

**Total Maximum Daily Load (TMDL)
North Fabius River
Pollutant: Sediment**

Name: North Fabius River

Downstream Location: Marion County

Hydrologic Unit Code (HUC): 07110002

Water Body Identification (WBID): 56

Missouri Stream Class: The impaired segment of North Fabius River is a Class P Stream¹.

Beneficial Uses²:

- Irrigation
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation - Category B
- Secondary Contact Recreation
- Drinking Water Supply

Size of Impaired Segment: 82 miles

Location of Impaired Segment³: From 24, 59N, 6W to 26, 67N, 14W (refer to Table H 10 CSR 20-7)

Pollutant: Sediment

Pollutant Source: Agricultural Non-point Source

TMDL Priority Ranking: Medium

1 Introduction

This North Fabius River Total Maximum Daily Load (TMDL) for sediment is being established in accordance with Section 303(d) of the Clean Water Act, because the State of Missouri determined on the 1998 and 2002 303(d) lists of impaired waters that the water quality standards (WQS) for North Fabius River were exceeded due to sediment. To meet the milestones of the 2001 Consent Decree, American Canoe

¹ Class C streams may cease flow in dry periods but maintain permanent pools, which support aquatic life. See 10 CSR 20-7.031(1)(F)

² For Beneficial Uses see 10 CSR 20-7.031(1)(C) and Table H.

³ See Table H 10 CSR 20-7

Association, et al. v. EPA, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001, EPA is establishing this TMDL.

The purpose of a TMDL is to determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the WQS established for each waterbody based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources. The LA is the fraction of the total pollutant load apportioned to non-point sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumption and data inadequacies.

2 Background and Water Quality Problems

North Fabius River is located in the North Fabius River Basin in Marion County, Missouri. The primary cause of the sediment impairment to North Fabius River has been identified as pollution caused by agricultural non-point sources (Table 1 and Figure 1).

All waters of the State, as per Missouri WQS, must provide suitable conditions for aquatic life. The conditions include both the physical habitat and the quality of the water. TMDLs are not written to address habitat, but are written to correct water quality conditions. Because the water body addressed by this TMDL was assessed as to its biological function, many factors may have contributed to the impairment. The State of Missouri continues to do field evaluation and in the future, may define the role sediment is playing in the potential biological impairment of this waterbody. However, the water quality condition for which North Fabius River is currently listed is sedimentation; therefore, this TMDL addresses sediment. The State of Missouri may submit and EPA may approve another TMDL or a modified 303d listing for this water at a later time to address new information on the impairment.

A combination of natural geology and land use in the prairie portions of the state (where North Fabius River is located) is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major problems are excessive rates of sediment deposition due to stream bank erosion and sheet erosion from agricultural lands, loss of stream length and loss of stream channel heterogeneity due to channelization, and changes in basin hydrology that have increased flood flows and prolonged low flow conditions. Loss of tree cover in riparian zones has caused elevated water temperatures in summer and a reduction in woody debris, a critical aquatic habitat component in prairie streams. The most compelling evidence of loss or impairment of aquatic habitat is the change in the historical distribution of fishes in Missouri. Many species of fish no longer appear in portions of the state where they once lived.⁴

⁴ Missouri Department of Natural Resources (MDNR) (2005). Total Maximum Daily Load (TMDL) Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment, <http://www.dnr.mo.gov/env/wpp/tmdl/info/habitat-info.pdf>

North Fabius River was placed on the Missouri 303(d) list for sedimentation. This was primarily based on best professional judgment because little sediment data exists to directly document sediment impacts to the stream. General fisheries data and the effect of sediment on fish were the initial data used to consider North Fabius River for 303(d) listing. For this TMDL, sediment targets were derived using generalized information from the ecological drainage unit (EDU).

Since the 303(d) listing, MDNR has developed a sediment protocol to determine if sediment is actually the pollutant in the streams listed and to arrive at a standard way to measure sediment. The first step of that protocol is a biological assessment to see if the biological community is actually impaired. A biological assessment was not available for this waterbody.

Table 1: Missouri Land Use Distribution for North Fabius River

Type	Percent
Barren or Sparsely Vegetated	<0.1%
Cropland	31.8%
Deciduous Forest	14.4%
Deciduous Woody/Herbaceous	3.6%
Evergreen Forest	<0.1%
Grassland	43.8%
Herbaceous-Dominated Wetland	0.6%
High Density Urban	<0.1%
Impervious	1.7%
Low Intensity Urban	0.4%
Open Water	0.9%
Woody-Dominated Wetland	2.9%
Watershed Area = 906 mi²	

3 Description of Sources

3.1 Point Sources

Thirty seven National Pollutant Discharge Elimination System (NPDES) permitted facilities are located within the watershed (Table 2). These facilities include construction, general and site specific permits.

Livestock in the watershed include many horses, cattle, and hogs held in pastures, feedlots, and Concentrated Animal Feeding Operations (CAFO). One operation is registered, certified or permitted within the watershed. CAFOs are animal feeding operations in which animals are confined to areas that are totally roofed. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application.

All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25-year, 24-hour rainfall/runoff event. NPDES permits, also non-discharging, are issued for facilities with more than 1,000 animal units. Total potential animal units (AU) for all facilities are approximately 1,920 AU. The actual number of AUs on site is variable, but typically less than potential numbers.

