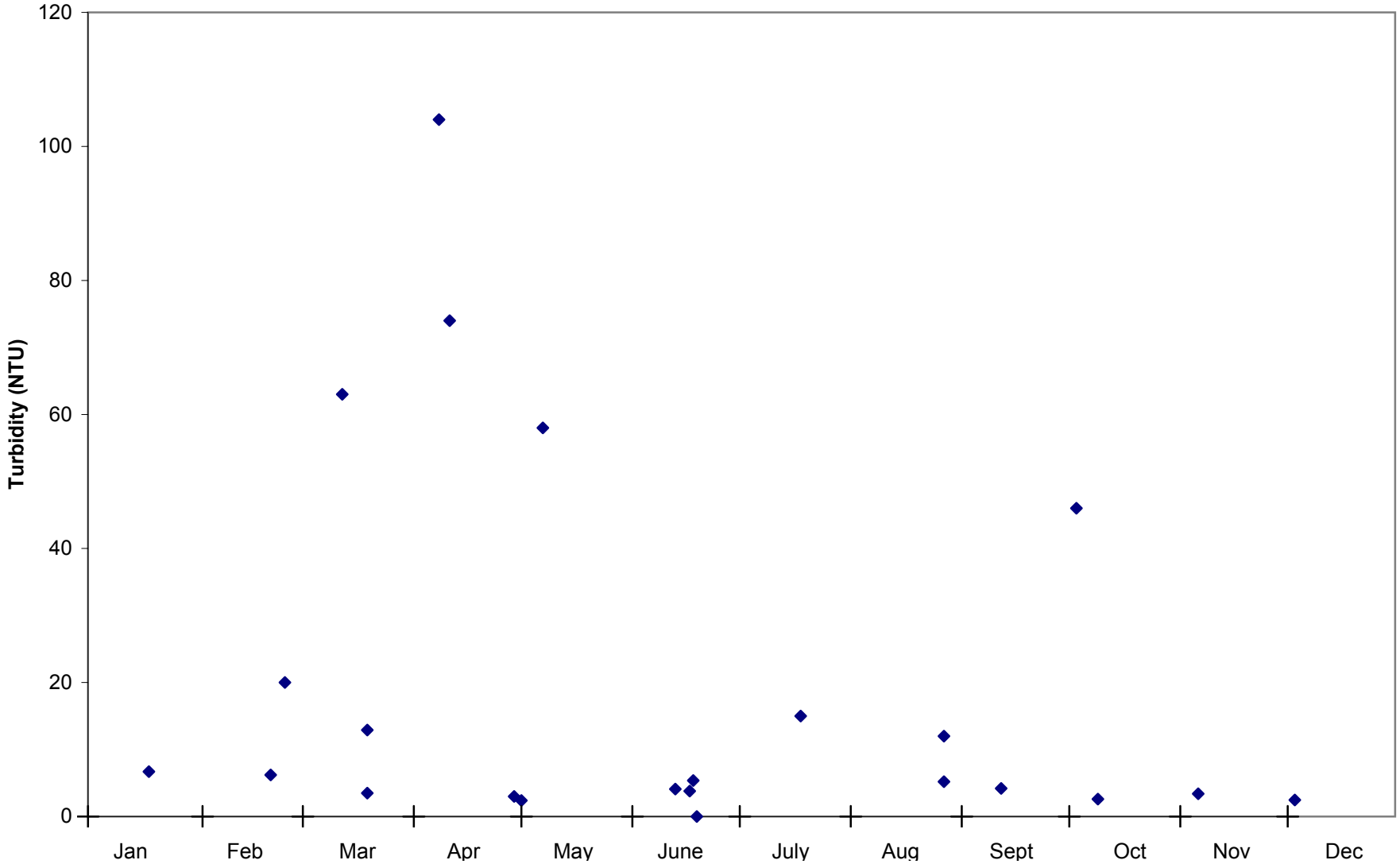


Figure C.3. Observed Seasonal TSS on Strawberry River at Hwy 167 (SBR0002)

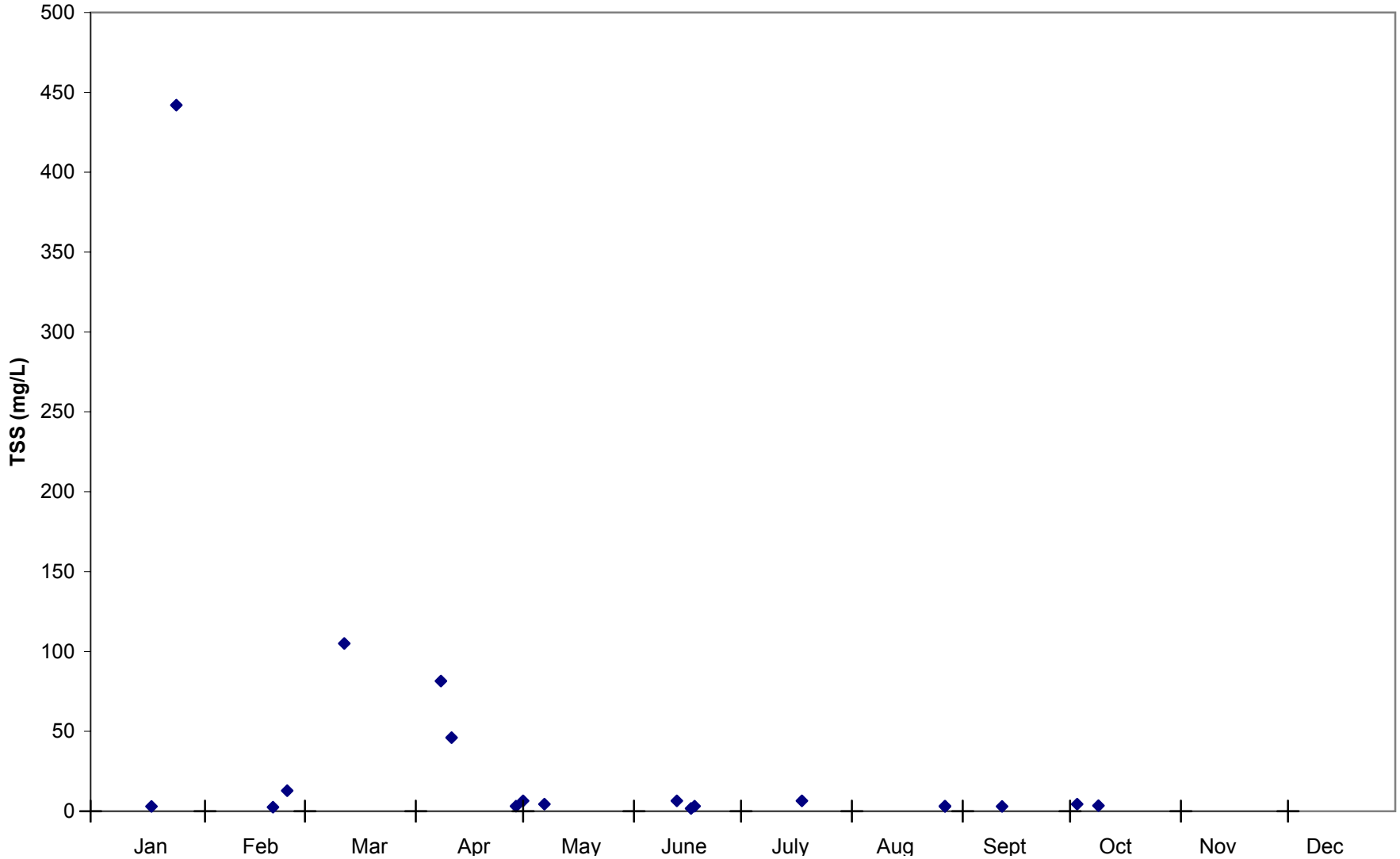


Figure C.4. Observed Seasonal Turbidity on Strawberry River at Hwy 167 (SBR0002)

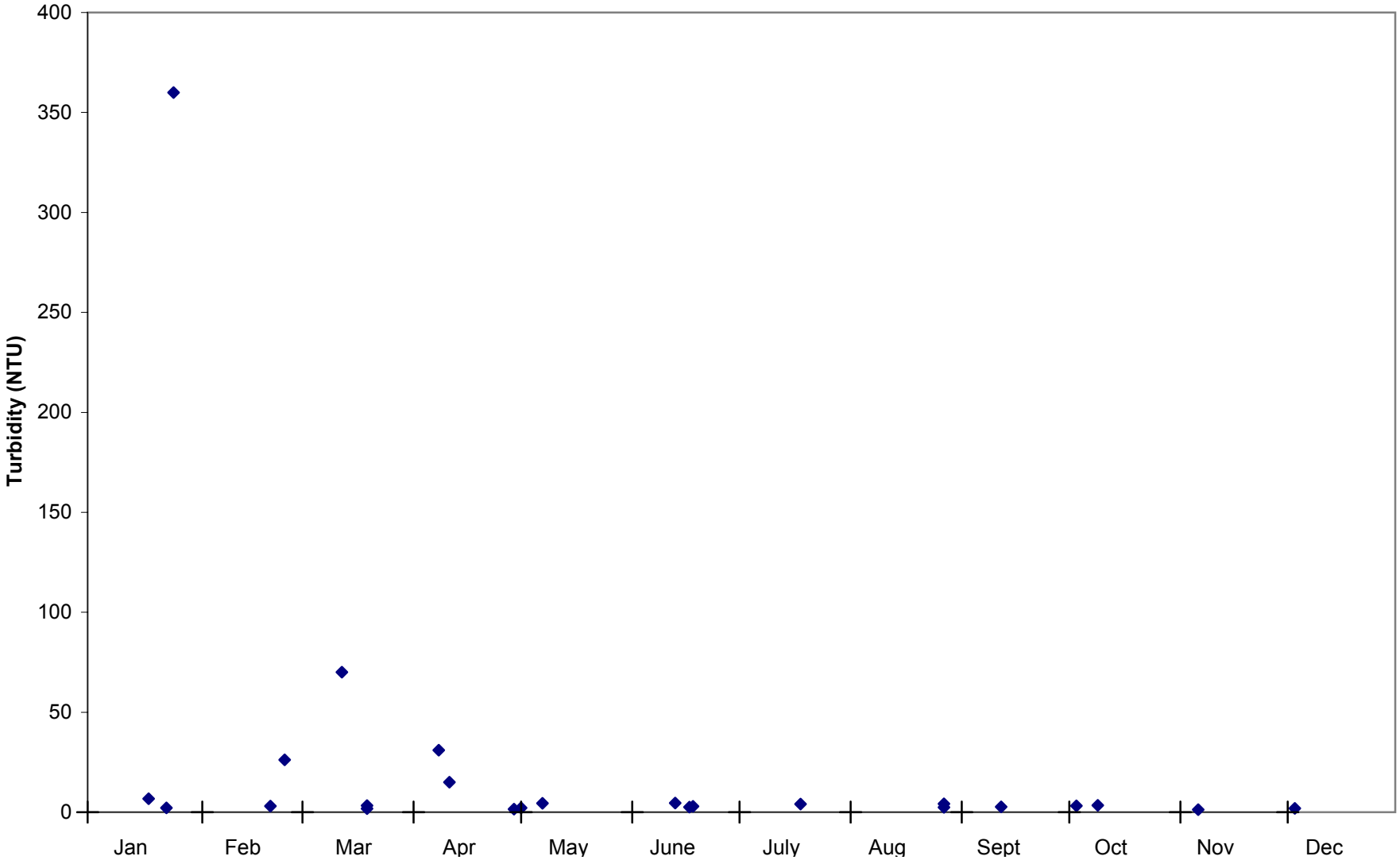


Figure C.5. Seasonal TSS for Strawberry River near Smithville, AR (WHI0024)

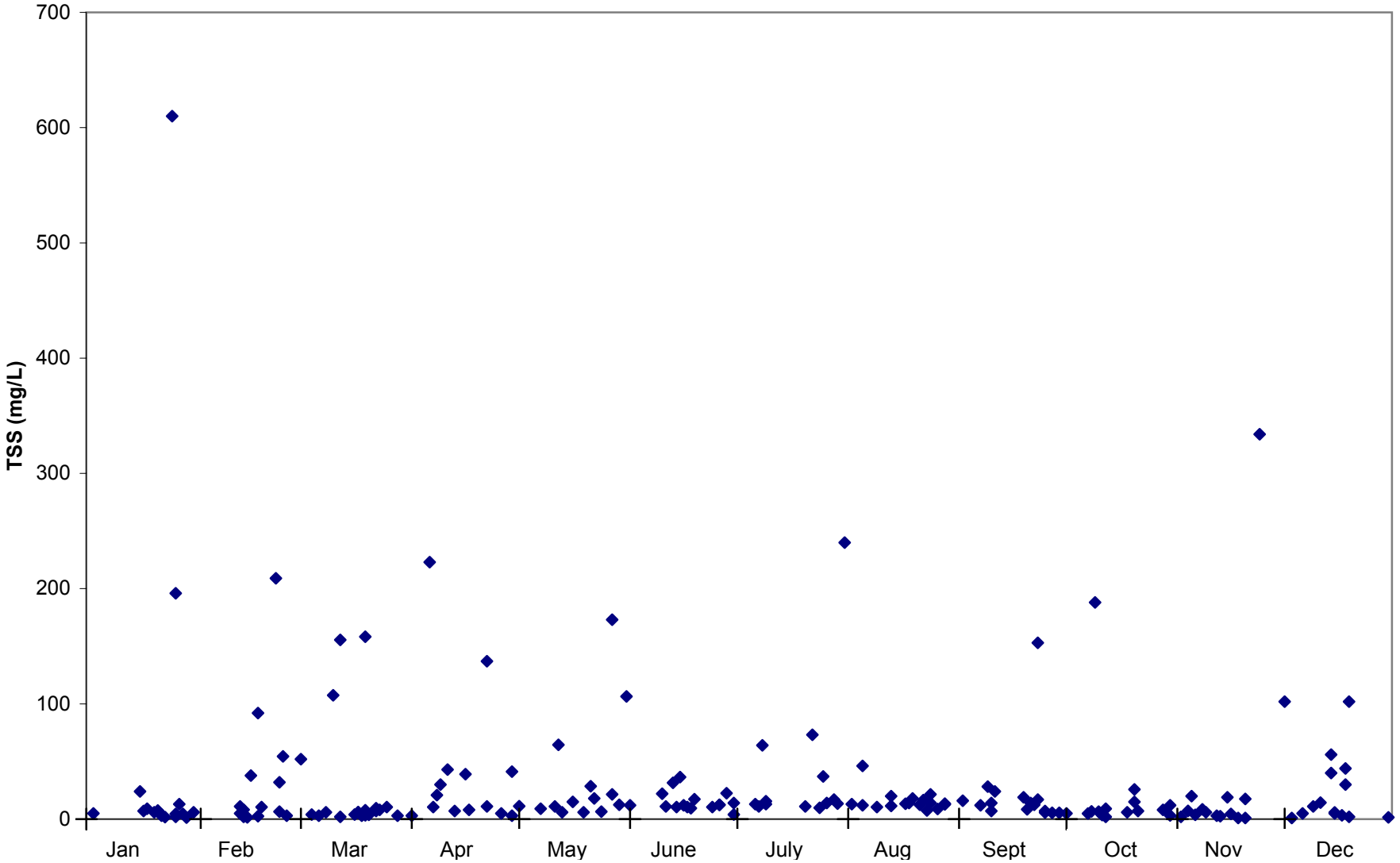


Figure C.6. Seasonal Turbidity for Strawberry River near Smithville, AR (WHI0024)

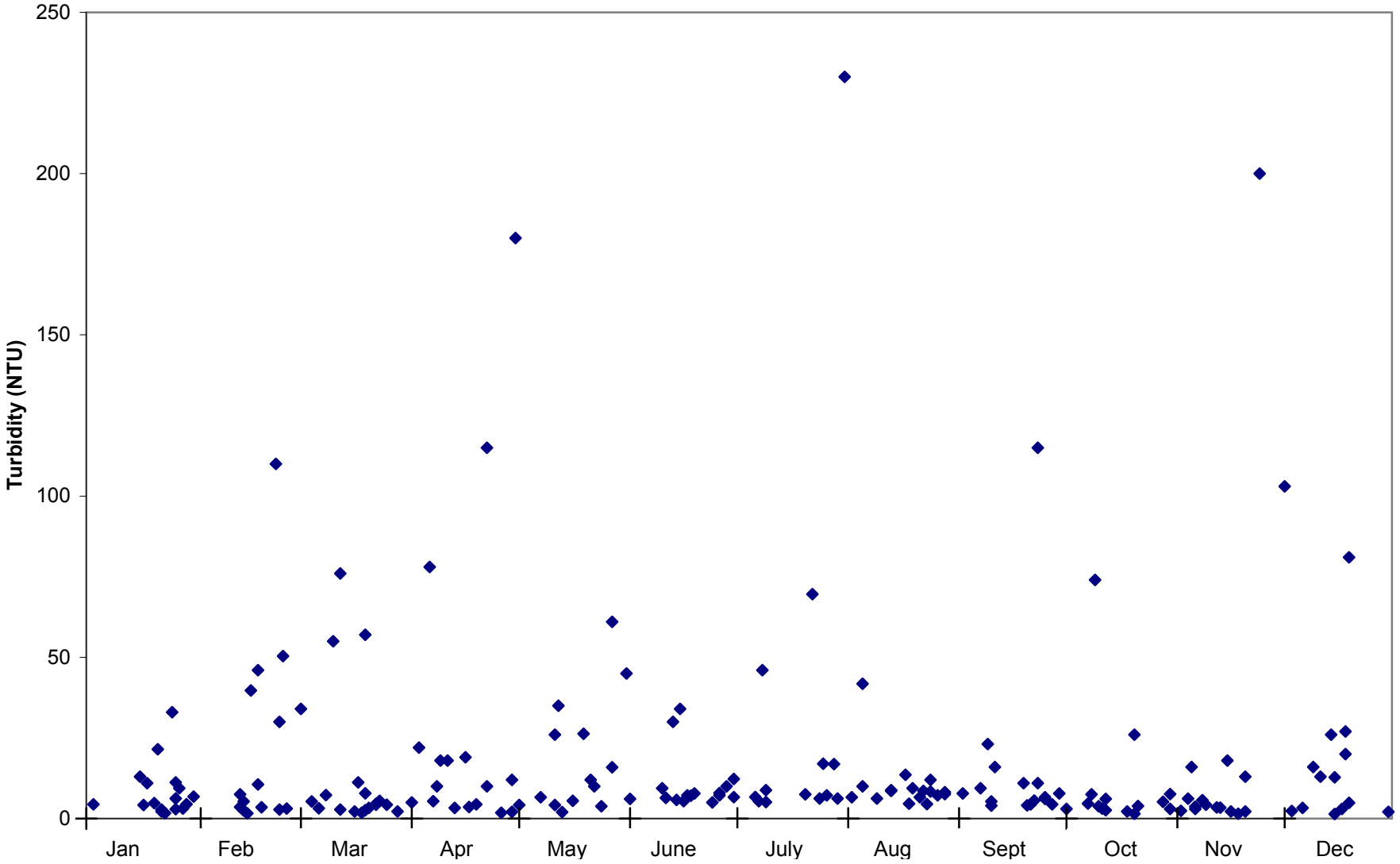


Figure C.7. Seasonal TSS for Strawberry River (WHI143h)

