Missouri Department of Natural Resources
Water Protection Program

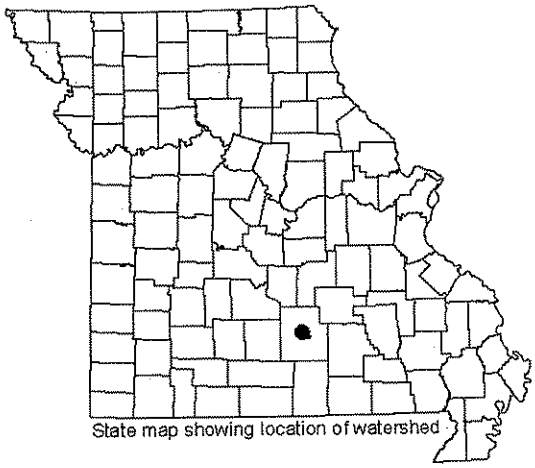
Total Maximum Daily Load (TMDL)

for

Brushy Creek
Texas County, Missouri

Completed: October 20, 2005
Approved: NOV 30 2005

Total Maximum Daily Loads (TMDLs)
For Brushy Creek
Pollutants: Biochemical Oxygen Demand (BOD)
Volatile Suspended Solids (VSS)


State map showing location of watershed

Name: Brushy Creek

Location: Near Houston in Texas County, Missouri

Hydrologic Unit Code (HUC): 10290202-020001

Water Body # (WBID): 1592

Missouri Stream Class: P [1]

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

Size of Impaired Segment: 0.4 mile

Location of Impaired Segment: Wholly contained in NE¼, Section 6, T30N, R9W

Pollutants:
- Biochemical Oxygen Demand (BOD)
- Volatile Suspended Solids (VSS)

Pollutant Source: Houston Brushy Creek Wastewater Treatment Plant

Permit Number: Missouri State Operating Permit No. MO-0039675 [2]

TMDL Priority Ranking: High

1. Background and Water Quality Problems

Geography:
Brushy Creek is about seven miles long and flows northwest through Houston, Missouri. It is a tributary to the Big Piney River. The Big Piney Watershed lies within the Salem Plateau

[1] Streams that maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations 20-7.031(1)(F). The WQS can be found at the following uniform resource locator (URL): http://www.dnr.mo.gov/wpscd/wpcp/wqstandards/wq_standard_hm.htm
[2] The state permitting system is Missouri's program for administering the National Pollution Discharge Elimination System (NPDES) program.

Subdivision of the Ozark Plateau Physiographic Region, which is a highly dissected plateau with upland elevations ranging from 1,000 to 1,400 feet above mean sea level. The geology of the Big Piney Watershed consists primarily of soluble rock formations of dolomites and sandstone dolomites. As is the case in most watersheds of the Ozarks, this geology, in combination with an average annual precipitation of over 42 inches, has created a karst landscape.[3]

Area History[4]:
The largest of Missouri's 114 counties, Texas contains 1,183 square miles of Ozark highlands. When it was formed in 1843, it was named for the explorer, fur trader and first Lt. Governor of Missouri, William H. Ashley. But when formally organized in 1845, it was named for the Republic of Texas. The county seat was laid out in 1846 near the center of the county on Brushy Creek and named for the first president of the Texas Republic, Sam Houston. In the Civil War, the county was ravaged by guerrilla warfare and the town was destroyed. Houston's modern development has been as a trading center for dairy, poultry, livestock and lumber.

Rugged hills, springs and caves abound in Texas County. The area was part of the 1808 Osage Indian land cession and there are still Indian paintings on the White Rock Bluffs on the Little Piney River. The bluff is about 75 feet high and ¼ mile long. From west to east its color changes from gray to brick red to gray again to yellow and finally to white. Pioneers came to the area in the 1820s from Virginia, Kentucky, Tennessee and North Carolina and set up sawmills along the Piney River. In the early 1800s, William Ashley leached saltpeter from bat guano in a cave to the northeast for use in making gunpowder in his factory in Potosi.

Soils and Land Use:
In the bottomlands of Brushy Creek, the soil types are the Kaintuck-Relfe and the Dunning-Hercules complexes. These are very deep soils with 0-3 percent slopes. They are frequently flooded with negligible runoff and are poorly to well drained. The Deible silt loam has similar characteristics to these complexes, but it is found on the stream terraces and is rarely flooded. On the back slopes of the hills, the dominant soil is the Bendavis-Poyner complex, which is rocky and stony to very stony. The slopes range from 8-50 percent. This soil is moderately deep and moderately well drained with very fast runoff. Other back slope soils are the Lily-Bender (3-15 percent slopes) and Bender-Rock outcrop (15-35 percent slopes) complexes. In places, very steep bluffs line the creek. These are the Bender-Alred-Rock outcrop complex with 15-60 percent slopes. This complex is very stony, moderately deep, well drained with very high runoff. On the ridges, shoulders and summits, the Tonti silt loams are very prevalent with 1-8 percent slopes. These loams are very deep and moderately well drained with medium to low runoff.

The land use in the Brushy Creek watershed is 65 percent grassland and 33 percent forest or woodland. Only 1.7 percent is urban (see land use map in Appendix A).

Defining the Problem:
The Missouri Department of Natural Resources (the department) has performed visual examinations and sampling of the kinds of aquatic invertebrates (like water insects and crayfish) in Brushy Creek

[3] www.conservation.state.mo.us/fish/watershed/bigpiney/geology/010getxt.htm
[4] Texas County Missouri Heritage, Vol. I. Page 1, photos of a plaque. Published by Texas Co. Genealogical and Historical Society 1989.

upstream and downstream from the Houston Brushy Creek Wastewater Treatment Plant (WWTP). The 1998 303(d) listing for the impaired reach of Brushy Creek was based on just such a stream survey in 1993 when moderate sludge deposits were observed below the outfall. Abundant physa (pollution tolerant snails), leeches and a dense covering of filamentous algae were also observed, but no fish were present. While Brushy Creek runs through the town of Houston above the WWTP, these impairments do not appear until downstream of the plant. Additionally, these types of problems (sludge and filamentous algae) are usually associated with WWTPs and there are no other plants in this watershed or other sources that could contribute to the impairment. A 1999 Water Quality Review Sheet also cited Missouri Department of Conservation personnel and citizen complaints about the "polluted" condition of Brushy Creek in the WWTP area. In 2001, a fish kill occurred in Brushy Creek near Houston. The source of the kill was reported to be the result of continuous sewage bypass releases from the WWTP. The department conducted a stream survey in August 2001 and two more in July and August 2002 (see Appendices B and C for data and map).

These violations are a concern because wastewater high in Biochemical Oxygen Demand (BOD) reduces the amount of dissolved oxygen in the stream's water. Most aquatic organisms require high levels of oxygen to survive. The type of aquatic organisms that can thrive in an effluent-dominated stream usually changes. Most pollution-sensitive species of fish and invertebrates disappear and mainly pollution-tolerant organisms remain. In addition, volatile suspended solids (VSS), also known as suspended solids, can settle onto the bottom of a stream smothering natural substrates (materials in the streambed), aquatic invertebrate animals (like water insects and crayfish) and fish eggs.

