Missouri Department of Natural Resources
Water Pollution Control Program

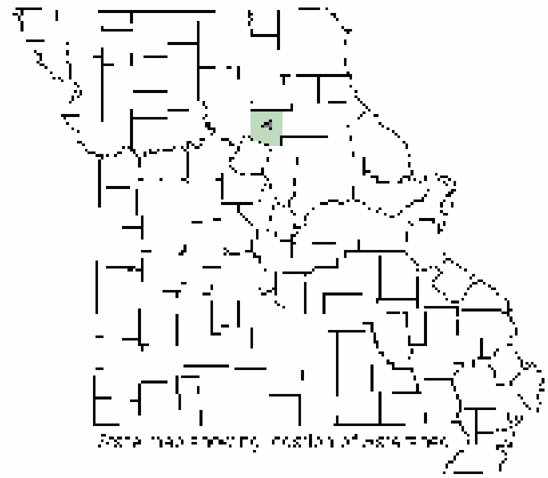
Total Maximum Daily Load (TMDL)

for

Sugar Creek
Randolph County, Missouri

Completed: November 25, 2002
Approved:

Final Total Maximum Daily Load (TMDL)
For Sugar Creek
Pollutant: Low pH



Name: Sugar Creek

Location: Randolph County near Huntsville, Missouri

Hydrologic Unit Code (HUC): 10280203-040002

Water Body Identification (WBID): 0686

Missouri Stream Class: P[1]

Beneficial uses:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life and Human Health associated with Fish Consumption

Size of Impaired Segment: 2.7 mile[2]

Legal Description of Impaired Segment: The upstream end of this segment is in SW Section 19, T54N, R14W at the Moberly Lake (also called Sugar Creek Lake) dam and the downstream end is in SE Section 23, T54N, R15W at its mouth, where it empties into the East Fork of the Chariton River.

Pollutant: Low pH

Pollutant Sources: 1.52 mile due to Huntsville Abandoned Mine Land
1.18 mile due to Calfee Mine Flow

TMDL Priority Ranking: Low

1. Background and Water Quality Problems

Area History[3]:
Sugar Creek originates in central Randolph County. It exits Moberly Lake (also called Sugar Creek Lake) and flows westerly past Huntsville into the East Fork of the Chariton River, where it is a

[1] Class P streams maintain flow even during drought conditions. See Missouri Water Quality Standards 10 CSR 20-7.031(1)(F). Sugar Creek and its watershed are developed in glacial till overlying Pennsylvanian aged bedrock and the creek is considered a prairie stream. Missouri's Water Quality Standards allow prairie type Class P streams to be classified as "limited" warmwater fisheries.
[2] The length of the impaired portion was incorrectly listed as 1.5 miles on the 1998 303(d) list, 1.0 mile due to Huntsville AML and 0.5 from the Calfee Mine Flow. This will be corrected on the 2002 303(d) list.
[3] History of the Moberly Area, http://www.moberly.com/chamber/history.htm

major tributary. Legals for the upstream and downstream end of the impaired segment are given above.

Randolph County was named for John Randolph, Virginia statesman and an early advocate of the States' Rights doctrine. He served in the US Senate from 1825 –1827. In 1829, Randolph County was carved from its neighbor to the west, Chariton County, which in turn was carved from Howard County to the south in 1820. Eight years after it was formed, in 1837, a chunk of Randolph County helped create Macon County to the north. Pioneers from the southern states of Kentucky, Tennessee and Virginia settled the county, so the area became known as Little Dixie. Some settlers were slave owners while others were strict abolitionists. Even though no major battles were fought on county soil during the Civil War, the war took its toll. Randolph County lives were lost and the North Missouri Railroad Company, with its north-south line, was a target of both sides.

A unique geographic feature of the county is the “great divide”. This high ridge of land divides the water flowing to the Mississippi River from the water flowing to the Missouri. It stretches from Boone County, Missouri, north to Iowa and is easily distinguished as one travels through the county. Moberly sits on the divide and, because of this, was thought to be safe from tornadoes. This was disproved on July 4, 1995, when a tornado ripped through the center of town.

Huntsville is the county seat. There was a long-standing rivalry between Moberly and Huntsville for the county seat.

Soils and Land Use:
The low land soils are Piopolis silty clay loam and Bremer silt loam. These are nearly level soils with poor drainage. Both the permeability and the runoff are slow. The uplands consist of the Gosport-Gorin soil association. This association is low in natural fertility and organic matter. Permeability is slow and the runoff is medium to rapid depending on slope, which varies from 5-30 percent. Land use in the Sugar Creek watershed is predominately row and close-grown crops, grassland and woodland (See Appendix A).