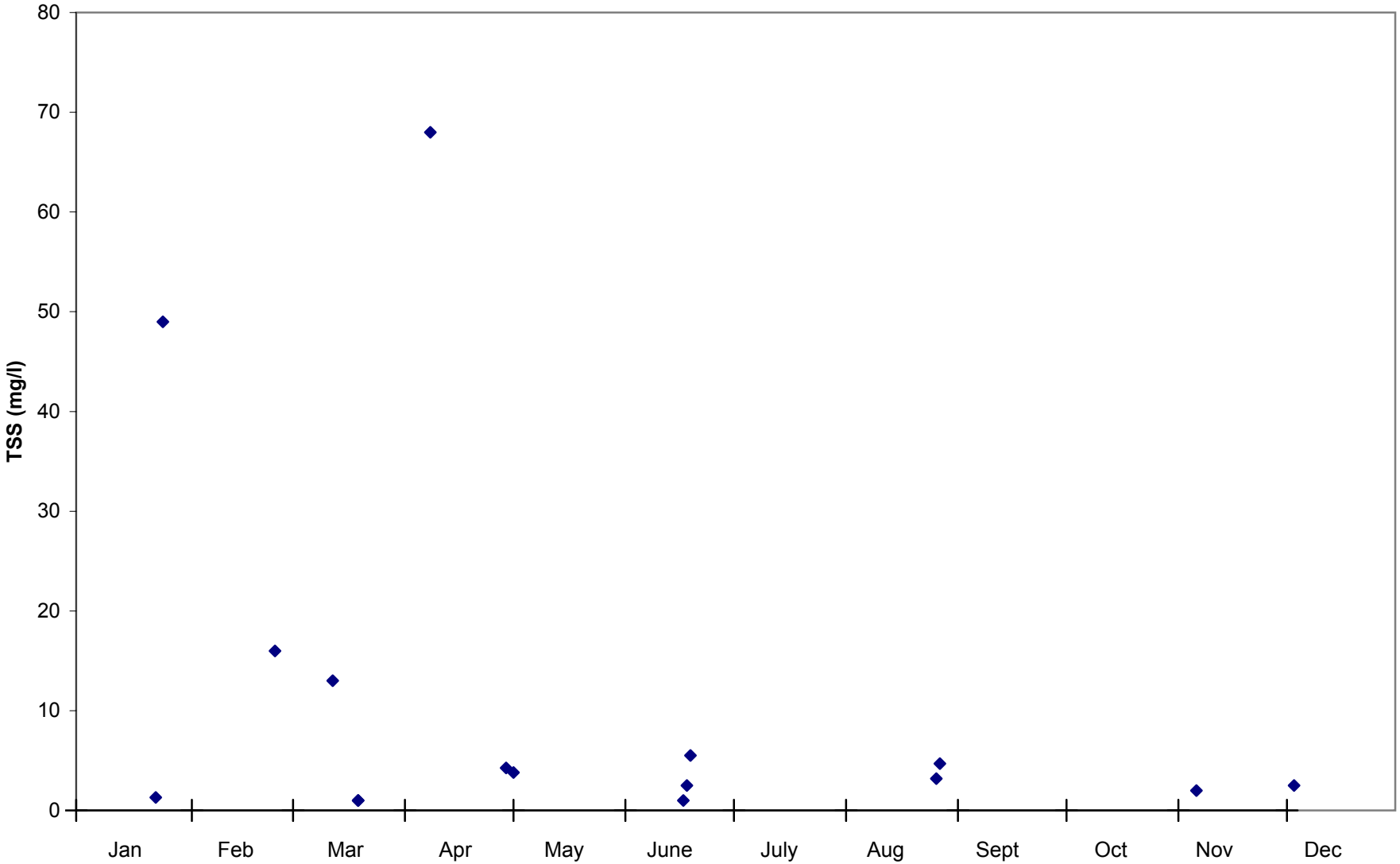
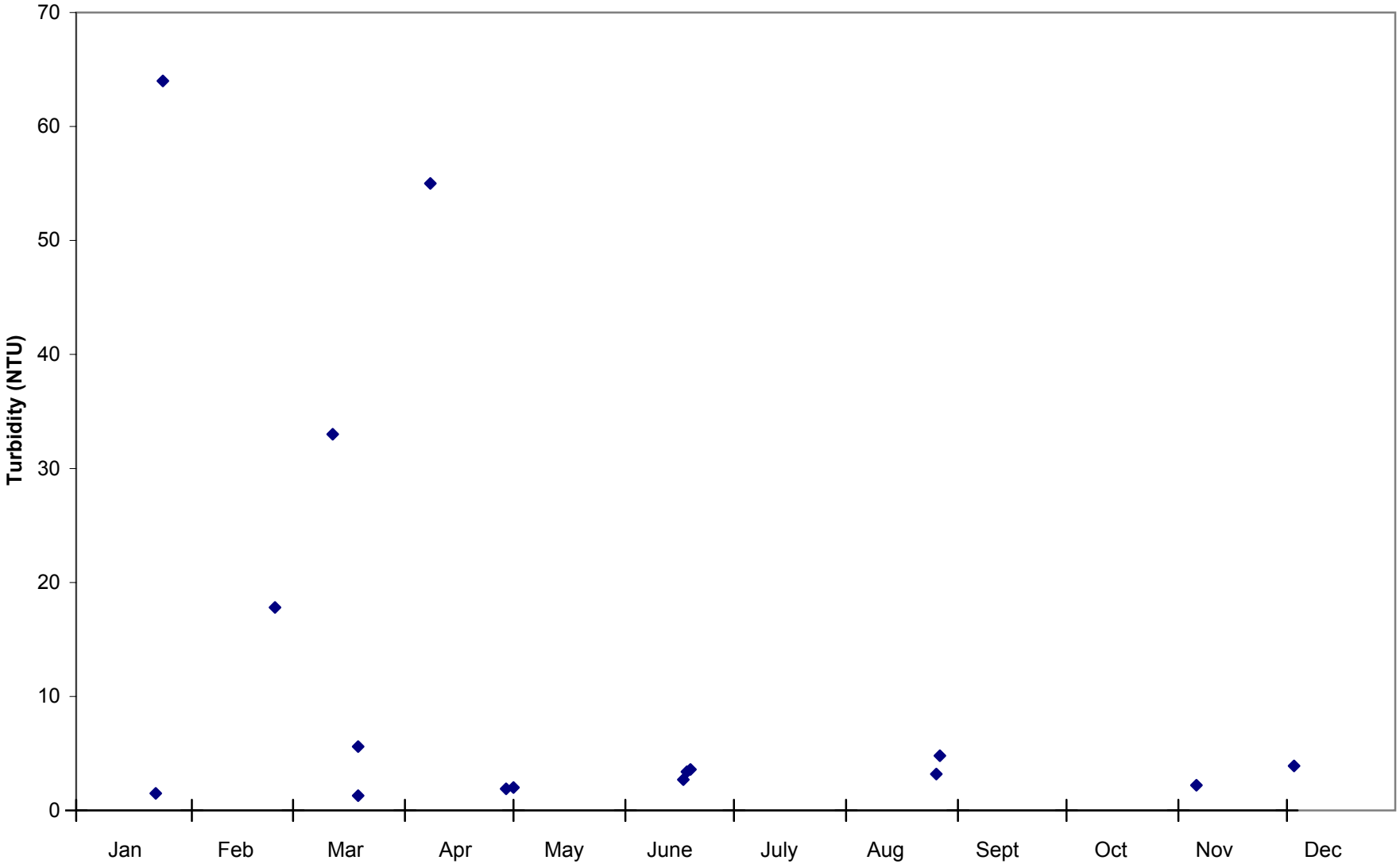


Figure C.8. Seasonal Turbidity for Strawberry River (WHI143h)



APPENDIX D

Plots of Turbidity and TSS vs Flow

Figure D.1. TSS vs flow for Strawberry River near Wiseman, AR (SBR0001)

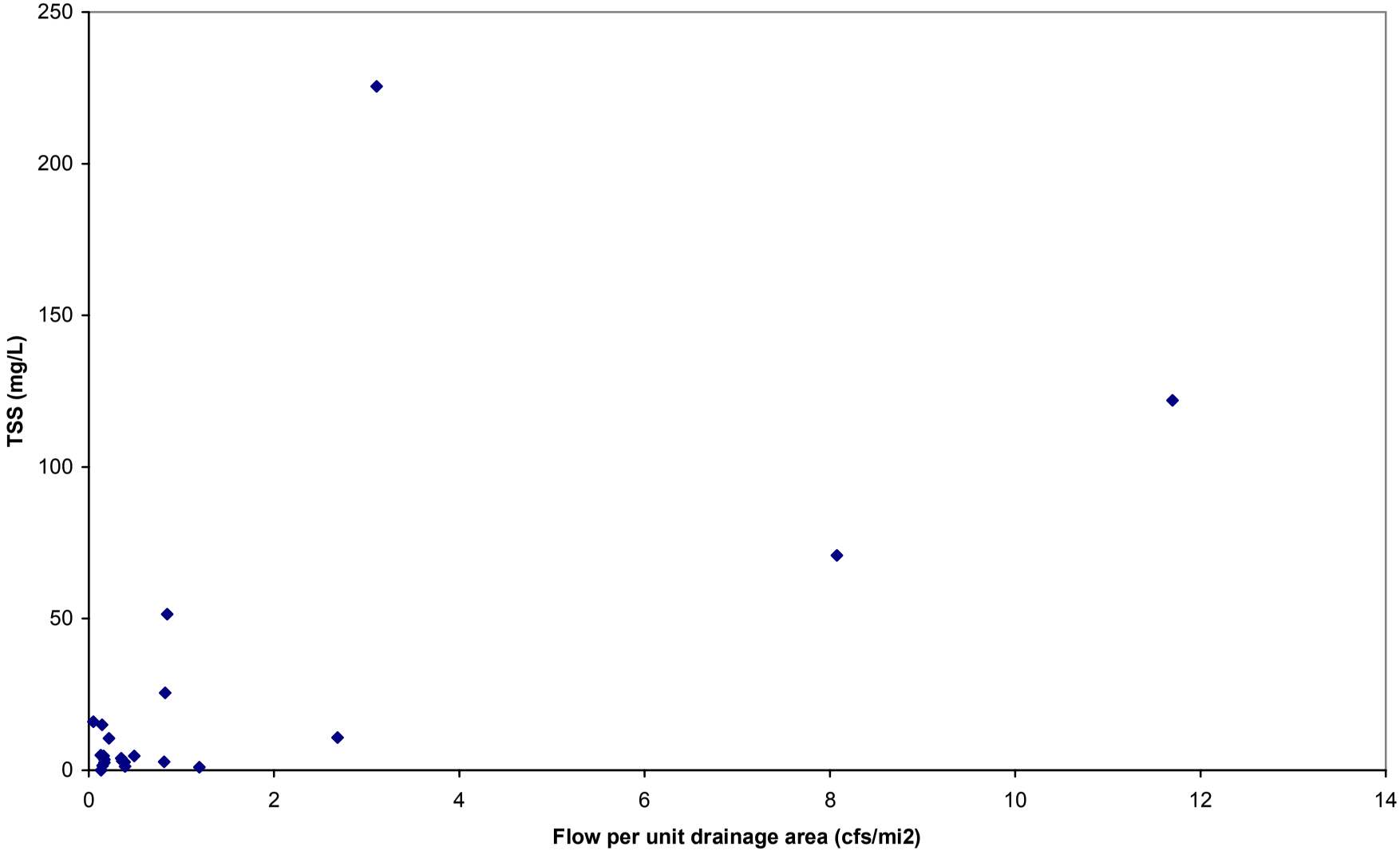


Figure D.2. Turbidity vs flow for Strawberry River near Wiseman, AR (SBR0001)

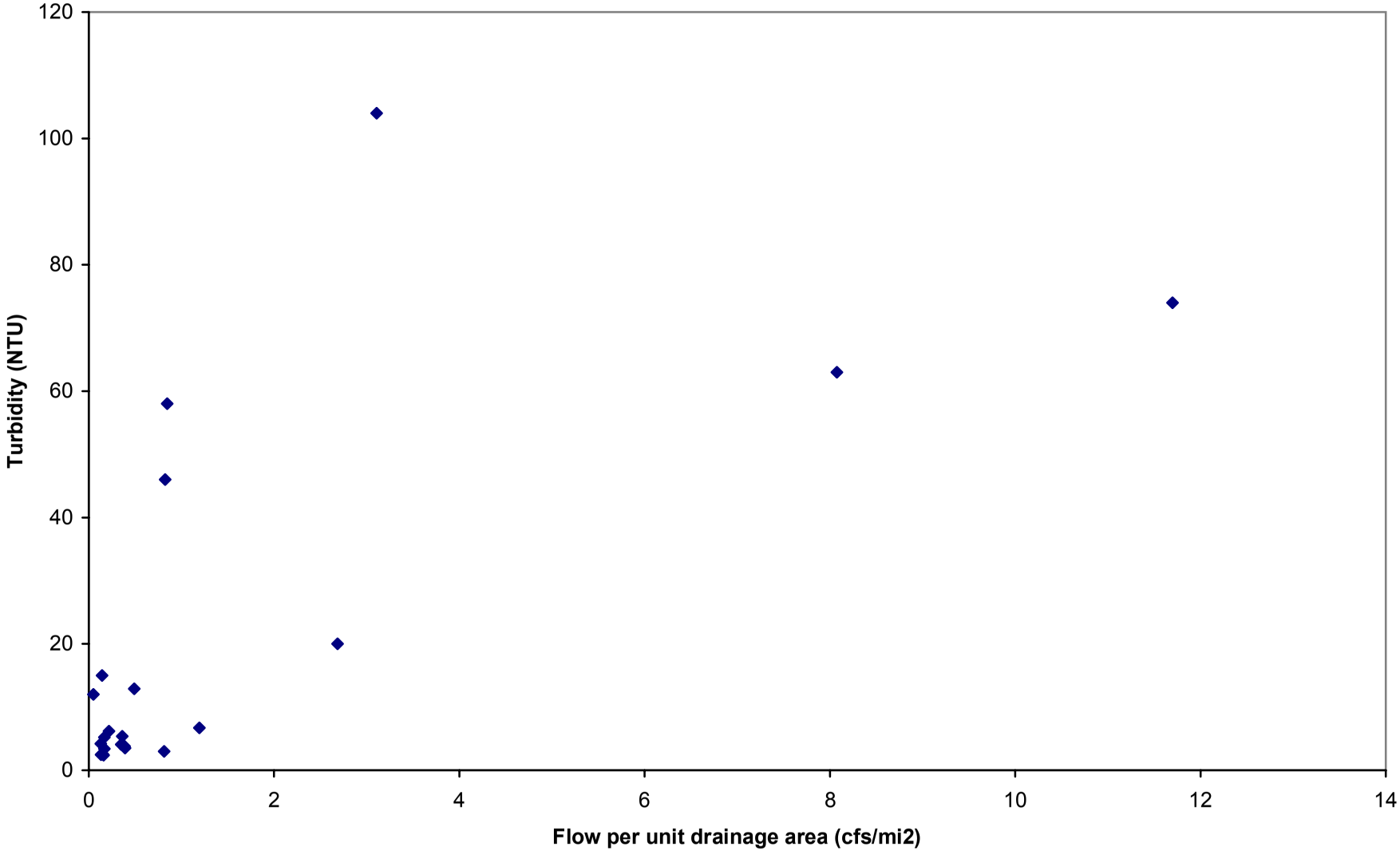


Figure D.3. Turbidity vs flow for Strawberry River at Hwy 187 (SBR0002)

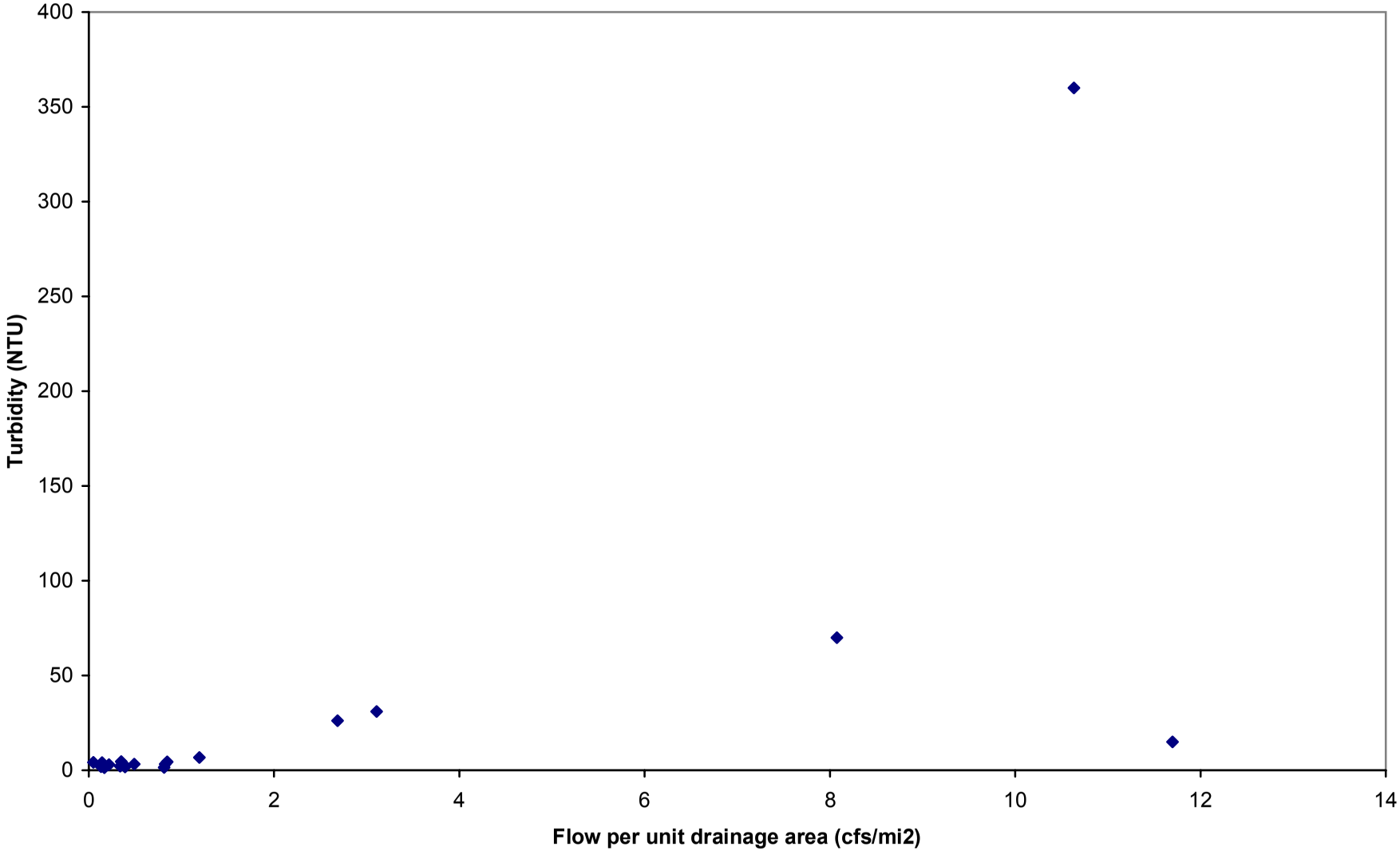


Figure D.4. TSS vs flow for Strawberry River at Hwy 187 (SBR0002)

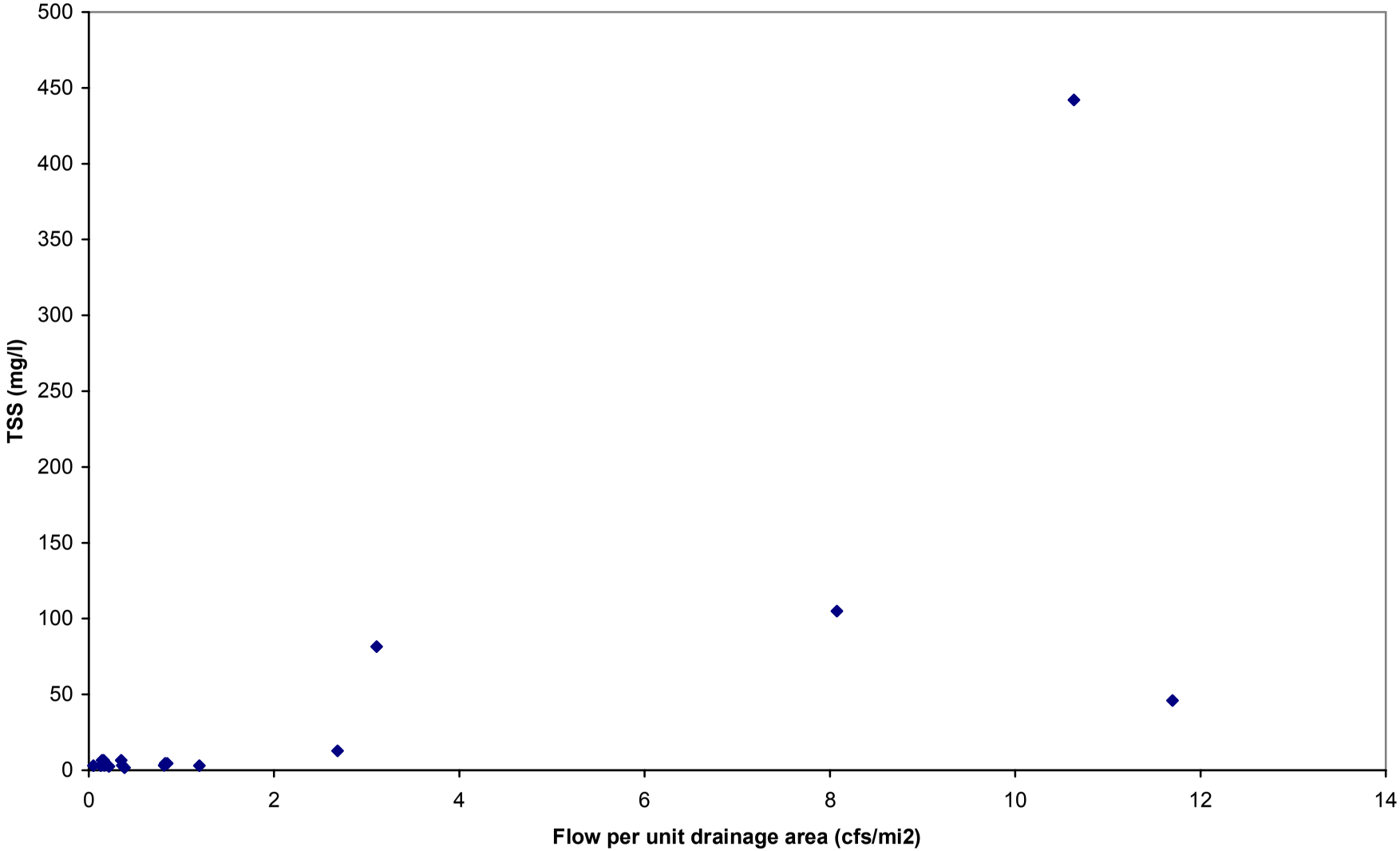


Figure D.5. TSS vs flow for Strawberry River near Smithville, AR (WHI0024)