The Houston Brushy Creek WWTP, permit number MO-0039675, has a trickling filter, aerobic digester and performs chlorination. The sludge is being land applied. The design flow is 400,000 gallons per day (which translates to 0.62 cubic feet per second (ft^3/sec)). It discharges directly to Brushy Creek. Like all wastewater discharges in Missouri, the Houston Brushy Creek WWTP has to meet the requirements of a discharge permit issued by the department. Their current limits for BOD are 60 milligrams per liter (mg/L) weekly average and 40 mg/L monthly average, or 60/40. The current limits for Total Suspended Solids (TSS)[5] are also 60/40. The permit expires October 4, 2006.

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

Designated Uses and Mixing Zone:
The designated uses of this section of Brushy Creek, WBID 1592, are:

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

The stream designated uses and classifications may be found at 10 CSR 20-7.031 (1)(C) and (F) and Table H. A mixing zone applies to this TMDL. From 10 CSR 20-7.031 (4)5.B.(II)(a): for streams

[5] VSS is the volatile (can be burned off) portion of TSS. The VSS standard (as a narrative of no noticeable downstream objectionable deposits) will be achieved by a daily maximum TSS permit limit.

with 7Q10[6] low flow of 0.1 – 20 ft^3/sec, the mixing zone shall be one-quarter of the stream width, cross-sectional area or volume of flow; length one-quarter mile.

Anti-degradation Policy:
Missouri's Water Quality Standards include the U. S. Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, 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 instream water uses are those uses that were attained on or after November 29, 1975, the date of EPA's first Water Quality Standards 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 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 antidegradation 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 best management practices for nonpoint 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 water 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).

Specific Criteria:

Biochemical Oxygen Demand (BOD)

Dissolved oxygen (DO) is the water quality standard that is exceeded in Brushy Creek. DO is not a pollutant and cannot be allocated in a TMDL. Biochemical Oxygen Demand (BOD) is the parameter used to determine the impact that wastewater will cause on DO levels in a receiving stream. There is no numeric criterion in the Missouri Water Quality Standards (WQS) for BOD. Since DO cannot be allocated, but **does** have a numeric criterion, DO is linked to BOD. BOD is a pollutant that is measurable and may be allocated in a TMDL.

BOD is composed of carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). NBOD is estimated directly from Total Kjeldahl Nitrogen (TKN), which is ammonia nitrogen (NH_3-N) plus organic nitrogen. The numeric link between DO and BOD is generated by the water quality model QUAL2E, and is supported by EPA. The QUAL2E model calculates BOD by using $CBOD_5$, organic nitrogen, and ammonia data from actual sample analyses. State water quality standards for all Missouri streams except cold water fisheries

[6] 7Q10 is the lowest average flow for seven consecutive days with a recurrence interval of ten years.

call for daily minimum of **5 milligrams per liter (mg/L or parts per million) dissolved oxygen**[7] or the normal background level of dissolved oxygen, whichever is lower.[8]

Volatile Suspended Solids (VSS)

A stream survey conducted during summer low flows by the department resulted in Brushy Creek being placed on the 1998 303(d) impaired waters list for the presence of sewage sludge. There is no numeric standard for VSS. Deposits of sewage sludge (VSS) in waters of the state are interpreted as violations of the general (narrative) criteria of the Water Quality Standards (WQS). These standards may be found in 10 CSR 20-7.031(3)(A) and (C) where it states:

- "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."
- "Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses."

Numeric Water Quality Targets:

For details on how the targets were derived, see the Wasteload Allocation, Section 5.

Biochemical Oxygen Demand (BOD)

To maintain the state criteria 5.0 mg/L of dissolved oxygen (the target) in the stream, the Wasteload Allocation (WLA) for CBOD is set at 8 mg/L.

Volatile Suspended Solids (VSS)

Since there are no numeric standards for VSS, the target is to meet the general criteria of "no noticeable downstream objectionable deposits". This will be accomplished be setting the permit limit for Total Suspended Solids equal to the BOD_5 limits (see Sections 5 and 9).

Ammonia as Nitrogen (NH_3-N)

Ammonia nitrogen load is an additional cause of depletion of dissolved oxygen. The in-stream targets for NH_3-N (from the WQS) are 1.0 mg/L in summer and 1.75 mg/L in winter. The load for the Houston Brushy Creek WWTP is calculated at 1.9 mg/L in the summer and 2.4 mg/L in the winter.

3. Calculation of Load Capacity

Load Capacity (LC) is defined as the greatest amount of a pollutant a waterbody can assimilate without violating Missouri Water Quality Standards. This total load is then divided among a Wasteload Allocation (WLA) for point sources, a Load Allocation (LA) for nonpoint sources and a Margin of Safety (MOS). To calculate the total load (or LC), this formula is used:

(design stream flow in ft^3/sec*)(maximum allowable pollutant concentration in mg/L)(5.395*)= pounds/day*

*5.395 is the constant used to convert ft^3/sec times mg/L to pounds/day.

The LC in this case is equal to the WLA, because there is no nonpoint source contribution and the MOS is implicit. See the WLA, Section 5.

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[7] 10 CSR 20-7.031(4)(J)

[8] 10 CSR 20-7.031(4)(A)(3)

To find that pollutant concentration, the QUAL2E model was used. Calibration of the model was based on water quality data collected in July and August of 2002 (see data and map in Appendices B and C). The estimated 7Q10 for Brushy Creek (based on that of the Big Piney River) is 0.83 ft^3/s. This estimated flow was reduced by 75 percent (to 0.21 ft^3/s) for modeling purposes in accordance with the Missouri code of state regulations for mixing zones in streams this size (see Section 2 for details).

4. Load Allocation (Nonpoint Source Load)

Load Allocation (LA) is the maximum allowable amount of the pollutant that can be assigned to nonpoint sources. No measurable concentrations of BOD, VSS or total phosphorus were detected upstream of the area of influence of the Houston facility, so the nonpoint source load allocation for these parameters is zero pounds per day.

5. Waste Load Allocation (Point Source Loads)

The Wasteload Allocation (WLA) is the maximum allowable amount of the pollutant that can be assigned to point sources.

Biochemical Oxygen Demand (BOD):
The surveys in 2002 indicated there was a high concentration of algae just downstream of the Brushy Creek treatment plant outfall. While the Carbonaceous Biochemical Oxygen Demand (CBOD) at the outfall measured during the surveys was not particularly high, (a maximum of 19 mg/L), there was a wide diurnal fluctuation of dissolved oxygen (DO) concentration in-stream ranging from 2.6 to 13.8 mg/L. Nutrient concentrations at the outfall were high. Total nitrogen was 21 mg/L and total phosphorus was 4.6 mg/L. This may be an indication that the low DO readings during the early morning hours were due more to alga respiration than to BOD concentration from the outfall. This would explain the high concentration of DO in the water in the afternoon, when photosynthesis is the dominant factor.