Defining the Problem:
Many small coal-mining operations in the Huntsville area pre-date the 1940s. Large parts of the area around Huntsville lie over abandoned, underground coal mines that were most actively mined in the early 1900s. From approximately 1943 until 1950, Huntsville-Sinclair Mining Company mined the area. Peabody Coal Company purchased mineral rights in 1950 and mined until 1955. Numerous occurrences of ground subsidence and red, acidic water have been reported by residents of the area. Eroding coal waste areas just east of Huntsville sent large amounts of coal wastes into Sugar Creek and one of its tributaries, and even spilled coal wastes over five acres of farmland. When sulfide minerals in rocks are exposed to water and oxygen, they oxidize and form highly acidic (low pH) iron- and sulfate-rich drainage, which is harmful to aquatic life. Pyrite and marcasite are the iron sulfides common in coal regions. These minerals have a significant presence in a large amount of the coal wastes around Sugar Creek. The water draining through these coal wastes was extremely acid and 1.5 miles of Sugar Creek was polluted by acid mine drainage (AMD). The acid problems caused by the flow of surface water were aggravated by acid water emerging from flooded underground coal mines. Other problems were steep areas, unstable banks of coal waste and even places where coal waste was burning.

The negative impact on water and land resources downstream of the gob pile (coal wastes) was a major concern to the state and a headache to landowners. From 1983 to 1994, at a cost of $4.3 million, the Missouri Department of Natural Resources conducted reclamation projects on three coal waste areas in the Huntsville Abandoned Mine Land totaling 109 acres. Reclaiming these areas included removing coal wastes from a one-mile length of Sugar Creek and from a major tributary (sometimes called Huntsville Gob Branch) draining the Huntsville gob pile. Prior to reclamation, adjacent farmlands were contaminated by acidic coal waste sediment when they flooded. The reclamation removed coal waste sediment from approximately five acres of prime farmland and hauled back to the gob pile. A total of 90,000 tons of sediment was removed. The gob pile was graded to a gentle slope and two feet of cover material was spread above the coal waste and revegetated. The cover material was excess glacial till overburden (soil layer on top of the rock) from the Moberly Stone limestone quarry southeast of the reclamation site. No reclamation has been conducted below the Calfee Slope Seep (or the Calfee Mine Flow).

Acidity problems in Sugar Creek are less serious now than prior to reclamation due to the elimination of erosion of coal wastes. However, acid problems persist in the lower 1.5 miles of Sugar Creek because acid groundwater still seeps from the reclaimed areas. Also, acid mine drainage (AMD) from underground workings continues to affect the tributary draining the Huntsville gob pile. Drainage from the gob pile travels approximately one mile down this tributary before entering Sugar Creek. The groundwater recharge of the underground mine voids maintains a steady flow of AMD largely independent of precipitation. While Sugar Creek dilutes the AMD for much of the year, dilution is reduced during summer and then water quality in the creek declines. The mine openings cannot be closed since the hydrostatic head will build resulting in a blowout at the mine opening or at some other unknown point. Filling the mine voids to prevent groundwater contamination would be cost prohibitive. A solution to these problems has yet to be found.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

Designated Uses:
The designated uses of Sugar Creek, WBID 686, are:

- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life and Human Health associated with Fish Consumption.

The Limited Warm Water Fishery classification applies to this prairie stream. The stream classifications and designated uses may be found at 10 CSR20-7.031(1)(C) and Table H.

Anti-degradation Policy:
Missouri's Water Quality Standards include the Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier I defines baseline conditions for all waters and requires that existing beneficial uses are protected. TMDLs would normally be based on this tier, assuring that numeric criteria (such as dissolved oxygen and ammonia) are met to protect uses.

Tier II requires that no degradation of high-quality waters occur unless limited lowering of quality is shown to be necessary for "economic and social development." A clear implementation policy for this tier has not been developed, although if sufficient data on high-quality waters are available, TMDLs could be based on maintaining existing conditions, rather than the minimal Tier I criteria.

Tier III (the most stringent tier) applies to waters designated in the water quality standards as outstanding state and national resource waters; Tier III requires that no degradation under any conditions occurs. Management may prohibit discharge or certain polluting activities. TMDLs would need to assure no measurable increase in pollutant loading.

These TMDLs will result in the protection of existing beneficial uses, which conforms to Missouri's Tier I anti-degradation policy.

Specific Criteria:

pH Standards

Missouri's Water Quality Standards (WQS), 10 CSR20-7.031 Section (4)(E), states that water contaminants shall not cause pH to be outside of the range of 6.5-9.0 Standard Units (SU).

Mixing Zone

Because the AML area is a diffuse nonpoint source, mixing zone allowances will not apply to this TMDL recommendation.

Numeric Water Quality Targets

pH is the expression of hydrogen ion activity in water and is highly dependent on chemical reactions that consume or produce hydrogen ions. In natural waters, these chemical reactions determine the assimilative "buffering" capacity of the solution to neutralize additional acidity or alkalinity. For TMDL loading purposes, pH will be used to determine the alkalinity required to buffer the acidity present in Sugar Creek. The pH water quality target will be the state standard of 6.5-9.0 SU.