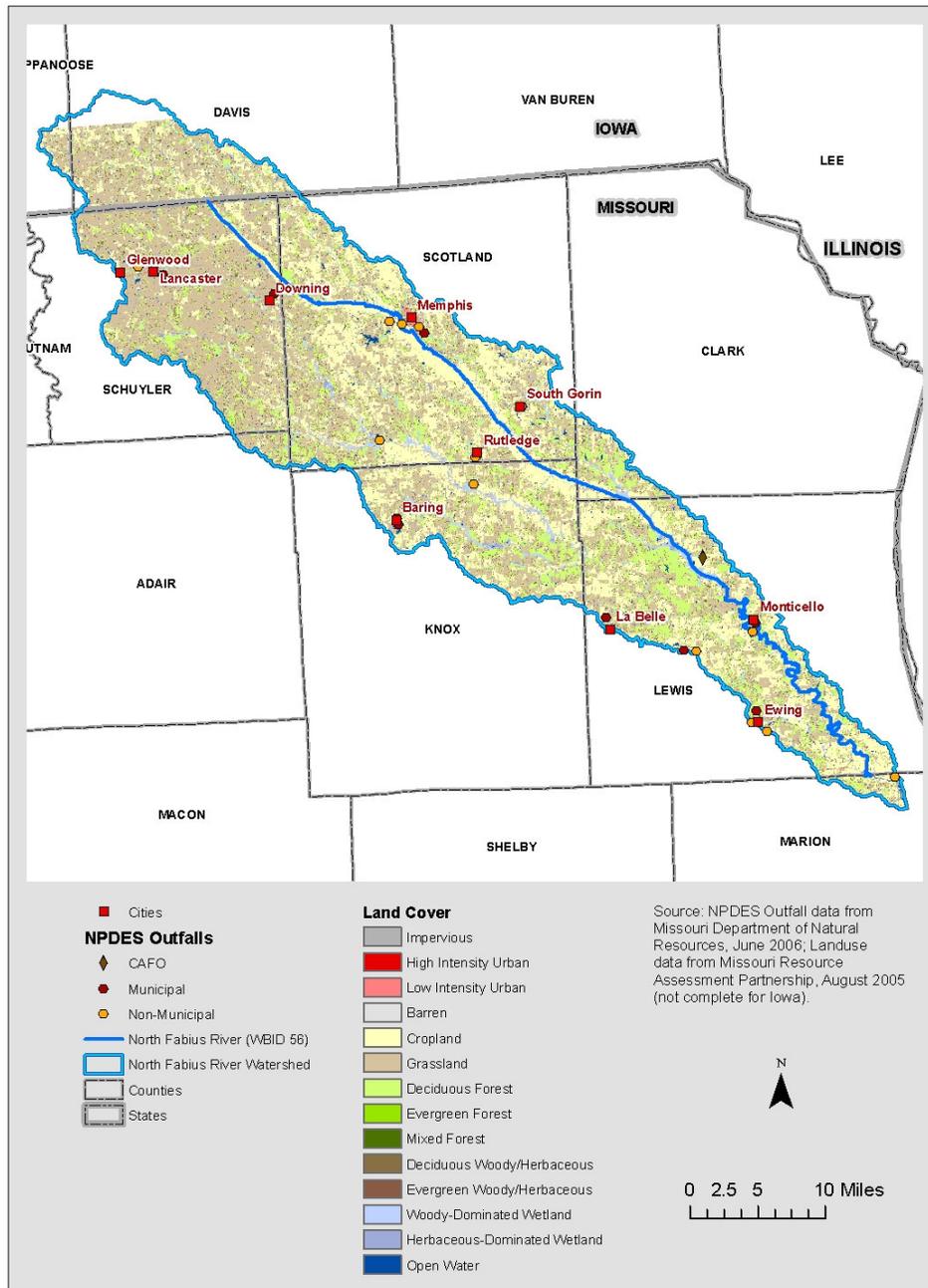


Figure 1: Land Use Map for North Fabius River Watershed

Table 2: Permitted Facilities

Facility - CAFOs	Permit number	County	Design Flow
S & K Custom Works	MO-G010618	Lewis	Non discharging
Facility - Construction			
Lewistown WWTF Construction	MO-R104807	Lewis	storm water discharge
Freeman to Whiting No. 5	MO-R105649	Scotland	storm water discharge
Lewistown Lagoon Reclamation	MO-R106853	Lewis	storm water discharge
S & K Custom Works Farm	MO-R109141	Lewis	storm water discharge
Jay Sensenig	MO-R109188	Scotland	storm water discharge
Baring Farm Service Inc	MO-R240007	Knox	storm water discharge
MFA Agri Service – Memphis	MO-R240064	Scotland	storm water discharge
Northeast MO COOP Service	MO-R240073	Knox	storm water discharge
Farmers COOP Service	MO-R240099	Lewis	storm water discharge
Humphrey Feed & Seed Mont	MO-R240262	Lewis	storm water discharge
Farmers Elevator/Produce	MO-R240348	Scotland	storm water discharge
MFA Agri Serv - Lancaster	MO-R240382	Schuyler	storm water discharge
Smith Bros. Farm Supply	MO-R240396	Lewis	storm water discharge
Facility – Other			
Lancaster WWTF	MO-0039691	Schuyler	0.157
Memphis WWTF	MO-0041173	Scotland	0.214
Baring S WWTF	MO-0045811	Knox	0.016
Baring N WWTF	MO-0056642	Knox	0.01
Gorin R-III School	MO-0091677	Scotland	0.002
Social Restaurant/Lounge	MO-0101834	Scotland	0.0012
Ewing WWTF	MO-0104671	Lewis	0.03
Downing WWTF	MO-0109240	Schuyler	0.055
Country Aire Retirement	MO-0112615	Lewis	0.009
Lewistown WWTF	MO-0120570	Lewis	0.075
Monticello WWTF	MO-0123803	Lewis	0.025