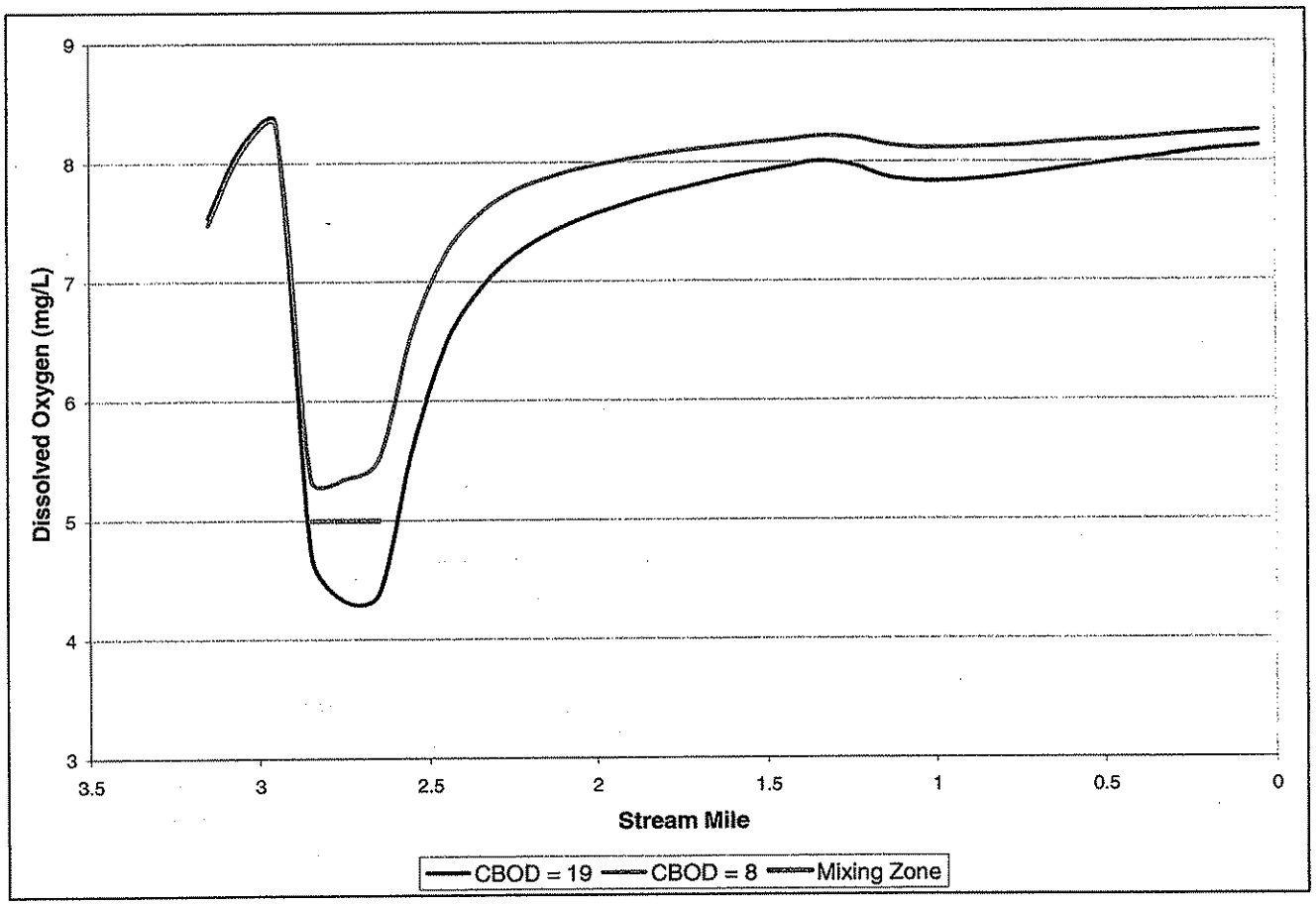
Chlorophyll-a was measured in-stream at all sampling points. It was not practical to measure it at the outfall. In order for the model to achieve calibration with in-stream data, the point source was assumed to have a high concentration, about 3500 μg/L. CBOD inputs were tested at 19 mg/L (CBOD at the time of the survey) and 8 mg/L at the outfall. Results are in figure 1.

All other factors being equal, compliance with water quality standards at the end of the mixing zone requires a WLA for CBOD of 8 mg/L. However, it is evident from both observation of the stream and examination of the data that a significant reduction in nutrient loading would allow for more flexibility for CBOD limits. The relationship between nutrient (nitrogen and phosphorus) loading and diurnal oxygen depletion can be difficult to quantify. There is a large number of environmental variables that influence DO concentration, such as shading, type of stream substrate, and types of periphyton present[9].

[9] US EPA 2000a. Nutrient Criteria Technical Guidance Manual – Rivers and Streams. Office of Water. Office of Science and Technology. EPA 822-B-00-002. Washington, D.C.

Model output demonstrated that reducing nutrient input from the discharge, increased the DO concentration in the stream. Algae growth would be reduced, resulting in reduced rates of respiration and decomposition as algae dies off. There would also be reduced mineralization of the organic compounds containing nitrogen and phosphorus.

Figure 1: QUAL2E simulation of the effect of CBOD concentration on dissolved oxygen concentration in Brushy Creek



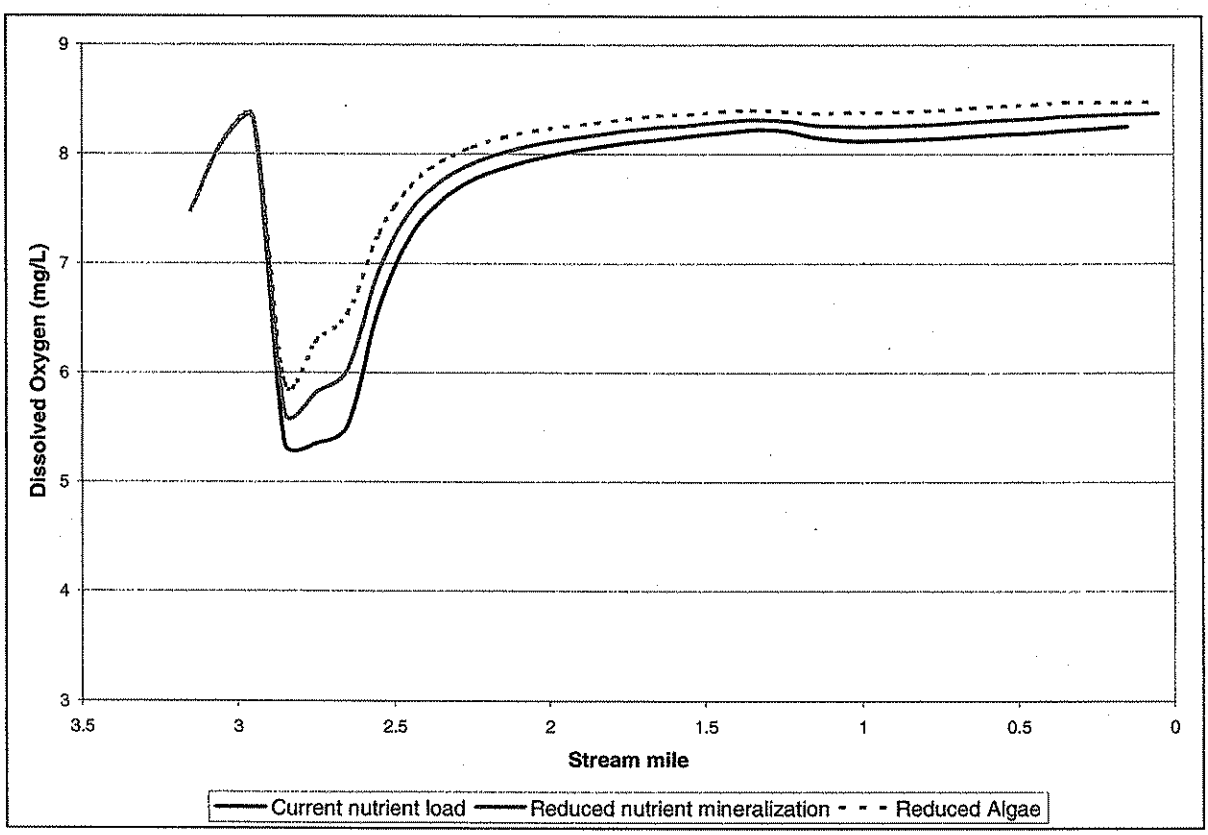
The WLA for CBOD is calculated using this formula:

(WWTP design flow in ft^3/sec*)(CBOD in mg/L)(5.395) = CBOD in pounds/day*

(0.62 ft^3/sec)(8 mg/L)(5.395) = **26.8 pounds/day of CBOD**

Figure 2 illustrates an estimated benefit from controlling nutrient load in the effluent. The reduced mineralization scenario is based on QUAL2E simulation of DO concentration resulting from a reduction in total nitrogen and total phosphorus by 80 percent. The reduced algae scenario is based on the assumption that algae respiration and decomposition occurs at an equivalent rate to mineralization of nutrients. This is a conservative assumption and it is probable that net reduction of algae blooms downstream from the treatment plant would significantly reduce oxygen deficit. Note: This is only a scenario and is not included in the actual WLA.

Figure 2: QUAL2E simulation of the effect of reducing nutrient loading by 80 percent from Houston treatment plant



Volatile Suspended Solids (VSS):
At the time data was gathered for this WLA, the stream was listed for Non-Filterable Residue (NFR). Any waterbody that was listed for NFR in 1998, such as Brushy Creek, is now being listed as Volatile Suspended Solids (VSS). This change was made to better distinguish between organic solids coming from wastewater treatment plants (VSS) and mineral solids (soil or mineral particles) coming from soil erosion or erosion of mine waste materials or stockpiles (Non-Volatile Suspended Solids or NVSS). Modeling of VSS instream can be reasonably approximated based on the NFR data that is available.

Normally, the target value for non-conservative parameters, such as NFR and VSS, is based on data from immediately upstream of the point source in question. However, the data available indicate that there is probable loading of NFR from the Redi-mix facility (permit number MOG-500002) just upstream from the Houston treatment plant. NFR in the discharge from Redi-mix would be principally in the form of NVSS, and it is not considered to be a contributor of VSS[10].

The current permit for the Houston treatment plant was issued with effluent limits for Total Suspended Solids (TSS) of 60/40 mg/L (weekly/monthly averages). Direct application of these

[10] Since 2002, when the data used in modeling was collected, this facility has closed and moved its operations out of the Brushy Creek watershed.

limits is not protective of water quality during low-flow conditions in Brushy Creek. Water Quality Based Effluent Limits (WQBELs) for the WWTP have been calculated using the methods and proceedures outlined in the EPA Technical Support Document (for more detail, see Section 9. Implementation). Given that the WQBELs calculated for BOD_5 are more restrictive than standard secondary treatment, TSS effluent limits at the same level of treatment should be protective of general criteria. Therefore, TSS effluent limits will be set equal to those of BOD_5 (below). These limits represent a greater than 70 percent reduction of the solids loading to the receiving stream.

BOD_5 Maximum Daily Limit (MDL) = **18.0 mg/L = TSS MDL**
BOD_5 Average Monthly Limit (AML) = **11.5 mg/L = TSS AML**

Ammonia as Nitrogen (NH_3-N):

Ammonia nitrogen (NH_3-N) in the stream causes oxygen depletion with nitrification. It also is directly toxic to aquatic life. Maintenance of sufficient DO in the stream is more critical during the warm season, and is subject to depletion as a function of NH_3-N concentration (Figure 3). However, for this location, potential ammonia toxicity is the prevailing concern, during both the warm and cool seasons (Figures 4 and 5).

The specific criteria for ammonia are found in 10 CSR 20-7.031 Table B. These limits are pH and water temperature dependent. Seasonal ammonia limits (under the heading "General Warm Water Fishery") at the typical seasonal pH and water temperature values (7.8 pH and 8°C winter and 26°C summer) are 1.2 mg/L (summer) and 2.1 mg/L (winter). Note that all values in 10 CSR 20-7.031 Table B are given as total ammonia while permit limits are expressed as "ammonia as N[itrogen]" (NH_3-N). To convert from total ammonia to NH_3-N, divide by 1.2. Doing the math results in a standard of 1.0 mg/L for NH_3-N during the warm season. From the model, this is maintained at the end of the mixing zone with a WLA of 1.9 mg/L NH_3-N. During the cool season, a total ammonia of 2.1 mg/L gives 1.75 mg/L NH_3-N. That criterion is maintained with a WLA of 2.4 mg/L.

The WLA for NH_3-N is calculated as follows:

(WWTP design flow in ft^3/sec)(NH_3-N in mg/L)(5.395) = NH_3-N in pounds/day

NH_3-N (May 1- Oct 31): (0.62 ft^3/sec)(1.9 mg/L)(5.395) = **6.36 pounds/day**
NH_3-N (Nov 1- Apr 30): (0.62 ft^3/sec)(2.4 mg/L)(5.395) = **8.03 pounds/day**

Figure 3: Dissolved Oxygen response to ammonia nitrogen concentrations in discharge from the Houston Brushy Creek WWTP