As discussed in the Margin of Safety (Section 6), the pH criterion alone may not provide sufficient assurance that the proper pH range will be maintained in Sugar Creek. This is due to possible latent acidity. Net alkalinity is the preferred secondary water quality target because it may be treated as a conservative constituent. However, the lack of acidity data for the site makes a statistical analysis of net alkalinity difficult. Review of data from this site and nearby Cedar Creek, (which is similar), suggests that total acidity will not be significant at higher total alkalinity values. Thus, total alkalinity is a good approximation of net alkalinity at Sugar Creek. For this reason, total alkalinity will be used as the secondary numeric water quality target. To assure that the pH water quality standard is met and maintained in Sugar Creek, Missouri calculates the total alkalinity target to be 90 mg/L or more year round.

3. Loading Capacity

The Loading Capacity (LC) is the greatest amount of pollutant loading that a stream can assimilate without becoming impaired. It is equal to the sum of the Load Allocation (LA), the Wasteload Allocation (WLA) and the Margin of Safety (MOS).

Dry weather design flow from the Sugar Creek AML can not be accurately determined because surface flow and seepage rates from this area are variable. Sugar Creek is a Class P stream, which maintains permanent flow even in dry periods. Dry weather design flow is therefore 0.1 cfs or greater. Since there can be minimal upstream dilution during dry weather conditions, the flow of water coming from the Sugar Creek AML area will have to meet in-stream water quality standards for pH (6.5-9.0 SU) and an alkalinity of 90 mg/L or more. Neither the pH nor the alkalinity concentrations used as the numeric TMDL endpoints can be summed as Load Allocations (LAs) + Wasteload Allocations (WLAs) + Margin of Safety (MOS).

4. Load Allocations (Nonpoint Source Load)

Load Allocation (LA) is the maximum allowable amount of the pollutant that can be assigned to nonpoint sources. Since the Load Capacity for Sugar Creek is concentration based, discharges to the stream will be required to meet the 70 mg/L alkalinity target.

5. Wasteload Allocation (Point Source Load)

The Wasteload Allocation (WLA) is the maximum allowable amount of the pollutant that can be assigned to point sources. There are presently no point sources discharging to the affected segment of Sugar Creek; therefore, the WLA is zero.

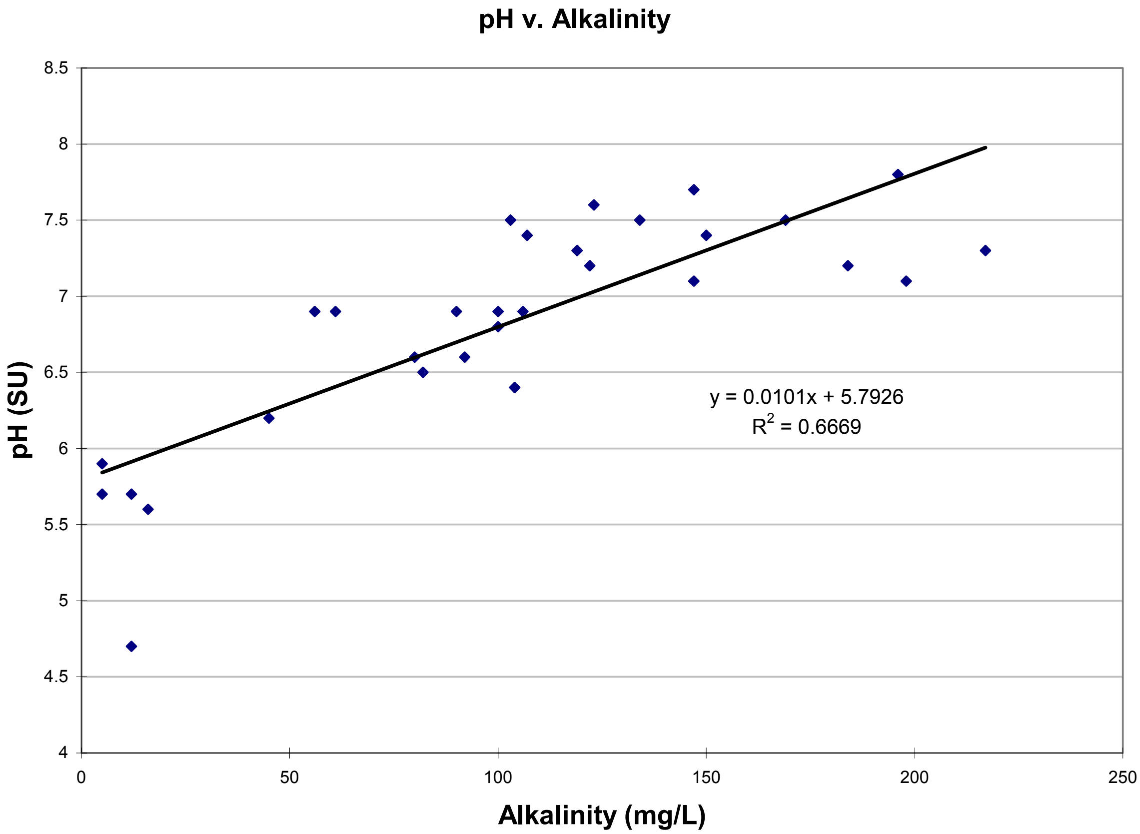
6. Margin of Safety (MOS)