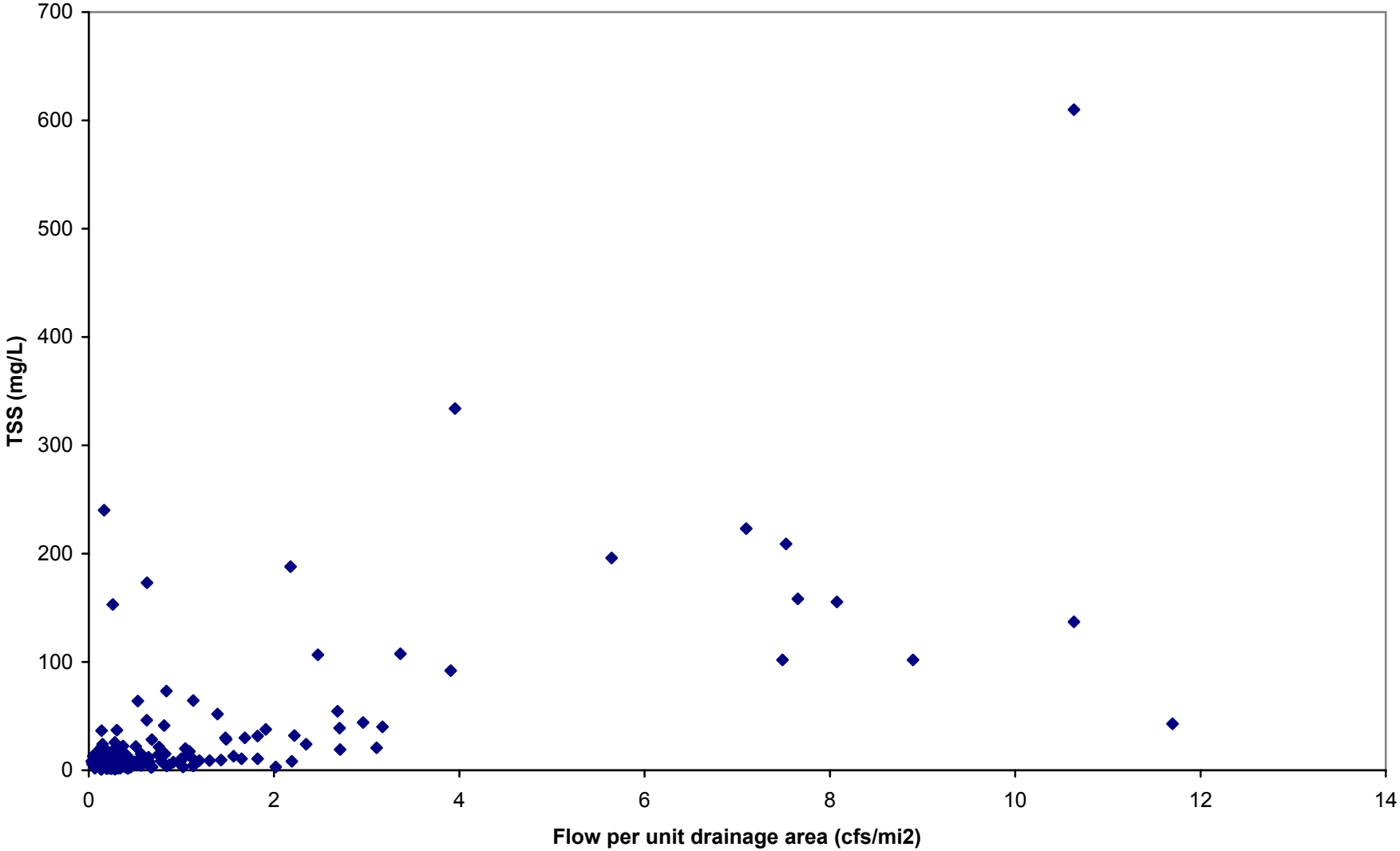


Figure D.6. Turbidity vs flow for Strawberry River near SMithville, AR (WHI0024)

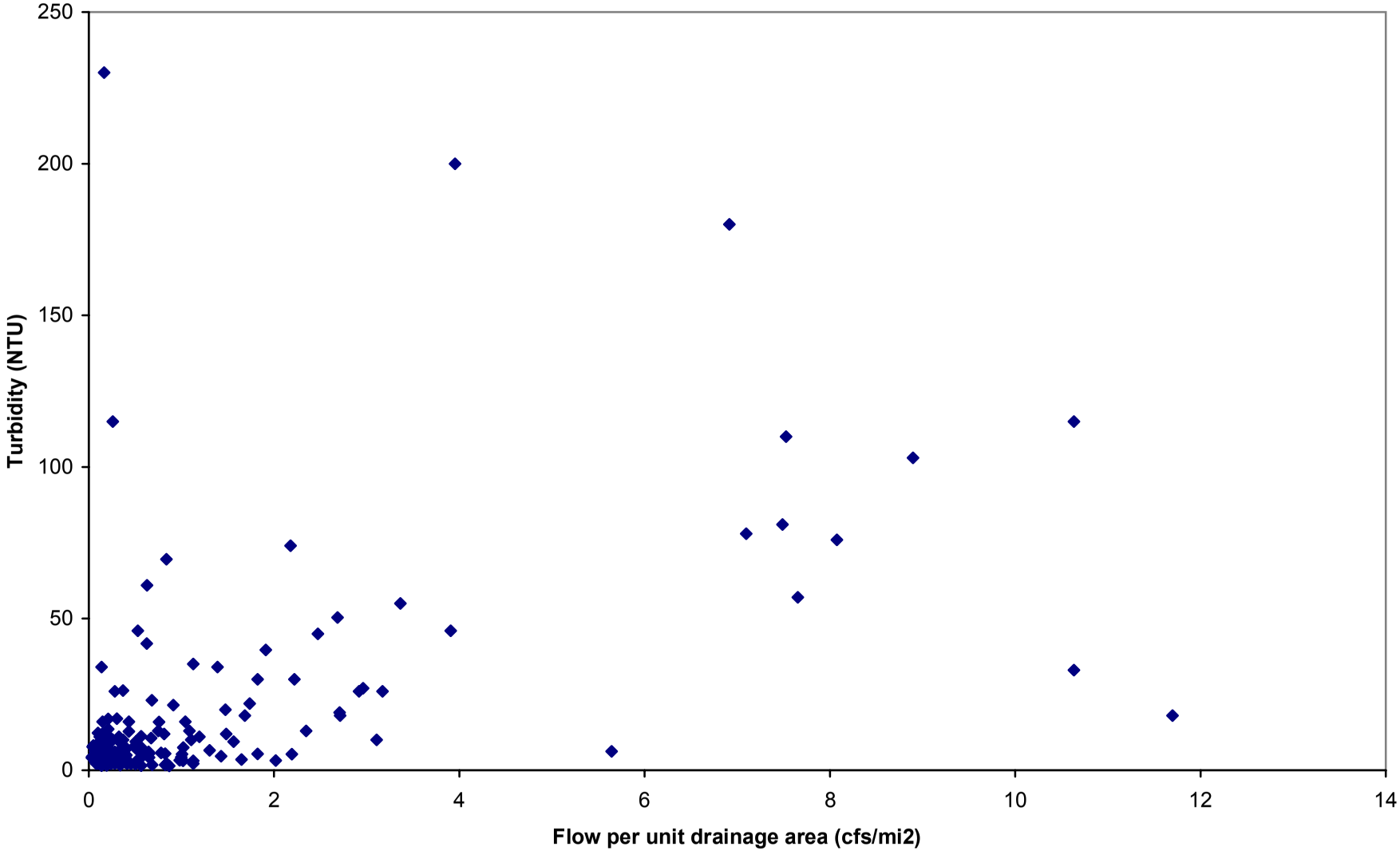


Figure D.7. TSS vs flow for Strawberry River (WHI143h)

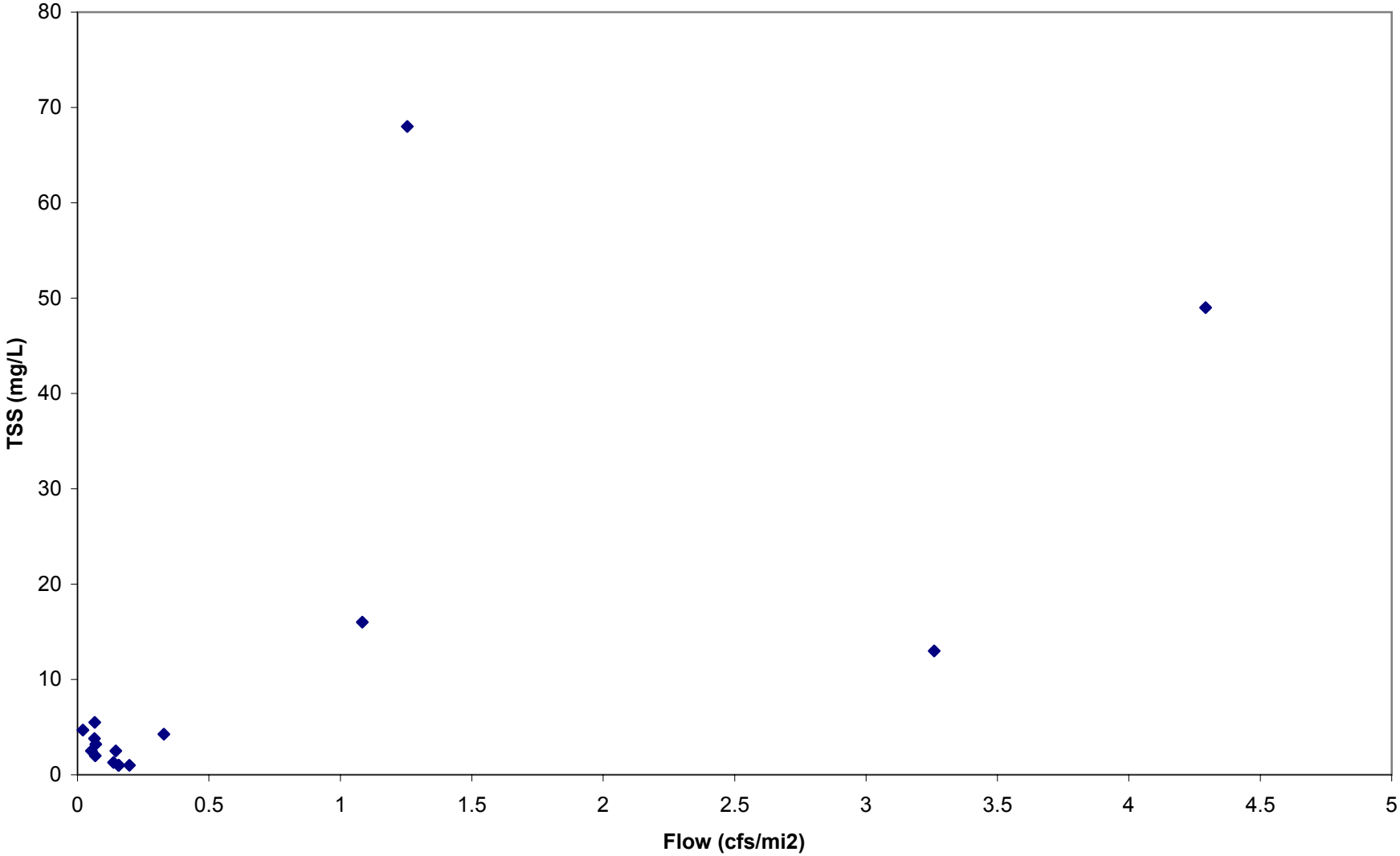
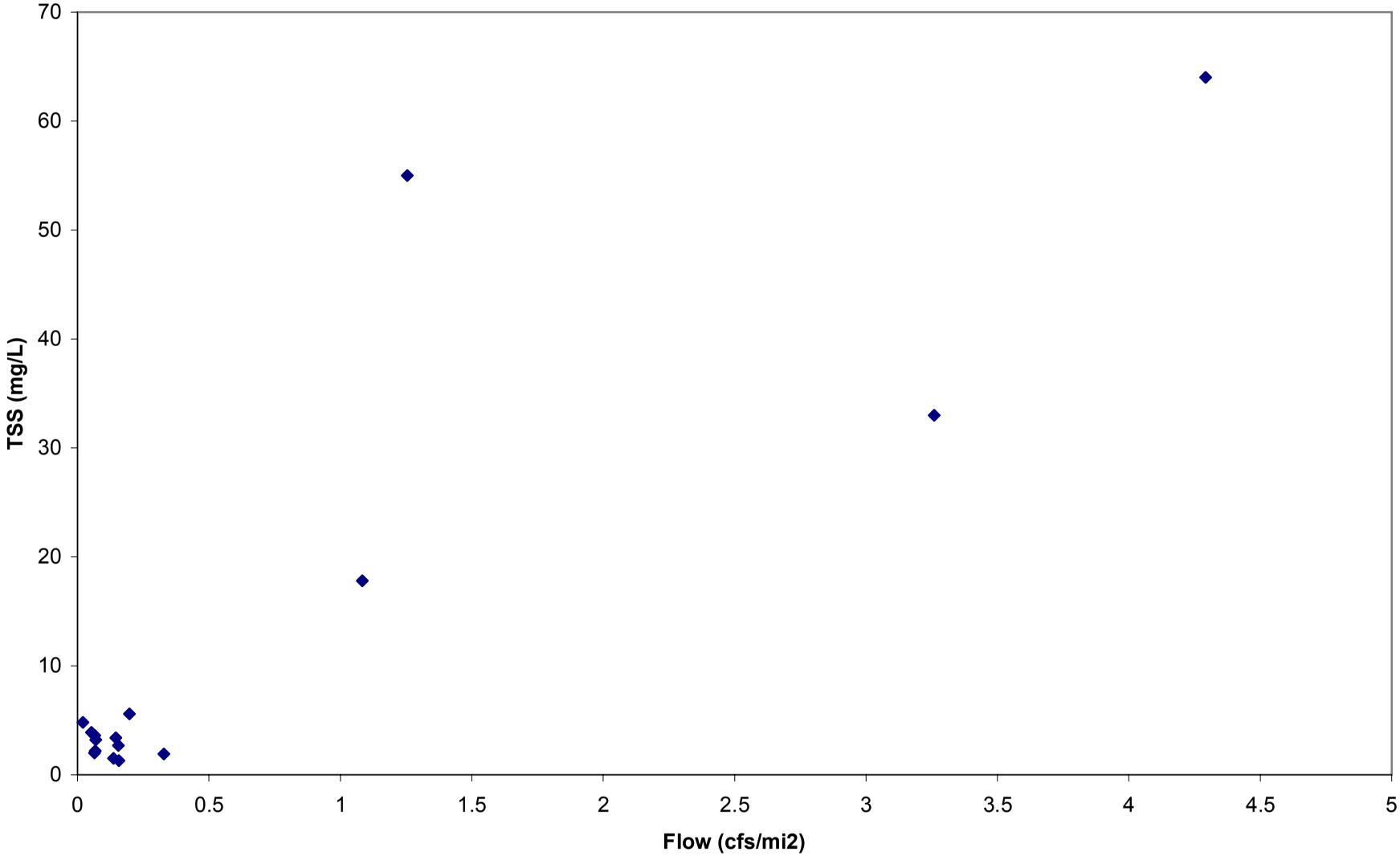


Figure D.8. Turb vs flow for Strawberry River (WHI143h)



APPENDIX E

Plots of TSS vs Turbidity

Figure E.1. Base flow regression for TSS vs Turbidity for Strawberry River near Wiseman, AR (SBR0001)

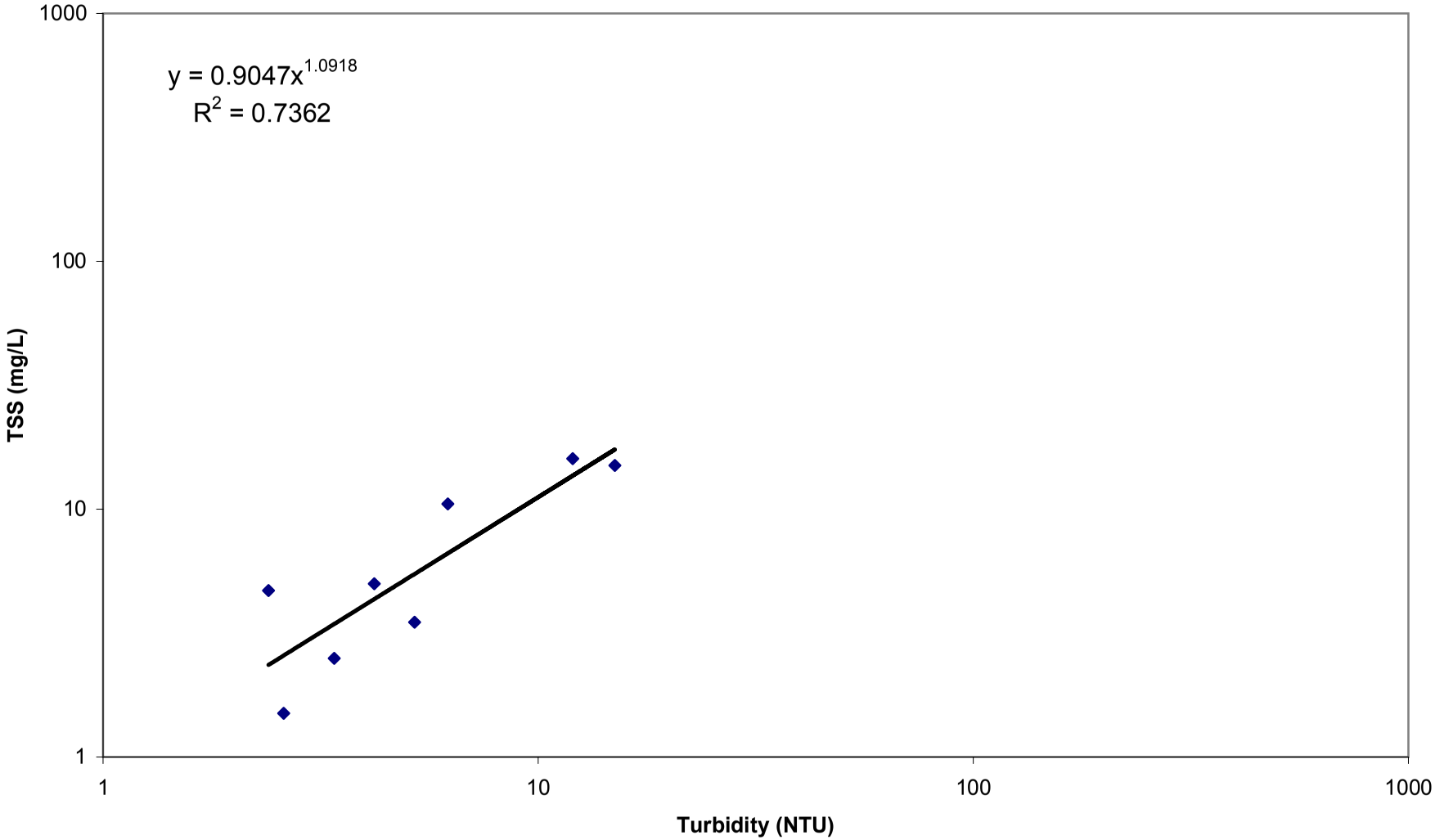


Figure E.2. Storm flow regression for TSS vs Turbidity for Strawberry River near Wiseman, AR (SBR0001)

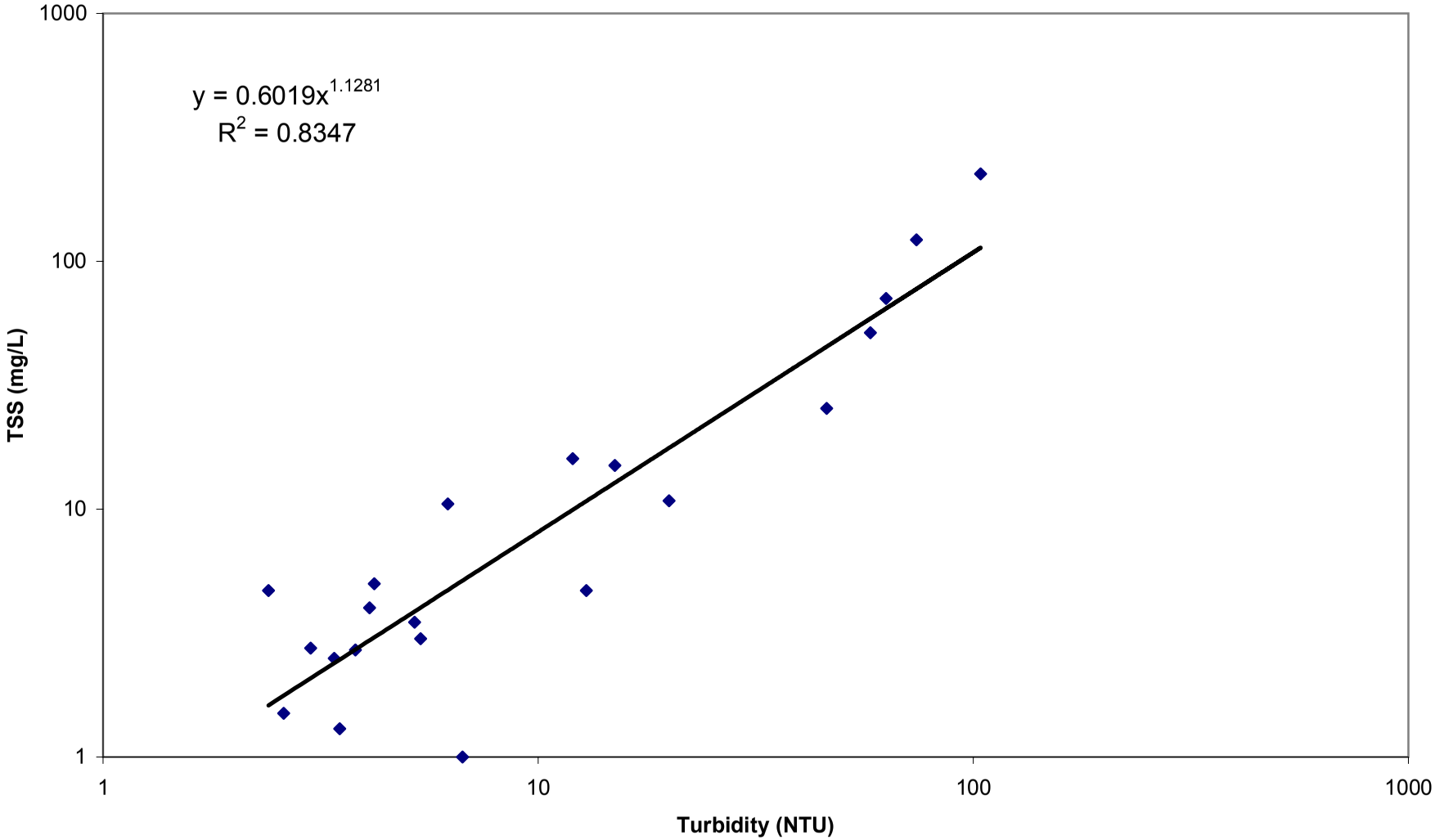


Figure E.3. Base flow regresssion for TSS vs Turbidity for Strawberry River at Hwy 187 (SBR0002)