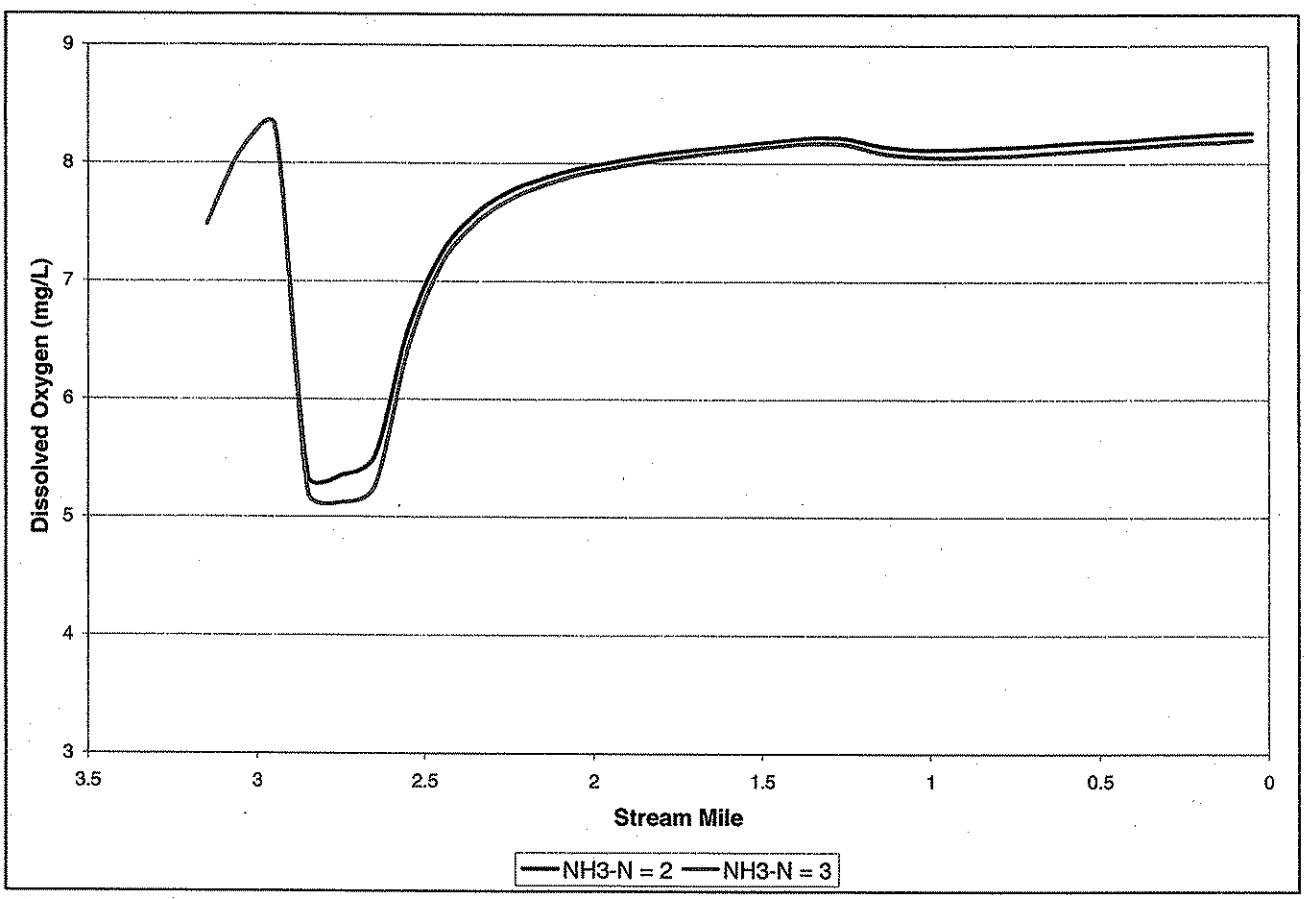


Figure 4: Instream Ammonia Nitrogen in Winter Conditions

Note: The short horizontal line represents the length and position of the mixing zone

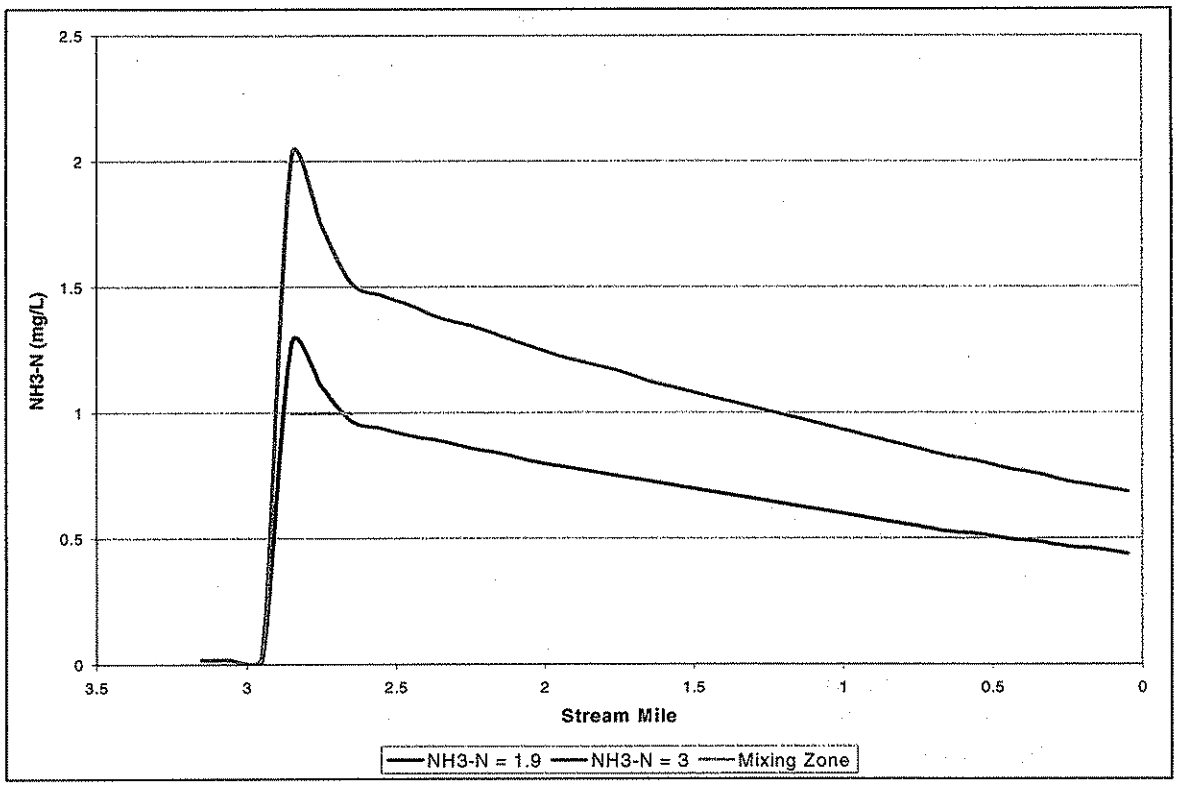
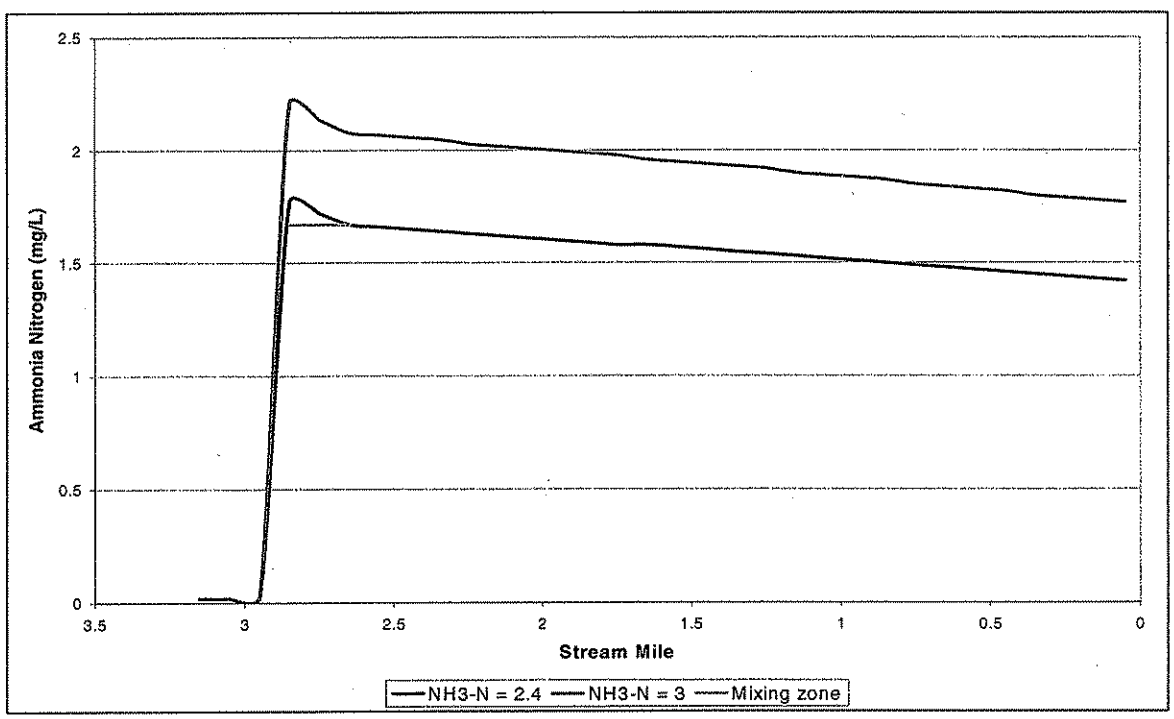