MFA Bulk Plant - Lancaster	MO-G350081	Schuyler	storm water discharge
MFA Oil Bulk Plant – MEMP	MO-G350226	Scotland	storm water discharge
Central Stone Company	MO-G490026	Scotland	storm water discharge
Central Stone CO-CS08	MO-G490072	Lewis	storm water discharge
Central Stone CX3 6 Ewing	MO-G490073	Lewis	storm water discharge
Central Stone CO-CS11	MO-G490149	Marion	storm water discharge
Mo & O Concrete Inc	MO-G490852	Scotland	storm water discharge
Lancaster WTP	MO-G640040	Schuyler	filter back wash discharge
Memphis Water Treatment	MO-G640120	Scotland	filter back wash discharge
BP Pipeline-Freeman Whitney	MO-G670230	Scotland	hydrostatic test water discharge
Rutledge Meat Processing	MO-G822017	Scotland	Non-discharging
Weiler Dairy	MO-G822152	Knox	Non-discharging

3.2 Non-Point Sources

Most of the watershed is grassland (44%), cropland (32%), or deciduous forest (14%). The cropland in the watershed appears to be concentrated towards the center. Cropland that is adjacent to and drains into North Fabius River could contribute to the sediment impairment. There is one NPDES-permitted CAFO in the watershed (Table 2), as well as other livestock (Tables 3 and 4). Overland runoff can easily carry sediment into the stream. Soil, from exposed land, runs into the river, increasing the turbidity and concentration of total suspended solids (TSS) and decreasing the transparency. Background levels of TSS come from natural fluvial processes. Sediment becomes suspended during high flow events as soil along the banks is eroded and bed sediment is resuspended. Sediment loading in the North Fabius River watershed comes predominantly from nonpoint source pollution.

Table 3: Livestock Estimates (AU) per Missouri County⁵

	Lewis	Marion	Schuyler	Scotland	Knox	Clark	Adair
Cattle							
Beef	(D)	9,801	13,653	9,147	11,706	10,666	17,907
Milk	(D)	671	327	3,583	1,243	256	187
Cow/Calf	29,320	22,328	23,999	25,049	26,372	26,354	32,065
Hogs/Pigs	16,159	39,348	1,024	5,178	6,488	2,481	2,662
Sheep/Lambs	602	553	5,144	1,001	1,207	379	1,050
Poultry							
Layers	758	913	726	807	222	383	666
Broilers	85	350	(D)	70	(D)	164	225

(D) Withheld to avoid disclosing data for individual farms.

Table 4: Livestock Estimates (AU) per Iowa County⁶

	Davis	Appanoose
Cattle		
Beef	22,907	22,139
Milk	2,149	350
Cow/Calf	47,894	38,693
Hogs/Pigs	47,042	2,027
Sheep/Lambs	5,512	1,019
Poultry		
Layers	1,505	295
Broilers	2,657	(D)

(D) Withheld to avoid disclosing data for individual farms.

4 Description of the Applicable WQS and Water Quality Targets

4.1 Beneficial Uses

North Fabius River has the following beneficial uses:

- Irrigation
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation - Category B

⁵ USDA- NASS Quick Stats (Livestock) 2002 Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf

⁶ USDA- NASS Quick Stats (Livestock) 2002 Census of Agriculture, Volume 1 Chapter 2: Iowa County Level Data <http://www.nass.usda.gov/census/census02/volume1/ia/IAVolume104.pdf>

- Secondary Contact Recreation
- Drinking Water Supply

The stream classifications and designated uses may be found at 10 CSR20-7.031(1)(C) and (F) and Table H.

Use that is impaired:

- Protection of Warm Water Aquatic Life

4.2 Antidegradation Policy

Missouri's WQS include the EPA "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing in-stream water uses are those uses that were attained on or after November 29, 1975, the date of EPA's first WQS Regulation, or uses for which existing water quality is suitable unless prevented by physical problems such as substrate or flow.

Tier 2 – Protects the level of water quality necessary to support the propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than required to support these uses. Before water quality in Tier 2 waters can be lowered, there must be an anti-degradation review consisting of: (1) a finding that it is necessary to accommodate important economical or social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and BMPs for non-point sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national resources, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality (with the exception of some limited activities that result in temporary and short-term changes in water quality).

4.3 Narrative Criteria

General or narrative criteria are contained in Missouri's WQS 10 CSR 20-7.030 (3)(A)(C) and (G). These criteria state:

- (A) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses;

- (C) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses;
- (G) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

When the WQS is expressed as a narrative value, a measurable indicator of the pollutant may be selected to express the narrative as a numeric value. There are many quantitative indicators of sediment, such as, TSS, turbidity, and bedload sediment, which are appropriate to describe sediment in rivers and streams.⁷ TSS was selected as the numeric target for this TMDL because it enables the use of the highest quality data available, including permit conditions and monitoring data.

5 Calculation of Load Capacity

Load capacity (LC) is defined as the maximum pollutant load that a waterbody can assimilate and still attain WQS. This total load is then divided among a WLA for point sources, a LA for nonpoint sources and a MOS. The LC for this TMDL has been defined as a curve over the range of flows for North Fabius River, see Figure 2, where the solid (red) curve is the TMDL. TSS measurements are shown in Figure 2, where the round (black) points are loads calculated from the concentrations and the corresponding horizontal (red) bars are the percent reduction required to meet the TMDL. Available data indicates required reductions of up to 87% in TSS loading.