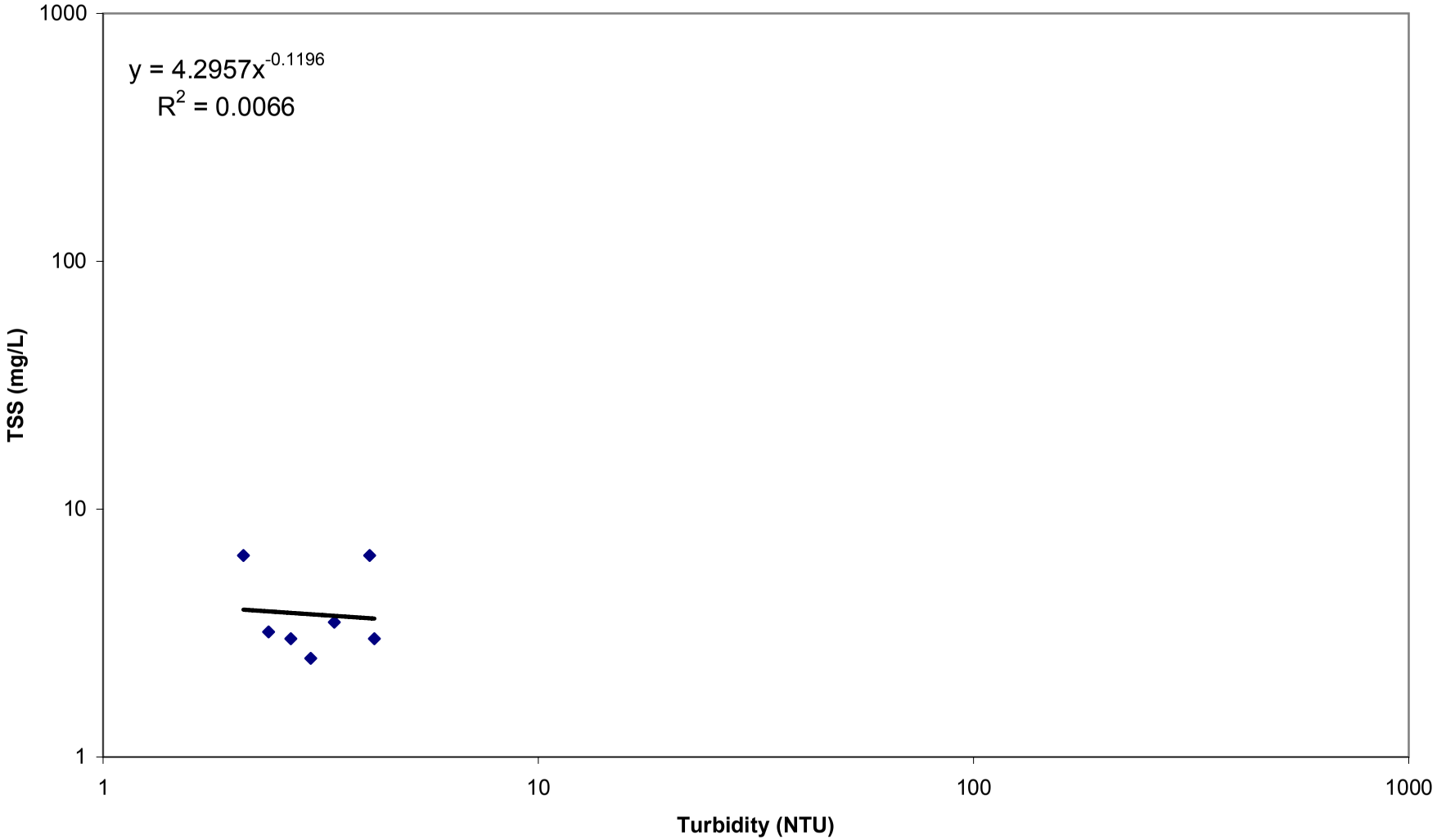


Figure E.4. Storm flow regression for TSS vs Turbidity for Strawberry River at Hwy 187 (SBR0002)

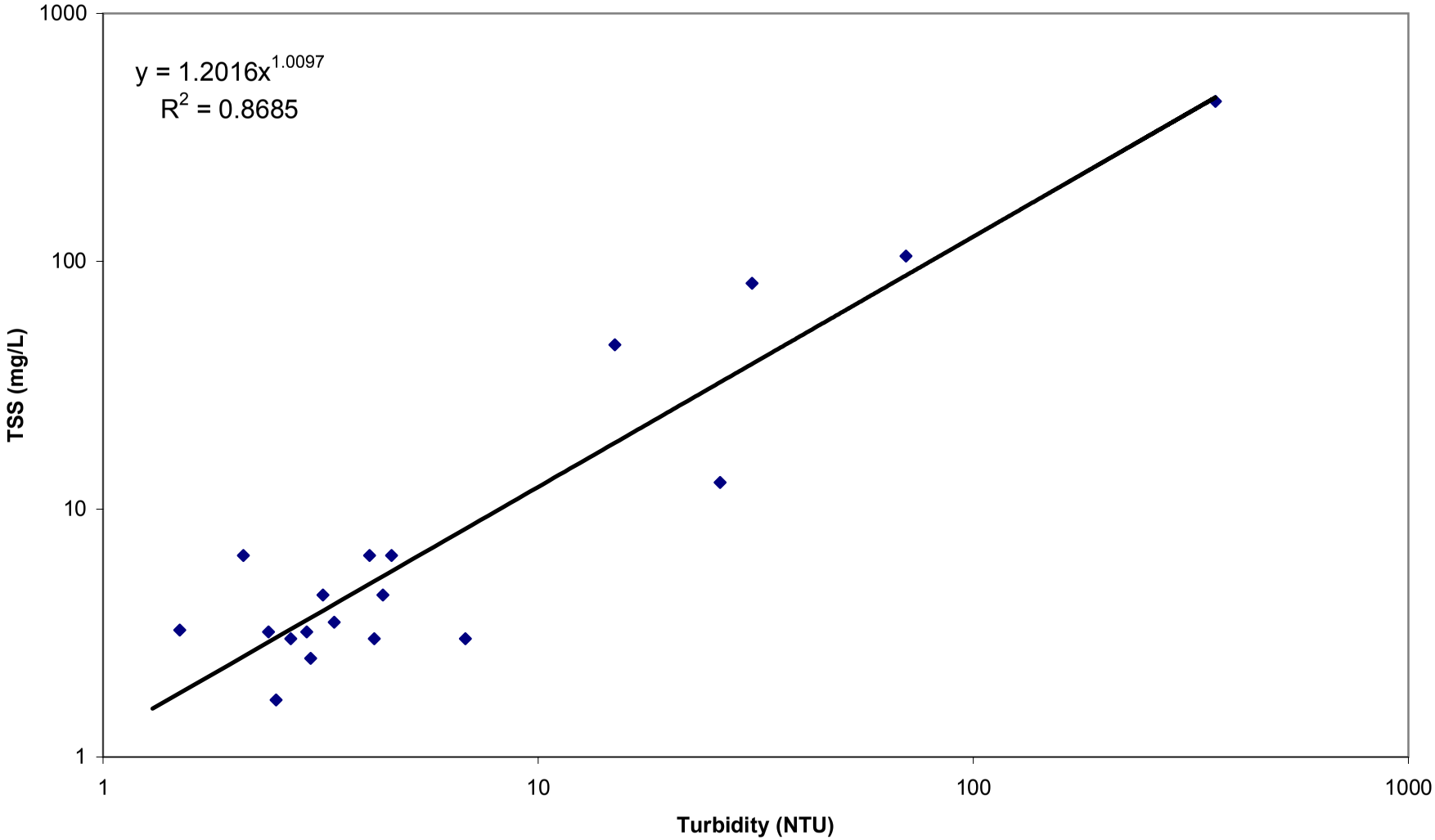


Figure E.5. Base flow Regression for TSS vs Turbidity for Strawberry River near Smithville, AR (WHI0024)

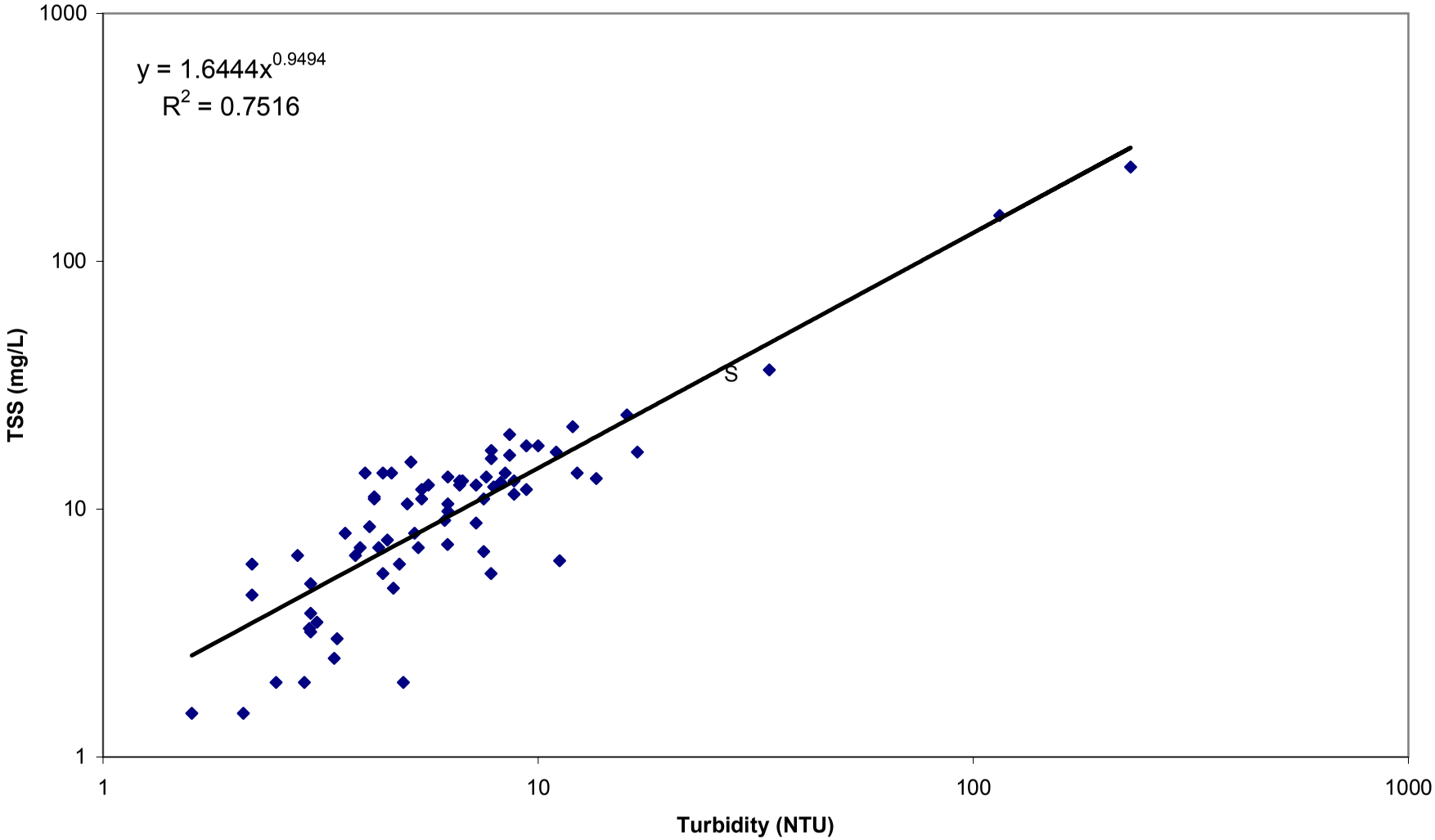


Figure E.6. Storm flow Regression for TSS vs Turbidity for Strawberry River near Smithville, AR (WHI0024)

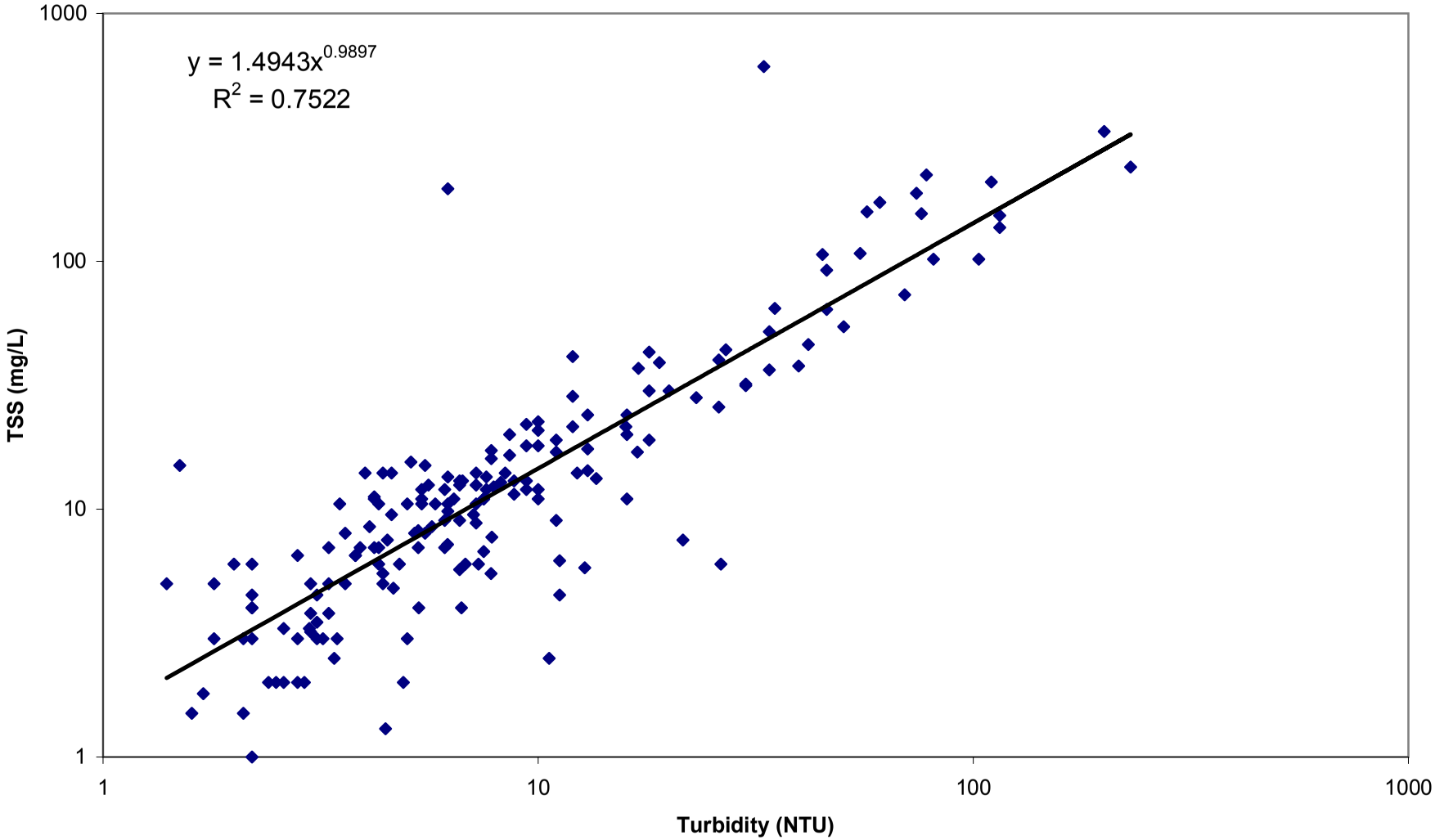


Figure E.7. Base flow Regression of TSS vs Turbidity for Strawberry River (WHI143h)

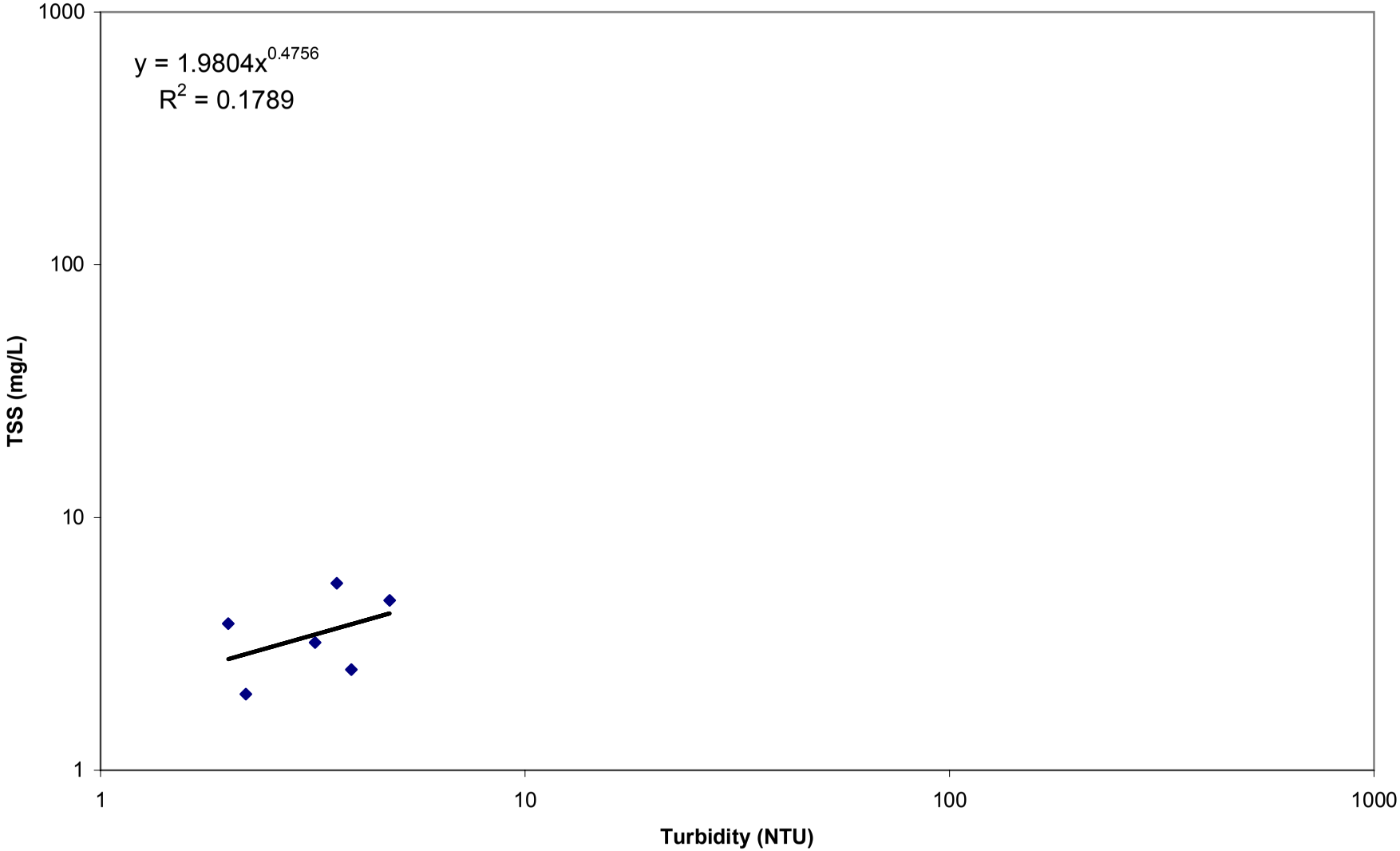


Figure E.8. Storm flow Regression of TSS vs Turbidity for Strawberry River (WHI143h)

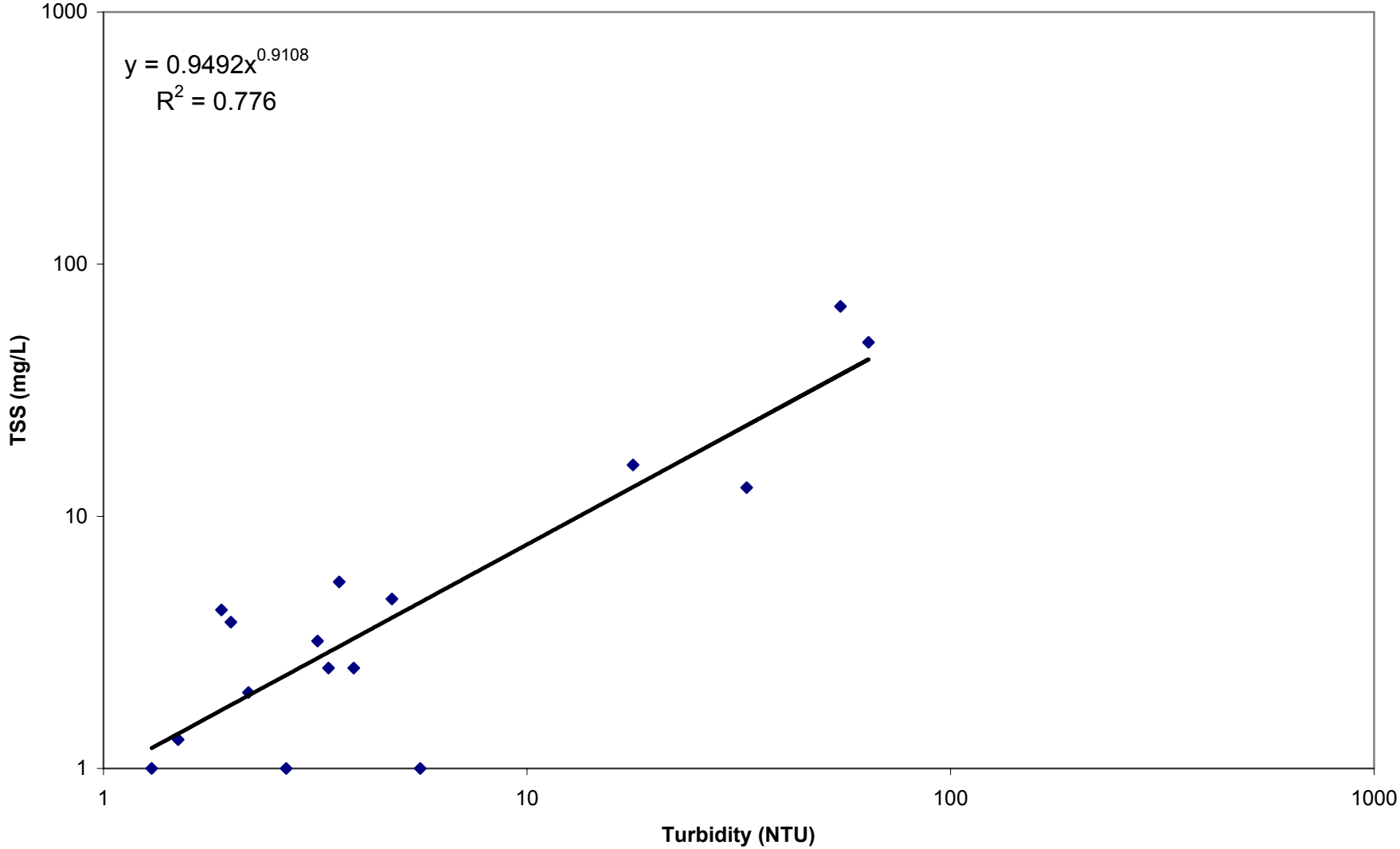


Figure E.9. Base-flow Regression for TSS versus Turbidity on the Strawberry River