Figure 5: Instream Ammonia Nitrogen in Summer Conditions

Note: The short horizontal line represents the length and position of the mixing zone



Concluding Remarks:
Brushy Creek is listed for biochemical oxygen demand and volatile suspended solids (VSS). Data from stream surveys indicate that total nitrogen and total phosphorus are significant factors contributing to impairment of the stream. Houston Brushy Creek WWTP management is aware that there is an issue with phosphorus at the facility, citing struggles with periodic discharges from the washing and preparation process of one of the city's industries. This is being addressed. While there are no nutrient criteria that are applicable to Brushy Creek at this time, it is strongly recommended that any upgrade to this treatment plant must include necessary components to reduce total phosphorus and total nitrogen as much as practical. When nutrient standards are promulgated, appropriate limits for this facility will need to be calculated. It should be noted that the nutrient scenario cited in Section 5 is not included in the actual WLA. However, if the impairment is not fixed as the result of implementing this TMDL, then the nutrient scenario will be considered in Phase II.

6. Margin of Safety

A Margin of Safety (MOS) is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. 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 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 waste load allocation and the load allocation calculations by making conservative assumptions in the analysis.

This MOS is implicit in this TMDL, included in the model assumptions and calculations. The limits for CBOD and VSS were derived from QUAL2E simulations that maintained at least a 10 percent margin beyond target concentrations.

Since the Redi-mix plant is not longer operating upstream of the WWTP, consideration of it in the model is an added MOS.

7. Seasonal Variation

Seasonal variation is taken into consideration for ammonia as nitrogen and a separate limit calculated for each summer and winter. Also, colder water (winter) holds more oxygen, so low flow conditions (7Q10) in summer are always used to calculate all the limits to offer the maximum protection for the stream.

8. Monitoring Plans

The department will conduct two special sediment studies in Brushy Creek, one in 2007 and one in 2008. In addition, instream monitoring is already required in Houston's permit, which lists four instream monitoring points. The parameters that are to be collected once a month at these points include pH, temperature, total ammonia, dissolved oxygen and phosphorus. As with all of Missouri's TMDLs, if continuing monitoring reveals that water quality standards are not being met,

the TMDL will be reopened and re-evaluated accordingly. This TMDL will be incorporated into Missouri's Water Quality Management Plan.

9. Implementation

This TMDL will be implemented through permit limits. The current Houston Brushy Creek WWTP permit (MO-0039675) was issued October 5, 2001, with limits for BOD of 60/40 mg/L (weekly/monthly averages) and 60/40 mg/L Total Suspended Solids (TSS)[11]. Based on the WLAs detailed in this TMDL, Water Quality Based Effluent Limits (WQBELs) for the WWTP have been calculated using the methods and proceedures outlined in the EPA Technical Support Document (EPA/505/2-90-001). This results in the following effluent limits for **CBOD**:
CBOD WLA = 8 mg/L
CBOD Long Term Average (LTA) = 4.2 mg/L

CBOD Maximum Daily Limit (MDL) = **13.0 mg/L**
CBOD Average Monthly Limit (AML) = **6.5 mg/L**

BOD_5 MDL = **18.0 mg/L**
BOD_5 AML = **11.5 mg/L**

Direct application of the current effluent limits for TSS is not protective of water quality during low-flow conditions in Brushy Creek. Given that the WQBELs calculated for BOD_5 are more restrictive than standard secondary treatment, TSS effluent limits at the same level of treatment should be protective of general criteria. Therefore, **TSS effluent limits will be set equal to those of BOD_5 (above).** These limits represent a greater than 70 percent reduction of the solids loading to the receiving stream.

The limits for **NH_3-N** are as follows:

Summer	Winter
WLA = 1.9 mg/L	WLA = 2.4 mg/L
LTA = 1.0 mg/L	LTA = 1.3 mg/L
MDL = 3.1 mg/L	**MDL = 4.0 mg/L**
AML = 1.6 mg/L	**AML = 2.0 mg/L**

These new limits will be incorporated into Houston Brushy Creek WWTP's permit when it comes up for renewal on October 4, 2006.

10. Reasonable Assurances

The department has the authority to write and enforce NPDES permits. Inclusion of effluent limits into a state NPDES permit, and quarterly monitoring of the effluent reported to the department, should provide reasonable assurance that instream water quality standards will be met.

[11] TSS is the parameter currently used in Missouri state operating permits. It is the sum of VSS and NVSS. Since VSS is the organic solids coming from WWTPs, TSS and VSS are considered equivalent.