5.1 Modeling Approach

In cases where pollutant data for the impaired stream is not available a reference approach is used. In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all data available within the EDU in which the waterbody is located. Therefore, the 25th percentile is targeted as the TMDL load duration curve (LDC). For a full description of the development of suspended sediment targets using reference load duration curves refer to Appendix B. Specific data sources for this TMDL's flow and EDU-wide TSS data are listed in Appendix C. Table 5 shows estimates of discharge at flow percentiles.

⁷ Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

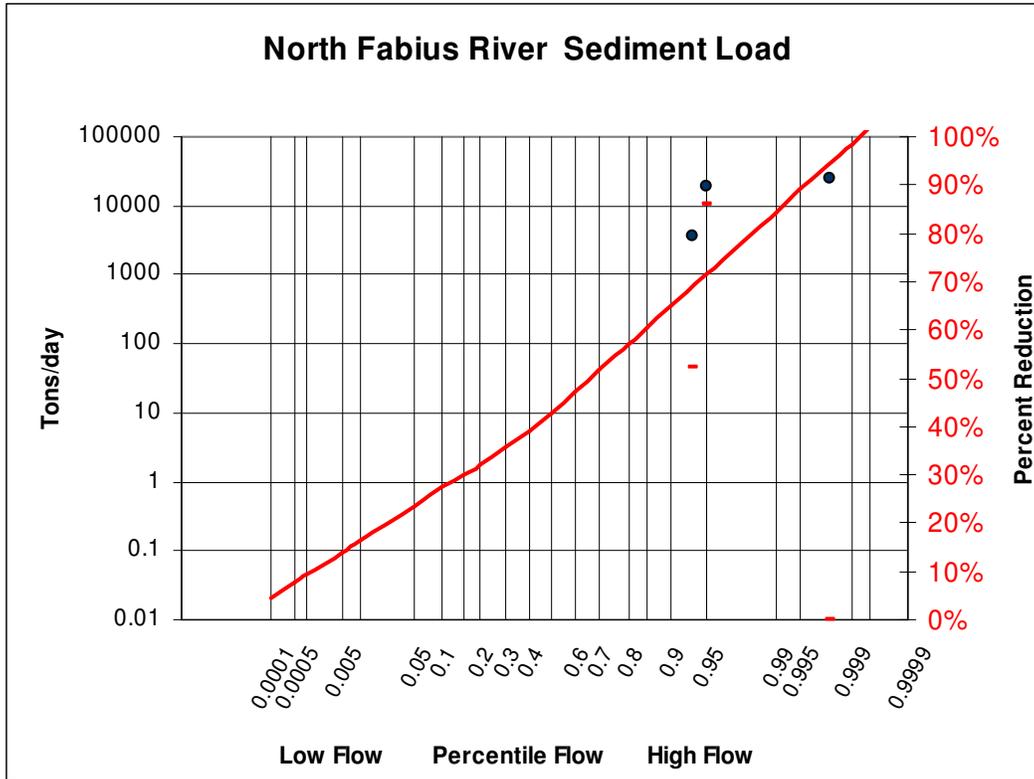


Figure 2 -- TMDL Curve over the Range of Flows for North Fabius River

Table 5: Estimated Flow for Range of Percentiles at the Impaired Segment Outlet

	Percent of Flow Occurrence	Discharge (cubic feet per second)
Flow Estimate for North Fabius River Based on Drainage Area and Synthetic Ecological Drainage Unit Flow	10	10.3
	30	39.9
	50	106
	70	290
	90	1340

6 Waste Load Allocation (Point Source Loads)

WLA is the allowable amount of the pollutant that can be assigned to point sources. The WLA is set to the lesser of current permit limits or technology based effluent limits (TBELs). TBELs are defined in a permit based on facility type. Mechanical WWTFs' permit limits are a weekly average TSS concentration of 45 mg/L and a monthly average TSS concentration of 30 mg/L. Secondary equivalent WWTFs' permit limits are a weekly average TSS concentration of 60 mg/L and a monthly average TSS concentration of 45 mg/L. Waste water treatment lagoon facilities' permit limits are up to a weekly average TSS concentration of 120 mg/L and a monthly average TSS

concentration of 80 mg/L. Additionally, permits can be written to target lower limits if the specific facility is capable of performance exceeding TBELs. Table 6 lists the site specific permitted point sources in the watershed and WLAs based on their current permit limits and permitted design flows. In addition any general permits need evaluation to determine if a site specific permit is needed to address sediment loading. Based on the assessment of sources, point sources do not contribute to water quality impairment relative to sediment impacts on stream biology. Thus, the WLAs are zero percentage net reduction in sediment load. These facilities' WLAs are set at the current permit limits and conditions. The WLAs listed in this TMDL do not preclude the establishment of future point sources of sediment loading in the watershed. Any future point sources should be evaluated in light of the TMDL established and the range of flows into which any additional load will impact.

Table 6. WLA for site specific permitted facilities.