The Margin of Safety (MOS) is an additional 20 mg/L of alkalinity above the 70 mg/L that would otherwise correspond to a pH of 6.5 based on a regression analysis. The alkalinity target is therefore 90 mg/L. As stated before, the pH criterion alone may not provide sufficient assurance that the proper pH range will be maintained in Sugar Creek. This is due to possible latent acidity. Net alkalinity would be the preferred secondary water quality target, but the lack of sufficient acidity data make this analysis difficult. Therefore, total alkalinity will be used as the secondary numeric water quality target. Alkalinity is a measurable characteristic in Sugar Creek and can be linked to the pH water quality criterion. Alkalinity has units of mg/L as $CaCO_3$ (calcium carbonate) as discussed in Standard Methods for the Examination of Water and Wastewater.

An Ordinary Least Squares approach was used to calculate the regression line (Figure 1) and associated statistics for Sugar Creek pH and alkalinity values[4]. The predicted alkalinity associated with a pH of 6.5, with a confidence interval of 95 percent, would be 70 mg/L alkalinity ± 20 mg/L alkalinity. Choosing the upper confidence limit of +20 mg/L alkalinity, an in-stream target of 90 mg/L alkalinity (70 mg/L + 20 mg/L) should assure adequate buffering to prevent in-stream pH values from dropping below 6.5. To ensure that the pH water quality standard is met and maintained in Sugar Creek, the total alkalinity target is set at 90 mg/l or more year round.

[4] See Appendix C for the Ordinary Least Squares (OLS) Analysis

Figure 1. The Relationship of pH and Alkalinity in Sugar Creek, Randolph County, MO



<u>Regression Analysis</u>

Mean pH	6.827
Mean Alkalinity	102.733
Sum of Squares (x^2 = Alkalinity)	101627.776
Sum of Squares (y^2 = pH)	15.439
Sum of Squares (xy = Alkalinity and pH)	1022.934
Pearson Correlation Coefficient	0.817
Regression Slope	0.0101
Mean Square Error	0.184
Standard Error of the Regression	0.429

The data used to generate the pH and alkalinity relationship can be found in Table 1 (for site locations, see map in Appendix B). These data span a number of years, seasons, flows and sampling locations. As a result, these data are representative of all the conditions that may reasonably be expected to occur in Sugar Creek, and should be sufficient to construct a reasonable model of the behavior of the pH and alkalinity in Sugar Creek.

Table 1. Sugar Creek Data

ID	Site	Site Name	Year	Mo	Day	pH	Alk
55	686/1.1	Sugar Cr. below Calfee trib.	2000	3	15	5.7	4.99
64	686/1.1	Sugar Cr. below Calfee trib.	2000	4	24	4.7	12
101	686/1.1	Sugar Cr. below Calfee trib.	2000	7	21	6.6	80
478	686/1.1	Sugar Cr. below Calfee trib.	2000	11	29	6.8	100
479	686/1.1	Sugar Cr. below Calfee trib.	2001	3	6	7.5	103
446	686/1.1	Sugar Cr. below Calfee trib.	2001	6	14	7.3	119
469	686/1.1	Sugar Cr. below Calfee trib.	2001	9	4	5.7	12
495	686/1.1	Sugar Cr. Below Calfee trib.	2001	10	25	6.9	100
508	686/1.1	Sugar Cr. below Calfee trib.	2001	12	20	6.2	45
520	686/1.1	Sugar Cr. below Calfee trib.	2002	1	10	6.9	56
60	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2000	3	15	5.9	4.99
69	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2000	4	24	5.6	16
100	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2000	7	21	6.9	90
476	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2000	11	29	6.4	104
410	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2001	3	6	7.4	107
447	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2001	6	14	7.2	122
471	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2001	9	4	6.5	82
496	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2001	10	25	6.9	106
506	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2001	12	20	6.6	92
518	686/1.3	Sugar Cr. 0.1mi. above Calfee trib.	2002	1	10	6.9	61
63	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2000	3	15	7.5	134
72	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2000	4	24	7.7	147
97	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2000	7	21	7.3	217
477	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2000	11	29	7.2	184
413	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2001	3	6	7.6	123
480	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2001	6	14	7.4	150
473	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2001	9	4	7.1	147
499	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2001	10	25	7.8	196
504	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2001	12	20	7.5	169
516	686/2.6	Sugar Cr. 0.2 mi. above Huntsville Gob trib.	2002	1	10	7.1	198
				Mean		**6.827**	**102.733**

pH in Standard Units
Alk = Alkalinity in mg/L as $CaCO_3$

7. Seasonal variation

The water quality data collected to this point represents all seasons, but no conclusions about seasonal trends are evident. The primary processes involved in the formation of acid water and the oxidation of sulfide are not significantly impacted by differences in air and water temperatures associated with seasonal change.