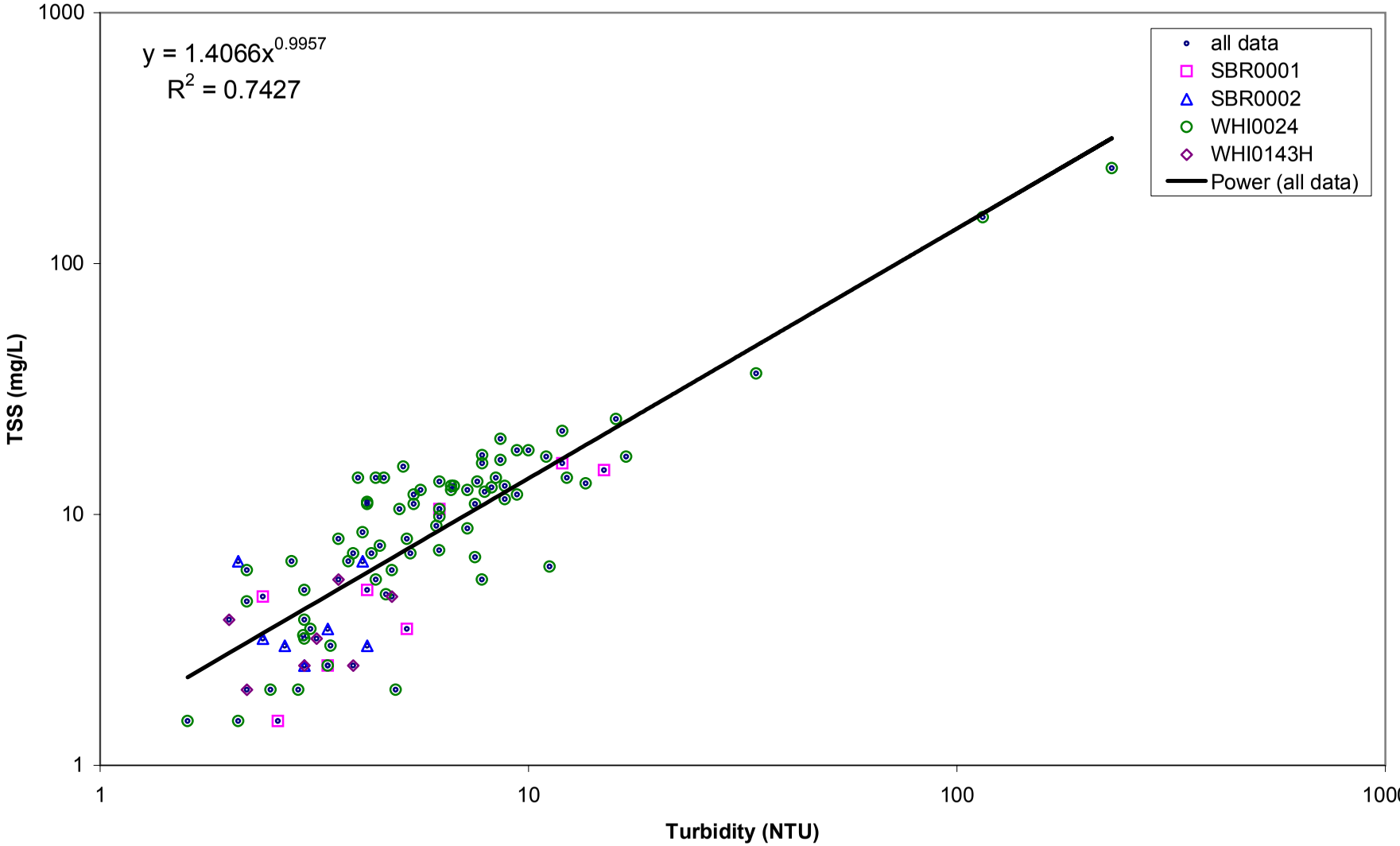
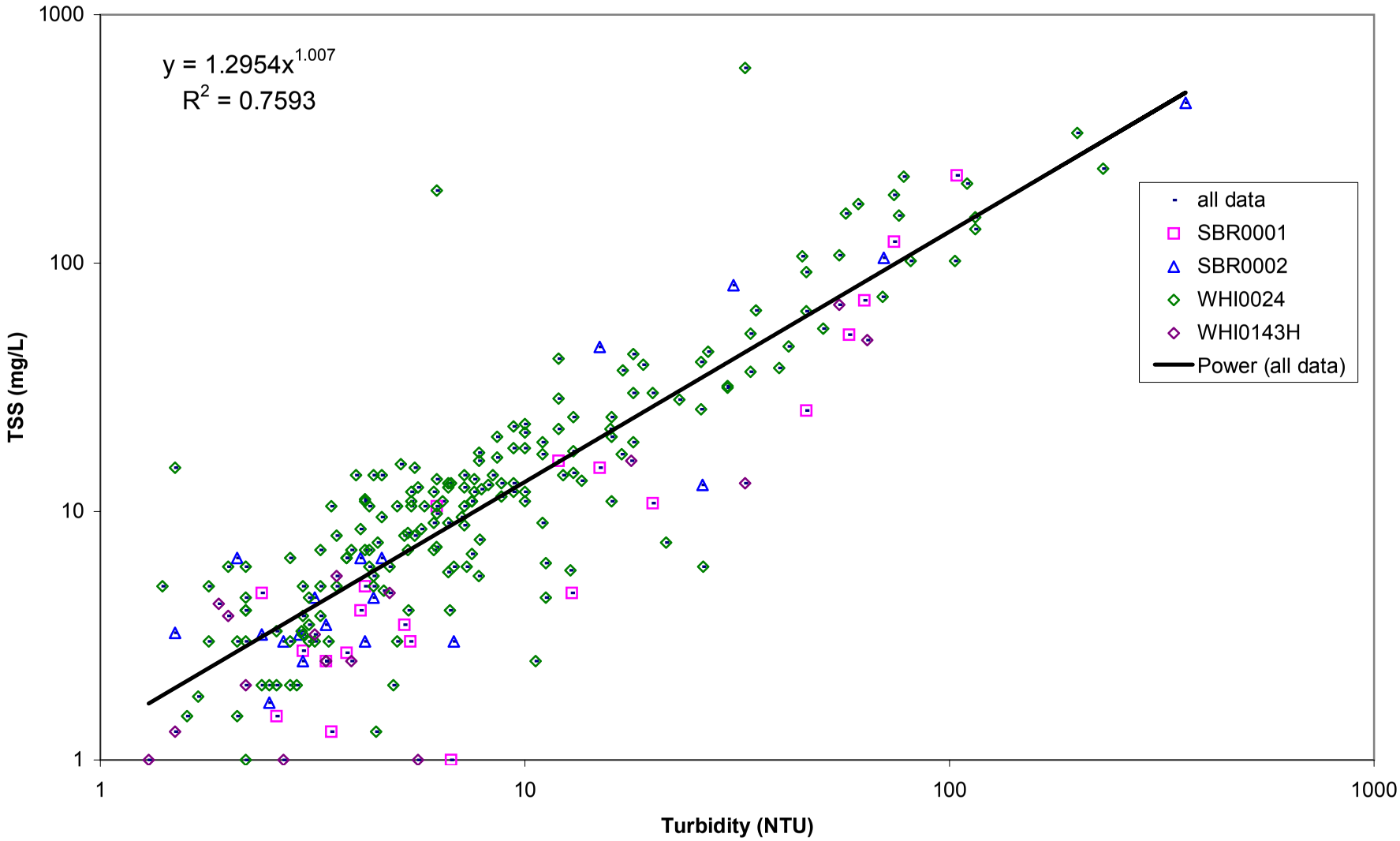


Figure E.10. Storm-flow Regression for TSS versus Turbidity on the Strawberry River



APPENDIX F

Load Duration Curves and TMDL Calculations

Figure F.1. Flow Duration Curve For Strawberry River near Poughkeepsie, AR (USGS 07074000)