Facility - CAFOs	Permit number	WLA (tons/day) d/w/m*
S & K Custom Works	MO-G010618	0/0/0
Facility – Other		
Lancaster WWTF	MO-0039691	NA/0.07/ 0.02
Memphis WWTF	MO-0041173	NA/0.11/0.04
Baring S WWTF	MO-0045811	NA/0.008/0.003
Baring N WWTF	MO-0056642	NA/0.005/0.002
Gorin R-III School	MO-0091677	NA/0.0004/0.00005
Social Restaurant/Lounge	MO-0101834	NA/0.0006/0.0002
Ewing WWTF	MO-0104671	NA/0.03/0.01
Downing WWTF	MO-0109240	NA/0.02/0.007
Country Aire Retirement	MO-0112615	NA/0.004/0.002
Lewistown WWTF	MO-0120570	NA/0.03/0.01
Monticello WWTF	MO-0123803	NA/0.01/0.003

*Permit limits based on current design loads where d=daily, w=weekly average, m=monthly average.

General permitted facilities in the watershed with MOG-35xxxx are required to have a Storm Water Pollution Prevention Plan (SWPPP). General permits MOG-49xxxx limit non-stormwater discharges to TSS concentrations of 70 mg/L and stormwater discharges of settleable solids (SS) to 1.5 ml/L/hr. General permits MOG-64xxxx limit SS to 1.0 ml/L/hr and this WLA also requires the inclusion of BMPs. General permits MOG-67xxxx are limited to a discharge TSS concentration of 100 mg/L. General permits MOG-82xxxx are non-discharging and have a WLA of zero (0).

Stormwater runoff from all permitted facilities, also discharge to the stream. Compliance with the Missouri Storm Water Permit (MOR-101xxx to 108xxx) will ensure construction sites meet the TMDL area weighted loadings. The permittee will develop a SWPPP. The SWPPP ensures the design, implementation, and maintenance BMPs. Permits MOR-109xxx cover land disturbances near valuable water resources and have more specific requirements for BMPs and specific requirements for activities undertaken within 50 feet of a stream or drainage areas. These requirements are outlined in Missouri

Department of Natural Resources (MDNR) publications. Permits MOR-24xxxx apply to stormwater discharges and limit SS to a daily maximum of 1.5 mL/L/hr and a monthly average of 1.0 mL/L/hr. EPA assumes that construction activities in the watershed will be conducted in compliance with Missouri's Storm Water Permit including monitoring and discharge limitations. Compliance with this permit should lead to sediment loadings from the construction site at or below applicable targets.

7 Load Allocation (Non-point Source Loads)

LA is the allowable amount of the pollutant that can be assigned to non-point sources. The TMDL curve in Figure 2 is set at an estimate of reference conditions over the range of flows. The LA is set at 90% of the TMDL curve.

8 Margin of Safety

A Margin of Safety (MOS) is added to a TMDL to account for the uncertainties inherent in the calculations and data gathering. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

- (1) Explicit – Reserve a numeric portion of the loading capacity as a separate term in the TMDL.
- (2) Implicit – Incorporate the MOS as part of the critical conditions for the WLA and the LA calculations by making conservative assumptions in the analysis.

Available data for North Fabius River shows instances where load exceeds the TMDL (Figure 2). To account for uncertainties in the modeling an explicit 10% MOS is assigned to this TMDL. As an example, with a flow probability of 0.5 (median flow) the TMDL is 10.1 tons/day and the MOS would be 1.0 tons/day.

9 Seasonal Variation

The TMDL curve represents flow under all seasonal conditions. The LA and TMDL (expressed as concentrations) are applicable at all flow conditions, hence all seasons. The advantage of LDC approach is to avoid the constraints associated with using a single-flow critical condition during the development of a TMDL. Therefore, all flow conditions including seasonal variation are taken into account for TMDL calculations.

10 Monitoring Plans for North Fabius River

No future monitoring has been scheduled for North Fabius River at this time. However, MDNR will routinely examine physical habitat, water quality, invertebrate community, and fish community data collected by the Missouri Department of Conservation under its Resource Assessment and Monitoring (RAM) Program. This

program randomly samples streams across Missouri on a five to six year rotating schedule.

11 Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this TMDL for North Fabius River on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: <http://www.epa.gov/region07/water/apprtmdl.htm#Missouri>.

This water quality limited segment of North Fabius River in Schuyler, Scotland, Clark, Adair, Knox, Lewis and Marion Counties, Missouri, is included on the EPA approved 1998 and 2002 303(d) lists for Missouri. This TMDL is being produced by EPA to meet the requirements of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001. EPA is developing this TMDL in cooperation with the State of Missouri, and EPA is establishing this TMDL at this time to fulfill the *American Canoe* consent decree obligations. Missouri may submit and EPA may approve another TMDL for this water at a later time.

As part of the public notice process, MDNR assists EPA by providing a distribution list of interested persons to which EPA will provide an announcement of the North Fabius River TMDL. Groups that receive the public notice announcement include the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, Stream Team Volunteers in the county, county legislators, and potentially impacted cities, towns and facilities. EPA will respond to comments on this draft TMDL after public notice ends on September 29, 2006, and will post the response to comments on the EPA website: <http://www.epa.gov/region07/water/apprtmdl.htm#Missouri>.