8. Monitoring Plan for TMDLs Developed Under the Phased Approach

Since these are phased TMDLs, the department will continue low flow water chemistry monitoring of Sugar Creek during implementation and post-implementation. Monitoring is also part of the Agriculture Nonpoint Source Special Area Land Treatment project to assess progress and measure success. After the restoration plan (to be determined by the Feasibility Study) has been implemented, time will be allowed for the stream to respond. If post-implementation monitoring reveals that water quality standards are still not being met for pH (6.5 to 9.0 SU) or the numeric target is not being met for alkalinity (90 mg/L or more), then this TMDL will be re-opened and re-evaluated.

9. Implementation Plans

A proposal for an Agriculture Nonpoint Source (AgNPS) Special Area Land Treatment (SALT) project for the Sugar Creek and Dark Creek watersheds was approved in May 2002. This is a seven-year project to be completed by June 30, 2009. One of the objectives is to improve the quality of water entering Sugar Creek. Many of the practices offered will indirectly reduce the acid mine drainage which is the identified pollutant. Available management practices include critical area land treatment, tree planting and runoff control in addition to the more traditional agricultural practices such as livestock exclusion from riparian buffers and planned grazing systems. The watershed stakeholders will be involved via annual meetings, water quality demonstrations, Scout groups, civic groups, newsletters and adult field days. Additional support for the project is being provided by:

- Missouri Department of Conservation
- Associated Electric Cooperative Incorporated (AECI)
- University Outreach and Extension
- Missouri Lakes
- City of Moberly
- Randolph County Farm Bureau

Abandoned Mine Land (AML) funds are insufficient for the department’s Land Reclamation Program to undertake the more expensive remedies that might improve water quality in Sugar Creek (described below). And under the ranking system for AML sites, funds that are available would not likely be devoted to remediation efforts on Sugar Creek. The rankings give top priority to the protection of public health, safety and general welfare. Environmental restoration (improving water quality) is a Priority III under the current ranking system.

An alternative source of funds is available under Section 319 of the Clean Water Act. A 319 grant will be used for a Feasibility Study regarding restoration on Dark and Sugar creeks. The study will be part of a Watershed Management Plan. Partners in this study are U.S. Geological Survey

(USGS) and the Office of Surface Mining (OSM). The USGS will be performing monitoring and assessment, which will be coordinated with the AgNPS SALT project. OSM will be responsible for the economic and logistical feasibility of treatment options. The 319 grant has been approved and the study will be initiated in January 2003.

The AgNPS SALT project requires the creation of a watershed association in the Sugar Creek basin. The purpose of the group will be to develop workable solutions for the restoration of Sugar Creek. Citizen groups can also obtain funding from the Office of Surface Mining (OSM). OSM has the capability of designing a restoration plan and they may choose to help fund it. The restoration plan could include the anaerobic-wetland/alkalinity-producing type systems that have recently been constructed in the Upper Cedar Creek AML of Boone and Callaway counties. These systems are designed to neutralize acidity and remove metals, particularly sulfate. They allow acidic, iron-and sulfate-rich water to seep through an organic substrate and underlying bed of crushed limestone. The primary function of the organic matter is to consume dissolved oxygen and convert iron and manganese already in solution to reduced forms. These reactions are necessary so that the limestone gravel does not become coated with metal precipitates that would impair its ability to buffer the acidity of the runoff. Sulfate reduction is an important secondary benefit of the organic matter. The life of the wetlands and the organic/limestone/ag-lime cells in Upper Cedar Creek is calculated to be 20 years. The Feasibility Study will determine if this type of system would be appropriate for Sugar Creek.

This TMDL will be incorporated into Missouri's Water Quality Management Plan.

10. Reasonable Assurances

The department’s Water Pollution Control Program will continue low-flow water chemistry monitoring of Sugar Creek through implementation and beyond. Also, the citizen’s group under the Ag NPS SALT agreement is charged to follow through with certain responsibilities toward improving the creek. This, along with periodic review of the department’s Water Quality Management Plans and monitoring data by the department, should provide reasonable assurance that Sugar Creek will move towards meeting water quality standards.

11. Public Participation

This water quality limited segment of Sugar Creek is included on the approved 1998 303(d) list for Missouri. Six public meetings were held between Aug. 18 and Sept. 22, 1999 to allow input from the public on which waters were included on that list. No comments pertaining to Sugar Creek were received during those public meetings.

After the Missouri Department of Natural Resources develops a TMDL, it is sent to EPA for examination and then the edited draft is placed on public notice. The public notice period for the draft Sugar Creek TMDL was from October 11 to November 10, 2002. Groups receiving the public notice announcement included the Missouri Clean Water Commission, Randolph County head commissioner, the Water Quality Coordinating Committee, the TMDL Policy Advisory Committee, Randolph County Soil and Water Conservation District, Stream Team volunteers in the county (19), the appropriate legislators (2) and others that routinely receive the public notice of Missouri State

Operating Permits. A copy of the notice, the comments received and the department responses have been placed in the Sugar Creek file.