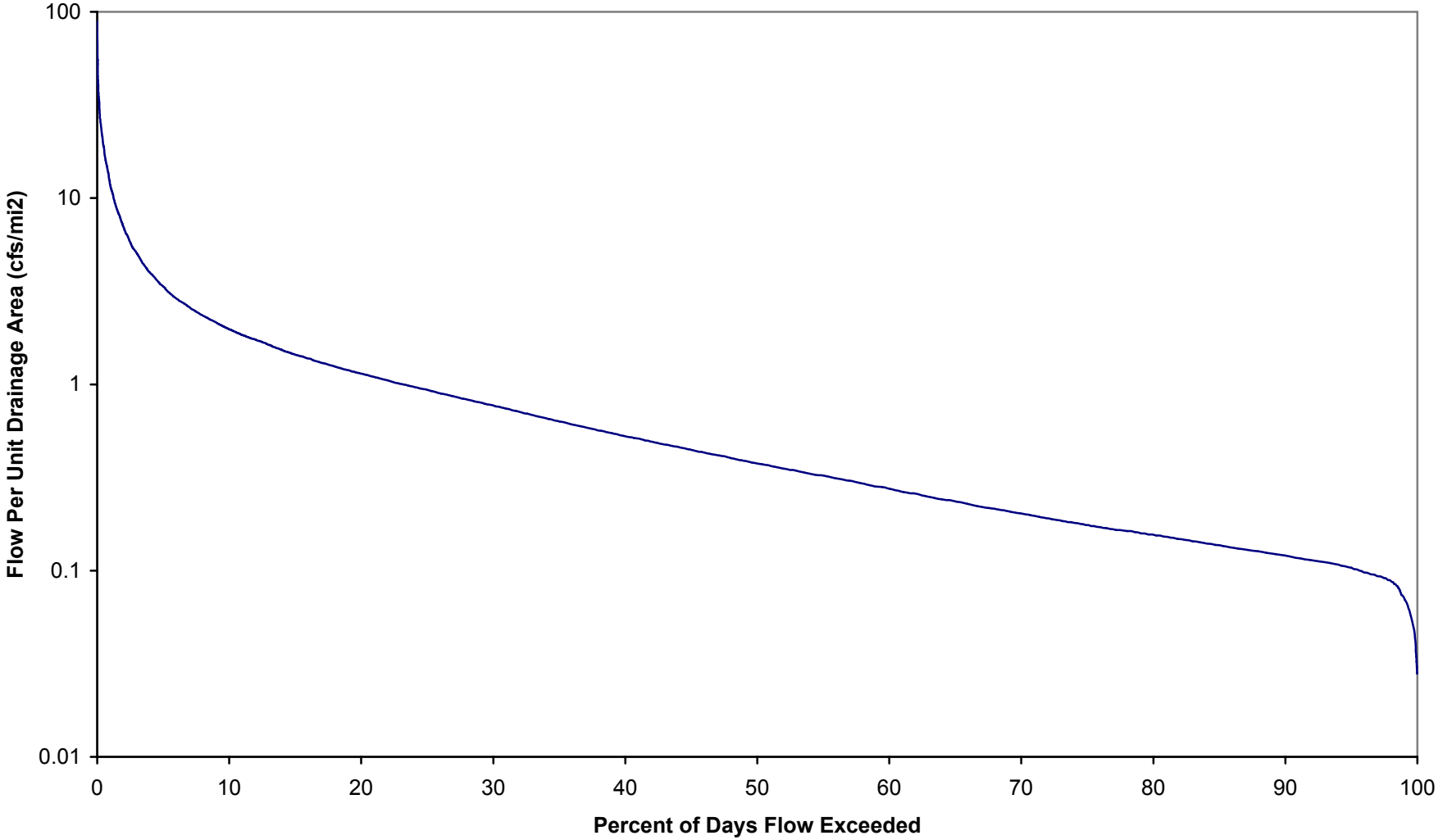


Figure F.2. Storm-Flow Load Duration Curve for Strawberry River at SBR0001

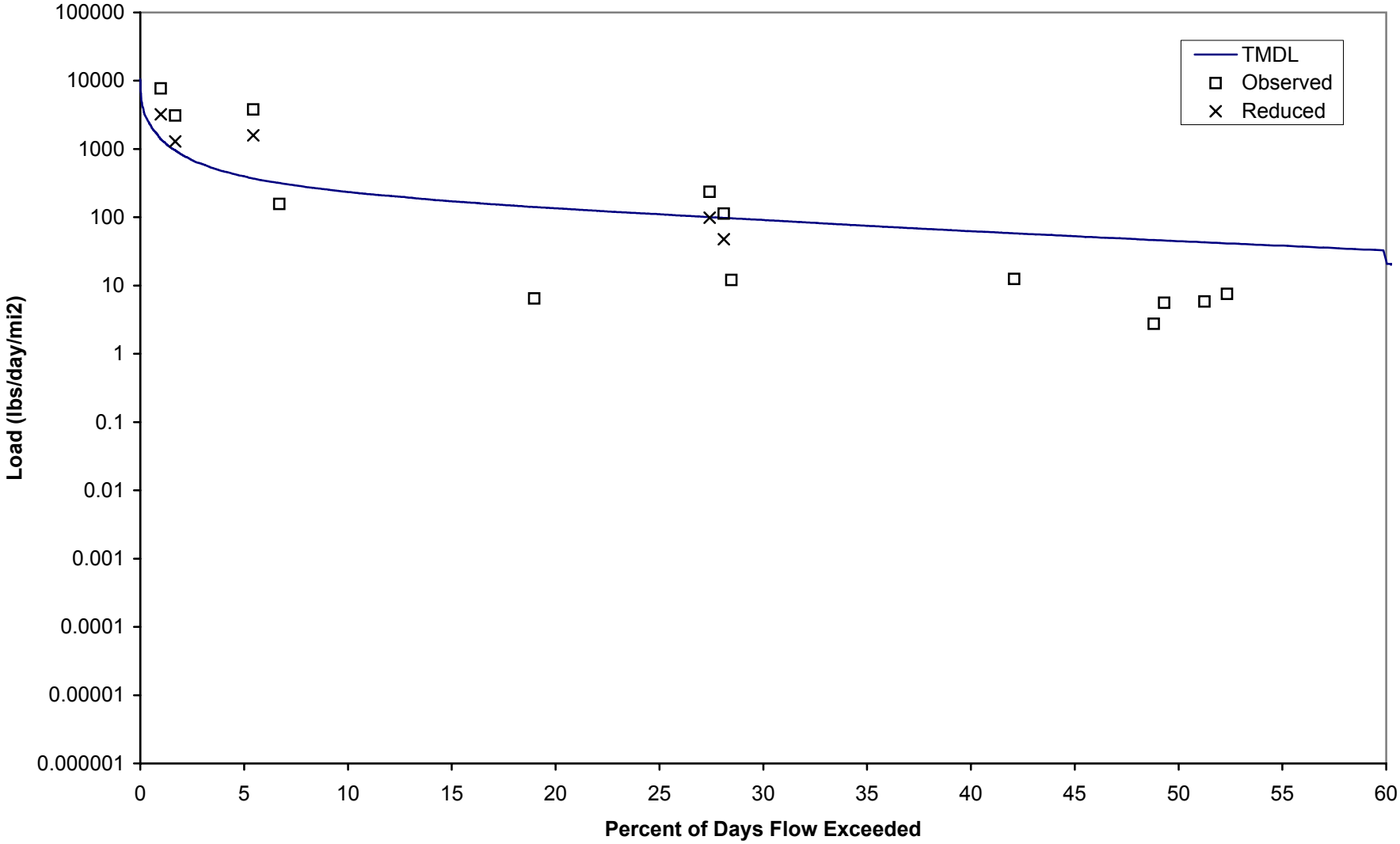


Figure F.3. Base Flow Load Duration Curve For Strawberry River at SBR0001

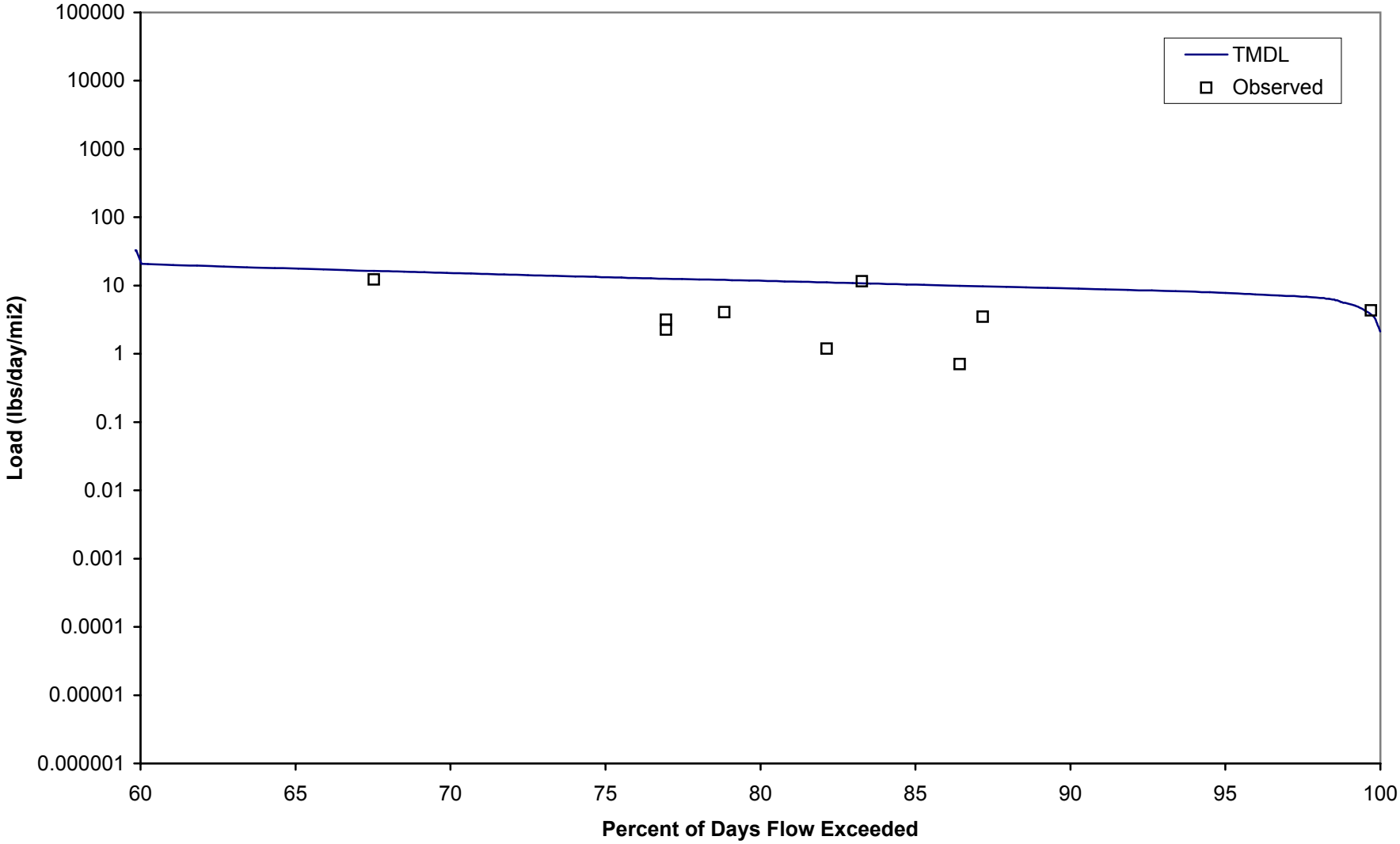


Figure F.4. Storm Flow Load Duration Curve for Strawberry River at SBR0002

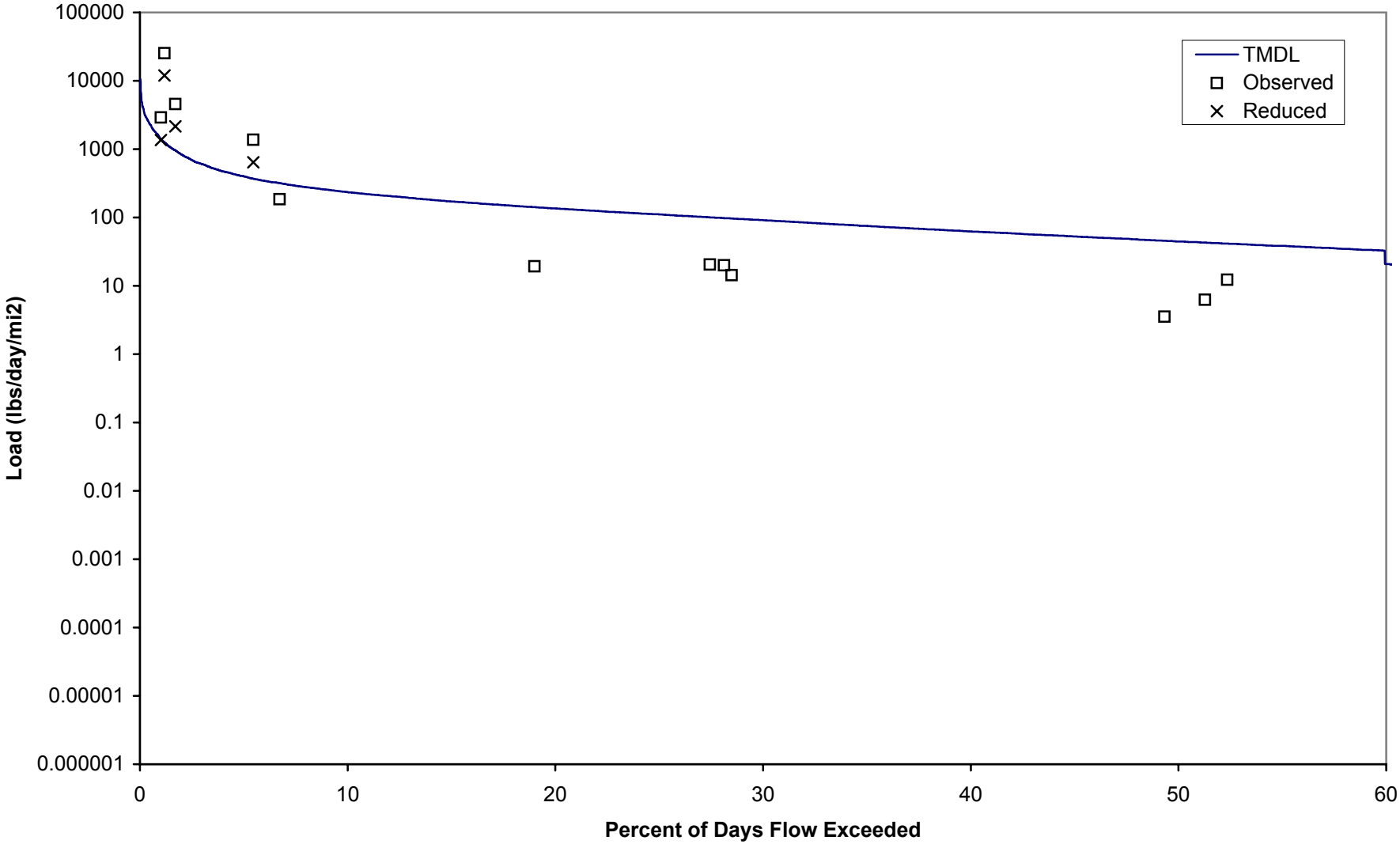


Figure F.5. Base Flow Load Duration Curve For Strawberry River SBR0002

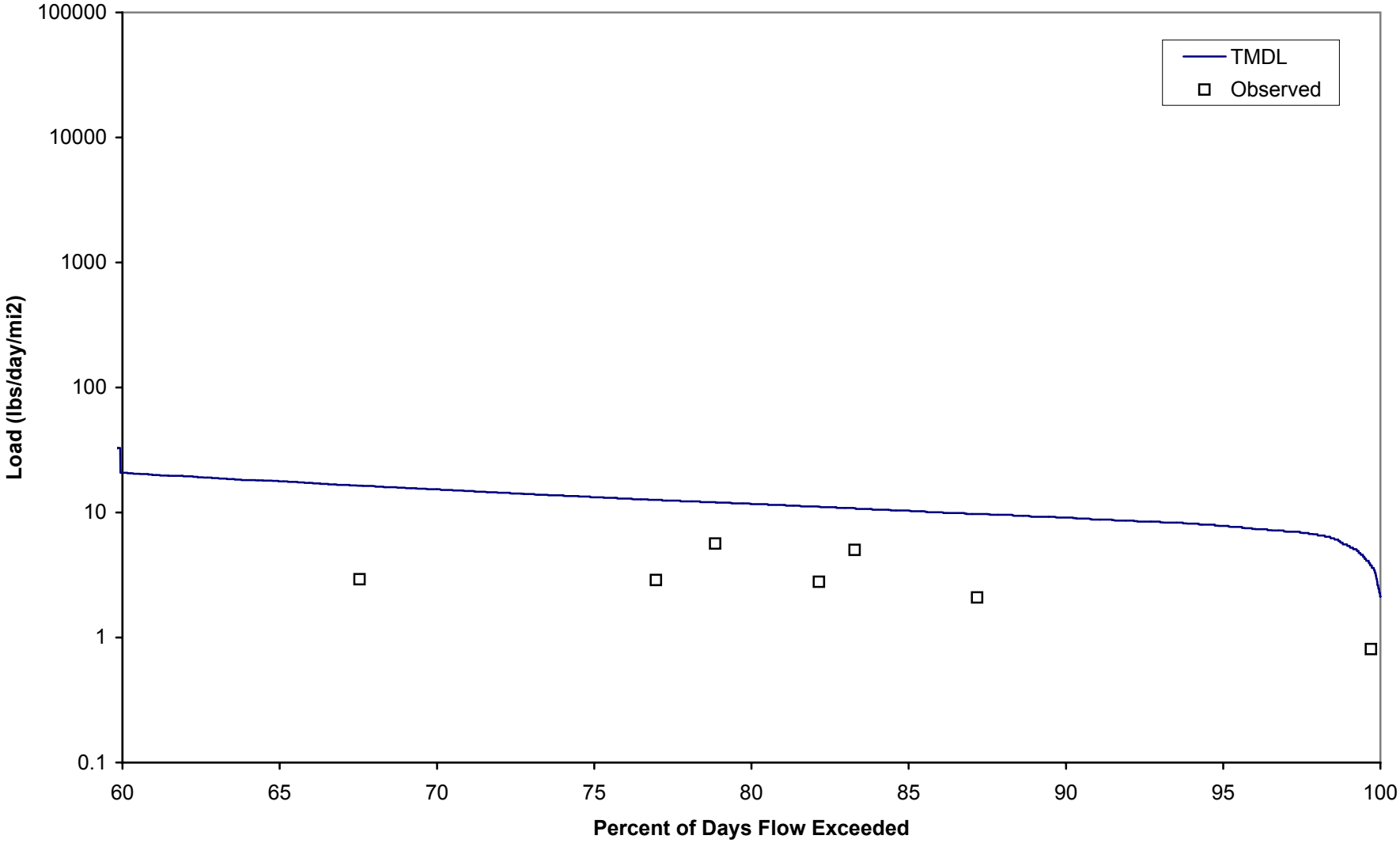


Figure F.6. Storm-Flow Load Duration Curve for Strawberry River at WHI0024

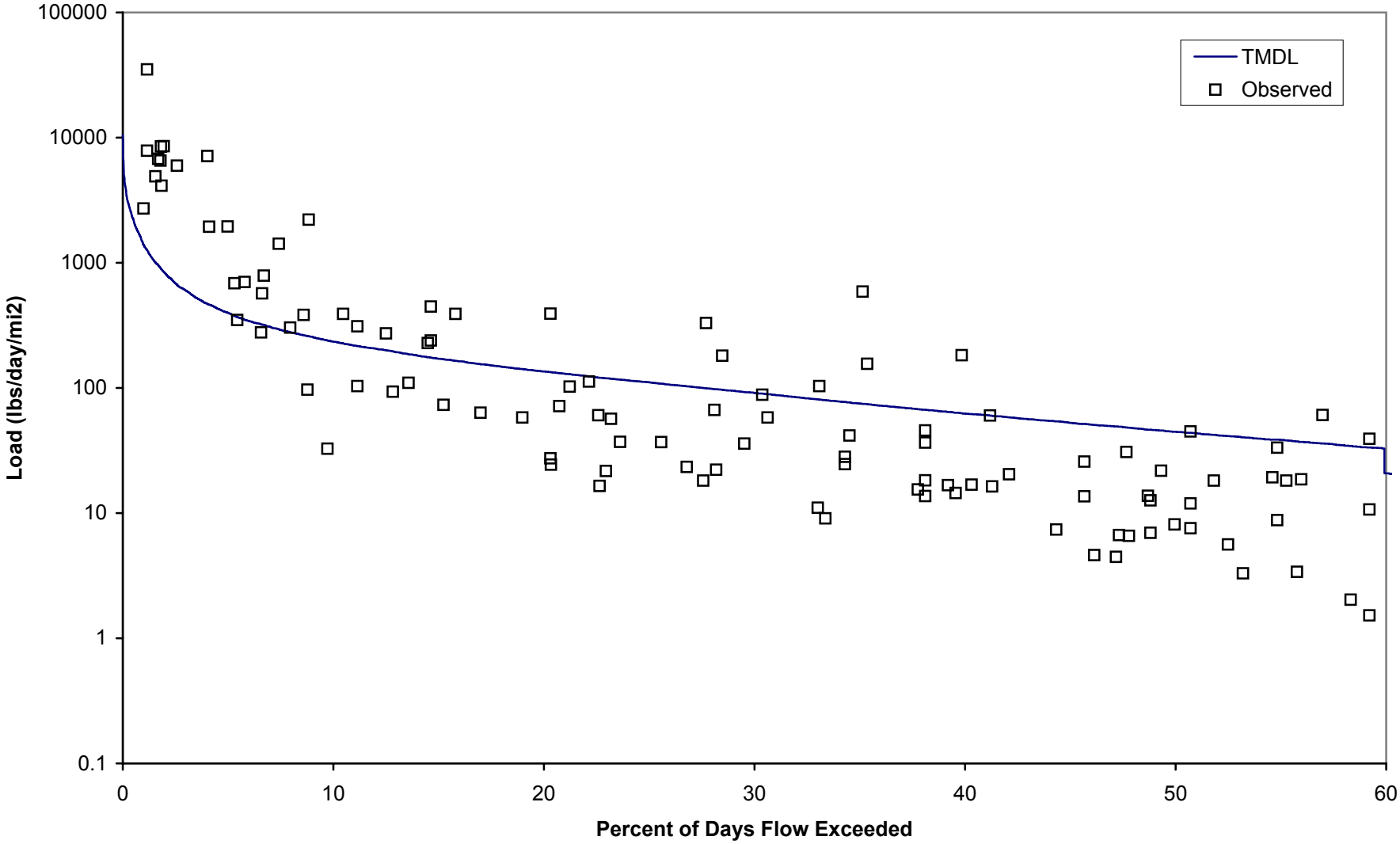


Figure F.7. Base Flow Load Duration Curve For Strawberry River at WHI0024

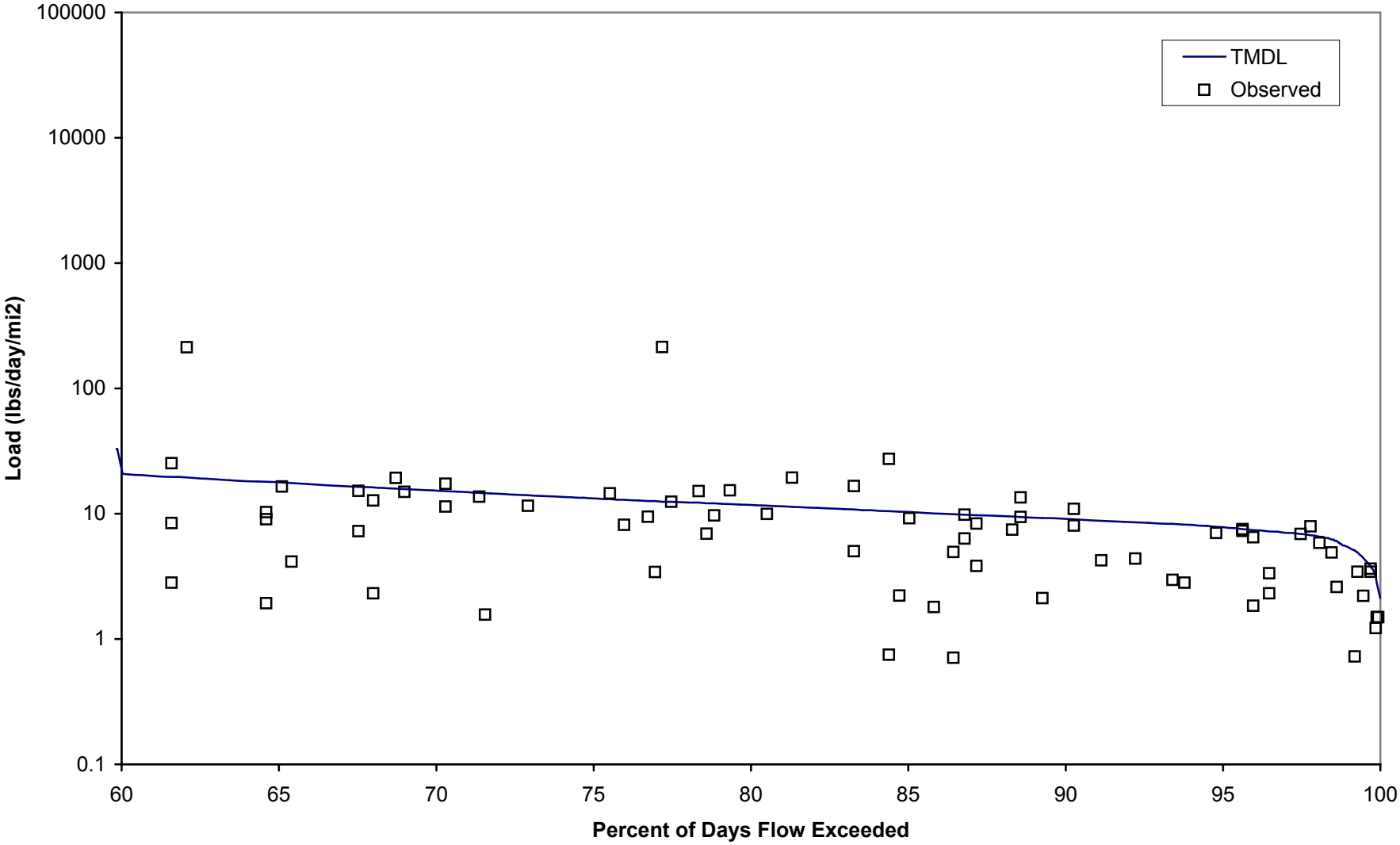


Figure F.8. Storm-Flow Load Duration Curve for Little Strawberry River at WHI0143h

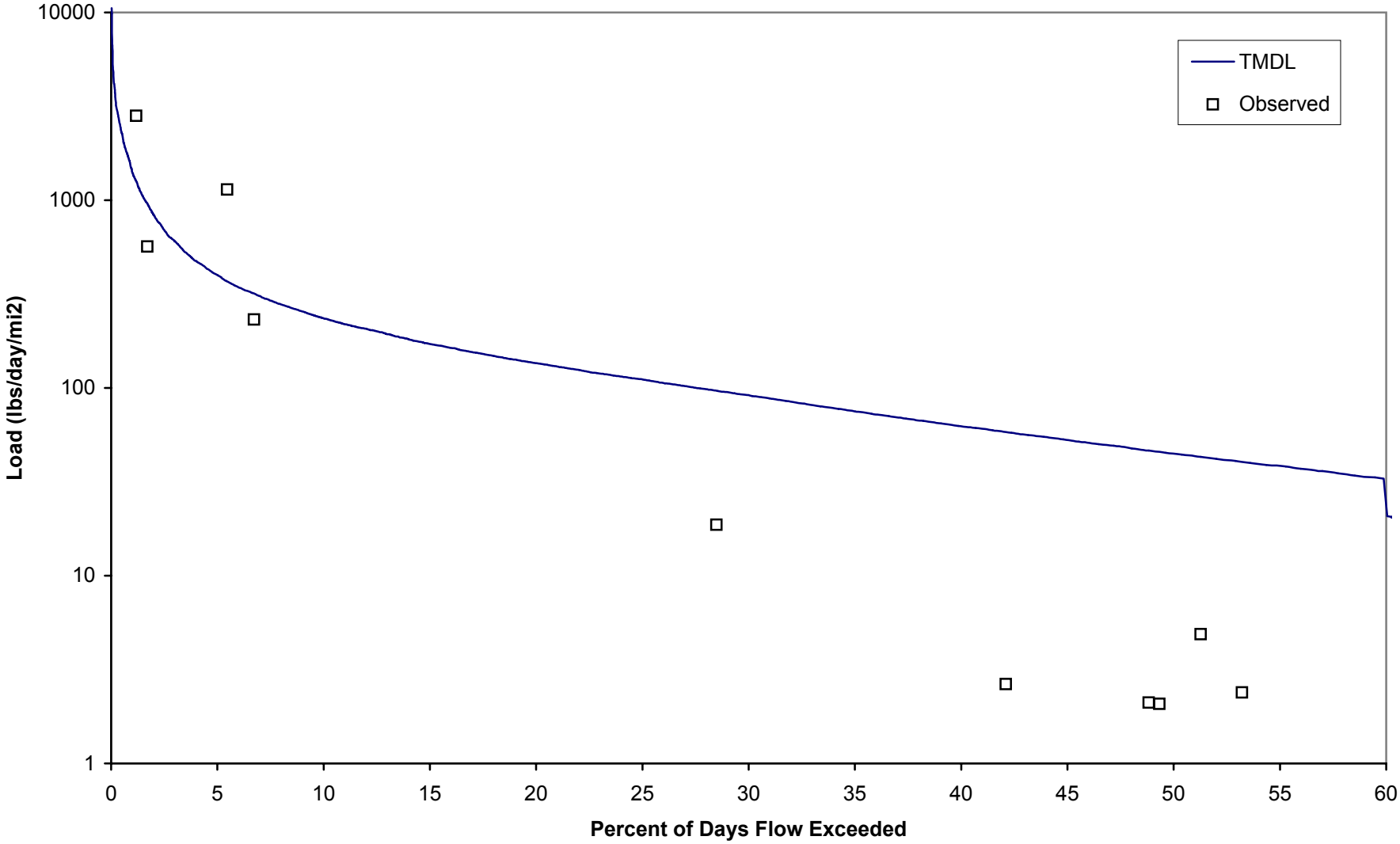


Figure F.9. Base Flow Load Duration Curve For Little Strawberry River at WHI0143h

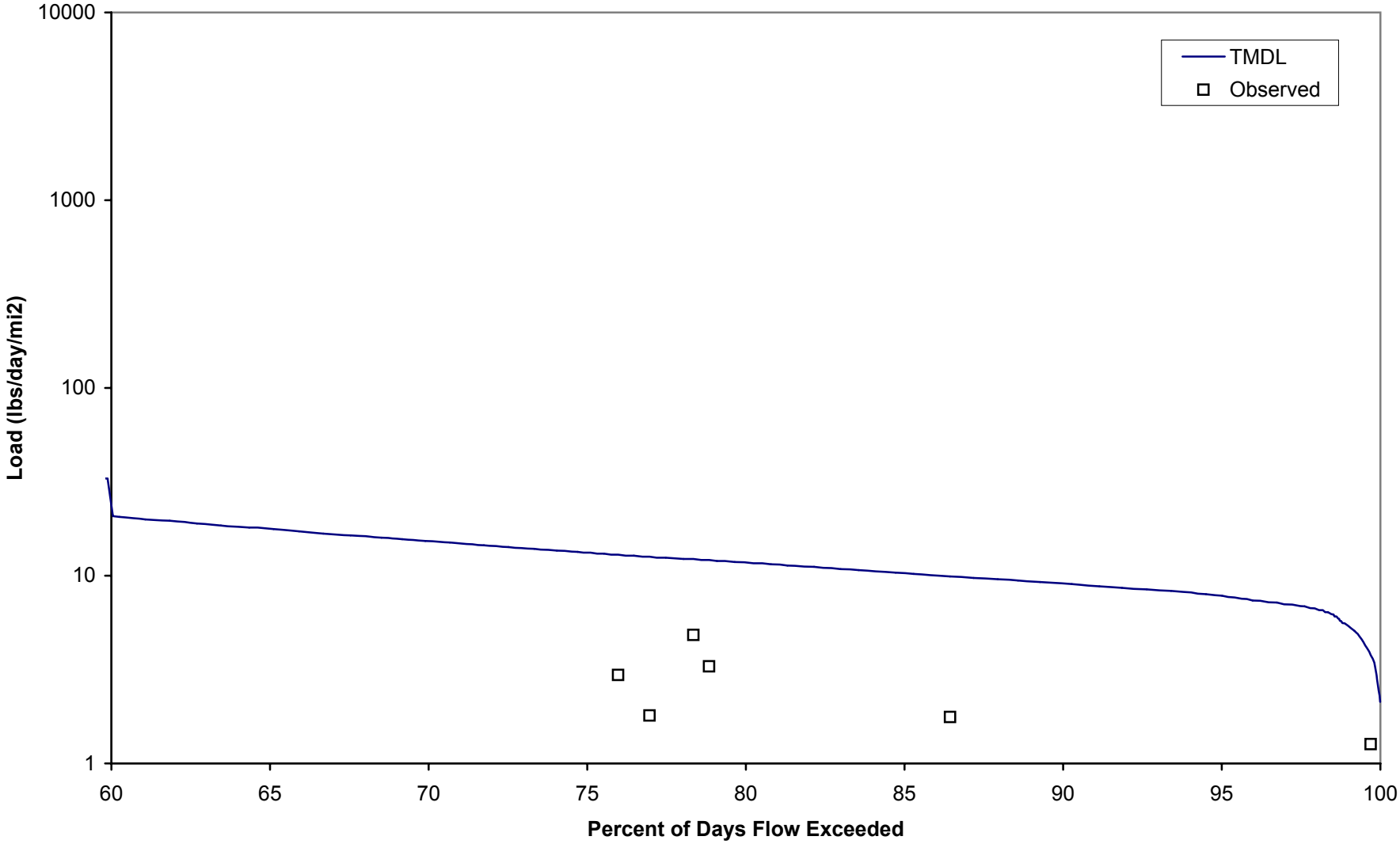


Table F.1. Calcuations for allowable load for Strawberry River Station SBR0001.
drainage area at USGS flow gage = 473 mi2, (Strawberry River near Poughkeepsie)