References

Missouri Department of Natural Resources (MDNR) (2005). Total Maximum Daily Load (TMDL) Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment, <http://www.dnr.mo.gov/env/wpp/tmdl/info/habitat-info.pdf>

Missouri Department of Natural Resources (MDNR) (2007). Quality Assurance Project Plan for Wasteload Allocations/Special Studies

Kansas Department of Health and Environment (KDHE) (2000). Upper Wakarusa River TMDL (Sediment Impact on Aquatic Life), <http://www.kdheks.gov/tmdl/klr/UpWakaTSS.pdf> and Little Arkansas River TMDL (Sediment Impact on Aquatic Life), <http://www.kdheks.gov/tmdl/la/LittleArkSed.pdf>

USDA (2002). NASS Quick Stats (Livestock) Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data
http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf

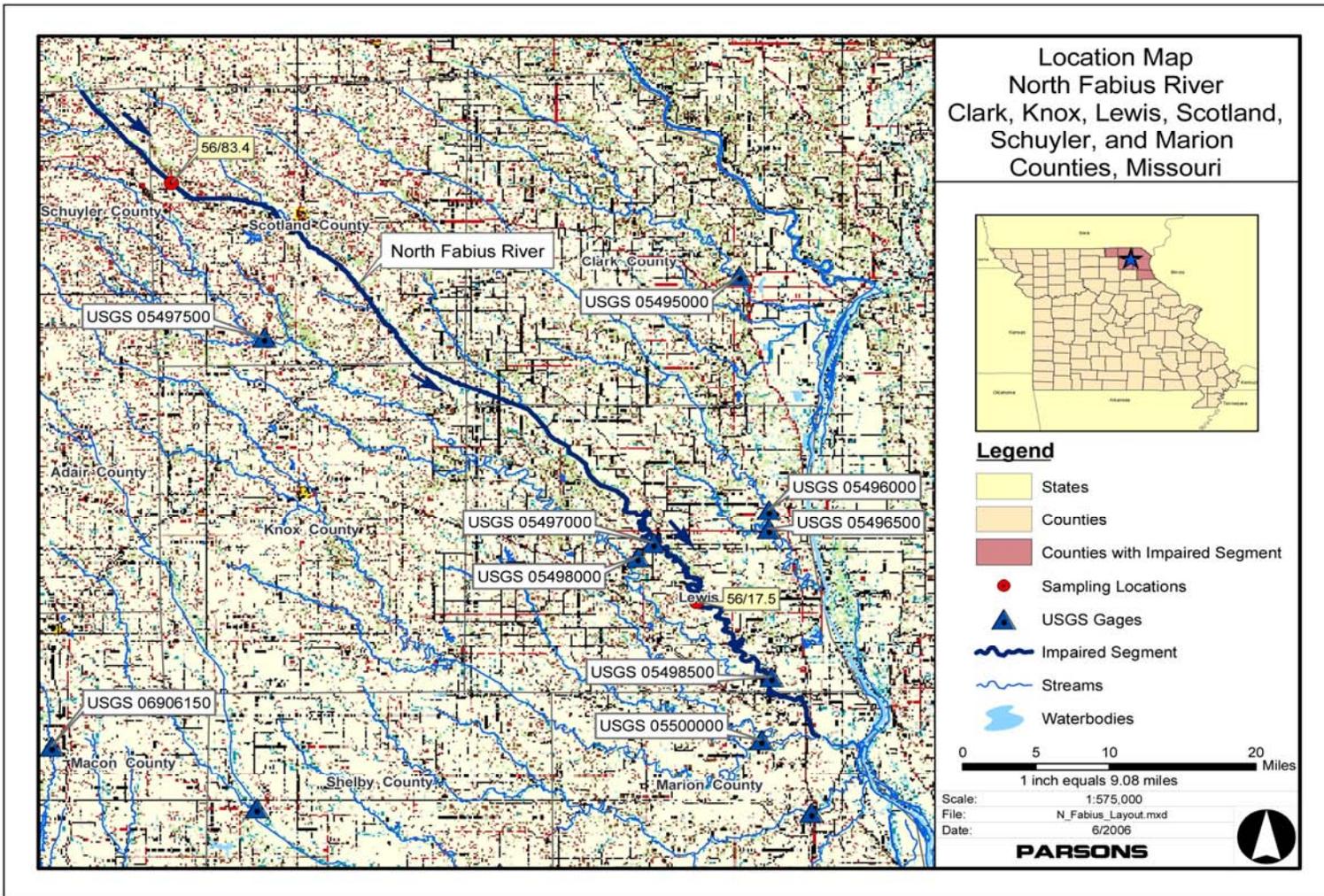
USEPA (2006). Development of Suspended Sediment Targets using Reference Load Duration Curves, EPA Region 7, Kansas City, KS

Appendices

Appendix A: Location Map for North Fabius River

Appendix B: Development of Suspended Sediment Targets using Reference Load Duration Curves

Appendix C: Data sources Used to Develop TMDL



Appendix A: Location Map for North Fabius River

Appendix B

Development of Suspended Sediment Targets using Reference Load Duration Curves

Overview

This procedure is used when a lotic system is placed on the 303(d) impaired waterbody list for a pollutant and the designated use being addressed is aquatic life. In cases where pollutant data for the impaired stream is not available a reference approach is used. The target for pollutant loading is the 25th percentile calculated from all data available within the ecological drainage unit (EDU) in which the waterbody is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case a synthetic flow record is needed. In order to develop a synthetic flow record calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is entirely contained within the EDU. From this synthetic record develop a flow duration from which to build a load duration curve for the pollutant within the EDU.

From this population of load durations follow the reference method used in setting nutrient targets in lakes and reservoirs. In this methodology the average concentration of either the 75th percentile of reference lakes or the 25th percentile of all lakes in the region is targeted in the TMDL. For most cases available pollutant data for reference streams is also not likely to be available. Therefore follow the alternative method and target the 25th percentile of load duration of the available data within the EDU as the TMDL load duration curve. During periods of low flow the actual pollutant concentration may be more important than load. To account for this during periods of low flow the load duration curve uses the 25th percentile of EDU concentration at flows where surface runoff is less than 1% of the stream flow. This results in an inflection point in the curve below which the TMDL is calculated using this reference concentration.