12. Administrative Record and Supporting Documentation

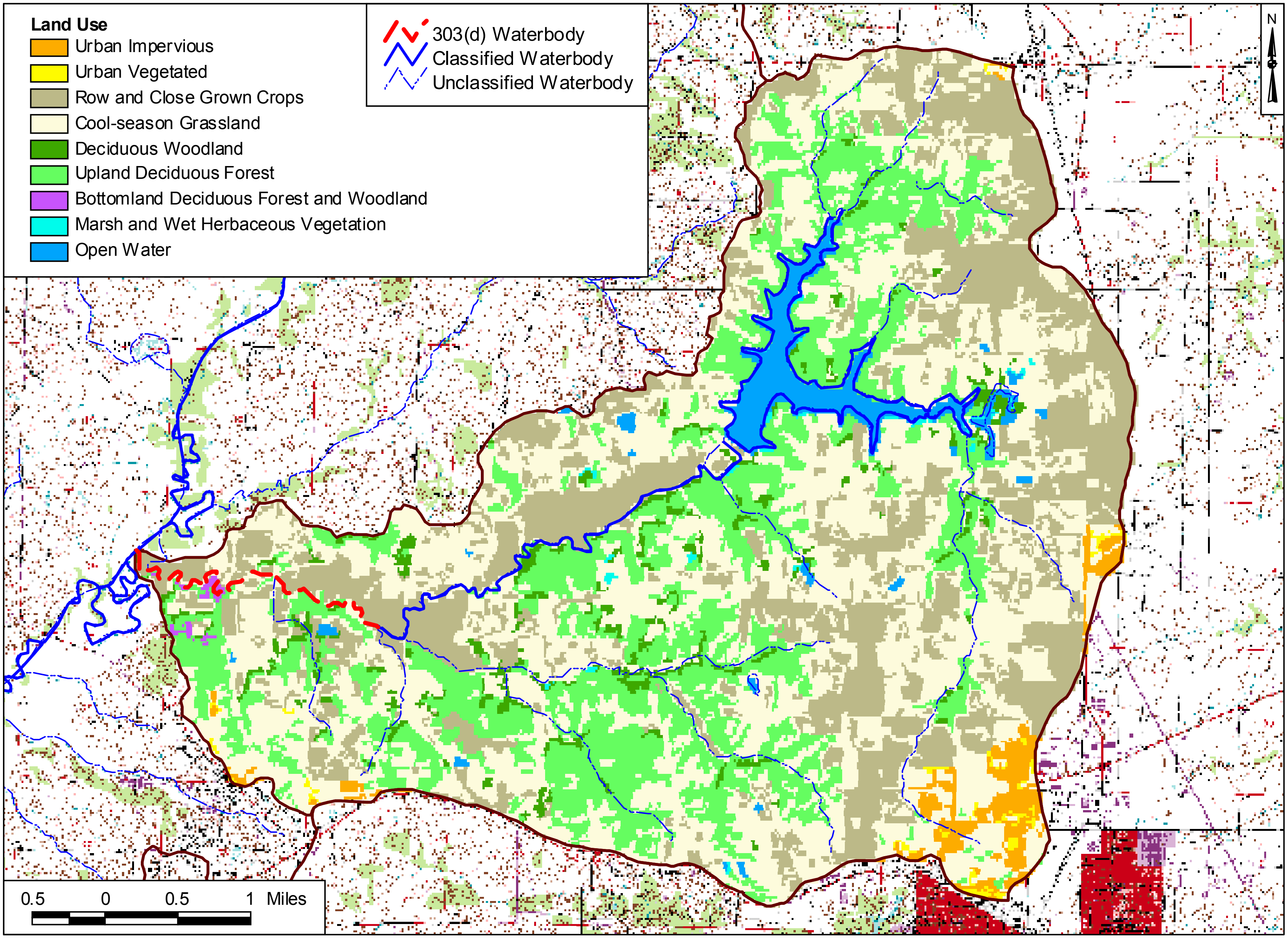
An administrative record on the Sugar Creek TMDL has been assembled and is being kept on file with the Missouri Department of Natural Resources. It includes the following:

- The Agriculture Nonpoint Source (AgNPS) Special Area Land Treatment (SALT) project for the Sugar Creek and Dark Creek watersheds
- The USGS/OSM Feasibility Study
- Sugar Creek data
- Public notice announcement
- Sugar Creek Information Sheet