11. Public Participation

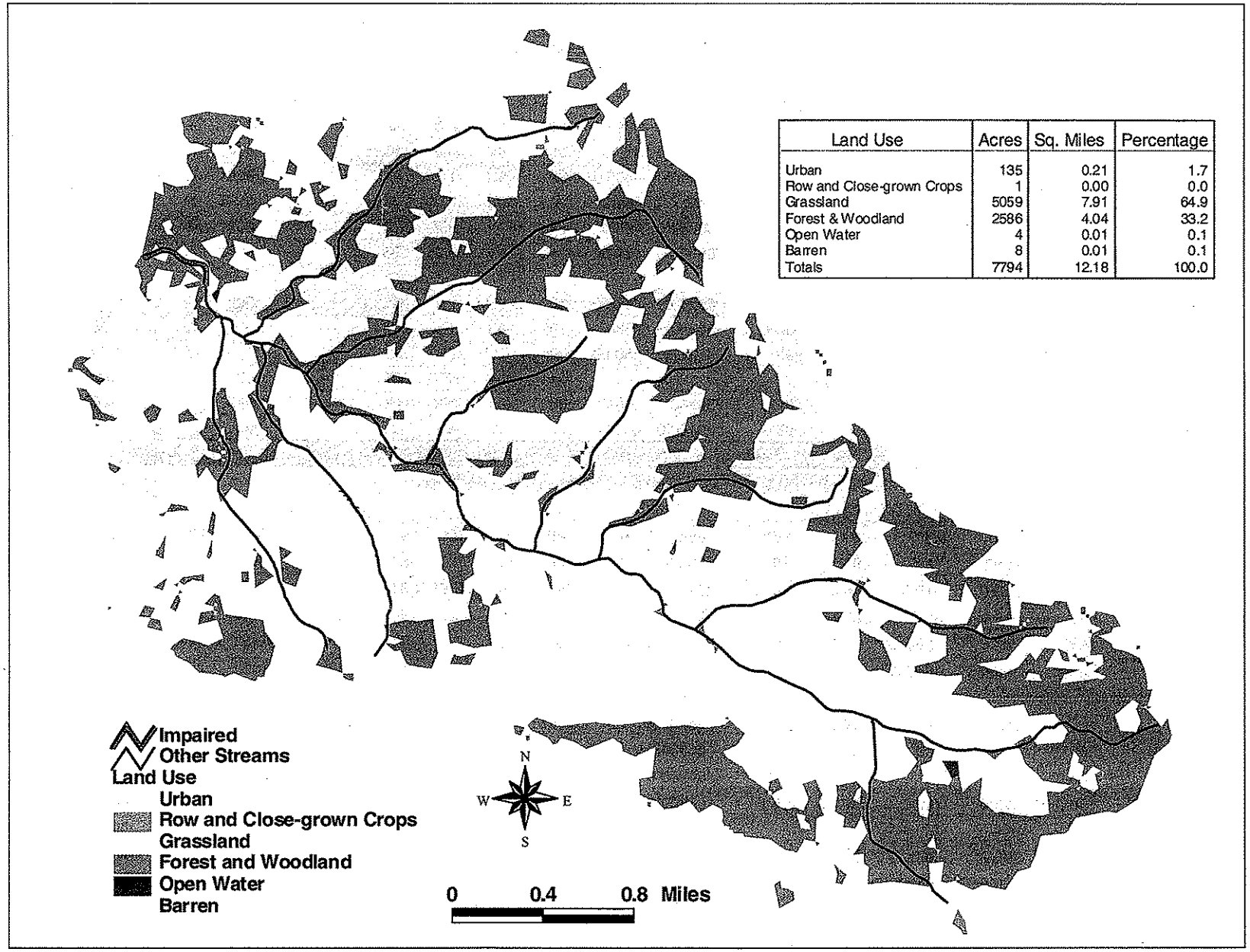
This water quality limited segment is included on the approved 2002 303(d) list for Missouri. The department's Water Protection Program developed this TMDL. The public notice period was from August 26 to September 25, 2005. Groups that received the public notice announcement included the Missouri Clean Water Commission, Houston Brushy Creek WWTP, the Water Quality Coordinating Committee, Stream Team volunteers in the county (27), the legislators representing Texas County (3) and others that routinely receive the public notice of NPDES permits. One comment was received, but it did not necessitate changes to the TMDL. It, along with the department's response, has been placed in the Brushy Creek file.

12. Appendices and List of Documents on File with the Department

Appendices:
Appendix A – Land use map for the Brushy Creek watershed
Appendix B – Data for Brushy Creek from July and August 2002 (used in the model)
Appendix C – Topographic map showing WWTP location, impaired segment and sampling sites

Documents on file:
Houston Brushy Creek WWTP Permit #MO-0039657
Stream Survey Sampling Reports: Houston Brushy Creek WWTP and Brushy Creek, Houston, Missouri. Texas County. 2001 & 2002. Environmental Services Program.
Water Protection Program stream surveys from 1983-1999
Input and output from the QUAL2E model
Public Notice announcement
Brushy Creek Information Sheet
Comment letter and department response

Appendix A
Land Use Map for Brushy Creek Watershed



Land Use	Acres	Sq. Miles	Percentage
Urban	135	0.21	1.7
Row and Close-grown Crops	1	0.00	0.0
Grassland	5059	7.91	64.9
Forest & Woodland	2586	4.04	33.2
Open Water	4	0.01	0.1
Barren	8	0.01	0.1
Totals	7794	12.18	100.0

Appendix B

Brushy Creek Water Quality Data, July 2002

Site #	Year	Mo	Day	Time	Flow	C	DO	pH	SC	KJN	NH3N	NO3N	TN	PO4	TP	CBOD	TSS
M2	2002	7	24	530	1.9657	23	5.7	7.7	335	0.099	0.02499	0.37	0.47	0.02499	0.02499	0.99	5
M3	2002	7	24	550	2.3223	19	6.3	7.5	360	0.099	0.02499	0.81	0.91	0.02499	0.05	0.99	8
M4	2002	7	24	600	0.3755	22	4.4	7.5	711								
M5	2002	7	24	630	1.2051	20	2.6	7.4	400	0.29	0.02499	1.9	2.19	0.38	0.46	0.99	2.499
M5	2002	7	24	635		20.1	2.5	7.45	399	0.2	0.02499	1.89	2.09		0.47	0.99	9
M6	2002	7	24	610	4.5529	22	5.2	7.8	387	0.099	0.02499	1.82	1.92	0.37	0.44	0.99	2.499
M8	2002	7	24	550	2.1255	23	4.2	7.8	393	0.8	0.02499	1.75	2.55	0.34	0.4	0.99	5
M2	2002	7	24	1340		27	9.2	8	378	0.099	0.02499	0.31	0.41	0.02499	0.02499	0.99	2.499
M3	2002	7	24	1315		23	10	7.5	359	0.28	0.02499	0.79	1.07	0.02499	0.06	0.99	9
M4	2002	7	24	1335	0.4412	26	5.8	7.6	777	7.22	2.6	14.7	21.92	3.8	4.61	19	26
M5	2002	7	24	1300		22	13.8	7.6	404	0.71	0.07	2.23	2.94	0.51	0.62	0.99	2.499
M6	2002	7	24	1320		24	10.8	8.2	384	0.3	0.02499	1.69	1.98	0.42	0.42	0.99	2.499
M8	2002	7	24	1300		25	9.6	8	382	0.099	0.02499	1.49	1.59	0.37	0.4	0.99	2.499