Date	Flow at gage (cfs)	Flow (cfs/mi2)	Percent of days flow exceeded	WQ Standard type	WQ Standard (NTU)	Target TSS (mg/L)	Allowable TSS load (lbs/day/mi2)
09/11/95	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
09/12/95	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
11/04/97	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
The rows between 98.99 and 80.23 percent flow exceedances are not shown for the sake of brevity.							
09/23/02	73	1.54E-01	80.23%	Base flow	10	14	1.17E+01
12/08/02	73	1.54E-01	80.23%	Base flow	10	14	1.17E+01
12/12/02	73	1.54E-01	80.23%	Base flow	10	14	1.17E+01
The rows between 98.99 and 60.03 percent flow exceedances are not shown for the sake of brevity.							
07/23/93	130	2.75E-01	60.03%	Base flow	10	14	2.08E+01
07/22/94	130	2.75E-01	60.03%	Base flow	10	14	2.08E+01
06/23/02	130	2.75E-01	60.03%	Base flow	10	14	2.08E+01
06/16/40	131	2.77E-01	59.86%	Storm-flow	17	22	3.29E+01
06/17/40	131	2.77E-01	59.86%	Storm-flow	17	22	3.29E+01
12/08/40	131	2.77E-01	59.86%	Storm-flow	17	22	3.29E+01
The rows between 59.86 and 30.04 percent flow exceedances are not shown for the sake of brevity.							
01/26/82	363	7.67E-01	30.04%	Storm-flow	17	22	9.11E+01
04/19/82	363	7.67E-01	30.04%	Storm-flow	17	22	9.11E+01
05/28/93	363	7.67E-01	30.04%	Storm-flow	17	22	9.11E+01
The rows between 30.04 and 0.01 percent flow exceedances are not shown for the sake of brevity.							
01/25/49	38800	8.20E+01	0.01%	Storm-flow	17	22	9.73E+03
05/27/00	39211	8.29E+01	0.00%	Storm-flow	17	22	9.84E+03
12/03/82	42000	8.88E+01	0.00%	Storm-flow	17	22	1.05E+04

Flow per unit area in middle of base flow range (80% exceedance) =	0.154	cfs/mi2
Cumulative drainage area at downstream end of reach 011 =	83.76	mi2
Flow at downstream end of reach 011 for base flow conditions =	12.9	cfs
Target TSS for base flow conditions for reach 011 =	14	mg/L
Allowable TSS load for base flow conditions for reach 011 =	0.488	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.77	cfs/mi2
Cumulative drainage area at downstream end of reach 011 =	83.76	mi2
Flow at downstream end of reach 011 for stormwater conditions =	64.3	cfs
Target TSS for stormwater conditions for reach 011 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 011 =	3.81	tons/day

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Table F.2. Calcuations allowable load for Strawberry River at SBR0002.
drainage area at USGS flow gage = 473 mi2, (Strawberry River at Puoghkeepsie)

Date	Flow at gage (cfs)	Flow (cfs/mi2)	Percent of days flow exceeded	WQ Standard type	WQ Standard (NTU)	Target TSS (mg/L)	Allowable TSS load (lbs/day/mi2)
09/11/95	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
09/12/95	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
11/04/97	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
The rows between 99.99 and 80.24 percent flow exceedances are not shown for the sake of brevity.							
08/29/02	73	1.54E-01	80.24%	Base flow	10	14	1.17E+01
09/19/02	73	1.54E-01	80.24%	Base flow	10	14	1.17E+01
09/23/02	73	1.54E-01	80.24%	Base flow	10	14	1.17E+01
The rows between 80.24 and 60.05 percent flow exceedances are not shown for the sake of brevity.							
07/23/93	130	2.75E-01	60.05%	Base flow	10	14	2.08E+01
07/22/94	130	2.75E-01	60.05%	Base flow	10	14	2.08E+01
06/23/02	130	2.75E-01	60.05%	Base flow	10	14	2.08E+01
06/16/40	131	2.77E-01	59.88%	Storm flow	17	22	3.29E+01
06/17/40	131	2.77E-01	59.88%	Storm flow	17	22	3.29E+01
12/08/40	131	2.77E-01	59.88%	Storm flow	17	22	3.29E+01
The rows between 59.98 and 30.02 percent flow exceedances are not shown for the sake of brevity.							
05/21/66	364	7.70E-01	30.02%	Storm flow	17	22	9.13E+01
09/27/77	364	7.70E-01	30.02%	Storm flow	17	22	9.13E+01
12/26/93	364	7.70E-01	30.02%	Storm flow	17	22	9.13E+01
The rows between 30.02 and 0.03 percent flow exceedances are not shown for the sake of brevity.							
01/25/49	38800	8.20E+01	0.03%	Storm flow	17	22	9.73E+03
05/27/00	39211	8.29E+01	0.03%	Storm flow	17	22	9.84E+03
12/03/82	42000	8.88E+01	0.03%	Storm flow	17	22	1.05E+04

Flow per unit area in middle of base flow range (80% exceedance) =	0.154	cfs/mi2
Cumulative drainage area at downstream end of reach 008 =	451.93	mi2
Flow at downstream end of reach 008 for base flow conditions =	69.7	cfs
Target TSS for base flow conditions for reach 008 =	14	mg/L
Allowable TSS load for base flow conditions for reach 008 =	2.63	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.77	cfs/mi2
Cumulative drainage area at downstream end of reach 008 =	451.93	mi2
Flow at downstream end of reach 008 for stormwater conditions =	349	cfs
Target TSS for stormwater conditions for reach 008 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 008 =	20.7	tons/day
Flow per unit area in middle of base flow range (80% exceedance) =	0.156	cfs/mi2
Cumulative drainage area at downstream end of reach 009 =	338.38	mi2

Flow at downstream end of reach 009 for base flow conditions =	52.9	cfs
Target TSS for base flow conditions for reach 009 =	14	mg/L
Allowable TSS load for base flow conditions for reach 009 =	2.00	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.77	cfs/mi2
Cumulative drainage area at downstream end of reach 009 =	338.38	mi2
Flow at downstream end of reach 009 for stormwater conditions =	262	cfs
Target TSS for stormwater conditions for reach 009 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 009 =	15.5	tons/day

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Table F.3. Calcuations for allowable load for Strawberry River (WHI0024).
drainage area at USGS flow gage = 473 mi2, at USGS flow gage

Date	Flow at gage (cfs)	Flow (cfs/mi2)	Percent of days flow exceeded	WQ Standard type	WQ Standard (NTU)	Target TSS (mg/L)	Allowable TSS load (lbs/day/mi2)
09/11/95	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
09/12/95	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
11/04/97	13	2.82E-02	99.99%	Base flow	10	14	2.13E+00
The rows between 99.99 and 80.23 percent flow exceedances are not shown for the sake of brevity.							
12/08/02	73	1.54E-01	80.23%	Base flow	10	14	1.17E+01
07/22/94	130	2.75E-01	60.03%	Base flow	10	14	2.08E+01
06/23/02	130	2.75E-01	60.03%	Base flow	10	14	2.08E+01
06/16/40	131	2.77E-01	59.86%	Storm flow	17	22	3.29E+01
06/17/40	131	2.77E-01	59.86%	Storm flow	17	22	3.29E+01
12/08/40	131	2.77E-01	59.86%	Storm flow	17	22	3.29E+01
The rows between 59.86 and 30.04 percent flow exceedances are not shown for the sake of brevity.							
05/21/66	364	7.70E-01	30.00%	Storm flow	17	22	9.13E+01
09/27/77	364	7.70E-01	30.00%	Storm flow	17	22	9.13E+01
12/26/93	364	7.70E-01	30.00%	Storm flow	17	22	9.13E+01
The rows between 30.00 and 0.01 percent flow exceedances are not shown for the sake of brevity.							
01/25/49	38800	8.20E+01	0.01%	Storm flow	17	22	9.73E+03
05/27/00	39211	8.29E+01	0.00%	Storm flow	17	22	9.84E+03
12/03/82	42000	8.88E+01	0.00%	Storm flow	17	22	1.05E+04

Flow per unit area in middle of base flow range (80% exceedance) =	0.154	cfs/mi2
Cumulative drainage area at downstream end of reach 004 =	681	mi2
Flow at downstream end of reach 004 for base flow conditions =	105	cfs
Target TSS for base flow conditions for reach 004 =	14	mg/L
Allowable TSS load for base flow conditions for reach 004 =	3.97	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.77	cfs/mi2
Cumulative drainage area at downstream end of reach 004 =	681	mi2
Flow at downstream end of reach 004 for stormwater conditions =	524	cfs
Target TSS for stormwater conditions for reach 004 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 004 =	31.1	tons/day
Flow per unit area in middle of base flow range (80% exceedance) =	0.156	cfs/mi2
Cumulative drainage area at downstream end of reach 005 =	635.31	mi2
Flow at downstream end of reach 005 for base flow conditions =	99.3	cfs
Target TSS for base flow conditions for reach 005 =	14	mg/L
Allowable TSS load for base flow conditions for reach 005 =	3.75	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.77	cfs/mi2
Cumulative drainage area at downstream end of reach 005 =	635.31	mi2

Flow at downstream end of reach 005 for stormwater conditions =	490	cfs
Target TSS for stormwater conditions for reach 005 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 005 =	29.1	tons/day
Flow per unit area in middle of base flow range (80% exceedance) =	0.156	cfs/mi2
Cumulative drainage area at downstream end of reach 006 =	595.99	mi2
Flow at downstream end of reach 006 for base flow conditions =	93.2	cfs
Target TSS for base flow conditions for reach 006 =	14	mg/L
Allowable TSS load for base flow conditions for reach 006 =	3.52	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.77	cfs/mi2
Cumulative drainage area at downstream end of reach 006 =	595.99	mi2
Flow at downstream end of reach 006 for stormwater conditions =	461	cfs
Target TSS for stormwater conditions for reach 006 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 006 =	27.4	tons/day

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Table F.3. Allowable Load WHI0024 Calculations

Table F.4. Calcuations for allowable load for Strawberry River at WHI0143h.
drainage area at USGS flow gage = 473 mi2, at USGS flow gage

Date	Flow at gage (cfs)	Flow (cfs/mi2)	Percent of days flow exceeded	WQ Standard type	WQ Standard (NTU)	Target TSS (mg/L)	Allowable TSS load (lbs/day/mi2)
09/11/95	13.34421	2.82E-02	99.99%	Base flow	10	14	2.13E+00
09/12/95	13.34421	2.82E-02	99.99%	Base flow	10	14	2.13E+00
11/04/97	13.34421	2.82E-02	99.99%	Base flow	10	14	2.13E+00
The rows between 99.98 and 80.24 percent flow exceedances are not shown for the sake of brevity.							
09/23/02	73	1.54E-01	80.24%	Base flow	10	14	1.17E+01
12/08/02	73	1.54E-01	80.24%	Base flow	10	14	1.17E+01
12/12/02	73	1.54E-01	80.24%	Base flow	10	14	1.17E+01
The rows between 80.24 and 60.05 percent flow exceedances are not shown for the sake of brevity.							
07/23/93	130	2.75E-01	60.05%	Base flow	10	14	2.08E+01
07/22/94	130	2.75E-01	60.05%	Base flow	10	14	2.08E+01
06/23/02	130	2.75E-01	60.05%	Base flow	10	14	2.08E+01
06/16/40	131	2.77E-01	59.88%	Storm-flow	17	22	3.29E+01
06/17/40	131	2.77E-01	59.88%	Storm-flow	17	22	3.29E+01
12/08/40	131	2.77E-01	59.88%	Storm-flow	17	22	3.29E+01
The rows between 59.88 and 30.02 percent flow exceedances are not shown for the sake of brevity.							
05/21/66	364	7.70E-01	30.02%	Storm-flow	17	22	9.13E+01
09/27/77	364	7.70E-01	30.02%	Storm-flow	17	22	9.13E+01
12/26/93	364	7.70E-01	30.02%	Storm-flow	17	22	9.13E+01
The rows between 30.02 and 0.03 percent flow exceedances are not shown for the sake of brevity.							
01/25/49	38800	8.20E+01	0.03%	Storm-flow	17	22	9.73E+03
05/27/00	39211.46	8.29E+01	0.03%	Storm-flow	17	22	9.84E+03
12/03/82	42000	8.88E+01	0.03%	Storm-flow	17	22	1.05E+04

Flow per unit area in middle of base flow range (80% exceedance) =	0.154	cfs/mi2
Cumulative drainage area at downstream end of reach 010 =	40.02	mi2
Flow at downstream end of reach 010 for base flow conditions =	6.2	cfs
Target TSS for base flow conditions for reach 010 =	14	mg/L
Allowable TSS load for base flow conditions for reach 010 =	0.233	tons/day
Flow in middle of stormwater range (30% exceedance) =	0.770	cfs/mi2
Cumulative drainage area at downstream end of reach 010 =	40.02	mi2
Flow at downstream end of reach 010 for stormwater conditions =	30.8	cfs
Target TSS for stormwater conditions for reach 010 =	22	mg/L
Allowable TSS load for stormwater conditions for reach 010 =	1.83	tons/day

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TABLE F.5. CALCULATIONS FOR PERCENT REDUCTION FOR STORM-FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION SBR0001)

Storm-flow target TSS conc. = 22 mg/L
Percent reduction needed = 58%
Error check for reduction is / is not needed: ok
Error check for less or more reduction needed: ok

Category	Date	Observed TSS at SBR0001 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	6/13/1994	4	0.35	52.33%	7.52	3.16	41.39	Yes
Storm-flow	6/18/2003	3	0.36	51.25%	5.85	2.46	42.89	Yes
Storm-flow	6/17/2002	2.7	0.38	49.31%	5.60	2.35	45.65	Yes
Storm-flow	3/19/2001	1.3	0.39	48.81%	2.74	1.15	46.35	Yes
Storm-flow	3/19/2003	4.7	0.49	42.09%	12.43	5.22	58.19	Yes
Storm-flow	4/29/2002	2.75	0.81	28.47%	12.07	5.07	96.57	Yes
Storm-flow	10/3/1995	25.5	0.82	28.10%	113.41	47.63	97.84	Yes
Storm-flow	5/6/1996	51.5	0.85	27.42%	235.06	98.73	100.41	Yes
Storm-flow	1/17/1995	1	1.19	18.97%	6.44	2.70	141.61	Yes
Storm-flow	2/24/2003	10.8	2.68	6.70%	156.38	65.68	318.56	Yes
Storm-flow	4/8/2002	225.5	3.11	5.44%	3779.42	1587.35	368.72	No
Storm-flow	3/12/2002	70.8	8.08	1.68%	3083.60	1295.11	958.18	No
Storm-flow	4/11/1995	122	11.70	0.99%	7695.89	3232.28	1387.78	No

Total number of values = 13
Allowable % of exceedances = 20%
Allowable no. of exceedances = 3
No. of exceedances before reductions = 5
No. of exceedances after reductions = 3

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TABLE F.6. CALCULATIONS FOR PERCENT REDUCTION FOR BASE FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION SBR0001)

Base flow target TSS conc. = 14 mg/L
Percent reduction needed = 0%
Error check for reduction is / is not needed: ok
Error check for less or more reduction needed: ok

Category	Date	Observed TSS at SBR0001 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Base flow	8/27/2001	16	0.05	99.69%	4.31	4.31	3.77	No
Base flow	9/12/1994	5	0.13	87.17%	3.48	3.48	9.74	Yes
Base flow	7/18/1995	15	0.14	83.28%	11.59	11.59	10.81	No
Base flow	12/3/2002	<1	0.13	86.43%	0.71	0.71	9.90	Yes
Base flow	10/8/1996	1.5	0.15	82.14%	1.19	1.19	11.14	Yes
Base flow	5/1/2001	4.7	0.16	78.84%	4.07	4.07	12.12	Yes
Base flow	11/6/2001	2.5	0.17	76.96%	2.25	2.25	12.61	Yes
Base flow	8/27/2002	3.5	0.17	76.96%	3.15	3.15	12.61	Yes
Base flow	2/20/1996	10.5	0.22	67.53%	12.29	12.29	16.38	Yes

Total number of values = 9
Allowable % of exceedances = 25%
Allowable no. of exceedances = 3
No. of exceedances before reductions = 2
No. of exceedances after reductions = 2

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TABLE F.7. CALCULATIONS FOR PERCENT REDUCTION FOR STORM-FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION SBR0002)

Storm-flow target TSS conc. =	22 mg/L	Error check for reduction is / is not needed:	ok
Percent reduction needed =	53%	Error check for less or more reduction needed:	ok

Category	Date	Observed TSS at SBR0002 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	1/22/2002	<1	3.40E-01	53.2%	1.8	0.9	40.4	Yes
Storm-flow	6/13/1994	6.5	3.49E-01	52.3%	12.2	5.7	41.4	Yes
Storm-flow	6/18/2003	3.2	3.62E-01	51.3%	6.2	2.9	42.9	Yes
Storm-flow	6/17/2002	1.7	3.85E-01	49.3%	3.5	1.7	45.7	Yes
Storm-flow	3/19/2001	<1	3.91E-01	48.8%	2.1	1.0	46.3	Yes
Storm-flow	3/19/2003	<1	4.90E-01	42.1%	2.6	1.2	58.2	Yes
Storm-flow	4/29/2002	3.25	8.14E-01	28.5%	14.3	6.7	96.6	Yes
Storm-flow	10/3/1995	4.5	8.25E-01	28.1%	20.0	9.4	97.8	Yes
Storm-flow	5/6/1996	4.5	8.46E-01	27.4%	20.5	9.7	100.4	Yes
Storm-flow	1/17/1995	3	1.19E+00	19.0%	19.3	9.1	141.6	Yes
Storm-flow	2/24/2003	12.8	2.68E+00	6.7%	185.3	87.1	318.6	Yes
Storm-flow	4/8/2002	81.5	3.11E+00	5.5%	1366.0	642.0	368.7	No
Storm-flow	3/12/2002	105	8.08E+00	1.7%	4573.1	2149.4	958.2	No
Storm-flow	1/24/2002	442	1.06E+01	1.2%	25348.4	11913.8	1261.7	No
Storm-flow	4/11/1995	46	1.17E+01	1.0%	2901.7	1363.8	1387.8	Yes

Total number of values =	15
Allowable % of exceedances =	20%
Allowable no. of exceedances =	3
No. of exceedances before reductions =	4
No. of exceedances after reductions =	3

TABLE F.8. CALCULATIONS FOR PERCENT REDUCTION FOR BASE FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION SBR0002)

Base flow target TSS conc. = 14 mg/L
Percent reduction needed = 0%
Error check for reduction is / is not needed: ok
Error check for less or more reduction needed: ok

Category	Date	Observed TSS at SBR0002 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Base flow	8/27/2001	3	4.99E-02	99.7%	0.81	0.81	3.77	Yes
Base flow	9/12/1994	3	1.29E-01	87.2%	2.09	2.09	9.74	Yes
Base flow	12/3/2002	<1	1.31E-01	86.4%	0.71	0.71	9.90	Yes
Base flow	7/18/1995	6.5	1.43E-01	83.3%	5.02	5.02	10.81	Yes
Base flow	10/8/1996	3.5	1.48E-01	82.1%	2.79	2.79	11.14	Yes
Base flow	5/1/2001	6.5	1.61E-01	78.8%	5.63	5.63	12.12	Yes
Base flow	6/19/2001		1.63E-01	78.3%	0.00	0.00	12.29	Yes
Base flow	11/6/2001	<1	1.67E-01	77.0%	0.90	0.90	12.61	Yes
Base flow	8/27/2002	3.2	1.67E-01	77.0%	2.88	2.88	12.61	Yes
Base flow	2/20/1996	2.5	2.17E-01	67.5%	2.93	2.93	16.38	Yes

Total number of values = 9
Allowable % of exceedances = 25%
Allowable no. of exceedances = 3
No. of exceedances before reductions = 0
No. of exceedances after reductions = 0

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TABLE F.9. CALCULATIONS FOR PERCENT REDUCTION FOR STORM-FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION WHI0024)

Storm-flow target TSS conc. =	22 mg/L	Error check for reduction is / is not needed:	ok
Percent reduction needed =	50%	Error check for less or more reduction needed:	ok

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	11/20/1995	1	2.82E-01	59.20%	1.52	0.76	33.47	Yes
Storm-flow	9/24/1996	7	2.82E-01	59.20%	10.65	5.33	33.47	Yes
Storm-flow	10/19/2004	25.8	2.82E-01	59.20%	39.25	19.63	33.47	Yes
Storm-flow	1/28/2003	1.3	2.90E-01	58.31%	2.03	1.02	34.36	Yes
Storm-flow	7/25/1995	37	3.04E-01	56.97%	60.62	30.31	36.05	Yes
Storm-flow	4/22/2003	11	3.13E-01	55.97%	18.56	9.28	37.12	Yes
Storm-flow	10/12/1993	2	3.15E-01	55.76%	3.40	1.70	37.37	Yes
Storm-flow	6/14/1994	10.5	3.21E-01	55.26%	18.20	9.10	38.13	Yes
Storm-flow	12/6/1994	5	3.26E-01	54.83%	8.78	4.39	38.62	Yes
Storm-flow	9/19/1995	19	3.26E-01	54.83%	33.35	16.68	38.62	Yes
Storm-flow	6/11/1991	11	3.26E-01	54.60%	19.31	9.66	38.63	Yes
Storm-flow	1/22/2002	1.8	3.40E-01	53.20%	3.30	1.65	40.38	Yes
Storm-flow	1/21/1997	3	3.47E-01	52.49%	5.62	2.81	41.20	Yes
Storm-flow	6/18/2002	9.5	3.55E-01	51.81%	18.20	9.10	42.14	Yes
Storm-flow	6/27/2000	22.5	3.69E-01	50.71%	44.77	22.38	43.77	Yes
Storm-flow	3/20/2001	3.8	3.69E-01	50.71%	7.56	3.78	43.77	Yes
Storm-flow	5/18/2004	6	3.69E-01	50.71%	11.94	5.97	43.77	Yes
Storm-flow	6/30/2003	4	3.76E-01	49.96%	8.12	4.06	44.65	Yes
Storm-flow	6/17/2002	10.5	3.85E-01	49.31%	21.79	10.89	45.65	Yes
Storm-flow	11/9/1998	6	3.91E-01	48.81%	12.64	6.32	46.35	Yes
Storm-flow	3/19/2001	3.3	3.91E-01	48.81%	6.95	3.48	46.35	Yes
Storm-flow	5/24/1994	6.5	3.91E-01	48.68%	13.71	6.86	46.40	Yes
Storm-flow	4/1/2003	3	4.06E-01	47.79%	6.57	3.28	48.16	Yes
Storm-flow	7/26/1994	14	4.08E-01	47.67%	30.81	15.40	48.41	Yes
Storm-flow	3/28/1995	3	4.12E-01	47.31%	6.67	3.34	48.92	Yes