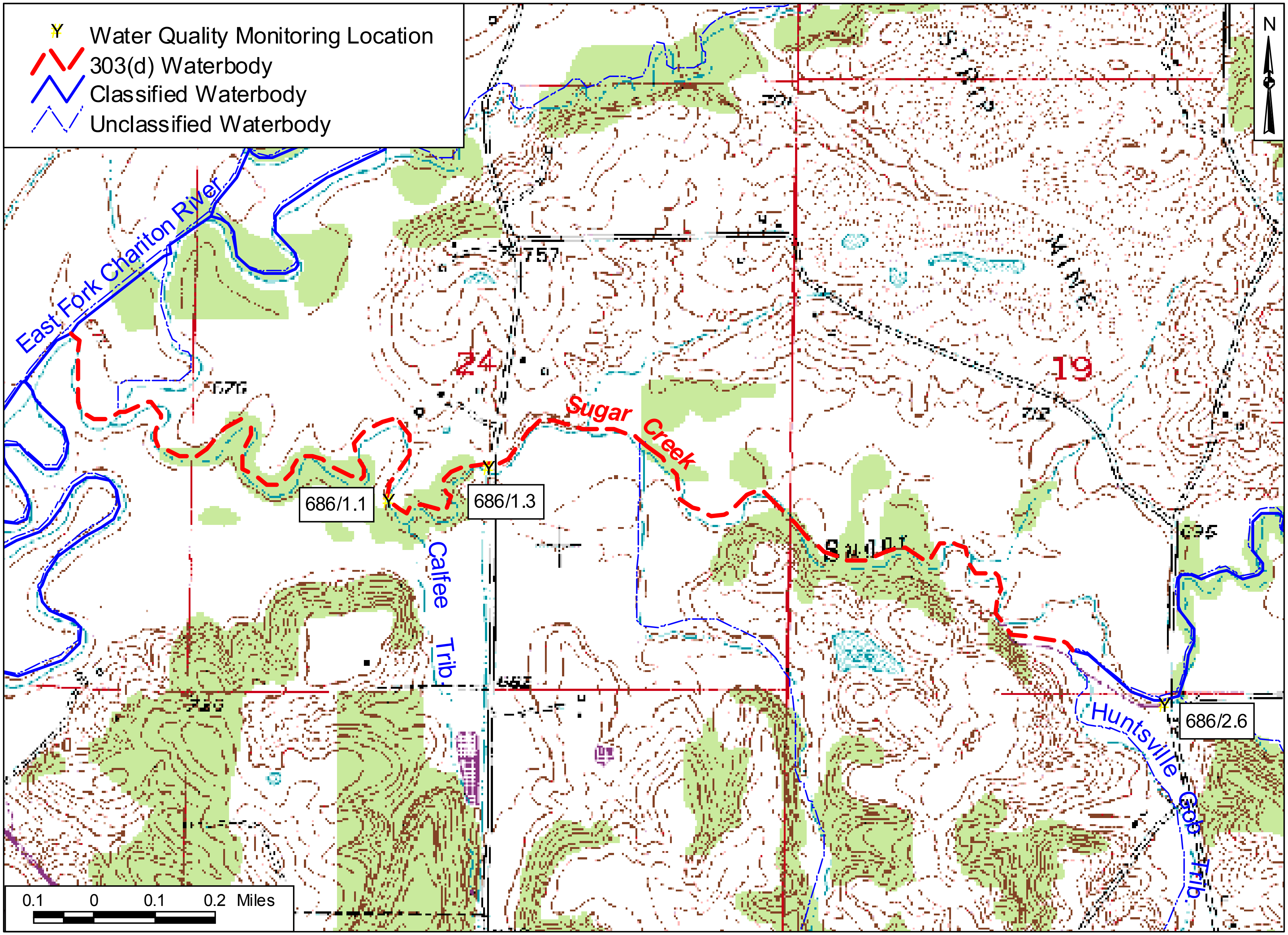
13. Appendices

- Appendix A – Land Use map for Sugar Creek watershed
- Appendix B – Topographic map showing sampling sites and impaired segment
- Appendix C – Ordinary Least Squares (OLS) Analysis

Appendix A - Land Use map for Sugar Creek watershed



Appendix B - Map of Sample Locations and Impaired Stream Segment of Sugar Creek, Randolph County, Missouri



Appendix C - Ordinary Least Squares (OLS) Analysis, Sugar Creek, Randolph County, Missouri

Ordinary Least Squares (OLS) Analysis
Sugar Creek, Randolph County, Missouri

Regression Statistics	
Multiple R	0.816650911
R Square	0.66691871
Adjusted R Square	0.65502295
Standard Error	0.428549506
Observations	30