Brushy Creek Water Quality Data, August 2002

Site #	Yr	Mo	Dy	Time	Flow	C	DO	pH	SC	KJN	NH3N	NO3N	TN	PO4	TP	CBOD	TSS
M2	2002	8	6	530		25	4.6	7.7	345	0.099	0.02499	0.24	0.34	0.02499	0.02499	0.99	7
M3	2002	8	6	545		20	5.4	7.3	369	0.099	0.02499	0.9	1	0.02499	0.02499	0.99	16
M4	2002	8	6	600		25	2.9	7.2	741								
M5	2002	8	6	615		21	1.7	7.2	430	0.099	0.13	2.8	2.9	0.59	0.65	0.99	5
M6	2002	8	6	605		23	5.1	7.8	407	0.099	0.02499	1.96	2.06	0.35	0.38	0.99	7
M8	2002	8	6	630		25	4	7.8	394	0.099	0.02499	1.58	1.68	0.33	0.35	0.99	8
M2	2002	8	6	1310		26	8.5	7.8	340	0.16	0.02499	0.22	0.38	0.02499	0.02499	0.99	6
M3	2002	8	6	1300		23	8.4	7.6	357	0.23	0.02499	0.84	1.07	0.02499	0.02499	0.99	13
M4	2002	8	6	1310		27	5.8	7.5	781	3.69	2.24	16.9	20.59	4.11	4.65	15.6	16
M5	2002	8	6	1345		22	11	7.8	425	0.099	0.02499	2.84	2.94	0.73	0.67	0.99	7
M6	2002	8	6	1350		24	10.9	8.2	412	0.35	0.02499	2.22	2.57	0.39	0.39	0.99	6
M8	2002	8	6	1430		26	9.3	8.1	390	0.099	0.02499	1.33	1.43	0.43	0.33	0.99	7

Abbreviations defined:

MO = Month; Time is 24-hour time; C = Temperature in degrees Celsius; DO = Dissolved Oxygen; SC = Specific Conductivity; KJN = Kjeldahl Nitrogen; NH3N = Ammonia Nitrogen; NO3N = Nitrate Nitrogen; TN = Total Nitrogen; PO4 = Phosphate; TP = Total Phosphorus; TSS = Total suspended solids; CBOD = Carbonaceous Biochemical Oxygen Demand

Periphyton samples in Brushy Creek, Natural Substrate, July 23, 2002
Note: These periphyton samples are measured in milligrams per meter squared (mg/m^2)

Site #	Near Left Bank	Center	Near Right Bank
M2	64.2	52.4	69.2
M3	167	194	228
M5	213	205	716
M6	483	544	610
M8	312	217	250

Periphyton samples in Brushy Creek, Natural Substrate, Aug 6, 2002

Site #	Near Left Bank	Center	Near Right Bank
M2	80	68.5	43.9
M3	72.2	82.9	244
M5	285	279	196
M6	391	100	90.9
M8	336	331	230

Periphyton samples in Brushy Creek, Artificial Substrate, July 23, 2002

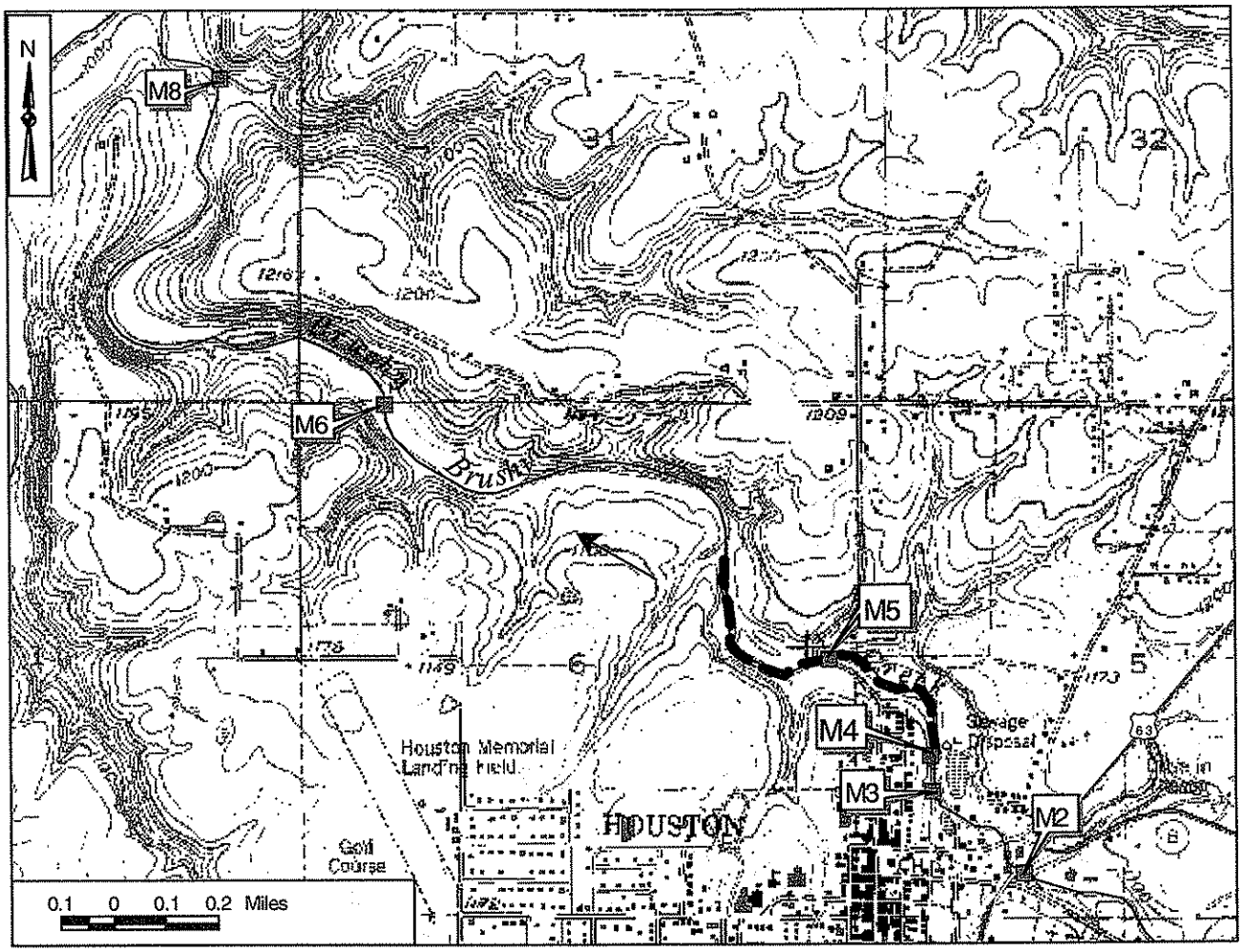
Site #	Near Left Bank	Center	Near Right Bank
M2	29.6	26.7	28.2
M5	4.8	3.6	3.8
M8	206	225	395

Periphyton samples in Brushy Creek, Artificial Substrate, Aug 6, 2002

Site #	Near Left Bank	Center	Near Right Bank
M2	19.7	25.7	33
M5	5.2	6.4	9.3
M8	311	376	363

Note: These periphyton samples are measured in milligrams per meter squared (mg/m^2)

Appendix C
Topographic Map of Brushy Creek in Texas County with Sampling Sites



Site Index

M2 – Brushy Creek 20 yards upstream from U.S. 63
M3 – Brushy Creek 200 yards upstream from Houston Brushy Creek WWTP
M4 – Houston Brushy Creek Treatment Plant
M5 – Brushy Creek ¼ mile downstream from Houston Brushy Creek WWTP
M6 – Brushy Creek 1¾ miles downstream from Houston Brushy Creek WWTP
M8 – Brushy Creek 2½ miles downstream from Houston Brushy Creek WWTP