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	11/2/1993	2	4.14E-01	47.17%	4.47	2.23	49.16	Yes
Storm-flow	3/12/1991	2	4.27E-01	46.14%	4.61	2.30	50.67	Yes
Storm-flow	12/9/2003	11	4.34E-01	45.67%	25.75	12.87	51.49	Yes
Storm-flow	12/14/2004	5.8	4.34E-01	45.67%	13.58	6.79	51.49	Yes
Storm-flow	4/29/1997	3	4.56E-01	44.33%	7.37	3.69	54.07	Yes
Storm-flow	3/19/2003	7.7	4.90E-01	42.09%	20.37	10.18	58.19	Yes
Storm-flow	5/12/1992	6	5.05E-01	41.29%	16.35	8.17	59.95	Yes
Storm-flow	6/9/1992	22	5.07E-01	41.19%	60.20	30.10	60.20	Yes
Storm-flow	1/30/1996	6	5.21E-01	40.32%	16.85	8.43	61.79	Yes
Storm-flow	7/7/1992	64	5.29E-01	39.84%	182.42	91.21	62.71	No
Storm-flow	2/12/1991	5	5.35E-01	39.55%	14.42	7.21	63.46	Yes
Storm-flow	9/25/2001	5.7	5.43E-01	39.19%	16.68	8.34	64.37	Yes
Storm-flow	10/29/1996	12	5.64E-01	38.11%	36.51	18.26	66.94	Yes
Storm-flow	10/20/1998	15	5.64E-01	38.11%	45.64	22.82	66.94	Yes
Storm-flow	1/25/2005	4.5	5.64E-01	38.11%	13.69	6.85	66.94	Yes
Storm-flow	3/8/2005	6	5.64E-01	38.11%	18.26	9.13	66.94	Yes
Storm-flow	1/2/2002	5	5.71E-01	37.76%	15.39	7.70	67.72	Yes
Storm-flow	8/5/2003	46.2	6.26E-01	35.35%	155.92	77.96	74.25	No
Storm-flow	5/27/1997	173	6.29E-01	35.14%	587.16	293.58	74.67	No
Storm-flow	6/1/1993	12	6.45E-01	34.51%	41.73	20.86	76.50	Yes
Storm-flow	3/23/1999	8	6.51E-01	34.29%	28.09	14.04	77.24	Yes
Storm-flow	1/16/2001	7	6.51E-01	34.29%	24.58	12.29	77.24	Yes
Storm-flow	2/17/2004	2.5	6.73E-01	33.37%	9.07	4.54	79.82	Yes
Storm-flow	9/9/2003	28.2	6.81E-01	33.09%	103.53	51.76	80.77	Yes
Storm-flow	3/17/1992	3	6.83E-01	33.00%	11.05	5.52	81.02	Yes
Storm-flow	12/11/2001	14.3	7.51E-01	30.63%	57.88	28.94	89.05	Yes
Storm-flow	5/27/2003	21.5	7.59E-01	30.38%	88.00	44.00	90.05	Yes
Storm-flow	11/7/2000	8.5	7.81E-01	29.52%	35.81	17.91	92.69	Yes
Storm-flow	4/29/2002	41.25	8.14E-01	28.47%	181.07	90.53	96.57	Yes
Storm-flow	4/26/1994	5	8.25E-01	28.18%	22.23	11.12	97.82	Yes
Storm-flow	5/16/1995	15	8.25E-01	28.10%	66.71	33.35	97.84	Yes

Table F.9. Storm-flow percent reductions
WHI0024

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	7/22/2003	73.2	8.37E-01	27.70%	330.50	165.25	99.33	No
Storm-flow	3/16/1993	4	8.41E-01	27.57%	18.15	9.08	99.83	Yes
Storm-flow	12/15/1998	5	8.68E-01	26.79%	23.41	11.70	102.99	Yes
Storm-flow	1/20/2004	7.5	9.11E-01	25.57%	36.87	18.43	108.14	Yes
Storm-flow	4/13/1993	7	9.81E-01	23.62%	37.03	18.52	116.39	Yes
Storm-flow	3/25/1997	10.5	9.98E-01	23.19%	56.53	28.26	118.44	Yes
Storm-flow	3/4/2003	4	1.01E+00	22.95%	21.71	10.85	119.40	Yes
Storm-flow	2/25/1992	3	1.02E+00	22.64%	16.45	8.23	120.65	Yes
Storm-flow	2/12/2002	11	1.02E+00	22.59%	60.45	30.23	120.90	Yes
Storm-flow	11/5/1991	20	1.04E+00	22.14%	112.42	56.21	123.66	Yes
Storm-flow	11/19/1996	17.5	1.09E+00	21.22%	102.40	51.20	128.74	Yes
Storm-flow	8/4/1992	12	1.11E+00	20.74%	71.56	35.78	131.19	Yes
Storm-flow	1/21/1992	4	1.13E+00	20.33%	24.31	12.15	133.69	Yes
Storm-flow	1/27/1998	4.5	1.13E+00	20.31%	27.39	13.69	133.89	Yes
Storm-flow	5/12/1998	64.5	1.13E+00	20.31%	392.53	196.27	133.89	No
Storm-flow	1/17/1995	9	1.19E+00	18.97%	57.93	28.97	141.61	Yes
Storm-flow	5/7/1991	9	1.30E+00	17.00%	63.31	31.66	154.76	Yes
Storm-flow	2/29/2000	52	1.39E+00	15.80%	389.49	194.74	164.78	No
Storm-flow	3/22/1994	9.5	1.43E+00	15.23%	73.22	36.61	169.56	Yes
Storm-flow	12/17/1996	30	1.48E+00	14.63%	238.75	119.37	175.08	Yes
Storm-flow	12/14/1999	56	1.48E+00	14.63%	445.66	222.83	175.08	No
Storm-flow	5/21/2002	28.5	1.48E+00	14.49%	228.11	114.05	176.08	Yes
Storm-flow	1/26/1993	13	1.56E+00	13.57%	109.68	54.84	185.62	Yes
Storm-flow	2/18/1997	10.5	1.65E+00	12.83%	93.39	46.70	195.68	Yes
Storm-flow	4/9/1991	30	1.68E+00	12.51%	272.61	136.30	199.91	Yes
Storm-flow	6/13/1995	31.5	1.82E+00	11.14%	309.67	154.84	216.28	Yes
Storm-flow	4/7/1998	10.5	1.82E+00	11.14%	103.22	51.61	216.28	Yes
Storm-flow	2/15/2005	37.8	1.91E+00	10.47%	389.30	194.65	226.58	Yes
Storm-flow	3/5/1996	3	2.02E+00	9.73%	32.65	16.33	239.45	Yes
Storm-flow	10/9/1990	188	2.18E+00	8.83%	2207.78	1103.89	258.36	No
Storm-flow	2/13/2001	8.2	2.19E+00	8.77%	96.93	48.46	260.05	Yes

Table F.9. Storm-flow percent reductions
WHI0024

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	2/23/1993	32	2.22E+00	8.59%	383.09	191.54	263.37	Yes
Storm-flow	1/15/1991	24	2.35E+00	7.96%	303.74	151.87	278.42	Yes
Storm-flow	5/30/2000	106.5	2.47E+00	7.41%	1420.90	710.45	293.52	No
Storm-flow	2/24/2003	54.5	2.68E+00	6.70%	789.15	394.58	318.56	No
Storm-flow	4/16/2002	39	2.71E+00	6.62%	569.16	284.58	321.07	Yes
Storm-flow	11/15/1994	19	2.71E+00	6.57%	277.95	138.98	321.84	Yes
Storm-flow	12/18/1990	44	2.96E+00	5.79%	702.33	351.17	351.17	Yes
Storm-flow	4/8/2002	20.8	3.11E+00	5.44%	348.61	174.31	368.72	Yes
Storm-flow	12/14/1993	40	3.17E+00	5.31%	684.09	342.04	376.25	Yes
Storm-flow	3/10/1998	107.5	3.36E+00	4.98%	1950.07	975.04	399.08	No
Storm-flow	2/17/1998	92	3.91E+00	4.10%	1938.08	969.04	463.45	No
Storm-flow	11/23/1992	334	3.95E+00	4.02%	7121.13	3560.57	469.06	No
Storm-flow	1/25/1994	196	5.64E+00	2.57%	5966.62	2983.31	669.72	No
Storm-flow	4/6/1999	223	7.10E+00	1.95%	8534.21	4267.10	841.94	No
Storm-flow	12/19/1995	102	7.49E+00	1.84%	4118.41	2059.21	888.28	No
Storm-flow	2/22/1994	209	7.53E+00	1.82%	8483.15	4241.58	892.96	No
Storm-flow	3/19/2002	158.3	7.65E+00	1.79%	6533.57	3266.78	908.01	No
Storm-flow	3/12/2002	155.5	8.08E+00	1.68%	6772.59	3386.29	958.18	No
Storm-flow	11/30/2004	102	8.90E+00	1.55%	4894.34	2447.17	1055.64	No
Storm-flow	4/21/1992	137	1.06E+01	1.16%	7856.87	3928.43	1261.69	No
Storm-flow	1/24/2002	610	1.06E+01	1.16%	34983.13	17491.57	1261.69	No
Storm-flow	4/11/1995	43	1.17E+01	0.99%	2712.49	1356.24	1387.78	Yes

Total number of values =	109
Allowable % of exceedances =	20%
Allowable no. of exceedances =	22
No. of exceedances before reductions =	38
No. of exceedances after reductions =	22

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Table F.9. Storm-flow percent reductions
WHI0024

TABLE F.10. CALCULATIONS FOR PERCENT REDUCTION FOR BASE FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION WHI0024)

Base flow target TSS conc. =	14 mg/L	Error check for reduction is / is not needed:	ok
Percent reduction needed =	0%	Error check for less or more reduction needed:	ok

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Base flow	9/19/2000	8.5	3.26E-02	99.94%	1.49	1.49	2.46	Yes
Base flow	8/22/2000	7.5	3.69E-02	99.89%	1.49	1.49	2.79	Yes
Base flow	9/28/2004	5.5	4.12E-02	99.85%	1.22	1.22	3.11	Yes
Base flow	8/28/2001	13.5	4.99E-02	99.69%	3.63	3.63	3.77	Yes
Base flow	8/28/2001	12.8	4.99E-02	99.69%	3.45	3.45	3.77	Yes
Base flow	10/21/1997	7	5.86E-02	99.46%	2.21	2.21	4.42	Yes
Base flow	7/24/2001	9.8	6.51E-02	99.27%	3.44	3.44	4.92	Yes
Base flow	1/25/2000	2	6.73E-02	99.18%	0.73	0.73	5.08	Yes
Base flow	10/17/2000	6	8.03E-02	98.61%	2.60	2.60	6.06	Yes
Base flow	7/20/1999	11	8.25E-02	98.45%	4.89	4.89	6.23	Yes
Base flow	8/20/1996	12.5	8.68E-02	98.06%	5.85	5.85	6.55	Yes
Base flow	8/22/1995	16.5	8.90E-02	97.78%	7.92	7.92	6.72	No
Base flow	9/21/1999	14	9.11E-02	97.47%	6.88	6.88	6.88	Yes
Base flow	10/10/1995	6.5	9.55E-02	96.47%	3.35	3.35	7.21	Yes
Base flow	11/16/1999	4.5	9.55E-02	96.47%	2.32	2.32	7.21	Yes
Base flow	10/11/1994	3.5	9.77E-02	95.96%	1.84	1.84	7.37	Yes
Base flow	6/26/2001	12.3	9.77E-02	95.96%	6.48	6.48	7.37	Yes
Base flow	7/29/1997	13.5	9.98E-02	95.63%	7.27	7.27	7.54	Yes
Base flow	6/29/2004	14	9.98E-02	95.63%	7.54	7.54	7.54	Yes
Base flow	6/25/1996	12.5	1.04E-01	94.78%	7.02	7.02	7.86	Yes
Base flow	10/7/2003	4.8	1.09E-01	93.78%	2.81	2.81	8.19	Yes
Base flow	10/1/1991	5	1.10E-01	93.40%	2.96	2.96	8.30	Yes
Base flow	11/4/2003	7.2	1.13E-01	92.21%	4.38	4.38	8.52	Yes
Base flow	10/8/2002	6.75	1.16E-01	91.13%	4.23	4.23	8.78	Yes

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Base flow	9/23/1997	17	1.19E-01	90.27%	10.94	10.94	9.01	No
Base flow	9/22/1998	12.5	1.19E-01	90.27%	8.05	8.05	9.01	Yes
Base flow	10/30/2001	3.2	1.23E-01	89.26%	2.12	2.12	9.26	Yes
Base flow	8/13/1991	20	1.25E-01	88.57%	13.45	13.45	9.42	No
Base flow	8/24/1993	14	1.25E-01	88.57%	9.42	9.42	9.42	Yes
Base flow	7/7/1998	11	1.26E-01	88.30%	7.47	7.47	9.50	Yes
Base flow	9/7/1993	12	1.29E-01	87.17%	8.35	8.35	9.74	Yes
Base flow	9/27/1994	5.5	1.29E-01	87.17%	3.83	3.83	9.74	Yes
Base flow	8/18/1998	14	1.30E-01	86.79%	9.83	9.83	9.83	Yes
Base flow	10/12/1999	9	1.30E-01	86.79%	6.32	6.32	9.83	Yes
Base flow	9/10/2002	7	1.31E-01	86.43%	4.95	4.95	9.90	Yes
Base flow	12/3/2002	<1	1.31E-01	86.43%	0.71	0.71	9.90	Yes
Base flow	11/13/2001	2.5	1.33E-01	85.81%	1.80	1.80	10.06	Yes
Base flow	5/28/1996	12.5	1.37E-01	85.03%	9.22	9.22	10.32	Yes
Base flow	11/12/2002	3	1.37E-01	84.71%	2.22	2.22	10.38	Yes
Base flow	11/18/1997	<1	1.39E-01	84.39%	0.75	0.75	10.49	Yes
Base flow	6/15/1999	36.5	1.39E-01	84.39%	27.34	27.34	10.49	No
Base flow	2/23/1999	6.5	1.43E-01	83.28%	5.02	5.02	10.81	Yes
Base flow	8/24/1999	21.5	1.43E-01	83.28%	16.61	16.61	10.81	No
Base flow	9/11/1990	24	1.50E-01	81.30%	19.43	19.43	11.33	No
Base flow	6/16/1998	12	1.54E-01	80.51%	9.97	9.97	11.63	Yes
Base flow	8/19/1997	18	1.58E-01	79.33%	15.38	15.38	11.96	No
Base flow	5/1/2001	11.2	1.61E-01	78.84%	9.70	9.70	12.12	Yes
Base flow	10/27/1992	8	1.61E-01	78.59%	6.93	6.93	12.13	Yes
Base flow	6/19/2001	17.25	1.63E-01	78.34%	15.14	15.14	12.29	No
Base flow	9/10/1991	14	1.65E-01	77.47%	12.45	12.45	12.45	Yes
Base flow	7/30/1996	240	1.65E-01	77.18%	213.47	213.47	12.45	No
Base flow	11/6/2001	3.8	1.67E-01	76.96%	3.42	3.42	12.61	Yes
Base flow	6/24/1997	10.5	1.67E-01	76.73%	9.46	9.46	12.62	Yes
Base flow	8/26/2002	8.8	1.71E-01	75.97%	8.13	8.13	12.93	Yes

Table F.10. Base flow percent reductions
WHI0024

Category	Date	Observed TSS at WHI0024 (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Base flow	7/9/2002	15.5	1.73E-01	75.52%	14.49	14.49	13.09	No
Base flow	8/13/2002	11.5	1.86E-01	72.91%	11.54	11.54	14.05	Yes
Base flow	2/14/1995	1.5	1.93E-01	71.55%	1.56	1.56	14.58	Yes
Base flow	7/9/1991	13	1.95E-01	71.37%	13.64	13.64	14.69	Yes
Base flow	9/1/1992	16	2.01E-01	70.30%	17.33	17.33	15.16	No
Base flow	8/9/1994	10.5	2.01E-01	70.30%	11.37	11.37	15.16	Yes
Base flow	8/16/2004	13.3	2.08E-01	68.98%	14.94	14.94	15.73	Yes
Base flow	7/27/2004	17	2.11E-01	68.72%	19.30	19.30	15.89	No
Base flow	2/13/1996	2	2.15E-01	68.00%	2.32	2.32	16.22	Yes
Base flow	5/11/1999	11	2.15E-01	68.00%	12.74	12.74	16.22	Yes
Base flow	8/1/2000	13	2.17E-01	67.53%	15.21	15.21	16.38	Yes
Base flow	3/16/2004	6.2	2.17E-01	67.53%	7.26	7.26	16.38	Yes
Base flow	12/17/2002	3.3	2.33E-01	65.40%	4.14	4.14	17.56	Yes
Base flow	7/6/1993	13	2.35E-01	65.09%	16.45	16.45	17.72	Yes
Base flow	12/30/1997	1.5	2.39E-01	64.59%	1.93	1.93	18.02	Yes
Base flow	3/21/2000	7	2.39E-01	64.59%	9.01	9.01	18.02	Yes
Base flow	4/17/2001	8	2.39E-01	64.59%	10.30	10.30	18.02	Yes
Base flow	9/22/1992	153	2.58E-01	62.07%	212.82	212.82	19.47	No
Base flow	1/19/1999	6	2.60E-01	61.59%	8.43	8.43	19.66	Yes
Base flow	12/18/2000	2	2.60E-01	61.59%	2.81	2.81	19.66	Yes
Base flow	5/22/2001	18	2.60E-01	61.59%	25.28	25.28	19.66	No

Total number of values =	75
Allowable % of exceedances =	25%
Allowable no. of exceedances =	19
No. of exceedances before reductions =	14
No. of exceedances after reductions =	14

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Table F.10. Base flow percent reductions
WHI0024

TABLE F.11. CALCULATIONS FOR PERCENT REDUCTION FOR STORM-FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION WHI0143h)

Storm-flow target TSS conc. = 22 mg/L
Percent reduction needed = 0%
Error check for reduction is / is not needed: ok
Error check for less or more reduction needed: ok

Category	Date	Observed TSS at WHI0143h (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Storm-flow	1/22/2002	1.3	3.40E-01	53.2%	2.4	2.4	40.4	Yes
Storm-flow	6/18/2003	2.5	3.62E-01	51.3%	4.9	4.9	42.9	Yes
Storm-flow	6/17/2002	1	3.85E-01	49.3%	2.1	2.1	45.7	Yes
Storm-flow	3/19/2001	<1	3.91E-01	48.8%	2.1	2.1	46.3	Yes
Storm-flow	3/19/2003	1	4.90E-01	42.1%	2.6	2.6	58.2	Yes
Storm-flow	4/29/2002	4.25	8.14E-01	28.5%	18.7	18.7	96.6	Yes
Storm-flow	2/24/2003	16	2.68E+00	6.7%	231.7	231.7	318.6	Yes
Storm-flow	4/8/2002	68	3.11E+00	5.5%	1139.7	1139.7	368.7	No
Storm-flow	3/12/2002	13	8.08E+00	1.7%	566.2	566.2	958.2	Yes
Storm-flow	1/24/2002	49	1.06E+01	1.2%	2810.1	2810.1	1261.7	No

Total number of values = 10
Allowable % of exceedances = 20%
Allowable no. of exceedances = 2
No. of exceedances before reductions = 2
No. of exceedances after reductions = 2

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Table F.11. Storm-flow percent reduction
WHI0143h

TABLE F.12. CALCULATIONS FOR PERCENT REDUCTION FOR BASE FLOW CONDITIONS
FOR STRAWBERRY RIVER (STATION WHI143h)

Base flow target TSS conc. =	14 mg/L	Error check for reduction is / is not needed:	ok
Percent reduction needed =	0%	Error check for less or more reduction needed:	ok

Category	Date	Observed TSS at WHI0143h (mg/L)	Flow per unit area on sampling day (cfs/mi2)	Percent exceedance for flow on sampling day	Current TSS load (lbs/day)/mi2	Reduced TSS load (lbs/day)/mi2	Allowable TSS load (lbs/day)/mi2	Reduced load less than or equal to allow. load?
Base flow	8/27/2001	4.7	4.99E-02	99.7%	1.27	1.27	3.77	Yes
Base flow	12/3/2002	2.5	1.31E-01	86.4%	1.77	1.77	9.90	Yes
Base flow	5/1/2001	3.8	1.61E-01	78.8%	3.29	3.29	12.12	Yes
Base flow	6/19/2001	5.5	1.63E-01	78.3%	4.83	4.83	12.29	Yes
Base flow	11/6/2001	2	1.67E-01	77.0%	1.80	1.80	12.61	Yes
Base flow	8/26/2002	3.2	1.71E-01	76.0%	2.96	2.96	12.93	Yes

Total number of values =	6
Allowable % of exceedances =	25%
Allowable no. of exceedances =	2
No. of exceedances before reductions =	0
No. of exceedances after reductions =	0

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