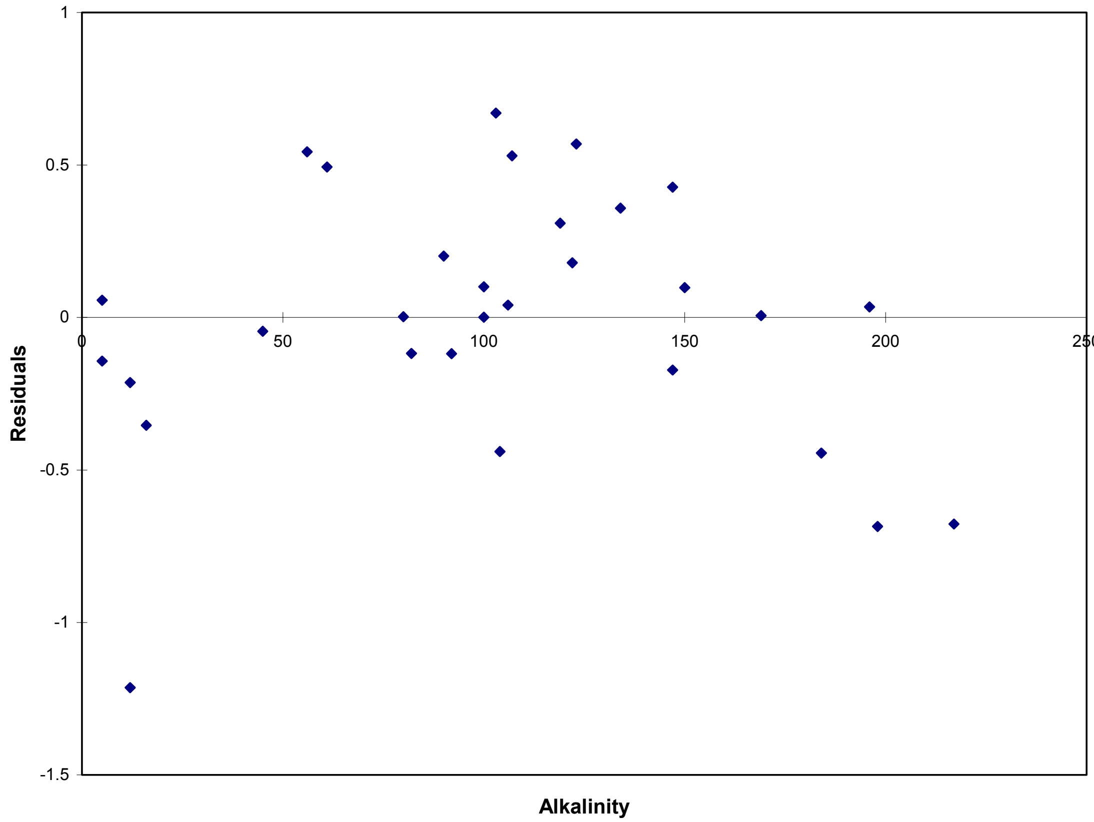
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	10.29634	10.29634	56.06356	3.72547E-08
Residual	28	5.14233	0.18365		
Total	29	15.43867			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	5.79261	0.15873	36.49416	3.71666E-25	5.46747	6.11775
Alk	0.01007	0.00134	7.48756	3.72547E-08	0.00731	0.01282

	Alk	pH	SS_x	SS_y	SS_{xy}	b	S^2	S
	12	4.7	8232.423	4.523	192.961	0.010065	0.183655	0.42855
	16	5.6	7522.561	1.505	106.395			
	4.99	5.7	9553.635	1.269	110.127			
	12	5.7	8232.423	1.269	102.229	**y = 0.0101x + 5.7926**		
	4.99	5.9	9553.635	0.859	90.578			
	45	6.2	3333.065	0.393	36.181	**n = 30**		
	104	6.4	1.606	0.182	-0.541			
	82	6.5	429.845	0.107	6.773			
	80	6.6	516.776	0.051	5.154	[redacted]		
	92	6.6	115.191	0.051	2.433			
	100	6.8	7.468	0.001	0.073	**MOS**	$\hat{y} \pm ts\sqrt{1/n + \frac{(x_o - \bar{x})^2}{SS_x}}$	
	56	6.9	2183.945	0.005	-3.426	0.183788		
	61	6.9	1741.618	0.005	-3.059			
	90	6.9	162.122	0.005	-0.933		95% Percentile: t = 2.048	
	100	6.9	7.468	0.005	-0.200			
	106	6.9	10.675	0.005	0.239	MOS = 0.183788		
	147	7.1	1959.594	0.075	12.098			
	198	7.1	9075.858	0.075	26.037	y + MOS	6.7	
	122	7.2	371.229	0.139	7.192	y - MOS	6.3	
	184	7.2	6604.374	0.139	30.337			
	119	7.3	264.625	0.224	7.699			
	217	7.3	13057.016	0.224	54.083	y = 6.5		
	107	7.4	18.210	0.329	2.446	x = 70.04	70.03960	
	150	7.4	2234.198	0.329	27.098			
	103	7.5	0.071	0.453	0.180	y = 6.7		**Upper 95% CI**
	134	7.5	977.644	0.453	21.052	x = 89.84	89.84158	
	169	7.5	4391.355	0.453	44.618			
	123	7.6	410.763	0.598	15.673	y = 6.3		**Lower 95% CI**
	147	7.7	1959.594	0.763	38.659	x = 50.24	50.23762	
	196	7.8	8698.789	0.947	90.777			
Mean:	**102.7**	**6.827**	**101627.776**	**15.439**	**1022.934**			

Alkalinity Residual Plot for OLS Analysis, Sugar Creek, Randolph County, Missouri



Normal Probability Plot for OLS Analysis, Sugar Creek, Randolph County, Missouri