Methodology

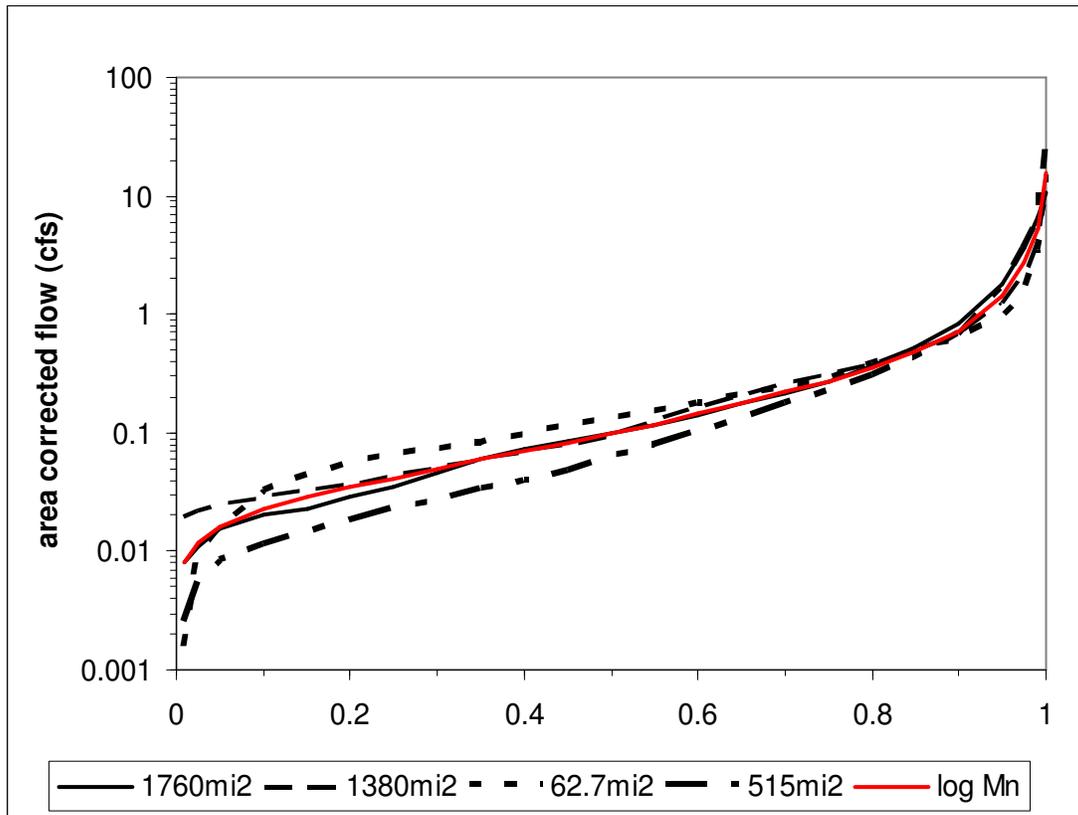
The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both the date and pollutant concentration are needed in order to match the measured data to the synthetic EDU flow record.

Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the

relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow.

The following examples show the application of the approach to one Missouri EDU.

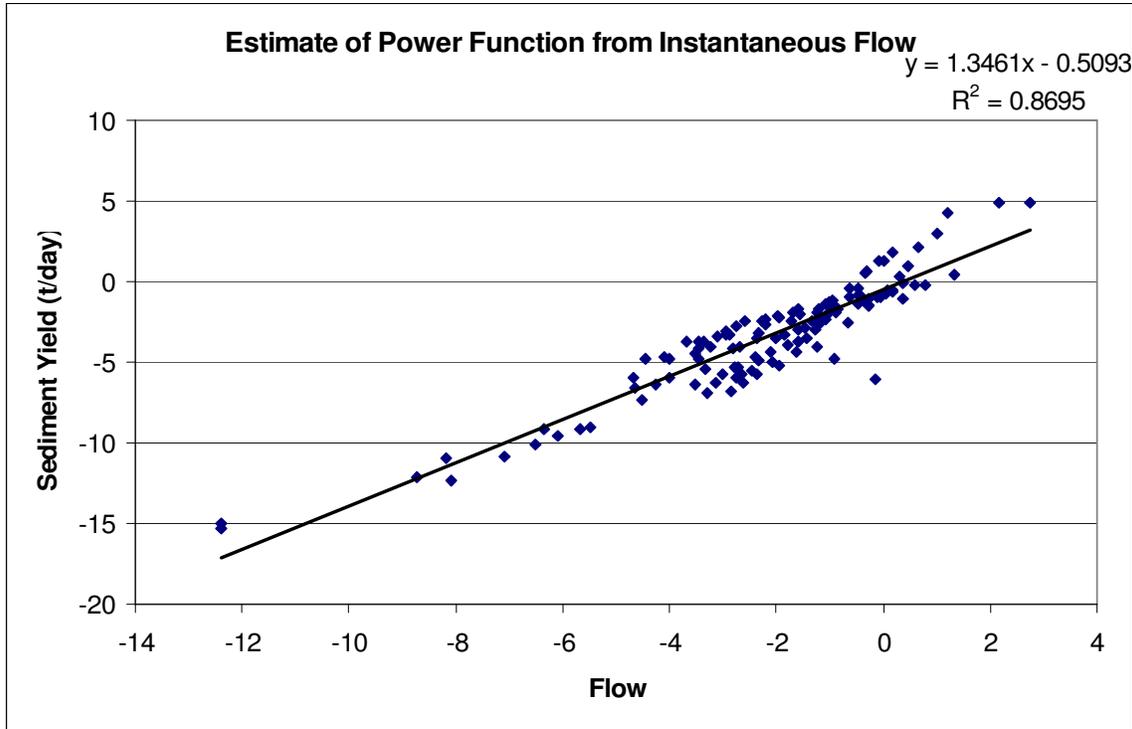
The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The result of this analysis is displayed in the following figure and table:



Gage	gage	area (mi ²)	normal Nash-Sutcliffe	lognormal Nash-Sutcliffe
Platte River	06820500	1760	80%	99%
Nodaway River	06817700	1380	90%	96%
Squaw Creek	06815575	62.7	86%	95%
102 River	06819500	515	99%	96%

This demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi²/day) and the instantaneous flow (cfs/mi².) The following graph shows the EDU relationship:



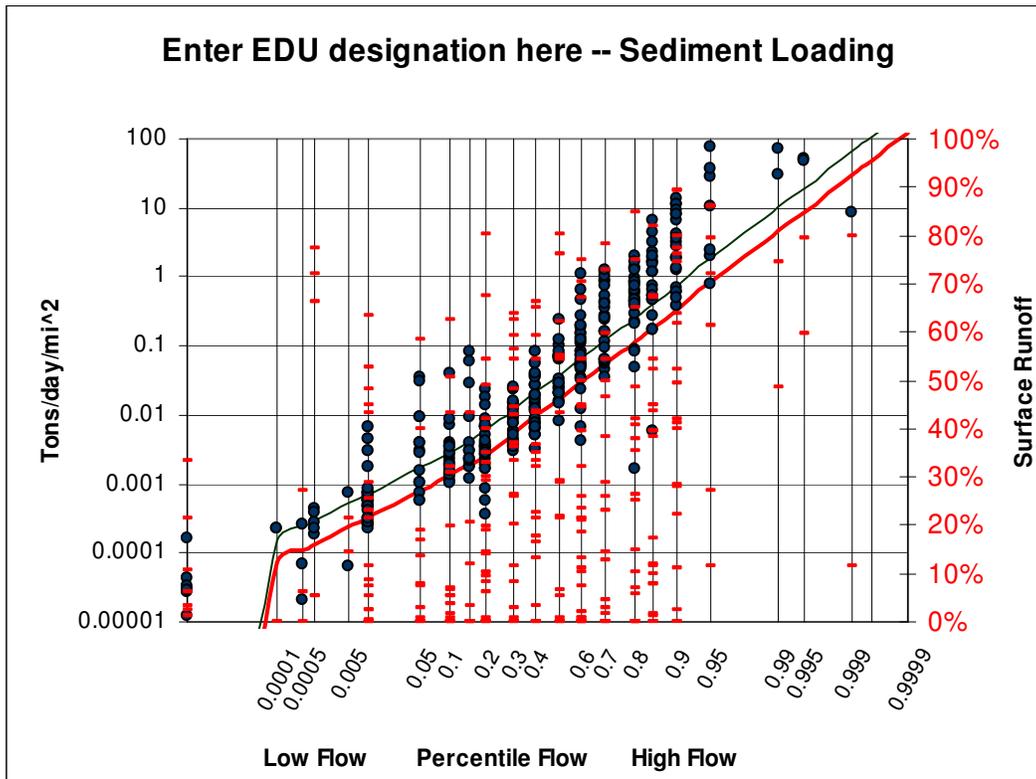
Further statistical analyses on this relationship are included in the following Table:

m	1.34608498	b	-0.509320019
Standard Error (m)	0.04721684	Standard Error (b)	0.152201589
r ²	0.86948229	Standard Error (y)	1.269553159
F	812.739077	DF	122
SSreg	1309.94458	SSres	196.6353573

The standard error of y was used to estimate the 25%ile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z₇₅ statistic times the standard error of (y). The resulting TMDL Equation is the following:

$$\text{Sediment yield (t/day/mi}^2\text{)} = \exp(1.34608498 * \ln(\text{flow}) - 1.36627)$$

A resulting pooled TMDL of all data in the watershed is shown in the following graph:



To apply this process to a specific watershed would entail using the individual watershed data compared to the above TMDL curve that has been multiplied by the watershed area. Data from the impaired segment is then plotted as a load (tons/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis.

For more information contact:
 Environmental Protection Agency, Region 7
 Water, Wetlands, and Pesticides Division
 Total Maximum Daily Load Program
 901 North 5th Street
 Kansas City, Kansas 66101
 Website: <http://www.epa.gov/region07/water/tmdl.htm>

Appendix C

Data sources Used to Develop TMDL

USGS stream gages used to generate synthetic flow

Wyaconda River above Canton, MO	05496000
North Fabius at Monticello, MO	05497000
Middle Fabius River near Monticello, MO	05498000
South Fabius River near Taylor, MO	05500000
North Fork Salt River near Shelbina, MO	05502500

USGS stream sample sites used to generate EDU TMDL

Middle Fabius River nr Monticello, MO	05498000
Salt River nr Shelbina, MO	05502500
Salt River nr Hunnewell, MO	05503500
South Fork Salt River at Santa Fe, MO	05505000
Youngs Creek nr Mexico, MO	05506000
Middle Fork Salt River nr Paris, MO	05506500
Elk Fork Salt River nr Paris, MO	05507000